

External Peer Review  
Graduate School WIAS

Documentation over 2009-2014



**WAGENINGEN UR**  
*For quality of life*

June 2015



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## Preface

In the Dutch national research evaluation system, all publicly funded research is evaluated by an international peer review committee once every six years. The outlines for this evaluation are provided by the Standard Evaluation Protocol (SEP) 2015-2021 developed in 2014 by the Association of Universities in the Netherlands (VSNU) and the Royal Netherlands Academy of Arts and Sciences (KNAW). In this system, the graduate school “Wageningen Institute of Animal Sciences” (WIAS) has been previously evaluated according to the SEP 2003-2009, in June 2009. The results of the evaluation are intended to assist the research organisation, the management of the Chair groups and the individual researchers in their attempts to improve the scientific quality and relevance to society of the research and to strengthen the viability of the Chair groups.

The goal of the present review is twofold. First the WIAS Peer Review Committee is requested to evaluate the overall scientific performance of the individual Chair groups that participate in the graduate school WIAS, according to the criteria set by the Dutch Standard Evaluation Protocol, e.g., the quality of research, the relevance to society and the viability of the group. Second, the WIAS Peer Review Committee is requested to comment on specific elements of the graduate school WIAS, as described below:

1. The graduate school provides a well-organised, coherent, and productive research environment for the PhD programme
2. The graduate school offers a sound and institutionalised programme, in which PhD candidates are trained to become independent researchers
3. The budget of the graduate school is sufficient for the graduate school’s planned capacity and strategy

The graduate school generates a ‘self-evaluation report’ once every three years, one in preparation of the external review, and one three years later as a mid-term review. The present report contains the self-evaluations of the graduate school WIAS and its Chair groups for the External Peer Review 2015.

In the first part of the report, issues are addressed relating to the research and PhD programmes at the level of the graduate school (Part A). In the second part (Part B) results of the individual Chairs groups are given.

In addition, the WIAS peer review committee receives supplementary documents, such as:

- Curriculum Vitae of all scientific staff members
- A compiled document consisting of:
  - List of WIAS Staff members
  - List of WIAS courses and seminars 2009-2014
  - Template WIAS Training and Supervision Plan (TSP)
  - Template WIAS Research Proposal
  - Template WIAS Midterm Progress Report
  - Template WIAS Exit Form
  - Template Go-No go Form
- WIAS Peer Review 2009 – assessment report
- WIAS Midterm Review 2012 – assessment report
- Wageningen University PhD programme self-evaluation 2015
- Wageningen University PhD programme review panel (EUA) report 2015
- Wageningen University PhD programme response of Executive Board WU 2015



**Part A.**



# 1. General

## 1.1 Organizational Context

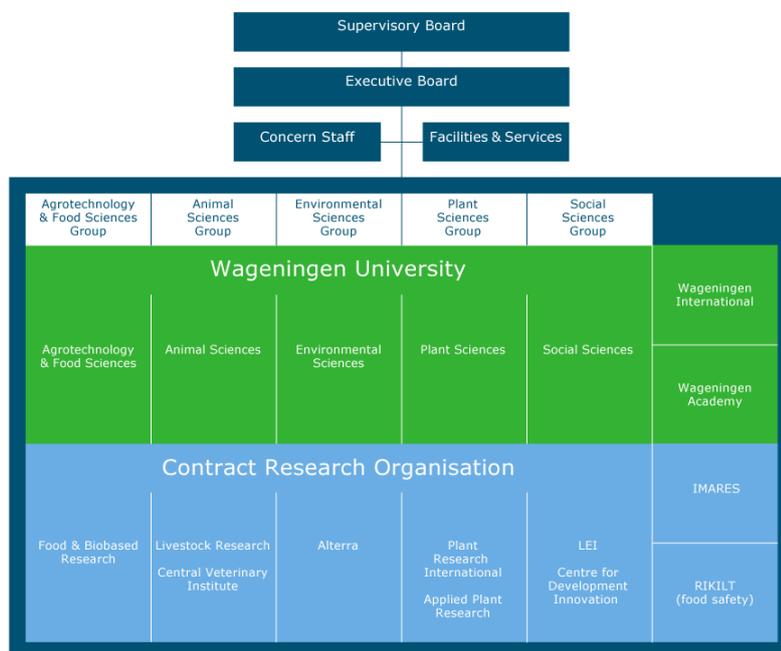
### Wageningen University and Research Centre

Wageningen University and Research Centre (Wageningen UR) combines Wageningen University (WU) and 10 research institutes of the Foundation “DLO”. The joint mission is ‘to explore the potential of nature to improve the quality of life’. The whole organisation, the University and the research institutes, work on the broad domain of Healthy Food and Environment. About 10,000 Bachelor and Master students, 1,900 PhD candidates, and 6,500 staff work on the pursuit of this mission for the benefit of science, policy, business, and society at large. The Executive Board is responsible for the overall management of Wageningen UR. The Board is accountable to a Supervisory Board, appointed by the Minister of Economic Affairs. The Rector Magnificus is vice-president of the Executive Board. Within the executive board, he is specifically responsible for education, student affairs, and research.

Wageningen UR is organised in five management units called Sciences Groups. The university is also organised along five departments. Each Wageningen UR Sciences Group consists of one university department and one or more research institutes. Wageningen UR also includes some specialised organizations with a specific assignment: Wageningen International (responsible for policies regarding internationalisation), Wageningen Academy (responsible for translating Wageningen UR’s knowledge into professional training courses for industry and other societal groups), IMARES (Wageningen’s marine research institute), and RIKILT (Wageningen’s food safety institute) (see Figure 1.1).

Each Sciences Group is chaired by a director general, who reports to the Executive Board of Wageningen UR. The Sciences Groups create the environment in which research groups of Wageningen University and DLO can cooperate.

Figure 1.1: Organisational scheme Wageningen University and Research Centre.



One of the five Sciences Groups is the *Animal Sciences Group (ASG)*, consisting of the University Department of Animal Sciences and two DLO research institutes: Wageningen Livestock Research and the Central Veterinary Institute (CVI). In addition, the research institute IMARES, although formally not part of ASG, is also directed by the same Director General. The Department of Animal Sciences and Wageningen Livestock Research are both located in Wageningen, the Central Veterinary Institute is located in Lelystad (100km from Wageningen) and Imares is located on multiple locations along the coast (varying between 100km and 200km from Wageningen).

**Wageningen University**

Wageningen University has only one faculty. According to Dutch legislation, each faculty has one board dealing with BSc and MSc education. For Wageningen University, this is the Education institute. All PhD education is governed by a group of six graduate schools. The graduate schools, however, are not responsible for MSc education, although there is some involvement with respect to the research master trajectories.

The six graduate schools are (see Figure 1.2):

- Experimental Plant Sciences (EPS)
- Production Ecology and Resource Conservation (PE&RC)
- Food Technology, Agrobiotechnology, Nutrition and Health Sciences (VLAG)
- Wageningen School of Social Sciences (WASS)
- Wageningen Institute of Animal Sciences (WIAS)
- Wageningen Institute for Environment and Climate Research (WIMEK, part of the national school of environmental sciences SENSE)

Four of these schools (EPS, PE&RC, VLAG, WIMEK) are national graduate schools, consisting of research groups from several universities. Two of these schools (WIAS, WASS) are local schools consisting of research groups from Wagening University only.

The lines of accountability are quite complex at Wageningen University and are organized along a matrix structure (Figure 1.2). In the columns of the matrix are the Sciences Groups; in the rows are the Education Institute and the Graduate Schools.

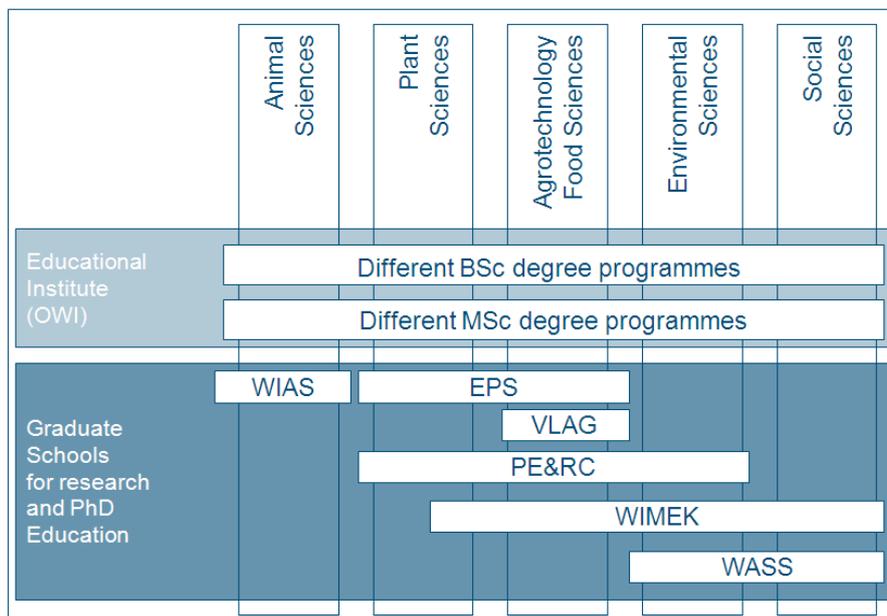


Figure 1.2 Organisational scheme of BSc, MSc, and PhD programmes by the five Sciences Groups and six graduate schools.

Chair groups of Wageningen University participate with their staff, postdocs and PhD candidates in one or more graduate schools. Eleven WIAS Chair groups are part of the Animal Sciences group. The Chair group Farm Technology is part of the Plant Sciences Group but participates both in WIAS and in PE&RC. Farm Technology will be evaluated through the graduate school PE&RC and will therefore not be referred to anymore in the current report. An overview of chair groups in WIAS is in Table 2.1 (section 2.1). Scientists of the DLO Institutes can also be members of a graduate school.

## 1.2 WGS-structure

The six graduate schools of Wageningen University work together under an umbrella organisation, called the 'Wageningen Graduate Schools' (WGS). WGS is coordinated by the Dean of Sciences, who is appointed by the Executive Board of Wageningen UR. The Dean's responsibilities are to stimulate scientific quality within, and cooperation between, the graduate schools, and to address matters of common interest. The Dean of Sciences is also advisor to the Executive Board of Wageningen UR and may represent the Rector in national forums.

Wageningen Graduate Schools receives a budget for:

- Professional skills courses for PhD candidates
- Training for supervisors
- Fellowships for sandwich PhD candidates, either on an individual basis (Wageningen Sandwich Programme) or in interdisciplinary programmes (INREF programme). Both programmes are on a competitive basis with external peer review of proposals

Early 2015, WU asked a review panel with experts from the European University Association (EUA) to assess the admission, structure, training and examination of the Wageningen University PhD programme and to evaluate whether the learning targets of the Wageningen PhD programme meet international standards. The self-evaluation report, the report of the review panel and the response of the Executive Board of Wageningen University can be found in the supplementary documents provided to the committee (USB-stick).

Besides the task to evaluate the scientific performance of the individual Chair Groups, the WIAS Peer Review Committee is, therefore, requested to focus its overall review of WIAS by commenting on specific elements, as described below:

1. The graduate school provides a well-organised, coherent, and productive research environment for the PhD programme
2. The graduate school offers a sound and institutionalised programme, in which PhD candidates are trained to become independent researchers
3. The budget of the graduate school is sufficient for the graduate school's planned capacity and strategy

## 1.3 Supporting structures for the PhD programme<sup>1</sup>

### PhD Services, Doctorate Secretariat and Students Desk

PhD Services handles administrative matters concerning registration and formal admission, and the Doctorate Secretariat handles procedures for thesis evaluation and the public defence. This is done through a registration system called Promis. Operational since 2010, Promis is continuously improved, in terms of data quality, user-friendliness and supply of management information.

PhD candidates, who intend to take Master-level courses, need to register at the Students Desk. PhD Services, Doctorate Secretariat and Students Desk are part of the corporate office "Education, Research & Innovation". The Dean of Sciences has only an advisory role in these matters.

This division of responsibilities for PhD candidates has been addressed only recently, initiated by the present Dean. The aim is to create a "one-stop shop" for PhD candidates.

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<sup>1</sup> A complete and extensive overview can be found in the EUA review self-evaluation report

### **Academic Board**

The Academic Board is the “gatekeeper” of the quality of PhD theses at Wageningen University. The Board currently consists of the Rector, the Dean of Education, the Dean of Sciences and 10 professors appointed by the Executive Board. The role of the Academic Board in the evaluation of the PhD thesis is described in section 3.5.

### **Wageningen PhD Council**

The Wageningen PhD Council is a forum in which representatives of the PhD councils from each of the six graduate schools discuss and address common issues and concerns that touch upon the work and life of PhD candidates.

As such, the PhD Council is first and foremost a body that represents the interests of PhD candidates at a university-wide level. The council has quarterly meetings with the Dean of Sciences and is represented in the national PhD Network of the Netherlands. Examples of issues that have been considered over the last year are:

- Integrity, most notably the relationship between PhD candidates and their supervisors
- PhD housing opportunities in Wageningen
- Participation of PhD candidates in the WUR Council
- Participation of PhD candidates in advisory committees for appointment of full professors
- Quality of supervision
- The grading system of PhD theses and defences
- The national government’s plans to introduce a bursary system for PhD candidates

## **1.4 Research groups and funding, Tenure Track, Gender Policy, Facilities, Postdoc policy**

### **Chair groups and funding**

At Wageningen University, Chair groups constitute the basic unit of organisation. A Chair group consists typically of a Chair holder, about 2-5 tenured staff (associate and assistant professors), about 1-3 non-tenured staff (including postdocs), about 20 PhD candidates and support staff work who together in well-defined research projects. Obviously, the size of a Chair group can vary, depending on the amount of teaching duties, PhD graduations and the acquisition of external funds. On average, 40% of tenured-staff time is available for research, including supervision of PhD candidates. The remaining 60% of staff time is spent on teaching (BSc and MSc level, about 40%) and management tasks (about 20%). Wageningen University has an output-based financial model: the university pays the Chair group for BSc/MSc teaching (based on student participation) and PhD supervision (based on completed PhD theses). The university provides a fixed core-funding for a Chair group that allows for the employment of only one full professor and a lump sum of approximately 100K€. All other tenured and non-tenured staff are funded from a variety of other sources. These sources can be divided into three main categories, which reflect the funding streams in table 2.2 of each Chair group’s self-assessment study:

- Direct University funds generated from output financing of education and research (see above). PhD graduations are an important source of income, where Chair groups receive a compensation for PhD supervision of €56,600 for a PhD graduation *with* an education certificate (as proof of a completed education programme), and a compensation of €41,600 for a PhD graduation *without* a certificate.
- Funds from the Netherlands Organisation for Scientific Research (NWO) and The Netherlands Academy of Sciences (KNAW). The acquisition of competitive research funding from NWO and KNAW is regarded as very prestigious. The university, therefore, matches these funds for uncovered internal costs.
- Funds from third parties, such as the European Union (EU), private companies, governments, and international funds. This also includes funding from the European Research Council (ERC) who provides starting- and advanced investigator grants, and is also regarded as prestigious funding for independent researchers. The latter funds are, however, not matched by the university.

In many cases, special and personal professors, postdocs and contracted researchers are also members of the Chair group. Special and personal professors (both have the right to promote PhD studies, e.g., ius promovendi) can play an important role in Chair groups, by leading specific lines of research and providing extra capacity for PhD supervision. Typically, special professors have a 20% assignment and personal professors have a fulltime assignment. The Chair holder is responsible for the scientific research and education in the research group, the finances of the group within the financial framework and conditions set by the directorate of the Sciences Group.

A Chair holder has integral responsibilities for the human resources, finances and facilities of the Chair group. He/she interacts with the graduate school with regard to the focus, direction, and quality of the research and PhD programme. The Chair groups, therefore, are at the intersection of the axes of the matrix, meaning that Chair holders develop a strategy and policy towards their Chair group in dialogue with the Sciences group and the graduate school. The Chair holder interacts with the relevant Programme committees of the Education Institute on teaching duties for BSc and MSc education.

Tenured staff of Wageningen University who perform research and supervise PhD candidates must be member of a graduate school. Criteria for membership include quantity and quality of research publications, involvement in PhD supervision, involvement in acquisition of external projects and contribution to postgraduate education. The graduate school periodically evaluates the scientific output and quality of its staff members.

### **Tenure Track**

In 2009, Wageningen University implemented Tenure Track for newly appointed academic staff. Wageningen University aims to enhance the quality of scientific research and education by attracting top level academics. The Tenure Track policy makes it possible for someone hired as Assistant Professor to become a personal professor within twelve years, provided the candidate meets all requirements. The demands are high, but the university also offers extra support to those in Tenure Track. Existing staff may choose to participate in Tenure Track, but are not obliged.

### **Gender**

Wageningen University strives for more females at higher university positions. The current representation of females in higher academic positions does not reflect in the PhD and postdoc population, where the number of females and males are balanced. This imbalance resulted in a gender action-plan not only at the level of the university but also at the level of the Wageningen Graduate Schools. The plan focuses on appropriate stimulation and selection mechanisms for women at higher positions.

There is a positive trend towards a more balanced gender representation among the younger staff. On August 2012, about 40% of people in Tenure Track were female. Increasing the number of females at professor positions requires a sufficient pool of female academics at lower levels to recruit from. Taking into account the availability of full professor vacancies in the short term, it will take at least 10 more years to reach a balance at the higher levels.

### **Facilities**

All research groups within Wageningen University have moved to new up-to-date buildings with state-of-the-art research laboratories at Wageningen Campus.

Within Wageningen University, PhD candidates and staff have access to the large collection of the Wageningen UR Library. The Wageningen UR Digital Library provides access to the collections of Wageningen UR Library from any Wageningen UR computer account. This collection includes full-text versions of dissertations and other material published by students and staff of Wageningen University.

PhD candidates and staff have also electronic access to full-text versions of articles from most well-known journals, particularly in the field of life sciences.

Wageningen is well acknowledged for its excellent student sports and computer facilities. All staff, PhD candidates and students in Wageningen have access to the university electronic network. Staff and PhD candidates have their own computer with the required general software. In 2014, for the tenth consecutive year, Wageningen has been selected as the best Dutch university for full-time education in The Netherlands, providing the best university facilities to students.

### **Postdoc policy**

In 2008 WIAS started a “Talents & Topics” programme. This programme was meant to train young ambitious scientists to obtain the skills and competences needed by a research leader: writing grant proposals, establishing focus in their research and profiling themselves with a research theme while managing a research group. This programme was so successful that it was taken over by WGS as a university-wide support for postdoc’s. Given that a limited number of university tenured-staff positions are available, the WGS programme focusses not only on careers inside academia but also on careers outside academia. The university-wide postdoc programme consists of modules on self-awareness, writing grant proposals, entrepreneurship in and outside science and various modules to support postdocs in their attempts to acquire one of the prestigious grants from NWO and ERC.

## **1.5 Research integrity**

### **Research integrity**

For scientists, research integrity is essential for the advancement of sound scientific knowledge. Wageningen University has regulations and rules, which are briefly presented below:

### **Principles of Netherlands Code of Conduct for Scientific Practice**

All universities in the Netherland endorse the Netherlands Code of Conduct for Scientific Practice, drawn up by the VSNU (the Association of Universities in the Netherlands). The Code is based on five principles for the practice of scientists:

- Scrupulousness
- Reliability
- Verifiability
- Impartiality
- Independence

The full text is available at [The Dutch Code of Conduct for Scientific Practice](#).

### **Wageningen UR Integrity Code**

The Integrity Code of Wageningen University prescribes, for example, that all research results are made accessible as soon as possible upon completion of the research, increasingly via Open Access channels. If the research is funded by a third party, this party can designate research topics but the research questions remain independent of the financier. The Wageningen UR full text is available at [Wageningen UR Integrity Code](#).

### **Committees on Integrity at Wageningen University:**

- Medical Ethics Committee (METC) – to evaluate research proposals on compliance with the Dutch Law on Medical Scientific Research (Wet Medisch Wetenschappelijk Onderzoek)

- Animal experiment committee (DEC) – to coordinate applications to the Central Committee on Animal Experiments, established in accordance with the Dutch Law on Animal Experiments (Wet op de Dierproeven)
- Social sciences ethics committee (SEC) – to review ethical aspects of research projects involving human subjects
- Committee on scientific integrity and confidential counsellors– to investigate complaints about violations of scientific integrity, the confidential counsellors are the first point of contact for questions about scientific integrity

### **Recommendations for co-authorships**

Researchers at Wageningen University are expected to act according to the Wageningen University Recommendations for Co-Authorship of Scientific Publications [Recommendations for co-authorship](#).

### **Data management**

Since April 2014, all Chair groups at Wageningen University must have developed a data management policy, describing the processes to assure adequate management and storage of research data. All PhD candidates are obliged to describe their plans for data management in their research proposals. In their plans, they may refer to the data management policy of their Chair group. To aid PhD candidates in drawing up their data management plans, Wageningen Graduate Schools provides a course for PhD candidates, in which they learn how to manage their research data. Additionally, an online support desk was recently opened by The Wageningen UR Library.

### **Awareness and support**

Implementation of the Wageningen UR integrity code takes place at each level of the organisation. The graduate schools of Wageningen UR have integrated a discussion on scientific integrity into their introduction courses, which are obligatory for PhD candidates. This discussion makes sure that starting PhD candidates are aware of the code of conduct and what it implies. Wageningen Graduate Schools offers also the following courses:

- Ethics and Philosophy in Life Sciences
- Philosophy and Ethics of Food Science and Technology
- Research Ethics: Ethical Reflection on Human Subjects Research



## 2. The graduate school WIAS

### 2.1 Organisation WIAS

#### 2.1.1 Vision, Mission and Research context

The Wageningen Institute of Animal Sciences (WIAS) was established May 25, 1993. WIAS is one of six graduate schools of Wageningen University, involving activities in animal sciences and related fields, engaging in fundamental and strategic research, and providing training for young researchers. WIAS was first accredited by the Royal Netherlands Academy of Sciences (KNAW) in 1995, and re-accredited in 2000, 2005 and, most recently, in 2011.

**Our mission:** Improving our understanding of animals and their various roles for mankind through fundamental and strategic research and training of early stage researchers

The core of WIAS research encompasses the life-science fields of zoology, genetics, immunology, epidemiology, physiology, nutrition, and ecology. It offers an integrated and comprehensive approach to research on societally and scientifically relevant animals and animals which are relevant for science itself. An overview of the WIAS Chair groups is in Table 2.1.

*Table 2.1. WIAS Chair groups and their chair holders.*

<b>Animal Sciences group</b>	
<u>Chair group</u>	<u>Chair holder</u>
Adaptation Physiology (ADP)	Prof. Bas Kemp
Animal Breeding and Genetics (ABG)	Prof. Johan van Arendonk
Animal Production Systems (APS)	Prof. Imke de Boer
Aquaculture and Fisheries (AFI)	Prof. Johan Verreth
Behavioural Ecology <sup>1</sup> (BHE)	Prof. Marc Naguib
Cell Biology and Immunology (CBI)	Prof. Huub Savelkoul
Experimental Zoology (EZO)	Prof. Johan van Leeuwen
Host-Microbe Interactomics <sup>2</sup> (HMI)	Prof. Jerry Wells
Human and Animal Physiology <sup>2</sup> (HAP)	Prof. Jaap Keijer
Quantitative Veterinary Epidemiology (QVE)	Prof. Mart de Jong
<b>Plant Sciences group</b>	
<u>Chair group</u>	<u>Chair holder</u>
Farm Technology <sup>1</sup>	Prof. Peter Groot Koerkamp

<sup>1</sup> Behavioural Ecology and Farm Technology participate within the graduate schools WIAS and PE&RC. Behavioural Ecology will be assessed within the WIAS; Farm Technology will be assessed within the PE&RC.

<sup>2</sup> Host-Microbe Interactomics and Human and Animal Physiology participate within the graduate schools WIAS and VLAG. Both are assessed with WIAS.

Of the 12 WIAS Chair groups, 11 are in the Animal Sciences Group and 1 is in the Plant Sciences Group. Within Animal Sciences Group, Chair groups are combined into 3 larger managerial entities, called clusters, to stimulate cross disciplinary talk and strategic collaboration in research and teaching.

- *Cluster 1. Biology and Aquatic Resilience*, which combines the Chair groups of Aquaculture and Fisheries, Cell Biology and Immunology, Experimental Zoology, and the new Chair group (process of establishment is ongoing) Marine Animal Ecology (MAE). These 4 Chair groups have in common that their research involves, at least partly, aquatic animals.

- *Cluster 2. Epidemiology, Genomics and Interactomics*, which combines the Chair groups of Host-Microbe Interactomics, Quantitative Veterinary Epidemiology, and Animal Breeding and Genetics. These 3 Chair groups share expertise in either modelling or molecular approaches.
- *Cluster 3. Adaptive Animals and Systems*, which combines the Chair groups of Adaptation Physiology, Animal Nutrition, Animal Production Systems, Behavioural Ecology and Human and Animal Physiology. These Chair groups share expertise in the behavioural and physiological responses of the animal to changes in its environment, and in the environmental impact of animal production.

WIAS used to work with the research themes 'Animal health and welfare', 'Sustainable systems' and 'Healthy and safe products'. Although some research is still ongoing, the themes do not reflect current research within WIAS. Therefore, WIAS is in the process of replacing the above themes with themes that fit better within Wageningen UR's new strategic research priorities, such as "One Health", "Resilience" and "Resource Use Efficiency".

#### *Internal collaboration*

Chair groups within WIAS collaborate with their counterparts at the DLO Institutes<sup>2</sup> in a number of expertise centres. Joint centres for Animal Breeding and Genomics (Animal Breeding and Genomics Centre, ABGC), Animal Nutrition (Centre for Animal Nutrition, CAN), Animal Welfare and Adaptation (WACA) and Aquaculture (Wageningen Aquaculture) have been established to enhance collaboration. In addition, the Animal Production Systems group (APS) participates in the interdepartmental Centre for Agroecology and Systems Analysis (WaCASA). WaCASA links the activities of 3 Chair groups: APS, Plant Production Systems and Organic Farming Systems.

#### *External collaboration*

Within the Netherlands, long-standing collaboration exists with the Veterinary Faculty (University of Utrecht), The National Institute for Public Health and the Environment (RIVM), the Netherlands Institute of Ecology (NIOO), GD-Animal Health, and many other Dutch universities and research institutes. Large public-private partnerships were established with clusters from industry in the domain of animal nutrition (Feed4foodure), animal breeding (Breed4Food) and with the Top Institute for Food and Nutrition (TIFN). The strength of these collaborations is reflected by dual (e.g., prof. Hendriks) or special professorships (e.g., prof. van Neerven, Schukken, Visser, Kleerebezem, den Hartog).

Long-standing collaboration exists with the National Institute for Agricultural Research (INRA; France), the CGIAR Institutes, International Livestock Research Institute (ILRI; Kenya) and World Fish (Malaysia). A joint doctorate with a number of European Universities has been established via the European Graduate School in Animal Breeding and Genomics (EGS-ABG), which was recognized by the EU as an Erasmus Mundus Joint Doctorate Programme. Furthermore, WIAS seeks further international collaboration to develop joint courses and/or to explore the feasibility of establishing more joint doctorate programmes. Examples of international collaboration are UC-Davis (joint courses), Agrénum (France cluster of universities) (joint courses, possibly joint doctorate), Norwegian University of Life Sciences (UMB) (joint doctorate) and most recently, the Global Challenge University Association (summer schools in the domain of Global One Health, with universities in Europe, Asia, and USA).

#### **WIAS key points**

Three key focus points of WIAS are PhD training, quality of the PhD programme and talent development.

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<sup>2</sup> Central Veterinary Institute (CVI), Wageningen Livestock Research (WLR) and Institute for Marine Resources and Ecosystem Studies (IMARES).

*PhD training*

At Wageningen University, the PhD education programme works with so-called “T-shaped skills”: a combination of training in broad personal skills and in disciplinary scientific knowledge, each of which is essential for a PhD candidate to become an independent, professional scientist with a high academic level. A Training and Supervision Plan (TSP) describes the education timeline of the candidate and represents a personal training programme based on each candidate’s individual needs.

*Quality of the PhD programme*

The quality of the PhD programme is monitored and guaranteed by a “plan-do-check-revisit” cycle. Each PhD candidate submits a research proposal that is reviewed by external (mainly international) peers. In this way, WIAS guarantees the scientific quality of the PhD research, including its feasibility to be completed within the prescribed period of 4 years. The international peer review of the proposals, moreover, serves as a guarantee that PhD projects are being developed at international quality standards. To safeguard the quality of supervision, supervisors must register with WIAS and meet the admission criteria to become a WIAS staff member.

Every two years, a PhD Experiences Survey is done to check if PhD candidates are satisfied with the quality and quantity of their supervision. The outcome of this survey is analysed and discussed with the Chair holders, who are primarily responsible for the quality of supervision. If necessary, actions are requested.

*Talent development*

Talent development is a strong focus of WIAS. We have two talent-programmes: “Talents & Topics” and the “WIAS Graduate Programme”.

The course Talents & Topics intended to train young ambitious scientists to obtain skills and competences needed by a research leader: writing projects for granting agencies, establishing focus in their research and profiling themselves with a research theme and managing a research group. Since 2012, the WIAS Talents & Topics programme has become a university-wide programme.

In 2012, WIAS received a prestigious grant from NWO to facilitate and stimulate talented MSc students to become excellent researchers. With this grant selected MSc students receive in-depth training, the opportunity to write their own PhD proposal, select a supervisor/Chair group from within WIAS and perform PhD research in the area and topic of their interest. In 2015, the first 4 PhD grants were awarded, after a highly competitive selection process that started with 16 WU and 10 international MSc students.

**Organisation and Management**

Wageningen Institute of Animal Sciences (WIAS) encompasses the research of 12 Chair groups of Wageningen University. Intensive cooperation exists with other graduate schools of Wageningen University and with various national and international partners. The organisational structure of WIAS is shown in Table 2.2.

*Table 2.2. Organisational structure of WIAS*

<b>Advice</b>	<b>Decision</b>	<b>Execution and advice</b>
- International Advisory Board (IAB)	WIAS Board	Scientific Director: Prof. dr. Johan Verreth
- Education Committee (EC)		Executive Secretary: Denise Magendans MSc
- PhD Council (WAPS)		Education Coordinator: ir. Marianne Bruining
		Secretariat: Annet Willink

*WIAS Board:* The WIAS Board makes strategic decisions with respect to the research and postgraduate education programme. These decisions are based on advice of the International Advisory Board, the Education Committee, and the WIAS-associated PhD Council. The WIAS Board also advises the Executive Board of Wageningen University and Research Centre on the appointment of the new scientific director. The WIAS Board consists of 4 members: 3 Professors and the chairman of the WIAS PhD council.

*Scientific Director and Executive staff:* The scientific director is responsible for the operation and performance of the graduate school, and is appointed for a term of 4 years. The current director has an appointment of 0.3 FTE. The director is supported by an executive staff consisting of an executive secretary (1 FTE), an education coordinator (0.5 FTE) and administrative support (0.5 FTE).

*International Advisory Board (IAB):* The IAB advises the board and scientific director on research and education programmes and policies. The IAB consists of five world-wide renowned scientists in the domain of WIAS.

*Education Committee (EC):* The EC advises the board and the scientific director on the content and format of the training and supervision plan (TSP) and on the WIAS education programme, in general. The committee evaluates all PhD courses and give input and advice concerning PhD education within WIAS. The 6-member EC consists of 3 staff members and 3 PhD candidates.

*WIAS-associated PhD (WAPS) Council:* The WAPS council consists of 8 members and has an advisory function to the WIAS Board and the scientific director on all aspects of the PhD programme. WAPS organizes course surveys on a regular basis. The PhD candidates also organize the annual WIAS Science Day.

### **Annual budget**

The WIAS Graduate School has an annual budget for:

- PhD courses and seminars (90K€ per year, excluding fees from participants);
- Strategic postdoc and PhD projects (200K€ per year, 2-4 new projects every two years, depending on type of project and external matching funds);
- Fellowships for visiting scientists (35K€ per year);
- Personnel costs of the Scientific Director, Executive Secretary, and Education Coordinator and costs of materials (220K€ per year).

### **Facilities for Master students and PhD candidates**

Since 2007, Wageningen University has intensified the interaction between research and education. By locating the education building and the research institutes on a single campus, interaction between researchers from various disciplines and between students and researchers is facilitated, resulting in a synergistic environment for exchange of ideas. WIAS and the Department of Animal Sciences moved to the campus in 2011. In 2014, Wageningen Livestock Research also moved from Lelystad to Wageningen and now shares office buildings with the Department of Animal Sciences to enhance collaboration.

Staff and PhD candidates have their own computers, which are connected to an up-to-date central IT system. MSc students are provided with a workplace within the Chair groups, when they are working on their theses. The Wageningen UR digital library contains a collection of over 5.000 electronic publications and is accessible via the university's electronic network. Language services and sport facilities are also available.

The special facilities of WIAS currently include:

- Experimental facilities (called CARUS) for dairy cows, pigs, poultry and other farm animals; for fish and shrimp; for rats and mice; and for dogs, cats and horses
- IRMS (Isotope Ratio Mass Spectrometry) equipment (co-funded by NWO)
- Climate/respiration units for terrestrial and aquatic animals (co-funded by NWO)
- Laboratory for genome analysis
- HPC Agrogenomics, a high performance computing facility for large scale computing
- High content bioimager (BD-Pathway)
- Specialised equipment and laboratories for each Chair group, with qualified staff

The contract research organisations associated with WIAS, Central Veterinary Institute, Wageningen Livestock Research and IMARES, have their own research facilities, which are also used by WIAS PhD candidates and staff.

## 2.1.2 Research staff and output

### Research staff

The number and full time equivalent (FTE) research input of tenured staff of WIAS has increased from 2009 until 2014. This increase is partly a result of the expansion of the Chair group Host-Microbe Interactomics, the creation of the new Chair group Behavioural Ecology and expansion of some of the other WIAS Chair groups. The number of PhD candidates also has increased. For the entire WIAS, the average workload per supervisor has stabilized during the last five years (2.53 FTE (=88.6/(20.8+15.7)) PhD candidates per FTE supervisor capacity), although the PhD/supervisor staff ratio differs among Chair groups. Particularly Chair groups that experience a sudden and strong increase in their PhD recruitment may suffer temporarily from a high workload. This is partly related to the financial compensation for PhD supervision that is granted only two and three years after graduation. WIAS keeps a close eye on the PhD/supervisor staff ratio to ensure a high level of supervision quality.

Table 2.3. Research input: number<sup>1</sup> and FTE<sup>2</sup> of Scientific staff, Post-docs and PhD candidates by year

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff <sup>4</sup>	63	19	66	20	72	20	76	22	74	22	74	22	71	21
Post-docs <sup>5</sup>	28	15	30	13	29	13	39	19	40	17	40	17	34	16
PhD candidates <sup>3,6</sup>	113	63	135	81	166	86	181	95	191	106	178	102	161	89
<b>Total research staff</b>	<b>204</b>	<b>97</b>	<b>231</b>	<b>113</b>	<b>267</b>	<b>120</b>	<b>296</b>	<b>135</b>	<b>305</b>	<b>144</b>	<b>292</b>	<b>141</b>	<b>266</b>	<b>125</b>

<sup>1</sup> Total number of staff and PhD candidates

<sup>2</sup> Available research time in full time equivalent (FTE)

<sup>3</sup> All PhD categories, except external PhDs

Standards for Research Capacity (in case of part time appointment adjustment is applied):

<sup>4</sup> Professor, Assistant Professor and Associated Professor: Research Capacity = 40% of the appointment

<sup>5</sup> Post-doc: Research Capacity = 90% of the appointment

<sup>6</sup> PhD candidate: Research Capacity = 75% of the appointment (all categories)

During the last six years, the number of PhD candidates has increased from 113 in 2009 to 178 in 2014 (Table 2.3). This increase is seen mainly in projects funded by contracts (Table 2.4). The figures in tables 2.3 and 2.4 are based on a maximum duration of 4 years for a PhD study. PhD candidates, however, take often longer to graduate and, therefore, the total number of PhD candidates in WIAS is currently 210.

Table 2.4. Funding of Scientific staff, Postdocs and PhD candidates by year

Funding:	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%
Direct funding <sup>1</sup>	33	34	37	32	34	29	36	27	39	27	40	28	36	30
Research grants <sup>2</sup>	16	17	19	17	19	16	18	13	17	11	16	11	18	14
Contract research <sup>3</sup>	48	49	57	51	66	55	81	60	88	61	86	61	71	56
<b>Total funding</b>	<b>97</b>	<b>100</b>	<b>113</b>	<b>100</b>	<b>120</b>	<b>100</b>	<b>135</b>	<b>100</b>	<b>144</b>	<b>100</b>	<b>141</b>	<b>100</b>	<b>125</b>	<b>100</b>

<sup>1</sup> Direct funding by the University

<sup>2</sup> Research grants obtained in national scientific competition (e.g. grants from NWO, KNAW)

<sup>3</sup> Research contracts for specific research projects obtained from external organisations, such as industry, governmental ministries, European Commission, charity organisations

## Output

An overview of WIAS research output from 2009 through 2014 is in table 2.5. The number of peer reviewed articles has increased during the last 6 years from 224 to 325. This is in line with the increase in publications of Wageningen UR as a whole.

Table 2.5. Categories of research output by year.

Category:	Year						Total	Average 2012-2014
	2009	2010	2011	2012	2013	2014		
<b>Academic publications</b>								
a. Refereed articles	224	234	318	331	348	325	1780	297
b. Non-refereed articles	6	4	7	2	4	5	28	5
c. Books	0	0	0	0	0	0	0	0
d.1. Refereed book chapters	15	9	15	10	9	7	65	11
d.2. Non-refereed book chapters	9	3	1	1	0	1	15	3
e. PhD Theses	18	23	22	32	29	31	155	26
f. Conference papers	34	61	52	62	77	52	338	56
<b>Total academic publications</b>	<b>306</b>	<b>333</b>	<b>416</b>	<b>438</b>	<b>467</b>	<b>421</b>	<b>2381</b>	<b>397</b>

A bibliometric analysis for 2009-2013 publications has been done for WIAS publications of Wageningen University using the database Essential Science Indicators (ESI). ESI provides the world average number of citations and percentile thresholds of citations of publications for 22 research fields in Web of Science (the report is part of the documentation of this evaluation). The results are shown in Table 2.6.

Table 2.6. Bibliometric indicators for WIAS over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	217	4342	3008	20.01	1.56	19% (42)	2% (5)
2009	211	3832	2504	18.16	1.56	17% (36)	2% (5)
2010	228	3010	2313	13.2	1.41	16% (36)	3% (6)
2011	305	3684	2202	12.08	1.76	26% (78)	2% (7)
2012	320	2382	1399	7.44	1.78	18% (57)	3% (8)
2013	328	1420	638	4.33	2.13	22% (72)	4% (13)
<b>all years</b>	<b>1609</b>	<b>18670</b>	<b>12063</b>	<b>11.6</b>	<b>1.74</b>	<b>20% (321)</b>	<b>3% (44)</b>

The Relative Impact (RI) shows that over all years WIAS research was cited 74% more than the world average (1.00) for our domain. In addition, 20% of the published articles belong to the 10% most cited in their field (%T10) and 3% to the top 1% most cited (%T1).

## 2.2 The WIAS PhD Programme

### 2.2.1 Aims of the programme

PhD candidates are the prime stakeholders of WIAS. The central task of the Graduate School is therefore to enhance, support, and monitor the progress and quality of the programme that the PhD candidates are following:

1. Quality control and progress evaluation of the PhD project
2. Development, coordination and facilitation of PhD training and education activities

3. Offering a Training and Supervision Plan (TSP), which formulises training / education activities and supervision
4. Support in career planning and development
5. Setting clear guidelines and procedures for the PhD programme
6. Counselling, mediating, and providing support when PhD candidates experience issues related to their PhD programme.

In this section, we elaborate on these elements whereby the aims, structure, procedures, and rights and duties of the PhD Programme are presented. In early 2015, as mentioned in the first section of this document, WU asked a review panel with experts from the European University Association (EUA) to assess the admission, structure, training and examination of the Wageningen University PhD programme and to evaluate whether the learning targets of the Wageningen PhD programme met international standards. The self-evaluation report, the report of the review panel and the response of the Executive Board of Wageningen University are available and can be found in the supplementary documents. The focus of the present review is therefore on specific elements of WIAS and its course programme as has been described in the sections below.

A PhD study at Wageningen University usually lasts 4 years: 3-3.5 years (75%) on the research project leading to the PhD thesis and 0.5-1.0 years (25%, min. 30 ECTS) on completing the tailor-made education and training programme. The education programme developed so-called “T-shaped skills”: a combination of broad personal skills and in-depth scientific knowledge, which is essential for a PhD candidate to become an independent, professional animal scientist with a high academic level.

According to the ‘Doctoral degree regulations’ of Wageningen University, the recipient of the doctorate is capable of:

1. Functioning as an independent practitioner of science, as shown by:
  - a. Formulating scientific questions, whether based on social issues or scientific progress;
  - b. Conducting original scientific research;
  - c. Publishing articles in leading journals, publishing books with leading publishers or making a technical design;
2. Integrating his or her own research in, or placing it within the framework of, the corresponding scientific discipline and against the background of a broader scientific area;
3. Placing the research aims and research results in a societal context;
4. Postulating concisely worded propositions in scientific and societal areas, formulated in such a way that they are subject to opposition and defence.

The PhD thesis demonstrates whether the learning goals were met. The thesis contains at least 4 research chapters, equivalent to four publishable papers in international peer-reviewed scientific journals, plus a general introduction and a general discussion. The supervisor(s) is responsible for discussing the specified requirements of the PhD study with the prospective PhD candidate at the start of the PhD study. This discussion primarily focuses on what is expected in order to get to the final thesis.

The formal regulations and protocol concerning thesis format and public defence are described in the Doctoral Degree Regulations (see: [www.wageningenur.nl/en/Education-Programmes/PhD](http://www.wageningenur.nl/en/Education-Programmes/PhD)). After the thesis has been approved by the supervisors(s), an (inter)national examining committee, appointed by the Academic Board of the University, evaluates the dissertation. A public defence of the dissertation takes place only in the case of a positive evaluation. The Graduate School is not formally involved in this final examination.

A Training and Supervision Plan (TSP) describes the education timeline of the candidate and represents a personal training programme, based on each candidate’s individual needs. The TSP must be submitted within 6 months after start of the PhD trajectory to the WIAS education coordinator.

Upon fulfilling the requirements for the TSP, a PhD candidate is awarded an education certificate, which is included in the PhD thesis. The number of graduations with and without WIAS education certificate is in table 3.1.

*Table 3.1. Number of PhD graduations with and without WIAS Education Certificate by year*

	2009	2010	2011	2012	2013	2014	Average 2009-2014
<b>with Certificate</b>	16	21	20	25	25	28	22.5
<b>without Certificate</b>	2	2	2	7	4	3	3.3

In 2014, 55% more PhD candidates graduated with certificate in comparison to 2009. On average less than 15% graduates defended their thesis without education certificate. The majority of the latter group are external PhD candidates who had no formal relation with Wageningen University except for the admission to the PhD programme and the defence.

### 2.2.2 Structure of the training and supervision programme

Major tasks of WIAS are to ensure the quality of supervision and to give the PhD candidates the opportunity to develop themselves, with the help of a Training and Supervision Plan (TSP). To make the TSP fully tailor-made, WIAS developed a new format, where PhD candidates have more room to attend courses to develop their professional- and research skills and to gain in-depth knowledge. To support the PhD candidates in creating their TSP and selection of courses, each new PhD candidate has to do an online assessment of personal competences and personality characteristics and has to discuss the results with one of the 3 appointed PhD advisors. This new procedure started in April 2014 and turned out to be a success. PhD candidates from abroad especially appreciate the attention that is paid to them and the help they receive in formulating their learning goals.

The WIAS Training and Supervision plan is divided into 5 categories:

#### A. The Basic Package

The basic package consists of compulsory elements for each WIAS PhD candidate who wants to obtain a TSP certificate. It includes the “WIAS Introduction Day” and an Ethics and Philosophy course. WIAS further recommends each PhD candidate to follow a course on personal efficacy, including student/supervisor communication.

#### B. Disciplinary Competences (minimum 2 courses)

This category is intended to provide PhD candidates with an in-depth training in the specific area of study. It may contain different course elements, such as:

- a. Writing a PhD research proposal or Literature review (mandatory): this element focuses on the higher cognitive abilities of synthesis, integration and evaluation, which are necessary in science. *WIAS requests that all PhD candidates comply with this competence training*, either by writing their own research proposal or, if a research proposal is already available, by writing a literature review. The research proposal or literature review must be submitted to WIAS for approval, within 6 months after start of the PhD study. WIAS will grant a maximum of 6 credits for this element.
- b. Attending any advanced course geared to PhD candidates
- c. Training in specific research skills (e.g. an external period at a top institute elsewhere, max 2 credits) that is deemed necessary for the training of an individual PhD student (to be evaluated with the PhD study adviser).
- d. Participating in a PhD discussion group, if this is acknowledged by WIAS (max 2 credits)

- e. Attending statistics courses

MSc courses may also be included in this category, up to a maximum 6 credits, to cater for possible deficiencies in specific knowledge.

### C. Professional Competences (minimum 2 courses)

These competences are preferably based on results of the online assessment. Examples of course elements to improve professional competences:

- a. Career-related competences/personal development
- b. Project planning and management/time management (highly recommended)
- c. Techniques for scientific writing
- d. How to supervise a MSc thesis student

In this category, credits also can be earned for organisation of seminars or PhD courses (max 2 credits) or for membership on PhD council boards and committees (max 4 credits).

### D. Presentation Skills (maximum 4 credits)

A specific subcategory of professional competences which relates to presentation skills and media training was created. Delivering an oral or poster presentation at a conference will be recommended. A minimum of 2 original presentations are required of which at least 1 is oral, and at least 1 is at an international conference (1 credit each).

### E. Teaching Competences (optional, max 6 credits)

Teaching can consume up to 10% of a PhD candidate's time, and is not necessarily part of the TSP but part of the employment conditions. For PhD candidates who have an interest in a career in education, up to 6 credits can be part of the TSP for elements such as:

- a. Lecturing (including preparation)
- b. Supervising practicals and excursions
- c. Supervising theses (max 2 credits for MSc major, 1.5 credit for MSc minor, 1 credit for BSc thesis)
- d. Tutoring

The number of WIAS courses and seminars expressed in ECTS credits is in table 3.2.

*Table 3.2. Amount of courses and seminars offered (ECTS credits, 1 ECTS = 28 hours)*

	Year						Average 2009-2014 credits
	2009 credits	2010 credits	2011 credits	2012 credits	2013 credits	2014 credits	
<b>Courses</b>	13.7	14.7	17.5	22.5	23.7	19.6	18.6
<b>Seminars</b>	2.1	2.55	1.95	2.60	1.95	1.8	2.2
<b>Total</b>	<b>15.8</b>	<b>17.3</b>	<b>19.5</b>	<b>25.1</b>	<b>25.7</b>	<b>21.4</b>	<b>20.8</b>

On average the total number of credits for WIAS courses and seminars increased during the last 6 years. PhD candidates can receive education credits by, writing their PhD project proposal, organising seminars and courses, being a member of boards and committees, lecturing or supervising MSc students. A group of PhD candidates organises also the yearly WIAS Science Day where PhD candidates share their research with the WIAS community. Since 2014, WIAS organises monthly lunch lectures where postdocs present their research.

### 2.2.3 Rights and duties of the supervisors and the PhD candidates

The PhD candidate must comply and work according to the "Dutch Code of Conduct for Scientific Practice". The latter are further elaborated in the rules and regulations of the Executive Board of

Wageningen University and the Graduate School. WIAS introduces all PhD candidates to these rules during the mandatory “WIAS Introduction Day”. On the other hand, the PhD candidate is entitled to receive top quality supervision with clear guidelines, support and training. The candidate should also be capable to attend courses and other training activities to fulfil the requirements of their TSP.

To ensure that supervision is of a qualified level, the promotor and the daily supervisor must be a staff member of WIAS, who complied with the admission requirements. Agreements on supervision are discussed and recorded in the Training and Supervision Plan and in the WIAS proposal. After 2 years, the agreements are evaluated and, if necessary adjusted, in a mid-term TSP. After 2 years, in addition, the PhD candidate submits a Midterm Progress Report which is again a moment of reflection where sources of possible delays can be identified and appropriate measures can be taken. In all of these processes, WIAS offers help whenever necessary.

The PhD supervision surveys of 2010 and 2013 identified that “time management” and “poor communication between supervisor and PhD candidate” were among the main sources for delays. To address these problems, an online assessment of personal competences and personality characteristics was implemented. The intention was, that by increasing awareness of the personal learning styles and attitudes, communication with the supervisor might be improved and pitfalls in time management might be recognized. The PhD candidate often shares the results of the assessment with the supervisor. These results and the learning goals are then discussed during a second meeting with the PhD advisor, where the supervisor is present as well.

WIAS stimulates supervisors similarly to follow a course on PhD supervision to improve their supervisory skills. This course is already included as an element in the University Tenure Track system and in the terms of academic teaching and supervision qualifications (“BKO, Basis Kwalificatie Onderwijs” which is required for undergraduate teaching). We feel that it is important that each supervisor follows such a course. Therefore we recently included a successful participation in this course as one of the new admission criteria for WIAS staff members.

#### **2.2.4 Procedure for approving research projects for PhD candidates**

Each WIAS PhD project proposal is reviewed by three external referees (usually from abroad). The aims are to guarantee scientific quality of PhD research within WIAS and to safeguard the feasibility of PhD projects. A limited number of PhD project proposals are written by WIAS staff members and granted by NWO or the EU before recruiting the PhD student. These projects, already reviewed by scientists when granted, are not re-evaluated by WIAS referees. We believe, however, that proof of competence in defining a research problem, synthesising and intergrating knowledge and in formulating a hypothesis, are crucial for a PhD candidate. WIAS therefore requests that those PhD candidates who do not write a PhD proposal, must instead submit a literature review. The majority of PhD project proposals, however, are written by the PhD candidates themselves, under the guidance of their daily supervisors.

In 2012, the WIAS research proposal review process was internally evaluated. Of all WIAS PhD proposals externally reviewed in 2010-2011 and evaluated by the former assistant-director, 36% of the proposals required slight revisions and 19% required major revision before approval. The best scores were on quality of supervision, perspectives of the proposed research and use of existing knowledge. Scores on feasibility, proposed methodology and originality could be improved, but were evaluated as “good” in all cases. The external referees gave the score “high scientific quality” for 81% of the proposals.

Since 2013, the review process has been revisited. Currently approximately 80% of the proposals require a rebuttal.

### **2.2.5 Focus on excellence**

In 2012, WIAS successfully applied for a grant from the NWO Graduate Programme to offer 4 PhD positions to excellent MSc students participating in the Research Master Variant (RMV) of the two-year Masters in Animal Sciences (MAS) and the Masters in Aquaculture and Marine Resource Management (MAM). Excellent MSc students were recruited and selected for the WIAS graduate programme based on their Curriculum Vitae, grades in courses, a personal motivation letter and an interview.

The WIAS graduate programme includes four elements for students of the Masters Animal Sciences and the Masters Aquaculture and Marine Resources Management:

- Rotations of short acquaintance periods at different WIAS research groups, during the first half of the first MSc year
- Attendance of the annual WIAS Science Day where WIAS research is presented and discussed
- Attendance in the course “Research Master Cluster” (RMC), in the beginning of the second MSc year
- Two MSc theses (a major and minor) in the second half of the MSc (long rotations); the minor thesis has to be done outside the Netherlands.

Staff members of WIAS developed the RMC, teach the course and act as mentors. The RMC aims at acquiring and improving students’ professional skills in writing and defending a scientific research proposal. The students are free to choose the topic of their research. The only condition, however, is that it complies with the scientific scope of WIAS. A maximum of 16 students participate in the RMC, which results in 16 proposals that are evaluated by a jury on scientific quality and feasibility. The jury is composed of directors of different graduate schools and other external high level scientists. The top 6 proposals continue in a second round of competitive selection for the WIAS Graduate Programme grant. Because 50% of the WIAS PhD candidates are international students, the second round is also opened for 6 candidates from abroad. These candidates are recruited and proposed by the clusters within the Department (2 candidates per cluster for a total of 6). This process brings the total number of candidates to 12 in the second and final selection round for the 4 PhD grants.

The latter 12 proposals are evaluated and ranked by a jury composed of members of the International Board of WIAS. Decisions are based on scientific quality, feasibility, a defence and interview with each student. The top 4 students will receive the WIAS Graduate Programme Grant. The next four promising students (ranked 5-8) will be supported actively to obtain a PhD position. In this way, a group of 8 excellent candidates can start their PhD.

In 2013, the programme started with the first cohort of MSc students who were selected to participate in the RMC. The final selection of the 4 winning candidates was done in February 2015. The NWO grant was a one-time award. WIAS however will continue the programme and finance at least 1 PhD position per year from the graduate schools’ strategic funds. The second cohort already has started and the final selection will be in February 2016. We will take action to attract additional funds for 1 or 2 more PhD grants annually.

## **2.3 Quality assurance in PhD education and supervision**

### **2.3.1 Criteria for senior researchers responsible for training and supervision**

WIAS staff members compete at the highest international levels in their respective areas of research. They are involved in supervision of MSc students and PhD candidates, and contribute to BSc, MSc and PhD education.

Following the recommendations of the WIAS midterm review (2012), the WIAS Board decided to tighten the admission criteria for WIAS staff members. The new admission criteria are:

**Junior Staff member:**

- Have a PhD
- Have a minimum of 5 publications in refereed journals of which 3 are in the first quartile
- Have at least 3 months research experience abroad or comparable
- Have followed a course on how to supervise PhD candidates

**Senior Staff member:**

- All junior requirements
- Have a minimum of 15 publications in refereed journals of which 9 are in the first quartile during the past 5 years; a first authorship counts as two publications
- Have acted at least 3 times as promoter, co-promoter or daily supervisor of a PhD candidate during the past 5 years
- Have (co-)acquired at least one externally-funded PhD or postdoc project during the past 5 years
- Have a Relative Impact factor  $\geq 1$  over the past 5 years
- Have been recognised for scientific achievement (e.g. honorary doctorates, scientific awards, membership on editorial boards, keynote speaker or keynote plenary session)

A major change is the category of junior staff member. Junior staff members may supervise PhD candidates, if at least 2 hours/week of senior supervision is guaranteed. The supervision time per week per supervisor must be stated in the WIAS proposal and TSP. These agreements are monitored after 2 years in the Midterm Progress Report.

The percentage of staff members of WIAS admitted to the graduate school is in table 4, based on the old criteria. The new criteria were implemented in 2015, and a transition period of 2 years is given for current staff members who do not comply with the new criteria.

*Table 4. Admission of WIAS staff Wageningen University based on old criteria*

Reference year	2004-2009	2009-2014
Senior (%)	70	62
Admitted (%)	23	35
Conditionally admitted (%)	7	3
Total number of staff (n)	56	85
Research capacity (FTE)	20.5	27.4

### 2.3.2 Appointment of, and budget for, research and PhD fellowships

WIAS benefits from an annual budget of 35K€ for fellowships to enable scientists to visit our university. Since 2013, we have used part of this budget to enable our WIAS PhD candidates to visit a lab or institute abroad and to gain international experience.

#### Research fellowships

The objective of this fellowship is to support visiting scientists who want to spend a sabbatical period at a WIAS Chair group. The fellowship is provided as a stimulus, and thus does not cover all costs. There must be a proven benefit for the WIAS community with a measurable deliverable at the end of the period.

Two kinds of fellowships are available:

- Junior fellowships: €1200 per month for young scientists who have not yet, or just recently, received their PhD degree. The purpose of the junior fellowship is typically to write a (collaborative) post-doc proposal or assist in developing a WIAS PhD course
- Senior fellowships: €1600 per month for scientists who have more than three years research experience. The purpose of the senior fellowship is typically to develop PhD training, write joint books, organise WIAS symposia or develop a joint research programme

### **WIAS PhD fellowships**

The objective of these fellowships is to sponsor current WIAS PhD candidates to visit a top research institute or university abroad. This fellowship can be used to co-author a joint paper with a top scientist from abroad, to learn research methods or to work on databases provided by the host.

Field or other research work that was already foreseen in the WIAS proposal is not eligible for this grant.

This fellowship covers expenses up to €1000 per month with a maximum of €3500 (including travel costs) and is administered by the Chair group of the PhD candidate.

### **2.3.3 System of internal quality assurance for training and supervision**

Most quality assurance measures for PhD candidates have been mentioned in previous sections of the document. Briefly summarizing the system of internal quality assurance involves:

- Admission criteria to enter the PhD programme
- Online assessment and meeting(s) with PhD advisor to determine learning goals
- Evaluation of training and supervision plan (TSP)
- (International) peer review of the project proposal
- Go/No-Go decision, taken by the supervisors, on continuation of the PhD candidate. In most cases this decision is taken after 12 months but must be taken within 18 months. This procedure allows supervisors to end a project when they do not have the confidence that the candidate will be able to succeed to graduation
- Similar to other personnel at Wageningen University, PhD candidates have an annual 'Results & Development' interview with their supervisors. In the interview, the progress of the candidate and the coaching role of the supervisors are evaluated. If the PhD research has been delayed then ways to solve the delay are decided on jointly. Sometimes the solution is to give an extension of the contract for a few months.
- Evaluation of WIAS courses and meetings by participants after which alterations are made when needed
- Courses for staff on PhD supervision
- Evaluation of progress and of supervision, midway the PhD trajectory (Midterm Progress Report)
- Biannual questionnaires in which PhD candidates are asked to evaluate their supervision, the PhD process and WIAS courses and activities
- Exit questionnaires in which PhD candidates are asked to give a final judgement on their supervisors, the PhD process and the role of WIAS
- The WIAS director has an annual management meeting with each Chair holder who participates in WIAS

### **PhD Experience Survey**

At the end of 2010, a first Supervision Survey was held among PhD candidates. The survey included background questions about the PhD candidate and their supervisors. In 2013, the Wageningen Graduate Schools together developed a "PhD Experience Survey" to evaluate the entire PhD trajectory. WIAS performed this survey at the end of 2013 and it will be repeated biannually. Compared with 2010,

satisfaction of PhD candidates of their supervision improved by 2% to 93% of which 83% score their supervision “good” to “excellent” (a 5% increase compared to 2010). WIAS has made an action plan to improve the quality of PhD supervision even further.

## 2.4 Graduation rate

*Table 6. Enrolment and the success rate of the PhD programme within WIAS*

Enrolment			Success rates												Median time from start to graduation					
Starting year	Enrolment	Total M/F	Graduated by year 4	Graduated by year 5	Graduated by year 6	Graduated by year 7	Not yet finished	Discontinued <18 months	Discontinued 18-48 months	Discontinued >48 months										
	#M	#F	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	years	
2006	7	8	15	1	6.7	9	60.0	12	80.0	14	93.3	0	0.0	0	0.0	0	0.0	0	0.0	4.8
2007	12	14	26	2	7.7	13	50.0	19	73.1	22	84.6	2	7.7	0	0.0	0	0.0	0	0.0	4.9
2008	8	18	26	0	0.0	16	61.5	19	73.1	20	76.9	6	23.1	0	0.0	0	0.0	0	0.0	4.6
2009	13	22	35	3	8.6	22	62.9	28	80.0	-	-	4	11.4	0	0.0	2	5.7	0	0.0	4.7
2010	15	9	24	3	12.5	15	62.5	-	-	-	-	6	25.0	1	4.2	1	4.2	0	0.0	4.6
<b>Total</b>	<b>55</b>	<b>71</b>	<b>126</b>	<b>9</b>	<b>7.1</b>	<b>75</b>	<b>59.5</b>	<b>78</b>	<b>76.5</b>	<b>56</b>	<b>83.6</b>	<b>18</b>	<b>14.3</b>	<b>1</b>	<b>0.8</b>	<b>3</b>	<b>2.4</b>	<b>0</b>	<b>0.0</b>	

*Note: All PhD candidates conducting research with the primary aim/obligation of graduating, based on a 0.8-1.0 FTE contract. This includes PhD candidates with employee status (research assistant) and contract PhD candidates without employee status, receiving external funding or a university scholarship, who are conducting research under the authority of the Graduate School with the primary aim of graduating (guest, sandwich).*

The duration of a PhD candidate’s employment or fellowship is typically 4 years, on fulltime basis. Within those four years, the PhD candidate should have completed the research and and have written the thesis. Another 3-6 months is needed to complete the formal procedure for approval and defence of the thesis. WIAS therefore aims for a graduation time of about 4.5 years for PhD candidate who work on a fulltime basis, excluding for example, pregnancy leave or parttime employment from this total time.

The median time from start to graduation is about 4.6 years as is seen in table 6. Almost 60% of PhD candidates graduates within 5 years after the start of the PhD. This average includes female candidates who had a temporary stop for pregnancy leave or other cause of delay. More than 83% of the PhD candidates had graduated by year 7. WIAS has a high completion rate of 93.3% and a drop-out rate of only 3.2%. With these numbers, WIAS outcompetes all other Wageningen graduate schools.

## 2.5 Career prospects for alumni

In October 2014, Wageningen University and KLV Wageningen Alumni Network carried out a career survey among the 1099 PhD alumni who graduated in the period 2009-2013. Of these graduates, 81% could be reached by email. Response rate was 53% and the respondents were representative in gender, country of origin, previous education, type of PhD candidate and graduation year (only the year 2009 is slightly underrepresented due to a lower number of valid email accounts). Hereunder we give only the relevant results of WIAS alumni. The percentage of WIAS graduates by employment status and by sector and job level are in in tables 5.1 and 5.2.

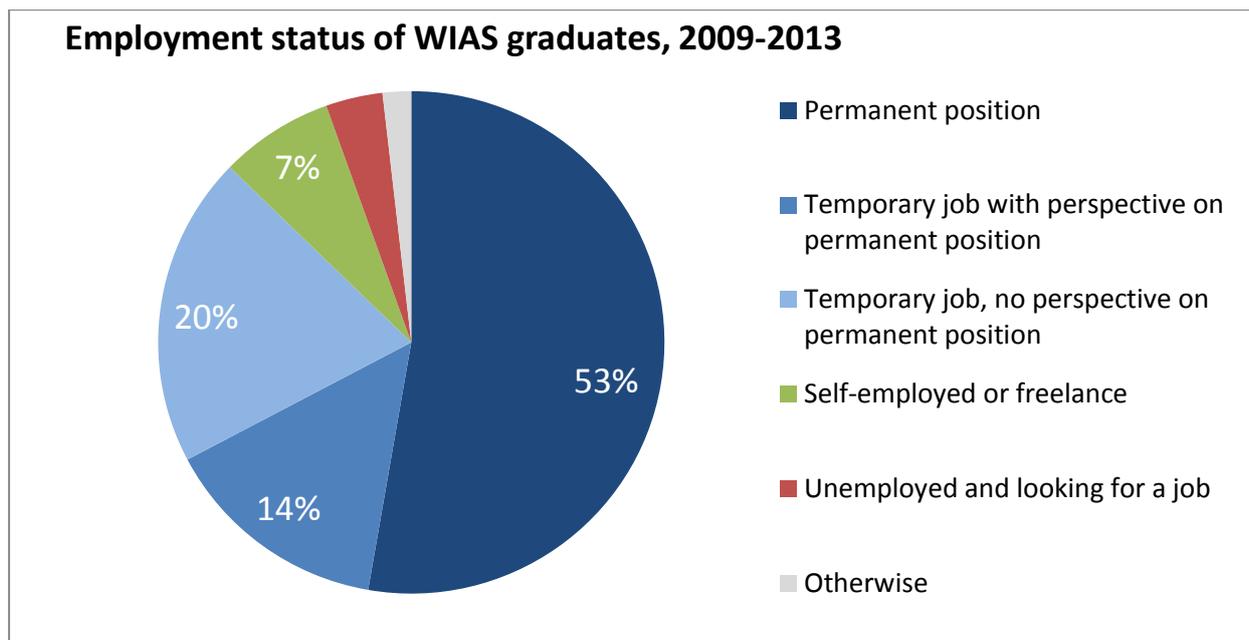


Figure 5.1 Percentage of WIAS graduates by employment status, 2009-2013

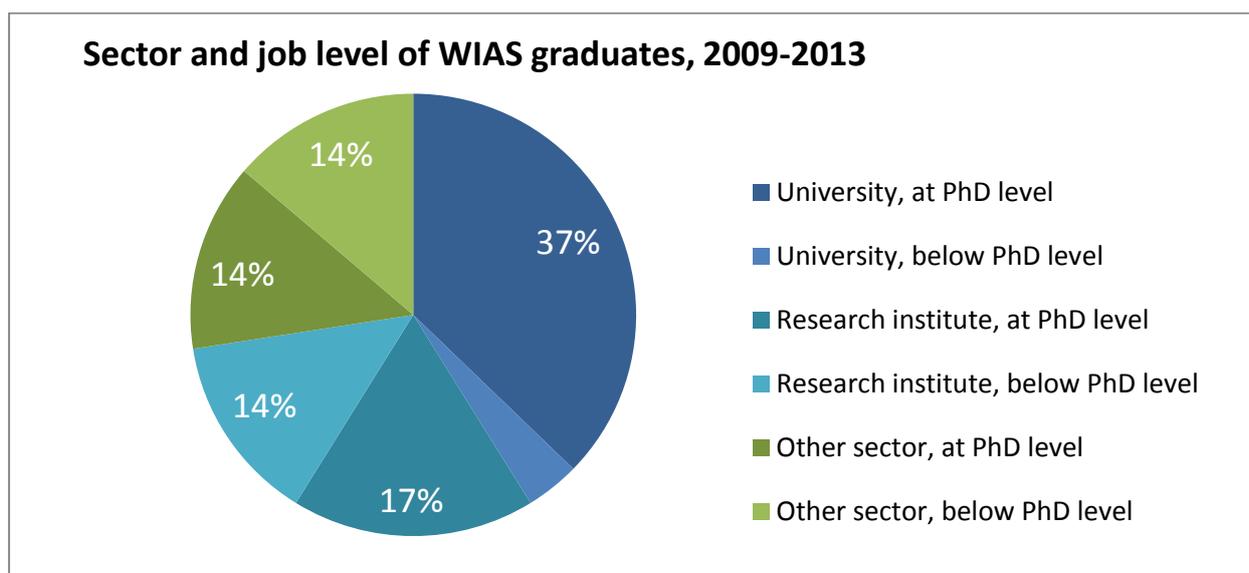


Figure 5.2 Percentage of WIAS graduates by sector and job level, 2009-2013

Most WIAS graduates (53%) have a permanent position and 14% have a temporary position with prospect for a permanent position. Most graduates work at PhD level (68%) and 68% work at a university or research institute. A large percentage of graduates (28%) do not end up in research. In its training WIAS therefore also pays attention to other career perspectives and competences than those required for research.

## 2.6 SWOT analysis and strategy for the future

### 2.6.1. SWOT analysis

#### Strengths

- Complementary groups working on a broad range of topics related to animals and fish
- High quality research, with impact far above the world average in our domain
- Well organised and mature PhD programme
- Efficient supervision and time management, leading to a short time from start to graduation compared with other Wageningen and Dutch graduate schools.
- Qualified supervision that is highly appreciated by PhD candidates, as shown by an 93% “satisfied to excellent” score and 83% “good to excellent” score in subsequent PhD supervision surveys
- Strong international collaboration with high-ranked universities and institutes; strategic collaboration with CGIAR institutes,
- International opportunities for our PhD candidates, via EU joint Masters and PhD programmes, and fellowships that help PhD candidates to gain international experience
- Effective selection and training of talent through the WIAS graduate programme, through fellowships for recent PhD graduates to write an application for a postdoc grant, and through postdoc career modules
- Strong links with the agro-food industry
- High quality research infrastructure and facilities for animal experiments

#### Weaknesses

- The number of awarded personal NWO (Veni/Vidi/Vici) and ERC grants, although improving, is relatively low compared with other Wageningen graduate schools
- WIAS, being a small graduate school, has less opportunities for economy of scale and limited flexibility to use strategic funds for development of in-depth courses and scholarships

#### Opportunities

- Additional funds via our links with the agro-food industry could increase the number of grants for the WIAS graduate programme
- Strong collaborations with international partners who are interested to collaborate in PhD and postdoc projects
- Strong linkages with the Animal Task Force, the Global Research Alliance and the European Aquaculture Technology and Innovation Platform provide good prospects for influencing the international research agenda
- The increasing worldwide demand for animal-derived protein produced in a sustainable manner requires research to support innovations for sustainable production
- Dutch agro-food industry is a global player in need of innovations and highly qualified staff

#### Threats

- A rapidly increasing number of PhD candidates, combined with the delayed compensation according the University financial system, can lead to an excessive workload for Chair groups
- Increasing difficulty to finance animal experiments and facilities

### **2.6.2. Future strategy**

In its future strategy, WIAS will address the weaknesses and threats and aims to safeguard the strengths and capitalize on the opportunities identified in the SWOT analysis. The strategy prioritizes three areas:

#### **Quality of PhD research and supervision**

To further improve the quality of PhD research and safeguard the international standard of our work, the review process of PhD proposals was tightened after its last review in 2012 (see paragraph 2.2.4). Since then, 80% of the candidates are asked for a rebuttal before the PhD proposal is accepted.

WIAS will intensify training to improve the quality of supervision and coaching. In 2013, 93% of PhD candidates assessed the quality of supervision as good or excellent, although a small percentage (7%) of the candidates remain dissatisfied. To further improve the quality of supervision, WIAS follows three strategies:

- a) the admission criteria for WIAS membership are more strict and requests that each supervisor follows a special training on PhD supervision, and that junior staff members are coached by an experienced senior in their supervision of PhD candidates
- b) new PhD candidates have to complete an on-line assessment on their personal competences and characteristics at the start of their study. This online assessment increases their awareness of personal skills that can be improved to complete the PhD study successfully. This procedure helps PhD candidates to work more effectively and to communicate better with their supervisors
- c) WIAS promotes establishment of a formal accreditation requirement for PhD supervision, similar to that requested for BSc/MSc teaching (the so-called “BKO”)

To make WIAS more flexible and effective, the structure of the governing boards have been changed and reduced in size.

#### **Internationalisation**

WIAS invests heavily in internationalisation through internally and externally oriented strategies.

Internally, WIAS stimulates WIAS PhD candidates to go abroad and gain international experience in addition to attending international conferences. WIAS, therefore, provides grants to prospective WIAS PhD candidates who wish to pursue an internship or sabbatical period at a reputable institution elsewhere in the world. WIAS funds five to seven of these grants per year. The grant enables a PhD candidate to work under co-supervision of an international renowned expert in the field, which enhances the quality of their PhD work, often leading to a chapter in the PhD thesis.

Externally, WIAS stimulates international collaboration for doctoral education, which could eventually lead to joint PhD degrees. WIAS follows a stepwise approach. First, the objective of seeking international collaboration is to increase the availability of short PhD courses, summer schools, workshops etcetera. WIAS has collaborations with a cluster of French universities, linked to INRA (Agréenum), the Norwegian University of Life Sciences, UC-Davis, the University of Illinois, the University of Sao Paulo, and the Catholic University of Valparaiso. Recently, WIAS joined the Global Challenge University Association in its attempts to develop summer schools in the domain of Global One Health, with universities in Europe, Asia, and USA. These initiatives are currently underway. Future collaborations will focus on supporting disciplinary consortia, e.g., in Animal Breeding, Nutrition, Physiology, Aquaculture and Marine Sciences. A second step in our approach is to establish joint doctoral programmes, such as the existing joint doctoral programme in animal breeding (EGS-ABG).

#### **Talent development**

WIAS has a strong track record in talent development, via its “Talents & Topics” training, which was geared towards advanced postdocs. For the coming years, WIAS aims to recruit and train talent at all the

crucial transition points in an academic career: at the selection of talented PhD candidates (geared to advanced MSc students) and at the selection of talented junior and advanced postdocs (candidates for a possible Veni or Vidi/ERC grant). For the latter transition points, we aim to benefit from an approach at the University level. WIAS therefore upgraded its Talents & Topics course to a University wide, specific training for Veni, Vidi and ERC applicants, in collaboration with other WU graduate schools. In addition, for advanced MSc students, WIAS developed a “WIAS graduate programme” that combines a training in writing and defending PhD proposals, and in personal competences needed for excellence in science. This programme entails a highly competitive selection of the most talented MSc students, who then receive a PhD scholarship. WIAS attracted a prestigious NWO grant for the development of this WIAS graduate programme. WIAS has secured strategic funds for the continuation of the programme and will raise additional funds for more PhD scholarships.

**3. Bibliometric Analysis**



## **Bibliometric Analysis of the graduate school Wageningen Institute of Animal Sciences - WIAS**

2008-2013

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## 1. Introduction

The objective of this bibliometric analysis is to provide an overview of the publication output and international impact of graduate school WIAS from 2008 through 2013. This overview is based on a quantitative analysis of peer reviewed articles published in scholarly journals and serials covered by the Science Citation Index (SCI) the Social Science Citation Index (SSCI) and the Arts & Humanities Index (AHCI) of the Thomson Reuters Scientific (formerly known as ISI) in Philadelphia (USA). These three databases are also known as, and available on the Web of Science (WoS).

The number of active refereed scientific journals was estimated 28325 of which 20928 online. Despite rumours to that effect there is no evidence that the growth of the number of scientific articles declines and the number of articles that scientists reads increases accordingly (Tenopir *et al.*, 2011). WoS covers about 12.000 peer reviewed journals in all scientific disciplines and this number is still growing. These journals are generally considered the most prestigious, or so-called core journals, of peer reviewed scientific journals (Garfield, 1997). In addition to standard bibliographic details, WoS stores the article's cited reference list. This made the database unique on its own and de facto the world standard for citation analysis. Nowadays more citation based databases are available (e.g. Scopus, Google Scholar) but for the time being WoS is perceived as the gold standard in the field of bibliometrics.

Thomson Reuters Scientific also produces two analytical databases based on data collected in the SCI, SSCI and AHCI. These are the Journal Citation Reports, in which they publish the journal Impact Factors (IF) amongst other journal performance indicators. The other analytical database is the Essential Science Indicators (ESI) which provides the world average number of citations of publications for 22 different research areas over the last 10 years and the current year building. These world averages are the so-called baselines for citations by discipline. In addition to the world average baselines, the percentile thresholds of which the top decile (10%) and top percentile (1%) of citation impact of papers are the most useful, are also presented in ESI.

Results of the bibliometric analysis over the period 2002-2007 can be found in the report "Bibliometric analysis of the Graduate School Wageningen Institute of Animal Sciences - WIAS - 2002-2007" which was part of the documentation for the External Peer Review 2002-2007 and is available at the graduate school.

In chapter 2 the used methods are explained. Furthermore, in chapter 3 the results for the graduate school WIAS as a whole are presented. In chapter 4 the results per chair group are presented. And in chapter 5 the used references are given.

## 2. Methods

In this analysis the citation impact of publications of the staff of WIAS was investigated. Articles, reviews, and letters (except editorial material) were included in this analysis, because these publication types are most likely to report on substantial research results that have been subjected to peer review.

### 2.1 Data collection

Publication lists were taken from the research information system from Wageningen UR (Metis) for every chair group. In this system all scientific output from Wageningen UR is registered. On a daily basis, registered publications are checked and validated. Chair groups have the responsibility to keep their publication list up-to-date. For analysis of WIAS as a whole only articles that are labelled as from WIAS were taken from the system. The queries that were used to retrieve the data from Staff Publications, can be found in the appendix.

### 2.2 Citations and self-citations

The number of citations of each publication was harvested from Web of Science on February 16th 2015. There is an ongoing debate on how self-citations should be used in bibliometric analyses. We chose not to correct for self-citations for the following reasons. Firstly, the baselines for world average citations (provided by Thomson Reuters Scientific) that were used for bench marking are not corrected for self-citations. In the second place, it has been demonstrated that self-citations are an inevitable part of the research process and have no influence on the outcome of bibliometric indicators at the department or institute level (Glänzel *et al.*, 2006). Thirdly, the self-citation patterns are constant within disciplines (Snyder & Bonzi, 1998). Recently, Van Raan (2008) has shown that self-citations have an increasing effect on external citations and thereby an accumulating effect on the total number of citations for research groups.

### 2.3 Benchmarking

The database Essential Science Indicators (ESI) provides the world average number of citations and percentile thresholds of citedness of publications for 22 different research fields. These baselines allow us to benchmark the citation results of the publications against the world average citations for each research field. The publications are therefore assigned to one of the research fields from the Essential Science Indicators on the basis of the journal in which the article was published. The journal lists are publically available at: <http://ipsience-help.thomsonreuters.com>.

For publications published in the set of multidisciplinary journals, such as Nature, Science, PNAS, Plos One etc., the assignment to a research field was done for each publication individually on the basis of the research group that published the article and the title of the article itself. In this way for each publication of a given age, the world average number of citations and the top decile (10%) and top percentile (1%) most cited publications thresholds in their research field can be established.

For the current analysis we used the baselines retrieved from ESI on 15 February 2015.

### 2.4 Relative Impact

The relative impact (RI) is the common measure that is used as a proxy for the impact of a publication. The number of citations provides a measure for the impact of the publication to which these citations refer. However, the number of citations to a publication varies considerably across different research fields. For this reason the impact of a publication is normalized by dividing the number of citations to a publication by the world average number of citations for the research field to which the publication belongs. Recently there have been discussions how the impact of aggregations of publications (e.g. by author, research group or institute) should be calculated (Ophhof & Leydesdorff, 2010, Van Raan *et al.* 2010, Waltman *et al.* 2011, Leydesdorff *et al.* 2011). There is now consensus that the "Crown indicator" should be replaced by the MNCS indicator. In this study the MNCS indicator is referred to as RI and is calculated according to the method described by van Veller *et al.* (2010).

The Relative Impact (RI) for a series of publications is calculated as follows:

$$RI = \frac{\sum_i^N \frac{C_i}{Wavg_i}}{N}$$

with:

$C_i$  = number of citations to publication  $i$ ;

$N$  = total number of publications in series that is analysed;

$Wavg_i$  = World average number of citations for publication  $i$  (determined by research field for the journal in which publication  $i$  is included and the publication year of publication  $i$ ).

In this bibliometric analysis the measure for the relative impact is given as a decimal number that shows the relation of the measure to the world average (which is set to the value of 1). For example, a Relative Impact of 0.9 for a particular series of publications from a certain research group means that the research group's publications are cited 10% below the world average of all publications of the same age that are produced in the same research field. Alternatively, in case of Relative Impact of 1.2 the research group's publications are cited 20% above world average.

Based upon the value of RI, research groups can be divided into groups with low, average and high impact (Van Raan, 2004). The Centre for Science and Technology Studies at Leiden uses the criteria presented in Table 2.1 for the classification of the relative impact at the level of universities, institutes or graduate schools.

*Table 0.1 Classification based on relative impact at the level of universities, institutes or graduate schools.*

relative impact	classification
$RI \leq 0.5$	far below world average impact
$0.5 < RI \leq 0.8$	below world average impact
$0.8 < RI \leq 1.2$	world average impact
$1.2 < RI \leq 1.5$	high average impact
$RI > 1.5$	very high average impact

At the lower aggregation level, e.g. for chair groups or business units, for which the volume of peer reviewed publications is in the order of 10 - 50 publications per year the classes for RI as presented in Table 2.3 are distinguished (Van Raan, 2004).

*Table 2.3 Classification based on relative impact at the level of chair groups or business units.*

relative impact	classification
$RI \leq 0.8$	below world average impact
$0.8 < RI \leq 1.2$	world average impact
$1.2 < RI \leq 2.0$	above world average impact
$2.0 < RI \leq 3.0$	very good average impact
$RI > 3.0$	excellent average impact

An alternative measure in bibliometrics is the h-index. This is the most common measure for the individual performance of scientists (Hirsch, 2005). The H-index takes both the number of publications and their citedness into account. Since this metric is dependent on the number of publication, group size would influence the outcome. It is difficult to compare groups based on this metric and is therefore not taken into account.

### 2.5 Top 10% most cited publications

Comparing the number of citations per publication with the percentile thresholds of the top 10% (T10), the top decile, most cited publications of the same age in the same research field yields the absolute number of publications meeting this criterion. In addition to the absolute number of highly cited publications, it is more meaningful to look at the number of highly cited publications as a percentage of total publications produced. The percentage of highly cited publications is a good indicator to distinguish excellent research groups from the best research groups (Tijssen *et al.*, 2002; Bornmann & Marx, 2013).

Besides the top 10% most cited publications, also the top 1% most cited publications (T1), the top percentile, is given in the results.

### 2.6 Journal quartiles

When journals are ranked in the Journal Citations Report on their impact factor within their domain, journals can be clustered in Quartiles. The 12,000 journals in the Journal Citation Reports are classified in 250 different domains. Q1 being the top 25% journals in their domain and so on. The journal quartile score normally has a large effect on the impact of the articles. We have therefore analysed the impact of the articles according to their quartiles as well. The total of publications divided over the quartiles can deviate from the total amount of publications used in the impact analysis because some journals don't have an impact factor yet, but are already included in WoS, but are therefore not present in the quartile distributions. Determination of the quartile of a publication is based on the JCR in the year of publication.

### 2.7 Bibliometric indicators and terminology used

In the next chapters we will present tables with bibliometric indicators per graduate school and research group. In these tables we use the following parameters:

- N: the number of peer reviewed publications retrieved from the Science Citation Index (SCI) the Social Science Citation Index (SSCI) and the Arts & Humanities Index (AHCI);
- C: total number of citations to these publications;
- Wavg: the world average amount of citations for these articles with the same age and research field;
- CPP: average number of citations per publication;
- RI: relative impact (see paragraph 0);
- %T10: percentage publications from this group in the world's top 10% most cited publications of the same age and from the same research area (absolute number between brackets);
- %T1: percentage publications from this group in the world's top 1% most cited publications of the same age and from the same research area (absolute number between brackets);
- %NC: percentage not cited publications (absolute number between brackets).

Throughout this report the term articles, publications and papers were used. With all three terms we refer to articles or reviews published in peer-reviewed scientific journals.

When we refer to Web of Science (WoS) in the discussion of the results in chapter 3 and 4, we mean the Web of Science Core Collection that covers the Science Citation Index (SCI) the Social Science Citation Index (SSCI) and the Arts & Humanities Index (AHCI).

### 2.8 Bibliometric analysis SciVal for benchmark

SciVal is an online tool of Elsevier to visualize research performance and based on the Scopus database. WIAS used this tool to benchmark the Chair groups in section 5.1 of the Chair groups self-evaluations. Every Chair group is compared to a maximum of 4 groups per research domain. The metrics used for benchmarking are: number of articles, citations per publication and field weighted citation impact for the years 2008-2013. The calculation of the Field Weighted Citation Impact (FWCI) can be found below.

At the time of writing, Scopus includes:

- 21,912 titles from more than 5,000 international publishers. These titles contain 20,874 peer-reviewed journals (including 2,800 open access journals), 367 trade journals and 421 book series;
- 30,000 books;
- 5.5 million conference papers;
- "Articles-in-Press" from more than 3,750 journals and publishers such as Cambridge University Press, Elsevier, Springer, Wiley-Blackwell, Nature Publishing Group and the IEEE (Institute of Electrical and Electronics Engineers).

Reference lists are captured from 1996 onwards. For this analysis, we focussed on the period 2007 -2012. The data in SciVal are updated every week from the Scopus database.

We created a group of researchers for every selected research group. For this selected group of researchers the publications are merged into a list of unique publications. After creation of the groups the SciVal metrics are available.

In SciVal 15 metrics are available, such as scholarly output, citation count and the field weighted citation impact. More details on the SciVal, their metrics and opportunities for analysis can be found in the SciVal Guidebook (Colledge & Verlinde, 2014).

### **Field Weighted Citations Impact**

The calculation of the Field Weighted Citation Impact (FWCI) corresponds to the calculation of the Relative Impact as described in paragraph 0, except that the citation count is restricted to the citations received in the publication year and the 3 following years. The FWCI for a set of N publications is defined as:

$$FWCI = \frac{\sum_{i=1}^N \frac{c_i}{e_i}}{N}$$

$c_i$  = citations received by publication  $i$  in the publication year plus following 3 years;

$e_i$  = expected number of citations received by all similar publications in the publication year plus following 3 years.

When a publication is allocated to more than one journal category, the harmonic mean is used to calculate  $e_i$ . For a publication that is part of two journal categories  $e_i$  is calculated by:

$$e_i = \frac{(e_A + e_B)}{2}$$

$e_A, e_B$  = the expected number of citations received by similar publications in journal category A or B in the publication year plus following 3 years.

### 3. Bibliometric analysis results for WIAS

In Table 3.1 the bibliometric analysis for WIAS as a whole for the period 2008-2013 is presented with a view to the chronological development. In Table 3.2 the bibliometric indicators per research field are presented. Furthermore, in Table 3.3 an overview of the bibliometric indicators per WIAS chair group is given for the whole period 2008-2013. These indicators are taken from the bibliometric analysis for every chair group individually that are presented in chapter 4. For the period 2008-2013, 95% of the peer reviewed articles were published in journals covered by Web of Science.

*Table 3.1 Bibliometric indicators for WIAS over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

year of publication	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	217	4342	3008	20.01	1.56	19% (42)	2% (5)
2009	211	3832	2504	18.16	1.56	17% (36)	2% (5)
2010	228	3010	2313	13.2	1.41	16% (36)	3% (6)
2011	305	3684	2202	12.08	1.76	26% (78)	2% (7)
2012	320	2382	1399	7.44	1.78	18% (57)	3% (8)
2013	328	1420	638	4.33	2.13	22% (72)	4% (13)
<b>all years</b>	<b>1609</b>	<b>18670</b>	<b>12063</b>	<b>11.6</b>	<b>1.74</b>	<b>20% (321)</b>	<b>3% (44)</b>

WIAS produces on average 321 peer reviewed articles in journal covered by Web of Science per year. The production increased since 2008 with a considerable growth in 2011. The relative impact of these publications is 1.74, which is on the level of graduate schools a very high average impact. This is reflected by the fact that 20% of the publications belong to the top 10% most cited publications and 3% of the publications belong to the top 1% most cited publications in their field.

*Table 3.2 Bibliometric indicators for WIAS per research field for the period 2008-2013. The rows are ordered in descending number of publications. The bibliometric indicators are explained in paragraph 2.7.*

research field	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	780	6705	4698	8.6	1.52	16% (122)	1% (7)
Agricultural Sciences	305	3320	1606	10.9	2.10	28% (85)	5% (16)
Molecular Biology & Genetics	115	2362	1950	20.5	1.45	18% (21)	2% (2)
Biology & Biochemistry	76	1055	777	13.9	1.31	17% (13)	1% (1)
Immunology	76	998	1035	13.1	1.12	8% (6)	0% (0)
Clinical Medicine	62	822	495	13.3	1.83	26% (16)	3% (2)
Environment/Ecology	62	923	471	14.9	2.19	31% (19)	5% (3)
Microbiology	52	1433	456	27.6	3.84	35% (18)	17% (9)
Social Sciences, General	22	367	112	16.7	3.24	41% (9)	14% (3)
Neuroscience & Behavior	20	223	199	11.2	1.25	10% (2)	0% (0)
Chemistry	10	74	84	7.4	0.95	0% (0)	0% (0)
Pharmacology & Toxicology	10	110	76	11.0	1.64	30% (3)	0% (0)
Engineering	8	166	33	20.8	4.38	63% (5)	13% (1)
Psychiatry/Psychology	5	56	39	11.2	1.09	20% (1)	0% (0)
Computer Science	2	3	9	1.5	0.35	0% (0)	0% (0)
Economics & Business	2	38	9	19.0	2.48	50% (1)	0% (0)
Materials Science	1	13	13	13.0	1.03	0% (0)	0% (0)
Physics	1	2	2	2.0	0.84	0% (0)	0% (0)
<b>all fields</b>	<b>1609</b>	<b>18670</b>	<b>12063</b>	<b>11.6</b>	<b>1.74</b>	<b>20% (321)</b>	<b>3% (44)</b>

The WIAS publications cover a wide range of research fields. However almost half of the publications (49%) belong to the research field Plant & Animal Science with Agricultural Sciences as second largest research field (19%). The relative impact for the publications in Plant & Animal Sciences (1.52) is lower

than the WIAS average, but for the graduate school as a whole counts as a very high average impact. This can be explained by the fact that generally plant science publications receive more citations than animal science publications. Therefore it is more difficult for WIAS to perform well in this research field. Publications in the field of Agricultural Sciences score better with a relative impact of 2.09, again a very high average impact. The shares of top 10% and top 1% most cited publications confirm the picture that we see for the RI for those two research fields.

*Table 3.3 Bibliometric indicators for WIAS chair groups for the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

<b>chair group</b>	<b>N</b>	<b>C</b>	<b>Wavg</b>	<b>CPP</b>	<b>RI</b>	<b>%T10 (#T10)</b>	<b>%T1 (#T1)</b>
ADP	209	1637	1379	7.8	1.38	12% (26)	0% (1)
ABG	371	5079	3122	13.7	1.83	20% (75)	2% (9)
ANU	307	2524	1758	8.2	1.60	19% (58)	3% (8)
APS	98	912	514	9.3	1.70	19% (19)	3% (3)
AFI	203	1825	1326	9.0	1.47	16% (33)	1% (3)
BHE	25	127	68	5.08	2.05	28% (7)	0% (0)
CBI	175	2492	1706	14.2	1.72	22% (38)	3% (5)
EZO	75	933	720	12.4	1.48	19% (14)	1% (1)
HAP	68	903	768	13.3	1.35	18% (12)	0% (0)
HMI	115	2382	740	20.7	4.14	33% (38)	11% (13)
QVE	109	1282	780	11.8	1.79	19% (21)	3% (3)

ADP = Adaptation Physiology, ABG = Animal Breeding and Genetics, ANU = Animal Nutrition, APS = Animal Production Systems, AFI = Aquaculture and Fisheries, BHE = Behavioural Ecology, CBI = Cell Biology and Immunology, EZO = Experimental Zoology, HAP = Human and Animal Physiology, HMI = Host-Microbe Interatomics, QVE = Quantitative Veterinary Epidemiology

Nearly all groups that comprise WIAS show an above world average relative impact. Behavioural Ecology (BHE) shows a very good average impact and Host-Microbe Interatomics (HMI) shows an excellent average impact. This latter group also showed the largest shares of top 10% and 1% most cited publications.

## 4. Bibliometric analysis results per chair group

### 4.1 Adaptation Physiology (ADP)

In this paragraph the bibliometric results for the Adaptation Physiology Group (ADP) are presented and discussed. For the period 2008-2013, 99% of the peer reviewed publications were published in journals covered by Web of Science.

*Table 4.1 Bibliometric indicators for ADP over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

year of publication	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	27	355	326	13.2	1.21	11% (3)	0% (0)
2009	26	292	280	11.2	1.04	4% (1)	0% (0)
2010	41	384	354	9.4	1.12	10% (4)	0% (0)
2011	36	316	212	8.8	1.47	22% (8)	0% (0)
2012	36	142	131	3.9	1.10	6% (2)	0% (0)
2013	43	148	75	3.4	2.11	19% (8)	2% (1)
<b>all years</b>	<b>209</b>	<b>1637</b>	<b>1379</b>	<b>7.8</b>	<b>1.38</b>	<b>12% (26)</b>	<b>0% (1)</b>

ADP produces on average 35 peer reviewed articles per year in journals covered by Web of Science (Table 4.1). The number of reviewed articles per year was less than 30 in 2008 and in 2009 but shows an increase thereafter. The mean relative impact in the period 2008-2013 is with 1.38 above world average. Over the whole period under study 12% of the publications belong to the top 10% most cited publications in their field. One paper belongs to the top 1% most cited publications in their field.

*Table 4.2 Bibliometric indicators for ADP per research field for the period 2008-2013. The rows are ordered in descending number of publications. The bibliometric indicators are explained in paragraph 2.7.*

research field	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	141	1000	861	7.1	1.28	11% (15)	0% (0)
Agricultural Sciences	33	277	173	8.4	1.99	18% (6)	3% (1)
Clinical Medicine	11	133	103	12.1	1.49	9% (1)	0% (0)
Neuroscience & Behavior	6	42	88	7.0	0.40	0% (0)	0% (0)
Immunology	5	31	32	6.2	0.86	0% (0)	0% (0)
Biology & Biochemistry	3	18	24	6.0	0.92	0% (0)	0% (0)
Social Sciences, General	3	66	28	22.0	2.55	67% (2)	0% (0)
Environment/Ecology	3	22	12	7.3	1.19	33% (1)	0% (0)
Psychiatry/Psychology	2	34	23	17.0	1.60	50% (1)	0% (0)
Chemistry	1	6	3	6.0	2.03	0% (0)	0% (0)
Molecular Biology & Genetics	1	8	33	8.0	0.24	0% (0)	0% (0)
<b>all fields</b>	<b>209</b>	<b>1637</b>	<b>1379</b>	<b>7.8</b>	<b>1.38</b>	<b>12% (26)</b>	<b>0% (1)</b>

The most important research field for ADP publications is Plant & Animal Science (67%) with Agricultural Sciences (11%) as second largest research field (Table 4.2). The publications in the research field Plant & Animal Science have a relative impact of 1.28, which is above world average impact. 11% of the publications in this research field belong to the top 10% most cited publications in their research field. None of the papers belong to the top 1% most cited publications in their research field. The publications in the research field Agricultural Sciences have a relative impact of nearly 2, which is above world average impact. 18% of these publications belong to the top 10% most cited publications in their field and 3% even belong to the top 1% most cited publications in their field. The numbers of articles in the other research fields are too low for a meaningful analysis.

*Table 4.3 Bibliometric indicators per journal quartile for ADP for the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

<b>quartile</b>	<b>N</b>	<b>C</b>	<b>Wavg</b>	<b>CPP</b>	<b>RI</b>	<b>%T10 (#T10)</b>	<b>%T1 (#T1)</b>	<b>%NC (# NC)</b>
1	161	1255	1040	7.8	1.43	12% (20)	1% (1)	6% (9)
2	40	348	265	8.7	1.35	13% (5)	0% (0)	18% (7)
3	6	34	64	5.7	0.72	17% (1)	0% (0)	33% (2)
4	2	0	10	0.0	0.00	0% (0)	0% (0)	100% (2)
<b>all quartiles</b>	<b>209</b>	<b>1637</b>	<b>1379</b>	<b>7.8</b>	<b>1.38</b>	<b>12% (26)</b>	<b>0% (1)</b>	<b>10% (20)</b>

77% of all ADP publications are published in quartile 1 journals and nearly 20% in quartile 2 journals (Table 4.3). There is not much difference in relative impact between publications in quartile 1 and quartile 2 journals. Albeit, articles published in quartile 1 journals show a slightly better relative impact compared to those in quartile 2 journals. Only few articles were published in quartile 3 and quartile 4 journals. The relative impact of these publications is much lower than that in quartile 1 and 2 journals. The share of uncited articles increases clearly from quartile 1 to quartile 4 journals.

#### 4.2 Animal Breeding and Genetics (ABG)

In this paragraph the bibliometric results for the Animal Breeding and Genetics Group (ABG) are presented and discussed. For the period 2008-2013, 93% of the peer reviewed publications were published in journals covered by Web of Science.

*Table 4.4 Bibliometric indicators for ABG over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

year of publication	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	48	1231	669	25.7	2.02	25% (12)	4% (2)
2009	64	1301	807	20.3	1.57	19% (12)	2% (1)
2010	57	902	689	15.8	1.30	14% (8)	2% (1)
2011	54	599	485	11.1	1.34	15% (8)	0% (0)
2012	69	746	311	10.8	2.84	26% (18)	6% (4)
2013	79	300	161	3.8	1.76	22% (17)	1% (1)
<b>all years</b>	<b>371</b>	<b>5079</b>	<b>3122</b>	<b>13.7</b>	<b>1.83</b>	<b>20% (75)</b>	<b>2% (9)</b>

ABG produces on average 62 peer reviewed articles per year in journals covered by Web of Science (Table 4.4). The number of peer reviewed articles in 2012 and 2013 is higher than in the preceding years. The mean relative impact in the period 2008-2013 is with 1.83 above world average with a peak of 2.84 in 2012. This is also reflected in the share of papers that reached 1% most cited papers threshold in that year. Over the whole period under study 20% of the publications belong to the top 10% most cited publications in their field and 2% belong to the top 1% most cited publications in their field.

*Table 4.5 Bibliometric indicators for ABG per research field for the period 2008-2013. The rows are ordered in descending number of publications. The bibliometric indicators are explained in paragraph 2.7.*

research field	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	175	1748	1053	10.0	1.85	14% (25)	1% (2)
Agricultural Sciences	84	988	471	11.8	1.99	26% (22)	6% (5)
Molecular Biology & Genetics	73	1576	1233	21.6	1.34	18% (13)	0% (0)
Environment/Ecology	12	283	74	23.6	3.65	67% (8)	8% (1)
Neuroscience & Behavior	7	82	58	11.7	1.66	14% (1)	0% (0)
Biology & Biochemistry	6	211	70	35.2	2.79	33% (2)	17% (1)
Immunology	5	65	90	13.0	0.58	0% (0)	0% (0)
Social Sciences, General	4	29	24	7.3	0.92	25% (1)	0% (0)
Clinical Medicine	2	40	19	20.0	2.31	50% (1)	0% (0)
Microbiology	2	31	20	15.5	2.09	50% (1)	0% (0)
Psychiatry/Psychology	1	26	10	26.0	2.58	100% (1)	0% (0)
<b>all fields</b>	<b>371</b>	<b>5079</b>	<b>3122</b>	<b>13.69</b>	<b>1.83</b>	<b>20% (75)</b>	<b>2% (9)</b>

The three main research fields for ABG publications are Plant & Animal Science (175 publications), Agricultural Sciences (84 publications) and Molecular Biology & Genetics (73 publications) (Table 4.5). Within these three research fields publications in Agricultural Sciences yield the highest average impact, (1.99). Publications within Plant & Animal Sciences and Molecular Biology & Genetics have also an above world average impact of respectively 1.85 and 1.34. The share of publications within the top 10% most cited publications in their field is highest for publications within Agricultural Sciences, namely 26%. 6% of the ABG publications in this research field are even in the top 1% most cited publications in their field. Publications within the research fields Plant & Animal Science and Molecular Biology & Genetics have a share of respectively 14% and 18% in the top 10% most cited publications in their field. The numbers of articles in the other research fields are too low for a meaningful analysis.

*Table 4.6 Bibliometric indicators per journal quartile for ABG for the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

<b>Quartile</b>	<b>N</b>	<b>C</b>	<b>Wavg</b>	<b>CPP</b>	<b>RI</b>	<b>%T10 (#T10)</b>	<b>%T1 (#T1)</b>	<b>%NC (# NC)</b>
1	266	3912	2082	14.7	2.10	24% (63)	3% (8)	5% (14)
2	71	620	572	8.7	1.18	13% (9)	0% (0)	7% (5)
3	25	257	363	10.3	0.68	4% (1)	0% (0)	4% (1)
4	4	18	29	4.5	0.43	0% (0)	0% (0)	50% (2)
<b>all quartiles</b>	<b>366</b>	<b>4807</b>	<b>3045</b>	<b>13.13</b>	<b>1.81</b>	<b>20% (73)</b>	<b>2% (8)</b>	<b>6% (22)</b>

73% of all ABG publications are published in quartile 1 journals and 19% in quartile 2 journals (Table 4.6). Relative impact, share of publications within the top 10% most cited publications in their field and share of publications within the top 1% most cited publications in their field decreases from quartile 1 journals to quartile 4 journals. The share of uncited articles is highest in quartile 4 journals.

The total amount of peer reviewed publications (N) in Table 4.6 is slightly lower than the totals in Table 4.4 and in Table 4.5. This is because some articles are published in journals already included in WoS but these journals did not yet receive an Impact Factor. This also results in small differences in the average relative impact (RI) and the other variables.

### 4.3 Animal Nutrition (ANU)

In this paragraph the bibliometric results for the Animal Nutrition Group (ANU) are presented and discussed. For the period 2008-2013, 97% of the peer reviewed publications were published in journals covered by Web of Science.

*Table 4.7 Bibliometric indicators for ANU over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

year of publication	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	47	774	530	16.5	1.48	17% (8)	0% (0)
2009	30	350	295	11.7	1.16	7% (2)	3% (1)
2010	38	301	292	7.9	1.02	13% (5)	0% (0)
2011	55	564	299	10.3	1.87	29% (16)	5% (3)
2012	67	319	236	4.8	1.43	18% (12)	0% (0)
2013	70	216	107	3.1	2.13	21% (15)	6% (4)
<b>all years</b>	<b>307</b>	<b>2524</b>	<b>1758</b>	<b>8.2</b>	<b>1.60</b>	<b>19% (58)</b>	<b>3% (8)</b>

ANU produces on average 51 peer reviewed articles per year in journals covered by Web of Science (Table 4.7). Since 2011 the number of peer reviewed publications per year shows an increase. The mean relative impact in the period 2008-2013 is with 1.60 above world average. Over the whole period under study 19% of the publications belong to the top 10% most cited publications in their field and 3% belong to the top 1% most cited publications in their field.

*Table 4.8 Bibliometric indicators for ANU per research field for the period 2008-2013. The rows are ordered in descending number of publications. The bibliometric indicators are explained in paragraph 2.7.*

research field	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	175	1087	986	6.2	1.25	13% (22)	1% (2)
Agricultural Sciences	109	1087	558	10.0	2.16	28% (31)	5% (5)
Biology & Biochemistry	11	149	114	13.6	0.94	9% (1)	0% (0)
Environment/Ecology	4	62	27	15.5	1.67	50% (2)	0% (0)
Microbiology	3	49	50	16.3	1.10	0% (0)	0% (0)
Neuroscience & Behavior	2	13	10	6.5	1.24	0% (0)	0% (0)
Chemistry	1	6	3	6.0	2.03	0% (0)	0% (0)
Clinical Medicine	1	63	8	63.0	7.81	100% (1)	100% (1)
Social Sciences, General	1	8	2	8.0	3.65	100% (1)	0% (0)
<b>all fields</b>	<b>307</b>	<b>2524</b>	<b>1758</b>	<b>8.2</b>	<b>1.60</b>	<b>19% (58)</b>	<b>3% (8)</b>

ANU publishes mainly within the research fields Plant & Animal Science and Agricultural Sciences (Table 4.8). More than 92% of their publications are assigned to these two research fields. The relative impact of publications within Agricultural Sciences (2.16) is much higher than that in Plant and Animal Science (1.25). This is also reflected by the shares of publications within the top 10% and top 1% most cited publications within their field. The numbers of articles in the other research fields are too low for a meaningful analysis.

*Table 4.9 Bibliometric indicators per journal quartile for ANU for the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

quartile	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)	% NC (# NC)
1	216	2042	1157	9.5	1.91	24% (52)	3% (7)	11% (23)
2	70	402	450	5.7	0.97	7% (5)	1% (1)	11% (8)
3	19	76	143	4.0	0.48	5% (1)	0% (0)	16% (3)
4	2	4	9	2.0	0.58	0% (0)	0% (0)	0% (0)
<b>all quartiles</b>	<b>307</b>	<b>2524</b>	<b>1758</b>	<b>8.2</b>	<b>1.6</b>	<b>19% (58)</b>	<b>3% (8)</b>	<b>11% (34)</b>

ANU publishes mainly in quartile 1 and quartile 2 journals (Table 4.9). The relative impact of publications within these journals is much higher than that of publications in quartile 3 and 4 journals. The relative impact of articles in quartile 1 journals is nearly double the relative impact of quartile 2 journal articles. The share of publications within the top 10% most cited publications in their field is much higher in quartile 1 journals than in quartile 2 journals.

#### 4.4 Animal Production Systems (APS)

In this paragraph the bibliometric results for the Animal Production Group (APS) are presented and discussed. For the period 2008-2013, 84% of the peer reviewed publications were published in journals covered by Web of Science.

*Table 4.10 Bibliometric indicators for APS over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

year of publication	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	12	349	117	29.1	3.13	33% (4)	17% (2)
2009	9	69	82	7.7	0.93	11% (1)	0% (0)
2010	7	140	60	20.0	2.56	14% (1)	14% (1)
2011	24	201	141	8.4	1.44	21% (5)	0% (0)
2012	25	93	84	3.7	0.99	8% (2)	0% (0)
2013	21	60	30	2.9	2.09	29% (6)	0% (0)
<b>all years</b>	<b>98</b>	<b>912</b>	<b>514</b>	<b>9.3</b>	<b>1.70</b>	<b>19% (19)</b>	<b>3% (3)</b>

APS produces on average 16 peer reviewed articles per year in journals covered by Web of Science (Table 4.10). Since 2011 the number of peer reviewed publications per year shows a significant increase. The relative impact shows large fluctuations with peaks of 3.13 and 2.56 in 2008 and 2010 respectively and lows of 0.93 and 0.99 in 2009 and 2012 respectively, which however are still world average relative impact values. There are also fluctuations in the share of publications within the top 10% most cited publications in their field. The high relative impacts in 2008 and 2012 are the results of a few highly cited articles, reaching the top 1% most cited in their field (2 in 2008 and 1 in 2010) in years with a relatively small number of articles. Over the whole period under study 3% of the publications belong to the top 1% most cited publications in their field.

*Table 4.11 Bibliometric indicators for APS per research field for the period 2008-2013. The rows are ordered in descending number of publications. The bibliometric indicators are explained in paragraph 2.7.*

research field	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	41	317	223	7.7	1.51	15% (6)	2% (1)
Agricultural Sciences	32	276	143	8.6	1.54	16% (5)	3% (1)
Environment/Ecology	6	61	41	10.2	1.47	17% (1)	0% (0)
Social Sciences, General	7	74	35	10.6	1.65	29% (2)	0% (0)
Engineering	5	96	14	19.2	4.85	60% (3)	20% (1)
Chemistry	3	31	28	10.3	1.11	0% (0)	0% (0)
Biology & Biochemistry	1	16	7	16.0	2.45	100% (1)	0% (0)
Computer Science	1	2	4	2.0	0.52	0% (0)	0% (0)
Economics & Business	1	38	8	38.0	4.96	100% (1)	0% (0)
Pharmacology & Toxicology	1	1	11	1.0	0.09	0% (0)	0% (0)
<b>all fields</b>	<b>98</b>	<b>912</b>	<b>514</b>	<b>9.3</b>	<b>1.70</b>	<b>19% (19)</b>	<b>3% (3)</b>

Nearly 75% of all APS peer reviewed publications belong to the research fields Plant & Animal Science and Agricultural Sciences (Table 4.11). The relative impact in both research fields is similar, about 1.5, which is above world average. In both research fields about 15% of the publications are within the top 10% most cited publications in their field and 2-3% is within the top 1% most cited publications in their field. The numbers of articles in the other research fields are too low for a meaningful analysis.

*Table 4.12 Bibliometric indicators per journal quartile for APS for the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

<b>quartile</b>	<b>N</b>	<b>C</b>	<b>Wavg</b>	<b>CPP</b>	<b>RI</b>	<b>%T10 (#T10)</b>	<b>%T1 (#T1)</b>	<b>% NC (#NC)</b>
1	58	520	263	9.0	1.88	28% (16)	2% (1)	10% (6)
2	31	358	173	11.6	1.71	10% (3)	6% (2)	13% (4)
3	4	30	35	7.5	1.03	0% (0)	0% (0)	25% (1)
4	3	2	29	0.7	0.07	0% (0)	0% (0)	33% (1)
<b>all quartiles</b>	<b>96</b>	<b>910</b>	<b>500</b>	<b>9.5</b>	<b>1.73</b>	<b>20% (19)</b>	<b>3% (3)</b>	<b>13% (12)</b>

Table 4.12 shows that the relative impact of publications in quartile 1 and quartile 2 journals is almost similar. The values of 1.88 and 1.71 are above world average. The share of publications in the top 10% most cited publications in their field is however higher for quartile 1 journals than for quartile 2 journals. Only few papers are published in quartile 3 and quartile 4 journals. The relative impact of these publications is significantly lower than that of publications in quartile 1 and 2 journals. None of these publications are within the top 10% most cited publications in their field.

The total amount of peer reviewed publications (N) in Table 4.12 is slightly lower than the totals in Table 4.10 and in Table 4.11. This is because some articles are published in journals already included in WoS but these journals did not yet receive an Impact Factor. This also results in small differences in the average relative impact (RI) and the other variables.

#### 4.5 Aquaculture and Fisheries (AFI)

In this paragraph the bibliometric results for the Aquaculture and Fisheries Group (AFI) are presented and discussed. For the period 2008-2013, 91% of the peer reviewed publications were published in journals covered by Web of Science.

*Table 4.13 Bibliometric indicators for AFI over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

year of publication	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	32	430	401	13.44	1.12	19% (6)	0% (0)
2009	26	435	279	16.73	1.65	15% (4)	4% (1)
2010	28	337	225	12.04	1.54	21% (6)	0% (0)
2011	35	241	201	6.89	1.21	14% (5)	0% (0)
2012	37	262	145	7.08	1.76	14% (5)	3% (1)
2013	45	120	75	2.67	1.55	16% (7)	2% (1)
<b>all years</b>	<b>203</b>	<b>1825</b>	<b>1326</b>	<b>9.0</b>	<b>1.47</b>	<b>16% (33)</b>	<b>1% (3)</b>

AFI produces on average 34 peer reviewed articles per year in journals covered by Web of Science (Table 4.13). The number of articles per year is higher from 2011-2013 than from 2008-2010. The average relative impact over the period under study is 1.47, which is above world average. 16% of all publications belong to the top 10% most cited publications in their field and 1% belong to the top 1% most cited publications in their field.

*Table 4.14 Bibliometric indicators for AFI per research field for the period 2008-2013. The rows are ordered in descending number of publications. The bibliometric indicators are explained in paragraph 2.7.*

research field	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	150	1342	927	9.0	1.44	18% (27)	1% (1)
Environment/Ecology	27	344	231	12.7	1.96	11% (3)	7% (2)
Agricultural Sciences	10	39	31	3.9	1.32	20% (2)	0% (0)
Biology & Biochemistry	5	23	41	4.6	1.15	20% (1)	0% (0)
Clinical Medicine	2	16	16	8.0	0.76	0% (0)	0% (0)
Engineering	2	12	7	6.0	1.48	0% (0)	0% (0)
Microbiology	2	6	9	3.0	0.72	0% (0)	0% (0)
Chemistry	1	4	14	4.0	0.28	0% (0)	0% (0)
Computer Science	1	2	4	2.0	0.52	0% (0)	0% (0)
Molecular Biology & Genetics	1	17	33	17.0	0.51	0% (0)	0% (0)
Neuroscience & Behavior	1	8	7	8.0	1.16	0% (0)	0% (0)
Social Sciences, General	1	12	5	12.0	2.25	0% (0)	0% (0)
<b>all fields</b>	<b>203</b>	<b>1825</b>	<b>1326</b>	<b>9.0</b>	<b>1.47</b>	<b>16% (33)</b>	<b>1% (3)</b>

Plant & Animal Science is by far the most important research field for AFI (Table 4.14). Nearly 75% of all publications are published within this research field. In addition 13% of their publications appear in the research field Environment/Ecology. The relative impact of publications within Environment/Ecology is nearly 2, which is above world average. The relative impact of publications within Plant & Animal Science is with 1.44 somewhat lower, but still above world average. On the contrary, the share of publications within the top 10% most cited publications in their field is higher for Plant & Animal Science than for Environment/Ecology. The latter however includes 2 publications within the top 1% most cited publications in their field. The numbers of articles in the other research fields are too low for a meaningful analysis.

*Table 4.15 Bibliometric indicators per journal quartile for AFI for the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

<b>Quartile</b>	<b>N</b>	<b>C</b>	<b>Wavg</b>	<b>CPP</b>	<b>RI</b>	<b>%T10 (#T10)</b>	<b>%T1 (#T1)</b>	<b>%NC (#NC)</b>
1	118	1349	796	11.4	1.74	20% (24)	3% (3)	8% (10)
2	52	310	297	6.0	1.34	15% (8)	0% (0)	13% (7)
3	27	155	201	5.7	0.78	4% (1)	0% (0)	15% (4)
4	3	8	27	2.7	0.28	0% (0)	0% (0)	0% (0)
<b>all quartiles</b>	<b>200</b>	<b>1822</b>	<b>1321</b>	<b>9.1</b>	<b>1.49</b>	<b>17% (33)</b>	<b>2% (3)</b>	<b>11% (21)</b>

Nearly 60% of the AFI articles are published in quartile 1 journals and over 25% are published in quartile 2 journals. Table 4.15 shows that the relative impact decreases from publication in quartile 1 journals to quartile 4 journals. Such a tendency is also seen in the share of articles within the top 10% most cited publications in their field.

The total amount of peer reviewed publications (N) in Table 4.15 is slightly lower than the totals in Table 4.13 and in Table 4.14. This is because some articles are published in journals already included in WoS but these journals did not yet receive an Impact Factor. This also results in small differences in the average relative impact (RI) and the other variables.

#### 4.6 Behavioural Ecology (BHE)

In this paragraph the bibliometric results for the Behavioural Ecology Group (BHE) are presented and discussed. The BHE group was recently established. For the years 2012 and 2013, 93% of the peer reviewed publications were published in journals covered by Web of Science.

*Table 4.16 Bibliometric indicators for BHE over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

year of publication	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2012	9	58	38	6.44	1.71	22% (2)	0% (0)
2013	16	69	31	4.31	2.24	31% (5)	0% (0)
<b>all years</b>	<b>25</b>	<b>127</b>	<b>68</b>	<b>5.08</b>	<b>2.05</b>	<b>28% (7)</b>	<b>0% (0)</b>

The number of peer reviewed publications of the BHE group increased from 9 in 2012 to 16 in 2013 (Table 4.16). The relative impact also increased in these two years from 1.71 to 2.24. The relative impact over these two years is 2.05, which is a very good average impact. However, the very good average impact of the 2013 articles can partly be explained by early citations that weigh heavy compared to the world average. The share of publications within the top 10% most cited publications in their field shows a similar increase. So far, no publications were within the top 1% most cited publications within their field.

*Table 4.17 Bibliometric indicators for BHE per research field for the period 2008-2013. The rows are ordered in descending number of publications. The bibliometric indicators are explained in paragraph 2.7.*

research field	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	14	77	32	5.5	2.51	36% (5)	0% (0)
Neuroscience & Behavior	5	31	19	6.2	1.8	20% (1)	0% (0)
Agricultural Sciences	2	3	3	1.5	1.13	0% (0)	0% (0)
Environment/Ecology	2	6	10	3	0.57	0% (0)	0% (0)
Biology & Biochemistry	1	10	3	10	3.5	100% (1)	0% (0)
Psychiatry/Psychology	1	0	2	0	0	0% (0)	0% (0)
<b>all fields</b>	<b>25</b>	<b>127</b>	<b>68</b>	<b>5.08</b>	<b>2.05</b>	<b>28% (7)</b>	<b>0% (0)</b>

More than half of the publications of BHE are within the research field Plant & Animal Science (Table 4.17). The relative impact of these publications is with 2.51 very good. 36% of these publications are within the top 10% most cited publications in their field. The numbers of articles in the other research fields are too low for a meaningful analysis.

*Table 4.18 Bibliometric indicators per journal quartile for BHE for the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

Quartile	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)	%NC (# NC)
1	14	70	39	5	1.99	29% (4)	0% (0)	0% (0)
2	9	47	24	5.22	2.19	22% (2)	0% (0)	11% (1)
3	2	10	5	5	1.75	50% (1)	0% (0)	50% (1)
4	-	-	-	-	-	-	-	-
<b>all quartiles</b>	<b>25</b>	<b>127</b>	<b>68</b>	<b>5.08</b>	<b>2.05</b>	<b>28% (7)</b>	<b>0% (0)</b>	<b>8% (2)</b>

BHE publishes more than half of their articles (56%) in quartile 1 journals and 36% in quartile 2 journals (**Error! Reference source not found.**). Publications in both journal quartiles have a relative impact of about 2. The relative impact of publications in quartile 3 journals is with 1.75 still above world average.



#### 4.7 Cell Biology and Immunology (CBI)

In this paragraph the bibliometric results for the Cell Biology and Immunology Group (CBI) are presented and discussed. For the period 2008-2013, 96% of the peer reviewed publications were published in journals covered by Web of Science.

*Table 4.19 Bibliometric indicators for CBI over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

year of publication	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	29	656	536	22.6	1.31	21% (6)	0% (0)
2009	26	487	350	18.7	1.41	12% (3)	0% (0)
2010	24	353	281	14.7	1.40	29% (7)	0% (0)
2011	36	629	315	17.5	2.20	31% (11)	6% (2)
2012	23	207	137	9.0	1.79	22% (5)	4% (1)
2013	37	160	86	4.3	1.96	16% (6)	5% (2)
<b>all years</b>	<b>175</b>	<b>2492</b>	<b>1706</b>	<b>14.2</b>	<b>1.72</b>	<b>22% (38)</b>	<b>3% (5)</b>

CBI produces on average 29 peer reviewed articles per year in journals covered by Web of Science (Table 4.19). The mean relative impact over the period 2008-2013 is 1.72, which is above world average. The relative impact in the years 2011-2013 is higher than in the preceding years. 22% of the publications are within the top 10% most cited publications in their field and 3% are even within the top 1% most cited publications in their field.

*Table 4.20 Bibliometric indicators for CBI per research field for the period 2008-2013. The rows are ordered in descending number of publications. The bibliometric indicators are explained in paragraph 2.7.*

research field	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	58	699	383	12.1	1.91	28% (16)	2% (1)
Immunology	53	760	752	14.3	1.07	6% (3)	0% (0)
Clinical Medicine	16	167	132	10.4	1.48	25% (4)	0% (0)
Agricultural Sciences	13	121	64	9.3	2.56	38% (5)	8% (1)
Biology & Biochemistry	12	268	113	22.3	2.08	33% (4)	8% (1)
Microbiology	6	272	55	45.3	5.78	83% (5)	33% (2)
Pharmacology & Toxicology	6	91	58	15.2	1.36	17% (1)	0% (0)
Molecular Biology & Genetics	4	34	70	8.5	0.52	0% (0)	0% (0)
Chemistry	2	25	27	12.5	0.93	0% (0)	0% (0)
Environment/Ecology	2	4	14	2.0	0.39	0% (0)	0% (0)
Neuroscience & Behavior	1	19	20	19.0	0.97	0% (0)	0% (0)
Psychiatry/Psychology	1	21	13	21.0	1.63	0% (0)	0% (0)
Social Sciences, General	1	11	7	11.0	1.61	0% (0)	0% (0)
<b>all fields</b>	<b>175</b>	<b>2492</b>	<b>1706</b>	<b>14.2</b>	<b>1.72</b>	<b>22% (38)</b>	<b>3% (5)</b>

The research fields Plant & Animal Science and Immunology are equally important for CBI (Table 4.20), covering respectively 33% and 30% of the publications. The publications in the research field Plant & Animal Science have an above world average relative impact (1.91). The publications in the research field Immunology have a lower relative impact (1.07), which is a world average impact. This is because human related studies have prevalence over animal related studies. The numbers of articles in the other research fields are too low for a meaningful analysis.

*Table 4.21 Bibliometric indicators per journal quartile for CBI for the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

<b>quartile</b>	<b>N</b>	<b>C</b>	<b>Wavg</b>	<b>CPP</b>	<b>RI</b>	<b>%T10 (#T10)</b>	<b>%T1 (#T1)</b>	<b>% NC (# NC)</b>
1	117	1744	1078	14.9	1.82	25% (29)	2% (2)	5% (6)
2	38	533	440	14.0	1.54	16% (6)	5% (2)	13% (5)
3	13	170	113	13.1	1.82	15% (2)	8% (1)	23% (3)
4	4	13	51	3.3	0.18	0% (0)	0% (0)	50% (2)
<b>all quartiles</b>	<b>172</b>	<b>2460</b>	<b>1683</b>	<b>14.3</b>	<b>1.72</b>	<b>22% (37)</b>	<b>3% (5)</b>	<b>9% (16)</b>

CBI publishes 68% of their articles in quartile 1 journals and 22% in quartile 2 journals (Table 4.21). The share of publications within the top 10% most cited publications in their field decreases from quartile 1 journals to quartile 4 journals. Such a clear tendency is not seen with the relative impact. In quartile 4 journals it is low, but in quartile 3 journals it is as high as in quartile 1 journals. The above world average impact of articles published in quartile 3 journals is contrary to what is normally observed.

The total amount of peer reviewed publications (N) in Table 4.21 is slightly lower than the totals in Table 4.19 and in Table 4.20. This is because some articles are published in journals already included in WoS but these journals did not yet receive an Impact Factor. This also results in small differences in the average relative impact (RI) and the other variables.

#### 4.8 Experimental Zoology (EZO)

In this paragraph the bibliometric results for the Experimental Zoology Group (EZO) are presented and discussed. For the period 2008-2013, 100% of the peer reviewed publications were published in journals covered by Web of Science.

*Table 4.22 Bibliometric indicators for EZO over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

year of publication	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	11	223	182	20.3	1.25	18% (2)	0% (0)
2009	9	184	117	20.4	1.50	22% (2)	0% (0)
2010	14	106	162	7.6	0.84	14% (2)	0% (0)
2011	15	249	152	16.6	1.63	20% (3)	0% (0)
2012	16	71	78	4.4	1.00	6% (1)	0% (0)
2013	10	100	30	10.0	3.17	40% (4)	10% (1)
<b>all years</b>	<b>75</b>	<b>933</b>	<b>720</b>	<b>12.4</b>	<b>1.48</b>	<b>19% (14)</b>	<b>1% (1)</b>

EZO produces on average 13 peer reviewed articles per year in journals covered by Web of Science (Table 4.22). The mean relative impact over the period 2008-2013 is 1.48, which is an above world average impact. 19% of the publications over the period under study are within the top 10% most cited publications in their field. The share of articles reaching the top 1% is 1%. The excellent average impact of the 2013 articles can be explained by early citations that weigh heavy compared to the world average.

*Table 4.23 Bibliometric indicators for EZO per research field for the period 2008-2013. The rows are ordered in descending number of publications. The bibliometric indicators are explained in paragraph 2.7.*

research field	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	30	211	213	7.0	1.05	13% (4)	0% (0)
Molecular Biology & Genetics	14	308	210	22.0	2.08	29% (4)	7% (1)
Biology & Biochemistry	13	214	183	16.5	0.99	8% (1)	0% (0)
Clinical Medicine	7	100	45	14.3	3.00	29% (2)	0% (0)
Neuroscience & Behavior	4	15	32	3.8	0.48	0% (0)	0% (0)
Environment/Ecology	3	18	16	6.0	1.47	33% (1)	0% (0)
Agricultural Sciences	2	7	8	3.5	0.84	0% (0)	0% (0)
Engineering	2	60	14	30.0	4.28	100% (2)	0% (0)
<b>all fields</b>	<b>75</b>	<b>933</b>	<b>720</b>	<b>12.4</b>	<b>1.48</b>	<b>19% (14)</b>	<b>1% (1)</b>

The most important research field for EZO is Plant & Animal Science (Table 4.23). Other relative important research fields are Molecular Biology & Genetics and Biology & Biochemistry. The highest relative impact and share in the top 10% most cited publications in their field are seen within Molecular Biology & Genetics, respectively 2.08 and 29%. The relative impact within Plant & Animal Science and Biology & Biochemistry is on the world average. Around 10% of the publications within these two research fields belong to the top 10% most cited publications in their field. The numbers of articles in the other research fields are too low for a meaningful analysis.

*Table 4.24 Bibliometric indicators per journal quartile for EZO for the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

quartile	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)	%NC (# NC)
1	51	686	436	13.5	1.80	24% (12)	2% (1)	6% (3)
2	13	153	155	11.8	0.82	8% (1)	0% (0)	8% (1)
3	10	81	113	8.1	0.80	10% (1)	0% (0)	20% (2)
4	1	13	16	13.0	0.82	0% (0)	0% (0)	0% (0)
<b>all quartiles</b>	<b>75</b>	<b>933</b>	<b>720</b>	<b>12.4</b>	<b>1.48</b>	<b>19% (14)</b>	<b>1% (1)</b>	<b>8% (6)</b>

68% of the EZO publications appear in quartile 1 journals, 17% in quartile 2 journals and 13% in quartile 3 journals (**Error! Reference source not found.**). It is beneficial to publish in quartile 1 journals as can be seen from the higher relative impact and higher share in the top 10% most cited publications in their field.

#### 4.9 Human and Animal Physiology (HAP)

In this paragraph the bibliometric results for the Human and Animal Physiology Group (HAP) are presented and discussed. For the period 2008-2013, 96% of the peer reviewed publications were published in journals covered by Web of Science.

*Table 4.25 Bibliometric indicators for HAP over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

year of publication	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	11	238	209	21.6	1.16	18% (2)	0% (0)
2009	18	369	252	20.5	1.77	22% (4)	0% (0)
2010	11	104	138	9.5	0.84	0% (0)	0% (0)
2011	10	115	108	11.5	1.22	20% (2)	0% (0)
2012	6	39	36	6.5	1.13	17% (1)	0% (0)
2013	12	38	26	3.2	1.59	25% (3)	0% (0)
<b>all years</b>	<b>68</b>	<b>903</b>	<b>768</b>	<b>13.3</b>	<b>1.35</b>	<b>18% (12)</b>	<b>0% (0)</b>

HAP publishes on average 11 peer reviewed publications per year in journals covered by Web of Science (Table 4.25). The number of publications per year is quite variable, varying from 6 in 2012 to 18 in 2009. The mean relative impact over the period under study is 1.35, which is above world average. 18% of the publications in this period are within the top 10% most cited publications within their field. None of the publications are within the top 1% most cited publications in their field.

*Table 4.26 Bibliometric indicators for HAP per research field for the period 2008-2013. The rows are ordered in descending number of publications. The bibliometric indicators are explained in paragraph 2.7.*

research field	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Clinical Medicine	20	284	197	14.2	1.54	30% (6)	0% (0)
Agricultural Sciences	16	197	98	12.3	1.86	25% (4)	0% (0)
Biology & Biochemistry	11	140	145	12.7	1.01	0% (0)	0% (0)
Molecular Biology & Genetics	11	157	228	14.3	0.63	0% (0)	0% (0)
Pharmacology & Toxicology	4	82	33	20.5	2.13	50% (2)	0% (0)
Plant & Animal Science	4	37	38	9.3	1.01	0% (0)	0% (0)
Chemistry	1	4	6	4.0	0.62	0% (0)	0% (0)
Neuroscience & Behavior	1	2	23	2.0	0.09	0% (0)	0% (0)
Clinical Medicine	20	284	197	14.2	1.54	30% (6)	0% (0)
<b>all fields</b>	<b>68</b>	<b>903</b>	<b>768</b>	<b>13.28</b>	<b>1.35</b>	<b>18% (12)</b>	<b>0% (0)</b>

HAP publishes in various research fields, of which Clinical Medicine and Agricultural Sciences are the two most important (30% and 24%). Furthermore, considerable numbers of publications appear in the research fields Biology & Biochemistry and Molecular Biology & Genetics. The relative impact is highest in Agricultural Sciences, followed by Clinical Medicine. With respectively 1.86 and 1.54, the relative impact of these fields is above world average. This is reflected by a high share of publications within the top 10% most cited publications in their field (30% and 25%). The publications within Biology & Biochemistry have a relative impact of about 1, which is a world average impact. Those within Molecular Biology & Genetics have a relative impact of 0.63, which is below world average impact. The numbers of articles in the other research fields are too low for a meaningful analysis.

*Table 4.27 Bibliometric indicators per journal quartile for HAP for the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

<b>Quartile</b>	<b>N</b>	<b>C</b>	<b>Wavg</b>	<b>CPP</b>	<b>RI</b>	<b>%T10 (#T10)</b>	<b>%T1 (#T1)</b>	<b>%NC (# NC)</b>
1	48	728	506	15.2	1.61	25% (12)	0% (0)	2% (1)
2	15	136	178	9.1	0.79	0% (0)	0% (0)	7% (1)
3	3	15	47	5.0	0.43	0% (0)	0% (0)	0% (0)
4	1	16	28	16.0	0.57	0% (0)	0% (0)	0% (0)
<b>all quartiles</b>	<b>67</b>	<b>895</b>	<b>759</b>	<b>13.4</b>	<b>1.36</b>	<b>18% (12)</b>	<b>0% (0)</b>	<b>3% (2)</b>

The majority of publications (94%) of HAP appears in quartile 1 and quartile 2 journals (Table 4.27). This is beneficial as the relative impact decreases from quartile 1 to quartile 4 journals. Only papers in quartile 1 journals are within the top 10% most cited publications in their field.

The total amount of peer reviewed publications (N) in Table 4.27 is slightly lower than the totals in Table 4.25 and in Table 4.26. This is because some articles are published in journals already included in WoS but these journals did not yet receive an Impact Factor. This also results in small differences in the average relative impact (RI) and the other variables.

#### 4.10 Host-Microbe Interatomics (HMI)

In this paragraph the bibliometric results for the Host-Microbe Interatomics Group (HMI) are presented and discussed. For the period 2008-2013, 94% of the peer reviewed publications were published in journals covered by Web of Science.

*Table 4.28 Bibliometric indicators for HMI over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

year of publication	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	2	222	53	111.0	5.17	50% (1)	50% (1)
2009	3	170	44	56.7	3.35	33% (1)	33% (1)
2010	10	368	117	36.8	3.6	50% (5)	30% (3)
2011	20	510	185	25.5	3.21	40% (8)	15% (3)
2012	32	394	214	12.3	1.89	19% (6)	3% (1)
2013	48	718	125	15.0	6.16	35% (17)	8% (4)
<b>all years</b>	<b>115</b>	<b>2382</b>	<b>740</b>	<b>20.7</b>	<b>4.14</b>	<b>33% (38)</b>	<b>11% (13)</b>

Over the period under study the mean number of peer reviewed publications per year in journals covered by Web of Science is 19 (Table 4.28). The number of publications increases steadily from 2009 onward. The mean relative impact over the period under study is 4.14, which is an excellent average impact. One third of all publications are within the top 10% most cited publications in their field and 11% is even within the top 1% most cited publications in their field. The excellent average impact of the 2013 articles can be explained by early citations that weigh heavy compared to the world average.

*Table 4.29 Bibliometric indicators for HMI per research field for the period 2008-2013. The rows are ordered in descending number of publications. The bibliometric indicators are explained in paragraph 2.7.*

research field	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Microbiology	46	1193	312	25.9	4.02	37% (17)	15% (7)
Biology & Biochemistry	19	147	106	7.7	1.28	21% (4)	0% (0)
Clinical Medicine	15	509	71	33.9	11.94	40% (6)	20% (3)
Immunology	11	138	85	12.6	2.00	27% (3)	0% (0)
Molecular Biology & Genetics	8	116	95	14.5	1.35	25% (2)	0% (0)
Agricultural Sciences	7	211	29	30.1	5.79	57% (4)	43% (3)
Plant & Animal Science	4	23	22	5.8	1.08	0% (0)	0% (0)
Chemistry	2	4	6	2.0	0.68	0% (0)	0% (0)
Environment/Ecology	2	31	10	15.5	2.22	50% (1)	0% (0)
Pharmacology & Toxicology	1	10	2	10.0	4.50	100% (1)	0% (0)
Microbiology	46	1193	312	25.9	4.02	37% (17)	15% (7)
<b>all fields</b>	<b>115</b>	<b>2382</b>	<b>740</b>	<b>20.7</b>	<b>4.14</b>	<b>33% (38)</b>	<b>11% (13)</b>

The most important research field for HMI publications is Microbiology (Table 4.29). Publications within this research field have an excellent relative impact of about 4, a share of 37% in the top 10% most cited publications in their field and a share of 15% in the top 1% most cited publications in their field. Publications within the research field Clinical Medicine are also successful with an extremely high relative impact of nearly 12, a share of 40% in the top 10% most cited publications in their field and a share of 20% in the top 1% most cited publications in their field. Considerable numbers of articles are also published in the research field Biology & Biochemistry. The relative impact of publications within this research field is lower than in Microbiology and Clinical Medicine, but still above world average. The numbers of articles in the other research fields are too low for a meaningful analysis.

Table 4.30 Bibliometric indicators per journal quartile for HMI for the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.

Quartile	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)	% NC (# NC)
1	81	2032	514	25.09	5.15	38% (31)	16% (13)	9% (7)
2	26	254	170	9.77	1.64	15% (4)	0% (0)	8% (2)
3	5	22	26	4.4	1.28	20% (1)	0% (0)	20% (1)
<b>all quartiles</b>	<b>112</b>	<b>2308</b>	<b>711</b>	<b>20.61</b>	<b>4.16</b>	<b>32% (36)</b>	<b>12% (13)</b>	<b>9% (10)</b>

72% of the HMI articles are published in quartile 1 journals and 23% in quartile 2 journals (**Error! Reference source not found.**). Publications in quartile 1 journals have an excellent average relative impact of more than 5, a share of 38% within the top 10% most cited publications in their field and a share of 16% within the top 1% most cited publications in their field. The relative impact of the articles declines with increasing journal quartiles as can be expected.

The total amount of peer reviewed publications (N) in **Error! Reference source not found.** is slightly lower than the totals in **Error! Reference source not found.** and in **Error! Reference source not found.**. This is because some articles are published in journals already included in WoS but these journals did not yet receive an Impact Factor. This also results in small differences in the average relative impact (RI) and the other variables.

#### 4.11 Quantitative Veterinary Epidemiology (QVE)

In this paragraph the bibliometric results for the Quantitative Veterinary Epidemiology Group (QVE) are presented and discussed. For the period 2008-2013, 97% of the peer reviewed publications were published in journals covered by Web of Science.

*Table 4.31 Bibliometric indicators for QVE over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

year of publication	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	11	228	153	20.7	1.79	27% (3)	0% (0)
2009	15	350	144	23.3	2.60	40% (6)	7% (1)
2010	19	214	183	11.3	1.64	11% (2)	5% (1)
2011	30	366	197	12.2	1.87	23% (7)	0% (0)
2012	20	87	77	4.4	1.21	10% (2)	0% (0)
2013	14	37	25	2.6	1.82	7% (1)	7% (1)
<b>all years</b>	<b>109</b>	<b>1282</b>	<b>780</b>	<b>11.8</b>	<b>1.79</b>	<b>19% (21)</b>	<b>3% (3)</b>

QVE produces on average 18 peer reviewed articles per year in journals covered by Web of Science (Table 4.31). The mean relative impact over the period 2008-2013 is 1.79, which is above world average. 19% of the publications are within the top 10% most cited publications in their field and 3% are within the top 1% most cited publications in their field.

*Table 4.32 Bibliometric indicators for QVE per research field for the period 2008-2013. The rows are ordered in descending number of publications. The bibliometric indicators are explained in paragraph 2.7.*

research field	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	66	684	398	10.4	1.63	20% (13)	0% (0)
Agricultural Sciences	9	70	46	7.8	1.32	11% (1)	0% (0)
Microbiology	8	98	85	12.3	1.06	13% (1)	0% (0)
Social Sciences, General	7	232	37	33.1	6.78	71% (5)	43% (3)
Immunology	6	46	88	7.7	0.71	0% (0)	0% (0)
Biology & Biochemistry	4	19	41	4.8	0.58	0% (0)	0% (0)
Clinical Medicine	4	55	36	13.8	1.67	25% (1)	0% (0)
Chemistry	2	25	19	12.5	1.35	0% (0)	0% (0)
Psychiatry/Psychology	2	22	15	11.0	1.12	0% (0)	0% (0)
Molecular Biology & Genetics	1	31	16	31.0	1.95	0% (0)	0% (0)
<b>all fields</b>	<b>109</b>	<b>1282</b>	<b>780</b>	<b>11.8</b>	<b>1.79</b>	<b>19% (21)</b>	<b>3% (3)</b>

Over 60% of all QVE peer reviewed publications belong to the research fields Plant & Animal Science. (Table 4.32). The relative impact of these publications is 1.63, which is above world average. 20% of these publications are within the top 10% most cited publications in their field. None of these publications is within the top 1% most cited publications in their field. The numbers of articles in the other research fields are too low for a meaningful analysis.

*Table 4.33 Bibliometric indicators per journal quartile for QVE for the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7.*

quartile	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)	% NC (# NC)
1	74	847	508	11.5	1.71	19% (14)	0% (0)	4% (3)
2	24	337	171	14.0	2.32	21% (5)	13% (3)	25% (6)
3	6	32	55	5.3	1.08	17% (1)	0% (0)	0% (0)
4	2	5	8	2.5	0.54	0% (0)	0% (0)	0% (0)
<b>all quartiles</b>	<b>106</b>	<b>1221</b>	<b>742</b>	<b>11.5</b>	<b>1.79</b>	<b>19% (20)</b>	<b>3% (3)</b>	<b>8% (9)</b>

Nearly 70% of the QVE articles are published in quartile 1 journals and 23% in quartile 2 journals (Table 4.33). The relative impact of publications in quartile 2 journals is higher than that in quartile 1 journals, this is contradictory to what is expected. The share of publications within the top 10% most cited publications in their field is similar for publications in quartile 1 and quartile 2 journals and even comparable to that of publications in quartile 3 journals. However, the relative impact in quartile 3 journals is lower than that in quartile 1 and 2 journals.

The total amount of peer reviewed publications (N) in Table 4.33 is slightly lower than the totals in Table 4.31 and in Table 4.32. This is because some articles are published in journals already included in WoS but these journals did not yet receive an Impact Factor. This also results in small differences in the average relative impact (RI) and the other variables.

## 5. References

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## Appendix

Queries used to retrieve bibliometric data from Staff Publications. These links are available only for Wageningen UR staff and students.

Chair group	
ADP	<a href="http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=58&amp;A143=58&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013">http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=58&amp;A143=58&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013</a> (access date: 2 April 2015)
ABG	<a href="http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=51&amp;A143=51&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013">http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=51&amp;A143=51&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013</a> (access date: 15 April 2015)
ANU	<a href="http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=52&amp;A143=52&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013">http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=52&amp;A143=52&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013</a> (access date: 2 April 2015)
APS	<a href="http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=53&amp;A143=53&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013">http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=53&amp;A143=53&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013</a> (access date: 2 April 2015)
AFI	<a href="http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=54&amp;A143=54&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013">http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=54&amp;A143=54&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013</a> (access date: 2 April 2015)
BHE	<a href="http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=330&amp;A143=330&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2012%2F%2F2013">http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=330&amp;A143=330&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2012%2F%2F2013</a> (access date: 7 April 2015)
CBI	<a href="http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=48&amp;A143=48&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013">http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=48&amp;A143=48&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013</a> (access date: 2 April 2015)
EZO	<a href="http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=49&amp;A143=49&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013">http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=49&amp;A143=49&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013</a> (access date: 2 April 2015)
HAP	<a href="http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=50&amp;A143=50&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013">http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=50&amp;A143=50&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013</a> (access date: 2 April 2015)
HMI	<a href="http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=56&amp;A143=56&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013">http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=56&amp;A143=56&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013</a> (access date: 2 April 2015)
QVE	<a href="http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=60&amp;A143=60&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013">http://library.wur.nl/WebQuery/wurpubs/wos?wq_inf1=60&amp;A143=60&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013</a> (access date: 2 April 2015)
WIAS	<a href="http://library.wur.nl/WebQuery/wurpubs/wos?wq_par=open&amp;A150%2Fonderzoeksschool=%3DWIAS+Wageningen+Institute+of+Animal+Sciences+1994+1999&amp;wq_rel=AND&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_par=close&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013">http://library.wur.nl/WebQuery/wurpubs/wos?wq_par=open&amp;A150%2Fonderzoeksschool=%3DWIAS+Wageningen+Institute+of+Animal+Sciences+1994+1999&amp;wq_rel=AND&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_par=close&amp;wurpublikatie%2Fcitatie%2Fscore%2Ffisi-nummer=*&amp;wq_inf_pre=pluspre&amp;A200=2008%2F%2F2013</a> (access date: 2 April 2015)

ADP = Adaptation Physiology, ABG = Animal Breeding and Genetics, ANU = Animal Nutrition, APS = Animal Production Systems, AFI = Aquaculture and Fisheries, BHE = Behavioural Ecology, CBI = Cell Biology and Immunology, EZO = Experimental Zoology, HAP = Human and Animal Physiology, HMI = Host-Microbe Interatomics, QVE = Quantitative Veterinary Epidemiology

#### 4. Links to all scientific output for period 2009-2014

Links to all academic publications, professional publications and products and other research output per Chair group for the period 2009-2014. These links are publically available.

Chair group	
ADP	<a href="http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=58&amp;A143=58&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014">http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=58&amp;A143=58&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014</a>
ABG	<a href="http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=51&amp;A143=51&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014">http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=51&amp;A143=51&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014</a>
ANU	<a href="http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=52&amp;A143=52&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014">http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=52&amp;A143=52&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014</a>
APS	<a href="http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=53&amp;A143=53&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014">http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=53&amp;A143=53&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014</a>
AFI	<a href="http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=54&amp;A143=54&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014">http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=54&amp;A143=54&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014</a>
BHE	<a href="http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=330&amp;A143=330&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2011%2F%2F2014">http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=330&amp;A143=330&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2011%2F%2F2014</a>
CBI	<a href="http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=48&amp;A143=48&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014">http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=48&amp;A143=48&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014</a>
EZO	<a href="http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=49&amp;A143=49&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014">http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=49&amp;A143=49&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014</a>
HMI	<a href="http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=56&amp;A143=56&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014">http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=56&amp;A143=56&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014</a>
HAP	<a href="http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=50&amp;A143=50&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014">http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=50&amp;A143=50&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014</a>
QVE	<a href="http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=60&amp;A143=60&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014">http://library.wur.nl/WebQuery/wurpubs/list?wq_inf1=60&amp;A143=60&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014</a>
WIAS	<a href="http://library.wur.nl/WebQuery/wurpubs/list?A150%2Fonderzoeksschool=%3DWIAS+Wageningen+Institute+of+Animal+Sciences+1994+1999&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014">http://library.wur.nl/WebQuery/wurpubs/list?A150%2Fonderzoeksschool=%3DWIAS+Wageningen+Institute+of+Animal+Sciences+1994+1999&amp;wq_inf_grouping=SEP&amp;wq_inf_pre=pluspre&amp;A200=2009%2F%2F2014</a>



**Part B.**



## Adaptation Physiology (ADP)

Programme leader(s): Bas Kemp – from 2000 onwards

For a full staff survey see appendix 1.

### 1. Objectives and Research Area

#### 1.1 Vision, Mission and Objectives

**Vision:** The vision of ADP is that **health, welfare, and productivity are shaped by the animal's capacity to adapt**. A "load" of simultaneous, persistent or severe challenges exceeding the adaptive capacity of animals might lead to reduced resilience and culminate in behavioural and physiological disturbances and disease susceptibility (see Figure 1). Problems regarding health, welfare and productivity in farm animals can be prevented by ensuring a balance between the challenges animals are exposed to and their adaptive capacity.

**Mission:** Our mission is to **improve and facilitate adaptation by development of robust animals in supportive environments**. By increasing and disseminating knowledge on this topic, ADP will contribute, firstly, to the development of robust animals that have the capacity to cope with changing and challenging conditions, and, secondly, to the development of suitable (early) environments that support the adaptive responses of animals and reduce their 'allostatic load'.

**Objectives:** Our objectives are to **understand challenges that animals encounter in different stages of their life**, and to **translate that understanding into innovative housing, feeding and management solutions that improve the health and welfare of animals and that are societally acceptable**. In this way, our research contributes to sustainable animal husbandry.

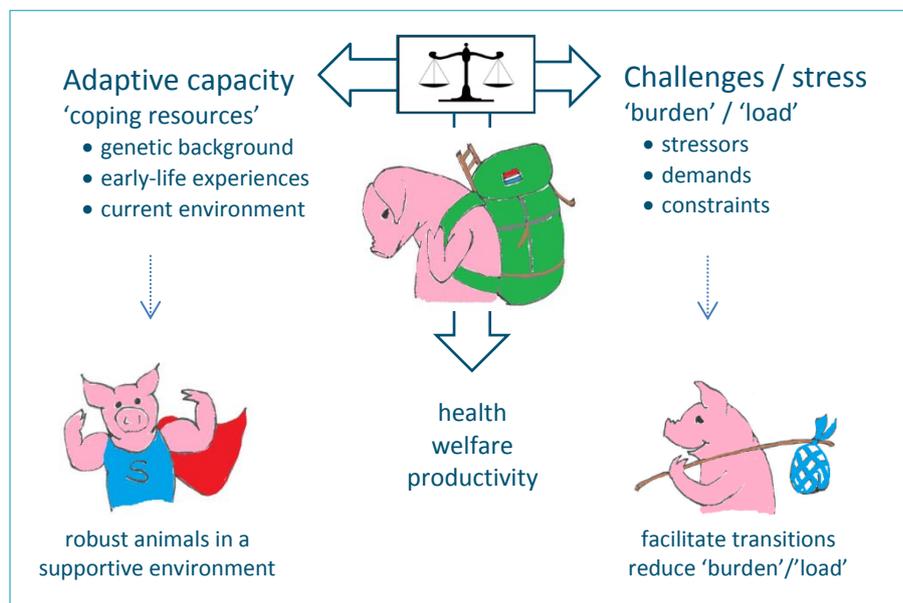


Figure 1. The balance between the adaptive capacity of animals, and their 'load' of challenges, which might impact their health, welfare, and productivity. ADP will contribute to improvements on both sides of this balance (bottom images).

### **1.2 Research Area / research line(s)**

The ability of animals to adapt to challenging conditions is influenced by their genetic background, their early-life experiences, and their current environment: management, feeding and housing. We develop knowledge in 4 areas:

- 1) Consequences of different genetic backgrounds or selection strategies on behaviour, reproduction, immunology, and metabolism (e.g. divergent selection on innate and adaptive immune responses).
- 2) Effects of early life experiences of farm animals on their adaptive capacity during critical transition periods (e.g. birth, hatching, weaning, onset of lactation). We investigate prenatal (e.g. incubation temperature, maternal nutrition) and early postnatal (e.g. early feed intake, mother-offspring communication) conditions that might affect health and welfare in later life.
- 3) Impact of management, feeding, and housing conditions that might facilitate adaptation or reduce allostatic load (e.g. variation in the length of the dry period before lactation in dairy cows, environmental enrichment in pigs).
- 4) Societal and ethical issues related to management and housing of farm animals (e.g. culling of male chicks after hatching).

We study farm animals using an integrated, multidisciplinary research approach. About 15% of our FTE contributes to Area 1, 50% to Area 2, 30% to Area 3 and 5% to Area 4, with most staff members contributing to several areas. Where needed, expertise from other groups (e.g. ANU and ABG for work on feeding and breeding, see 1.4) complements the multidisciplinary expertise within ADP (see 1.3).

### **1.3 Strategy**

To support our multidisciplinary research approach, ADP has staff members from several scientific fields (immunology, reproductive physiology, energy metabolism, behavioural biology) and a strong cooperation with other groups (see 1.4). We aim for a mixture of fundamental and applied research, and strive to combine scientific excellence with a high societal impact, by contributing to real-life solutions for complex problems. To support our labour-intensive experimental work, we have invested in a strong team of technicians, in outstanding administrative support staff (both selected as Team of the Year of the Animal Sciences Group in 2014 and 2013), and in up-to-date facilities (see 2.2).

We foster the development of our PhD candidates by providing close supervision, approachable staff, ample technical assistance, and an open, friendly atmosphere. Our approach has led to a number of prizes (see 3.3) and high-quality PhD theses (see 3). Our PhD candidates, furthermore, graduate in time and with good job perspectives. PhD candidates and post docs are encouraged to follow (inter)national courses and to attend (inter)national conferences. We aim for a balanced contribution of funds from research grants, industry, and university to finance our research.

During the past six years, our research output has increased in quantity and quality (see 2 and 3). ADP has grown in four research areas: behavioural physiology, dairy-cow metabolism and health, incubation and early feeding in chickens, and the role of natural antibodies in adaptation of livestock. Societal impact of our work has grown by increased dissemination of results to a non-scientific audience, with many findings being put into practice (see 4). The group also has established a strong international reputation with rising numbers of international collaborations (see 1.4 and 3).

In the future, we want to accomplish four goals: retain our research focus, while remaining responsive to changes and opportunities; grow by getting post docs in tenured staff positions; expand our international orientation; and remain or become a world-leader in a selected number of themes (see 5.3).

#### 1.4 Research environment and embedding

Our research is well-embedded in the Graduate School, Wageningen Institute of Animal Sciences. We collaborate with almost all groups within our department: ANU, CBI, ABG, BHE, QVE, APS, EZO, HMI and HAP, leading to joint publications, grant applications and projects. ADP is one of the five members of the cluster Adaptive Animals and Systems, which develops joint research initiatives on adaptation of animals and systems to environmental challenges. We represent and help each other, share research facilities and are a sounding board to increase opportunities and effectiveness, and to minimise risks. In 2011, ADP founded a unique Centre for Animal Welfare and Adaptation (Wageningen CAWA), together with BHE and the Animal Welfare group of Wageningen UR Livestock Research. CAWA coordinates and facilitates acquisition of projects and knowledge transfer in the field of animal welfare and adaptation. CAWA publishes a newsletter and has weekly scientific meetings. ADP collaborates with groups from other Departments within Wageningen University (e.g. Farm Technology, Business Economics & Consumer Studies, Microbiology, Human Nutrition, Entomology) and with other Dutch universities, leading to joint projects and publications.

Places of research groups in the world with which ADP has joint peer-reviewed publications is shown in Figure 2. There is no international forum focussing on adaptation in animals, but our research is internationally recognized in the fields of porcine reproduction, weaning in pigs, pig behaviour, incubation and early feeding in chickens, poultry immunology, and metabolism in poultry, pigs, and cattle. Within these fields, our multidisciplinary, integrative approach and focus on adaptation is appreciated, and results increasingly in collaborations. The group is attractive for international PhD candidates and post docs. From 2009 through 2014, ADP had 15 international visiting fellows from 11 countries (see Table 2.1). In 2015, about 35% of our PhD students are from abroad. From 2009 through 2014, about 50% of our peer-reviewed scientific publications was shared with other groups within our Department, 15 % with Livestock Research, 15% with other groups from Wageningen University, 15 % with other Dutch universities and 35 % with international collaborators.



Figure 2. Places of research groups in the world with which the ADP group has joint peer-reviewed publications.

### 1.5 Reference to previous assessments

Review recommendations and actions:

- 1) *Continue policy to publish in higher ranking journals not specialized in production animals:* Publication in higher ranking journals and for a broader audience has increased. From 2009 through 2014, 48 publications were published in journals with an Impact Factor (IF) above 3 (compared with 19 publications from 2003 through 2008). Journals with IF greater than 3 include: PLoS-ONE, Biology Letters, Developmental and Comparative Immunology, Vaccine, Functional Ecology, and Animal Behaviour.
- 2) *Be more active in NWO competition:* We have been successful in NWO competitions during the past 6 years. Collaborative NWO (ALW or STW) projects were funded on feather pecking in poultry (2 PhD candidates, 2 post docs), on sociable swine (4 PhD candidates, 0.5 technician), on osteochondrosis in pigs (1 PhD candidate, 1 post doc), and on selection for natural antibodies in poultry (1 PhD candidate, 1 post doc, 1 technician).
- 3) *Consider closer cooperation with Human and Animal Physiology group:* We have increased collaboration with HAP, resulting in 2 joint applications for NWO funding, a WIAS/NWO grant, and 2 joint publications. A joint PhD project will start this year. The strategic focus of both groups is different, but we see good opportunities for future cooperation in the fields of reproduction and energy metabolism.
- 4) *Risk of no specific own core activities and expertise in broad cooperation:* Our group is recognized for our integrative approach and focus on adaptation and has established a strong track record in six fields: porcine reproduction, weaning in pigs, pig behaviour, incubation and early feeding in chickens, poultry immunology, and metabolism in poultry, pigs, and dairy cattle. Our staff members, have an excellent reputation within their own disciplinary fields. Within these fields, our integrative approach and focus on adaptation is appreciated, and results increasingly in collaborations.
- 5) *Absence of specific behavioural and neurobiological expertise is a matter of concern:* Since the last peer review, we have been successful in acquiring and conducting projects that require expertise in behaviour: 5 PhD projects funded, one cum laude PhD graduation in 2011, one PhD graduation in 2013, and 5 PhD graduations in 2014. Liesbeth Bolhuis, our behaviour expert, is now in tenure track. Furthermore, we have close cooperation with the new chair group Behavioural Ecology (BHE), which strengthens the pool of behavioural experts within WIAS. With BHE, we play an active role in our cluster and in CAWA. We cooperate with colleagues from other universities when we need neurobiological expertise (e.g. we shared a PhD candidate with Dr. M.S. Korte from Utrecht University).

## 2. Resources and Facilities

### 2.1 Researchers

In this review period, the number of total research staff increased from 26 to 35 and number of PhD candidates from 15 to 22 (see table 2.1). Compared with the previous review period from 2003 through 2008 the FTE scientific staff increased for 1.8 to 4.2. The proportion of PhD candidates from abroad (China, Vietnam, Thailand, Indonesia, Germany, Brazil) has increased from 17% to 35% and we had 15 international visiting fellows (see 1.4).

Table 2.1. Research input: number<sup>1</sup> and FTE<sup>2</sup> of Scientific staff, Post-docs and PhD candidates by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	#	FTE												
Scientific staff <sup>4</sup>	8	3.5	10	4.2	12	4.6	12	4.5	10	4.5	10	3.9	10	4.1
Post-docs <sup>5</sup>	3	1.5	3	0.6	1	0.1	2	0.9	2	0.8	3	1.7	2	0.9
PhD candidates <sup>3,6</sup>	15	9.7	16	11.7	18	11.5	22	10.3	23	12.8	22	13.5	19	11.6
<b>Total research staff</b>	<b>26</b>	<b>14.7</b>	<b>29</b>	<b>16.5</b>	<b>31</b>	<b>16.2</b>	<b>36</b>	<b>15.7</b>	<b>35</b>	<b>18.1</b>	<b>35</b>	<b>19.1</b>	<b>32</b>	<b>16.6</b>
Lab Technicians	9	6.3	9	6.3	9	6.7	9	6.7	9	6.7	10	7.0	9	6.6
Visiting fellows	1	0.2	2	0.4	3	0.8	1	0.3	1	0.3	7	2.1	3	0.7
<b>Total staff</b>	<b>36</b>	<b>21.2</b>	<b>40</b>	<b>23.2</b>	<b>43</b>	<b>23.7</b>	<b>46</b>	<b>22.7</b>	<b>45</b>	<b>25.1</b>	<b>52</b>	<b>28.2</b>	<b>44</b>	<b>23.9</b>

<sup>1</sup> Total number of staff and PhD candidates

<sup>2</sup> Available research time in full time equivalent (FTE)

<sup>3</sup> All PhD categories, except external PhDs

Standards for Research Capacity (in case of part time appointment adjustment is applied):

<sup>4</sup> Professor, Assistant Professor and Associated Professor: Research Capacity = 40% of the appointment

<sup>5</sup> Post-doc: Research Capacity = 90% of the appointment

<sup>6</sup> PhD candidate: Research Capacity = 75% of the appointment (all categories)

## 2.2 Research Funds

Average total funding almost doubled from 8.7 FTE for the previous peer review period to 16.7 FTE/year (see Table 2.2). Direct funding by the university remained similar in absolute amounts (about 4.2 FTE), but decreased from 54% in the previous period to 30% now). Average funding from research grants increased for 6% to 23% and average funding from contract research from 40% to 47%.

We obtained 6 international grants from funding agencies over the world. We will further increase our efforts to obtain international and personal grants. Important future targets for funding include research grants and contracts because direct financial support from the university will not rise in the near future.

New animal research facilities have been built with state-of-the-art behaviour test rooms, with world-class climate respiration and egg incubation chambers. We have good laboratories housed in modern facilities, and invested in software and hardware for behavioural studies and animal tracking, and in a video analysis laboratory.

Table 2.2. Funding of Scientific staff, Postdocs and PhD candidates by year and Expenditure of Chair group by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	FTE	%												
<i>Funding:</i>														
Direct funding <sup>1</sup>	6.2	42	6.0	36	5.3	33	5.6	35	2.9	16	3.3	17	4.9	30
Research grants <sup>2</sup>	1.8	12	4.5	28	4.7	29	4.2	27	4.6	25	3.0	16	3.8	23
Contract research <sup>3</sup>	6.8	46	6.0	36	6.2	38	5.9	38	10.6	59	12.9	67	8.1	47
<b>Total funding</b>	<b>14.8</b>	<b>100</b>	<b>16.5</b>	<b>100</b>	<b>16.2</b>	<b>100</b>	<b>15.7</b>	<b>100</b>	<b>18.1</b>	<b>100</b>	<b>19.2</b>	<b>100</b>	<b>16.8</b>	<b>100</b>
<i>Expenditure<sup>4</sup>:</i>	<b>K€</b>	<b>%</b>												
Personnel costs	1,397	68	1,470	70	1,616	59	1,826	65	1,883	59	1,871	57	1,677	63
Other costs	658	32	640	30	1,110	41	992	35	1,317	41	1,425	43	1,024	37
<b>Total expenditure</b>	<b>2,055</b>	<b>100</b>	<b>2,110</b>	<b>100</b>	<b>2,726</b>	<b>100</b>	<b>2,818</b>	<b>100</b>	<b>3,200</b>	<b>100</b>	<b>3,296</b>	<b>100</b>	<b>2,701</b>	<b>100</b>

<sup>1</sup> Direct funding by the University

<sup>2</sup> Research grants obtained in national and international scientific competition (e.g. grants from NWO, KNAW)

<sup>3</sup> Research contracts for specific research projects obtained from external organisations, such as industry, governmental ministries, European Commission (including ERC), charity organisations

<sup>4</sup> Expenditure from financial system of Wageningen University which not only includes research but also teaching and other activities

### 3. Research Quality

We select journals based on target audience, quality, and impact. We publish part of our work in journals with a broader scientific audience than animal scientists. Publications in journals with an impact factor above 3 have increased from 19 (11%) in 2003-2008 to 48 (21%). Number of refereed articles/yr increased from 28.7 (2003-2008) to 38.2 (Table 3.1).

Staff members are world-leading authors in a number of fields. Rankings of ADP authors were based on numbers of papers published in 2009-2014, with specific key words using WoS search (March 2015): (*pigs AND behav\**) #1(Bolhuis), #2(Kemp); (*pigs AND lactation*) #1(Kemp), #4(Soede); (*chick\*AND immun\**) #15 Parmentier); (*chick\* AND incubation*) #1(vdBrand), #2(Kemp); and (*sows AND fertility*) #4 (Soede), #5 (Kemp) (*NOT guinea* added to search on pigs). Staff members are regularly invited to deliver keynote addresses at national and international conferences. They are also active in organisation of conferences and in editorial boards (Table 3.3). The quality of ADP PhD theses is high: 53% were graded as very good/excellent by examining committees (Wageningen University average: 20%). Moreover, our PhD candidates regularly win prizes (19 in the last 5 years). Our international profile is developing strongly (see 1.4). We have been selected by the Rural Development Administration of Korea to be one of the 11 worldwide, overseas labs to develop cooperation with their national animal sciences institute. We also established cooperation with Togo on a program financed by the World Bank to develop an MSc/PhD training centre.

5 key publications of the chair group:

- Lammers, A.; Wieland, W.H.; Kruijt, L.; Jansma, A.; Straetemans, T.; Schots, A.; Hartog, C.G. den; Parmentier, H.K. (2010). Successive immunoglobulin and cytokine expression in the small intestine of juvenile chicken. *Developmental and Comparative Immunology* 34: 1254-1262. RF: Immunology, RI: 1.0
- Molenaar, R.; Hulet, R.; Meijerhof, R.; Maatjens, C.M.; Kemp, B.; Brand, H. van den (2011). High eggshell temperature during incubation decrease growth performance and increase the incidence of ascites in broiler chickens. *Poultry Science* 90 (3): 624-632. RI: 3.12 Top 10% publication
- Reimert, I.; Bolhuis, J.E.; Kemp, B.; Rodenburg, T.B. (2013) Indicators of positive and negative emotions and emotional contagion in pigs. *Physiology and Behaviour* 109 (1): 42-50. RI: 4.79 Top 10% publication.
- Bruijnijis, M.R.N., Beerda, B.; Hogeveen, H; Stassen, E.N. (2012) Assessing the welfare impact of foot disorders in dairy cattle by a modelling approach. *Animal* 6 (6): 962-970. RI 5.88 Top 10% publication.
- Knegsel, A.T.M. van; Drift, S.G.A. van der; Cermakova, J. Kemp, B. (2014). Effects of shortening the dry period of dairy cows on milk production, energy balance, health and fertility: A systemic review. *The Veterinary Journal* 198 (3): 707-713. IF 4.03 Top 10 % publication.

### 3.1 Demonstrable products - Research products for peers in science

Table 3.1. Categories of research output by year.

Category:	Year						Total	Average 2009-2014
	2009	2010	2011	2012	2013	2014		
<b>Academic publications</b>								
a. Refereed articles	26	42	36	35	46	45	<b>230</b>	38
b. Non-refereed articles	0	0	0	0	0	0	<b>0</b>	0
c. Books	0	0	0	0	0	0	<b>0</b>	0
d.1. Refereed book chapters	5	0	0	1	3	1	<b>10</b>	2
d.2. Non-refereed book chapters	1	0	0	0	0	0	<b>1</b>	0
e. PhD Theses	2	3	4	6	5	6	<b>26</b>	4
f. Conference papers	3	6	7	9	15	5	<b>45</b>	8
<b>Total academic publications</b>	<b>37</b>	<b>51</b>	<b>47</b>	<b>51</b>	<b>69</b>	<b>57</b>	<b>312</b>	<b>52</b>

### 3.2 Demonstrable use of products - Use of research products by peers

Table 3.2.1. Bibliometric indicators for ADP over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	27	355	326	13.2	1.21	11% (3)	0% (0)
2009	26	292	280	11.2	1.04	4% (1)	0% (0)
2010	41	384	354	9.4	1.12	10% (4)	0% (0)
2011	36	316	212	8.8	1.47	22% (8)	0% (0)
2012	36	142	131	3.9	1.10	6% (2)	0% (0)
2013	43	148	75	3.4	2.11	19% (8)	2% (1)
<b>all years</b>	<b>209</b>	<b>1637</b>	<b>1379</b>	<b>7.8</b>	<b>1.38</b>	<b>12% (26)</b>	<b>0% (1)</b>

Table 3.2.2. Bibliometric indicators for ADP per research field over the period 2008-2013. The rows are ordered in descending number of publications (N). The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

research field	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	141	1000	861	7.1	1.3	11% (15)	0% (0)
Agricultural Sciences	33	277	173	8.4	2	18% (6)	3% (1)
Neuroscience & Behavior	11	133	103	12.1	1.5	9% (1)	0% (0)
Immunology	6	42	88	7	0.4	0% (0)	0% (0)
Clinical Medicine	5	31	32	6.2	0.9	0% (0)	0% (0)
Biology & Biochemistry	4	19	26	4.8	0.8	0% (0)	0% (0)
Social Sciences, General	3	22	12	7.3	1.2	33% (1)	0% (0)
Environment/Ecology	3	66	28	22	2.6	67% (2)	0% (0)
Psychiatry/Psychology	2	34	23	17	1.6	50% (1)	0% (0)
Molecular Biology & Genetics	1	8	33	8	0.2	0% (0)	0% (0)
Chemistry	1	6	3	6	2	0% (0)	0% (0)
<b>all fields</b>	<b>209</b>	<b>1637</b>	<b>1379</b>	<b>7.8</b>	<b>1.38</b>	<b>12% (26)</b>	<b>0% (1)</b>

Most of our publications are in a relatively small research domain (e.g. pig reproduction and poultry incubation), so we are happy with the relative impact factors (RI) in the larger domains of Agricultural sciences (2.0) and of Plant & Animal Science (1.3) which are our main research fields (Table 3.2).

Proportion of publications in Q1 journals is about 80%. Sometimes, however, we select Q2 journals because of their larger target audience. Our papers (n=9 from 2008-2013) in *Physiology & Behavior* (Q2 in large domain of Neuroscience & Behavior) are well cited (one in %T10) and have a relative impact of 1.5 in Neuroscience & Behavior. Compared with the previous review period, our overall RI increased from 1.27 to 1.38.

We have also developed several research techniques and models. Examples of models are a mathematical model of the bovine oestrus cycle and a model to validate porcine insemination strategies. Examples of techniques are transrectal and transabdominal ultrasonography of porcine ovaries, measurement of eggshell temperature and identification of natural (auto)antibodies in livestock which has been incorporated into PhD projects of several WIAS groups.

### 3.3 Demonstrable marks of recognition - Marks of recognition from peers

*Table 3.3. Most important prizes, keynotes etc. of staff. For remaining achievements see mini CVs (Separate file called mini CVs).*

<b>Science awards, Scholarly prizes, Research grants awarded to individuals</b>		
Year(s)	Prize description	Person(s)
2008-2014	WIAS prizes and grants	M. Oostindjer (publication prize 2010, presentation prize 2011) R. Molenaar (poster prize 2010), C. Souza da Silva (poster prize 2011, 3-month fellowship 2013), D.B. de Koning (poster prize 2013), N. Mayasari (poster prize 2014), I. Camerlink (working visit grant 2013, 3-month fellowship 2014), I. Reimert (3-month fellowship 2014), N. Ursinus (3-month fellowship 2014)
2008-2014	European Association for Animal Production (EAAP)	C. Souza da Silva (best oral presentation by young researcher, 2010), I. Camerlink (scholarship 2013), M.T.W. Verhoeven (best oral presentation by young researcher, 2014)
2008-2014	NZV (Dutch Zootechnical Association) prize for best poster	C. Souza da Silva (2010), E.N. de Haas (2012)
2011	Storm-Van der Chijs stipend for talented female PhD candidates	M. Oostindjer
2011	Honorary Member KNMvD (Royal Dutch Society of Veterinary Science)	E.N. Stassen
2014	Student Award Avialter (Professional Association of Alternative Poultry Production)	E.N. de Haas (best abstract on alternative poultry production at the 48th Congress of the International Society for Applied Ethology)
<b>Plenary/Keynote Lectures at major conferences</b>		
2010	N.M. Soede	European Society of Porcine Health Management, Germany
2011	J.E. Bolhuis	International Workshop on Farm Animal Welfare, China
2012	B. Kemp	International Congress on Animal Reproduction, Canada
2012	A.T.M. van Knegsel	Annual Meeting of the European Federation of Animal Science (EAAP), Slovakia
2012	E.N. Stassen	International Committee for Animal Recording, ICAR/EFSA, Turkey
2013	N.M. Soede	George Foxcroft Honour Lectureship in Swine Production Research, Banff Pork Seminar, Canada

**Organisation of International Scientific Conferences**

2008-14	N.M. Soede	International Conference on Pig Reproduction (2009, 2013)
2008-14	N.M. Soede	Annual Meeting of the European Society for Animal Reproduction (2011, 2012, 2013, 2014)
2008-14	J.E. Bolhuis, M.T.W. Verhoeven, I. Reimert	Benelux Congress of the International Society for Applied Ethology (2013, 2014 J.E.B.; 2013 M.T.W.V.; 2014 I.R.)
2011	H. van den Brand	5 <sup>th</sup> International Workshop on Fundamental Physiology and Perinatal Development in Chickens

**Editorships and editorial boards**

H. Parmentier	Poultry Science, 2010 until present
J.E. Bolhuis	Animal Biology, 2012 until present
B. Kemp	Reproduction in Domestic Animals, 2009 until present
B. Kemp	Journal of Animal Science, 2010 until present

**4. Relevance to Society**

ADP disseminates its research findings to society by giving lectures, by writing reports and publications for the public and stakeholders of animal husbandry (see 4.1), and by organising courses and workshops (see 4.2). Part of our work focusses on societal and ethical issues related to current production systems (e.g. killing of one-day-old male chickens in laying hen production systems) and to newly-developed production systems (e.g. analyses of stakeholder attitudes and convictions towards a variety of poultry production systems). In addition, our work appears regularly in popular media. We contribute to societal committees and advisory boards that deal with complex ethical issues regarding the keeping and handling of animals (see 4.3). Through close cooperation with Swine Innovation Centre VIC Sterksel, Dairy Campus, and industry, moreover, we ensure that our solutions to real life problems are rapidly disseminated and put into practice.

A major focus of the group's current research is to study effects of early-life experiences of farm animals on their adaptive capacity during critical transition periods. Two examples of these critical transition periods are incubation, hatching and early development of chickens, and weaning of piglets. Below we describe briefly the societal impact of our research on these two examples. Our research on incubation, hatching and early development of chickens is conducted in collaboration with innovative companies, such as HatchTech and Vencomatic, and is supported by various agencies such as the European Fund for Regional Development (EFRO) and the Product Board Animal Feed. We have shown that health, welfare, and productivity of chickens are improved if incubation settings are adjusted to the (metabolic) needs of the embryos. Provision of water and feed immediately after hatching - currently not a common commercial practice -, moreover, improves metabolic and immune development of chicks. This work has contributed to the development of new production systems, in which chicks have feed and water access during hatching. Such systems include the Patio System (Vencomatic) and the HatchCare system (HatchTech). The latter system has won the prestigious Innovation Award at VIV Europe 2014.

Our work on weaning of piglets, supported by Technology Foundation STW, Product Boards and (inter)national (feed and flavour) companies, revealed new strategies to battle health, welfare, and production problems related to weaning. We have shown that early exploration and ingestion of feed can be stimulated by facilitating transfer of information from sow to piglet (through flavour conditioning *in utero* and social learning) and by providing feed in a form that matches the developmental and behavioural needs of piglets. This early feeding, in turn, is vital to facilitate a good adaptation to weaning. The work has led to innovations in the feeding industry (e.g. flavour conditioning diets for piglets and sows, XL pellets for piglets) and in the design of farrowing pens and feeders that enable piglets and sows to eat together.

#### 4.1 Demonstrable products - Research products for societal target groups

Table 4.1: Overview of output for societal target groups by year.

	Year						Total
	2009	2010	2011	2012	2013	2014	
Professional publications and output	9	10	12	19	20	19	<b>89</b>
Publications for the general public	2	1	1	2	3	7	<b>16</b>
Other research output	51	54	66	112	108	79	<b>470</b>
Lectures (for general public, policy makers, farmers, industry, other stakeholders of animal production)			29	38	47	22	<b>136</b>
Contributions to exhibitions and activities for primary and secondary education				1	2	4	<b>7</b>

#### 4.2 Demonstrable use of products - Use of research products by societal groups

ADP endeavours to educate students in scientific research and in being responsible towards animals. Our students find jobs in the domains of academia, research institutes, governmental bodies, NGOs and industry, where they perform research, teach, or have advisory roles. ADP's extensive network in these domains facilitates the students' employability. ADP organizes post-academic courses, workshops, and masterclasses (see Table 4.2).

ADP wants to be a creative partner for industry, NGOs and governmental bodies for research and transfer of knowledge. A substantial number of our projects are funded by or in cooperation with societal groups, e.g. the Ministry of Economic Affairs, Provinces (Overijssel, Gelderland), and EFRO. In several projects, societal groups (e.g. Animal Protection Society) are involved as advisors.

ADP also conducts contract research and consults for government and industry (e.g. development of new farming systems). About 29% of our scientific publications is co-authored by industrial partners.

Between 2009-2014, a patent was achieved (P6025294EP - Methods of measuring natural resistance in milk; HK Parmentier with JAM van Arendonk from ABG). Natural (auto)antibodies in milk are used as a potential health marker by the Animal Health Service, and by breeding and feeding companies.

Table 4.2. Number of training activities: courses, workshops, masterclasses and networks, 2009-2014 (max 6 per category).

<b>Post-academic courses (veterinarians, animal scientists working in the livestock industry)</b>	
Fertility and reproduction of pigs <sup>1</sup>	3
Pig feeding in practice <sup>2</sup>	3
Cattle feeding <sup>2</sup>	5
Incubation biology and management <sup>1</sup>	2
Gut health in pigs and poultry <sup>2</sup>	2
Healthy production <sup>2</sup>	1
Control of voluntary feed intake <sup>1</sup>	1
Indirect calorimetry <sup>2</sup>	1
<b>PhD courses (WIAS PhD candidates, PhD candidates from other groups)</b>	
Epigenesis and epigenetics, WIAS/VLAG <sup>1</sup>	2
Energy balance and energy metabolism in dairy cows, PhD course Ghent University <sup>2</sup>	1
Ethics and philosophy in life sciences, WIAS <sup>1</sup>	6
Adaptation of animals and farming systems in a global change context, INRA France/ADP <sup>1</sup>	1
<b>(WIAS) seminars (PhD candidates, stakeholders from livestock farming)</b>	
Friends or Fiends: consequences of social interactions for artificial breeding programs and evolution in natural populations, ADP/ABG <sup>2</sup>	1

Lactation management for piglets and sows <sup>1</sup>	1
Animal reproduction research <sup>1</sup>	1
Learning how to eat like a pig <sup>1</sup>	1
The embryonic life of chickens	1
Healthy animal production <sup>2</sup>	2
Pigs in the picture <sup>1</sup>	1
<b>Workshops and masterclasses (farmers, policy makers, and other stakeholders from livestock farming), networks</b>	
Workshop sow-piglet information transfer to facilitate weaning in piglets <sup>1</sup>	1
Workshop peaceful pigs <sup>1</sup>	1
Masterclass tail biting <sup>1</sup>	1
Workshop preventive feather pecking in practice, BHE <sup>2</sup>	1
Summer school weaning pigs <sup>2</sup>	4
Farmers' study clubs on shortening the dry period in dairy cattle – effects on health <sup>1</sup>	5
Coordination and supervision of a farmers' network on shortening the dry period in cows <sup>1</sup>	6
<b>TOTAL 2009-2014</b>	<b>54</b>

<sup>1</sup> Organised or co-organised by ADP members.

<sup>2</sup> Contribution by ADP members.

#### 4.3 Demonstrable marks of recognition - Marks of recognition by societal groups

Our research has been reported not only in scientific and professional publications (Tables 3.1/ 4.1), but also in popular media, including (inter)national newspapers (e.g. Telegraaf, NRC, Le Monde), blogs and internet news sites (e.g. Science Magazine, Scientific American), professional magazines, an exhibition in the natural history museum of Neuchatel, Switzerland, and on radio (7 times from 2009-2014). Two episodes of Klokhuis (Educational TV programme) have been recorded recently.

Because of their expertise and reputation, ADP staff are regularly invited by societal groups to participate in committees and civil advisory bodies (see table 4.3)

*Table 4.3. Contributions to societal committees and advisory bodies.*

1. Expert opinion commission of the Ministry of Economic Affairs on group housing after insemination in pregnant sows
2. The Central Authority for Scientific Procedures in Animals (CCD)
3. The KNAW committee on the use of non-human primates in research (2013-2014)
4. Platform Sustainable Livestock Farming
5. Platform ABRES (Antibiotics Resistance)
6. Working Group Ethics of the EAAP (European Federation of Animal Science)
7. The Ethical Committee (chair) of the KNMvD (Royal Dutch Society of Veterinary Science)
8. The Programme Committee The Value of Animal Welfare (national research programme on animal welfare with strong societal embedding)

## 5. Viability

### 5.1 Benchmark

For our benchmark, we have chosen two peer groups: INRA Pegase in Rennes, France; and the Department of Animal Sciences of Aarhus University, Denmark. For INRA we selected 3 Pegase groups: Adaptation, Lactation, and Swine systems and researchers working on incubation and immunology. For Aarhus University, we also selected three groups: Behaviour and Stress Biology, Integrated Physiology and the Immunology and Microbiology. The selected groups have a strong international reputation in the fields ADP that is working in, and each group has a slightly higher number of researchers (each 12) than ADP (8) (see Appendix 2 for a list of names). Despite less researchers, ADP produces a similar number of publications (about 170) with similar numbers of citations per publication (about 9). The field weighed citation impact, however, is, higher for ADP (1.7) than for its peers (1.4), indicating a high citation impact of ADP staff in the fields they work in.

Table 5.1. Benchmark ADP with peer groups (Aarhus, INRA) by year and number of publications, citations per publication and field weighed citation impact.

Year	Number of Publications			Citations per Publication			Field Weighed Citation Impact		
	ADP	Aarhus	INRA	ADP	Aarhus	INRA	ADP	Aarhus	INRA
2008	21	37	18	15.3	13.6	22.7	1.3	1.4	1.2
2009	27	25	31	13.4	12.8	13.8	1.2	1.2	1.3
2010	35	28	39	9.8	9.1	8.1	1.1	1.3	1.1
2011	28	28	22	10.7	7.5	9.6	2.1	1.3	1.5
2012	27	31	33	4.5	5.6	5.1	1.6	1.5	1.4
2013	34	28	25	4.4	2.9	3	2.7	1.6	2.0
<b>Total</b>	<b>172</b>	<b>177</b>	<b>168</b>	<b>9.3</b>	<b>8.7</b>	<b>9.6</b>	<b>1.7</b>	<b>1.4</b>	<b>1.4</b>

## 5.2 SWOT-analysis

Strengths	<ul style="list-style-type: none"> <li>• Strong focus of multidisciplinary on adaptation, able to tackle multifactorial problems</li> <li>• Good funding in a balanced portfolio</li> <li>• Strong (inter)national reputation as a trustworthy and solid collaborative partner</li> <li>• Strong in animal experimental work, with good facilities</li> <li>• High-quality staff (scientific, technical and administrative support), which is well balanced by gender, age, and stage of career</li> <li>• Open, friendly atmosphere</li> </ul>
Weaknesses	<ul style="list-style-type: none"> <li>• Difficult to benchmark against other groups</li> </ul>
Opportunities	<ul style="list-style-type: none"> <li>• Strong and increasing interest by livestock industry and society in adaptation as a concept to increase animal health, welfare, and robustness</li> <li>• Increased attention for animal health (e.g. reduction of antibiotics)</li> <li>• Increased NGO activity towards animal welfare</li> <li>• Increased collaborations in the field of animal behaviour with the new chair in Behavioural Ecology</li> </ul>
Threats	<ul style="list-style-type: none"> <li>• Industry less organized in animal husbandry than in breeding and nutrition</li> <li>• Reduced involvement of ministry in research agenda</li> <li>• Expense of animal experimental work as core business</li> </ul>

### Strengths and weaknesses

ADP is a viable and vital group that shows a substantial increase in research capacity and output in the past years. Almost all recommendations made by the previous review committee have been implemented. We established a good mix of quality and impact of our research. Impact is established through active dissemination of research, contributions to innovative housing and management solutions, and active involvement in societal committees and advisory boards. Our strong (inter)national reputation as a trustworthy, collaborative partner and our excellent experimental work in first-class facilities make ADP a valuable partner to work with. Our many collaborations have resulted in a large number of shared scientific papers and visiting fellows who appreciate our open and friendly research environment. We have a balanced distribution in levels of staff (currently: 1.5 fte full professor, 2 fte associate professor, 3 fte assistant professor (one in tenure track) and 5 fte researchers or post docs) and balance in their gender and age. We also have a balanced portfolio in research funding, allowing us to work on a mix of fundamental and applied research. Our research approach is recognized and appreciated nationally and internationally, both for its science and its impact. Although our combination of staff members, with varied scientific disciplines working to facilitate adaptation, is hard to benchmark against other international groups, we are appreciated and recognized for our approach in the various disciplinary fields.

### *Opportunities and threats*

Welfare, health, and robustness of farm animals are high on the agenda of the (inter)national government, NGOs and industry. These parties are interested in sustainable and socially acceptable new strategies or systems that support welfare and health of animals. They are especially interested in approaches that allow for a substantial reduction in the use of antibiotics, most of which are applied during the critical transition periods that we study.

Together with other members of CAWA, we tackle threats such as the less-organised industry in animal husbandry and the reduced involvement of the ministry in the research agenda by developing large public/ private partnerships that also support the development of new NWO programs. We have also been successful in public/private partnerships and NWO programs developed by the feeding and breeding industry because the industry research priorities fit well with the themes in which ADP has a strong reputation.

Although animal experimental work is expensive, we are recognized for our excellent research through a mix of financing. Based on the relevance of our group's research for societal concerns, our academic reputation, balanced mix of funding sources and sustained growth, we regard the viability of ADP as high.

### **5.3 Future strategy**

We want to continue to be recognized as key innovators, using our approach of facilitating adaptation of farm animals. During this review period, our group developed a stronger international profile. We want to further expand our international orientation by attracting more international PhD students and postdocs. We are actively involved in the development of new EU projects and will continue to do so.

In the coming years, we want to strengthen further the cross-fertilization between disciplines, themes, and animal species under study in our group. The behavioural expertise, which was built up in pigs, will be applied to other species in collaboration with BHE. We have a strong track record in perinatal immune and metabolic development in chickens, and our expertise in this area will be used in new projects on viability and health of piglets. Our expertise on the impact of early-life experiences in pigs and poultry, similarly, can be extended to calves, in collaboration with Livestock Research. We want to extend work on transgenerational effects of feeding, behaviour, and immune responsiveness, given the opportunities to optimize livestock management. In our work on perinatal effects, we are exploring opportunities to use pigs and chickens as models for humans.

To safeguard the development of the theoretical framework underlying our research, we will expand further expand our cooperation with other WIAS groups, such as HMI, HAP, CBI, and EZO. This year we will start joint PhD projects with HMI, HAP, and CBI. Furthermore, we will invest in development of postdoc projects on fundamental concepts of adaptation. Wageningen University has announced two new key development themes, Resilience and One Health, which fit well with our research and may result in cross-fertilization with other groups within the university on concepts on resilience and health. In 2015 we obtained 2 NWO/STW projects and will remain active in acquisition of new projects.

Success in the future depends on an environment that creates space for individuals to advance their career in science and pursue excellence. Career development opportunities are also important for long-term succession planning. For the coming years we envision the establishment of personal chairs and a number of post docs that will be tenured staff positions. Part of our financial revenues is invested in young talents. In 2015, for example, we will invest in 3 more postdocs. Their development is supported by staff and by dedicated university programs such WIAS grants for project writing and University 'Veni grant writing' courses. A healthy, and still increasing, number of PhD and MSc students allows for a significant research capacity.

Our future strategy builds upon the past 6 years. We believe that with our future strategy we will develop further into a balanced, collegial, high quality, and creative group that is resilient against external threats and capable of seizing new opportunities.

## **6. Research Integrity**

In our research, we follow the Netherlands Code of Conduct for Scientific Practice and the relevant legislation at the national and European level, especially with respect to experiments on animals. Experiments need to be approved by the Animal Care and Use Committee and in the future the Central Authority for Scientific Procedures in Animals. Within our graduate school, ample attention is given to scientific integrity, ethics, and self-reflection of actions. ADP staff members contribute to the WIAS Course Ethics and Philosophy in Life Sciences. We hope that the open, friendly atmosphere and the approachable staff in our chair group allows PhD candidates, post docs and others to discuss freely issues of integrity and ethics and to seek immediately support or advice in case of (potential) problems. If problems cannot be resolved within our group, WIAS provides a confidant person and Wageningen University provides a scientific integrity officer, with whom issues can be reported or discussed confidentially: our chair leader has had this post for other groups in the past. We stimulate publication of the outcome of well-designed experiments, no matter what the results are. There are now a growing number of journals that support publication of 'negative results' to avoid publication bias. All contracts with industry contain a paragraph stating that all research should be published in international journals, with a maximum of 6-months delay. A data management and data storage program was developed at ADP, recently, so that original data of each experiment can be traced.

**Appendix 1 - Research staff Adaptation Physiology group**

Table I - Research staff input at Chair Group level

<b>Name staff</b>		<b>Funding 1, 2, 3*</b>	<b>2009 FTE**</b>	<b>2010 FTE</b>	<b>2011 FTE</b>	<b>2012 FTE</b>	<b>2013 FTE</b>	<b>2014 FTE</b>
<i>Full professors</i>								
Prof dr ir B. Kemp (1 fte)	Tenured	1	0.3	0.3	0.3	0.3	0.3	0.3
Prof dr E.N. Stassen (0.5 fte)	Tenured	1			0.1	0.1	0.1	0.1
<i>Special chairs</i>								
Prof.dr. E. Decuypere (0 fte)	1-9-2004/1-6-2012	1		0.05	0.05	0.03		
Prof.dr. B. Gremmen (0.3 fte)	Tenured/15-7-2016	1			0.05	0.1	0.1	0.1
<i>Associate professors</i>								
Dr ir H. van den Brand (1 fte)	Tenured	1	0.4	0.4	0.4	0.4	0.4	0.4
Dr ir N.M. Soede (1 fte)	Tenured	1	0.32	0.36	0.36	0.4	0.4	0.4
Dr.ir. J.E. Bolhuis (1 fte)	1-1-2014 Tenured	1						0.4
<i>Assistant professors</i>								
Drs J.A.M. van der Borg (0.5 fte)	Tenured	1	0.1	0.1	0.1	0		
Dr Ing W. Hazeleger (1 fte)	Tenured	1	0.3	0.3	0.3	0.3	0.3	0.1
Dr ir H.K. Parmentier (1 fte)	Tenured	1	0.4	0.4	0.4	0.4	0.4	0.4
<i>Researchers</i>								
Dr.ir. J.E. Bolhuis (1 fte)	1-1-2007 / 31-12-2013	2,1	0.9	0.9	0.85	0.8	0.8	
Dr A. Lammers (1 fte)	Tenured	1,3	0.8	0.8	0.8	0.8	0.8	0.8
Dr.Ir. A.T.M. van Knegsel (1 fte)	1-4-2010 Tenured	2		0.6	0.9	0.9	0.9	0.9
<i>Post-docs</i>								
Dr.ir. B. Beerda (0.5 fte)	1-1-2006 / 1-1-2014	1	0.1	0.1	0.1	0.2	0.1	
Dr.ir. M.R.N. Bruijnis (0.8 fte)	1-1-2012 / 1-6-2015	2				0.7	0.7	0.7
Dr.Ir. A.T.M. van Knegsel (1 fte)	6-5-2007 / 1-4-2010	3	0.9	0.3				
Dr ir E.H. van der Waaij (1 fte)	1-9-2008/1-9-2010	1	0.5	0.17				
Dr. I. Reimert (1 fte)	1-4-2014/1-1-2016	1						0.675
Dr. W.W. Ursinus (0.8 fte)	1-7-2014/1-8-2015	1						0.35
Dr.ir. B. Beerda (0.5 fte)	1-1-2006 / 1-1-2014	1	0.1	0.1	0.1	0.2	0.1	
Dr.ir. M.R.N. Bruijnis (0.8 fte)	1-1-2012 / 1-6-2015	2				0.7	0.7	0.7
Dr.Ir. A.T.M. van Knegsel (1 fte)	6-5-2007 / 1-4-2010	3	0.9	0.3				
Dr ir E.H. van der Waaij (1 fte)	1-9-2008/1-9-2010	1	0.5	0.17				
Dr K M Schachtschneider (1 fte)	01-08-2013/01-08-2016	3						0.3
<i>Visiting fellows</i>								
Melotti, Luca	2009	UK	0.17					
Jensen, Trine	2010	Denmark		0.25				
Taylor, Bob	2010	USA		0.17				
Cermakova, Jana	2011	Tsjech			0.25			
Daigle, Courtney	2011	USA			0.25			
Willemsen, Hielke	2011	Belgium			0.25			
Janczak, Andrew	2012	Norway				0.25		
Morita, Viviane de Souza	2013-2014	Brasil					0.25	0.25
Clouard, Caroline	2014	France						1.00
Dong-Huyn Lim	2014	South Korea						0.08
Grazia, Maria	2014	Italy						0.08
Michalsky Barbosa, Vanessa	2014	Brasil						0.50
Ocak, Sezen	2014	Turkey						0.08
Ogun, Sinam	2014	Turkey						0.08
<b>Total scientific staff</b>			<b>5.19</b>	<b>5.20</b>	<b>5.46</b>	<b>5.68</b>	<b>5.55</b>	<b>7.71</b>
<i>Support staff</i>								
I. van den Anker (0.9 fte)	15-9-2006/		1	0.8	0.8	0.8	0.8	0.8
J.A.J. Arts (0.8 fte)	1-7-2012/1-7-2015		1	0.68	0.68	0.68	0.68	0.68

<i>Support staff continued</i>			<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
M.J.W. Heetkamp (1 fte)	15-10-1987/	1	0.85	0.85	0.85	0.85	0.85	0.85
R.E. Koopmanschap (1 fte)	1-6-2005/	1	0.8	0.8	0.8	0.8	0.8	0.8
B.F.A. Laurensen (1 fte)	6-9-2004/	1	0.75	0.75	0.75	0.75	0.75	0.75
M.G.B. Nieuwland (1 fte)	1-3-1973/	1	0.7	0.7	0.7	0.7	0.7	0.7
M. Ooms (1 fte)	1-8-2007/	1	0.35	0.35	0.7	0.7	0.7	0.7
G. de Vries Reilingh (0.842 fte)	1-5-1984/	1	0.67	0.67	0.67	0.67	0.67	0.67
H.J. Wijnen (1 fte)	1-8-2014/1-9-2015	1						0.33
I. van den Anker (0.9 fte)	15-9-2006/	1	0.8	0.8	0.8	0.8	0.8	0.8
J.A.J. Arts (0.8 fte)	1-7-2012/1-7-2015	1	0.68	0.68	0.68	0.68	0.68	0.68
<b>Total staff</b>			<b>11.5</b>	<b>11.5</b>	<b>12.1</b>	<b>12.3</b>	<b>12.2</b>	<b>14.7</b>

\* Funding scores: 1= direct funding by University; 2= funding obtained in national scientific competition (e.g. grants from NWO, KNAW) ; and 3= funding obtained from external organisations, such as industry, governmental ministries, European Commission and charity organisations.

\*\* FTE reported in this table regards the research appointment part of the total appointment (e.g. tenured staff has 40% available for research, postdocs have 60% available for research).

**Appendix 2** - Scientist for benchmark Adaptation Physiology group*Table II. Scientist selected at the University of Århus (Aarh), the French National Institute for Agricultural Research (INRAf), and Scotland's Rural College (SRUC) for benchmarking ADP.*

<b>ADP</b>	<b>Aarh</b>	<b>INRAf</b>	<b>SRUC</b>
Kemp, B.	Hansen, S.W.	Beaumont, C.M.	Baxter, E.M.
Bolhuis, J.E.	Herskin, M.S.	Boutinaud, M.	Camerlink, I.
Van Den Brand, H.D.	Jensen, M.B.	Collin, A.	D'Eath, R.B.
Soede, N.M.	Pedersen, L.J.	Flamant, J.C.	Dixon, L.M.
Parmentier, H.K.	Juul-Madsen, J.E.	Le Floc'h, N.	Dwyer, C.M.
Lammers, A.	Jørgensen, J.E.	Merlot, E.	Haskell, M.J.
Van Knegsel, A.T.M.	Larsen, T.K.	Meunier-Salaün, M.C.	Langford, F.M.
	Malmkvist, J.	Montagne, L.	Lee, M.
	Munksgaard, L.	Pastorelli, H.	MacKay, J.R.D.
	Poulsen, A.S.R.	Prunier, A.	Rutherford, K.M.D.
	Riber, A.B.	Quesnel, H.	Sandilands, V.
	Thodberg, K.	Tallet, C.	Sparks, N.H.C.
			Turner, S.P.
			Wemelsfelder, F.
			Zanella, A.J.



## Animal Breeding and Genetics (ABG)

**Programme leader(s):** Johan van Arendonk (2002-now)

*For a full staff survey see appendix 1.*

### 1. Objectives and Research Area

#### 1.1 Vision, Mission and Objectives

**Vision:** Innovations in animal breeding contribute to a more sustainable livestock and fish sector, which supplies the human population with safe and healthy food of animal origin, reduces the impact on the environment, makes better use of resources, and meets the needs of society.

**Mission:** The mission of Animal Breeding and Genetics group (ABG) is “To perform excellent animal breeding and genomic research and education to create knowledge which contributes to sustainable livestock and fish production in an international context”.

**Objectives:** To better realize and predict genetic change in populations, we generate knowledge on:

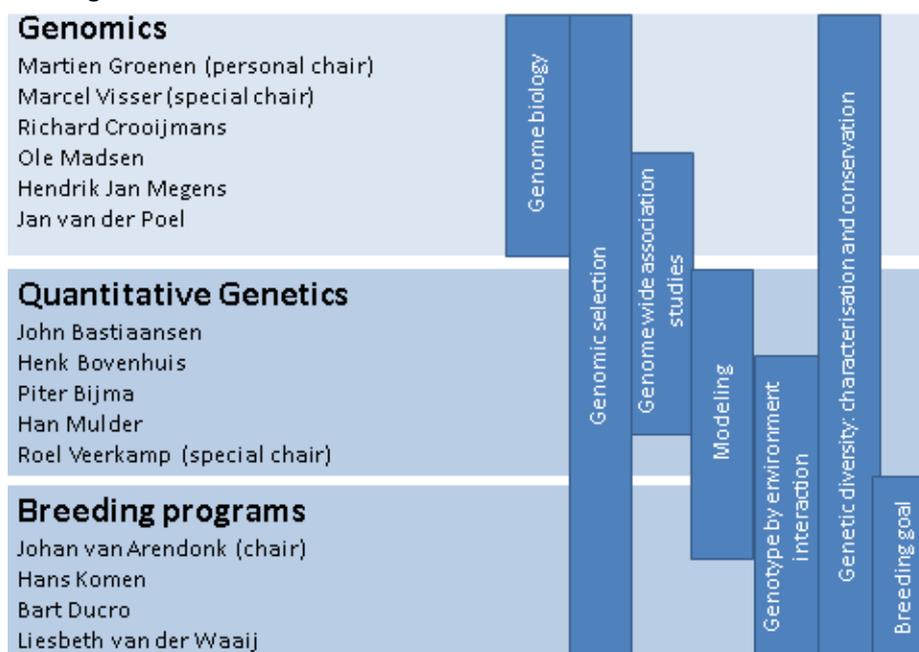
- origin and role of genetic variation in animals;
- genetic relationships between welfare, productivity, and resource efficiency;
- methods to analyse genetic variation at molecular and population levels;
- programs to exploit and safeguard naturally occurring genetic variation in breeding programmes.

To generate this knowledge, we integrate expertise in quantitative genetics, genomics, and breeding programmes. The main focus of our research is on farmed animals (cattle, pigs, poultry, and fish) that are subject to artificial selection. The group also studies non-farmed animals not only to further strengthen position of ABG in the broader domain of genetics, but also to contribute to our research on farmed animals.

#### 1.2 Research Area / research line(s)

To realise our mission, the group combines expertise in three closely related disciplinary domains: genomics, quantitative genetics, and breeding programmes. These domains are integrated in our research as illustrated in the figure below.

Our research is focused on improving the prediction and creation of genetic change in populations. We perform research at the level of DNA, animals, and populations to gain knowledge on the origin and impact of genetic variation in complex traits, including the long-term impact of selection strategies to create genetic change.



The combination of genomics, quantitative genetics, and design of breeding programmes continues to play an important role in the research strategy of ABG.

Most phenotypes are complex and quantitative in nature, and we focus our research on using genome information to predict such complex phenotypes. Many of our recent advances have been driven by genome sequence information. Combined with deep pedigrees and extensive phenotypic records, the latest molecular genomics and quantitative genetic tools provide an opportunity to understand better the relation between genotype and phenotype. We conduct research in this relation and increasingly explore opportunities for genomic prediction based on biological information (biology-driven genomic prediction). Genomic prediction is aimed not only at genetic change in performance of the population in the next generation (genomic selection), but also at the long-term consequence for performance and genetic diversity (breeding programs).

### 1.3 Strategy

Our research focusses on generating knowledge to improve prediction of genetic change in populations. Our efforts are focussed increasingly around biology-driven genomic prediction of performance of animal populations. At the level of DNA, we analyse and study changes that result from selection and domestication. The emphasis is increasingly on obtaining knowledge about all functional sequences in the genome (coding and non-coding) and the observed variation in these sequences. Information collected at the DNA level is linked to performance of animals to improve the reliability of genomic breeding values (genomic prediction) and to identify genomic regions and genes contributing to genetic variation (genome-wide association studies). At the population level, we perform research on the impact of social interactions (indirect genetic effects), genotype by environment interaction, and uniformity of groups of animals. In that research, we use DNA information and modelling which demonstrates the close linkages between the disciplinary domains in our group. Research on breeding programmes focuses on how to use increased knowledge on the genetic background of traits or on new technologies to improve the speed and direction of genetic change in a population with minimal loss of genetic diversity. The emphasis is shifting increasingly from understanding the genotype-phenotype relation to actively predicting the genotype-phenotype relation. More details on the future outlook are in 5.3.

Highlights of what has been realised include:

- Contributions to publication and analysis of the pig genome sequence.
- Characterization of molecular genetic factors in the pig under selection during speciation, domestication, and breeding.
- Unravelling of the genetic background of detailed composition of milk.
- Development and application of methods to quantify the role of indirect genetic effects in farm animals (pigs and poultry) and in ecology.
- Design and implementation of breeding programs for village producers of poultry and aquaculture.

### 1.4 Research environment and embedding

Key to meeting our objectives are (1) ABGC, (2) collaboration with industry, (3) collaboration with groups with complementary expertise, and (4) international collaboration.

- 1 The Animal Breeding and Genomics Centre ([ABGC](#)) was created in 2008 by combining activities in the domain of animal breeding and genomics of Wageningen University (ABG) and Wageningen UR Livestock Research (Department of Genomics). In 2014, all members of ABGC moved to one location at Wageningen Campus.
- 2 Collaboration with industry is crucial for our research activities not only to focus on the long-term needs of the animal breeding industry, but also to gain access to large populations with known phenotypes and genotypes. In 2012, we established the public-private partnership Breed4Food. Breed4Food is a consortium of four international animal-breeding companies and ABGC, with the ambition to be the world's leading centre for research and innovation in livestock genetics. We are a founding member of the Farm Animal Breeding and Reproduction Technology Platform (FABTE-TP). FABRE-TP is officially recognised by the European Commission and provides input for its research agenda.

- 3 ABG is an active member of the WIAS graduate school. We collaborate with groups that have complementary expertise on the biology of a trait (e.g. behaviour, methane emission, disease resistance, milk quality), of a species (e.g. fish) or of the production system (APS). With the other 2 groups in our cluster (HMI and QVE) we have developed a joint research strategy. This strategy has enabled a fruitful collaboration between Mart de Jong (QVE) and Piter Bijma (ABG) involving 2 PhD candidates and applications for joint research projects by ABG and HMI.
- 4 The international position of ABG is strengthened by the formation of the European Graduate School on Animal Breeding and Genetics (EGS-ABG) in 2010. EGS-ABG is a joint doctoral programme of four universities: AgroParisTech, Aarhus University, Swedish University of Agricultural Sciences, and WU, funded by the Erasmus Mundus programme of the EU in 2011. ABG is involved in 17 of the 30 PhD projects started between 2011 and 2014 in EGSABG. Further, ABG is an active partner in the chicken, pig, and turkey genome sequencing consortium, and in the consortium on Functional Annotation of Animal Genomes (FAANG).

Table 1.4. The impact of collaboration on PhD supervision (n=46), authorship of papers in peer reviewed journals (n=426) and an overview of the first job of PhD graduates (n=46).

	Supervision PhD graduates (%)	Authors scientific papers (%)	First job PhD graduates (%)
ABG only	35	10	9
ABGC not ABG	22	14	4
WIAS not ABGC	11	16	0
Other groups of Wageningen UR	7	12	2
Other academic groups Netherlands	7	10	9
International	30	45	37
Industry (national and international)	7	18	37

### 1.5 Reference to previous assessments

Give a brief reflection on the recommendations of the previous external assessment(s).

- The review group was slightly concerned that mission not explicitly include “understanding and knowledge generation. The mission statement has been modified to express that understanding and generating knowledge plays an important role in our activities. Our activities are not restricted to farm-animal breeding, as illustrated by the close collaboration with Netherlands Institute of Ecology (NIOO-KNAW), which started with genomics of song birds and resulted in the appointment of Marcel Visser as special chair on ecological genetics in 2012.
- There has been a rapid increase in numbers of PhD students and the group is aware that it will be challenging to maintain this level in a rigorous funding environment. Some staff seem to have a heavy load of PhD supervision consequential on the requirement for PhD students to be promoted by a full professor.

We recognized the need to increase the number of full professors (i.e. with ius promovendi). Two special chairs, Roel Veerkamp (2011) and Marcel Visser (2012), have been appointed in this review period. In addition, three staff members have entered the tenure-track system, which is expected to increase the number of personal professors from 1 to 3 in 2015.

- The group’s past record demonstrates their ability to respond to the changing technological and societal environment with uptake of new technologies and refocus of projects in new directions. However, many new opportunities arise in the rapidly developing field of genomics .. In this light the Review Committee felt that ABG should consider carefully the relevance of epigenetic mechanisms to their programme.

The direction of our research programme is regularly evaluated in light of changes in the research environment and available technologies. To remain at the forefront of using sequencing technologies, we invested mainly in this area. In addition, Ole Madsen worked on epigenetics (methylation), Martien Groenen became one of the coordinators of The International Swine Methylome Consortium (ISMC), and in 2013 a post-doc started research in this area.

- *It is recommended that ABG make a careful assessment of future research directions as well as working hard to maintain their current level of external funding.*

We aim to maintain a research programme in areas that are at the forefront of our domain. In the current review period, we managed to increase the external funding, which helped to realise that ambition, in three ways: we increased the collaboration within Wageningen UR through the establishment of ABGC, we intensified collaboration with industry by the establishing Breed4Food, and we participated in an EU-funded consortium on graduate research and training (EGSABG). ABGC, Breed4Food, and EGSABG help us to maintain a strong international position in research and training.

## 2. Resources and Facilities

**Funding trends:** The number (#) and research capacity (fte) of tenured staff, non-tenured staff, and PhD candidates in the review period are in Table 2.1. Compared with the previous peer review (2003-2008) research capacity doubled from 15.6 fte to 35.0 fte (Table 2.2), while direct funding by the university remained almost unchanged (+15%). Research funding (+72%) and in particular contract funding (+215%) increased. Contract funding includes the ERC grant awarded in 2010, and the EU-funded European Graduate School (EGSABG) and Research Training Network awarded in 2011. For details on our funding strategy, see section 5.3.

**Personnel:** University funding is used increasingly to fund tenured scientific staff: university funding of staff increased while university funding of PhD candidates decreased. The supervision of PhD candidates is well spread over the scientific staff. Due to the increased collaboration within ABGC more scientists are involved in the supervision for PhD candidates. The number of full professors with ius promovendi increased from 2 to 4 and a further increase is expected. For the coming years, we aim to maintain the composition of the research staff and the current level of funding.

**Research facilities:** Developments in the field of genomics, such as Next Generation Sequencing, result in an increase of generated data. Processing these data requires a large computing and storage capacity. We initiated an investment in a High Performance Computing (HPC) cluster at Wageningen Campus. This state-of-the-art computing facility for research and application was realised in 2013.

### 2.1 Researchers

Table 2.1. Research input: number<sup>1</sup> and FTE<sup>2</sup> of Scientific staff, Post-docs and PhD candidates by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	#	FTE												
Scientific staff <sup>4</sup>	9	3.1	9	3.0	12	3.4	13	3.9	13	3.9	13	4.1	11	3.6
Post-docs <sup>5</sup>	10	5.9	13	5.6	10	4.5	10	4.3	10	4.1	10	4.7	11	4.8
PhD candidates <sup>3,6</sup>	36	17.9	45	22.9	54	26.3	53	28.4	61	32.2	54	31.7	51	26.6
<b>Total res. staff</b>	<b>55</b>	<b>26.9</b>	<b>67</b>	<b>31.5</b>	<b>76</b>	<b>34.2</b>	<b>76</b>	<b>36.6</b>	<b>84</b>	<b>40.1</b>	<b>77</b>	<b>40.4</b>	<b>72</b>	<b>35.0</b>
Lab Technicians	7	2.9	5	2.9	6	2.9	4	2.3	4	2.1	4	2.1	5	2.5
Visiting fellows	3	0.8	3	1.3	12	2.6	19	4.2	11	4.8	9	2.1	5	1.5
<b>Total staff</b>	<b>65</b>	<b>30.6</b>	<b>75</b>	<b>35.7</b>	<b>94</b>	<b>39.7</b>	<b>99</b>	<b>43.1</b>	<b>99</b>	<b>47.0</b>	<b>90</b>	<b>44.6</b>	<b>82</b>	<b>39.0</b>

<sup>1</sup> Total number of staff and PhD candidates

<sup>2</sup> Available research time in full time equivalent (FTE)

<sup>3</sup> All PhD categories, except external PhDs

Standards for Research Capacity (in case of part time appointment adjustment is applied):

<sup>4</sup> Professor, Assistant Professor and Associated Professor: Research Capacity = 40% of the appointment

<sup>5</sup> Post-doc: Research Capacity = 90% of the appointment

<sup>6</sup> PhD candidate: Research Capacity = 75% of the appointment (all categories)

## 2.2 Research Funds

Table 2.2. Funding of Scientific staff, Postdocs and PhD candidates by year and Expenditure of Chair group by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
<i>Funding:</i>	FTE	%												
Direct funding <sup>1</sup>	5.7	21	6.8	22	6.6	19	5.8	16	5.9	15	5.1	13	5.9	17
Research grants <sup>2</sup>	9.1	34	9.6	30	8.1	24	6.9	19	5.8	15	5.3	13	7.6	23
Contract research <sup>3</sup>	12.1	45	15.1	48	19.6	57	23.7	65	28.4	71	30.0	74	21.5	60
<b>Total funding</b>	<b>26.9</b>	<b>100</b>	<b>31.5</b>	<b>100</b>	<b>34.3</b>	<b>100</b>	<b>36.5</b>	<b>100</b>	<b>40.1</b>	<b>100</b>	<b>40.4</b>	<b>100</b>	<b>35.0</b>	<b>100</b>
<i>Expenditure<sup>4</sup>:</i>	K€	%												
Personnel costs	2,713	51	2,743	51	2,866	54	2,803	50	2,757	54	2,981	59	2,810	53
Other costs	2,593	49	2,687	49	2,432	46	2,817	50	2,340	46	2,044	41	2,485	47
<b>Total expenditure</b>	<b>5,306</b>	<b>100</b>	<b>5,430</b>	<b>100</b>	<b>5,298</b>	<b>100</b>	<b>5,620</b>	<b>100</b>	<b>5,097</b>	<b>100</b>	<b>5,024</b>	<b>100</b>	<b>5,296</b>	<b>100</b>

<sup>1</sup> Direct funding by the University

<sup>2</sup> Research grants obtained in national and international scientific competition (e.g. grants from NWO, KNAW)

<sup>3</sup> Research contracts for specific research projects obtained from external organisations, such as industry, governmental ministries, European Commission (including ERC), charity organisations

<sup>4</sup> Expenditure from financial system of Wageningen University which not only includes research but also teaching and other activities

## 3. Research Quality

High quality of our research is key to our success. For our success, we aim to achieve excellence for three performance indicators:

- *Quality of scientific staff as measured by the number of personal grants, participation in tenure track and involvement in scientific networks.*

We aim for one personal grant every two years. In the review period, Martien Groenen and Marcel Visser were awarded an advanced ERC grant, and Piter Bijma was awarded a VIDI grant. For 2015, three applications are under review. Three staff members have entered into tenure track (Henk Bovenhuis, Hans Komen and Han Mulder) in the review period and two (Henk Bovenhuis and Hans Komen) will submit their application to become personal professor in 2015. Our scientists are frequently invited to present international lectures and to be involved in international scientific activities.

- *Publications in high ranking journals in our domain.*

One of our aims is to increase the number of publications of high quality. We, therefore, focus our research activities and invest in high-quality staff and PhD candidates. The weighted average impact factor (IF) of journals in which we published our peer reviewed papers increased from 2.8 (using most recent IF) in previous review period to 3.2 in current review period.

- *Impact of our research as measured in citation analysis and employability of our PhD graduates and postdocs.*

With the increase in number of peer-reviewed publications and in average impact factor of journals, we succeeded to maintain the relative impact of our papers, as reflected by bibliometric analysis (Table 3.2.1.). Our PhD graduates are in high demand and most find employment in R&D at universities, research institutes, and industry (more details in section on relevance to society).

### Five key publications

- Blonk, R.J.W.; Komen, J.; Kamstra, A.; Arendonk, J.A.M. van (2010). Estimating Breeding Values With Molecular Relatedness and Reconstructed Pedigrees in Natural Mating Populations of Common Sole, *Solea solea*. *Genetics* 184: 213 - 219.
- Bosse, M.; Megens, H.J.; Frantz, L.A.F.; Madsen, O.; Paudel, Y.; Duijvestein, N.; Crooijmans, R.P.M.A.; Groenen, M. (2014) Genomic analysis reveals selection for Asian genes in European pigs following human-mediated introgression. *Nature Communications* 5: 8.
- Bijma, P. (2010). Fisher's fundamental theorem of inclusive fitness and the change in fitness due to natural selection when conspecifics interact. *Journal of Evolutionary Biology* 23: 194 – 206.
- Groenen, M.A.M. et al. (2012) Analyses of pig genomes provide insight to porcine demography and evolution. *Nature* 491: 393 - 398.
- Mulder, H.A.; Calus, M.P.L.; Druet, T.; Schrooten, C. (2012) Imputation of genotypes with low-density chips and its effect on reliability of direct genomic values in Dutch Holstein cattle. *J. Dairy Sci.* 95: 876.

### 3.1 Demonstrable products - Research products for peers in science

Table 3.1. Categories of research output by year.

Category:	Year						Total	Average 2009-2014
	2009	2010	2011	2012	2013	2014		
<b>Academic publications</b>								
a. Refereed articles	71	61	60	72	84	78	426	71
b. Non-refereed articles	1	2	0	1	0	1	5	1
c. Books	0	0	0	0	0	0	0	0
d.1. Refereed book chapters	1	1	1	1	0	0	4	1
d.2. Non-refereed book chapters	3	0	0	0	0	0	3	1
e. PhD Theses	7	9	7	9	8	8	48	8
f. Conference papers	7	30	7	21	15	35	115	19
<b>Total academic publications</b>	<b>90</b>	<b>103</b>	<b>75</b>	<b>104</b>	<b>107</b>	<b>122</b>	<b>601</b>	<b>100</b>

### 3.2 Demonstrable use of products - Use of research products by peers

(The text in italics below is taken directly from report on WIAS bibliometric-analysis, par 4.2)

*“ABG produces on average 62 peer reviewed articles per year in journals covered by Web of Science (Table 3.2.1). The number of peer reviewed articles in 2012 and 2013 is higher than in the preceding years. The mean relative impact in the period 2008-2013 is with 1.83 above world average with a peak of 2.84 in 2012. This is also reflected in the share of papers that reached 1% most cited papers threshold in that year. Over the whole period under study 20% of the publications belong to the top 10% most cited publications in their field and 2% belong to the top 1% most cited publications in their field.”*

Table 3.2.1. Bibliometric indicators for ABG over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	48	1231	669	25.7	2.02	25% (12)	4% (2)
2009	64	1301	807	20.3	1.57	19% (12)	2% (1)
2010	57	902	689	15.8	1.30	14% (8)	2% (1)
2011	54	599	485	11.1	1.34	15% (8)	0% (0)
2012	69	746	311	10.8	2.84	26% (18)	6% (4)
2013	79	300	161	3.8	1.76	22% (17)	1% (1)
<b>all years</b>	<b>371</b>	<b>5079</b>	<b>3122</b>	<b>13.7</b>	<b>1.83</b>	<b>20% (75)</b>	<b>2% (9)</b>

Table 3.2.2 . Bibliometric indicators for ABG per research field over the period 2008-2013. The rows are ordered in descending number of publications (N). The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

research field	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	175	1748	1053	10.0	1.85	14% (25)	1% (2)
Agricultural Sciences	84	988	471	11.8	1.99	26% (22)	6% (5)
Molecular Biology & Genetics	73	1576	1233	21.6	1.34	18% (13)	0% (0)
Environment/Ecology	12	283	74	23.6	3.65	67% (8)	8% (1)
Neuroscience & Behavior	7	82	58	11.7	1.66	14% (1)	0% (0)
Biology & Biochemistry	6	211	70	35.2	2.79	33% (2)	17% (1)
Immunology	5	65	90	13.0	0.58	0% (0)	0% (0)
Social Sciences, General	4	29	24	7.3	0.92	25% (1)	0% (0)
Clinical Medicine	2	40	19	20.0	2.31	50% (1)	0% (0)
Microbiology	2	31	20	15.5	2.09	50% (1)	0% (0)
Psychiatry/Psychology	1	26	10	26.0	2.58	100% (1)	0% (0)
Plant & Animal Science	175	1748	1053	10.0	1.85	14% (25)	1% (2)
<b>all years</b>	<b>371</b>	<b>5079</b>	<b>3122</b>	<b>13.69</b>	<b>1.83</b>	<b>20% (75)</b>	<b>2% (9)</b>

#### Reflection on bibliometric analysis:

Compared with the previous bibliometric analysis (2002-2007), we:

- Increased the number of publications from 245 to 371, while maintaining the above-world-average relative impact (about 1.8) and the %T10 (about 20%).
- Published in a broader range of disciplines, as reflected by the reduction of the proportion of papers published in the field of “Plant&Animal Science” (from 65 to 47%).
- The weighted average impact factor of journals (using the most recent impact factors) increased from 2.8 to 3.2.
- Increased the percentage of publications in “Molecular Biology & Genetics” (from 13 to 20%)
- Increased the relative impact of publications in “Molecular Biology & Genetics” (from 0.91 to 1.34)

### 3.3 Demonstrable marks of recognition - Marks of recognition from peers

Table 3.3. Most important prizes, keynotes etc. of staff (max 6 per category). For remaining achievements see mini CVs (Separate file called mini CVs).

Science awards, Scholarly prizes, Research grants by year and person		
Year	Person	Award, Prize or Grant
2009	P. Bijma	NWO VIDI grant “Social genetic effects”
2010	M.A.M. Groenen	ERC Advanced grant “SelSweep”
2011	J.A.M. van Arendonk	“Doctor Honoris Causa” degree at University of Life Sciences, Poznan (Poland)
2013-	R.F. Veerkamp	Professor Resource Efficiency, Norwegian University of Life Sciences (Norway)
2013-	R.F. Veerkamp	Visiting professor Numerical Genetics, SRUC, Edinburgh (Scotland)
2014	M.E. Visser	ERC Advanced grant “Evolutionary responses”
Plenary/Keynote* Lectures at major conferences by year and person		
2009	M.A.M. Groenen	Gordon Conf. on Quant. Genet. And Genomics, Galveston (USA)
2011	J.A.M. van Arendonk	19 <sup>th</sup> Conference of AAABG”, Perth (Australia)
2012	M.A.M. Groenen	The 7 <sup>th</sup> Int’l Conf. on Genomics & Bio-IT APAC (Hong Kong)
2014	M.A.M. Groenen	34 <sup>th</sup> ISAG conference, Xi’an (China)
2014	J.W.M. Bastiaansen	Invited speaker WCGALP (Canada)
2015	P. Bijma	Gordon Conf. on Quant. Genet. and Genomics (Italy)

**Organisation of International Scientific Conferences by year and person**

Year	Person	Conference
2009	M.A.M. Groenen	Pig Genome III, Hinxtton (UK)
2012	J.A.M. van Arendonk	10th International Symposium: Milk Genomics & Human Health, Wageningen (NL)
2014	M.A.M. Groenen	Ag-Encode workshop, San Diego, USA (preceding PAG)
2014	R.F. Veerkamp	Member of permanent committee of WCGALP

**Editorships and editorial boards by person**

B. Ducro	Section editor Livestock Science, Genetics (2013-)
J. Komen	Member editorial board Aquaculture (2002-2010)
J.A.M. van Arendonk	Associate editor Frontiers in Sciences, Livestock Genomics (2010-)
J.W.M. Bastiaansen	Associate editor Animal Genetics (2012-2014)
M.A.M. Groenen	Section editor BMC Genomics (2013-)
M.E. Visser	Editorial Board of Philosophical Transactions Royal Society B (2013-)

**Memberships of academies and committees by person**

J.A.M. van Arendonk	Dean of Sciences of Wageningen UR (0.4 fte, 2010-2015)
R.P.M.A. Crooijmans	Chair of the Avian Genetics and Genomics committee of the International Society of Animal Genetics (2002-)
H.A. Mulder	Vice-president of Genetics commission of EAAP (2014-)
J. Komen	Member of scientific advisory group for organisation of zoos and aquaria in the Netherlands (2014-)

**4. Relevance to Society**

Society expects animal production to respect animals and animal populations, while adequately supplying it with safe and healthy food. For animal breeding, this expectation means that selection is required without negative side effects on the animals or on the genetic diversity of populations. At the same time, breeding organisations need scientific underpinning of their breeding programs, timely implementation of new insights, and well-qualified people. Because ABG and the breeding industry recognize society's expectations, we jointly strive to fulfil these needs by balancing selection goals, genetic diversity, and applications of biotechnology. ABG generates knowledge on these issues and engages in a dialogue with society. We contribute to discussions on societal acceptability of applications and implications of animal breeding.

**4.1 Demonstrable products - Research products for societal target groups**

*Breeding industry:* Dutch breeding organisations are among the world leaders in breeding of farm animals and horses. Four of these breeding organisations are involved in Breed4Food which improved the interaction by discussing not only research findings but also research needs. We have contributed to their innovations (Table 4.2), and trained a large number of their employees. We organize jointly the biennial round-table "F&G connection", in which researchers in science and industry exchange ideas and recent findings. We participate in advisory boards and contribute to international events.

*Developing countries:* For the development and dissemination of our expertise on use of genetic resources in the tropics, we have several joint PhD projects mostly with ILRI and WorldFish. Our pioneering work in poultry genetic improvement in Ethiopia has resulted in a project funded by the Bill & Melinda Gates foundation, in which we are responsible for developing the poultry breeding "road map". In 2015, we will strengthen our collaborations with ILRI and Worldfish by establishing a joint ABG/ADP special chair on "Livestock and Fish Breeding for Production Systems in Developing Countries".

*Society at large:* Members of ABG regularly contribute to meetings for a non-scientific audience, participate in interest groups (e.g. membership of the National Council for Animal Affairs and Platform Sustainable Animal Breeding), publish in popular magazines, and present findings in interviews (Table 4.1). Investigating societal aspects of animal breeding are included explicitly in some projects.

Two examples to underline our activities are:

- Breeding sociable swine (2010-2014): during this research programme several activities were organised to engage stakeholders (from farmers to citizens).
- Breeding and Reproductive Technologies”: In 2010, ABG played a leading role in the development by the Council of Animal Affairs of a framework to address moral issues regarding animal breeding.

*Table 4.1.1. Overview of output for societal target groups by year.*

	Year						2009-2014
	2009	2010	2011	2012	2013	2014	Average
Professional publications and output	11	5	7	14	5	17	10
Publications for the general public	2	2	1	1	0	2	1
Other research output	75	32	46	49	40	63	51

*Table 4.1.2. Relevant output for societal target groups by category and year (max 6 per category).*

#### **Animal breeding industry**

2009-2014: Contributed to the development of SNP chips for pigs, poultry and turkey for genomic selection by industry worldwide.

2009-2014: Development for software for genomic selection by Dutch breeding organisations.

2013: Definition of breeding goal for international trout breeding organisation.

2014: DNA test for detection of carriers for dwarfism gene in Friesian horses.

2014: Introduction of breeding value for claw health for French dairy cattle farmers.

2012: Implementation of genetic evaluation for social genetic effects in pigs.

#### **Professional publications and products**

2010 Report “Breeding and Reproductive Technologies” by council for animal affairs (J.A.M. van Arendonk)

2009 Contribution to “Evolution is in your genes”: Bio-cahier of foundation Bio Sciences and society aimed at informing general audience.

2012 Electronic text book on animal breeding and genetics for students at universities of applied sciences.

#### **Publications for the general public**

2012 Interviews on Pig Genome on RTL news (television), on BNR radio, and in The press.

2013 “Social Swine” symposium with stakeholders in pig production chain

2014 Asian introgression (Nature comm. paper Mirte Bosse) radio Interview (German)

2014 Radio interview L. Franz (Neanderthal paper)

2014 Seminar on 10 years Milk Genomics (Bovenhuis and Visker) leading to publications in popular journals

2014 “Chicken from African Soil”, news item in national newspaper linked to information on website on research on breeding chicken for small holder farmers in East Africa.

#### **4.2 Demonstrable use of products - Use of research products by societal groups**

*Overview of first jobs:* Sixty percent of the 48 PhD graduates (50% Dutch Nationality) in this review period, had their first job in a research institute or university and 30% had their first job in the animal breeding industry. We view this as an important indicator for relevance to society.

*Joint publications:* Many of our peer-reviewed publications co-authored by international partners (45%), industry (18%), and Dutch research groups (38%) (for details see section 1.4).

*Participation in training courses:* ABG organizes at least one advanced course each year. These PhD courses are aimed not only at PhD candidates, but also at researchers working in industry. Typically, we have 40 participants in a course, of which 5 are from industry. The courses offer a unique opportunity for networking and exchanging ideas. An overview of the training courses is given in Appendix 3.

*Use of genomic resources:* Contributed to the development of medium (60-80k) and high density (650K) beadchip is used by industry worldwide for genomic selection in pigs and turkey.

#### 4.3 Demonstrable marks of recognition - Marks of recognition by societal groups

*Prizes:* We have had only a limited number of public-prize winners. Our young scientists, nevertheless, won a number of prizes for presentations at international scientific meetings.

*Joints appointments:* Eight out of 48 of our PhD graduates combined their PhD research with activities for breeding organisations. Many PhD candidates are involved in projects in which data are generated by breeding organisations, which leads to close interactions with people in those organisations.

*Media exposure:* In collaboration with our communication department, we produce press releases and organise press meetings to inform journalists of our research findings. Examples include the launch of Breed4Food (2011), publication of Pig Genome in Nature (2012), 10-years of milk genomics (2014), and seeking sociable swine (2014).

## 5. Viability

### 5.1 Benchmark

#### International bench marking:

We benchmarked ourselves against three research groups that we regard as leading internationally in our domain: two departments at universities (SLU; Ames, Iowa) and one division at a research institute (Roslin) which contributes to teaching at Edinburgh University. We contacted these groups and exchanged composition of groups, results of the analysis of publications from SciVal. For number of citations per paper, we rank second (15.5) after Roslin (22.5). For field weighted citation impact, our performance is close to that of Roslin (about 2.0) and higher than that of the two other groups (see Table below). The analysis reveals that we are an internationally leading group in our domain.

*Table 5.1.1. Benchmark of ABG group with three comparabel research groups. Scientists per group can be found in Appendix 2.*

<i>Parameter:</i>	<b>ABG</b>	<b>Ames</b>	<b>Roslin</b>	<b>SLU</b>
Number of scientists included in analysis	19	18	22	21
Number of publications per year	63	65	83	43
Number of citations per publication	15.5	13.5	22.5	11.8
Field Weighted citation impact	1.9	1.7	2.0	1.4
Number of PhD graduates per year	8	4	9	5
Contribution to BSc and MSc training	150/30	170/2	180/50	80/21

*ABG* *Animal Breeding and Genetics group, WU*

*Ames* *Section Animal Breeding and Genetics, Department of Animal Sciences, Iowa State University*

*Roslin* *Division Genetics and Genomics, Roslin Institute, Edinburgh University*

*SLU* *Department of Animal Breeding and Genetics, Swedish University of Agricultural Sciences, Uppsala*

#### Comparison to previous peer review

The comparison of parameters of the previous (2004-2008) and present (2009-2014) peer-review period reveals that we doubled our scientific output in number of peer reviewed publications (from 35 to 71) and PhD graduates (from 4.6 to 8.0). We maintained our scientific quality, as reflected by RI (1.8) and %T10 (20%). We are very pleased with these results which reflect our ambitions to be an important international player.

*Table 5.1.2. Comparison output 2005-2008 with 2009-2014.*

<i>Parameter:</i>	<b>ABG</b>	<b>Ames</b>
Number of PhD graduates/yr.	4.6	8.0
No peer reviewed publications/yr.	35	71
Average Impact Factor journals	2.8	3.2
Relative impact (RI)	1.88	1.83
Proportion of top-10 publications (%T10)	20%	20%
h-index of tenured staff	22	30

## 5.2 SWOT-analysis

For each dimension max. 5 most essential remarks are indicated.

Strengths	<ul style="list-style-type: none"> <li>• Good quality scientific staff with expertise in quantitative genetics, genomics, and animal breeding programs, and thus ample opportunity for further integration of these fields.</li> <li>• Strong international position in our fields, as reflected by funding from EU, contribution to international initiatives, and involvement in EGSABG</li> <li>• Large number of scientific publications in a broad range of good quality journals</li> <li>• ABGC: unique collaboration in the domain of Animal Breeding and Genomics within Wageningen UR, providing sufficient critical mass</li> <li>• Fruitful and long-standing collaboration with industry through Breed4Food</li> </ul>
Weaknesses	<ul style="list-style-type: none"> <li>• Unsubsidized infrastructure for research (compared with international level)</li> <li>• Gender imbalance in tenured staff (not enough women)</li> <li>• Difficulty in attracting top-ranking international talents for tenured positions</li> </ul>
Opportunities	<ul style="list-style-type: none"> <li>• Rapid developments in the area of genomics</li> <li>• Growing recognition of potential of animal breeding to help solving grand challenges in developed and developing countries</li> <li>• Increased interest for resource efficiency, agrobiodiversity, health and welfare of animals under a wide range of environments</li> <li>• Emphasis on personal grants by two funding agencies NWO and ERC</li> <li>• Sharing facilities at campus for research in plant and animal breeding and genomics</li> </ul>
Threats	<ul style="list-style-type: none"> <li>• Increasing difficulty in finding funding for infrastructure for molecular genetic research and bioinformatics</li> <li>• Funding agencies (EU, NWO) are moving away from open programmes towards large thematic programmes</li> <li>• Legislation restrictions on the use of gene editing in research</li> </ul>

## 5.3 Future strategy

Reflection	<ul style="list-style-type: none"> <li>• ABG is in the forefront of its scientific domain</li> <li>• Focus on “Biology inspired genomic prediction” is timely</li> <li>• ABG’s combination of expertises is important for realizing its mission</li> <li>• Combining animal breeding and genomics research of Wageningen UR in ABGC adds to the strength of ABG</li> <li>• Focus on larger research programmes and involvement in international alliances is important to safeguard quality</li> <li>• Tenure track and special professors offer good opportunities to increase the number of professors with ius promovendi and to strengthen collaboration</li> <li>• Collaboration with industrial partners is strengthened by Breed4Food</li> </ul>
Adjusted goals	<ul style="list-style-type: none"> <li>• It has proven difficult in recent years to realise our ambition of one personal grant every two years. Competition for these prestigious grants is increasing and we, therefore, need to put even more emphasis on it.</li> </ul>
Adjusted strategy	<ul style="list-style-type: none"> <li>• Aim for more women in tenured scientific staff</li> <li>• Aim for increased involvement to secure involvement in large thematic programmes</li> <li>• Share facilities in Radix to overcome difficulty of funding for infrastructure</li> <li>• Ask for approval to use gene editing in research, with industrial partners (Breed4Food)</li> <li>• Harvest the benefits of ABGC and Breed4Food</li> </ul>

### **Future outlook for research**

In our research, we use information on complete genome sequences of individual animals. It turns out to be difficult, however, to predict whether specific variants affect the phenotype. This difficulty highlights our limited knowledge on how genomes function. For the coming years, it is our ambition to include the characterization of non-coding sequences and epigenetic modifications to understand and be able to predict better the differences in phenotypes. We will also collaborate more closely with other groups, such as like bioinformatics and HMI to realise this ambition.

Genomic selection has been implemented successfully in many livestock species including cattle, chicken, and pigs. Its success builds upon a better estimation of genetic relationships over and above pedigree information. As a consequence, genomic prediction of breeding values (GEBV) is inaccurate for distantly related individuals and more so for individuals from different breeds. The inclusion of functional information is expected to remove this problem, although gene action may be dependent on genetic background. Current statistical models used for GEBV ignore functional information including causal variants. Such information, however, has the potential to improve our predictions. Therefore, we will explore ways to extract and incorporate such functional information to take genomic selection to the next level.

Looking differently at traits sometimes opens avenues for selection, as shown in recent years by the successful selection for litter size in pigs. Two examples of selection we will explore are selection of groups of animals and selection for uniformity in groups. To improve the prediction of health status of groups of animals, we will build on the collaboration between Piter Bijma and Mart de Jong (QVE). Focus will be on understanding the genetic background of infectivity and resistance. To improve selection for uniformity of farm animals and natural populations we will build on the recent collaboration between Han Mulder and NIOO-KNAW.

To enhance breeding programmes, emphasis will be on the design of such programmes for challenging environments. We will focus on reducing the yield gap in aquaculture species and poultry by better prediction of the suitability of breeds in specific environments.

### **6. Research Integrity**

We strive for an open atmosphere, in which principles of scientific quality and integrity are optimally guarded. The Netherlands code for good scientific practise is used as an important guiding principle. The code considers five principles. For each of them, the most important activities to ensure that the code is applied are given:

- I. **Scrupulousness:** We stimulate open discussions about research findings in the group. Authorship on publications is discussed during progress meetings.
- II. **Reliability:** We ensure that appropriate statistical analyses are used. This includes the development of new methods as part of our research activities. Draft publications, and in particular, results to support conclusions are challenged in meetings of PhD candidate with supervisors.
- III. **Verifiability:** We ensure that research is reproducible. In 2014, we developed and implemented a data management plan to store data and to document methods systematically. The HPC Agrogenomics is used to store the huge amount of genomics data.
- IV. **Impartiality:** Researchers and students take their own intellectual stance. Collaboration with scientists outside the group is encouraged. Many PhD candidates spend time in another research environment. Side activities of our scientists are registered in the public system of WU (we@wur) and are visible publicly to ensure transparency.
- V. **Independence:** we have many partnerships with industry. In all contracts, it is specified that results of research will be published. Partners may postpone the publication of research findings for a maximum of 6 months. The involvement of industry in research is acknowledged appropriately.

**Appendix 1** - Research staff Animal Breeding and Genetics Group

Table 1 - Research staff input at Chair Group level

<b>Name Scientific staff</b>		<b>Funding 1, 2, 3*</b>	<b>2009 FTE**</b>	<b>2010 FTE</b>	<b>2011 FTE</b>	<b>2012 FTE</b>	<b>2013 FTE</b>	<b>2014 FTE</b>
<i>Full professors</i>								
Prof dr ir J.A.M. van Arendonk (1 fte)	Tenured	1	0.3	0.3	0.2	0.2	0.2	0.2
Prof dr M.A.M. Groenen (1 fte)	Tenured	1	0.4	0.4	0.4	0.4	0.4	0.4
<i>Special chairs</i>								
Prof.dr. R.F. Veerkamp (0.2 fte)	1-10-2011/1-10-2015	3			0.02	0.08	0.08	0.08
Prof.dr. M.E. Visser (0.2 fte)	1-5-2012/1-5-2017	3				0.08	0.08	0.08
<i>Associate professors</i>								
Dr ir J. Komen (1 fte)	Tenured	1	0.4	0.4	0.4	0.4	0.4	0.4
Dr ir H. Bovenhuis (1 fte)	Tenured	1	0.4	0.4	0.4	0.4	0.4	0.4
<i>Assistant professors</i>								
Dr ir P. Bijma (1 fte)	Tenured	2	0.4	0.4	0.4	0.4	0.4	0.4
Dr Ing R.P.M.A. Crooijmans (1 fte)	Tenured	1	0.4	0.4	0.4	0.4	0.4	0.4
Dr ir E. Kanis (1 fte)	Tenured	1	0.1	0.1	0.1	0.1	0.1	0.1
Dr. A. Kause ( 1 fte)	1-12-2008/1-12-2010	1	0.4	0.3				
Dr J.J. van der Poel (1 fte)	Tenured	1	0.3	0.3	0.4	0.4	0.4	0.4
Dr. Ir. B.J. Ducro (1 fte)	1-7-2011	1			0.2	0.4	0.4	0.4
Dr. Ir. H. Mulder (1 fte)	6-6-2011	1			0.2	0.4	0.4	0.4
Dr. Ir. E.H. van der Waaij (1 fte)	1-3-2011/30-4-2015	1			0.3	0.2	0.2	0.4
<b>Total scientific staff</b>			<b>3.10</b>	<b>3.00</b>	<b>3.42</b>	<b>3.86</b>	<b>3.86</b>	<b>4.06</b>
<i>Post-docs</i>								
Ir B.J. Ducro (1 fte)	1-11-1997/31-06-2011	1	0.4	0.4				
Drs.Ir. N.E.M. van Bers ( 0.8 fte)	1-3-2008/1-1-2012	2	0.6	0.4	0.3			
Dr P. van As ( 1.0 fte)	1-4-2006/1-04-2010	2	0.3	0.15				
Dr.Ir J.W.M. Bastiaansen (0.6 fte)	1-9-2006/1-4-2017	3	0.4	0.4	0.4	0.4	0.4	0.4
Dr.Ir. E.D. Ellen (0.8 fte)	1-1-2009/30-10-2017	2		0.4	0.4	0.6	0.6	0.4
Dr. Ir. H.C.M. Heuven (0.2 fte)	1-11-2010/30-6-2013	3		0.05	0.1	0.1	0.05	
Dr Ir P.D. Koks (0.8 fte)	1-4-2006/1-04-2010	2	0.6	0.1				
Dr. O. Madsen (0.8 fte)	1-6-2007/	2	0.6	0.6	0.5	0.5		
Dr. O. Madsen (0.8 fte)	01-03-2010/28-02-2015	3					0.4	0.4
Dr. Ir. H.J. Megens (0.8 fte)	01-03-2010/28-02-2015	3	0.6	0.6	0.5	0.5	0.5	0.5
Dr.ir. T.B. Rodenburg (0.8 fte)	1-9-2006/1-07-2012	2	0.6	0.6	0.6	0.3		
Dr Ir M.J.M. Rutten (1 fte)	1-9-2008/31-12-2010	3	0.9	0.9				
Dr.ir. E.M. van Grevenhof (0.75 fte)	1-2-2011/10-02-2016	2			0.4	0.6	0.6	0.4
Dr.Ir R. Blonk (0.5 fte)	1-11-2010/31-12-2012	3		0.1	0.4	0.4		
Dr ir M.H.P.W. Visker ( 1 fte)	1-3-2006/1-03-2015	2	0.9	0.9	0.9	0.15		
Dr ir M.H.P.W. Visker ( 1 fte)	1-3-2006/30-04-2016	3				0.75	0.8	0.8
Dr Anouk Schurink (0.73 fte)	01-02-2013/9-9-2013	1					0.44	
Dr Anouk Schurink (0.73 fte)	01-11-2012/01-02-2013	2					0.11	
Dr Anouk Schurink (0.73 fte)	10-9-2013/31-10-2016	1					0.19	0.4
Dr Juan Medrana Herrero (1 fte)	1-6-2014/30-11-2015	3						0.4
Charlie den Hollander MSc (1 fte)	1-3-2014/28-2-2015	2						0.67
Dr K M Schachtschneider (1 fte)	01-08-2013 / 01-08-2016	3						0.3
<b>Total postdocs</b>			<b>5.90</b>	<b>5.60</b>	<b>4.50</b>	<b>4.30</b>	<b>4.09</b>	<b>4.67</b>

*Support staff*

Bert Dibbits (1 fte)	1-8-2002 /	1	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Kimberley Laport (1 fte)	1-7-2011 /	3			0.4	0.8	0.8	0.8	0.8
A. Veenendaal (0.8 fte)	15-06-1993 / 30-09-2011	3	0.6	0.6	0.4				
Silvia Kinders (1 fte)	1-1-2008/14-4-2009	2	0.2						
Alex Hulzebosch (0.8 fte)	15-9-1996/	1	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Raoul Meuldijk (0.8 fte)	1-12-2005/30-11-2009	2	0.5						
Rosilde Dijkhof (0.4 fte/0.6 fte)	15-6-1987/	1	0.3	0.3	0.3	0.3	0.1	0.1	
Jan-Willem van der Pauw (1 fte)	1-11-2009/31-10-2011	3	0.1	0.8	0.6				
<b>Total support staff</b>			<b>2.90</b>	<b>2.90</b>	<b>2.90</b>	<b>2.30</b>	<b>2.10</b>	<b>2.10</b>	

*Visiting fellows*

P As (Hendrix Genetics, NL)	25-04-2011 / 31-12-2014				0.1	0.1	0.1	0.1	
P Alexandri	01-08-2011 / 31-12-2013					0.3	0.8		
E Bartolome Medina	01-04-2011 / 01-09-2011				0.3				
E W Brascamp (NL)	01-03-2013 / 01-01-2016						0.6	0.4	
Ciu L	22-4-2014 / 30-07-2014							0.2	
J M Cordero	01-03-2012 / 31-05-2012						0.2		
C L Daigle	30-08-2011 / 20-12-2011				0.3				
E M V Diopere (Uni Leuven. Belgium)	11-04-2011 / 19-06-2011				0.2				
A Esteve Codina	01-08-2011 / 01-02-2012				0.4	0.1			
F Fonseca E Silva	17-02-2012 / 01-04-2012					0.1			
L Gu	08-11-2012 / 01-05-2014					0.1	0.8	0.3	
A K Kahi (Egerton, Kenya)	04-01-2012 / 15-03-2012					0.2			
B P Kinghorn (UNE, Australia)	18-04-2012 / 11-06-2012					0.3			
M L Kujawa	01-06-2011 / 01-09-2011				0.2				
K Krag (Aarhus University, Denmark)	12-10-2011 / 01-02-2012				0.2	0.1			
C Lee	16-04-2012 / 31-07-2012					0.2			
L Lima Verardo	01-09-2014 / 01-06-2015								0.3
Q Li (China Agricultural University, Beijing)	03-09-2012 / 01-09-2014					0.3	0.8	0.5	
S L Mucha (Poznan, Poland)	01-03-2012 / 01-07-2012					0.3			
S K Makelainen	01-11-2013 / 01-02-2014					0.1	0.1		
C H J Oers (NIOO, Netherlands)	01-09-2010 / 01-01-2012				0.2	0.4			
D Perez Montarelo	03-09-2012 / 01-07-2013					0.3	0.4		
M Perez Enciso (CRAG-UAB, Barcelona, Spain)	05-08-2013 / 10-10-2013						0.3		
J S Richards	04-05-2012 / 05-08-2012					0.2			
P Sae-Lim (Nofima, Norway)	01-03-2014 / 01-06-2014								0.3
M W Szembek	01-06-2011 / 01-09-2011				0.2				
J H J Werf (UNE, Australia)	16-04-2012 / 31-07-2012				0.2	0.3			
T Xu (Danzhou, Hainan, China)	01-02-2013 / 01-03-2014						0.7	0.1	
X Yan	01-03-2012 / 01-03-2013					0.7	0.1		
H Zheng	20-08-2012 / 15-11-2012					0.2			
K De Moraes Silva (SP, Brasil)	2009		0.2						
L. Canario (INRA, France)	15-09-2009 / 15-12-2009		0.3						
L. Li	01-09-2009 / 1-12-2010		0.3	0.7					
D J G Arts	04-01-2010 / 01-01-2016			0.1	0.1	0.1	0.1	0.1	0.1
<b>Total visiting fellows</b>			<b>0.80</b>	<b>1.00</b>	<b>2.60</b>	<b>4.20</b>	<b>4.80</b>	<b>2.30</b>	

\* Funding scores: 1= direct funding by University; 2= funding obtained in national scientific competition (e.g. grants from NWO, KNAW) ; and 3= funding obtained from external organisations, such as industry, governmental ministries, European Commission and charity organisations.

\*\*FTE reported in this table regards the research appointment part of the total appointment (e.g. tenured staff has 40% available for research, postdocs have 60% available for research).

**Appendix 2** - Details on scientist included in the benchmark for Animal Breeding and Genetics group

*Scientists of Ames, Roslin, SLU and ABG included in the benchmarking. See footnote for details on the groups*

<b>ABG</b>	<b>Ames</b>	<b>Roslin</b>	<b>SLU</b>
Bastiaansen, J.W.M.	Baas, T.J.	Archibald, A.L.	Andersson, G.
Bijma, P.	Carpenter, S.L.	Banos, G.	Berglund, B.
Bovenhuis, H.	Dekkers, J.C.M.	Bishop, S.C.	Bergström, T.F.
Crooijmans, R.P.M.A.	Ellinwood, N.M.	Bronsvort, B.M.C.	Bongcàm-Rudloff, E.
Ducro, B.J.	Fernando, R.L.	Burt, D.W.	Carlström, C.
Ellen, E.D.	Fritz-Waters, E.	Doeschl-Wilson, A.B.	De Koning, D.J.
Groenen, M.A.M.	Garrick, D.J.	Dunn, I.C.	Eriksson, S.
Kanis, E.	Grubbs, J.K.	Freeman, T.C.	Fikse, W.F.
Komen, J.	Koltes, J.E.	Glass, L.	Grandinson, K.
Madsen, O.	Lamont, S.J.	Haley, C.S.	Johansson, A.M.
Megens, H.J.	Reecy, J.M.	Hickey, J.M.	Jónás, E.A.
Mulder, H.A.	Rothschild, M.F.	Hocking, P.M.	Jorjani, H.
Schurink, A.	Schroyen, M.	Houston, R.D.	Lindgren, G.
Van Arendonk, J.A.M.	Serão, N.V.L.	Kranis, A.	Lundeheim, N.
Van Der Poel, J.J.	Spurlock, D.M.	Law, A.	Mikko, S.
Van Der Waaij, E.H.	Stalder, K.J.	Michoel, T.	Rönnegård, L.
Van Grevenhof, E.M.	Tuggle, C.K.	Prendergast, J.G.D.	Rydhmer, L.
Veerkamp, R.F.	Wolc, A.	Summers, K.M.	Strandberg, E.
Visker, M.H.P.W.		Tenesa, A.	Vuklund, Å
		Watson, M.J.	Wallenbeck, A.
		Wiener, P.	Wallerman, O.
		Woolliams, J.A.	

*ABG Animal Breeding and Genetics group, WU*

*Ames Section Animal Breeding and Genetics, Department of Animal Sciences, Iowa State University*

*Roslin Division Genetics and Genomics, Roslin Institute, Edinburgh University*

*SLU Department of Animal Breeding and Genetics, Swedish University of Agricultural Sciences, Uppsala*

**Appendix 3** - Overview of training courses involving staff from ABG (in bold) for PhD candidates and postdoc (at Wageningen University unless stated otherwise).

Date	Course	Organiser(s)	Teacher(s)
<b>2009</b>			
26-28 Jan	Nutrient Density of Milk (VLAG/WIAS course)	VLAG	Toon van Hooijdonk, <b>Johan van Arendonk</b>
4 Feb	Getting started in AS-Reml	<b>Bart Ducro</b>	<b>Alex Hulzebosch, Bart Ducro</b>
March	Genetics of social interactions (Armidale, Australia)	UNE	<b>Piter Bijma</b>
28 May-5 Jun	Statistics for the Life Sciences	WIAS/PERC	<b>Henk Bovenhuis</b> , Bas Engel, Gerrit Gort
15-26 Jun	Nordic PhD course on design and optimization of breeding schemes (Hårby, Dk)	NOVA	<b>Johan van Arendonk, Antii Kause</b>
8-9 Oct	Introduction to R for statistical analysis	WIAS	Gerrit Gort, <b>John Bastiaansen, Albart Coster</b>
<b>2010</b>			
17 Feb	Getting started in AS-Reml	<b>Bart Ducro</b>	<b>Alex Hulzebosch, Bart. Ducro</b>
1-8 Jun	Statistics for the Life Sciences	WIAS/PERC	<b>Henk Bovenhuis</b> , Bas Engel, Gerrit Gort
spring	WIAS course "Writing winning grant proposals"	Kor Oldenbroek	<b>Johan van Arendonk</b> , others
7-11 Jun	Quantitative genetics, with a focus on selection theory	<b>Piter Bijma</b>	Bruce Walsh, <b>Piter Bijma</b>
Aug	Genetics of competitions (Copenhagen, Denmark)	U_Copenhagen	<b>Piter Bijma</b>
<b>2011</b>			
20-27 May	Statistics for the Life Sciences	WIAS/PERC	<b>Henk Bovenhuis</b> , Bas Engel, Gerrit Gort
27 Jun - 1 Jul	Genomic Selection in Livestock	<b>Mario Calus</b>	Dorian Garrick, Rohan Fernando, <b>Mario Calus</b>
June	IAMZ-CIHEAM Genomic applications in Animal Breeding (Leon, Spain)	IAMZ	<b>Martien Groenen, Henk Bovenhuis</b> and others
1-12 Aug	Population genetics for genomic selection (Mustiala, Finland)	NOVA	<b>Piter Bijma</b>
17-21 Oct	Statistical Learning Methods for DNA-based Prediction of Complex Trait	<b>John Bastiaansen, Marco Bink</b>	Daniel Gianola, Gustavo de los Campos
<b>2012</b>			
May- Jun	Statistics for the Life Sciences	WIAS/PERC	<b>Henk Bovenhuis</b> , Bas Engel, Gerrit Gort
3-6 Jul	Identity By Descent approaches to genomic analysis of genetic traits	<b>John Bastiaansen, PERC, EPS</b>	Elisabeth Thompson
10-12 Oct	Techniques for Measuring Milk Phenotypes (WIAS / VLAG workshop)	WIAS/VLAG	<b>Marleen Visker</b> , Kasper Hettinga
28 Oct-1 Nov	EGSABG Summer School on "Animal Breeding and Food Security in Developing Countries", Addis Ababa, Ethiopia	<b>Hans Komen</b>	<b>Johan van Arendonk</b> and others
12-16 Nov	Advanced methods and algorithms in animal breeding with focus on genomic selection	<b>Roel Veerkamp</b>	Ignacy Misztal
10-14 Dec	Sequence Data Analysis training school	<b>John Bastiaansen</b>	Christoff Klopp, Mick Watson, <b>Hendrik-Jan Megens, Martien Groenen</b>

<b>Date</b>	<b>Course</b>	<b>Organiser(s)</b>	<b>Teacher(s)</b>
<b>2013</b>			
14-16 May	Social genetic effects: Theory and genetic analysis	<b>Ellen Esther</b>	<b>Piter Bijma</b>
23-30 May	Statistics for the Life Sciences	WIAS/PERC	<b>Henk Bovenhuis</b> , Bas Engel, Gerrit Gort
May	R and Genomic Selection (Vicoso, Brazil)	Vicoso	<b>John Bastiaansen</b>
June	Power of RNA sequencing	NBIC	<b>Ole Madsen</b> and others
Sep	Population genetics for genomic selection (Hohenheim, Germany)	Uni_Hohenheim	<b>Piter Bijma</b>
12 Dec	De novo assembly course	WU	<b>Hendrik-Jan Megens</b>
<b>2014</b>			
8-9 Jan	NBIC The Power of RNA-sequencing	NBIC	<b>Ole Madsen</b>
10-14 Feb	Genetic analysis using ASReml 4.0	<b>Roel Veerkamp</b>	Artur Gilmour
Apr	Social Interactions (Bielefeld, Germany)	Local	<b>Piter Bijma</b>
21-28 May	Statistics for the Life Sciences	WIAS/PERC	<b>Henk Bovenhuis</b> , Bas Engel, Gerrit Gort
13-17 Oct	Introduction to theory and implementation of Genomic Selection	<b>Henk Bovenhuis</b>	<b>Mario Calus, Piter Bijma, Henk Bovenhuis</b>



## Animal Nutrition (ANU)

**Programme leader(s):** Wouter Hendriks (2005 – present)

For a full staff survey see appendix 1.

### 1. Objectives and Research Area

#### 1.1 Vision, Mission and Objectives

**Vision:** The increasing scarcity of future feed resources requires knowledgeable experts to develop novel solutions and innovative diet formulations in animal nutrition. Research and education in animal nutrition are of paramount importance to meeting these future challenges

**Mission:** We advance and transfer knowledge in animal nutrition to secure nutritious and sustainable feeds for animals of importance in our society

The Animal Nutrition (ANU) group conducts research to provide a fundamental understanding of nutritional processes and the effects of dietary compounds on the health, growth, welfare and longevity of production and companion animals. We study the supply of nutrients via consumption of feed/food and utilisation by animals for efficiency of production, animal health and welfare, environmental impact of animal production systems, as well as behaviour, vitality and longevity.

**Objective:** To advance and transfer knowledge on feeds/ingredients and the nutrition of animals to contribute to resource efficiency, responsible food production, and health and well-being

We follow dietary nutrients as they are broken down (digested or fermented), absorbed and metabolised by animals. Feed technology, nutrient analysis, digestion/absorption, fermentation, nutrient metabolism and the effects of nutrients on gene expression are the core areas of our research. Our *in vitro* simulation methods for digestion/fermentation processes and mechanistic modelling of nutrient utilisation are instrumental in providing further insight into the nutrient metabolism by animals.

#### 1.2 Research area / research line(s)

Research areas/lines have been developed in close collaboration with our two Centre partners (see below). Nutrition research of production animals focusses on optimisation of sustainable production of safe and healthy foods for human consumption and to safeguard the health and welfare of animals. Nutrition research into companion animals aims to optimise animal health, welfare and longevity. Three major animal species groups have been established with a staff member responsible to develop and coordinate research in collaboration with the head of the group.

Capability	Animal species group			
	Production		Companion	
	Ruminants <sup>1,2</sup>	Pig/poultry/veal <sup>1</sup>	Cats/dogs <sup>2</sup>	Horses <sup>2</sup>
Feed technology	-	XX	XXX	-
Nutrient analyses	XXX	XXX	XXX	XX
<i>In vitro</i>	XXX	XX	XXX	X
Digestion/metabolism	XXX	XXX	XXX	X
Nutrigenomics	XX	XX	-	-
Modelling	XXX	XX	-	-

<sup>1</sup>with Centre partner, Livestock Research.  
<sup>2</sup>with Centre partner, Faculty of Veterinary Medicine, Utrecht University.

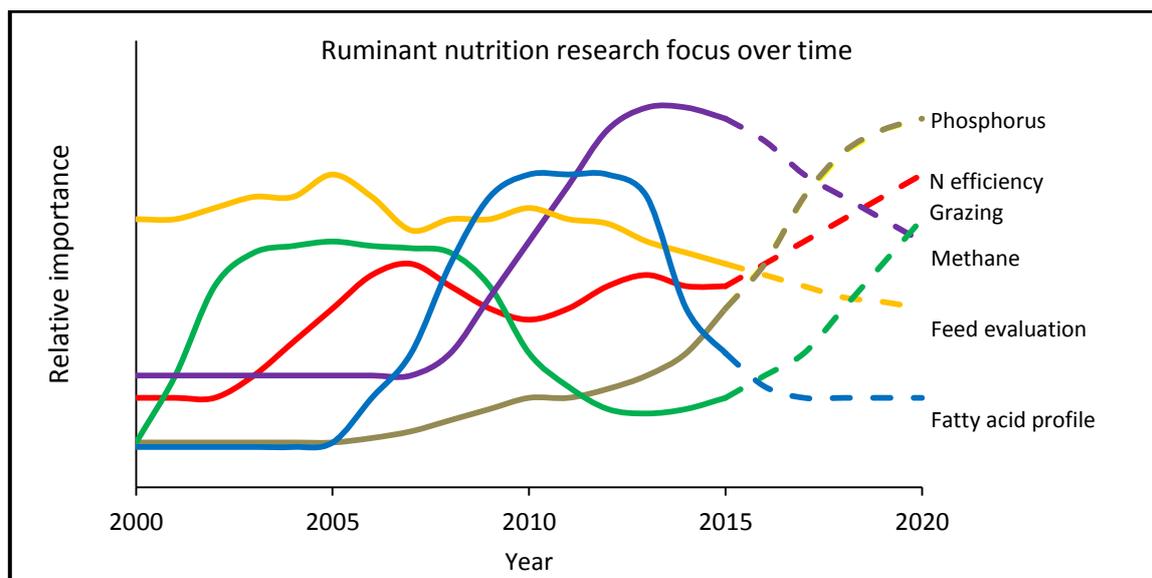
Research focus depends on animal species group. Ruminant nutrition (8.2 FTE<sub>2014</sub>) is currently focussed around the important processes/aspects of rumen fermentation, nitrogen and phosphorus efficiency, greenhouse gas emission/mitigation, feed evaluation and modelling of nutrient flows. Several research areas (5.6 FTE<sub>2014</sub>) have been identified for monogastric production animals (pigs/poultry/veal) including

feed evaluation, nutrition and immunology, nutrient requirements and modelling of nutrition processes. Canine/feline nutrition research (2.4 FTE<sub>2014</sub>) is centred around feed evaluation/technology, nutrient metabolism and evolutionary nutrition with equine nutrition research concentrated around digestive health. A close collaboration exists with our Centre partner Livestock Research in the line ruminant and pigs/poultry/veal. Feline/canine/equine nutrition research is conducted in close collaboration with our other Centre partner (Faculty of Veterinary Medicine, Utrecht University).

### 1.3 Strategy

The above-described focus, capabilities and expertise are utilised to conduct research that contributes to a number of themes within the domain of animal science and production. Feed evaluation science, efficiency of production, sustainability, environmental impact of production, animal health, product quality and feed ingredient security are major themes ANU focusses on. Within all these themes, nutrition plays a major role and ANU has been and remains to be expertly positioned to contribute to these industry, governmental/EU and societal themes. The strategic focus provides direct reference to areas of research interest and potential projects to be developed depending on the opportunities which are identified/provided for research funding nationally and internationally. As such, capabilities and expertise are utilised to develop research proposals for various funding organisations.

Changes in strategy are made as a result of our annual “review of strategy” meetings. Virtually all recommendations made by the 2008 WIAS peer review committee have been implemented. Changes in importance of research areas have occurred for each of the three animal species groups. Over time, certain research topics in ruminant nutrition research (see figure) have increased in importance while others have decreased. Similarly, research priorities within the other two species groups have seen changes over time.



Our equine nutrition research facilities have been consolidated at the Faculty of Veterinary Medicine (Utrecht University) and implementation of the strategy for our feed technology capabilities (due to retirement) is underway.

The future for ANU looks bright with the direction and strategic focus remaining well-conceived for the future. With “feed” being an integral part of the new WUR strategy, and the focus of the government and EU on resource use efficiency, increased competition of feed with food and fuel, and the growing demand for animal-derived foods, ANU (staff and facilities) is well positioned to contribute to these areas in the form of new knowledge development.

#### 1.4 Research environment and embedding

We actively seek collaborations to ensure relevance and impact of our research:

- *Centre for Animal Nutrition (CAN)* is a collaboration in research and education with the Division of Animal Nutrition, (Livestock Research) and the Nutrition chair group (held by Prof Hendriks) of Utrecht University. Research areas/lines and strategy have been conjointly developed and are reviewed annually.
- *Collaboration with industry* is one of our main strengths and key to the success of ANU. In 2013, we established the public-private partnership Feed4Foodure, a consortium of international Dutch feed and feed additive companies and CAN of Wageningen UR. The secondment of 4 industry research staff to ANU and the industry funded special professor (den Hartog) makes ANU/CAN a focal point for industry.
- *Active member of WIAS*: Over the past 6 years, with 37 PhD theses and 7 WIAS symposia/courses, ANU has made a significant contribution to the WIAS output.
- *National and international collaborations*: Of our 37 PhD graduates, 67% (25) had non-ANU co-supervisors (5 CAN partners, 9 WU chair groups, 11 outside WUR). ANU is one of the five members of the cluster Adaptive Animals and Systems where joint research initiatives on adaptation of animals to challenges in their environment are developed. We represent and help each other, share research facilities and are a sounding board to increase opportunities and effectiveness and to minimise risks. Long-standing international collaborations exist within the European Master programme-Sustainable Animal Feeding and Nutrition (<https://sites.wageningenur.nl/en/emsanf.htm>) of which ANU is coordinating institution as well as EU-FP7 programmes (e.g. Reading, INRA, Århus, Ghent). Active collaborations exist with leading Universities (e.g. Massey (NZ), Guelph (Can), California (Davis, US), Hue (Vietnam), Ghent (B), Reading (UK), UTAD (Por), Århus (Den)) and research institutes (e.g. Rowett, INRA, Tecaliman, Cetiom). Dr Dijkstra is Adjunct Professor at University of Guelph, while Prof Janssens (Ghent University) is an ANU honorary research fellow.

#### 1.5 Reference to previous assessments

Recommendations made by the 2008 WIAS peer review<sup>1</sup> and 2012 WIAS midterm review<sup>2</sup> committee:

*“secure some prestigious NWO and EU grants<sup>1</sup>”*

- Veni grant for Dr van der Borne
- NWO project entitled: “Novel roughage-based feeding strategies to improve welfare of veal calves”
- Partner in EU funded FP7 programmes “Interplay” and “REDNEX (coordinator)”
- Partner in a Marie Curie Research Training Network “Optimising plant polyphenols in LEGUMES for ruminant nutrition PLUS health PLUS environmental sustainability”, a continuation of the “HealthyHay”
- STW project “Increasing the utilization of organic waste and low value feeds with the help of lignin degrading fungi”

*“decrease funding of the group is of some concern<sup>1</sup>”*

In addition to the above, industry and University funded projects were secured e.g. PhD programmes from Product Boards (Animal Feeds, Dairy), Carbohydrate Competence Centre, Top Sector funding (Feed4Foodure, Breed&Feed4Food), Marie Curie RTN, Wageningen University Fund, Top Institute Food and Nutrition, Wageningen UR strategic investment funds (IPOP)

*“companion animal nutrition<sup>1</sup>”*

- Funding for a PhD scholar “Lysine carbohydrate interaction in processed pet foods”
- Funding for a post-doctoral fellow “Fermentation in the canine colon”
- A PhD candidate graduated studying the “Oxalate excretion by cats and dogs”
- Memorandum of Understanding with MARS

*“linkage with Human Nutrition and Wageningen’s Top Institute<sup>1,2</sup>”*

Closer linkage with Human Nutrition has been realised. We have an active collaboration with the chair group Nutrition, Metabolism and Genomics and other groups active in human nutrition incl. Food Chemistry, as well as Food Quality and Design. Linkage to Wageningen’s Top Institute has been achieved via the project entitled: “Towards sustainable dairy cattle production by improved understanding of and tools to measure methane emission”. Development of these linkages is on-going.

*“forges a closer alliance with the Human and Animal Physiology Chair group<sup>1”</sup>*

Together with the Human and Animal Physiology chair group, ANU is a member of the cluster Adaptive Animals and Systems. Regular meetings are held to discuss opportunities for research funding and collaborative research projects. In addition, we have conducted joint research projects in the area of nutrigenomics and at present, advanced discussions are taking place for close collaboration in the area of energy and protein metabolism using various chamber facilities available.

Cooperation between Centre partners has been strengthened and Prof Hendriks is tenured at the Faculty of Veterinary Medicine (Utrecht University), securing their contribution within the Centre. Equine nutrition research facilities are now located, and research is coordinated, at the Veterinary Faculty. CAN has been strengthened by further integration of, and collaboration between, staff from member groups<sup>2</sup>. In addition, CAN has integrated the activities of the Centraal Veevoeder Bureau (CVB), the feed evaluation activities of the Product Board Animal Feeds, into its activities. More focus on publishing in higher impact factor journal has resulted in increased bibliometrics<sup>2</sup>. Young, talented MSc students were actively guided and have taken up PhD positions at ANU. Overloading of staff has been a main priority in annual performance reviews<sup>2</sup>.

**2. Resources and Facilities**

Total research staff has increased to ~20 FTE. In 2014, we increased our tenured staff, decreasing our “post-doc” staff. The number of PhD scholars has increased to ~25. Overall, ANU has seen a strong growth in total staff to ~55 (~29 FTE). Staff/PhD scholar ratio is at an acceptable level in 2014. PhD scholars also have co-supervisors located at one of the two other CAN partners, other chair groups or based in industry. Of our 37 PhD graduates, 67% (25) had non-ANU co-supervisors.

Research funding has increased and concomitant the expenditure. In 2014, the first 2 PhD scholars within the industry-led programme “Feed4Foodure” (2.1 mEuro/year for 5 years) were appointed and it is expected that in the coming years more PhD scholars will be funded. Through the Wageningen University Fund, 3 overseas (Indonesia, Malaysia and China) PhD scholars have been funded and a large collaborative programme with DSM/STW is in the process of being developed. In light of the current changes by the Dutch government with respect to research and education, we aim to maintain our research funding at the 2012-2014 level.

ANU laboratories have been relocated and are now housed in modern facilities with much of the “aging” laboratory equipment replaced by new state-of-the-art equipment (e.g. GCC-IRMS, HPLC, GCs). Animal research facilities have been newly built. Of particular note is the co-location of our CAN partner (Livestock Research) with ANU in the Zodiac building.

## 2.1 Researchers

Table 2.1. Research input: number<sup>1</sup> and FTE<sup>2</sup> of Scientific staff, Post-docs and PhD candidates by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	#	FTE												
Scientific staff <sup>4</sup>	10	2.4	10	2.4	9	2.2	8	2.1	9	2.6	10	3.9	9	2.6
Post-docs <sup>5</sup>	3	1.9	5	2.8	6	4.5	8	4.8	9	3.6	8	1.9	7	3.3
PhD candidates <sup>3,6</sup>	16	8.2	18	12.3	23	12.6	26	14.4	24	13.9	23	12.5	22	12.3
<b>Total research staff</b>	<b>29</b>	<b>12.5</b>	<b>33</b>	<b>17.4</b>	<b>38</b>	<b>19.3</b>	<b>42</b>	<b>21.4</b>	<b>42</b>	<b>20.1</b>	<b>41</b>	<b>18.3</b>	<b>38</b>	<b>18.2</b>
Lab Technicians	7	6.4	8	7.8	9	8.8	10	8.9	10	9.5	11	9.9	9	8.6
Visiting fellows	0	0.0	2	0.8	3	1.1	5	1.0	6	1.4	3	0.5	3	0.8
<b>Total staff</b>	<b>36</b>	<b>18.9</b>	<b>43</b>	<b>26.1</b>	<b>50</b>	<b>29.3</b>	<b>57</b>	<b>31.3</b>	<b>58</b>	<b>31.0</b>	<b>55</b>	<b>28.7</b>	<b>50</b>	<b>27.6</b>

<sup>1</sup> Total number of staff and PhD candidates

<sup>2</sup> Available research time in full time equivalent (FTE)

<sup>3</sup> All PhD categories, except external PhDs

Standards for Research Capacity (in case of part time appointment adjustment is applied):

<sup>4</sup> Professor, Assistant Professor and Associated Professor: Research Capacity = 40% of the appointment

<sup>5</sup> Post-doc: Research Capacity = 90% of the appointment

<sup>6</sup> PhD candidate: Research Capacity = 75% of the appointment (all categories)

## 2.2 Research Funds

Table 2.2. Funding of Scientific staff, Postdocs and PhD candidates by year and Expenditure of Chair group by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	FTE	%												
<i>Funding:</i>														
Direct funding <sup>1</sup>	2.2	17	2.8	16	3.7	19	3.2	15	5.0	25	4.4	24	3.5	19
Research grants <sup>2</sup>	0.1	1	0.4	2	0.4	2	1.1	5	1.1	5	0.8	5	0.6	3
Contract research <sup>3</sup>	10.3	82	14.2	82	15.3	79	17.2	80	14.1	70	13.1	71	14.0	77
<b>Total funding</b>	<b>12.5</b>	<b>100</b>	<b>17.4</b>	<b>100</b>	<b>19.3</b>	<b>100</b>	<b>21.4</b>	<b>100</b>	<b>20.1</b>	<b>100</b>	<b>18.3</b>	<b>100</b>	<b>18.2</b>	<b>100</b>
<i>Expenditure<sup>4</sup>:</i>	<b>K€</b>	<b>%</b>												
Personnel costs	1,612	58	1,786	51	1,883	52	2,124	54	2,278	47	2,232	44	1,986	51
Other costs	1,151	42	1,685	49	1,733	48	1,827	46	2,615	53	2,836	56	1,975	49
<b>Total expenditure</b>	<b>2,763</b>	<b>100</b>	<b>3,472</b>	<b>100</b>	<b>3,615</b>	<b>100</b>	<b>3,951</b>	<b>100</b>	<b>4,892</b>	<b>100</b>	<b>5,069</b>	<b>100</b>	<b>3,960</b>	<b>100</b>

<sup>1</sup> Direct funding by the University

<sup>2</sup> Research grants obtained in national and international scientific competition (e.g. grants from NWO, KNAW)

<sup>3</sup> Research contracts for specific research projects obtained from external organisations, such as industry, governmental ministries, European Commission (including ERC), charity organisations

<sup>4</sup> Expenditure from financial system of Wageningen University which not only includes research but also teaching and other activities

### 3. Research Quality

Our strategy is to publish all results of our research efforts in peer reviewed journals to achieve the highest impact. This is not necessarily synonymous with publication in the highest impact journals. Impact also encompasses suitability of the journal in relation to the research focus. We aim to achieve impact in science but also in practice e.g. capability development at universities and research institutes in developing countries. We, therefore, consider a good distribution between high quality publications to number of publications within our field of research important. The journals considered top for animal nutrition research are The Journal of Nutrition (Q1), British Journal of Nutrition (Q2), Journal of Dairy Science (Q1) and Journal of Animal Science (Q1).

Eight of our 37 PhD graduates have taken up influential positions in their home country (e.g. Vietnam, Ethiopia, Indonesia and Pakistan) where they now educate/supervise students or are in governmental positions and work to increase national animal production. Our other 29 PhD graduates were all employed within 1 month after graduation with some employed before finishing their PhD (e.g. de Vries, Berends, van Rooijen).

- Sarnklong, C., Cone, J. W., Pellikaan, W. and Hendriks, W. H. (2010) Utilization of rice straw and different treatments to improve its feed value for ruminants: A review. *Asian-Australasian Journal of Animal Science* 23:680-692. (Q3, T10%, RI 2.63)
- Bannink, A., Van Schijndel, M.W. and Dijkstra, J. (2011). A model of enteric fermentation in dairy cows to estimate methane emission for the Dutch National Inventory Report using the IPCC Tier 3 approach. *Animal Feed Science and Technology* 166-167: 603-618. (Q1, T10%, RI 4.04)
- Plantinga, E. A., Bosch, G. and Hendriks, W. H. (2011) Feline paleolithic nutrition: A consideration of its nature and its implications for nutrition of domestic cats. *British Journal of Nutrition* 106: S35-S48. (Q2, T10%, RI 2.67)
- Gerrits, W.J.J., Bosch, M.W. and Borne, J.J.G.C. van den (2012) Quantifying resistant starch using novel, *in vivo* methodology and the energetic utilization of fermented starch in pigs. *The Journal of Nutrition* 142 (2), 238-244. (Q1, T10%, RI 3.59)
- Boland, M. J., Rae, A. N., Vereijken, J. M., Meuwissen, M. P. M., Fischer, A. R. H., van Boekel, M. A. J. S., Rutherford, S. M., Gruppen, H., Moughan, P. J. and Hendriks, W. H. (2013) The future supply of animal-derived protein for human consumption. *Trends in Food Science and Technology* 29: 62-73. (Q1, T1%, RI 7.52)

#### 3.1 Demonstrable products - Research products for peers in science

Table 3.1. Categories of research output by year.

Category:	Year						Total	Average 2009-2014
	2009	2010	2011	2012	2013	2014		
<b>Academic publications</b>								
a. Refereed articles	31	38	57	69	72	62	329	55
b. Non-refereed articles	0	0	1	0	0	0	1	0
c. Books	0	0	0	0	0	0	0	0
d.1. Refereed book chapters	2	7	4	0	2	0	15	3
d.2. Non-refereed book chapters	2	0	0	1	0	0	3	1
e. PhD Theses	4	6	8	5	7	7	37	6
f. Conference papers	15	14	27	16	44	6	122	20
<b>Total academic publications</b>	<b>54</b>	<b>65</b>	<b>97</b>	<b>91</b>	<b>125</b>	<b>75</b>	<b>507</b>	<b>85</b>

### 3.2 Demonstrable use of products - Use of research products by peers

Table 3.2.1. Bibliometric indicators for ANU over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	47	774	530	16.5	1.5	17% (8)	0% (0)
2009	30	350	295	11.7	1.2	7% (2)	3% (1)
2010	38	301	292	7.9	1.0	13% (5)	0% (0)
2011	55	564	299	10.3	1.9	29% (16)	5% (3)
2012	67	319	236	4.8	1.4	18% (12)	0% (0)
2013	70	216	107	3.1	2.1	21% (15)	6% (4)
<b>all years</b>	<b>307</b>	<b>2524</b>	<b>1758</b>	<b>8.2</b>	<b>1.6</b>	<b>19% (58)</b>	<b>3% (8)</b>

Research output strongly increased, resulting in increased citations. Overall, 19% of ANU publications belong to T10 and 3% are T1 publications. The relative impact has increased from 1.3 (2004-2007) to 1.6 (2008-2013). We published 16 review articles in amongst others, Nutrition Research Reviews, Current Opinion in Environmental Sustainability and the British Journal of Nutrition. ANU publishes mainly (92%) within the research fields Plant & Animal Science and Agricultural Sciences (Table 3.2.2). The RI of publications and the T10 and T1% within Agricultural Sciences (2.2) is higher than that in Plant and Animal Science (1.3). ANU publishes mainly in Q1 (70%) and Q2 (23%) journals (see part A). The RI of articles in Q1 journals (1.91) is double that of Q2 journal (0.91) articles.

Table 3.2.2. Bibliometric indicators for ANU per research field over the period 2008-2013. The rows are ordered in descending number of publications (N). The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

research field	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	175	1087	986	6.2	1.3	13% (22)	1% (2)
Agricultural Sciences	109	1087	558	10.0	2.2	28% (31)	5% (5)
Biology & Biochemistry	11	149	114	13.6	0.9	9% (1)	0% (0)
Environment/Ecology	4	62	27	15.5	1.7	50% (2)	0% (0)
Microbiology	3	49	50	16.3	1.1	0% (0)	0% (0)
Neuroscience & Behavior	2	13	10	6.5	1.2	0% (0)	0% (0)
Chemistry	1	6	3	6.0	2.0	0% (0)	0% (0)
Clinical Medicine	1	63	8	63.0	7.8	100% (1)	100% (1)
Social Sciences, General	1	8	2	8.0	3.7	100% (1)	0% (0)
<b>All fields</b>	<b>307</b>	<b>2524</b>	<b>1758</b>	<b>8.2</b>	<b>1.6</b>	<b>19% (58)</b>	<b>3% (8)</b>

Our Wageningen mechanistic model of fermentation and digestion processes in dairy cattle is used by researchers internationally (Canada, UK, USA) as well as by the Dutch national greenhouse gas emission inventory for methane production of dairy cattle. Our respiration chamber data on CH<sub>4</sub>-production of individual cows are shared worldwide, e.g. the Feed and Nutrition Network of the Global Research Alliance to provide expert recommendations for future research priorities, methodologies, and science-based greenhouse gas mitigation solutions to governments and non-governmental organizations, advisory/extension networks, and the livestock sector. Our *in vitro* gas production facilities as well as our facilities and expertise to label milk with stable isotopes have been used by our peers for scientific studies.

### 3.3 Demonstrable marks of recognition - Marks of recognition from peers

Table 3.3. Most important prizes, keynotes etc. of staff (max 6 per category). For remaining achievements see mini CVs (Separate file called mini CVs).

<b>Science awards, Scholarly prizes, Research grants awarded to individuals</b>		
Year	Prize description	Person
2010	Veni grant	J. van der Borne
	WIAS prizes and grants	C. Souza da Silva (poster prize 2011, 3-months fellowship 2013), S. de Vries (3-months fellowship 2014), M. Gilbert (3-months fellowship 2014), H. van Lingen (3-months fellowship 2014), S. van Kuijk (3-months fellowship 2014, best oral presentation 2014)
	European Association for Animal Production NZV (Dutch Zootechnical Association)	C. Souza da Silva (best oral presentation by young researcher at annual EAAP meeting 2010), C. Souza da Silva (best poster 2010)
	ADSA travel award	C.E. van Middelaar (American Dairy Science association) for best oral presentation at EAAP (European Association of Animal Production)
<b>Plenary/Keynote* Lectures at major conferences</b>		
Year	Person	Conference
2011	Wouter Hendriks	Protein Summit, Organised by the FAO, March 27-31, Auckland, New Zealand.
2013	Leo den Hartog	World Conference on Animal Production (Beijing, China)
2013	Jan Dijkstra	Greenhouse Gases and Animal Agricultural Conference (GGAA), Dublin, Ireland, 23rd - 26th June
2013	Wouter Hendriks	Waltham International Nutritional Sciences Symposium, "From pet food to pet care – bridging the gap", 1-4 October, Portland, Oregon, USA.
2014	Walter Gerrits	"Trends in Swine Nutrition Science", International Symposium on the occasion of the opening of Nutreco's Swine Research Centre, Boxmeer, NL
2014	Rene Kwakkel	Poultry Beyond 2020, 5th International Broiler Nutritionist conference, Queenstown, New Zealand, April
<b>Organisation of International Scientific Conferences</b>		
Year	Person	Conference
2010	Wouter Hendriks	Waltham International Nutritional Sciences Symposium, September 16-18, Cambridge UK, England
2011	Leo den Hartog	International Conference on "Responsible use of antibiotics in animals" (Noordwijk, The Netherlands)
2013	Leo den Hartog	World Conference on Animal Production (Beijing, China)
2013	Walter Gerrits	3-day International Course on indirect calorimetry, UC Davis, September 2013; Satellite workshop to International Symposium on Protein Metabolism, Sacramento, USA
2013	Wouter Hendriks	Waltham International Nutritional Sciences Symposium, "From pet food to pet care – bridging the gap", 1-4 October, Portland, Oregon, USA
2015	Rene Kwakkel	European Symposium on Poultry Nutrition, Prague, Czech Republic, August.
<b>Editorships and editorial boards</b>		
John Cone		Animal Feed Science and Technology (2000-present) Journal of the Science of Food and Agriculture (2011-present)
Jan Dijkstra		Journal of Agricultural Science, Cambridge (2007-present)
Walter Gerrits		ANIMAL (2006-present)
Wouter Hendriks		British Journal of Nutrition (2011-present)

Journal of the Science of Food and Agriculture (associated 2008- 2011, executive 2011-present)  
Journal of Animal Nutrition and Animal Physiology (2011-present)  
Animal Feed Science and Technology (2011-2014)  
Guest editor British Journal of Nutrition (2011, vol 106 suppl 1)  
Guest editor Journal of Nutritional Sciences (2014, vol 3)

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#### 4. Relevance to Society

The Animal Nutrition group conducts research to provide a fundamental understanding of nutritional processes and the effect of dietary compounds on the growth, health, welfare and longevity of production and companion animals. Our research contributes to the production of safe, animal derived foods for human consumption as well as foods consumed by companion animals. Global feed and feed additive companies, and the pet food industry are in need of this fundamental knowledge while NGOs, government and the general public are also served with objective information regarding animal nutrition. Our research has contributed amongst others to increases in efficiency of livestock production (industry and consumers), minimisation of the impact of animal production on the environment (government, NGOs, industry) and improving the welfare of companion animals (pet owners, industry).

With rising temperatures and sea levels, shifting ocean currents and weather patterns, climate change is a serious challenge facing the human race. The global livestock sector contributes a significant share (14.5%) to anthropogenic greenhouse gas (GHG) emissions, but it can also deliver a significant part of the necessary mitigation effort. Ruminant production accounts for the majority of the sector's emissions. Using our state-of-the-art climate respiration chambers, we have made significant contributions to understanding GHG, viz. CH<sub>4</sub> production by dairy cattle, whilst taking into account possible trade-offs with respect to other GHG, in particular changes in amount and source of N excretion leading to subsequent variation in N<sub>2</sub>O emissions. The large research programme secured by Dr Dijkstra (5 PhD students and 2 postdoctoral researchers) investigated/investigates mitigation strategies for CH<sub>4</sub> emission intensity (i.e., CH<sub>4</sub> produced per unit milk) by the quality of roughage and various additives e.g. nitrate and lipids. The data generated have been shared worldwide, e.g. the Feed and Nutrition Network of the Global Research Alliance to provide expert recommendations for future research priorities, methodologies, and science-based GHG mitigation solutions to governments and non-governmental organizations, advisory/extension networks, and the livestock sector. These data were incorporated in the official IPCC Tier 3 model to estimate methane production by dairy cattle and used annually by the Dutch national greenhouse gas emission inventory. The output of this extensive volume of research consists of an improved IPCC Tier 3 model, original peer reviewed research articles, scientific reviews, a patent, a FAO expert committee contribution, articles in industry magazines, media interviews and education of PhD, MSc and PhD scholars.

**Efficient utilisation of feed resources** is important as up to 80% of the costs associated with animal production are feed costs. Feeding the world in 2050 requires significant increases in food production including animal-derived foods making "resource use efficiency" a key societal issue in the near future. ANU has been contributing to efficient utilisation of feed resources for many years by assisting industry and government in their goals to reduce mineral and N pollution. The long-standing collaboration with industrial partners (Nutreco, ForFarmers, Agrifirm, Cargill, de Heus, DSM) has been intensified (incl. secondment of industry staff) and several of our industry-funded PhD scholars have published articles on novel ways to improve feed efficiency either through feed technology, improved understanding of digestion/fermentation/metabolism or the use of feed additives. Our industry collaborations have culminated in the integration of the Centraal Veevoeder Bureau (CVB) activities, the feed evaluation activities of the Product Board Animal Feeds, into CAN as well as Top Sector funding (Feed4Foodure, Breed&Feed4Foodure).

Our **companion animal research** has contributed to the current **paradigm shift occurring in the nutrition of cats and dogs**. Via peer reviewed journal articles, magazines, interviews, invited key note addresses, conference presentations, education of PhD and MSc students etc., we have influenced/informed the general public, pet owners, veterinarians and pet food companies of the importance of high protein diets for these true carnivores. We have raised the awareness of the omnivorous dog dogma persisting in our

society. Our research has contributed to increasing the protein content of commercial cat and dog foods by the largest pet food manufacturer in the world.

#### 4.1 Demonstrable products - Research products for societal target groups

*Animal Nutrition Industry:* The public private partnership Feed4Foodure established in 2013 as well as the secondment of industry staff has made ANU/CAN a focal point for industry. These collaborations assist to further improve the interaction with our Dutch industrial stakeholders, not only discussing research finding but also research needs.

*General society:* Of particular note is our contribution to four expert committees of the Food and Agricultural Organisation of the United Nations (FAO) in the past six years. ANU staff have acted as experts for specific court cases related to animal nutrition and ingredient use.

Table 4.1.1 Overview of output for societal target groups by year.

	Year						Total
	2009	2010	2011	2012	2013	2014	
Professional publications and output	13	3	8	8	7	16	55
Publications for the general public	1	0	2	0	0	0	3
Other research output	46	58	57	54	42	96	353

Table 4.1.2. Examples of output for societal target groups by ANU

Year	Output
<b>I. Professional publications and products</b>	
2009	E-learning book for Agricultural colleges to educate students in dairy cattle nutrition
2009	Solving the methane problem via feed. (in Dutch) <i>Veeteelt</i> , 26(9), 10-12.
2009	Nutrition the fastest way to reduce methane emission by ruminants (in Dutch), <i>De Molenaar</i> 114 (6), - p. 7 - 9.
2011	Dairying without methane emission is a utopia. (in Dutch) <i>Veeteelt</i> , 28(9), 34-35.
2011	Maze and fresh grass for methane reduction. (in Dutch) <i>Kennis Online</i> , 8 (June), 7.
2011	Simple calculation disproves protein fable of milk (in Dutch) <i>VoedingsMagazine</i> 24 (3), - p. 3
2011	<b>FAO Animal Production and Health Paper No. 14.</b> Quality assurance for animal feed analysis laboratories, Rome Italy. <a href="http://www.fao.org/docrep/014/i2441e/i2441e00.pdf">www.fao.org/docrep/014/i2441e/i2441e00.pdf</a>
2013	<b>FAO Animal Production and Health Paper No. 177.</b> Mitigation of greenhouse gas emissions in livestock production – A review of technical options for non-CO <sub>2</sub> emissions. FAO, Rome, Italy. <a href="http://www.fao.org/docrep/018/i3288e/i3288e.pdf">www.fao.org/docrep/018/i3288e/i3288e.pdf</a>
2013	<b>FAO Animal Production and Health paper No. 15.</b> The feed analysis laboratory: establishment and quality control, Rome Italy. <a href="http://www.fao.org/docrep/019/i3535e/i3535e.pdf">www.fao.org/docrep/019/i3535e/i3535e.pdf</a>
2014	Methane reduction: Possible without production loss. <i>All About Feed</i> , 22(10), 18-21.
2014	<b>FAO Expert working group</b> “Research Approaches and Methods for Assessing the Protein Quality for Humans” <a href="http://www.fao.org/3/a-i4325e.pdf">www.fao.org/3/a-i4325e.pdf</a>
<b>II. Publications for the general public</b>	
2009	Lowering green-house gas emission from cows, step by step. <i>Wageningen Update</i>
2011	Methane emission can be reduced. <i>Wageningen World</i> 3, p. 34-39
2014	The lignin refinery. (in Dutch) <i>Wageningen World</i> 2, p. 32-39.
<b>III. Other research output</b>	
2011	Becker, P.M., Wikselaar, P.G. van, Beekwilder, J., Krijnen, J., Pellikaan, W.F. & Cone, J.W. Target-oriented reduction of the methane emission of ruminants. (external report, Report / Wageningen UR Livestock Research, no 477). Lelystad: Wageningen UR Livestock Research.
2011	Haas, Y. de, Calus, M.P.L., Mulder, H.A., Haan, M.H.A. de, Bannink, A., Dijkstra, J., Windig, J.J. & Veerkamp, R.F. Genomic selection to improve feed efficiency and reduce methane emission. (External report, Rapport / Wageningen UR Livestock Research, no 450). Lelystad: Wageningen UR Livestock Research.

- 2012 Presentation of “Nutrition and Behaviour” for “DogVision”.
- 2014 Methane reduction: Possible without production loss. All About Feed 22(10) 18-21.
- 2014 Presentation to 120 primary school children (10-12 years) on “The menu card for cats and dogs”.

#### 4.2 Demonstrable use of products - Use of research products by societal groups

Table 4.2.1. Examples of use of research products by societal target groups of ANU

##### Tier 3 Mechanistic Rumen Fermentation model

Used nationally to calculate methane emission from dairy cattle in the Netherlands.

Used by international, Dutch-based feed companies to calculate feeding values of feed ingredients.

##### Overview first jobs/present jobs of alumni (domains)

All PhD students were employed within 1 month after graduation (often before graduation e.g. de Vries, Berends, Kapper, van Rooijen)

Overseas PhD students returning to their native country obtained (or already had) positions in academia, government or industry.

MSc students with specialisation Animal Nutrition readily obtain positions in industry, government or research institutes.

##### Post-graduate courses

Thirty post-academic courses (see Table 4.2) organised for industry staff, government employees, veterinarians, nutritionist, consultants, academics, teachers, etc. Courses included: Advances in feed evaluation science, The truth about pet foods, Pig nutrition, Poultry nutrition and management, Ruminant nutrition, Voluntary feed intake of farm animals, Gut health, and Healthy livestock production.

##### Erasmus Mundus programme Sustainable Animal Nutrition and Feeding

Coordinating institution of the EU funded Erasmus Mundus programme Sustainable Animal Nutrition and Feeding (<https://sites.wageningenur.nl/en/emsanf.htm>).

Table 4.2.2. Various societal indicators of the output of ANU over the period 2009-2015.

Societal indicators	2009	2010	2011	2012	2013	2014	Total
PhD graduates co-funded by industry	3	6	7	4	3	6	28
PhD graduates from developing countries	1		1	1	4	1	8
Patents	-	-	1 <sup>1</sup>	-	-	-	1
Post-graduate courses (1-5 days in length) <sup>2</sup>	3	4	5	5	6	7	30

<sup>1</sup>[https://www.lens.org/lens/patent/WO\\_2011\\_010921\\_A2](https://www.lens.org/lens/patent/WO_2011_010921_A2)

<sup>2</sup> [www.wageningenur.nl/en/Education-Programmes/wageningenacademy-1.htm](http://www.wageningenur.nl/en/Education-Programmes/wageningenacademy-1.htm)

#### 4.3 Demonstrable marks of recognition - Marks of recognition by societal groups

Table 4.3. Examples of marks of recognition by societal target groups of ANU.

##### Collaboration with industry

Four international feed/additive companies have scientific staff seconded to ANU. Prof L. den Hartog's position is funded by industry.

##### ANU expertise requests

Three times as experts for specific court cases related to animal nutrition and ingredient use.

~15 times to provide expert opinion for radio and television.

Participated in committees and civil society advisory bodies. Examples: Food and Agricultural Organisation (FAO) of the United Nations (see Table 4.1.2), Committee of Expert for Manure Management, Independent Council for the Welfare of Animals, scientific advisor for SofiProteol (a French cooperative of the oil seed industry), Chairman of the Scientific Advisory Board of the Dutch Mink Industry, expert of the Committee on amino acids for the European Petfood Manufacturers Association, Feed Evaluation activities of the Product Board Animal Feeds.

**Prizes**

Prof den Hartog received the biyearly award by Molenaar magazine in the Benelux for contribution to the Feed Industry.

**Newsletter**

The Centre for Animal Nutrition distributes quarterly a newsletter to over 1,400 recipients ([www.anu.wur.nl/uk](http://www.anu.wur.nl/uk)).

**5. Viability****5.1 Benchmark**

*International benchmarking:* Three renowned Universities were selected based on similarity in animal nutrition activities, and international ranking in the agricultural area. In 2014, the ISI web of knowledge database rates the University of California–Davis, USA (DAV), University of Illinois–Urbana Champaign, USA (URB) and University of Århus–Denmark (AAR) as 8, 32 and 37 in the agricultural sciences (WUR ranked 6), and 9, 44 and 75 in plant and animal sciences (WUR ranked 14). QS top university ranking in agriculture and forestry ranks these universities 1, 28 and 51-100 (WUR ranked 2<sup>nd</sup>).

Each University conducts research on the nutrition of production animals, although differences exist in focus (e.g. companion animals, mink). Animal nutrition scientists (excluding PhD scholars and post docs) at the Department of Animal Sciences at these 3 Universities (see appendix 2) were identified whereafter one scientist at each university verified/corrected the list before SciVal was used to derive bibliometric data.

*Table 5.1.1. Selected output of ANU against international top animal nutrition groups for 2008-2013.*

Item*	2008	2009	2010	2011	2012	2013	Average
<b>Number of publications</b>							
ANU	41	25	42	47	56	56	45 (3.7)
University of Århus	34	43	71	41	77	59	54 (3.4)
University of California Davis	53	47	48	37	45	34	44 (4.4)
University of Illinois–Urbana Champaign	34	56	60	60	71	85	61 (3.1)
<b>Citation per publication</b>							
ANU	17.0	14.0	6.3	11.8	5.7	3.7	9.0
University of Århus	16.9	18.4	10.6	9.4	4.5	4.5	9.6
University of California Davis	15.2	13.1	9.0	5.6	3.6	3.7	8.9
University of Illinois–Urbana Champaign	22.9	18.7	13.2	10.5	6.8	3.5	11.0
<b>Field weighted citation impact</b>							
ANU	1.4	1.2	0.8	2.1	1.7	1.6	1.5
University of Århus	1.3	1.9	1.1	1.2	1.1	1.8	1.4
University of California Davis	1.3	1.2	1.2	0.9	0.9	1.2	1.1
University of Illinois–Urbana Champaign	1.7	1.4	1.4	1.6	1.5	1.6	1.6

\*n=12, 16, 10 and 20 for ANU, AAR, DAV and URB (see appendix 2 for names).

Comparing data per scientist (data between brackets) shows DAV researchers (average 4.4) to be the most productive followed by ANU (3.7). Values for AAR and URB are 3.4 and 3.1, respectively. Noticeable is the increase in productivity of ANU, AAR and URB against DAV researchers, the latter publish less articles per scientist over time. URB obtains the most citations per publication (11.0) followed by AAR and ANU and DAV. The field weighted citation impact shows URB, ANU and AAR to have similar values (1.6-1.4) with DAV scoring only a 1.1.

*Benchmarking against previous period:* Compared to the previous review period (2003-2008), peer reviewed publications and total publication increased with the number of these remaining constant. Top 1 and 10% publications increased but above all the relative impact increased to 1.6. ANU now publishes more articles in Q1 journals.

*Table 5.1.2 Selected output of ANU against the previous period (2003-2008).*

Parameter	2003-2008	2009-2014
Peer reviewed publications	272	329
PhD graduations/yr	6.5	6.2
Total scientific publications/yr	67.5	84.5
Top 1 and 10% publications*	0 and 17%	3 and 19%
Relative impact (RI)*	1.30	1.60
Quartile 1 and 2 publications*	52 and 34%	70 and 23%

\*Data 2003 not available.

The overall conclusion of the benchmarking is that ANU rates among the top animal nutrition groups in the world and that there has been a strong increase in productivity over the past period.

## 5.2 SWOT-analysis

The research strategy of ANU, annually reviewed and modified, is working well. All recommendations made by the previous peer review committee have been implemented. Research funding has increased; especially prestigious NWO and EU grants and the collaboration with industry has been taken to a new level as evident by the co-financing of projects, incorporation of the activities of the Centraal Veevoeder Bureau (CVB), the feed evaluation activities of the Product Board Animal Feeds within the Centre and secondment of industry staff to ANU. Output in terms of scientific publications, number of PhD students and societal impact has also increased again. PhD scholar per scientific staff member has decreased as well as staff workload due to the increase in the number of scientific staff. Constant attention is required, however, to ensure manageable workload of staff in relation to the goals set.

CAN has been invaluable in achieving the goals and will be essential for future development in terms of funding, output and workloads. Continuation of leadership of the group at Utrecht University is essential for development of the Centre and ANU as well for achieving optimal performance.

The continued high demand of industry for our PhD/MSc students ensures rapid employment, often before graduation. This high demand, however, is hampering our development of Veni-grants awarded to individuals as our top PhD scholars are rapidly employed by industry. The secondment of research staff by industry to our chair group has made the Centre a focal point for internationally operating feed manufacturers and feed additive companies.

The changes in policy by the Dutch government towards research and education funding provide both an opportunity and a threat. Opportunities for fundamental research funding are reducing while applied research will be more linked to industry-priorities. ANU is well-positioned to take advantage of this shift in focus but will also encounter more competition for its more fundamental research proposals. Overall, however, the change in government policy is regarded as an opportunity for ANU.

Animal nutrition research remains costly in terms of facilities and laboratory. Our strong attitude towards development of research proposals needs to be maintained. Age and gender distribution of staff is of concern, and when possible, corrective action will be taken. Already a young scientist was appointed to take up the position of a, soon to, retire staff member.

Internal organisation	Strengths	Weaknesses
	<ul style="list-style-type: none"> <li>• High quality staff, unique (and new) facilities and novel ideas</li> <li>• Strong research focus and proposal development attitude</li> <li>• Always meet budgetary target</li> <li>• "Feed" prominent in the WUR strategy and strong support for the Centre/ANU</li> <li>• Centre for Animal Nutrition</li> <li>• Rapid employment of animal nutrition graduates (PhD and MSc)</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of Veni-funded scholars due to high industry demand</li> <li>• Costs associated with animal experimentation incl overhead</li> <li>• Gender and age distribution of staff</li> <li>• Reduced remuneration per student by the University</li> </ul>

External context	Opportunities	Threats
	<ul style="list-style-type: none"> <li>• Increase demand for animal derived protein</li> <li>• Increased focus on “resource efficiency”</li> <li>• EU funding “Horizon 2020”</li> <li>• Attractiveness of ANU to international feed and additive companies</li> <li>• Shift from fundamental to applied research funding in the Netherlands</li> <li>• High demand for animal nutrition graduates</li> <li>• Further consolidation of animal nutrition research in the Netherlands and Europe</li> </ul>	<ul style="list-style-type: none"> <li>• Animal nutrition research costs are marginally covered by fundamental research funds</li> <li>• Loss of independent University status due to industry involvement</li> <li>• Governmental priorities regarding Universities and research funding</li> </ul>

### 5.3 Future strategy

*Research focus in the coming period:* Our focus and expertise on following dietary nutrients as they are broken down (digested or fermented), absorbed and metabolised by animals (production or companion) will remain highly applicable to societal challenges.

*Continued development of the Centre:* A new strategic plan for CAN has been developed where targets and goals are set for 2015-2018, taking into account internal and external changes to our research and education environment. Amongst others, CAN will focus on strengthening its international position in animal nutrition, further integration, closely aligning to industry and contributing to the strategic themes of WUR. ANU’s policy on publishing all our research will be continued and transparency of procedures and activities will be continued to maintain our independent status. Industry collaboration (non-exclusive and non-discriminatory) will be continued as long as collaborators adhere to full publication and transparency of research results.

*New opportunities:* “Feed” was added to the new strategic plan of Wageningen UR, providing ANU with new opportunities. This stronger focus is brought on by the increased realisation of the finality of global resources, a focus on a bio-based economy and sustainability concerns of animal production. As such, major themes within the WUR strategy will involve animal feed ingredients. Competition of resources used for food, feed, fuel and fibre will place ANU at the heart of these opportunities. Within the European Union, several thematic research areas align well with ANU’s focus/expertise e.g. resource use efficiency, bio-economy, animal health, and waste and by-product valorisation. Within the Netherlands, the focus towards increased funding of industry priorities via the Top Sector policy of the government is favourable for ANU and the CAN. Already research funding for the Feed4Foodure (2.1 mEuro/yr) as well as the Breed&Feed4Food (1.1 mEuro/yr) programmes were secured. In 2015-2016, a large STW programme (co-funded by DSM) will be developed providing opportunities for several PhD programmes. ANU will strive to continue the Erasmus Mundus Master course (EM-SANF) with funding of the European Union and industry. We will apply for a European Industrial Doctorates under the Marie Skłodowska-Curie Actions of Horizon2020 with our industry partners and two partners of the EM-SANF.

Our facilities to conduct nutritional research are excellent, and with our existing collaborations within WUR, industry and international research groups, we can conduct our future research. ANU has to be vigilant to maintain its status as an independent research provider especially in light of its close collaboration with industry.

*Human resource development:* Our proactive culture to secure funding from various sources will be instrumental to capitalise on future opportunities. ANU has excellent staff who work as a team. Continuous development of capabilities of tenured staff and attracting highly skilled post-doctoral fellows will ensure that ANU remains an “interesting” research provider to various societal groups. Staff motivation is (and will be) given constant attention. Succession planning at all levels within ANU (incl. the chair) is a major part of our human resource management. To obtain Veni proposals, early identification of high potentials will be intensified including obtaining funding (WIAS, industry) to continue employment after graduation to write grants. Secondment of an eminent researcher from a global pet food company to ANU will be realised within the near future. Issues of gender and age balance will be addressed when opportunities arise.

## 6. Research Integrity

We follow the principles of “Research integrity” as provided in the WIAS documentation including Code of conduct of scientific practice, Wageningen UR integrity code, Animal Care and Use Committee, recommendations for co-authorships and data management. Our data management protocols (available on request) ensure protected and traceable storage of all original and other data (e.g. statistical output). In case research results deviate flagrantly from the prevailing scientific context, data will be thoroughly/independently checked (reanalysed if required) before results are submitted for publication. Starting PhD scholars are assigned a daily supervisor(s), receive the “ANU PhD Guide” (available on request) and a “buddy” (senior ANU PhD scholar). ANU members have an open-door policy and supervision is tailor-made to ensure development of the scholar to become an independent scientist. The ANU PhD council has monthly meetings with two tenured ANU scientific staff. The culture is open and informal with regular social events, allowing staff and scholars to interact. In case of (potential) issues, we stimulate ANU members to contact a confidence person from WIAS or the University, information which is also provided in the ANU PhD guide.

We firmly maintain our scientific independence. The following is an excerpt of the final evaluation report of an EZ/NWO-ALW programme: “The researchers really tried to find other ways than scientific media to communicate to the public. They did publish a couple of newspaper articles, even though that caused some friction with the industry. This showed that the researchers maintained their independence”.

**Appendix 1** - Research staff Animal Nutrition group

Table 1 - Research staff input at Chair Group level

<b>Name staff</b>		<b>Funding 1, 2, 3*</b>	<b>2009 FTE**</b>	<b>2010 FTE</b>	<b>2011 FTE</b>	<b>2012 FTE</b>	<b>2013 FTE</b>	<b>2014 FTE</b>
<i>Full professors</i>								
Prof.dr.ir. W.H. Hendriks (1 fte)	Tenured	1	0.24	0.24	0.24	0.24	0.24	0.24
<i>Special chairs</i>								
Prof.dr.ir. L.A. den Hartog (0.1 fte)	Tenured	3	0.05	0.05	0.05	0.05	0.05	0.05
Prof.dr. H.A.P. Urlings ( 0.1 fte)	Tenured	3	0.05	0.05	0.05			
<i>Associate professors</i>								
Dr. ir. A.F.B. van der Poel (1 fte)	Tenured	1	0.40	0.40	0.40	0.40	0.34	0.34
Dr. ir. W.J.J. Gerrits (0.8 fte)	Tenured	1	0.32	0.32	0.32	0.32	0.32	0.32
<i>Assistant professors</i>								
Dr. ir. J. Dijkstra (1 fte)	Tenured	1	0.40	0.40	0.40	0.40	0.40	0.40
Dr. ir. R.P. Kwakkel (0.5 fte)	Tenured	1	0.20	0.20	0.20	0.20	0.20	0.20
Dr. ir. W.F. Pellikaan ( 1.0 fte)	Tenured	1	0.40	0.40	0.40	0.40	0.40	0.40
Ir. M. Bruining (0.5 Fte)	15-05-1984/01-11-2010	1	0.20	0.17				
<i>Researchers</i>								
Dr. J.W. Cone (1 fte)	1-8-2008	3	0.13	0.13	0.13	0.13	0.13	0.75
Dr. J. van Baal ( 0.5 fte)	1-8-2013	3					0.53	0.90
Dr.ir. G. Bosch (1 fte)	1-9-2014	3						0.25
<i>Post-docs</i>								
Dr. J. van Baal ( 0.5 fte)	1-8-2007/31-7-2013	3	0.90	0.90	0.90	0.90	0.38	
Dr.ir. J.J.G.C. van den Borne (1 fte)	12-4-2006/1-5-2014	1,3	0.90	0.90	0.80	0.80	0.80	0.27
Dr E. Bruininx (0.2 fte)	1-3-2009	3	0.08	0.10	0.10	0.10	0.10	0.10
Dr. H. van Laar (0.1 fte)	1-3-2012	3				0.04	0.05	0.05
Dr. L. Marchal (0.2 fte)	1-11-2013	3					0.02	0.10
Dr.ir. G. Bosch (1 fte)	1-9-2010/30-8-2014	1,3		0.68	0.90	0.75	0.75	0.50
Dr. J. Ellis (1 Fte)	1-9-2010/20-12-2018	3		0.23	0.90	0.90	0.90	0.90
Dr. R. Kinley (1 fte)	01-06-2012 /18-05-2013	3				0.45	0.41	
Dr. P. Sakkas (1 fte)	01-10-2011 /28-02-2013	3			0.90	0.90	0.15	
<i>Visiting fellows</i>								
Dr N.A. Khan	06-07-2012 / 25-09-2012	3				0.15		
L. Alstrup	01-03-2012 / 30-04-2012	3				0.15		
Dr N. Baert	21-03-2013 / 10-06-2013	3					0.23	
D. Carreno	29-09-2014 / 27-11-2014	3						0.15
O. Esmaeilpour	24-06-2010 / Febr. 2011	3		0.45	0.15			
J. Geraldo de Lima	01-09-2013 / 31-10-2013	3					0.15	
A. Grosse Brinkhaus	01-09-2013/24-12-2013	3						0.08
S. Hook	01-09-2013 / 24-12-2013	3					0.23	
Dr M. Karonen	11-06-2013/31-07-2013	3					0.15	
Dr G. Keles	07-10-2013 / 2013-12-31	3					0.15	
E. Labussiere	02-03-2011 / 31-08-2011	3			0.45			
M. Mirzaei	15-10-2012 / 15-07-2013	3				0.15	0.53	
L.E. Moraes	07-2012 / 01-2013	3				0.38		
A. Pluschke	16-08-2012 / 30-12-2012	3				0.15		
Dr D.V. Tuyen	08-07-2010 / 08-07-2011	3		0.38	0.53			
Prof.dr.ir R. Zijlstra	18-08-2014 / 30-12-2014	3						0.26
<b>Total scientific staff</b>			<b>4.27</b>	<b>5.99</b>	<b>7.82</b>	<b>7.96</b>	<b>7.59</b>	<b>6.25</b>
<i>Support staff</i>								
Jonge, L.H. de	01-08-2002/	3	1	1	1	1	1	1
Laar-Schuppen, S. van	17-11-2003/	3	0.9	1	1	1	1	1
Breuer, M.	01-07-2010/	3		1	1	1	1	1

<i>Support staff continued</i>			2009	2010	2011	2012	2013	2014
Muijlaert, J.M.	01-10-1979/	3	1	1	1	1	1	1
Schans - Lé, X. vd	01-04-2009/	2,3	0.67	1	1	1	1	1
Beukers- Laar, E. van	01-09-2012/01-10-2015	3				0.1	0.62	0.62
Wissink, A.	01-11-2009/19-08-2015	3	0.84	0.84	0.84	0.84	0.84	0.84
Ambtman, H. den	03-02-2014/	3						0.48
Zandstra, T.	1-2-1982/	3	1	1	1	1	1	1
Alferink, S.	1-8-2002/	3	1	1	1	1	1	1
Velde, J. van der	17-10-2011 / 01-01-2015	3			1	1	1	1
<b>Total staff</b>			<b>10.68</b>	<b>13.83</b>	<b>16.66</b>	<b>16.90</b>	<b>17.05</b>	<b>16.19</b>

\* Funding scores: 1= direct funding by University; 2= funding obtained in national scientific competition (e.g. grants from NWO, KNAW) ; and 3= funding obtained from external organisations, such as industry, governmental ministries, European Commission and charity organisations.

\*\* FTE reported in this table regards the research appointment part of the total appointment (e.g. tenured staff has 40% available for research, postdocs have 60% available for research).

**Appendix 2** - Scientist for benchmark Animal Nutrition group**Table II.** Scientist selected at University of California (DAV), University of Århus (AAR) and University of Illinois (URB) for benchmarking ANU.

<b>ANU</b>	<b>DAV</b>	<b>URB</b>	<b>AAR</b>
Bosch, G.	Calvert, Christopher C.	Cardoso, Felipe C.	Blaabjerg, K.
Cone, John W.	Depeters, Edward J.	Clark, Jimmy H.	Hvelplund, Torben
Den Hartog, Leo A.	Fadel, James G.	Dailey, Megan J.	Jensen, Søren Krogh
Dijkstra, J.	Hung, Silas	Dilger, Ryan N.	Jørgensen, Henry H.
Gerrits, Walter J. J.	Kebreab, Ermias	Drackley, James K.	Knudsen, Knud Erik Bach
Hendriks, Wouter H.	Klasing, Kirk C.	Easter, Robert A.	Kristensen, Niels Bastian
Kwakkel, René P.	Oltjen, James W.	Emmert, Jason L.	Larsen, Mogens K.
Pellikaan, Wilbert F.	Robinson, Peter H.	Fahey, George C.	Lund, P.
Van Baal, Jürgen	Sainz, Roberto D.	Felix, Tara L.	Lærke, Helle Nygaard Ygaard
Van Den Borne, Joost J. G. C.	Zinn., Richard Avery	Garlick, Peter J.	Nørgaard, Jan Værum
Van Der Poel, Antonius F. B.		Hutjens, Michael F.	Poulsen, Hanne Damgaard
Verstegen, Martin W. A.		Loor, Juan Jose	Sehested, Jakob
		Merchen, Neal R.	Steenfeldt, Sanna
		Murphy, Michael R.	Theil, Peter Kappel
		Parsons, Carl M.	Vestergaard, Mogens
		Pettigrew, James E.	Weisbjerg, Martin Riis
		Robinson, James L.	
		Shike, Daniel W.	
		Stein, Hans Henrik	
		Swanson, Kelly S.	

## Animal Production Systems (APS)

### Programme leader(s):

2011-today	Prof. I.J.M. de Boer (official start 1-9-2011)
2010-2011	Prof. P.W.G. Groot Koerkamp (interim)
2000-2010	Prof. A.J. van der Zijpp

Since the previous peer review, internal leadership, mission, research strategy, and objectives of the Animal Production Systems group (APS) have changed. Prof. dr ir A.J. van der Zijpp, who chaired APS since 2000, retired in June 2010. From June 2010 until September 2011, Prof. dr ir P.W.G. Groot Koerkamp managed the APS group ad interim. In September 2011, Prof. dr ir I.J.M. de Boer started as head of APS. Since her start, the profile of the APS chair group has changed significantly. The vision, research aims, and objectives, described in this document, represent the current situation of APS. For a full staff survey see appendix 1.

### 1. Objectives and Research Area

#### 1.1 Vision, Mission and Objectives

Innovations in livestock systems are needed to meet the global challenge of producing enough animal-source food in a sustainable way. The *vision* of APS is to contribute to evidence-based innovation towards sustainable development of animal production systems. The *mission* of APS is to provide an integrative analysis to underpin sustainable innovation in animal production. Our *objective* is to explore the multi-dimensional, and sometimes conflicting, consequences of innovations (trade-offs and synergies) in livestock systems across the world, with special focus on their impact on the *environment* (i.e. efficient use of resources and on emissions to air, water and soil), *animal welfare* (i.e. behaviour and health) and *livelihood of people* (i.e. farm income, volatility, employability, and food security).

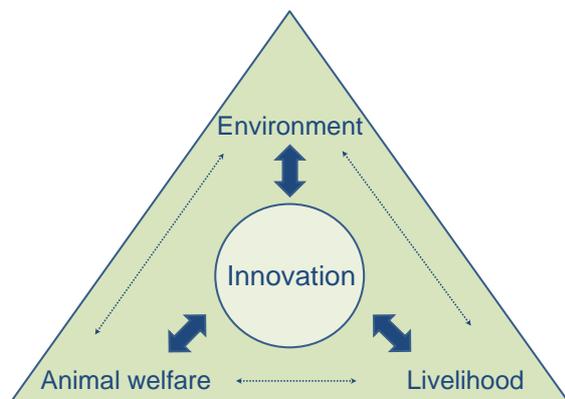


Figure 1. Focus of APS integrated system analysis.

#### 1.2 Research Area / research line(s)

A systems approach is vital to unravel complex livestock systems and assess multi-dimensional consequences of innovations. Our research and teaching approach, therefore, is rooted in systems analysis, and combines empirical knowledge and model development to reveal *trade-offs* and *synergies* among the impact of an innovation on the environment, animal welfare and livelihood of people. Using a combination of bio-economic modelling and life cycle assessment, for example, we explored the cost-effectiveness of feeding strategies to reduce greenhouse gas emissions in dairy production. We also developed improved feeding strategies for veal calves, by combining experimental data on health, welfare, and feed utilization with bio-economic modelling. We invest in novel approaches, such as agent-based modelling to explore trade-offs between animal welfare and productivity, or biophysical models to explore “yield gaps” in global livestock systems. The societal problems addressed require analysis at farm, regional and chain levels.

Our focus on livestock value chains, however, is unique in farming systems research. In addition to a farm or regional analysis, a chain analysis is essential to our approach, because specialization and globalization

disconnected stages along the livestock value chain. We want to analyze how changes at the farm level connect to changes along the entire chain, in their impact on the environmental impact, animal welfare, and the livelihood of people.

### 1.3 Strategy

Based on recommendations of the previous peer review, and on our own research strengths, our renewed ambition is directed at the integrative, multidisciplinary analysis of system innovations, with a special focus on their impact on the three domains: environment, animal welfare, and livelihood of people. To realize this ambition, we need sufficient and high-quality staff focusing on development of methods in each of these three domains (see below), and we need high-quality PhD projects exploring consequences of innovations between domains.

*Environment:* prof. de Boer, dr Gerber, dr van Middelaar, ir van Zanten (1.18 FTE)  
*Animal welfare:* dr Bokkers, dr Van Reenen (0.48 FTE)  
*Livelihood of people:* dr Oosting, dr Ripoll-Bosch (1 FTE)

#### *Past performance*

We developed an improved research objective and strategic plan, which is vital for the future of our group, and appointed Van Middelaar, Ripoll-Bosch, and Van Zanten to staff our vacant positions. We also successfully invested in PhD funding; we currently (co)supervise 31 PhDs, of which 25 started after 2010. Origin of PhD funding has remained almost unchanged, implying we were successful in raising projects by direct funding from the university, research grants, and contract research. We invested in committed PhD supervision, which significantly increased not only the *number*, but also the *quality* of scientific output. Dr Oosting entered the tenure track as associate professor in July 2014, dr Gerber became visiting professor in June 2014, and dr Bokkers will be appointed personal associate professor in 2015, guaranteeing a sound mix of leading and young research staff in each domain.

#### *Future outlook*

During the coming years we will build on our renewed focus and implement further our strategic research plan. We aim to maintain our current success in PhD funding and supervision, pointing towards a sound scientific output in the years to come. We support the entry of our three young staff members into tenure-track, guaranteeing the viability of our group. We aim to maintain a number of longer-term Post Doc positions by investing in personal grants. We envision including a personal professorship in “Tropical livestock production” (dr Oosting), and an endowed professor in “Global challenges for natural resource use efficiency in livestock systems” (dr Gerber). Overall, we have sufficient foundation to become one of the leading groups in our domain.

### 1.4 Research environment and embedding

APS is one of five members of the cluster Adaptive Animals and Systems, where joint research initiatives are developed on adaptation of animals and systems to challenges in their environment. We support and help each other, and share research facilities. We are a sounding board to increase opportunities and effectiveness, and to minimise risks. APS is embedded furthermore in the Wageningen Centre for Agroecology and Systems Analysis (WaCASA). WaCASA is a unique research and education initiative within Wageningen UR to develop and apply systems analysis approaches to the urgent and pressing problems facing agricultural systems today. The initiative was founded by the chair groups Plant Production Systems (Prof. K.E. Giller) and APS (Prof. I.J.M. de Boer) in 2011. WaCASA has a joint strategy for research and acquisition initiatives, monthly meetings of staff to exchange research findings and ideas, and regular meetings of the management to plan future collaboration.

Our interdisciplinary nature implies that **all** PhD projects include co-supervision with one or two other chair groups within Wageningen University (natural and social sciences); within Livestock Research; with research groups within Europe (e.g. Teagasc, SIK, INRA, Nofima, Matis, SEI, Aarhus University); and with international research organizations (FAO, ILRI, CSIRO) or universities (Egerton University, University of Venda, University of Stellenbosch). Most of our scientific publications, therefore, are co-authored with one of these groups (Figure 2). Our PhDs are embedded in the graduate schools WIAS, PE&RC, and WASS.

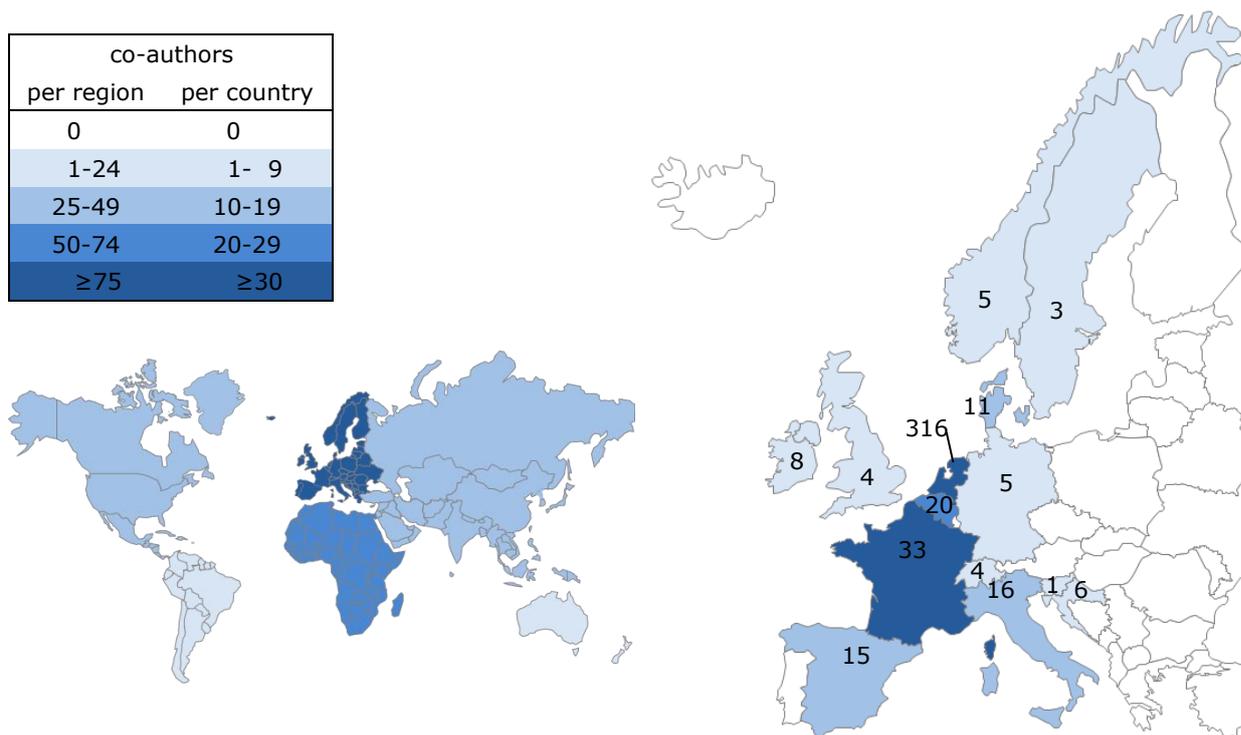


Figure 2. Global distribution of co-authors.

To strengthen our international position, we also invested in hosting PhDs and Post Docs for several months to work on joint papers. Since 2011 we hosted seven researchers from Technical University of Munich; INRA; University of Milan; CITA Zaragoza; Embrapa Brazil; Gadjah Mada University and the Leibniz-Institute for Agricultural Engineering, Potsdam-Bornim. This collaboration so far resulted in five joint published papers, a new staff member (Ripoll-Bosch, CITA Zaragoza), and a common EU application for Horizon2020.

### 1.5 Reference to previous assessments

The recommendations of the **2009 WIAS peer review** were taken into account during the development of the new strategic plan, and they are embedded, therefore, in our current strategy.

Specific comments were:

1. *It is recommended that the group continues to concentrate on world leading multidisciplinary research, including economic and social analysis, with an increase in volume of publications and a deliberate strategy of increasing impact and hence citations.*
2. *The strategy for the future takes into consideration Dutch government, EU and international preoccupations with greenhouse gas reduction, living with environmental change and balancing these with economic costs and animal welfare.*
3. *The Peer-Review Committee viewed a report of the "Structure Committee" on APS for the appointment of a new chair. It was felt that the Structure Committee needs to give more definitive advice concerning the future development of APS. There is a need for clarity concerning future strategies.*

As pointed out in description of the adapted vision and research objective, our current focus is directed exactly at integrative, multidisciplinary research (comment 1), with a special focus on the impact of an innovation on resource use efficiency, emissions to the environment, animal welfare and profitability (comment 2). We fully realize that development of sustainable animal food chains in the world includes many more aspects than the ones we now focus on in our chair group, aspects such as social embedding, landscape quality or the role of governance. A sound scientific exploration of the impact of an innovation on each domain (i.e. environment, animal welfare and livelihood) along the chain, however, requires a minimum critical mass, justifying our choice for this focus in the years to come (comment 3). We will build

on and expand cooperation with other research groups, with knowledge about social embedding, landscape quality or the role of governance (e.g. Knowledge Technology and Innovation) to contribute to a sustainable supply of animal-source food.

To increase the volume and quality of our scientific output (comment 1), we successfully invested in 31 new PhD projects within our new research domain. Results of this investment are clearly visible: we more than doubled our publication output in 2009-2013 compared with 2003-2008, while increasing the quality of our publications (see section 3 on page 6). We expect even further growth from 2014 onwards.

The **2012 WIAS midterm review** recommended to continue growth in line with the newly developed strategic focus, which is exactly what we did. The review also recommended to develop an intentional communication strategy to share the group's work with the wider public. We fully acknowledge the importance of sharing knowledge with the wider public, but we also realize that at this stage of our development only activities that contribute to our core activities and to knowledge sharing are feasible. We, therefore, are pleased that our ministry recently decided to support our idea financially to develop a MOOC (Massive Open Online Course) on systems analysis for sustainable food systems. Moreover, we decided to increase engagement with society, via participation in debates, symposia, and food events. Our increased engagement with society already increased our appearance in popular media, newspapers, blogs and internet news sites, professional magazines, and radio (see section 4 on societal impact).

## 2. Resources and Facilities

### 2.1 Researchers

Total research input increased from 9.0 FTE in 2009 to 16.8 FTE in 2014, which resulted mainly from an increase in the number of PhDs (Table 2.1). During the review period, 31 new PhDs started their research under guidance of APS staff (25 after 2010), of which 7 are located externally (not in Table 2.1). We also observe a decrease in scientific staff, due to retirement, the vacancy of the former position of Prof De Boer, and an anticipated career change of a former staff member. We were unable to find high-quality senior staff trained in the field of systems analysis. We tackled this temporary unbalanced PhD:staff ratio in three ways: by facilitating active involvement of retired staff; by establishing strategic collaborations regarding PhD supervision (with Livestock Research and Plant Production Systems), and by hiring and investing in high-potential Post Docs, who only co-supervise a PhD student under guidance of a senior staff member. This strategy appeared to be very successful. Our PhD:staff ratio, moreover, will normalize as we officially linked Dr van Reenen and Dr Gerber to our group and as we appointed three young staff members in 2015.

Table 2.1. Research input: number<sup>1</sup> and FTE<sup>2</sup> of Scientific staff, Post-docs and PhD candidates by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff <sup>4</sup>	6	1.9	6	1.8	6	1.7	5	1.7	5	1.2	5	1.2	6	1.57
Post-docs <sup>5</sup>	0	0.0	0	0.0	1	0.2	1	0.5	3	1.0	4	2.1	2	0.62
PhD candidates <sup>3,6</sup>	12	7.1	13	9.0	16	9.8	20	11.4	20	13.4	22	13.4	17	10.69
<b>Total research staff</b>	<b>18</b>	<b>9.0</b>	<b>19</b>	<b>10.8</b>	<b>23</b>	<b>11.7</b>	<b>26</b>	<b>13.5</b>	<b>28</b>	<b>15.5</b>	<b>31</b>	<b>16.8</b>	<b>24</b>	<b>12.89</b>
Lab Technicians	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.00
Visiting fellows	0	0.0	3	0.7	0	0.0	1	0.2	2	0.5	0	0.0	1	0.27
<b>Total staff</b>	<b>18</b>	<b>9.0</b>	<b>19</b>	<b>10.8</b>	<b>23</b>	<b>11.7</b>	<b>26</b>	<b>13.5</b>	<b>28</b>	<b>15.5</b>	<b>31</b>	<b>16.8</b>	<b>24</b>	<b>12.89</b>

<sup>1</sup> Total number of staff and PhD candidates

<sup>2</sup> Available research time in full time equivalent (FTE)

<sup>3</sup> All PhD categories, except external PhDs

*Standards for Research Capacity (in case of part time appointment adjustment is applied):*

<sup>4</sup> *Professor, Assistant Professor and Associated Professor: Research Capacity = 40% of the appointment*

<sup>5</sup> *Post-doc: Research Capacity = 60% of the appointment*

<sup>6</sup> *PhD candidate: Research Capacity = 75% of the appointment (all categories)*

## 2.2 Research Funds

Compared with the previous peer review, funding **more than doubled** from 5.1 FTE/yr to 12.9 FTE/yr (Table 2.2), while the relative contribution remained almost unchanged for direct funding, research grants and contract research. Because we do not expect an increase in financial support by the university, we will further develop our efforts to obtain personal, industrial, and international research grants.

*Table 2.2. Funding of Scientific staff, Postdocs and PhD candidates by year and Expenditure of Chair group by year.*

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
<i>Funding:</i>	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%
Direct funding <sup>1</sup>	3.4	38	3.1	29	3.1	27	3.2	24	5.3	34	6.7	39	4.1	32
Research grants <sup>2</sup>	0.7	7	1.4	13	1.7	14	2.0	15	1.3	9	1.2	7	1.4	11
Contract research <sup>3</sup>	4.9	55	6.3	58	6.8	59	8.3	62	8.9	58	9.0	54	7.4	57
<b>Total funding</b>	<b>9.0</b>	<b>100</b>	<b>10.8</b>	<b>100</b>	<b>11.7</b>	<b>100</b>	<b>13.5</b>	<b>100</b>	<b>15.5</b>	<b>100</b>	<b>16.8</b>	<b>100</b>	<b>12.9</b>	<b>100</b>
<i>Expenditure<sup>4</sup>:</i>	K€	%	K€	%	K€	%	K€	%	K€	%	K€	%	K€	%
Personnel costs	687	69	727	69	792	73	855	70	951	68	1,015	70	838	70
Other costs	307	31	326	31	298	27	368	30	444	32	445	30	365	30
<b>Total expenditure</b>	<b>994</b>	<b>100</b>	<b>1,054</b>	<b>100</b>	<b>1,090</b>	<b>100</b>	<b>1,223</b>	<b>100</b>	<b>1,395</b>	<b>100</b>	<b>1,461</b>	<b>100</b>	<b>1,203</b>	<b>100</b>

<sup>1</sup> *Direct funding by the University*

<sup>2</sup> *Research grants obtained in national and international scientific competition (e.g. grants from NWO, KNAW)*

<sup>3</sup> *Research contracts for specific research projects obtained from external organisations, such as industry, governmental ministries, European Commission (including ERC), charity organisations*

<sup>4</sup> *Expenditure from financial system of Wageningen University which not only includes research but also teaching and other activities*

## 3. Research Quality

One goal of the APS staff was to increase the number of publications of high quality. We invested, therefore, in high-quality PhD projects and in their committed supervision. The comparison of statistics between the previous and present peer review (see below) reveals that we almost doubled our annual scientific output in terms of refereed articles in peer-reviewed journals and PhD graduations. At the same time, we also succeeded to increase the quality of our papers as reflected by an increase in % of Q1 publications, a decrease in % of Q4 publications, an increase in % of publications published in high-ranking journals and an increase in relative impact (RI).

*Table 3. Selected output of APS against the previous period (2003-2008).*

Parameter	Previous review	Present review*
Refereed articles (in Web of Science)/year	13 (9)	23 (16)
% of Q1 publications	43	61
% of Q4 publications	11	3
% publications in high ranking journals (impact factor >3)	2.5	19
Relative impact (RI) of publications	1.2	1.7
No of PhD graduates/year	1.5	2.7

\*Statistics are given in Table 3.1 and 3.2

Given our current success in obtaining PhD grants (25 new PhDs since 2011), we aim at 4 or 5 PhD defences annually. Given the fact that most PhDs started since 2011, we expect an even further increase in scientific output and aim for a RI (relative impact) of our publications of about 2 (value in 2013).

#### Five key publications (Top 1% or Top-10% publications)

- De Vries, M. and I.J.M. de Boer. 2010. Comparing environmental impacts for livestock products: a review of life cycle assessments. *Livestock Science* 128: 1-11 (cited 114 times; top-10 most downloaded ScienceDirect articles by Netherlands-based authors; RI\*: 14.98; **Top 1% publication**).
- De Vries, M., E.A.M. Bokkers, T. Dijkstra, G. van Schaik and I.J.M. de Boer. 2011. Associations between variables of routine herd data and dairy cattle welfare. *Journal of Dairy Science* 94: 3213-3228 (RI: 2.87; **Top 10% publication**).
- Udo, H.M.J., Aklilu, H.A., Phong, L.T., Bosma, R.H., Budisatria, I.G.S., Patil, B.R., Samdup, T. and B.O. Bebe 2011. Impact of intensification of different types of livestock production in smallholder crop-livestock systems. *Livestock Science* 139: 22-29 (RI: 2.94; **Top 10% publication**).
- Van Middelaar, C.E., C. Cederberg, T.V. Vellinga, H.M.G. van der Werf and I.J.M. de Boer. 2013. Exploring variability in methods and data uncertainty in carbon footprint of feed ingredients. *International Journal of Life Cycle Assessment* 18: 768-782 (RI: 6.50; **Top 10% publication**).
- De Vries, J.W., C.M. Groenestein and I.J.M. de Boer. 2012. Environmental consequences of processing manure to produce mineral fertilizer and bio-energy. *Journal of Environmental Management* 102: 173-183 (RI: 3.65; **Top 10% publication**).

\* RI: Relative Impact. The number of citations to publications compared to the world average of citations to similar publications.

### 3.1 Demonstrable products - Research products for peers in science

Table 3.1. Categories of research output by year.

Category:	Year						Total	Average 2012-2014
	2009	2010	2011	2012	2013	2014		
<b>Academic publications</b>								
a. Refereed articles	13	11	27	26	25	37	139	23
b. Non-refereed articles	0	0	1	0	0	0	1	0
c. Books	0	0	0	0	0	0	0	0
d.1. Refereed book chapters	1	2	3	3	0	1	10	2
d.2. Non-refereed book chapters	0	2	1	1	0	3	7	1
e. PhD Theses	3	1	0	2	3	6	15	3
f. Conference papers	4	9	7	7	8	15	51	8
<b>Total academic publications</b>	<b>21</b>	<b>25</b>	<b>39</b>	<b>39</b>	<b>37</b>	<b>62</b>	<b>223</b>	<b>37</b>

### 3.2 Demonstrable use of products - Use of research products by peers

APS produces an average of 16.3 peer reviewed articles per year in journals covered by Web of Science (Table 3.2.1). Since 2011, however, the number of peer-reviewed publications per year increased (from 2011 to 2013 the average is 23.3). Our 7 review articles in scientific journals were also published mainly after 2010. The average relative impact (RI) of our publications is with 1.7 above the world average, whereas on average 19% of our publications are in the Top-10% (%T10) and 3% are in the Top-1 % (%T1). The relatively high fluctuations in RI and % of Top-publications across years is caused mainly by lagging behind of publications from research started before our renewed focus. We do believe that our new research strategy, implemented since 2011, enables a stable RI around 2 (i.e. very good average impact) and a high % of Top-publications from 2013 onwards.

For an overview of the use of developed tools and insights, see section 4.

Table 3.2.1. Bibliometric indicators for APS over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	12	349	117	29.1	3.13	33% (4)	17% (2)
2009	9	69	82	7.7	0.93	11% (1)	0% (0)
2010	7	140	60	20.0	2.56	14% (1)	14% (1)
2011	24	201	141	8.4	1.44	21% (5)	0% (0)
2012	25	93	84	3.7	0.99	8% (2)	0% (0)
2013	21	60	30	2.9	2.09	29% (6)	0% (0)
<b>all years</b>	<b>98</b>	<b>912</b>	<b>514</b>	<b>9.3</b>	<b>1.70</b>	<b>19% (19)</b>	<b>3% (3)</b>

Table 3.2.2. Bibliometric indicators for APS per research field over the period 2008-2013. The rows are ordered in descending number of publications (N). The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

research field	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	41	317	223	7.7	1.51	15% (6)	2% (1)
Agricultural Sciences	32	276	143	8.6	1.54	16% (5)	3% (1)
Environment/Ecology	6	61	41	10.2	1.47	17% (1)	0% (0)
Social Sciences, General	7	74	35	10.6	1.65	29% (2)	0% (0)
Engineering	5	96	14	19.2	4.85	60% (3)	20% (1)
Chemistry	3	31	28	10.3	1.11	0% (0)	0% (0)
Biology & Biochemistry	1	16	7	16.0	2.45	100% (1)	0% (0)
Computer Science	1	2	4	2.0	0.52	0% (0)	0% (0)
Economics & Business	1	38	8	38.0	4.96	100% (1)	0% (0)
Pharmacology & Toxicology	1	1	11	1.0	0.09	0% (0)	0% (0)
<b>All fields</b>	<b>98</b>	<b>912</b>	<b>514</b>	<b>9.3</b>	<b>1.70</b>	<b>19% (19)</b>	<b>3% (3)</b>

### 3.3 Demonstrable marks of recognition - Marks of recognition from peers

Table 3.3. Most important prizes, keynotes etc. of staff. For remaining achievements see mini CVs (Separate file called mini CVs).

Science awards, Scholarly prizes, Research grants awarded to individuals		
Year	Award/Prize description	Person
2011	Travel award of ADSA (American Dairy Science Association) for best oral presentation at EAAP (European Association of Animal Production)	C.E. van Middelaar
2009	Travel award for best young researcher at Dutch Zoological Association (NVZ)	M. de Vries
2011	Travel award for best young researcher at Dutch Zoological Association (NVZ)	L.E. Webb
2013	Prize for best oral presentation at International Society of Applied Ethology	I.J.M.M. Boumans
2014	WIAS education prize for best PhD course 'Tropical Livestock Systems'	S.J. Oosting
2014	WIAS research grant; result: proposal for Technology Foundation STW	L.E. Webb
2014	Prize for best oral presentation at EAAP	H.H.E. van Zanten
2014	Prize for best oral presentation AAAP (Asian-Australasian Association of Animal Production Societies)	W.T.S. Mastuti
Plenary/Keynote* Lectures at major conferences		
Year	Person	Conference
2010	H. Udo	International conference on tropical animal production, Yogyakarta, Indonesia: <i>Sustainable intensification of smallholder systems.</i>
2011	I.J.M. de Boer	EAAP, Stavanger, Denmark: <i>Water footprint of livestock products.</i>
2012	S.J. Oosting	EAAP, Bratislava, Slovakia: <i>Constraints for livestock production development in the tropics.</i>

2012	I.J.M. de Boer	EAAP; Bratislava, Slovakia <i>Environmental impact of beef production systems.</i>
2014	C.E. van Middelaar	LCAFood conference: <i>Mitigating climate change from dairy production.</i>
2014	E.A.M. Bokkers	International conference on Nutrition, Health and Welfare of Calves, Wageningen, The Netherlands: <i>Solid feed: what do calves need and prefer to optimize their welfare</i>

#### Organisation of International Scientific Conferences

Year	Person	Conference
2008-2014	I.J.M. de Boer	LCAfood (bi-annual conference on life cycle assessment (LCA) of food; scientific committee)
2013	S.J. Oosting	Sustainable Animal Production in the Tropics, Nantes, France.
2015	R. Ripoll-Bosch	EAAP (Livestock Farming Systems Commission)
2015	P.J. Gerber	LCA for feeding the planet and energy for life (scientific committee).
2017	E.A.M. Bokkers	WAFL (Welfare Assessment at Farm Level; scientific committee)

#### Editorships and editorial boards

Person	
I.J.M. de Boer	Member of editorial board Agricultural Systems (2012-today)
H.J.M. Udo	Member of editorial board Small Ruminant Research (2009-today)
S.J. Oosting	Editor of Animal (2011-present)
H.J.M. Udo	Editor NJAS – Wageningen Journal of Life Sciences (2011-2013)
E.A.M. Bokkers	Member of editorial Board of Animal Behaviour and Welfare (special section of Frontiers in Veterinary Science; 2014-today)

#### Memberships of academies

Person	
I.J.M. de Boer/ S.J. Oosting	Members of SPAC “Science and Partnership Advisory Committee” of CRP 3.7 Livestock and Fish (2011-present)
E.A.M Bokkers	Member of International Society of Applied Ethology

#### 4. Relevance to Society

Our research generates knowledge that enhances a transparent societal and political debate about future options and limitations of sustainable animal production systems across the world. The research yields tools and insights that can be, and are being used by the industry or retailers to improve the sustainability of their products and by governments or institutions (e.g. FAO and ILRI) to evaluate scenarios for sustainable development. The **first area** of utmost societal relevance is **mitigation of environmental impact from livestock production, especially emission of greenhouse gases**. On the global scale, our research insights contributed to important FAO policy documents directed at tackling climate change by livestock (Gerber et al., 2013) and to development of global guidelines for environmental foot printing of feed production (LEAP guidelines, see Table 4.1). At the industry level, we contributed actively to the development of tools (see Table 4.2.1) that are used by companies or extension services to explore strategies that reduce the environmental footprint of animal-source food.

The industry is interested in our research not only in the area of environmental impact assessment, but also in the **second area** of societal relevance **improving farm animal welfare in practice**. We collaborated in an NWO-project that was supported by the veal calf industry, which resulted in novel feeding strategies for veal calves; these novel feeding strategies are currently applied in practice. We also contributed to training of advisors or auditors of animal welfare via the welfare quality network, which indirectly contributes to improving farm animal welfare.

The increased interest from the industry is reflected also by their increase in funding projects during recent years (Table 4.2.2). Besides raising interest of the industry, we also succeeded to raise interest of the EU, by obtaining EU funding for three PhD projects, which had not occurred since about 25 years (Table 4.2.2).

The **third area** of utmost societal importance is **capacity building in developing countries**, especially regarding to the role of livestock to alleviate poverty sustainably (Table 4.2.2). Seven former PhD

students, trained in the domain of livestock, livelihood and environment, currently have important positions at local universities or development foundations. These positions vary from dean of graduate school, academic vice president of a university, to senior executive of a development foundation (Bharatiya Agro Industry Foundation). These graduates, therefore, contribute to local education and creation of opportunities for livestock holders to improve their quality of life. We invest also in capacity building via our MSc and PhD education. About 50% of our MSc students originate from abroad, partly from developing countries. We contributed to three PhD courses during the review period, and coordinated an additional course in early 2015 (Table 4.1). In 2015, we will start development of a MOOC (Massive Online Open Course) that will offer freely-accessible training of future professionals in the domain of sustainable food production.

#### 4.1 Demonstrable products - Research products for societal target groups

Table 4.1 - Main categories of output for societal target groups.

Year	Description output	Societal group	Person(s) from APS
2013	Report - Tackling climate change by livestock	Livestock actors - politicians	P.J. Gerber
2015	Report – LEAP <sup>1</sup> guidelines	Global actors along livestock supply chains	P.J. Gerber I.J.M de Boer
20XX <sup>2</sup>	Training network Welfare Quality	Training advisors/auditors of welfare of farm animals	E.A.M. Bokkers; C.G. van Reenen
	<i>PhD courses</i>	<i>Cooperating groups<sup>3</sup></i>	
2011/13	Tropical Livestock Systems	WaCASA; KTI	S.J. Oosting; H.M.J. Udo
2014	Adaptation of Animals and Farming Systems	ADP; INRA	L.E. Webb
2015	Environmental Impact Assessment of Livestock Systems	FAO, Teagasc; VU; PBL Chalmers University	I.J.M. de Boer; C.E. Van Middelaar

<sup>1</sup> LEAP (Livestock Environmental and Performance Partnership) involves global stakeholders across livestock sectors, all of whom share an interest to improve the environmental performance of livestock supply chains. The LEAP guidelines comprise a global standard for environmental footprinting of feed production.

<sup>2</sup> Continuous throughout review period.

<sup>3</sup> WaCASA: Wageningen Centre of Agroecology and Systems Analysis; KTI: Knowledge, Technology and Innovation Group of Wageningen University; ADP: Adaptation Physiology group of Wageningen University; INRA: French National Institute for Agricultural Research; FAO: Food and Agricultural Organisation; Teagasc: Agriculture and food development authority in Ireland; VU: University of Amsterdam; PBL: Netherlands environmental assessment agency.

#### 4.2 Demonstrable use of products – Societal indicators

Table 4.2.1 Tools used by the industry and farmers to improve their sustainable performance.

<b>Feedprint</b>	Environmental footprint tool used by feeding companies to explore environmentally sustainable diets for livestock (e.g. Nutreco, Agrifirm; Vellinga et al., 2013)
<b>MECD</b>	Model for Electricity Consumption on Dairy Farms used to advice dairy farmers in Ireland (Upton et al., 2014; Journal of Dairy Science)
<b>WHITEFISH-BSCI</b>	Standard for assessment of sustainability impacts of whitefish products (2015)
<b>Carbon-Milk</b>	Tool developed within FrieslandCampina to reach climate-neutral growth between 2010 and 2020, from cow to factory gate (2014).
<b>Water-Milk</b>	Tool developed within FrieslandCampina to reduce water use during the production of milk (2014).

Table 4.2.2 Societal indicators of APS by year.

Societal indicators	2009	2010	2011	2012	2013	2014	Total
Industry investment in PhDs (K€)	62.5	210	210	210	145	62.5	<b>900</b>
EU grants involving PhDs (K€)	0	0	0	125	125	125	<b>375</b>
PhDs working in developing countries (# since 2000)	7	8	8	9	10	12	<b>12</b>

#### 4.3 Demonstrable marks of recognition - Marks of recognition by societal groups

Prof. de Boer is scientific advisor of the European division of **The Sustainability Consortium (TSC)**, which acknowledges her excellence in the domain of sustainability assessment. TSC is a global initiative and aims at informing decision-makers about product sustainability across all sectors, throughout the entire life cycle. According to TSC, it creates scale as it represents over 100 of the world's largest organizations. Within the Netherlands, Prof. de Boer moreover is regularly invited to advise corporate social responsibility boards of agricultural businesses.

Our WaCASA colleagues facilitated involvement of APS in the 2<sup>nd</sup> phase of N2Africa, a project funded by the **Bill & Milinda Gates Foundation**. This phase of N2Africa is for five years and is led by Wageningen University (Plant Production Systems; Prof. K.E. Giller), together with the International Institute of Tropical Agriculture (IITA) and the International Livestock Research Institute (ILRI). N2Africa includes partners in Ghana, Nigeria, Ethiopia, Tanzania, and Uganda (Core countries), and in DR Congo, Rwanda, Kenya, Mozambique, Malawi, and Zimbabwe. In the 1<sup>st</sup> phase, N2Africa reached more than 230,000 farmers, who evaluated and used improved grain legume varieties, rhizobium inoculants, and phosphate based fertilizers. In the 2<sup>nd</sup> phase, we remain focused on research on and dissemination of major grain legumes in selected areas in the core countries. Our PhD, funded by N2Africa, will focus on use of residues of grain legumes as a livestock feed for smallholders in Ghana.

Finally, Prof. I.J.M. de Boer and Dr Simon Oosting were members of the Science and Partnership Advisory Committee of the Livestock and Fish CRP of CGIAR from 2012 till 2015.

## 5. Viability

### 5.1 Benchmark

We aim at understanding consequences of innovations in livestock systems across the world, and selected, therefore, two groups for benchmarking: the Agricultural Systems and Sustainability group at Aarhus University; and The Institute of Animal Production in the Tropics and Subtropics (APTS) at the University of Hohenheim.

1. The Agricultural Systems and Sustainability group, within the department of Agroecology at *Aarhus University*, is headed by Prof. J.H. Hermansen. Their research aim is to improve the sustainability of farming and food systems, while considering the balance between production efficiency, profitability, environmental impact, land use, and the contribution to the vitality of the rural areas. Even though their research aim highly coincides with ours, they focus on **livestock systems in the developed world** mainly.

2. The Institute of Animal Production in the Tropics and Subtropics (APTS), at the *University of Hohenheim*, is headed by Prof. Dr. Anne Valle Zárate. Their research aim is to analyse **tropical farming systems** to improve production efficiency and the livelihood of people, while maintaining the surrounding environment.

Average bibliometric results of our current staff, and staff of Aarhus University and University of Hohenheim are in Table 5.1. Staff of Aarhus and Hohenheim included in the benchmark were identified in consultation with department heads (appendix 2). To create full transparency, we shared final statistics with each department head.

*Table 5.1 Benchmark APS against the staff of Aarhus University and University of Hohenheim.*

	<b>Annual # publications per person</b>	<b>Citations per Publication</b>	<b>Field Weighed Citation Impact</b>
APS-average	3.2	9.0	2.4
Non-tropical	3.4	10.5	2.6
Tropical	2.8	5.4	1.7
Aarhus	2.3	12.3	3.0
Hohenheim	2.3	6.5	1.4

Compared with Aarhus and Hohenheim, we publish about one publication more per person per year (3.2 vs 2.3). Our tropical staff shows a similar pattern of citations as University of Hohenheim, whereas our non-tropical staff shows a slightly lower pattern compared with Aarhus University. The latter is partly explained by the fact that the majority of our non-tropical publications are recent, which is not the case for Aarhus, a well-established group working on systems analysis for many years. Citations per publication generally increase across years, which affects above described bibliometric results. We aim to reach a similar outstanding result as Aarhus University in a few years, but we also acknowledge that current publications of our non-tropical staff are cited already 2.6 times more than the world average (see Field Weighted Citation Impact in Table 5.1).

## 5.2 SWOT-analysis

Strengths	<ul style="list-style-type: none"> <li>• Strong international position in the field of life cycle assessment and livestock production;</li> <li>• Unique combination of expertise in the fields of environmental impact assessment and animal welfare assessment, i.e. an area of major trade-offs in development of sustainable livestock systems.</li> <li>• Unique combination of expertise in the fields of environmental impact assessment and livelihood assessment in tropical livestock systems.</li> <li>• Atmosphere: open atmosphere, sharing ideas, good collaboration among staff, PhD students are part of the community, rich diversity (age, gender, nationalities), unifying leadership.</li> </ul>
Weaknesses	<ul style="list-style-type: none"> <li>• Sourcing of high potential senior staff.</li> <li>• Lack of appropriate incentives and institutional settings to reward additional efforts of integrative research.</li> </ul>
Opportunities	<ul style="list-style-type: none"> <li>• Increased interest in life cycle sustainability assessment due to initiatives such as The Sustainability Consortium.</li> <li>• Recent cooperation in research with industry.</li> <li>• Increased potential for common research projects by embedding in WaCASA (so far 3 common PhDs).</li> <li>• Increased potential for collaboration in research and knowledge dissemination by housing of WUR Livestock research in Wageningen.</li> <li>• Potential to strengthen cooperation with FAO/ILRI/Worldbank/IIASA/CGIAR institutes.</li> </ul>
Threats	<ul style="list-style-type: none"> <li>• Science for impact is high on the political agenda: emphasis on research resulting in short-term societal impacts might limit fundamental research, and model development and improvement.</li> <li>• Increased competition and decline in funding available.</li> </ul>

### 5.3 Future strategy

Sustainable production of food, and especially animal-source food, has re-emerged at the top of the global political agenda, driven by two contemporary challenges: the challenge to produce enough nutritious food to feed a growing and more prosperous population; and the challenge to produce this food in a sustainable way. These twin challenges allow us to build on our renewed focus: analysing innovations regarding sustainable development of livestock systems in both developed and developing regions. Because of this unique focus, we have been approached increasingly by strong international research groups across the world to cooperate in research applications, which will strengthen our international embedding and further improve our scientific quality.

During the coming years, therefore, we want to **build on the current initiatives and implement further our strategic research plan**. We aim to build on our current success in PhD funding and supervision, which implies having a sound scientific output in the years to come. We will support the entry of our three young staff members into the tenure-track trajectory (at their own pace). We envision obtaining a personal professorship in “Tropical Livestock Production” (Dr Oosting), and an endowed professor in “Global challenges for natural resource use efficiency in livestock systems” (Dr Gerber). In 2015, we will also strengthen our collaboration with the CGIAR institutes by establishing a shared endowed professor with the Animal Breeding and Genetics group in “Livestock and Fish Breeding for production systems in developing countries”.

As high-quality senior staff trained in the field of systems analysis is scarce, we need to retain our investments in funding additional Post Docs on long term contracts (3-4 years). Post Docs increase our capacity for high-quality strategic research and can support PhD supervision. Moreover, a Post Doc position offers high potential PhD graduates an opportunity to continue their scientific career, and to attract young potentials from abroad (e.g. Ripoll Bosch from Spain).

As funding availability decreases and competition for strategic funding increases, we need to even invest more emphasis on obtaining strategic research funds. The foreseen personal and endowed professors, however, will strengthen our capability to obtain such funding.

Our leadership is focussed on teamwork and creating of mutual trust and respect between junior and senior staff. We strive to maintain a supporting and collegial working atmosphere, which enhances commitment and motivation, and allows personal development. Team spirit, motivation and development of individual staff are recognized as key factors for success. Overall, therefore, we have sufficient ground to become one of the leading groups in our domain.

### 6. Research Integrity

We follow the principles of good scientific teaching and research, as published by Wageningen University, and we adhere to (inter)national legislation. The teaching and research principles of Wageningen University are based largely on the Netherlands Code of Conduct for Scientific Practice. Animal experiments are approved by the Animal Care and Use Committee, and data of farmers, experts or companies used for modelling are treated anonymously.

Furthermore, we aim at creating an open and friendly atmosphere within our group, to enable frank discussions on content and procedures. In case of (potential) problems, we actively stimulate APS members to contact confidentially persons from WIAS or the University. During an annual research and development meeting with an APS member and the chair holder, we deliberately took time to discuss the workers' environment, mutual expectations, and expected and achieved results.

To guarantee our scientific integrity, we include a statement in each official contract with industry partners that all research results will be published in international journals independent of the outcomes, with a maximum of 6-months delay. Finally, a data management and storage program was developed at APS to ensure transparency of research results and related publications.

**Appendix 1** - Research staff Animal Production Systems group.

Table 1 - Research staff input at Chair Group level

<b>Name staff</b>		<b>Funding 1, 2, 3*</b>	<b>2009 FTE**</b>	<b>2010 FTE</b>	<b>2011 FTE</b>	<b>2012 FTE</b>	<b>2013 FTE</b>	<b>2014 FTE</b>
<i>Full professors</i>								
Prof dr ir I.J.M. de Boer (1fte)	Tenured 01-09-2011	1			0.12	0.30	0.30	0.30
Prof dr ir A.J. van der Zijpp (1 fte)	Tenured	1	0.30	0.15				
<i>Visiting professor</i>								
dr ir P.J. Gerber (0.2fte: june 2014)	Visiting professor	3						0.04
<i>Associate professors</i>								
Dr ir H.M.J. Udo (1 fte)	Tenured	1	0.32	0.32	0.32	0.32	0.06	
Dr ir I.J.M. de Boer (0.8 fte)	01-09-2010/01-09-2011	1			0.21			
<i>Assistant professors</i>								
Dr ir I.J.M. de Boer (0.8 fte)	Tenured/01-09-2010	1	0.30	0.32				
Dr. Ir E.A.M. Bokkers (0.8 fte)	Tenured	1	0.32	0.32	0.32	0.40	0.40	0.40
Dr ir C.H.A.M. Eilers (0.9 fte)	Tenured	1	0.28	0.28	0.28	0.25	0.02	
Dr ir S.J. Oosting (1 fte)	Tenured	1	0.40	0.40	0.40	0.40	0.40	0.40
<i>Researchers</i>								
Dr ir C. van Reenen (0.2 fte)	Researcher	1						0.08
<i>Post-docs</i>								
Dr.ir. H. Mollenhorst (0.8 fte)	Post-doc/lecturer	2			0.16	0.48	0.48	0.48
Dr.ir. M. de Vries (0.8 fte)	Post-doc/lecturer	1					0.40	0.48
Dr.ir. C.E. van Middelaar (1.0 fte)	Post-doc/lecturer	1					0.10	0.60
dr R. Ripoll-Bosch	Post-doc/lecturer							0.55
<i>Visiting fellows</i>								
U. Patanen - PhD University Helsinki	3 months	3		0.25				
R. Ripoll-Bosch - PhD Cita	3 months	1		0.25				
R. Botreau - PhD INRA	2 months	3		0.17				
M. Zehetmeier - PhD TUM	2 months	3				0.17		
M.C. Brito de Figueiredo - Post Doc Embrapa	3 months	3				0.25		
E. Handayanta - PhD Brawijaya University	2 months	3					0.25	
V. Stein - PhD TUM	2 months	3					0.25	
U. Patanen - PhD University Helsinki	3 months	3		0.25				
R. Ripoll-Bosch - PhD Cita	3 months	1		0.25				
R. Botreau - PhD INRA	2 months	3		0.17				
M. Zehetmeier - PhD TUM	2 months	3				0.17		
M.C. Brito de Figueiredo - Post Doc Embrapa	3 months	3				0.25		
E. Handayanta - PhD Brawijaya University	2 months	3					0.25	
V. Stein - PhD TUM	2 months	3					0.25	
<b>Total scientific staff</b>			<b>1.92</b>	<b>2.46</b>	<b>1.81</b>	<b>2.57</b>	<b>2.66</b>	<b>3.33</b>

\* Funding scores: 1= direct funding by University; 2= funding obtained in national scientific competition (e.g. grants from NWO, KNAW) ; and 3= funding obtained from external organisations, such as industry, governmental ministries, European Commission and charity organisations.

\*\*FTE reported in this table regards the research appointment part of the total appointment (e.g. tenured staff has 40% available for research, postdocs have 60% available for research).

**Appendix 2** - Scientist for benchmark Animal Production Systems group*Table II. Scientist selected at the University of Århus (AASS), University of Hohenheim (APTS) for benchmarking APS.*

<b>APS</b>	<b>AASS</b>	<b>APTS</b>
Bokkers, E.A.M.	Hermansen, J.E.	Dickhoefer, U.
De Boer, I.J.M.	Knudsen, M.T.	Lawrence, P.R.
Gerber, P.J.	Kristensen, T.P.	Reiber, C.
Oosting, S.J.	Mogensen, L.	Zárate, A.V.
Ripoll-Bosch, R.	Noe, E.	
Van Middelaar, C.E.		
Van Reenen, C.G.		

## Aquaculture and Fisheries (AFI)

**Programme leader:** Johan Verreth; 2009-2014

*For a full staff survey see appendix 1.*

### 1. Objectives and Research Area

#### 1.1 Vision, Mission and Objectives

*Vision:* AFI contributes, now and in the future, to sustainable fish production in a world where demands for seafood are rising to unprecedented levels. To meet these increased demands, while safeguarding environmental sustainability, we need innovations that use principles of animal biology and ecology and build on the potential of aquatic ecosystems.

*Mission:* To explore the potential of aquatic animals and aquatic ecosystems for sustainable fish production through academic research and training

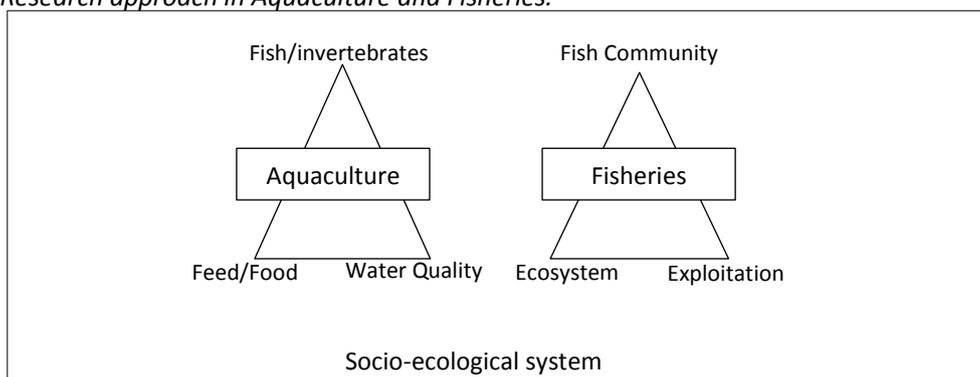
*Objectives:*

- contribute to sustainable fish production and resilient aquatic ecosystems through MSc and PhD training and research;
- understand the resilience of aquaculture production systems and of the farmed animals by studying the interaction among animal, feed/food, and environmental factors;
- understand the interaction among food web, fish community, and fisheries in exploited aquatic ecosystems

#### 1.2 Research Area / research line(s)

“Fisheries” stands for management and exploitation of natural fish populations. Aquaculture is farming of aquatic animals. AFI must develop the dual scientific fields of aquaculture and fisheries. AFI has developed a common approach for the two fields, combining research at the animal level with ecological and technical research at the level of the environment in which the animal lives. In line with its objectives, AFI contributes to innovations in aquaculture by studying the interactions of feeds, digestive processes, and the faecal and metabolic waste produced by the animal, on one hand, with the water quality and microbial ecology of the rearing environment, on the other hand. In our fisheries work, we analyse how factors such as fisheries exploitation, climate change, eutrophication and socio-economic environments affect the structure of fish communities, food-web dynamics, and their resilience. This leads to four different research lines. The bio-technical basis for the development of innovations in aquaculture and fisheries constitute the two core lines of research with currently resp. 1.2 FTE (Schrama, Verdegem, Eding, Verreth) and 0.65 FTE (Rijnsdorp, vZwieten, Nagelkerke) staff research input. A third, interdisciplinary, line of research (0.3 fte; Verreth, Bosma, vanZwieten) analyses how innovations in aquaculture and fisheries are implemented in relation to their social-ecological context. Marine invertebrate aquaculture is the fourth research line (0.28fte; Osinga, Smaal) and capitalizes on the strategic choice of Wageningen UR to develop a national profile in marine resources management.

*Figure 1. Research approach in Aquaculture and Fisheries.*



### 1.3 Strategy

#### *- general research strategy*

It is AFI's ambition to have a strong international position. We follow the strategy, therefore, to "be present where it matters". This strategy requires AFI to collaborate with leaders in academia and industry, and to work on societal hotspots for our domain, such as pangasius and shrimp farming, tuna fishery, Lake Victoria Nile Perch fishery, and coral restoration. Our integrative scientific approach helps us to develop concepts for ecosystem based approaches in aquaculture and fisheries. The implementation of these approaches in their socio-ecological context is studied in collaboration with colleagues from social and environmental sciences.

A strong team spirit and academic atmosphere in the group is a key factor for success. To create a stimulating academic environment, PhD and staff have weekly presentations by MSc students, and monthly meetings on the progress of research. Initiatives for projects and general strategies are discussed in monthly meetings of faculty staff.

#### *- achievements (last 6 years)*

- PhD graduate Saravanan developed the "oxystatic" theory for regulation of feed intake, providing a framework for further research on the relation of feed intake with nutritional and environmental factors.
- Our research in Lake Victoria showed that eutrophication plays a much larger role on the changes in fish communities and exploitation than believed previously.
- The interdisciplinary program 'RESCOPAR' demonstrated that resilience of coastal resources and people's livelihoods in SE Asia was improved when semi-intensive practices for shrimp farming were combined with mangrove resources.

We published scientific articles in journals of high impact for our domain (e.g., PLOS One, Journal of British Nutrition, Freshwater Biology, Coral Reefs, Ecology and Society). Of these articles, 14 were published together with our partners at INRA (France), with whom we developed a successful strategic alliance on fish nutrition. We also developed strong contacts with industry, NGOs, and governmental institutes.

#### *- possible adjustments*

Regarding aquaculture, we included the role of microbes, in the fish (gut) and in the rearing water, as an important element to understand the interaction between fish and environment. Regarding fisheries, we increased our emphasis on the functionality of fish biodiversity in exploited systems and made a shift to marine fisheries. Regarding the implementation of innovations in aquaculture and fisheries, we focused our research on the resilience of the socio-ecological system in which these sectors operate.

#### *- future outlook*

In aquaculture, a further integration of our nutritional and production-system expertise will help AFI to develop concepts for ecosystem-based aquaculture. We will explore interactions of feed composition and natural food with water quality and gut health in intensive ponds and Recirculating Aquaculture Systems (RAS). We intend to strengthen this research through cooperation with specialists in fish health.

In fisheries, we will explore the mechanisms underlying the structure and dynamics of fish communities. The functional traits of exploited organisms will be studied to contribute to goals of fisheries management, such as 'balanced harvesting'.

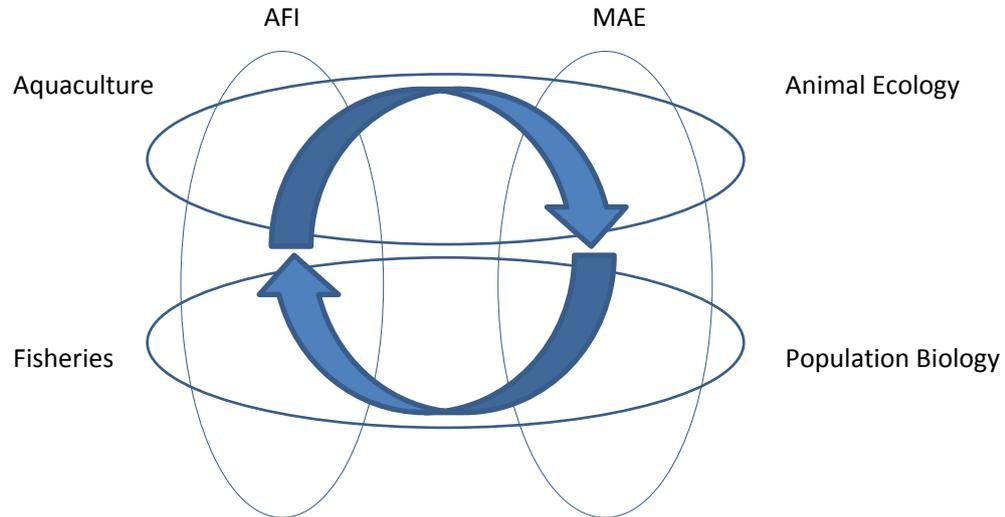
### 1.4 Research environment and embedding

The Chair groups Cell Biology and Immunology (CBI), Experimental Zoology (EZO), AFI and Marine Animal Ecology (MAE), constitute the cluster "Biology & Aquatic Resilience". The collaboration with CBI and EZO enables AFI to add "fish health" to our integrated approach to aquaculture. With MAE, we constitute a "marine" cluster-within-the-cluster which enables us to share staff and disciplines, increasing our flexibility to respond to scientific and societal challenges (see figure 2).

In the Netherlands, AFI is the only academic group working on aquaculture and fisheries. The leading Dutch organisation in marine fisheries (IMARES), has seconded two endowed Chairs to AFI: Prof. Rijnsdorp

holds a 0.4 fte professorship in marine fisheries and Prof. Smaal holds a 0.2 fte professorship in shellfish aquaculture. Many of our fisheries PhD candidates and MSc students do their research at IMARES. Together with the IMARES' aquaculture team, we have established the joint centre of expertise "Wageningen Aquaculture".

Figure 2: Clustering disciplines of AFI and MAE.



More than 85% of our PhD students are shared, with IMARES; with Chairs in Animal -, Environmental-, Food- and Social Sciences; and with teams in France (INRA), Portugal (UoAlgarve), and Asia (UPM Malaysia, WorldFish). AFI has initiated large interdisciplinary research programmes such as RESCOPAR and BESTTuna.

In Europe, we participate in different FP7 consortia (AquaExcel, Arraina, AquaTnet). Overseas, AFI is leading in developing and organizing international post-graduate education. It also collaborates with partners, such as TAFIRI (Tanzania), GosNIORKh (Russian Federation) and the WWF Coral Triangle Programme (Indonesia).

AFI staff members hold strategic positions in WU management (director WIAS, management team Animal Sciences Group, Chair programme committee MAM, Educational Board) and in international organizations (Board member and president European Aquaculture Society; INRA Scientific Advisory Board, WorldFish Scientific Advisory Council, EATiP Workgroups).

### 1.5 Reference to previous peer review

*a)..The Committee cautions the Group to carefully define its comparative advantage and to narrow the scope of research in this domain towards coastal aquaculture*

We have narrowed our research towards our strengths. We have invested in the role of microbes in aquaculture, leading to a firm collaboration with WU's top group (Microbiology), with which we share three PhD candidates funded by the Dutch Science Foundation NWO and EU-FP7. This collaboration will enable us to expand into the area of "gut health" and help future collaboration with our colleagues from CBI.

The RESCOPAR project enabled us to strengthen our expertise in WUR's strategic theme of resilience. The project focused on resilience of human and aquatic communities in mangrove-based coastal areas in SE-Asia. As a follow-up, we are now involved in two NWO projects in Vietnam (one co-funded by the International Union for Conservation of Nature IUCN, and one by industry) and will contribute to ECOSHAPÉ's programme in Indonesia, through public-private-partnership with Boskalis, Wetlands International, and IMARES (<http://www.ecoshape.nl>).

b)..encourages the Group to use all possibilities to increase staffing and funding through expanding contacts especially with the feed and food industry.

To fund its research on the ecological sustainability of pangasius culture, AFI attracted a cluster of companies in the value chain, such as DeHeus, Cargill (Aquafeeds), VihnHoan (producer) and Marine Harvest and Queens (importers) as partners in the project “Sustainable Pangasius”. To realize its research on alternative protein ingredients, AFI attracted funds from BIOMAR, AKIOLIS, Nutreco, and Unilever. The WOTRO-GCP project “Nutritious Pond” is co-funded by Nutreco, Skretting-Vietnam and Vemedin (Vietnam). Possibly the strongest reference point for our success in acquiring industry support is the secondment of Dr. Arjen Roem, a senior nutritionist of Skretting-Nutreco, (50% until 2014, 20%now).

After the peer review of 2009, we focused on improving the review scores. During the current review period, AFI pushed its output in productivity and in quality indicators. Data below were retrieved from the Wageningen Library’s webquery.

Table 1.5.1. Bibliometric indicators for AFI over the period 2002-2007 and 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication:	Bibliometric indicators					
	N	C	CPP	RI	%T10	%T1
<b>2002-2007</b>	142	919	6.47	1.17	11	0
<b>2008-2013*</b>	222	1825	8.99	1.47	16	1

\*data accessed from WoS on April 15 2015; this may lead to minor differences with section 2.

Table 1.5.2. Mean impact factor (IF) of the journals in which we published our article.

Category:	Year						
	2008	2009	2010	2011	2012	2013	2014
<b>IF (mean)</b>	1.91	1.98	2.02	2.29	3.22	3.35	2.6
<b>Publications (N)</b>	32	26	28	33	37	46	42
<b>Publications (IF not available) (N)</b>	0	0	0	2	0	5	9

## 2. Resources and Facilities

During the period 2009-2014, the total staff research input of AFI remained stable (Table 2.1). Because of collaboration with IMARES and the endowed Chairs of Rijnsdorp and Smaal, however, the number of PhD candidates increased 65% from 14 in 2009 to 23 in 2014. If the PhDs working at Imares are taken into account, then the number increased to 32. The total funding increased 12%, from 2,6 million€ to nearly 3million€ in 2013 (Table 2.2). The downward trend in the category “Research Grants” from 2.75 FTE in 2009 to 0.44 FTE in 2013, was corrected by successful NWO applications in 2012-2014 (4 PhDs, 1 Post Doc, 1 biotechnician), within two NWO programmes “More with less” and “Green”, and the WOTRO-Global Challenge Programme. The growth in PhDs was partly financed by successful applications for contract research.

Our research and international reputation received a strong stimulus through strategic collaborations with renowned teams at WU (Microbiology and Food Chemistry) and at INRA, France (NuMeA), and through availability of high quality research facilities (Carus-Aquaculture Research Facility, renewed in 2012). Since 2011, the Aquatic Metabolic Research Unit of AFI is part of a Large European Facility Infrastructure via a FP7 project (AQUAEXCEL). This project enabled us to develop the facility (e-infrastructure solutions) with remote access for the international scientific community. The facility was the most frequently used among all available European facilities in AQUAEXCEL.

## 2.1 Researchers

Table 2.1. Research input: number<sup>1</sup> and FTE<sup>2</sup> of Scientific staff, Post-docs and PhD candidates by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	#	FTE												
Scientific staff <sup>4</sup>	7	1.9	7	1.7	7	1.7	7	1.5	8	2.1	8	2.1	7	1.8
Post-docs <sup>5</sup>	4	1.2	3	1.1	3	0.9	3	0.8	3	0.7	3	0.6	3	0.9
PhD candidates <sup>3,6</sup>	14	9.2	18	11.7	22	10.0	26	10.4	25	12.5	23	11.3	21	10.9
<b>Total research staff</b>	<b>25</b>	<b>12.3</b>	<b>28</b>	<b>14.5</b>	<b>32</b>	<b>12.6</b>	<b>36</b>	<b>12.7</b>	<b>36</b>	<b>15.3</b>	<b>34</b>	<b>14.0</b>	<b>32</b>	<b>13.6</b>
Lab Technicians	4	2.7	4	2.7	4	2.5	4	2.3	4	2.3	4	2.3	4	2.5
Visiting fellows	1	0.6	0	0.0	1	0.2	1	0.2	2	0.8	3	1.2	1	0.5
<b>Total staff</b>	<b>30</b>	<b>15.6</b>	<b>32</b>	<b>17.2</b>	<b>37</b>	<b>15.3</b>	<b>41</b>	<b>15.2</b>	<b>42</b>	<b>18.4</b>	<b>41</b>	<b>17.5</b>	<b>37</b>	<b>16.5</b>

<sup>1</sup> Total number of staff and PhD candidates

<sup>2</sup> Available research time in full time equivalent (FTE)

<sup>3</sup> All PhD categories, except external PhDs

Standards for Research Capacity (in case of part time appointment adjustment is applied):

<sup>4</sup> Professor, Assistant Professor and Associated Professor: Research Capacity = 40% of the appointment

<sup>5</sup> Post-doc: Research Capacity = 90% of the appointment

<sup>6</sup> PhD candidate: Research Capacity = 75% of the appointment (all categories)

## 2.2 Research Funds

Table 2.2. Funding of Scientific staff, Postdocs and PhD candidates by year and Expenditure of Chair group by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	FTE	%												
<i>Funding:</i>														
Direct funding <sup>1</sup>	6.8	55	7.6	52	5.3	42	5.3	42	6.7	44	6.6	47	6.4	47
Research grants <sup>2</sup>	2.8	22	1.5	10	1.5	12	0.6	5	0.4	3	1.8	12	1.4	11
Contract research <sup>3</sup>	2.8	22	5.4	37	5.8	46	6.9	54	8.2	53	5.7	41	5.8	42
<b>Total funding</b>	<b>12.3</b>	<b>100</b>	<b>14.5</b>	<b>100</b>	<b>12.6</b>	<b>100</b>	<b>12.7</b>	<b>100</b>	<b>15.3</b>	<b>100</b>	<b>14.0</b>	<b>100</b>	<b>13.6</b>	<b>100</b>
<i>Expenditure<sup>4</sup>:</i>	<b>K€</b>	<b>%</b>												
Personnel costs	1,453	55	1,584	54	1,628	55	1,759	56	1,634	55	1,369	49	1,571	54
Other costs	1,203	45	1,337	46	1,338	45	1,410	44	1,340	45	1,415	51	1,340	46
<b>Total expenditure</b>	<b>2,656</b>	<b>100</b>	<b>2,921</b>	<b>100</b>	<b>2,966</b>	<b>100</b>	<b>3,169</b>	<b>100</b>	<b>2,973</b>	<b>100</b>	<b>2,784</b>	<b>100</b>	<b>2,911</b>	<b>100</b>

<sup>1</sup> Direct funding by the University

<sup>2</sup> Research grants obtained in national and international scientific competition (e.g. grants from NWO, KNAW)

<sup>3</sup> Research contracts for specific research projects obtained from external organisations, such as industry, governmental ministries, European Commission (including ERC), charity organisations

<sup>4</sup> Expenditure from financial system of Wageningen University which not only includes research but also teaching and other activities

### 3. Research Quality

To improve the scores for productivity (good to very good) and quality (very good) from the previous peer review, AFI invested in quantity and quality of its scientific output. Key goals for investment were rank of journals, citation index, and international visibility. These goals were achieved by a more strict selection of PhD students, by avoiding non-refereed articles and book chapters, by focusing research on explanatory processes, and by searching for strategic alliances with leaders in our fields (e.g., WU Chairs Microbiology, Food Chemistry, and Environmental Policy; INRA).

Our productivity increased from an average of 25 refereed articles per year (2003-2008) to an average of 38 in the current review period, with a peak of 51 articles in 2013 ( Table 3.1).

Approximately 60% of articles were published in Q1 journals. Most aquaculture journals in the JCR category *Fisheries* are ranked as Q2. About 17% of our publications are in the 10% most cited ones in their domain (Table 3.2), which is a 55% improvement compared with the previous review period (11%). In the future we will invest more on research within Wageningen, downsize our applied development programmes and focus our research activities even more than before.

We increased our visibility by initiating international consortia, such as the INRA-WUR Aquaculture Platform, the BestTuna consortium, and by co-founding the EU Large infrastructure AquaExcel. This strategy will not change.

The 5 key publication of AFI during the period 2009-2014 are:

Bosma RH, Nguyen H Tin, Siahainenia AJ, Tran TP Ha & Tran Ngoc Hai, (2014). Shrimp-based livelihoods in mangrove silvo-aquaculture farming systems. *Reviews in Aquaculture* 6:1-18. (IF 2.1; 5yrs average 3.6)

Górski, K, De Leeuw J J, Winter HV, Vekhov DA, Minin AE, Buijse AD & Nagelkerke LAJ (2011). Fish recruitment in a large, temperate floodplain: the importance of annual flooding, temperature and habitat complexity. *Freshwater Biology* 56: 2010-2225. (IF 2.9; 5yrs average 3.9)

Martins CIM, Eding EH, Verdegem MCJ, Heinsbroek LTN, Schneider O, Blancheton JP, d'Orbcastel ER & Verreth JAJ (2010). New developments in recirculating aquaculture systems in Europe: A perspective on environmental sustainability. *Aquacultural Engineering* 43:83-93. (IF 1.2, 5yrs average 1.8)

Saravanan S, Geurden I, Figueiredo-Silva AC, Kaushik S, Verreth JAJ & Schrama JW (2013). Voluntary feed intake in rainbow trout is regulated by diet-induced differences in oxygen use. *Journal of Nutrition* 143:781-787. (IF 4.2; 5yrs average 4.7)

Van Denderen PD, van Kooten T, Rijnsdorp AD (2013). When does fishing lead to more fish? Community consequences of bottom trawl fisheries in demersal food webs. *Proceedings of the Royal Society B – Biological Sciences* 280: 20131883. (IF 5.3; 5yrs average 5.8)

#### 3.1 Demonstrable products - Research products for peers in science

Table 3.1. Categories of research output by year.

Category:	Year						Total	Average 2009-2014
	2009	2010	2011	2012	2013	2014		
<b>Academic publications</b>								
a. Refereed articles	29	29	39	39	51	38	<b>225</b>	38
b. Non-refereed articles	1	1	1	0	2	1	<b>6</b>	1
c. Books	0	0	0	0	0	0	<b>0</b>	0
d.1. Refereed book chapters	3	1	0	1	0	2	<b>7</b>	1
d.2. Non-refereed book chapters	0	0	0	0	0	0	<b>0</b>	0
e. PhD Theses	1	4	0	4	6	3	<b>18</b>	3
f. Conference papers	0	2	0	7	1	1	<b>11</b>	2
<b>Total academic publications</b>	<b>34</b>	<b>37</b>	<b>40</b>	<b>51</b>	<b>60</b>	<b>45</b>	<b>267</b>	<b>45</b>

### 3.2 Demonstrable use of products - Use of research products by peers

Table 3.2.1. Bibliometric indicators for AFI over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	32	430	401	13.44	1.12	19% (6)	0% (0)
2009	26	435	279	16.73	1.65	15% (4)	4% (1)
2010	28	337	225	12.04	1.54	21% (6)	0% (0)
2011	35	241	201	6.89	1.21	14% (5)	0% (0)
2012	37	262	145	7.08	1.76	14% (5)	3% (1)
2013	45	120	75	2.67	1.55	16% (7)	2% (1)
<b>all years</b>	<b>203</b>	<b>1825</b>	<b>1326</b>	<b>9.0</b>	<b>1.47</b>	<b>16% (33)</b>	<b>1% (3)</b>

Table 3.2.2. Bibliometric indicators for AFI per research field over the period 2008-2013. The rows are ordered in descending number of publications (N). The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

research field	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	150	1342	927	9.0	1.44	18% (27)	1% (1)
Environment/Ecology	27	344	231	12.7	1.96	11% (3)	7% (2)
Agricultural Sciences	10	39	31	3.9	1.32	20% (2)	0% (0)
Biology & Biochemistry	5	23	41	4.6	1.15	20% (1)	0% (0)
Clinical Medicine	2	16	16	8.0	0.76	0% (0)	0% (0)
Engineering	2	12	7	6.0	1.48	0% (0)	0% (0)
Microbiology	2	6	9	3.0	0.72	0% (0)	0% (0)
Chemistry	1	4	14	4.0	0.28	0% (0)	0% (0)
Computer Science	1	2	4	2.0	0.52	0% (0)	0% (0)
Molecular Biology & Genetics	1	17	33	17.0	0.51	0% (0)	0% (0)
Neuroscience & Behavior	1	8	7	8.0	1.16	0% (0)	0% (0)
Social Sciences, General	1	12	5	12.0	2.25	0% (0)	0% (0)
<b>all fields</b>	<b>203</b>	<b>1825</b>	<b>1326</b>	<b>9.0</b>	<b>1.47</b>	<b>16% (33)</b>	<b>1% (3)</b>

We consider number of publications/FTE tenured staff member input, Relative Impact (RI) and the %T10 articles as proper indicators of our scientific performance. The first parameter is not mentioned in Table 3.2. AFI published an average of 17.3 refereed papers/FTE tenured staff member research input, compared with 13.1 in the period 2003-2008 and 10.5 in 1997-2002. The RI increased from an average of 1.17 for the period 2003-2008 to an average of 1.43 for the current review period. The T10% increased from an average of 11 (2009 peer review) to an average of 16%. We believe that our publication strategy will bring us to a RI of at least 1.75 in the course of the next three years.

AFI publishes 75% of its articles in Plant & Animal Sciences, followed by Environmental Sciences with 23% of the publications. In the first category, we had 18% %T10 articles compared to 11% for the area Environment/Ecology. In the latter category, the %T1, however, was significantly higher (7%) than in the other categories.

Since the last review, we published review papers on recirculation systems, microbial aspects in aquaculture, integrated shrimp-mangrove farming, and mineral requirements in fish. For several consecutive years, the review papers on recirculation systems belong to the top 25 most-cited papers in the journal *Aquacultural Engineering*.

### 3.3 Demonstrable marks of recognition - Marks of recognition from peers

Table 3.3. Most important prizes, keynotes etc. of staff (max 6 per category). For remaining achievements see mini CVs (Separate file called mini CVs).

<b>Science awards, Scholarly prizes, Research grants awarded to individuals</b>		
2014	Best student presentation	World Delta Conference Brenda Walles
2014	Best Overseas Indian Post-graduate Thesis award 2013 (PFGF, Mumbai India).	Saravanan Subramanian
2012	Best poster award	Aquaculture Europe 2012 Vasco Mota
2011	Best Article 2011 (Norsk Forening for Utviklingsforskning) (Forum Development Studies 38, 267 - 297)	Paul van Zwieten
<b>Plenary/Keynote* Lectures at major conferences</b>		
2013	R. Osinga	Invited speaker: International Sponge Seminar (Oslo Norway) "Sponges perspective for biomonitoring" (100 attendees)
2013	A.D. Rijnsdorp	Keynote: Dynamic Energy Budget Symposium (NIOZ, Texel, NL) "What do fisheries scientists need from eco-physiologists?" (150 attendees)
2013	P.A.M. van Zwieten	Keynote: 4th European Tuna Conference (Brussels Belgium) "The current status of the tuna stocks in our oceans" (500 attendees)
2014	A.D. Rijnsdorp	Keynote: Symposium Fishing effects on Benthic Ecosystems (Tromso, Norway) "Assessment of trawling impacts on benthic ecosystems with particular reference to shelf ecosystems" (150 attendees)
2014	J.A.J. Verreth	Keynote: NordicRAS Conference (Aalborg, Denmark) "Views on water quality control in recirculating aquaculture systems" (300 attendees)
<b>Organisation of International Scientific Conferences</b>		
2010	A.C. Smaal	Programme committee, Aquaculture Europe Porto Portugal
2010	R. Osinga/J.A.J. Verreth	Organizers, European Conference International Society for Reef Studies, Wageningen.
2011	A.C. Rijnsdorp	Organizer 8th International Flatfish Ecology Symposium,
2014	J.A.J. Verreth	Chair Organizing Committee, Aquaculture Europe Rotterdam
2014	A.C. Smaal	Chair programme committee, Aquaculture Europe Rotterdam
<b>Editorships and editorial boards</b>		
A.C. Smaal		Guest editor: Aquaculture International (2009 & 2015)
L.A.J. Nagelkerke		Review editor: Animal Biology (2012-date). Associate editor: African Zoology (2014-date)
J.W. Schrama		Editorial Board: Aquaculture Nutrition (2011-date)
A.C. Rijnsdorp		Editorial Board: Journal of Sea Research (1995-date); Editorial Board: Fisheries Research (2010-date)
M.C.J. Verdegem		Editor-in-Chief: Aquaculture Research (2009-date). Editorial Board: Aquaculture (2010-date); Editorial Board: Aquaculture Engineering (2014-date)
J.A.J. Verreth		Editorial Board: NJAS (2013-date); Editorial Board: Reviews in Aquaculture (2011-2012);
<b>Memberships of academies, a.o.</b>		
J.A.J. Verreth		Member National Scientific Advisory Board INRA (2005-2010) Member SAC Dept Phase INRA (2011-2013) Member SAC, Faculty Fisheries, South Bohemian University (2014-date) Member AERES Peer Review Committee IFREMER (2013) Member Peer Review Committee DTU-Aqua (2011) Member Peer Review European Master Marine Conservation for European Consortium for Accreditation (2012)

#### 4. Relevance to Society

Most of our graduates find a job in industry and NGO's. We want therefore to expose our students to societally relevant aspects of the domain.

Since the 1990s, environmentalists, NGOs and scientists, such as Daniel Pauly (*Nature* **418**, 689-695, 2002) criticized fisheries and aquaculture for destroying ocean biodiversity and for feeding fish to fish. As a response to this criticism, fish-feed manufacturers tried to replace marine ingredients by plant ingredients. In line with its mission, AFI decided to contribute to this societal debate by focusing its nutritional research on the digestion of carbohydrates and the anti-nutritional effects of the non-starch polysaccharide fraction in the diet. Sponsored by Nutreco-Skretting, the NWO/STW project "Vegetarian Fish" (2002-2006) and the PhD study (2008) of Urán on soybean induced enteritis helped Skretting to develop a scoring system for enteritis, which has become a standard in the industry. Retailers and food-service companies, furthermore, agreed to sell only MSC/ASC-certified sustainable seafood by 2015 or 2020 (<http://seafood-promises-of-retailers/>). In the framework of this agreement, the international retailer Royal Ahold asked advice from AFI to develop its Sustainable Seafood Policy. Using WWF and the New-England-Aquarium as review panel, we benchmarked different certification schemes against the FAO Guidelines for eco-labelling of fish and fishery products. The results were subsequently discussed with the standard owners of the different certification schemes (MSC, GlobalGap, GAA-BMP, ASC, FoS a.o.), who all adjusted their procedures based on our findings. A new consortium, *The Global Sustainable Seafood Initiative*, continues the work by developing a common Benchmarking Tool for seafood certification (<http://www.ourgssi.org/>), for which it employed, as its program manager, our student, who was involved in the Ahold study.

The search for sustainability certification has tremendous effects on the producers. Management plans, stock-allocation and Fishery-Improvement-Plans (FIPs) must be in place. Our project BESTTUNA ([www.besttuna.org](http://www.besttuna.org)) addresses these plans for the tuna fisheries in the Western Central Pacific Ocean. The adjacent action research program IFFIT ([www.IFITT.org](http://www.IFITT.org)) coordinates fisheries data and supply-chain information to manage better tuna hand-line and pole-line fisheries in Indonesia, together with IPNLF (<http://ipnlf.org/>). In this project, we also collaborate with MDPI-Indonesia ([www.mdpi.or.id](http://www.mdpi.or.id)), a fisheries NGO, led by our alumnus Momo Kochen, that supports the industry to work towards MSC labelling ([www.seafoodchampions.org/](http://www.seafoodchampions.org/)). IFITT is funded by the Adessium Foundation ([www.adessium.org](http://www.adessium.org)), a Dutch public-benefit organization, attached to a private investment fund.

AFI also initiated a series of interdisciplinary projects, by EU-FP6 projects 'Ponddyke' and 'Mangrove' and by WU-INREF projects POND and RESCOPAR, to contribute to the sustainable development of coastal resources and people's livelihoods. RESCOPAR ([www.rescopar.org](http://www.rescopar.org)) investigated the resilience of aquatic resources and people, living in mangrove-forested coastal areas in SE-Asia. Inspired by our approach, IUCN asked us to apply the RESCOPAR approach in four provinces of the Mekong Delta. A research program funded by NWO-WOTRO will verify the results of the IUCN project for policy-makers and farmers. ECOSHAPE (a foundation of the Dutch Sustainable Water Fund) invited us to participate in a rehabilitation program for a coastal area in Indonesia.

##### 4.1 Demonstrable products - Research products for societal target groups

Table 4.1: Examples of output for societal target groups by AFI.

Year	Output
<b>I. Professional publications or products</b>	
Handbook for sustainable aquaculture (111p).	2009: The handbook is available in all EU member country languages and targets aquaculture professionals. AFI wrote chapter 9 (p70-94). <a href="http://www.eurofish.dk/sustainaqua/">www.eurofish.dk/sustainaqua/</a>
"Aquacultuur" – Journal of the 'Dutch society of Aquaculture'.	2009-2014: 16 articles were published by AFI staff members, informing the sector on Dutch and global aquaculture activities of AFI.

Stichting Milieukeur (NGO) (Foundation Environmental Certification)

2013: Eding joins the Board of “Maatlat Aquacultuur” (product: a reference base for sustainable aquaculture in NL)

## II. Publications for the general public

WageningenUR (2014), feeding niche diagram.

Twitter: <https://twitter.com/search?q=voedselnis&src=typd>

Newspaper/website interviews

2009-2014: 15 interviews published in newspapers, including ‘Noordhollands Dagblad’, ‘Provinciaal Zeeuwse Courant’, ‘de Volkskrant’, ‘Trouw’, ‘IJmuider Courant’, ‘Visionair’, ‘Vrij Nederland’, ‘Resource’, ‘Reformatorisch Dagblad’ and ‘ATUNA’. Topics included fisheries, mussel farming, climate change, ASC label and balanced harvesting.

TV/Radio interviews

2009-2014: 7 interviews on fisheries, coral reefs, mussel culture, blue revolution, and sustainability/food-safety of seafood from Asia.

## III. Other research outputs

### - Reports (for the sake of policy making)

Eijsackers H., Nagelkerke L.A.J., Van der Meer J., Klinge M. & Van Dijk J., 2009. Streefbeeld Aal. Een deskundigenoordeel. (Ambitions Eel. An expert evaluation)

Expert advice commissioned by the Dutch Ministry; 17 pp. + 8 annexes.

Rabbinge, R., van der Meer, J., Quak, J., Verreth, J.A.J., van der Waal, A. & Nagelkerke, L.A.J. (2013) Herberekening Streefbeeld Aal: ... (Recalculation ambitions eel: an analysis of existing Dutch ambitions considering views of neighbouring countries)

Expert advice for the Dutch Minister of Economic Affairs, on specific request of the Parliament, House of Representatives; 20 pp. + annexes.

Schiphouwer, M.E., van Kessel, N., Matthews, J., Leuven, R.S.E.W. van de Koppel, S., Kranenburg, J., Haenen, O.L.M., Lenders, H.J.R., Nagelkerke, L.A.J., van der Velde, G., Crombaghs, B.H.J.M., Zollinger, R. (2014) Risk analysis of exotic fish species included in the Dutch Fisheries Act and their hybrids.

Policy report - Nederlands Expertise Centrum Exoten (NEC-E), Nijmegen. 207 pp.

van Kessel, N., Kranenburg, J., Dorenbosch, M., de Bruin, A., Nagelkerke, L.A.J., van der Velde, G., Leuven, R.S.E.W. (2013) Mitigatie van effecten van uitheemse grondels: kansen voor natuurvriendelijke oevers en uitgekende kunstwerken.

Policy Report on mitigation of impact of exotic fish species.  
*Verslagen Milieukunde 436. Institute for Water en Wetland Research, Radboud University, Nijmegen, 88 pp.*

### - Instruments, infrastructure

CARUS experimental facility

Fish respiration cells and tailor-made RAS systems accessible for European Researchers – [aquaexcel.eu](http://aquaexcel.eu)

### - Datasets, software tools, or designs developed

Corporate responsibility programme – Database to compile capture-data from fishers and tuna industry and to generate summary reports.

Program developed into an independent NGO in Indonesia with investment from Dutch parties (ANOVA – Adessium Foundation). Recordings of catches are necessary to check sustainability of fishery and to obtain licence to sell tuna in European markets.

Digital infrastructure to enable European scientists making use of our facilities

Design of an e-infrastructure for remote access to the sensor measurements in the metabolic research unit of AFI

**- Outreach activities for a general audience (lectures, exhibitions)**

Darwin lecture – June 2009 (Nagelkerke)

**- Activities with respect to primary and secondary education**

Workshop 'bijscholing' for teachers at vocational level, given by Eding

2014: Topic: fish production in environmentally friendly recirculation systems

#### 4.2 Demonstrable use of products - Use of research products by societal groups

*Table 4.2: Examples of use of research products by societal target groups of AFI.*

##### **Contract research (including consultancies), also co-publications**

Contract research in CARUS facilities:

- Aquafeed: Nutreco, Biomar, Ewos
- Feed ingredients: Dupont, Evonik, Akiolis

Consultancies:

- Development of RAS diets for salmon (2011)
- Development of commercial RAS in Africa (2013), Food Tech Africa project
- USA American eel culture – development of RAS systems for eel culture (2014)
- EU Peer review 'CGIAR' WorldFish project 'Improving the Techno-logical foundation for sustainable aquaculture' (2012)

##### **Overview first jobs/present jobs of alumni (domains)**

Domain Aquaculture

MSC graduates in 2014 & 2013 were already employed at time of graduation (feed companies, farm development, farm manager, researcher, Aquaculture Stewardship Council)

Domain Marine Resource Management

Ministry, NGOs (Stichting Noordzee, MSC, WWF), water authorities, research (IMARES)

##### **Participation in training courses (paid courses)**

Professionals in Recirculating Aquaculture System (RAS) Technology (Eding)

- Hungary – HAKI staff and east European professionals – 2014
- Saudi Arabia – farm professionals - 2014
- Aqua-Excel – young European Aquaculture professionals – 2013
- Spain, Zaragossa – Centre for International Mediterranean Studies – 2012

Professionals in pond management (Verdegem)

- Hungary – HAKI staff and east European professionals – 2014

New developments in aquaculture (Verdegem)

- Netherlands - HAKI staff – 2014

Professionals fish nutrition (Schrama, Heinsbroek)

- Hungary - staff and professionals from East European countries – 2013
- Netherlands - HAKI staff – 2014

Training of MBO teachers (vocational teaching) in Aquaculture & Fisheries	Training meetings through the Wageningen UR Knowledge Sharing program - 2012-2013
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**Projects in cooperation with societal groups (European Union, governments, international funds)**

SUPA project (Improving waste management for pangasius culture in the Mekong Delta of Vietnam)	Public-Private Partnership project: Dutch Ministry of Economic Affairs; Vietnam Ministry of Agriculture and Rural Development; Vietnamese Extension Service FITES, Vinh Hoan (World largest pangasius producer); De Heus (Dutch feed company); Cargill and scientists from AFI, RIA-2, and CanTho Univ
South Africa - Netherlands research Programme on Alternatives in Development (SANPAD)	Project: Alien fishes, assessing impacts and benefits: Do biodiversity costs outweigh economic, food security, and recreational benefits from alien fishes in South Africa? - 2009-2012
Improving Fisheries Information and Traceability for Tuna (IFITT) – funded by the Adessium foundation ( <a href="http://www.adessium.org/">http://www.adessium.org/</a> )	Project: Linking Catch-and-Effort-Data with Value Chain Traceability in tuna fisheries to monitor the sustainability of the fishery, and the transparency in the value chain. In cooperation with a NGO <i>Masyarakat dan Perikanan</i> (MDPI) (Indonesia), EcoTrust (Canada), and ANOVA-US (USA).

**4.3 Demonstrable marks of recognition - Marks of recognition by societal groups**

*Table 4.3: Examples of marks of recognition by societal target groups of AFI.*

<b>Valorization/Technology Transfer funding</b>	
Innovative concept of outdoor RAS for pangasius farming in Vietnam	Vinh Hoan constructed first outdoor RAS in Vietnam – US\$ 200 000 investment in equipment - 2014
De Heus Vietnam builds training and feed testing centre in Vietnam, with AFI consultancy.	Six ha station in centre of Mekong delta - 2013-2014
Spin-off company Tim Wijgerde (PhD graduate AFI)	Company ‘Sustainable Coral Farming’ cultures corals in Utrecht as alternative to collection of corals at sea - 2013–2014
Board membership Aqua-Spark Marc Verdegem	Aquaculture Investment Company – worldwide investments in medium sized aquaculture enterprises.
<b>Positions paid by societal groups</b>	
Secondment of Nutreco staff at AFI	2013– 2014 0.6 FTE (Dr. Roem) and 2015 0.2 FTE

**5. Viability**

AFI is a vital group, with senior faculty who have a high reputation in their specific field of research and who are active in national and international networks. AFI attracts increasing numbers of students (>25 PhD students, >30 MSc theses annually) which provides a sound basis for research and finances. The Chair group works on topics that are high on the agenda of industry and funding agencies, leading to an increasing and strong participation in programs funded by WorldBank, IUCN, EU, Dutch government and NWO, and in programs funded by industry. AFI is capable of increasing its output and scientific impact well above international standards.

### 5.1 Benchmark

A bibliometric analysis of aquaculture research from Canada (period 1996-2008) included a benchmark in which Verreth and Verdegem were ranked worldwide within the top 20 scientists in this field. This study did not include fisheries. Using Sci-Val, therefore, we benchmarked ourselves to teams that have a profile, similar to AFI in the various subdomains.

The Danish Technological University DTU has an aquaculture team that combines nutritional physiology and RAS, and that is considered to be one of the most prominent teams in RAS technology. DTU also has a world renowned team on marine fisheries and fish population biology. Prof. Michael Kaiser from Bangor University (Wales, UK) is world renowned for his research and textbooks on fisheries ecology, and his team encompasses also aquaculture specialists. For fish nutrition, the INRA team at St-Pée is considered to be the number 1 globally. Our work on aquaculture production systems compares best with the Sustainable Aquaculture Group at the University of Stirling (Scotland, UK), which has a worldwide reputation, and has alumni in the top of all international organisations, such as FAO and WorldFish.

Our productivity is the highest among our peers. We consider the Field Weighted Citation Index to be a proxy for the scientific impact. The ranking for this parameter is led by INRA (a pure fish nutrition team) followed by all other teams which cluster close to each other. AFI is in the middle of this group.

*Table 5.1. Benchmark AFI with peer groups by year and number of publications per person and field weighed citation impact.*

Year	Refereed papers per # person					Field Weighted Citation Index				
	AFI	DTU	Bangor	UoS	INRA	AFI	DTU	Bangor	UoS	INRA
2008	3.1	1.5	1.2	1.5	2.2	1.31	0.88	1.39	0.94	1.51
2009	2.0	1.5	1.4	1.2	2.5	2.01	1.19	0.90	0.93	1.17
2010	2.5	2.2	1.1	1.7	2.6	1.51	1.81	1.19	1.16	1.14
2011	3.4	2.2	1.5	2.0	2.6	1.28	1.52	1.51	1.55	1.68
2012	3.2	2.1	2.0	1.8	1.9	1.05	1.53	1.38	2.07	4.1
2013	4.4	3.3	2.6	0.8	2.8	1.18	1.48	1.2	1.67	1.44
<b>Average</b>	<b>3.1</b>	<b>2.1</b>	<b>1.6</b>	<b>1.5</b>	<b>2.4</b>	<b>1.33</b>	<b>1.45</b>	<b>1.27</b>	<b>1.41</b>	<b>1.74</b>

### 5.2 SWOT-analysis

AFI addressed all comments made by the previous peer review and achieved all its targets. The research scope was narrowed; funding from non-governmental sources was increased; and links with industry and NGOs were strengthened; output of refereed articles doubled, while average IF, number of citations and relative impact RI increased. The benchmark exercise, nevertheless, showed that we can still improve our publication strategy. Prestigious NWO/WOTRO grants were obtained, indicating that AFI's research gained in recognition of its scientific quality. Part of this success is based on AFI's unique combination of disciplines and its ease of crossing bridges between western and tropical aspects. These characteristics of AFI enables the Chair group to collaborate with top specialists from all over the world. Students, industry and NGOs, therefore, seek also collaboration with AFI. More than 2/3 of our PhDs are co-supervised by other research teams on a broad range of topics. We have been able to position ourselves at the frontier of developing new concepts for the sector. The notion that replacing marine with plant ingredients in fish diets can impact water quality and food-web dynamics was a result of the integrated approach in our research, and was an eye-opener for many colleagues. Some of the world leading nutritionists (e.g., from INRA) collaborate with us, precisely because they lack the possibility to cross disciplinary bridges as we do. Our integrated disciplinary approach also enables us to open new opportunities for innovative research topics, such as the biofloc project (PhD-JvdLoo, funded by NWO), or the chemical characterization and improvement of low-quality ingredients (Postdoc-Butre; co-funded by Akiolis & Biomar). AFI belongs to a small number of key European players in Asia, giving us a high profile in FAO, NACA, WorldFish, and others. Working in the tropics can be time consuming, but the combination of excellent western fish science, with extensive experience in tropical countries, distinguishes us from most colleagues in Europe. Our staff members are internationally recognised and our facilities are used by visiting scientists. We play a leading role in our domain by participating in international committees, networks, professional organizations, editorial boards, organizing conferences, international short courses, and summer schools. AFI initiated a specialized BSc Minor and the new MSc programme "Aquaculture & Marine Resources

Management". This initiative raised student numbers, providing sound perspectives for the future. The linkage with Imares has been invaluable: part of the growth in MSc students and PhD candidates was accommodated by joint supervision between Imares and AFI. The establishment of the cluster "Biology & Aquatic Resilience" opens opportunities for further development of a strong aquaculture and marine sciences unit within Wageningen, and increases flexibility in terms of human resources.

Internal	Strengths	Weaknesses
	<ol style="list-style-type: none"> <li>1. Strong international research profile</li> <li>2. Excellent network with industry and NGOs</li> <li>3. Growing number of MSc and PhD alumni at national and international senior positions</li> <li>4. High quality staff members and facilities, that are internationally recognised</li> <li>5. Capacity to collaborate with other WUR groups (e.g. IMARES, Chairs in Animal, Environmental, Social, and Food Sciences)</li> </ol>	<ol style="list-style-type: none"> <li>1. High demand from industry and NGOs for our MSc graduates results in reduced interest for a PhD study among our alumni and creates a narrow basis to recruit Veni and ERC scholars</li> <li>2. Demand for a broad coverage in MSc education conflicts with search for focus in research</li> </ol>
External	Opportunities	Threats
	<ol style="list-style-type: none"> <li>1. "Fish" and "Blue Growth" is a growing domain globally and "marine" is a centrepiece of WUR's strategy</li> <li>2. Growing expertise in microbial aspects of aquaculture provides opportunity to build a research focus on health aspects, together with WIAS Chairs CBI, HMI, and Microbiology</li> <li>3. The new Chair Marine Animal Ecology provides opportunities to build a coherent research program around trait-based approaches to climate effects and invasions of exotic species in fish communities</li> </ol>	<ol style="list-style-type: none"> <li>1. Constant attention is required to maintain focus in a period when we are approached increasingly for collaboration</li> <li>2. New regulations for animal experimentation increase the costs of conducting fish experiments, which creates a competitive disadvantage for us, compared with international competitors</li> </ol>

### 5.3 Future strategy

Three international trends reflect the growing popularity and strategic interest for AFI's domain. "Blue Growth" and "Sustainable use and conservation of marine resources" are concepts used in many policy and strategy documents from FAO, EU, and Worldbank. The European Marine Board, in its Rome Declaration (October 2014), calls for more integrated science, that recognizes stakeholder needs and promotes environmental sustainability ([www.marineboard.eu](http://www.marineboard.eu)). The European Aquaculture Technology and Innovation Platform EATiP identified 8 research themes in its strategic agenda ([www.eatip.eu](http://www.eatip.eu)), of which five fit with AFI's objectives. The international and national agenda, in addition, identifies "food security" as a priority domain.

Climate change is an important factor for resilience of aquaculture and fisheries systems. AFI studied multi-stressor effects in corals, as a tool for studying resilience. Together with MAE and Imares, we can expand the study of resilience to other taxa, such as fish, as we did in our research on Lake Victoria's fisheries. The future view on the use of seas and oceans changes from exploitation to multiple use, in function and space. This change in view requires knowledge on the interaction among marine habitats, effort allocation, and associated changes in societal claims on the use of marine resources. The required knowledge fits well to the current profile of AFI.

The new strategic plan of Wageningen UR identified use of resources and resilience as top priorities, which links well with AFI's core competences. The new DDW cluster "Biology & Aquatic Resilience", which brings together AFI, EZO, CBI, and MAE, provides opportunities to collaborate and to strengthen the AFI domain within Wageningen. During the current review period, AFI developed expertise in the interaction

among feed formulation, intestinal ecology, faeces composition, water quality changes, and system microbiology. In the future, we aim to add intestinal microbiology to this list, and combined with CBI's immunology knowledge, to build a strong research component on fish health. This component will link our work even better to the international research agenda set by EATiP, FAO, and Worldbank. In doing so, we will capitalize on increased collaboration with ASG-Centre for Animal Nutrition (CAN), with which we cooperate already in the current strategic program IP/OP of Wageningen UR. This increased collaboration will facilitate the inclusion of research on fish nutrition in the research proposals of CAN for the Dutch Innovation policy, and will create strong perspectives for future funding.

## **6. Research Integrity**

We endorse WU's policy regarding aspects of scientific integrity and ethical issues, as described in part A. The current WIAS director has promoted the inclusion of these aspects in the WIAS Introductory course and has stimulated PhD students and staff members, to pay attention to these aspects whenever possible. Within AFI, all PhD candidates have an intake-meeting with the Chair holder, where does and don'ts of pursuing a PhD at AFI are discussed, especially integrity issues. During the monthly Chair-group meetings, attention is also paid to these matters. Issues focus not only on (co-)authorship and data management, but also on fabrication and falsification of data.

AFI developed a data management plan with instructions how data, from experimental logbooks to field data, are stored. PhD students share all raw data with their supervisors and store them in @csv files with an associated metafile, which clarifies the structure of the stored data.

Daily supervision of PhD candidates is done by assistant and associate professors. The Chair holder joins the supervision for strategic discussions on the study design, progress, paper/thesis writing, and any other strategic choices. Annual evaluations of performance are discussed by the daily supervisor, and the candidate can then evaluate the functioning of the supervisor. Candidates may use often the Chair holder as mediator when conflicts or differences in views arise. We cherish an open and transparent culture within the team, with specific awareness for cultural differences.

**Appendix 1** - Research staff Aquaculture and Fisheries group

Table 1 - Research staff input at Chair Group level

<b>Name staff</b>		<b>Funding 1, 2, 3*</b>	<b>2009 FTE**</b>	<b>2010 FTE</b>	<b>2011 FTE</b>	<b>2012 FTE</b>	<b>2013 FTE</b>	<b>2014 FTE</b>
<i>Full professors</i>								
Prof dr J.A.J. Verreth (1 fte)	Tenured	1	0.3	0.2	0.2	0.2	0.2	0.2
<i>Special chairs</i>								
Prof. dr. A.D. Rijnsdorp ( 0.4 fte)	1-1-2008/1-1-2013	1	0.1	0.1	0.1	0.1	0.15	0.15
Prof. dr. A.C. Smaal (0.2 fte)	1-4-2007/	1	0.1	0.1	0.1	0.1	0.08	0.08
<i>Associate professors</i>								
Dr ir J.W. Schrama (1 fte)	Tenured	1	0.4	0.4	0.4	0.2	0.4	0.4
<i>Assistant professors</i>								
Dr ir L.A.J. Nagelkerke (1 fte)	Tenured	1	0.4	0.4	0.4	0.4	0.3	0.3
Dr ir M.C.J. Verdegem (1 fte)	Tenured	1	0.4	0.3	0.3	0.3	0.3	0.3
Ir P.A.M. van Zwieten (0.8 fte)	Tenured	1	0.2	0.2	0.2	0.2	0.3	0.3
<i>Researchers</i>								
Ing. E.H. Eding (1 fte)	Tenured	1					0.1	0.1
Ir L.T.N. Heinsbroek (0.8 fte)	15-6-2007/15-06-2008	3	0.4	0.6	0.5	0.4	0.25	
Dr ir R.H. Bosma (0.8 fte)	1-1-2005/1-1-2008	3	0.1	0.15	0.1	0.1	0.1	0.1
Dr R. Osinga (0.8 fte)	1-6-2005/1-06-2009	3	0.2	0.3	0.3	0.3	0.3	0.2
Dr. A. Roem (0.6 fte)	1-1-2013/	3					0.3	0.3
<i>Post-docs</i>								
Dr ir K.E. van de Wolfshaar (0.8 fte)	1-3-2007/1-03-2010	2	0.5					
Dr. C. Butré (1 fte)	1-9-2014/1-9-2016	1						0.3
<i>Visiting fellows</i>								
Dr Manuel Mendoza Carranza	1-8-2013/1-8-2014						0.33	0.58
Dr C.I.F. Silva	1-11-2012/1-6-2013					0.17	0.42	
Dr A.C. Figueiredo Silva	1-4-2011/1-6-2011				0.17			
Dr. Leonardo J. Magnoni	1-10-2014/1-1-2015							0.25
Peyman Mosberian Tanha, Msc	1-5-2014/31-8-2014							0.33
Dr. Luís André Sampaio	1-1-2008/1-8-2009		0.58					
<b>Total scientific staff</b>			<b>3.68</b>	<b>2.75</b>	<b>2.77</b>	<b>2.47</b>	<b>3.53</b>	<b>3.90</b>
<i>Support staff</i>								
R. Booms	Tenured	1	0.5	0.5	0.5	0.5	0.5	0.5
Ing. M. ter Veld	Tenured	1	0.8	0.8	0.6	0.4	0.4	0.4
T. Leffering	Tenured	1	1	1	1	1	1	1
Ing. E. Eding	Tenured	1	0.4	0.4	0.4	0.4	0.4	0.4
<b>Total staff</b>			<b>6.38</b>	<b>5.45</b>	<b>5.27</b>	<b>4.77</b>	<b>5.83</b>	<b>6.20</b>

\* Funding scores: 1= direct funding by University; 2= funding obtained in national scientific competition (e.g. grants from NWO, KNAW) ; and 3= funding obtained from external organisations, such as industry, governmental ministries, European Commission and charity organisations.

\*\* FTE reported in this table regards the research appointment part of the total appointment (e.g. tenured staff has 40% available for research, postdocs have 60% available for research).

**Appendix 2** - Scientist for benchmark Aquaculture and Fisheries group

*Table II. AFI compared with the the scientist selecte of the combination of DTU-fisheries (experts from the Ocean Centre) and DTU-aquaculture, with the UoS Stirling-Sustainable Aquaculture Group, with the INRA-team NuMeA at St.-Pée sur Nivelles), and with Bangor University (Fisheries & Conservation Science group).*

<b>AFI-Fisheries</b>	<b>DTU-Fisheries</b>	<b>Bangor-Aquaculture and Fisheries</b>	
Nagelkerke, L.A.J.	Andersen, K.H.	Bloor, I.S.M.	
Rijnsdorp, A.D.	Gislason, H.	Cambiè, G.	
Van Zwieten, P.A.M.	Lindegren, M.	Haig, J.A.	
	Mackenzie, B.R.	Hiddink, J.G.	
		Hold, N.	
		Kaiser, M.J.	
		Lambert, G.I.	
		LeVay, L.	
		McCarthy, I.D.	
		Murray, L.G.	

<b>AFI-Aquaculture</b>	<b>DTU-Aquaculture</b>	<b>UoS</b>	<b>INRA</b>
Bosma, R.H.	Dalsgaard, J.P.T.	Bostock, J.	Alami-Durante, H.
Eding, E.H.	Jokumsen, A.	Leschen, W.	Clément, O.
Osinga, R.	Larsen, B.K.	Little, D.C.	Corraze, G.R.
Schrama, J.W.	Lazado, C.C.	McAdam, B.J.	Fontagné, S.
Smaal, A.C.	Lund, I.	Ross, L.G.	Geurden, I.
Verdegem, M.C.J.	Paulsen, H.	Telfer, T.C.	Kaushik, S.J.
Verreth, J.A.	Pedersen, L.F.		Médale, F.
	Pedersen, P.B.		Panserat, S.
	Skov, P.V.		Seiliez, I.
			Skiba-Cassy, S.



## Behavioural Ecology (BHE)

**Programme leader(s): Prof. Dr Marc Naguib, Chair, since November 2011**

*For a full staff survey see appendix 1.*

### 1. Objectives and Research Area

#### 1.1 Vision, Mission and Objectives

**Vision:** Social environments are shaped by the characteristics of individuals

**Mission:** To improve understanding of the causes and consequences of social behaviours in animals in natural systems and husbandry systems

**Objectives:** We tackle our mission by conducting fundamental and applied research in social animals with known individual characteristics in captive situations as well as within their natural habitat. This includes research on early developmental effects on behaviour, family conflicts, communication, cognition, spatial behaviour and social networks using wild and captive animals, mainly birds, as model species.

- 1) Our fundamental research is aimed at a better understanding of behaviour from an evolutionary perspective and how individual behaviour contributes to higher order population processes.
- 2) Our applied research is aimed at identifying causes for development of e.g. undesired behaviour in farm animals such as feather pecking to provide knowledge improving animal welfare.

By applying our expertise in animal behaviour to different study systems - wild animals and farm animals and to some extent (mainly for educational and societal purposes) in companion animals, we cover three key areas of research in animal behaviour that are targeted at addressing fundamental, applied as well as societal issues.

#### 1.2 Research Area / research line(s)

Our research focuses on the causes and consequences of various social behaviours. This includes early developmental and maternal effects on behaviour, family conflicts, communication and sexual selection, cognition, and social networks in natural and husbandry systems, focussing on birds (Fig.1 ). A central theme is to identify causes and consequences of individual strategies and individual consistency in behaviour (animal personality). These individual characteristics are highly relevant to understanding within population diversity and how selection acts on this. This approach is also crucial for welfare questions, warranting a range of solutions to comply with the needs of different individuals. The main research fields are:

- 1) Behavioural ecology of songbirds to reveal behavioural principles in the wild and to determine how selection may act on them (family conflicts, communication, territorial behaviour, mate choice, sexual selection, cognition and social networks) (2fte; MN, CAH, postdocs and PhD students).
- 2) Behaviour of farm animals (poultry, feather pecking, behavioural development, cognition, social networks) to determine causes and consequences of behaviour that is (mal)adaptive and of welfare relevance. (1fte; TBR and PhD students)

Our fundamental scientific knowledge on animal behaviour is applied in research projects with dogs, and recently cats, mainly for education and addressing societal concerns (1.5fte; BB, JvdB). The main focus areas in our companion animal activities are owner-pet interactions, pet personality traits and problem behaviours.

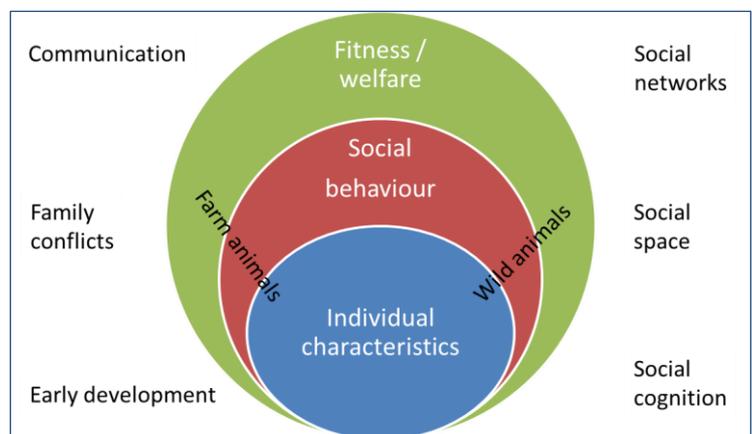


Fig. 1 Research topics and integration overview of the Behavioural Ecology Group (BHE)

### 1.3 Strategy

The overarching strategy is to tackle our objectives using experimental and descriptive approaches under standardized conditions (indoor test facilities) as well as under natural conditions in the wild (behavioural ecology) or on farms (applied animal behaviour). Part of this strategy is to cooperate with other top research groups and institutions in our fields and cooperate with industrial partners where feasible and appropriate. The composition of our group is internationally almost unique as we conduct research in applied animal behaviour as well as in evolutionary oriented fundamental research in behavioural ecology. This combination provides the unique opportunity to cross fertilize these fields by the different approaches to similar questions.

In behavioural ecology, some of our recent achievements were the identification of personality-dependent responses to noise pollution, social connectivity in wild song birds using novel automatized tracking techniques allowing us to track for the first time many resident birds simultaneously, leading to novel insights on personality-dependent social network structures, documentation of effects of the early social environment on personality development in birds, and principles of conflict resolution in parental songbirds.

In applied animal behaviour we revealed new causal factors leading to feather pecking in laying hens. Here, we have shown that stress in the parents transfers to the offspring and leads to an increase in feather pecking at an early age, especially in environments where birds have limited opportunities for normal foraging and pecking behaviour. *Note that the Behavioural Ecology Group was established in December 2011 with the scientific staff being appointed in summer 2012.*

Considering the future outlook over the coming 5 to 10 years we expect to develop a better understanding of the role of individuals within groups and the way they cope with challenges and solve conflicts. We aim to achieve this goal by, for instance, applying novel tracking and sensor technologies to collect data on individuals within groups to determine social dynamics and social network structures and their consequences, which will be a crucial step forward from our current position. The research strategy integrates with our educational activities from BSc to PhD level.

### 1.4 Research environment and embedding

We actively contribute to two research schools, WIAS and PE&RC, by being involved in seminars, working groups and plenary lectures (science days; WIAS 2011, PE&RC 2009), and through the Taskforce Ecology (PE&RC) to outline a vision for WUR future ecology. Camilla Hinde is also member of the Wageningen Young Academy. Within the Animal Sciences Department, the Behavioural Ecology Group is one of the five members of the cluster Adaptive Animals and Systems where joint research initiatives on adaptation of animals and systems to challenges in their environment are developed. We represent and help each other, share research facilities and are a sounding board to increase opportunities and effectiveness and to minimise risks. The Behavioural Ecology Group also is an active member within the Centre for Animal Welfare and Adaptation (CAWA), which integrates expertise on animal welfare of the Adaptation Physiology Group (ADP), our group, and Wageningen Livestock Research (WLR). Our staff has strong national and international ties to key research institutions. Nationally we have a very close and fruitful cooperation with the Netherlands Institute of Ecology (NIOO-KNAW), Behaviour Groups at Leiden University and the Veterinary Faculty of Utrecht University. Moreover, we are establishing a cooperation with Twente University and in the applied field cooperate with industrial partners (Ter Heerdt, Hendrix Genetics, Van Beek Group, Impex). Internationally we cooperate, among others, with Universities/Research Institutions in Belgium (ILVO, Ghent), England (Universities of Bristol, Exeter, Oxford, Cambridge QMU London), France (University Paris-Nanterre, INRA), Germany (Bielefeld University, Freie Universitaet Berlin, Max Planck Institute for Ornithology, Friedrich Löffler Institute Celle, Leibnitz Insitute for Fisheries), Norway (NMBU), Switzerland (Bern), Canada (University of Guelph), New Zealand (Waikato University) and are the leading group in a Europe wide application for an EU ITN training network grant. These cooperations involve joint publications and project applications. Our research staff is internationally among the top in their field and all have high international reputation.

### 1.5 Reference to previous assessments

The Behavioural Ecology Group was established in 2012 and was not part of the previous evaluation. The midterm review was very positive about our clear vision and strong potential “ *This is a newly established*

and promising chair group that was not part of the Peer Review 2009. The new chair has developed a comprehensive view on how to integrate knowledge from social behaviour of animals in the wild, farm animals and companion animals [...]. The group's scientific potential is great. The young staff already has an impressive track record, which is expected to grow in the near future.", with recommendations to further develop and integrate the talents in the group and to expand and strengthen existing networks within the University/Department, nationally and internationally. We have followed this advice and the Cluster Adaptive Animal and Systems has been very important instrumental for the within Department integration. We have initiated a number of projects which build on our strong expertise in social behaviour and on our strong national and international networks (EU ITN training network grant, STW Breed4Food application with ADP, WLR, Univ. Twente and Industry partners, WIAS/NWO grant on microbiota and behaviour with ADP), ALW open call grant submissions as well as a range of postdoc grants. Moreover, through educational activities (courses and thesis students) we have established a large network with other groups within Wageningen University out of which we expect to develop also research cooperations.

## 2. Resources and Facilities

The Behavioural Ecology Group is at a size which is typical for this field at other Universities. The current staff works very effectively and is well suited to address our objectives. As a growth scenario we are actively aiming to attract postdocs and are applying for funding for PhD students. We just appointed a new PhD student (WIAS/NWO funding). Postdocs applications are currently under consideration by NWO (Veni), the EU (ERC and Marie Skłodowska-Curie) and NERC, and PhD funding is sought through NWO (ALW, STW and Vidi), ERC grants, and an ITN training network grant. Moreover, we aim at increasing the number of research assistants to support our research and education activities. Our current grants are an ALW open competition grant and a CIG EU grant (Career integration network) and our group has two additional PhD students funded by WIAS and NWO. We also obtain substantial income through our (expanding) educational activities. Additionally, we had several short term postdoc fellowships through the graduate schools. Within the applied field we also apply for funding through the Breed4Food Consortium (STW Partnership call). Our current research combines research at the University (Carus) facilities, at commercial farms and for songbirds at the excellent field sites run by our cooperating partner, the Netherlands Institute of Ecology (NIOO-KNAW).

### 2.1 Researchers

Table 2.1. Research input: number<sup>1</sup> and FTE<sup>2</sup> of Scientific staff, Post-docs and PhD candidates by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff <sup>4</sup>							5	1.5	5	1.8	5	1.9	5	1.7
Post-docs <sup>5</sup>							1	0.7	1	0.3	1	0.9	1	0.6
PhD candidates <sup>3,6</sup>							1	0.7	2	1.0	2	1.5	2	1.1
<b>Total research staff</b>							<b>7</b>	<b>2.8</b>	<b>8</b>	<b>3.1</b>	<b>8</b>	<b>4.3</b>	<b>8</b>	<b>3.4</b>
Lab Technicians							1	1.0	2	0.5	1	1.0	1	0.8
Visiting fellows							0	0.0	0	0.0	0	0.0	0	0.0
<b>Total staff</b>							<b>8</b>	<b>3.8</b>	<b>10</b>	<b>3.6</b>	<b>9</b>	<b>5.3</b>	<b>9</b>	<b>4.2</b>

<sup>1</sup> Total number of staff and PhD candidates

<sup>2</sup> Available research time in full time equivalent (FTE)

<sup>3</sup> All PhD categories, except external PhDs

Standards for Research Capacity (in case of part time appointment adjustment is applied):

<sup>4</sup> Professor, Assistant Professor and Associated Professor: Research Capacity = 40% of the appointment

<sup>5</sup> Post-doc: Research Capacity = 90% of the appointment

<sup>6</sup> PhD candidate: Research Capacity = 75% of the appointment (all categories)

## 2.2 Research Funds

Table 2.2. Funding of Scientific staff, Postdocs and PhD candidates by year and Expenditure of Chair group by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
Funding:	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%
Direct funding <sup>1</sup>							2.2	76	2.4	76	3.6	83	2.7	78
Research grants <sup>2</sup>							0.7	24	0.8	24	0.8	17	0.7	22
Contract research <sup>3</sup>							0.0	0	0.0	0	0.0	0	0.0	0
<b>Total funding</b>							<b>2.8</b>	<b>100</b>	<b>3.1</b>	<b>100</b>	<b>4.3</b>	<b>100</b>	<b>3.4</b>	<b>100</b>
<i>Expenditure<sup>4</sup>:</i>							<b>K€</b>	<b>%</b>	<b>K€</b>	<b>%</b>	<b>K€</b>	<b>%</b>	<b>K€</b>	<b>%</b>
Personnel costs							383	69	477	65	573	72	478	68
Other costs							169	31	262	35	228	28	220	32
<b>Total expenditure</b>							<b>553</b>	<b>100</b>	<b>739</b>	<b>100</b>	<b>801</b>	<b>100</b>	<b>698</b>	<b>100</b>

<sup>1</sup> Direct funding by the University

<sup>2</sup> Research grants obtained in national and international scientific competition (e.g. grants from NWO, KNAW)

<sup>3</sup> Research contracts for specific research projects obtained from external organisations, such as industry, governmental ministries, European Commission (including ERC), charity organisations

<sup>4</sup> Expenditure from financial system of Wageningen University which not only includes research but also teaching and other activities

## 3. Research Quality

Our main strategy is to publish in the top journals within our fields and in leading interdisciplinary journals. This strategy has been very successful and our research is highly cited over many years. Marc Naguib is among the top authors in his area (WoS-search 12-5-2015; ranked #4 for “Animal communication”, and #5 for “Early developmental stress”), Bas Rodenburg is ranked #2 (WoS search 12-5-2015 “Behaviour AND Laying hens), Camilla Hinde is ranked #5 (WoS search 12-5-2015 “Parent-offspring conflict AND Negotiation”). To document our high quality research we target the highest journals within the respective areas such as *Animal Behaviour* or *Behavioural Ecology* (the leading journals in behaviour research) as well as higher impact broader journals such as *Proceedings Royal Soc Lond B* or *PloS one*. Moreover we target selected studies at high impact journals which take more time and endurance but leading to publications by CAH in *Science* and *Ecology Letters*. In animal behaviour smaller studies often are highly relevant, so we also publish these in respected journals, which yet have lower impact factors. Most relevant is that our research is recognized and picked up within our fields.

### 5 recent relevant publications:

Snijders, L., van Rooij, E. P., Burt, J., Hinde, C. A., van Oers, K., Naguib, M. 2014. Social networking in territorial great tits: slow explorers have the least central social network positions. **Animal Behaviour** 98, 95-102. . **Imp. Fact. 3.1**

de Haas, E.N., Bolhuis, J.E., Kemp, B., Groothuis, T.G.G., Rodenburg, T.B. 2014. Parents and Early Life Environment Affect Behavioral Development of Laying Hen Chickens. **Plos One** 9, e90577. **Imp. Fact. 3.5**

Head, M, Hinde, C.A., Moore, A, Royle, N. 2014. Correlated evolution in parental care in females but not males in response to selection on paternity assurance behaviour. **Ecology Letters**, 17:7, 803-810. **Imp. Fact. 13.0**

Naguib, M., van Oers, K., Braakhuis, A. Griffioen, M., de Goede, P., Waas, J.R. 2013

Noise annoys: effects of noise on breeding great tits depend on personality but not on noise characteristics. *Animal Behaviour* 85, 949-956. **Imp. Fact. 3.1**

**Hinde, C.A.**, Johnstone, R.A., Kilner, R.M. 2010 . Parent-offspring conflict and coadaptation. *Science* 327: 1373-1376. **Imp. Fact. 31.5**

### 3.1 Demonstrable products - Research products for peers in science

Table 3.1. Categories of research output by year.

Category:	Year						Total	Average 2009-2014
	2009	2010	2011	2012	2013	2014		
<b>Academic publications</b>								
a. Refereed articles				10	17	25	52	17
b. Non-refereed articles				0	1	0	1	0
c. Books				0	0	0	0	0
d.1. Refereed book chapters				2	1	2	5	2
d.2. Non-refereed book chapters				0	0	0	0	0
e. PhD Theses				0	0	2	2	1
f. Conference papers				0	4	2	6	2
<b>Total academic publications</b>				<b>12</b>	<b>23</b>	<b>31</b>	<b>66</b>	<b>22</b>

### 3.2 Demonstrable use of products - Use of research products by peers

Table 3.2.1. Bibliometric indicators for BHE over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008							
2009							
2010							
2011							
2012	9	58	38	6.44	1.71	22% (2)	0% (0)
2013	16	69	31	4.31	2.24	31% (5)	0% (0)
<b>all years</b>	<b>25</b>	<b>127</b>	<b>68</b>	<b>5.08</b>	<b>2.05</b>	<b>28% (7)</b>	<b>0% (0)</b>

Table 3.2.2. Bibliometric indicators for BHE per research field over the period 2008-2013. The rows are ordered in descending number of publications (N). The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

research field	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	14	77	32	5.5	2.51	36% (5)	0% (0)
Neuroscience & Behavior	5	31	19	6.2	1.8	20% (1)	0% (0)
Agricultural Sciences	2	3	3	1.5	1.13	0% (0)	0% (0)
Environment/Ecology	2	6	10	3	0.57	0% (0)	0% (0)
Biology & Biochemistry	1	10	3	10	3.5	100% (1)	0% (0)
Psychiatry/Psychology	1	0	2	0	0	0% (0)	0% (0)
<b>all fields</b>	<b>25</b>	<b>127</b>	<b>68</b>	<b>5.08</b>	<b>2.05</b>	<b>28% (7)</b>	<b>0% (0)</b>

The current bibliographic tables reflect our high research output activities. They do not include years 2011 and earlier, as the BHE group was founded only in November 2011. As a consequence they do not reflect our individual output on which the strength of this group and its future perspective is building. At the same time, 2012 to 2014 resulted in a high number of refereed articles and book chapters **with a very good RI of above 2.0**. A trend that we will seek to maintain in future year.

### 3.3 Demonstrable marks of recognition - Marks of recognition from peers

*Table 3.3. Most important prizes, keynotes etc. of staff (max 6 per category). For remaining achievements see mini CVs (Separate file called mini CVs).*

<b>Science awards, Scholarly prizes, Research grants awarded to individuals</b>		
Year	Prize description...	Person
2013	CIG EU grant	Camilla Hinde
2011	ALW open comp. grant	Marc Naguib
2009	NWO feather pecking grant	Bas Rodenburg
<b>Plenary/Keynote* Lectures at major conferences</b>		
Year	Person	Conference
2011	Bas Rodenburg	Poultry Science Symposium 'Alternative Systems for Poultry – Health, Welfare and Productivity', Glasgow, United Kingdom
2011	Bas Rodenburg	International Congress of the International Society for Applied Ethology, Vienna (ISAE), Austria
2010	Bas Rodenburg	International Conference on Production Disease in farm animals, Ghent, Belgium
<b>Organisation of International Scientific Conferences</b>		
Year	Person	Conference
2017	Bas Rodenburg	WAFI 2017 Workshop on welfare assessment at farm and group level (member of organisation committee; 350 participants expected)
<b>Editorships and editorial boards</b>		
Person	Editorship from... until...	
Marc Naguib	Editor, <i>Advances in the Study of Behaviour</i> (since 2003); Executive Editor <i>Advances in the Study of Behaviour</i> (since 2013) Editor, <i>Journal of Ornithology</i> (since 2013)	
Camilla Hinde	Associate Editor <i>BMC Ecology</i> (since 2012)	
Bas Rodenburg	Review Editor of <i>Applied Animal Behaviour Science</i> (since 2013) Associate Editor of <i>Poultry Science</i> (since 2012) Section Editor <i>Poultry of Animal Welfare</i> (since 2015)	
Bonne Beerda	Member board <i>Applied Animal Behaviour Science</i> (till 2012) Review Editor of <i>Applied Animal Behaviour Science</i> (since 2012)	
<b>Memberships of academies</b>		
Person	Member of... from... until...	
Camilla Hinde	Young academy, Wageningen University, since 2013	

### 4. Relevance to Society

Animal Behaviour attracts high social interest: curiosity-driven questions on how animals and animal societies function to applied questions on humans-companion animal interactions and on farm animal welfare. Our research is relevant to society at different levels, including knowledge transfer through various channels. The societal relevance of our fundamental research is mainly in the generation of new knowledge. Research on farm and companion animals has immediate direct links to societal demands.

**Example 1:** Our research in behavioural ecology on social networks, personality and conflict resolution in great tits has a major impact on the general understanding of behavioural decisions in the wild and how these link to fitness. These studies are important communicators between science and society, leading to increased awareness of the role of differences among individuals in nature. This provides, for example, an important basis for wildlife management where movements of different individuals need to be considered.

**Example 2:** In laying hens, we recently completed a project on reducing feather pecking. In our research, we worked with a commercial rearing company, Ter Heerdt, to translate scientific knowledge on how to reduce feather pecking to a commercial production environment. This resulted in a toolbox that can help to improve laying hen welfare in the Netherlands. This is especially important as the Dutch government decided to ban beak trimming in 2018. Research in this area continues. Through this project and related projects, we have excellent collaboration with partners in the poultry industry and we have several former MSc and PhD students taking up R&D positions in industry (for instance at Cargill Animal Nutrition, Eierhandel van Beek).

**Example 3:** Our research on companion animals involves Hulphond Nederland (training assistance dogs), Hondenbescherming (Dutch dog protection organization) and dog shelters. Moreover, we had various society-targeted activities like a TV feature “Pavlov” or production of a handbook on the care of animals used in human health care or establishment of a validated behaviour test for assessing fear and aggression in dogs. The latter is in collaboration with the Dutch kennel club and the Dutch ministry. Ongoing work involves the development and improvement of behaviour tests for (1) assessing personality traits in assistance dogs, to reduce the number of dogs failing the training program as well as for (2) shelter dogs, to better matching dogs with new owners, and (3) for privately-owned dogs with problem behaviours.

**Summary:** Our targets for societal relevance are (a) an increased awareness and knowledge about behaviour of wildlife as a daily part of our society’s life, (b) the improvement of welfare with a focus on laying hens but with contributions also to the pig and dairy sector and (c) solve societal issues around companion animals.

#### 4.1 Demonstrable products - Research products for societal target groups

*Table 4.1.1: Examples of output for societal target groups by BHE.*

Societal relevant output
<p><b>I. Professional publications and products</b></p> <ul style="list-style-type: none"> <li>• <u>Rodenburg, T. B.</u> (2011). Er vroeg bij zijn werkt. <i>Pluimveehouderij</i>. 41: 28-29.</li> <li>• <u>Rodenburg, T. B.</u> (2011). Preventing feather pecking in laying hens. <i>World Poultry</i>. 27: 12-13.</li> <li>• <u>Naguib, M.</u> 2013. Living in a noisy world: indirect effects of noise on animal communication. <i>Behaviour</i>, 150, 1069–1084</li> <li>• <u>Phillips, C.J.C., Beerda, B., Knierim, U., Waiblinger, S., Lidfors, L., Krohn, C. C., Canali, E., Valk, H., Veissier, I., Hopster H.</u> (2013). A review of the impact of housing on dairy cow behaviour, health and welfare. Wageningen Academic Publishers. pp 37-54.</li> <li>• <u>Sniiders, L</u> (2013) Quest. Science in 1 min. Facebook for great tits. <a href="https://www.youtube.com/watch?v=DwpgC2Lgf8">https://www.youtube.com/watch?v=DwpgC2Lgf8</a></li> <li>• National TV: Pavlov 4 October 2012; <a href="http://www.uitzendinggemist.nl/afleveringen/1293784">http://www.uitzendinggemist.nl/afleveringen/1293784</a></li> </ul> <p><b>II. Publications for the general public</b></p> <ul style="list-style-type: none"> <li>• <u>Rodenburg, T. B., et al.</u> (2010). Sociale scharrelaars of schadelijke schurken? Over zorgvuldige veehouderij - veel instrumenten, één concert. Wageningen, The Netherlands: 126-133.</li> <li>• <u>Bijma, P., Rodenburg, T. B. et al.</u> (2013). The rise of the social animal. Food for all - sustainable nutrition security. M. J. Kropff, J. A. M. van Arendonk and H. J. M. Loffler. Wageningen, The Netherlands, Wageningen UR: 124-127.</li> <li>• <u>Beerda, B., van der Borg, J.A.M.</u> (2013) Further development of the Dutch Socially Acceptable Behaviour (SAB) - test for assessing aggression and fear in dogs. Report for</li> </ul>

Dutch Ministry.

- Ophorst, C.S, Ruis, M.A.W., Pompe, V.M.M., Jong, de, M., van der Borg, J.A.M., Beerda, B., Visser, A.K., Oomkes, C., van Benten, P., van de Graaf-Kramer, P. (2014). 'Handboek Dieren in de Zorg'. Eds. C.S. Ophorst, M.A.W. Ruis. Uitgever: Ontwikkelcentrum, Ede, Nederland.
- National Radio: Kettingvraag bijdrage 21 11 2012 : waarom zijn varkens intelligent (20:00 – 21:00)
- <http://www.wetenschap24.nl/programmas/hoezo-radio/Uitzendingen.html>
- Hinde, C.A. (April 2009, March 2010) *Mother-offspring coadaptation* Canadian broadcasting corporation 'Quirks and Quarks' radio interviews.
- Hinde, C.A. (March 2010) *'Too much begging leads canary chicks nowhere'* Planet Earth.

### III. Other research output\*

- Aarnink, A., Rodenburg, T. B. et al. (2012). Update of the welfare aspects of various systems of keeping laying hens. T. van Niekerk, C. Nicol and J. Kjaer: 94 pages. Report for the European Food Safety Authority
- Lefebvre, D., Rodenburg, T. B. et al. (2010). Scientific / technical report submitted to EFSA - TOward an information system on broiler welfare: Genetic selection Aspects (TOGA): 47 pages. Report for the European Food Safety Authority

Table 4.1.2: Overview of output for societal target groups by year.

	Year					Total	2009-2014 Average	
	2009	2010	2011	2012	2013			2014
Professional publications and output				1	1	8	10	3
Publications for the general public				1	0	0	1	0
Other research output				51	70	64	185	62

#### 4.2 Demonstrable use of products - Use of research products by societal groups

Our main research products are the knowledge we generate along with contributing to developments of technical tools to monitor animal behaviour. We regularly provide feedback to companies or software developers from experience in applying these technological tools (animal radio tracking, video tracking, sound analysis) helping to fine-tune products used on broader scales. One example from our behavioural ecology research is our involvement in the E-track project of the 7<sup>th</sup> EU framework programme to develop tracking tools of wildlife. Our research is not targeted at generating patents or licences. We do have projects where we, sometimes in collaboration with WUR Livestock Research, work with companies to evaluate technologies or production systems: drinking nipples for Impex, RFID technology for great tits and laying hens with Dorset Identification and Van Beek, laying nests with Hendrix Genetics and Vencomatic. We also produced a companion animal report to be used by the public, and contributed to the University anniversary booklet *"Food for all"* published for the general public and policy makers.

#### 4.3 Demonstrable marks of recognition - Marks of recognition by societal groups

Our research is regularly covered by the media (see section 4 general) including major newspapers and news websites. We are regularly contacted by TV and radio stations and have contributed to public art related activities including various public podium discussions. Also the University magazine "Resource" regularly covers our research. Moreover we provided special lectures at schools. We do not see the social media as a good chair-group based platform for communicating our science, yet individual group members are highly connected through the professional networks ResearchGate and LinkedIn and some include research in Facebook posts and write research blogs. We were also invited to organize a lecture series on Animal personality targeted at the general public by the "Studium Generale", leading to one of their most highly attended lecture series ever (<http://www.wageningenur.nl/en/newsarticle/Studium-Generale-WUR.htm>).

## 5. Viability

As reflected by the benchmarking, the SWOT analysis, and our outlook to the future (section 6 and 7) we see our group as very viable within our research field as well as within the particular setting of the University and the Department. Animal Behaviour is a highly integrative field and beyond our own strong research lines we make strong links to other groups. Within our fields, staff belong to the groups of leading researchers with the internationally highest reputations.

### 5.1 Benchmark

Three comparable groups are the Animal Welfare division at the University Bern (CH), headed by Prof. Hanno Würbel, the Behavioural Biology Group at the University Hamburg (D), headed by Prof. Jutta Schneider and the Animal Communication Group at the University of Massachusetts, Amherst (US), headed by Prof. Jeff Podos (see Appendix 5 for staff details). All three groups are leading groups in their fields, similar-sized leading groups in Animal Behaviour, the heads of these groups are of similar age and stage as the Behavioural Ecology Chair and all cover aspects of our expertise. Prof. Hanno Würbel and his group are internationally among the most respected groups in Animal Welfare. Jutta Schneider is among the top cited German animal behaviourists (see Laborjournal March 2015) and heads a group with similar size and teaching load as BHE does. Prof. Jeff Podos is one of the leaders in research on vocal communication in birds. The output table indicates similar results of BHE and the benchmarking groups. The Behavioural Ecology Group was established after the last peer review so that there is no previous reference document. Because of this, the benchmarking (SciVal) includes individual staff output for the previous years, to document the scientific standing of the staff. For the actual group comparisons, only 2012 and 2013 can be used. Our individual track records document high scientific quality with high international recognition. Within our current excellent environment we expect an increase of strength and viability in the following years.

*Table 5.1. Selected output of BHE against international top animal nutrition groups for 2008-2013. BHE: Behavioural Ecology Group (WUR); AC: Animal Communication, Univ. Mass. Amherst, USA; AWD: Animal Welfare Division, Bern, CH; B: Behavioural Biology Univ. Hamburg, D.*

Year	Number of Publications (N)				Citations per Publication (CPP)				Field Weighted Citation Impact (RI)			
	BHE	AC	AWD	BB	BHE	AC	AWD	BB	BHE	AC	AWD	BB
2008	15	1	14	3	18.5	25.0	12.5	13.7	1.5	2.0	1.3	1.7
2009	15	4	10	13	20.4	35.8	19.0	24.2	1.5	2.3	1.8	2.4
2010	17	8	8	7	15.5	29.3	17.5	25.9	1.6	3.6	1.9	2.3
2011	10	6	17	18	8.7	10.0	7.7	9.1	1.6	1.5	1.4	1.4
2012	11	4	11	11	8.0	8.8	5.3	7.0	2.6	2.1	1.3	2.0
2013	19	7	8	7	4.5	2.0	2.0	4.9	2.9	0.7	0.9	2.6
<b>All</b>	<b>87</b>	<b>30</b>	<b>68</b>	<b>59</b>	<b>12.7</b>	<b>17.0</b>	<b>10.4</b>	<b>13.7</b>	<b>1.95</b>	<b>2.05</b>	<b>1.42</b>	<b>2.00</b>

### 5.2 SWOT-analysis

Strengths	<ul style="list-style-type: none"> <li>• Strong expertise in animal behaviour and behavioural ecology</li> <li>• Strong network in poultry research</li> <li>• Strong international reputation</li> <li>• Good facilities to work on farm animals</li> <li>• Outstanding field site to work on songbirds in cooperation with the NIOO-KNAW</li> <li>• Attractive field for students</li> <li>• Good integration of research and education</li> </ul>
Weaknesses	<ul style="list-style-type: none"> <li>• The steeply increasing educational activities can constrain our research output</li> <li>• High costs of using research facilities and University infrastructure</li> <li>• Still few postdocs and PhD students</li> </ul>

Opportunities	<ul style="list-style-type: none"> <li>• Animal behaviour is acknowledged as a core area in industry and society to improve animal welfare</li> <li>• Increased NGO activity towards animal welfare</li> <li>• Research falls within area of TOP sectoren</li> <li>• Combining expertise in behavioural ecology of wild animals with applied animal behaviour research is a unique strength</li> <li>• Improve education in animal behaviour</li> </ul>
Threats	<ul style="list-style-type: none"> <li>• Funding in fundamental research in behavioural ecology is extremely competitive in the Netherlands</li> <li>• The group is still small relative to others in the department, but collaboration within CAWA and within the cluster helps us to maintain our position.</li> </ul>

### 5.3 Future strategy

In the mid and long term we plan to remain strong in the fields as outlined above, while at the same time explore new opportunities for cooperation with other groups. The topics we are studying are very timely and we expect them to be of increasing interest in the coming years. Early developmental effects of behaviour, conflict resolution in animals, animal communication, and the behaviour of individual animals within groups all are hot topics which strongly benefit from both conceptual as well as technical advances.

Specifically new sensor and tracking technologies make it possible for the first time to follow individuals and their behaviour across larger spaces and in groups, allowing us to tackle questions in our fields in unprecedented ways. We are building upon our strengths in social network analysis and bird song to work together and answer new questions on communication networks. The broad field of behavioural ecology is rapidly evolving to consider life history in the context of the individual, rather than as a population mean. We are at the forefront of this research, considering questions such as individual differences in personality and mate choice, which are research topics that will be extended and developed in the future. For example, after the current project on individual differences in mate choice, we have a theoretical project planned, considering the effect that such individual differences in choice have on the maintenance of variation in the population.

Many changes are currently taking place in European animal production systems: e.g. banning of beak trimming in laying hens and tail docking in pigs, and moves from small group housing to large groups. For these transitions, knowledge on the social behaviour of animals and on how behavioural problems such as feather pecking, tail biting and aggression can be prevented is needed. Together with our partners with CAWA and within the cluster, we are strongly involved in collaborations with the livestock industry to make these transitions to welfare-friendly housing systems a success. Examples are our recent applications for the Marie Curie ITN Network GroupWell, the COST Action GroupHouseNet and the Breed4Food project PhenoGroup.

We thus are confident that our expertise and approaches in these fields are sustainable in the future. Our expertise in animal behaviour also links to larger national and international programmes, specifically those focusing on resilience and welfare, key research fields linking to larger funding programmes (top sectoren, Animal Task Force).

Our future strategy with respect to staff development is first to further strengthen the position and impact of the existing staff, while having a healthy growth by attracting international postdocs and PhD students. We are highly active in acquiring funding on various levels and various network sizes and strengthen and expand our existing cooperations to make use of our opportunities while being aware of the threats mentioned in our SWOT analysis.

## 6. Research Integrity

In our research we apply high standards of integrity and take ethical aspects with respect to both working with animals and scientific conduct very seriously. We regularly discuss the respective policies and not only adhere to the general scientific ethical guidelines but also communicate these explicitly and regularly to students when training them in courses and thesis projects as next generation academics. We have

established a specific data storage plan along the guidelines as discussed by the WIAS graduate school and make data available where journals offer this service. Experimental protocols are stored in field books or digital files, maintained by the project leaders. Protocols and methods also are described in a thesis and / or DEC (ethical committee) protocol. Information on the experimental protocols is part of a digital project folder that is stored on our network drive. Raw materials such as original video and audio files are stored and back-upped on labelled hard drives. Written notes from field and lab work and notes from experiments are archived by project leaders. The BHE research assistant manages a meta file/database where information about the location of the different data and notes and a link is made with the digital project folder. Data are stored for a minimum of 5 years after publication. We also aim to publish “negative” data or data contrasting the mainstream ideas to counter publication biases towards significant results as much as possible.

**Appendix 1** - Research staff Behavioural Ecology group

Table 1 - Research staff input at Chair Group level

<b>Name staff</b>		<b>Funding 1, 2, 3*</b>	<b>2009 FTE**</b>	<b>2010 FTE</b>	<b>2011 FTE</b>	<b>2012 FTE</b>	<b>2013 FTE</b>	<b>2014 FTE</b>
<i>Full professors</i>								
Prof.dr. M. Naguib ( 1 fte)	Tenured	1				0.40	0.40	0.40
<i>Assistant professors</i>								
J.A.M. van den Borg (0.5 fte)	Tenured	1				0.10	0.12	0.12
Dr ir. B. Beerda (1 fte)	Tenured	1				0.15	0.40	0.30
Dr C. Hinde (0.8 fte)	Tenured	1				0.40	0.54	0.54
Dr B. Rodenburg (0.8 fte)	Tenured	1				0.40	0.32	0.54
<i>Post-docs</i>								
Dr E. van Rooij (0.8 fte)	1-2-2013/1-10-2013	1				0.70	0.33	
Dr J. Savage	1-3-2014/16-8-2014	1						0.90
<b>Total scientific staff</b>						<b>2.15</b>	<b>2.11</b>	<b>2.80</b>
<i>Support staff</i>								
Dr E. van Rooij (0.8 fte)	1-2-2013/1-10-2013	1				0.70	0.33	
Dr J. Savage	1-3-2014/16-8-2014	1						0.90
<b>Total staff</b>						<b>3.15</b>	<b>2.61</b>	<b>3.80</b>

\* Funding scores: 1= direct funding by University; 2= funding obtained in national scientific competition (e.g. grants from NWO, KNAW) ; and 3= funding obtained from external organisations, such as industry, governmental ministries, European Commission and charity organisations.

\*\* FTE reported in this table regards the research appointment part of the total appointment (e.g. tenured staff has 40% available for research, postdocs have 60% available for research).

**Appendix 2** - Scientist for benchmark Behavioural Ecology group**Table II.** *Scientist selected at Animal Communication – USA (AC), Animal Welfare Division - Switzerland (AWD), and Behavioural Biology - Germany (BB) for benchmarking BHE.*

<b>BHE</b>	<b>AC</b>	<b>AWD</b>	<b>BB</b>
Beerda, B.	Goodwin, S.E.	Bailoo, J.D.	Drees, C.
Hinde, C.A.	Van T' Hof, D.	Dubé, M.B.	Schneider, J.M.
Naguib, M.	McClure, J.	Gebhardt-Henrich, S.G.	Schuett, W.
Rodenburg, T.B.	Podos, J.	Melotti, L.	
Van Rooij, E.P.		Reichlin, T.S.	
		Toscano, M.J.	
		Würbel, H.	



## Cell Biology and Immunology (CBI)

**Programme leader(s):** Huub F.J. Savelkoul

*For a full staff survey see appendix 1.*

### 1. Objectives and Research Area

#### 1.1 Vision, Mission and Objectives

##### Vision:

Generate fundamental insights and applicable innovations to improve immunomodulation by diet or vaccination to enhance immune competence, resistance to infections and prolonged health in (aquatic) veterinary species and humans.

##### Mission:

To provide academic training to students of all levels and generate knowledge to improve immune competence to infection and environmental challenges.

##### Objectives:

1. Develop fundamental knowledge on mucosal immunology to develop applications for immunomodulation at mucosal surfaces ((oral) vaccination strategies and immunomodulatory nutritional factors),
2. Develop fundamental knowledge on innate immunity to define biomarkers for and dietary approaches to enhance natural disease resistance,
3. Develop fundamental knowledge on adaptive immunity to study vaccine components, including studies on antigens, (molecular) adjuvants and delivery systems

By achieving our objectives we aim to perform fundamental research for the prevention of disease in (production) animals, contributing to a “healthy society” by supplying fundamentally new insights to improve health and welfare of animals and humans. We aim to use these new insights to offer practical solutions to health-related problems with societal relevance, relieving immune-mediated diseases (including allergy), enhancing natural disease resistance and improving healthy aging.

#### 1.2 Research Area / research line(s)

1. **Mucosal immunology and immunomodulation by food and feed**, including research lines on induction of mucosal tolerance, effects of probiotics on healthy aging, and the influence of diet on the mucosal barrier.
2. **Biomarkers for natural disease resistance**, including research lines on monitoring of specific treatments and effects on the innate immune system such as natural antibodies and investigations of trained immunity.
3. **Development of novel approaches to vaccine development**, including research lines on the use of (new) cytokine adjuvants for vaccination against allergy in horses and tumours in veterinary animal species and novel approaches such as DNA vaccination of fish.

These research lines fit precisely into the research theme “*Healthy and safe food for healthy lives*” and the investment theme “*Global One Health*” from the new strategic plan 2015-2018 of the university. We address fundamental questions in biology, bio-medical and bio-based studies as well as applied, aquaculture-related questions of evident importance to society.

#### 1.3 Strategy

##### General research strategy

Our research approach is comparative and integrates the evolution of the immune system, unravelling conserved and thereby fundamental immune defence strategies. The use of zebrafish as experimental animal unites, in an increasing manner, our fundamental insights in cell biological aspects of immunology with both medical and veterinary applications.

Main achievements:

- Funding from a balanced mix of fundamental research and more applied human and veterinary research.
- CBI continues to be coordinator of large EC programmes, and sustained its internationally recognized position for EC-Marie Curie training.
- CBI was awarded a prestigious NWO-Veni fellowship, which initiated research on DNA vaccination against deadly fish viruses, stimulating a new research line.
- Two new professorships replaced two former endowed chairs to strategically stimulate research on fish health and on mucosal immunology, including research on milk products as immune modifiers of human health in cooperation with industry.

Adjustments in research focus

Zebrafish have been implemented in the existing research lines and the new research line of dr. Sylvia Brugman, who will enter tenure track as envisaged new staff member. Post-doctoral fellows with external funding allowed us to explore new and high potential research lines leading sometimes to excellent research, that were, however, discontinued because of limited faculty staff resources and the need to remain focused (immunomodulating effects of low electromagnetic fields and on the role of micronutrients on the immune system of human beings infected with malaria). Nevertheless, these short-term appointments led to the implementation and refinement of existing research lines and will be continued by faculty staff (immunomodulatory effects of advanced glycation end-products, on the effects of IL-10 on the fish immune system, and on probiotics for fish health). Research has also led to the formulation of new (mucosal) adjuvants that are currently being tested for their veterinary applications and human vaccines.

**1.4 Research environment and embedding**

Graduate Schools. Research lines of CBI are fully integrated in WIAS, with collaborations with ANU (Feed4Foodure Top sector consortium), ABG and HMI (in TIFN). Additional collaborations exist within research school VLAG. CBI participates in the WIAS executive board. CBI is part of the cluster Biology and Aquatic Resilience (B&AR), with EZO and AFI), contributing with our insights in evolutionary biology and our comparative approach to improve immune competence and healthy adaptation to infection and environmental challenges. A joint AFI-CBI participation in an EC-funded (H2020) research infrastructure programme (AquaExcel) and a joint CBI-EZO PhD proposal recently awarded by the WIAS (NWO) Graduate Programme exemplify this integration.

National positioning. CBI has research collaborations in different projects and programs on (pre-) clinical food allergy and immunomodulation, with academic partners, patient organizations, research institutes, university medical centres and hospitals, and industrial partners. An intensive collaboration was established with Leiden University on zebrafish, resulting in the sequencing of the carp genome, transcriptomes and twinning studies on carp and zebrafish in a shared project (FP7-FishForPharma). A strong collaboration exists with the Veterinary Immunology group at Utrecht University (STW-IBH).

International positioning. Our integrated research lines with different species position CBI uniquely within Europe. CBI holds a strong position in food allergy and dietary immunomodulation (profs H Savelkoul, H Wichers and J van Neerven) exemplified by participation in a number of EU projects on allergy research (Europrevall, H2020, IFR in Norwich, SIGID, COST). Similarly, in fish immunology exemplified by prof Rombout (endowed chair until 2014 in Bodo, Norway) and by coordination of EU-FP7 TargetFish, and consolidation by the (personal) chair of prof. Wiegertjes. CBI has shared MSc, PhD and post-docs with France, Poland and Brazil (bio-based economy). Prof. Wiegertjes is invited annually to lecture in Japan whereas staff members are regular advisors and examiners at international universities.

**1.5 Reference to previous assessments**

The previous WIAS international peer review (2009) was very positive about the scientific quality (score 4.5) and productivity (score 4.5) of our research. We have managed to even further improve our scientific quality by increasing the average impact factors of our publications with several %T1 papers, while maintaining our total yearly output (chapter 3). To improve our the relevance of CBI, which received a medium score (3.5) due to the apparent broad research interests, we integrated our research lines such

that they mutually profit from each other within few united, comparative approaches. Some research lines were adapted or even stopped to improve the focus of the group. With our renewed integration we take optimal advantage of fundamental insights in biology to generate the rationale for strategic research on immunomodulation and vaccination to improve the health of (aquatic) veterinary species and humans. Thereby the research has become more homogeneous as reflected in the formulation of our research lines (section 1.2), the concepts used and the methodologies applied (section 1.1). Establishment of a zebrafish research facility, an approved VENI grant and a Post-Doc (and future faculty) position on research with zebrafish, collectively, have provided the group with a timely animal model further integrating the various research lines together. Our Vitality and Feasibility was rated high (4), mainly attributed to the 'considerable downstream potential', although considered 'not fully exploited'. The latter may reflect differences in the appreciation of fundamental research as compared to strategic research. Over the reviewing period we now have acquired more private funding from industry and industrial consortia (Top sector Agrofood, TIFN-affiliated companies), increased our funding from public-private partnerships (STW, EC), without neglecting fundamental research (NWO, ZonMW). Following the advice of the WIAS mid-term review (2012) review committee to invest more in mechanistic studies, we increased within WIAS collaborations with HMI (PhDs Meijerink, van Beek and Sovran; Mosaic project with FrieslandCampina), ANU (AGE project in cat food; Top sector VDI on Food, gut and immunity), ABG (PhDs on projects Weerbaar Vee, and STW project Insect Bite Hypersensitivity), positioning us to conduct high-level mechanistic research on important fundamental questions (papers) of societal importance (outreach) with the possibility to provide solutions (products, patents). Increased collaboration with EZO and AFI is foreseen within the new cluster B&AR; a projection of our wish to see further collaboration with the groups in this cluster, in particular. The first collaborative PhD with EZO was already granted. In summary, we took the recommendations of previous assessments serious and have substantially improved our relevance while maintaining high our scientific quality, productivity, relevance, vitality and feasibility, preparing the CBI group for the near future.

In order to optimize the performance of CBI, we have further invested in ensuring that the transfer, application, and expansion of knowledge in Cell Biology and Immunology are integrated in a challenging, amicable and group-oriented environment in which personal development of students and staff is paramount.

## 2. Resources and Facilities

Personnel and (future) funding. Rombout (retired in 2011) was succeeded by dr. Forlenza, and van Kemenade will retire in 2016 and will be succeeded by Brugman. These changes balance age, gender and tenure track at CBI.

Professorships of Schijns (2008-2013), and Wichers (2005-2010) were concluded, while new professorships were implemented in 2013: Wiegertjes (personal chair), and van Neerven (Mucosal Immunity) reflecting the renewed focus at CBI.

Funding is based on national sources and EC, large industrial grants supplemented with grants from industry. CBI participates as WP leader in "ParaFishControl" (H2020, 2015-2020).

Research facilities. With increasing numbers of MSc students, PhD students and post-docs research and animal facilities (CARUS and CKP) were sustained.

## 2.1 Researchers

Table 2.1. Research input: number<sup>1</sup> and FTE<sup>2</sup> of Scientific staff, Post-docs and PhD candidates by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff <sup>4</sup>	7	1.8	7	1.8	8	2.1	8	1.9	6	2.2	6	1.8	7	1.9
Post-docs <sup>5</sup>	4	2.1	4	2.6	4	2.2	8	3.3	5	3.1	5	2.7	5	2.7
PhD candidates <sup>3,6</sup>	9	5.4	10	5.3	10	5.8	10	6.1	9	5.4	10	6.2	10	5.7
<b>Total research staff</b>	<b>20</b>	<b>9.3</b>	<b>21</b>	<b>9.7</b>	<b>22</b>	<b>10.</b>	<b>26</b>	<b>11.3</b>	<b>20</b>	<b>10.6</b>	<b>21</b>	<b>10.7</b>	<b>22</b>	<b>10.3</b>
Lab Technicians	1	0.4	1	0.4	1	0.4	2	1.2	3	1.9	3	1.9	2	1.0
Visiting fellows	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<b>Total staff</b>	<b>21</b>	<b>9.7</b>	<b>22</b>	<b>10.1</b>	<b>23</b>	<b>10.4</b>	<b>28</b>	<b>12.5</b>	<b>23</b>	<b>12.5</b>	<b>24</b>	<b>12.7</b>	<b>24</b>	<b>11.3</b>

<sup>1</sup> Total number of staff and PhD candidates

<sup>2</sup> Available research time in full time equivalent (FTE)

<sup>3</sup> All PhD categories, except external PhDs

Standards for Research Capacity (in case of part time appointment adjustment is applied):

<sup>4</sup> Professor, Assistant Professor and Associated Professor: Research Capacity = 40% of the appointment

<sup>5</sup> Post-doc: Research Capacity = 90% of the appointment

<sup>6</sup> PhD candidate: Research Capacity = 75% of the appointment (all categories)

## 2.2 Research Funds

Table 2.2. Funding of Scientific staff, Postdocs and PhD candidates by year and Expenditure of Chair group by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	FTE	%												
<b>Funding:</b>														
Direct funding <sup>1</sup>	2.8	30	2.8	29	2.5	24	1.7	15	1.3	12	1.4	13	2.1	20
Research grants <sup>2</sup>	1.7	18	1.7	17	2.8	28	1.7	15	1.7	16	2.2	20	1.9	19
Contract research <sup>3</sup>	4.8	52	5.3	54	4.8	48	7.9	70	7.7	73	7.2	67	6.3	61
<b>Total funding</b>	<b>9.3</b>	<b>100</b>	<b>9.7</b>	<b>100</b>	<b>10</b>	<b>100</b>	<b>11.3</b>	<b>100</b>	<b>10.6</b>	<b>100</b>	<b>10.7</b>	<b>100</b>	<b>10.3</b>	<b>100</b>
<b>Expenditure<sup>4</sup>:</b>	<b>K€</b>	<b>%</b>												
Personnel costs	1,166	56	1,091	54	1,171	57	1,191	50	1,181	48	1,240	53	1,173	53
Other costs	925	44	921	46	900	43	1,204	50	1,279	52	1,078	47	1,051	47
<b>Total expenditure</b>	<b>2,091</b>	<b>100</b>	<b>2,012</b>	<b>100</b>	<b>2,072</b>	<b>100</b>	<b>2,395</b>	<b>100</b>	<b>2,461</b>	<b>100</b>	<b>2,318</b>	<b>100</b>	<b>2,225</b>	<b>100</b>

<sup>1</sup> Direct funding by the University

<sup>2</sup> Research grants obtained in national and international scientific competition (e.g. grants from NWO, KNAW)

<sup>3</sup> Research contracts for specific research projects obtained from external organisations, such as industry, governmental ministries, European Commission (including ERC), charity organisations

<sup>4</sup> Expenditure from financial system of Wageningen University which not only includes research but also teaching and other activities

Tenured staff allocates 40% of time to teaching, which is frequently awarded (education bonus, education innovation grants and nominating staff as “Teacher of the Year”). Non-tenured research staff relies for a large part on external funding. Funding comes from a balanced mix of fundamental research and more applied human and veterinary research. CBI managed to end the financial years with a positive outcome of +50 k€ for the last 5 years in a row, sustaining a financially healthy group, now and in the near future.

### 3. Research Quality

CBI has managed to sustain its high annual scientific output but increase its number of publications with high impact (impact factor >10) journals, including top 1% cited. Most importantly, we aim to sustain the current balanced mix of research grants from (inter)national sources such as NWO (Zon-MW, ALW, STW) and EC (H2020), but further increase our focus on supportive funding from Industry (including Top Institute Food and Nutrition TIFN-related companies and Top sector Agrofood-related companies), for example with the help of prof. Joost van Neerven his position at Friesland Campina. Initiatives have already been taken to intensify collaboration with Friesland Campina/Domo/Nestle/Danone as representative of the food industry as well as with MSD, ALK and ERC, Nutreco/Skretting/Denkavit and Biorigin, representatives of feed, representative of the pharmaceutical and vaccination industries. CBI maintains a group of comparative immunologists who interact in an enthusiastic and supportive environment to achieve a mutual strengthening of three main research lines. The key publications listed below reflect the outcome of our evolutionary approach to immunological and cell biological research on veterinary species including fish, and on humans, with continuous high impact.

#### Key publications:

1. Piazzon MC, Savelkoul HFJ, Pietretti D, Wiegertjes GF, Forlenza M (2015) Carp II10 Has Anti-Inflammatory Activities on Phagocytes, Promotes Proliferation of Memory T Cells, and Regulates B Cell Differentiation and Antibody Secretion. *Journal of Immunology* 194(1), 187-199. IF=5.520
2. Martin N Mwangi, Sumi Maskey, Pauline EA Andang'o, Noel K Shinali, Johanna M Roth, Laura Trijsburg, Alice M Mwangi, Han Zuilhof, Barend van Lagen, Huub FJ Savelkoul, Ayse Y Demir, Hans Verhoef (2014) Diagnostic utility of zinc protoporphyrin to detect iron deficiency in Kenyan pregnant women. *BMC medicine* 12 (1), 229. doi:10.1186/s12916-014-0229-8. IF=7.28
3. Chanput, W, Reitsma, M, Kleinjans L, Mes, JJ, Savelkoul HFJ, Wichers HJ (2012) B-glucans are involved in immune-modulation of THP-1. *Molecular Nutrition & Food Research*, 56(5), 822-833. IF=4.909
4. Neerven RJJ van, Knol EF, Heck JML, Savelkoul HFJ (2012) Which factors in raw cow's milk contribute to protection against allergies? *Journal of Allergy and Clinical Immunology*, 130(4), 853-858. IF=11.248
5. Ribeiro CMS, Hermsen GJ, Taverne-Thiele JJ, Savelkoul HFJ, Wiegertjes GF (2010) Evolution of recognition of ligands from gram-positive bacteria: similarities and differences in the TLR2-mediated response between mammalian vertebrates and teleost fish. *Journal of Immunology* 184 (5):2355 - 2368. IF=5.520

#### 3.1 Demonstrable products - Research products for peers in science

Table 3.1. Categories of research output by year.

Category:	Year						Total	Average 2009-2014
	2009	2010	2011	2012	2013	2014		
<b>Academic publications</b>								
a. Refereed articles	26	25	37	25	40	28	181	30
b. Non-refereed articles	3	0	2	1	1	1	8	1
c. Books	0	0	0	0	0	0	0	0
d.1. Refereed book chapters	2	0	2	1	2	2	9	2
d.2. Non-refereed book chapters	0	0	0	0	0	0	0	0
e. PhD Theses	5	2	5	4	3	1	20	3
f. Conference papers	0	1	0	0	0	2	3	1
<b>Total academic publications</b>	<b>36</b>	<b>28</b>	<b>46</b>	<b>31</b>	<b>46</b>	<b>34</b>	<b>221</b>	<b>37</b>

### 3.2 Demonstrable use of products - Use of research products by peers

Table 3.2.1. Bibliometric indicators for CBI over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	29	656	536	22.6	1.31	21	0
2009	26	487	350	18.7	1.41	12	0
2010	24	353	281	14.7	1.40	29	0
2011	36	629	315	17.5	2.20	31	6
2012	23	207	137	9.0	1.79	22	4
2013	37	160	86	4.3	1.96	16	5
<b>all years</b>	<b>175</b>	<b>2492</b>	<b>1706</b>	<b>14.2</b>	<b>1.72</b>	<b>22% (38)</b>	<b>3% (5)</b>

Table 3.2.2. Bibliometric indicators for CBI per research field over the period 2008-2013. The rows are ordered in descending number of publications (N). The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

research field	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	58	699	383	12.1	1.91	28% (16)	2% (1)
Immunology	53	760	752	14.3	1.07	6% (3)	0% (0)
Clinical Medicine	16	167	132	10.4	1.48	25% (4)	0% (0)
Agricultural Sciences	13	121	64	9.3	2.56	38% (5)	8% (1)
Biology & Biochemistry	12	268	113	22.3	2.08	33% (4)	8% (1)
Microbiology	6	272	55	45.3	5.78	83% (5)	33% (2)
Pharmacology & Toxicology	6	91	58	15.2	1.36	17% (1)	0% (0)
Molecular Biology & Genetics	4	34	70	8.5	0.52	0% (0)	0% (0)
Chemistry	2	25	27	12.5	0.93	0% (0)	0% (0)
Environment/Ecology	2	4	14	2.0	0.39	0% (0)	0% (0)
Neuroscience & Behavior	1	19	20	19.0	0.97	0% (0)	0% (0)
Psychiatry/Psychology	1	21	13	21.0	1.63	0% (0)	0% (0)
Social Sciences, General	1	11	7	11.0	1.61	0% (0)	0% (0)
<b>all fields</b>	<b>175</b>	<b>2492</b>	<b>1706</b>	<b>14.2</b>	<b>1.72</b>	<b>22% (38)</b>	<b>3% (5)</b>

CBI sustains an average of 30 publications per year, with a mean relative impact of 1.72, which is above world average and increasing. The percentage of articles in the top 10% cited publications is relatively constant with an average of 22% in the top 10% most cited publications in the field and an increasing 3% within the top 1% most cited publications in the field, with Plant & Animal Science (RI 1.91: above world avg) and Immunology of equal importance, covering respectively 33% and 30% of the publications. The publications in the field of Immunology are world avg (RI 1.07) because human related studies dominate in IF over animal related studies. CBI publishes 68% of the articles in quartile 1 journals and 22% in quartile 2 journals. When asked, peers consider the topics of CBI unique and of added value, thereby strengthening the research profile of Immunology in The Netherlands.

### 3.3 Demonstrable marks of recognition - Marks of recognition from peers

Table 3.3. Most important prizes, keynotes etc. of staff (max 6 per category). For remaining achievements see mini CVs (Separate file called mini CVs).

<b>Science awards, Scholarly prizes, Research grants awarded to individuals</b>		
Year	Prize description	Person
2009	Veni	Maria Forlenza
<b>Plenary/Keynote* Lectures at major conferences</b>		
Year	Person	Conference
2013	Wiegertjes	Department of Biochemistry, Cambridge, UK
2014	Wiegertjes	Laboratory of Fish Pathology, Department of Veterinary Medicine, Nihon University, Japan
2010	van Kemenade	European Conference of Comparative Endocrinology, Zurich, Switzerland
2012	Savelkoul	Immunomodulation by diet, Beijing, PR China
2013	Savelkoul	Eur Soc Vet Comp Nutrition, Ghent, Belgium
2014	Savelkoul	International Whey Conference, Rotterdam
<b>Organisation of International Scientific Conferences</b>		
Year	Person	Conference
2009	Wiegertjes, van Kemenade	11th Int Congress ISDCI, Prague, responsible for session
2011	Wiegertjes	13th Int Congress EAFP, Split, responsible for session
2012	Wiegertjes	12th Int Congress ISDCI Fukuoka, responsible for session
2013	Wiegertjes	14th IntCongress EAFP, Tampere, responsible for session
2010	van Kemenade	European Conference of Comparative Endocrinology, Zurich, Switzerland, responsible for session
<b>Editorships and editorial boards</b>		
Person	Editorship from... until...	
Wichers	Editor 'Chemical and Biological Properties of Food Allergens', 2009	
Wiegertjes	Editor Special Issue "Immunity to infectious diseases of fish", 2014	
Savelkoul	Edit Board member Mediators Inflammation (2009-present)	
Wiegertjes	Edit board member Developm Comp Immunol (2011-present)	
Wiegertjes	Edit board member Fish Shellfish Immunol (2009-present)	
Wiegertjes	Edit Board member Diseases of Aquatic Animals (2008-present)	
<b>Memberships of academies</b>		
Person	Member of... from... until...	
Savelkoul	Chairman Netherlands Asthma Foundation (2013-present)	
Savelkoul	Netherlands Health Council (2012-present)	
Wiegertjes	Intl Soc Dev Comp Immunol, Secretary Education (2012-present)	
Forlenza	Wageningen Young Academy (2012-present)	
van Kemenade	European Society of Comparative Endocrinology, Board member 2006 – 2014	

### 4. Relevance to Society

One of the CBI targets for relevance that continues to be important is the strong commitment to provide top level BSc and MSc teaching. Prof Savelkoul and dr Forlenza have been nominated and awarded (HS) as Teacher of the Year by the student council of Wageningen University. About 75% of our MSc students continue in the biomedical field as PhD candidates.

CBI also continuous to be committed to the transfer of scientific concepts and results to the general public, but mostly to (aquatic, veterinary, and human) health professionals, and policy makers.

Prof Savelkoul is member of the Governmental Scientific Advisory Board (Netherlands Health Council) for health-related issues. This is further reflected in numerous performances for the general public and at national study groups, expert panels, and publications for layman, advising policy makers (ministry of Agriculture, EU expert panels) and frequent performances at national radio and television programs (e.g. Zembla). The frequent writing of articles for the layman press and interviews complement our scientific efforts.

The allergy research is embedded in the “Allergy Consortium Wageningen” expertise centre, which continues to attract attention by the media and the general public at the Wageningen Food4You festival (2009-2014), organization of workshops for the industry (2013 and 2014), a summer course, and by now 10 PhD theses on allergy. Prof. Savelkoul and van Neerven are experts on allergy and consulted by industry during a recent (2014) discussion new EU rules on a uniform labelling system for food ingredients.

Immunomodulation by dietary compounds, alternatives for decreasing the use of antibiotics in animal feed, and rational design of new (oral) vaccines for human and veterinary use has increasingly become a topic for consultation (prof. Savelkoul, Wichers, van Neerven and dr Tijhaar) by policy makers, food and feed industry and nutritional organizations for which increasingly seminars and lectures are provided (2014: Schothorst, FrieslandCampina).

Immune competence studies are increasingly appreciated internationally, exemplified by prof Savelkoul being chairman of the scientific advisory board of the Laboratory association between France and India on Systems Immunology and Genetics of Infectious Diseases (SIGID).

European aquaculture production provides direct employment to 65.000 people with a turnover of 3 billion €. However, the lack of authorised veterinary medicinal products and the consequent disease outbreaks in farmed fish species costs the sector 20% of the production value. FP7 TargetFish, coordinated by Prof Wiegertjes aims to prevent disease by vaccination. The first promising results point at the possibility to produce oral vaccines against viruses that often kill young salmon, providing natural protection in a stress-free manner without any risk to the consumer of fish meat. Prof Wiegertjes has been consulted during a recent (2014) discussion in the national news on the use of antibiotics in aquaculture and associated health risks for humans (“One Health”).

CBI has developed a strategy to maintain and expands this (intern)national visibility and performance to underscore its societal relevance by implementing a mentoring system, voluntary media training, and popular science writing for young staff members by prof Savelkoul, van Neerven and Wiegertjes.

#### 4.1 Demonstrable products - Research products for societal target groups

*Table 4.1.1: Overview of output for societal target groups by year.*

	Year						Total
	2009	2010	2011	2012	2013	2014	
Professional publications and output	3	3	3	4	1	9	23
Publications for the general public	4	0	1	1	1	1	8
Other research output	26	26	26	26	19	20	143

*Table 4.1.2. Examples of research products for societal target groups of CBI.*

##### Diagnostic tests

- A “basophil-activation-test” (BAT) developed at CBI (Savelkoul) to identify allergen threshold levels of allergic patients, is now in common use at the Rijnstate Hospital of Arnhem (2014).
- A diagnostic test for “Sweet Itch hypersensitivity” an allergic medical condition of horses caused by an allergic response to midges has been developed and will be brought to the market (Tijhaar).

##### Datasets

- The carp genome dataset (Wiegertjes) is shared with other researchers, including groups from Poland and Japan.
- Datasets on food allergic patients (Savelkoul) are shared between allergologists in Arnhem, and Tilburg.
- Selected datasets of food allergic patients are shared between allergologist and industry (FrieslandCampina).

- CBI developed a dataset for the Freyall study (2009-present) on hay fever allergic individuals that will now be analysed in collaboration with the Social Sciences Group.

### Reports

- MM van Krimpen, MM Hulst, J van der Meulen, D Schokker, Savelkoul HFJ, Tijhaar EJ, Rutten VPMG (2014) Nutritional intervention in animals: benchmarking of strategies, monitoring biomarkers and immune competence. Wageningen UR Livestock Research nr: 800, 116 pp.

### Outreach activities for a general audience

- Savelkoul: Exhibition Allergiebeurs 3x public lectures (2009-2011);
- Advanced Clinical Nutrition (The Hague, 2012);
- Responsible Use of Antibiotics in Animals (Amsterdam, 2014);
- 9th Bertine Koperberg Conference: B cells in autoimmune diseases (Soesterberg, 2014);
- Bridge2Food - Top Class Protein Nutrition (Amsterdam, 2014) .
- Various interviews in the press and on radio were given together with various television performances (news and consumer programs) (Savelkoul, van Neerven).
- Maria Forlenza is co-organiser of FameLab Wageningen, which aims to discover charismatic, up-and-coming scientists who inspire people to see the world from a new perspective.

### Layman press

- Makkink, C.; Savelkoul, H.F.J. (2014) Weerbaarheid verbeteren via voer. *De Molenaar*, 17, 26 - 29. ISSN 0165- 4284.
- Beek, van A.A.; Knol, E.F.; Neerven, van R.J.J.; Savelkoul, H.F.J. (2013) Basofiele granulocyten als effectorcellen. *Nederlands Tijdschrift voor Allergie en Astma*, 13(1), 27 - 33. ISSN 1879-9434.
- HFJ Savelkoul (2013) Het Kerstboom syndroom. In: *EHBO.NL*, 6. ISSN 2214-6792.
- Verlaet, A.; Jansen, A.; Plaisier, A.; Huystee, van B.; Vissers, Y.M.; Savelkoul, H.F.J.; Ruinemans-Koerts, J. (2012) Diagnostische waarde van de IgE-screeningstest (Phadiatop Infant) bij kinderen tot 4 jaar. *Nederlands Tijdschrift voor Allergie en Astma*, 4, 172 - 179. ISSN 1879-9434
- Hartog, den C.G.; Savelkoul, H.F.J. (2012) Vitamine D en allergie. *Nederlands Tijdschrift voor Allergie en Astma*, 48 - 56. ISSN 1879-9434.
- HFJ Savelkoul (2011) Dieet oorzaak gedragsproblemen kinderen' (2011) *Kennis Online*, 8(okt)
- MA Smits, AJ Jansman, HFJ Savelkoul, AJM Rebel (2014) De rol van microbiota voor een evenwichtig afweersysteem. *Tijdschrift voor Diergeneeskunde* 6, 22-26;
- C Makkink, HFJ Savelkoul (2014) Weerbaarheid verbeteren via voer. *De Molenaar* 17, 26-29;
- R Vos, AM Kruyswijk-van der Heijden, HFJ Savelkoul (2014) Het brein en het metabool syndroom. *Voedingswaarde* 5, 16-17;
- Savelkoul HFJ (2014) Immun ontregeling in autismespectrumstoornis. *Wetenschappelijk Tijdschrift Autisme* 2014 (1), 3-11;
- K Versluis, HFJ Savelkoul (2014) Samen een practicum immunologie ontwerpen. *Bionieuws* 24 (9), 14-14;
- B Meijer, HFJ Savelkoul (2014) Analyse van de interactie tussen voeding en het immuunsysteem. *Analyse* 2014 (5), 148-155

### Activities with respect to primary and secondary education

- At the Johannes Fontanus High School Barneveld a lecture on Allergy was delivered in the Academic Week (2014).
  - In 2013-2014 a teachers development program in Immunology was provided to 15 high school level teachers in Biology (Savelkoul). As a result 2 lectures and practicals have been developed (on vaccination and food allergy) that are currently developed in commercial products that were tested by Savelkoul on an Immunology training for 100 Biology teachers in 2014 (NVON).
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#### 4.2 Demonstrable use of products - Use of research products by societal groups

*Table 4.2. Examples of use of research products by societal target groups of CBI.*

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##### **Patents**

The CBI group holds patent applications (both as inventors and assignees) on Immunomodulating probiotic lactic bacteria (2007-present), Immunomodulatory milk proteins (2011-present), Methods to induce Regulatory T cells (2008-present), Natural disease resistance in dairy cattle (2009-present), and two patents on the Development of a pathogen epitope prediction program, and evaluating its usefulness in designing fish vaccines (2006-present).

##### **Use of Research Facilities**

Specific pathogen-free carp breeding lines located at Carus Animal facility are shared with groups from Belgium, Germany, Poland, Czech Republic, France and Norway. Specific pathogen-free (transgenic) zebrafish breeding lines located at Carus Animal facility are shared with groups from the Netherlands, Germany, UK and France. The flow cytometers, confocal and stereo fluorescence microscope are shared with other chair groups within and outside the Department.

##### **Projects in cooperation with societal groups**

Both EC-funded (FP7, H2020) projects on fish health (TargetFish, ParaFishControl) have incorporated several societal groups in the large research consortia of partners, among which groups such as AquaTT who are committed to show demonstrable value creation from research, resulting in significant contributions towards solving many of the societal challenges facing Europe. In the STW Miracle project, CBI collaborates with the Netherlands Lung Foundation, the largest Netherlands patient's organization on asthma. In the STW Insect bite hypersensitivity project, the Collective Netherlands Studbook ('Koepel Paardenfokkerij') was involved.

##### **Contract research**

MSD (2010-2014), Tetra (2013), MeadJohnson (2011-2012), Immuent (2014), FrieslandCampina (2014), DOMO (2014), ERC (2013-2014).

##### **Overview jobs alumni**

Several of our alumni have leading (international) research positions at Academia: e.g. Jeroen Saeij (MIT), Mark Huisling (Salk Inst. San Diego), Magda Chadzinska (Jagiellonian Univ), Chris Secombes (Aberdeen Univ), Mark Engelsma (CVI), Ger Rijkers (UCR), Wasaporn Chanput (Thailand), Erik Baars (University of applied sciences Leiden). Several of our alumni take up leading research positions at Industry: Mark Bouwens (Nutreco), Joeri Kint (MSD), Arjen Companjen (Janssen Pharma), Corine Kruiswijk (RIVM), Prescilla Jeurink (Danone), Franci Weijts (Synthon), Aurelia de Mazon (Synthon), Lieke van der Aa (Scientific Institute of Public Health, Antwerpen), Yvonne Vissers (Nestle, Lausanne), Apostolos Stathopoulos (ERC), Gerco den Hartog (UC San Diego).

##### **Participation in Training Courses**

CBI organizes an annual Training Course on Fish Immunology/Vaccination for the last 16 years with >500 alumni and has participated in Training Courses on Equine Performance (2x in 2006-2007), Equine Nutrition (2007), ELISA (Avans University of Applied Sciences 2009-2014), Infection and Immunity course Utrecht University (2009-2012), Medical Immunology Course Erasmus University Rotterdam (Avans University of Applied Sciences) (2009-2014). International workshops were organized on insect bite hypersensitivity in horses (2009) and on "Low frequency electromagnetic field exposure and modulation of cellular functions" (2010).

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### 4.3 Demonstrable marks of recognition - Marks of recognition by societal groups

*Table 4.3. Examples of marks of recognition by societal target groups of CBI.*

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#### Public prizes

- During the evaluation period, one student received the WIAS Annual Publication Prize (M. Forlenza 2009)
- Three students (C. Ribeiro, 2010, J. Kint, 2013, L. Golbach, 2014) received the WIAS Annual Presentation Prize.
- Teacher 'Hors Classe' and Teacher of the Year Award (H. Savelkoul, 2010 and 2014)

#### Valorisation/Technology Transfer Funding

A better understanding of mechanisms involved in immune homeostasis in mucosal tissues is relevant for modern society, where chronic inflammatory diseases including allergy have increased enormously during the last decades, while the predominance of infectious diseases has decreased enormously.

This may be explained by the hygiene hypothesis and the altered hygiene hypothesis that have postulated that our ability to regulate immune responses has decreased as a result of a lower infection pressure. This holds true also for pet animals. Similarly, modern animal husbandry of agricultural species (including fish) has many parallels with increased hygiene, altered diets, changes in stress and exercise levels with increased inflammatory conditions as well (mastitis, enteritis, etc). STW horse insect bite hypersensitivity, MIRACLE, IDEAL, 'Weerbaar Vee' and MOSAIC. In addition, several diagnostics tests have been made (basophil activation test, horse specific IgE tests) and some will be brought to the market (teaching modules in Vaccination and Allergy).

#### Membership of civil society advisory bodies

Prof Huub Savelkoul has been elected member of The Health Council of the Netherlands, is chairman of the Netherlands Asthma Foundation, and chairman of the Folia Orthica Symposium (2013-present).

#### Media exposure

Radio, TV, Internet (YouTube; H. Savelkoul), newspapers, magazines; many discussion platforms and public seminars (H. Savelkoul, J. van Neerven). Several members are listed on ResearchGate.

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## 5. Viability

### 5.1 Benchmark

CBI uniquely integrates evolutionary approaches to immune defence strategies in (aquatic) veterinary species and humans, which complicates an objective benchmark. Thus, we have divided the research output on the basis of species, thereby providing one benchmark for the researchers more focused on 'fish' and one for the researchers more focused on 'veterinary species/humans', each in comparison with two top research university groups.

The domain of the 'fish species' researchers (drs Geert Wiegertjes, Maria Forlenza, Lidy van Kemenade) was benchmarked against: a) the Health and Welfare group of the Institute of Aquaculture at Stirling University, as top rated and world-largest aquaculture research and training department in the UK. Three established group leaders (drs Alexandra Adams, Brian Austin, James Bron) were included for benchmarking; b) the group of Professor Secombes of the School of Biological Sciences of Aberdeen University (including drs Tiehui Wang, Jun Zou, Jason Holland, Catherine Jones, Leslie Noble for benchmarking), is world leader in the research area.

The domain of the 'veterinary species and humans' researchers (drs Huub Savelkoul, Edwin Tijhaar, Joost van Neerven) was benchmarked against two top research groups; a) University of Stockholm (group members Annika Scheynius, Eva Sverremark-Ekström, Marita Troye-Blomberg) in the field of allergy and immune competence studies; and University of Vienna (group members Barbara Bohle, Karin Hoffmann-Sommergruber, Rudolf Valenta) on allergen structure-function analysis and modification of allergens.

Table 5.1. Selected output of CBI against international top CBI groups for 2008-2013.

Item*	2008	2009	2010	2011	2012	2013	Average
<b>Number of publications</b>							
<b>CBI-Fish</b>	13	12	6	7	11	4	53
Univ Aberdeen	12	23	20	23	18	21	117
Univ Stirling	19	12	26	18	23	11	109
<b>CBI-Vet/Human</b>	14	14	14	17	13	12	84
Univ Stockholm	17	35	17	28	25	23	145
Univ Vienna	47	24	17	48	29	25	190
<b>Citation per publication</b>							
<b>CBI-Fish</b>	27.5	16.1	21.7	11.6	8.4	4.0	16.4
Univ Aberdeen	33.3	22.0	26.6	18.9	5.0	5.3	17.7
Univ Stirling	15.9	18.9	14.9	8.0	6.7	3.2	11.5
<b>CBI-Vet/Human</b>	24.2	17.4	20.1	16.6	6.4	4.4	15.3
Univ Stockholm	20.2	24.5	11.2	15.6	10.5	10.5	16.1
Univ Vienna	26.6	20.3	22.8	14.8	18.3	5.1	18.4
<b>Field weighted citation impact</b>							
<b>CBI-Fish</b>	1.1	1.1	1.9	1.1	1.3	1.4	1.3
Univ Aberdeen	1.5	1.7	1.7	1.7	0.7	1.6	1.5
Univ Stirling	1.5	1.4	1.3	1.1	1.5	1.3	1.4
<b>CBI-Vet/Human</b>	1.1	1.2	2.0	2.3	1.1	1.6	1.6
Univ Stockholm	1.0	1.5	0.8	1.3	1.8	3.1	1.6
Univ Vienna	1.4	1.1	1.3	1.3	2.2	1.2	1.4

Benchmarking places the 'fish species-group' at CBI lower than the other groups in terms of number of publications, in part explained by the large size of the research group at Aberdeen University, but in the middle of the two groups with respect to citations per publication and field-weighted impact factor. Emphasis on research output with higher impact has resulted in an increasing trend in field weighted impact factor for the 'fish species-group' at CBI.

Benchmarking places the 'veterinary species/human-group' at CBI lower than the other groups in terms of number of publications, explained by the large size of the other research groups, close to the University of Stockholm with respect to citations per publication and in the middle of the two groups with respect to field-weighted impact factor.

## 5.2 SWOT-analysis

Internal organisation	Strengths	Weaknesses
	<ul style="list-style-type: none"> <li>- Translation from basic to strategic research questions in immunomodulation and immuno competence using comparative and interdisciplinary research.</li> <li>- Increased and balanced funding from public (NWO, EC), private (industry), and public-private partnerships (Topsector, TIFN).</li> <li>- Strong national and international reputation, particular in Fish Immunology and Fish Vaccination, and in (Food) Allergy research.</li> <li>- Strong integration of research outcomes with outreach activities, addressing complex multidisciplinary problems with impact for societal issues.</li> </ul>	<ul style="list-style-type: none"> <li>- Aquaculture industry operates worldwide but hardly within the Netherlands, minimizing opportunities for local support by industry</li> <li>- Although an established and dynamic network of collaborations exists, veterinary and human projects are dependent on samples from clinical partners outside WUR.</li> <li>- Our expertise in fish immunology and health complements that of ASG-Lelystad and IMARES. Such a framework is not yet in place with CVI and LRI when dealing with veterinary species.</li> </ul>

	<ul style="list-style-type: none"> <li>- High quality output, by highly motivated staff of a balanced age and gender built-up in a financially healthy group that shows improved growth and is ready for the future.</li> <li>- Strong research network in aquatic field is mainly international because of a relatively small research community within the Netherlands.</li> </ul>	
<b>External context</b>	<b>Opportunities</b>	<b>Threats</b>
	<ul style="list-style-type: none"> <li>- Increasing reputation and network to facilitate PPP consortia within the Topsector Agrofood, TIFN and One Health for new research applications for external funding.</li> <li>- In the allergy field, the group fits into the research theme <i>“Healthy and safe food for healthy lives” of the new strategic plan of the university (2015-2018)</i>.</li> <li>- Different groups within WUR are embracing teaching and research in immunology, which offers opportunities for collaboration (e.g. HMI, HNE, ADP).</li> <li>- Expanding on the relationship with CVI and the Veterinary Immunology group in Utrecht University to prepare for opportunities in a ‘One Health Center’.</li> <li>- Identifying partners from WUR, ASG and IMARES for sharing of technical expertise and research infrastructure. Development of the ‘Biology and Aquatic Resilience’ cluster within WIAS. Expanding on our unique position linking carp aquaculture to</li> </ul>	<ul style="list-style-type: none"> <li>- Centralized high level technical research facilities are urgently needed to accommodate the need for contemporary and high level equipment with dedicated operators and meeting the required matching obligations.</li> <li>- Economic importance of aquaculture, within the Netherlands (not worldwide) is limited.</li> <li>- Governmental Top sector related approach to funding of science could be a threat to fundamental science and funding possibilities of disciplinary groups.</li> <li>- The fixed number of permanent positions makes the group dependent on limited numbers of staff members with appropriate expertise for the further strategic development of the group.</li> </ul>

**5.3 Future strategy**

CBI is financially healthy with an annual net profit (+50 k€) over the last 5 years. Recent changes in research staff balance age, gender and tenure track at CBI. Funding is diverse but balanced because based on national sources such as NWO (Zon-MW, ALW, STW) and EC (FP4-FP7, Marie Curie), large industrial grants (Top Institute Food and Nutrition, TIFN) supplemented with smaller grants from Industry (Mead Johnson, Friesland Campina, MSD, ERC, ALK, DOMO, Tetra). CBI participates as WP leader in “ParaFishControl” (2015-2020), one of few H2020 research projects presently awarded at WU. Recent changes in professorships (Geert Wiegertjes, personal chair and Joost van Neervan, endowed chair) reflect the renewed focus at CBI.

The current research lines at CBI combine applicability and societal relevance with high-quality fundamental but also strategic research and therefore are highly viable. The use of zebrafish will unite, in an increasing manner, our insights in cell biological aspects of immunology with both biomedical and veterinary application of research outcomes. This new approach is central to “One Health”, one of the main focuses of the Strategic Plan of Wageningen University. Savelkoul, Tijhaar, and visiting scientist prof

Virgil Schijns are therefore involved in the further implementation of this strategic theme. Likewise, the funding opportunities within Topsector Agrofood/TIFN and the associated industry provide the research line 'Immunomodulation by dietary compounds' with excellent funding opportunities. Also the strategic alliance with FrieslandCampina (prof. Joost van Neerven) and the continued collaboration with former endowed chair prof Harry Wichers, and our medical partners can further strengthen our position in the field of (food) allergy. With the appointment of new staff (dr. Maria Forlenza and dr. Sylvia Brugman) due to retirements, our staff fte input in research has increased in viability. The efforts to increase the quality of our output will be continued in the coming period.

In the allergy field, the group is non-competitive on the patient level compared to medical partners and increasingly seen as complementary providing essential fundamental allergen knowledge. This research line fit precisely into the research theme "*Healthy and safe food for healthy lives*" from the new strategic plan 2015-2018 of the university.

Furthermore, as outlined above, we aim to sustain the healthy mix of research grants from national sources such as NWO (Zon-MW, ALW, STW) and EC (H2020), but increase our focus on supporting grants from Industry. The evolutionary approach of CBI, combining immunological and cell biological research on humans, mouse and diverse animals, provides us with a unique mix of comparative approaches, mutually strengthening the three main research lines and providing flexibility and viability to the group.

Our ambition and future outlook are summarized in a strategic plan, which is updated every 4 years based on extensive discussions with scientific staff. Every year we set our goals on strategic grant applications depending on the available and envisaged calls for proposals.

## 6. Research Integrity

Integrity, ethics and self-reflection: the highest possible standards of integrity and ethical principles are priority at CBI. Weekly progress meetings support an open atmosphere. New PhDs are housed together with advanced PhD as buddies to ensure self-criticism, reflection and ethics in research as outlined and discussed by supervisors.

Research culture: CBI staff creates a challenging, amicable and group-oriented environment in which personal development is paramount. Teamwork and collective responsibilities are key performance parameters besides intellectual and output-driven competences. This includes our endowed professor and guest scientists.

Raw and processed data: Typically, storage of primary data is in laboratory journals or electronically for large data files, which remain in possession of CBI. Digitally stored data are organized on hard drives with regular back-ups. As from April 2014, each PhD student submits his/her own data storage plan to WIAS for approval. Data management is part of the training for students, but CBI remains responsible for the instruction on management policy and data management.

Policy on deviating results: the student, supervisor and head of the group will discuss any issues and show the student how to learn from and adapt research lines, experimental design, performance and progress in his/her future career.

Dilemmas that have arisen: Controversial research on modulation of ADHD behaviour by dietary adaptations or potential health-related effects of exposure to electromagnetic fields from WIFI and mobile telephones have allegedly led to questions of scientific integrity. Our university has procedures to investigate and satisfactory deal with these issues.

**Appendix 1** - Research staff Cell Biology and Immunology group

Table 1 - Research staff input at Chair Group level

<b>Name staff</b>		<b>Funding 1, 2, 3*</b>	<b>2009 FTE**</b>	<b>2010 FTE</b>	<b>2011 FTE</b>	<b>2012 FTE</b>	<b>2013 FTE</b>	<b>2014 FTE</b>
<i>Full professors</i>								
Prof dr ir H.F.J. Savelkoul (1 fte)	Tenured	1	0.3	0.3	0.4	0.4	0.3	0.4
Prof dr ir G.F. Wiegertjes (1 fte)	1-9-2013 / Tenured	1					0.13	0.4
<i>Special chairs</i>								
Prof Dr V.E.J.C. Schijns (0.2 fte)	Tenured	1	0.08	0.08	0.08	0.08		
Prof.dr. H.J. Wichers (0.2 fte)	/ 1-4-2010	1	0.08	0.08				
Prof.dr. R.J.J. van Neerven	01-05-13/01-05-18	3					0.02	0.08
<i>Associate professors</i>								
Dr J.H.W.M. Rombout (1 fte)	Tenured	1	0.4	0.4	0.2	0		
Dr ir G.F. Wiegertjes (1 fte)	/1-9-2013	1	0.32	0.32	0.4	0.4	0.27	
Dr. ir M. Forlenza (1 fte)	01-06-2012 / Tenured	2			0.45	0.45	0.9	0.4
<i>Assistant professors</i>								
Dr E.J. Tijhaar (0.8 fte)	Tenured	1	0.32	0.32	0.32	0.32	0.32	0.32
Dr B.M.L. Verburg-van Kemenade (0.7 fte)	Tenured	1	0.28	0.28	0.28	0.28	0.24	0.24
<i>Post-docs</i>								
Dr M. Forlenza (1 fte)	01-09-2006/01-06-2012	3	0.9	0.9	0.45	0.45		
Drs R. Adriaansen-Tennekes (0.3 fte)	11-6-2009/11-06-2013	3	0.08	0.08	0.08	0.08		0.08
Ir M. Bouwens (1 fte)	1-1-2009/01-01-2012	2	0.9	0.9	0.9			
Dr A.E. Østergaard (0.8 fte)	1-9-2009/01-09-2012	3	0.24	0.72	0.72	0.72	0.24	
Dr. J.C.M. Verhoef (0.3 fte)	1-7-2004/1-6-2013	3				0.27	0.24	0.24
Dr. J.A. Falco (1 fte)	1-12-2011/1-12-2013	3				0.9	0.9	
Dr. C.M. Piazzon de Haro	1-5-2012/1-5-2014	3				0.68	0.9	0.9
Dr. M. Teodorowicz	16-10-2012/16-03-2015	3				0.19	0.8	0.72
Dr. S. Brugman (0.8 fte)	01-01-2014-1-1-2015	2						0.72
<b>Total scientific staff</b>			<b>3.90</b>	<b>4.38</b>	<b>4.28</b>	<b>5.22</b>	<b>5.26</b>	<b>4.50</b>
<i>Support staff</i>								
T. Hermsen	tenured	1	0.4	0.4	0.4	0.4	0.32	0.32
B. Meijer	tenured	1					0.8	0.8
M. Scheer	tenured	1				0.8	0.8	0.8
<b>Total staff</b>			<b>4.30</b>	<b>4.78</b>	<b>4.68</b>	<b>6.42</b>	<b>7.18</b>	<b>6.42</b>

\* Funding scores: 1= direct funding by University; 2= funding obtained in national scientific competition (e.g. grants from NWO, KNAW) ; and 3= funding obtained from external organisations, such as industry, governmental ministries, European Commission and charity organisations.

\*\* FTE reported in this table regards the research appointment part of the total appointment (e.g. tenured staff has 40% available for research, postdocs have 60% available for research).

**Appendix 2** - Scientist for benchmark Cell Biology and Immunology group**Table II.** *Scientist selected at the University of Århus (AAR), Aberdeen University (Aber), and the Stirling University (Stir) for benchmarking CBI-Fish. Scientists selected at University of Stockholm (Stock), and University of Vienna (Vienna) for benchmarking CBI-Humane.*

<b>CBI-Fish</b>	<b>Aber</b>	<b>Stir</b>
Forlenza, M.B.	Holland, J.W.	Adams, A.
Verburg-Van Kemenade, L.	Jones, C.S.R.	Austin, B.
Wiegertjes, G.F.	Noble, L.R.	Bron, J.E.
	Secombes, C.J.	
	Wang, T.	
	Zou, J.	
<b>CBI-Humane</b>	<b>Stock</b>	<b>Vienna</b>
Savelkoud, H.F.J.	Scheynius, A.	Bohle, B.
Tijhaar, E.J.	Sverremark-Ekström, E.	Hoffmann-Sommergruber, K.
Van Neerven, J.	Troye-Blomberg, M.	Valenta, R.

## Experimental Zoology (EZO)

**Programme leader(s): Prof. dr. ir. J.L. van Leeuwen (Sept. 1999 – present)**

*For a full staff survey see appendix 1.*

### 1. Objectives and Research Area

#### 1.1 Vision, Mission and Objectives

**Vision:** Animals are complex mechanical systems that behave, develop, and evolve on multiple timescales. Understanding their structure and function requires interdisciplinary quantitative analyses that span a range of temporal and architectural scales. In return, such analyses reveal unexpected design strategies and solutions as developed by natural selection. Reverse engineering of these solutions can help to solve similar problems of societal relevance.

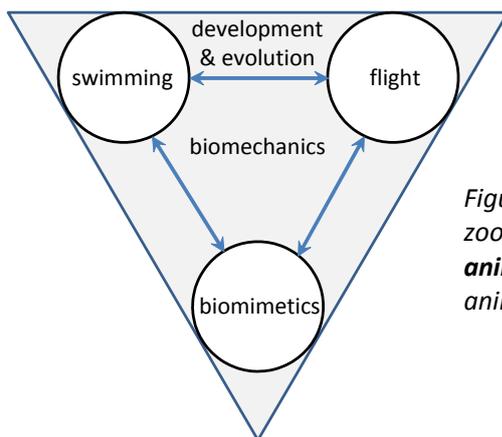
**Mission:** To unravel the relationships between form and function in zoological systems in a developmental and evolutionary context and to provide bioinspired solutions for technological and medical problems.

**Objectives:**

Combine physics, engineering, molecular techniques in a quantitative systems-analysis to solve complex problems in zoology.

Provide novel insights into the biomechanics and developmental mechanics of animal locomotion.

Translate elucidated biological mechanisms into solutions for animal and human health problems, and problems in robotics.



*Figure 1: The primary research field of EZO is **biomechanics** in a zoological context. We develop fundamental knowledge on **animal flight, fish swimming** and for **biomimetic** solutions to animal and human health problems (the main research lines).*

#### 1.2 Research Area / research line(s)

Our current main research area is the **biomechanics of motion systems in vertebrates and insects**, with three complementary research lines (figure 1): **(1) Biomechanics of animal flight** (0.9 fte staff, **PI: Muijres**), including the biofluid dynamics of avian and insect flight and in-flight host detection of malaria mosquitoes. **(2) Biomechanics of fish swimming** (1.3 fte staff, 5 PhDs; **PIs: Van Leeuwen, Lankheet, Pollux**), including swimming and developmental mechanics in larval fish, fin propulsion, visuo-motor-system development and effects of a livebearing reproductive strategy on swimming performance. This research line also includes developmental mechanics of bones and muscles, linking bone remodelling to molecular regulation. **(3) Bioinspired design solutions for human health** (0.3 fte staff, 2 PhDs, **PIs: Van Leeuwen, Gussekloo**), including development of steerable needles (inspired by the ovipositor biomechanics in parasitic wasps), and gentle grippers for delicate human tissues (inspired by wet adhesion of toe-pads in tree frogs).

All research lines share our biomechanical, quantitative systems approach, and aim to benefit society (particularly animal and human health) with technology inspired by nature.

### 1.3 Strategy

*General research strategy.* To meet our objectives, we formed an interdisciplinary team with expertise in biomechanics, engineering & physics, sensory biology, and molecular biology. We combine quantitative modelling with experiments to unravel fundamental mechanisms in our three main research lines.

*Main achievements.* We focus on research quality; 17% of our papers were published in journals with an impact factor >9.5, including four *Nature* and *Science* publications. We won the main Dutch research outreach competition (Academic Year Prize 2010). We patented a cow-milking technique, yielding strategic cooperation with an international dairy technology company. We developed new biomimetic research on development of medical instruments (STW/NWO sponsored, investment >1 M€). Personal grants have initiated research on livebearing fish (Pollux: Marie-Curie and Vidi) and mosquitoes (Muijres: Veni).

*Adjustments and future outlook (see also sections 1.5 and 5.3).* Current Dutch research-funding policies emphasize societal relevance; in response, we have decided to focus on species that threaten human health (mosquitoes), are beneficial (honeybees), or provide biomimetic solutions for medical and societal issues (zebrafish, parasitic wasps, and tree frogs). We aim to intensify our most successful research areas (biofluidynamics and evolutionary biology) and to expand biomimetic design for medical applications. These ends are served by the following strategic decisions: we terminated research on ecomorphology (2010) and horse locomotion (2012); we hired tenure-track faculty in biofluidynamics (Muijres) and evolutionary biology (Pollux); and we started two human-health-related biomimetics projects in collaboration with TU-Delft (with 2 PhD students in Wageningen and 2 PhD students in Delft). Within the Biology and Aquatic Resilience (B&AR) cluster, we started a joint PhD-project with CBI. These changes have increased our competitiveness to acquire research grants (staff fte research went up from 0.94 (2014) to 2.54 (2015)).

### 1.4 Research environment and embedding

*Graduate schools.* Together with *Cell Biology and Immunology* (CBI) and *Aquaculture and Fisheries* (AFI), we recently founded the WIAS cluster B&AR. Within WIAS, B&AR merges most aquatic research and is a spearhead for biological research and teaching. B&AR provides mutual benefit for the participating groups by sharing expert knowledge and experimental facilities to solve fundamental and applied problems of aquatic systems. We participate in the J.M. Burgerscentrum (JMBC), a national research school on fluid mechanics (<http://www.jmburgerscentrum.nl>) with eight participating universities, which strengthens our biofluidynamics work by facilitating collaborations with the Dutch technical universities.

*National and international positioning.* Our multidisciplinary approach, which applies physics, engineering, and biological techniques to zoology, bridges the gap between biology and engineering. This research program is unique in the Netherlands. We bridge the gap between biology and engineering, for example through our collaborative biomimetic projects. We have adapted our research focus (section 1.3) to the (inter)nationally increasing emphasis on societal relevance. Internationally, we play a leading role in biofluidynamics of swimming and flight, and fish evolution (with publications in *Nature* and *Science*).

*(Inter)national affiliations.* Within Wageningen UR, we have strong affiliations within B&AR, which we will exploit with new joint projects. We have growing collaborations with Physical Chemistry and Colloid Science (PCC) on biomimetics, with the Laboratory of Entomology (ENT) on malaria mosquitoes, and with the Resource Ecology Group (REG) and Plant Research International (PRI) on bee flight. We have strong partnerships with the Technical Universities in Delft and Eindhoven on biofluidmechanics and biomimetics. We collaborate with world-leading researchers at the California Institute of Technology (Caltech, USA), University of California Riverside (USA), Fresno State University (USA), Chiba University (Tokyo), The Rockefeller University (New York), and Lund University (Sweden). For our flight and swimming research, we recently initiated collaborations with the University of California, Berkeley (USA) and the University of Washington (USA).

### 1.5 Reference to previous assessments

The 2009 WIAS peer review gave a maximum score for research quality, and stated: “*It is recommended that the group continues to concentrate on world leading research wherever a suitable question arises*”, and “*They should continue their good start in patenting their original discoveries*”. We implemented their advice and adapted to an environment that emphasizes societal impact by expanding our applied-

research portfolio. The committee envisaged: *“The move to molecular studies linking biomechanics and cell responses will continue with likely high quality results”*. Our publications in high-impact journals (17.1% above 9.5) confirm this. They stated also: *“The balance with teaching of undergraduates and MSc students should be carefully monitored so as not to damage research”*. We redistributed teaching loads among staff and terminated our involvement in courses with a small EZO-contribution, enhancing teaching efficiency and available research time.

In the 2012 quality assessment of Dutch biology research, EZO received maximum scores (5) for quality, relevance and viability. Productivity was rated (4), above the 2009 WIAS peer review judgement. Differences in scores reflect the variable prioritization of fundamental research, and illustrate the importance of maintaining a suitable balance with applied studies. The committee supported our research strategy and stated: *“There are several areas in which the group’s research has strong potential for societal impact, particularly in biomimetic design and animal welfare”*. We strengthened our involvement in these areas with medical biomimetic projects.

The 2012 mid-term review committee stated *“Mission, vision and approach combining physics, engineering, molecular techniques and modelling in a quantitative systems analysis have brought the group worldwide to the forefront of science in animal mechanics and developmental mechanics with applications to animal health and welfare and bio-inspired designs.”*, with the side-note that: *“Attention is needed to reduce the apparent contrast between high profiling publications, prestigious prizes, and the rather low citation scores”*. We aim for high-quality publications in high-impact journals. This has resulted in an average journal impact of 5.656, which is much higher than the ISI 2012 Median Impact Factors (MIF) for Zoology (1.059). Also, papers with mathematical and physical complexity tend to be cited less than more accessible papers (our RI in engineering is > 4). For more details, see section 3. It was also advised to develop an expansion strategy; *“the university should consider increased financial support”*; we were advised to *“continue to explore target international funding, such as ERC and Marie Curie (individual grants or training grants), and attract PhD students and post-docs having own funding ...”*. We grew through personal grants (2 awarded NWO/Veni’s (Seidle, Muijres), 1 EU-post doc and 1 NWO/Vidi (Pollux), and 1 PhD) and acquired several open competition biomimetic and fundamental research projects. In contrast, the university *decreased* funding. Finally, the committee advised to *“Intensify strategic alliances, e.g. with technical universities facilitating implementation of results, enhanced industry collaboration and allowing recruitment of quantitatively trained students”*. With TU-Delft, we have obtained funds for 4 PhD students (value >1M€), and collaborate with industry.

Summarizing, our overall *viability* increased by (1) increased funding (i.p. personal grants and PhD projects), (2) key roles in international forums and symposia. (3) academic year prize with huge media exposure, (4) embedding in B&AR cluster (section 1.4).

## 2. Resources and Facilities

*Personnel and funding.* Two associate professors retired. Lentink accepted a faculty position at Stanford (2012). Muijres was appointed as research fellow (2014), followed by a tenure-track position. PhD-student number increased from 4 to 8, because funding increased (mainly ALW/NWO and STW/NWO projects). Muijres and Seidl (he went to Bocholt) obtained NWO-Veni grants; Pollux obtained an EU Marie-Curie return grant and a prestigious NWO/Vidi grant including 2 PhD-positions (2015). Future funding targets will be ALW, STW (+companies), personal NWO grants, EU Marie Curie, ERC, and ETN/EU grants. Staff/PhD ratio is well balanced. **External research funding increased from 30% (2011) to 61% (2014); it is expected to reach ≈80% (2015).**

*Research facilities.* Through NWO (Veni grant) and CatAgro (WU) support, we acquired a world-class 3D high-speed video system and a wind tunnel to elucidate the 3D-flight dynamics of mosquitoes and honeybees. We developed a unique 3D automatic tracking system for free-swimming fish, and an ultra-sensitive imaging system to record muscle activity in transparent larval fish. We have a sophisticated computational environment to model complex fluid-structure interactions. We acquired a microCt scanner and flow tunnels for swimming experiments and force transducers for bio-adhesion studies. We have well-equipped histological and molecular labs.

## 2.1 Researchers

Table 2.1. Research input: number<sup>1</sup> and FTE<sup>2</sup> of Scientific staff, Post-docs and PhD candidates by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	#	FTE												
Scientific staff <sup>4</sup>	8	1.6	8	2.0	7	1.9	7	1.6	6	1.2	5	0.9	7	1.5
Post-docs <sup>5</sup>	0	0.0	0	0.0	0	0.0	1	0.9	1	0.9	2	1.2	1	0.5
PhD candidates <sup>3,6</sup>	3	1.9	5	1.8	5	2.4	6	3.1	7	3.6	8	3.4	6	2.7
<b>Total research staff</b>	<b>11</b>	<b>3.5</b>	<b>13</b>	<b>3.8</b>	<b>12</b>	<b>4.4</b>	<b>14</b>	<b>5.6</b>	<b>14</b>	<b>5.7</b>	<b>15</b>	<b>5.5</b>	<b>13</b>	<b>4.8</b>
Lab Technicians	3	2.0	2	1.2	2	1.2	3	1.9	3	1.9	3	1.9	3	1.7
Visiting fellows	0	0.0	0	0.0	0	0.0	1	0.1	1	0.1	0	0.0	0	0.0
<b>Total staff</b>	<b>14</b>	<b>5.5</b>	<b>15</b>	<b>5.0</b>	<b>14</b>	<b>5.6</b>	<b>18</b>	<b>7.6</b>	<b>18</b>	<b>7.7</b>	<b>18</b>	<b>7.4</b>	<b>16</b>	<b>6.5</b>

<sup>1</sup> Total number of staff and PhD candidates

<sup>2</sup> Available research time in full time equivalent (FTE)

<sup>3</sup> All PhD categories, except external PhDs

Standards for Research Capacity (in case of part time appointment adjustment is applied):

<sup>4</sup> Professor, Assistant Professor and Associated Professor: Research Capacity = 40% of the appointment

<sup>5</sup> Post-doc: Research Capacity = 90% of the appointment

<sup>6</sup> PhD candidate: Research Capacity = 75% of the appointment (all categories)

## 2.2 Research Funds

Table 2.2. Funding of Scientific staff, Postdocs and PhD candidates by year and Expenditure of Chair group by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	FTE	%												
<b>Funding:</b>														
Direct funding <sup>1</sup>	2.0	57	2.9	75	3.1	70	2.9	51	3.2	56	2.2	39	2.7	58
Research grants <sup>2</sup>	0.8	21	0.8	20	0.8	17	1.7	29	1.4	24	2.4	43	1.3	26
Contract research <sup>3</sup>	0.8	21	0.2	5	0.6	13	1.1	20	1.1	20	1.0	18	0.8	16
<b>Total funding</b>	<b>3.5</b>	<b>100</b>	<b>3.8</b>	<b>100</b>	<b>4.4</b>	<b>100</b>	<b>5.6</b>	<b>100</b>	<b>5.7</b>	<b>100</b>	<b>5.5</b>	<b>100</b>	<b>4.8</b>	<b>100</b>
<b>Expenditure<sup>4</sup>:</b>	<b>K€</b>	<b>%</b>												
Personnel costs	947	62	959	61	1,001	56	1,066	60	1,062	56	1,029	57	1,011	59
Other costs	569	38	603	39	796	44	712	40	820	44	761	43	710	41
<b>Total expenditure</b>	<b>1,516</b>	<b>100</b>	<b>1,562</b>	<b>100</b>	<b>1,797</b>	<b>100</b>	<b>1,778</b>	<b>100</b>	<b>1,883</b>	<b>100</b>	<b>1,790</b>	<b>100</b>	<b>1,721</b>	<b>100</b>

<sup>1</sup> Direct funding by the University

<sup>2</sup> Research grants obtained in national and international scientific competition (e.g. grants from NWO, KNAW)

<sup>3</sup> Research contracts for specific research projects obtained from external organisations, such as industry, governmental ministries, European Commission (including ERC), charity organisations

<sup>4</sup> Expenditure from financial system of Wageningen University which not only includes research but also teaching and other activities

### 3. Research Quality

We emphasize research quality rather than quantity, resulting in a high percentage of papers in high-ranking journals. During the review period, 13 papers (17%) were published in journals with an IF>9.5, and 4 papers with journal IF>30. The ISI 2012 Median Impact Factors (MIF) for our research field of Zoology is 1.059, while **our MIF is 3.338, and our mean journal impact factor is more than five times higher (5.656)** (the latter based on 2013/2014 impact factors). The National Science Foundation (NSF) uses the MIF metric to rate research quality. Over the years, our chair has a relatively high percentage of PhD candidates who received a 'distinction' grade reserved for the top 3% (30%), underlining the quality of their research. To promote quality, we emphasize originality, quality and depth of analysis by applying a quantitative systems approach that combines modelling and experiments. We design and build completely novel experimental setups and complementary unique software environments. This approach requires a highly skilled multi-disciplinary research team with biologists, engineers and physicists. Building such experimental set ups takes time, which puts some pressure on the publication number. This solid research approach has worked well over the years and will be continued.

*Selected publications (RL #, relates to research lines (section 1.2)):*

Lentink D, Dickson WB, van Leeuwen JL, Dickinson MH (2009) Leading-Edge vortices elevate lift of autorotating plant seeds. *Science* **324**: 1438–1440. **IF: 31.5 (RL 1)**

Huitema LFA, Apschner A, Logister I, Spoorendonk KM, Bussmann J, Hammond, CL, Schulte-Merker, S. (2012) *Entpd5* is essential for skeletal mineralization and regulates phosphate homeostasis in zebrafish (online) *Proceedings of the National Academy of Sciences of the United States of America* **109** 21372–21377. **IF: 9.8 (RL 2)**

Kozlov AS, Baumgart J, Risler T, Versteegh CPC, Hudspeth AJ (2011) Forces between clustered stereocilia minimize friction in the ear on a subnanometre scale. *Nature* **474**: 376–379. **IF: 42.4 (RL 2)**

Dodou D, Breedveld P, Winter JCF, Dankelman J, van Leeuwen JL (2011) Mechanisms of temporary adhesion in benthic animals. *Biological reviews* **86**: 15–32. **IF: 9.8 (RL 3)**

Pollux, BJA, Meredith, RW, Springer, MS, Garland, T, Reznick, DN (2014) The evolution of the placenta drives a shift in sexual selection in livebearing fish. *Nature* **513**: 233–236. **IF: 42.4 (RL 2)**

#### 3.1 Demonstrable products - Research products for peers in science

Table 3.1. Categories of research output by year.

Category:	Year						Total	Average 2009-2014
	2009	2010	2011	2012	2013	2014		
<b>Academic publications</b>								
a. Refereed articles	9	14	15	16	10	14	<b>78</b>	13
b. Non-refereed articles	0	1	0	0	0	2	<b>3</b>	1
c. Books	0	0	0	0	0	0	<b>0</b>	0
d.1. Refereed book chapters	4	0	0	0	1	0	<b>5</b>	1
d.2. Non-refereed book chapters	0	1	0	0	0	1	<b>2</b>	0
e. PhD Theses	0	2	0	1	2	0	<b>5</b>	1
f. Conference papers	0	1	1	2	1	1	<b>6</b>	1
<b>Total academic publications</b>	<b>13</b>	<b>19</b>	<b>16</b>	<b>19</b>	<b>14</b>	<b>18</b>	<b>88</b>	17

### 3.2 Demonstrable use of products - Use of research products by peers

Table 3.2.1. Bibliometric indicators for EZO over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	11	223	182	20.3	1.25	18% (2)	0% (0)
2009	9	184	117	20.4	1.50	22% (2)	0% (0)
2010	14	106	162	7.6	0.84	14% (2)	0% (0)
2011	15	249	152	16.6	1.63	20% (3)	0% (0)
2012	16	71	78	4.4	1.00	6% (1)	0% (0)
2013	10	100	30	10.0	3.17	40% (4)	10% (1)
<b>all years</b>	<b>75</b>	<b>933</b>	<b>720</b>	<b>12.4</b>	<b>1.48</b>	<b>19% (14)</b>	<b>1% (1)</b>

Due to the interdisciplinary nature of our work, we publish in a wide range of journals including *Nature* and *Science*. Our subfield is small compared to the adopted science fields of the Essential Sciences Indicators (used to derive RI values), putting pressure on citation numbers and causing variable figures over the years. However, our mean journal impact is much higher than the ISI 2012 Median Impact Factors for zoology (see above). Furthermore, 68% of our papers appear in quartile 1 journals, and 71% of our citations originates from papers published in the top 25 % quartile. We wrote several reviews, e.g. for *Biological Reviews* (IF 9.8). We aim to reduce the share of Q3 and Q4 papers. The library scores provided are affected by missing science fields (e.g. biophysics), and erroneous categorizations of some journals (e.g. *J. Biomechanics*) in the science fields of the Essential Sciences Indicators data base (acknowledged by WUR library). Our state-of-the-art high-speed video equipment and data base fosters important collaborations with the Universities of Chiba, U.C. Riverside, Fresno State, and recently U.C. Berkeley.

Table 3.2.2. Bibliometric indicators for EZO per research field over the period 2008-2013. The rows are ordered in descending number of publications (N). The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

research field	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	30	211	213	7.0	1.05	13% (4)	0% (0)
Molecular Biology & Genetics	14	308	210	22.0	2.08	29% (4)	7% (1)
Biology & Biochemistry	13	214	183	16.5	0.99	8% (1)	0% (0)
Clinical Medicine	7	100	45	14.3	3.00	29% (2)	0% (0)
Neuroscience & Behavior	4	15	32	3.8	0.48	0% (0)	0% (0)
Environment/Ecology	3	18	16	6.0	1.47	33% (1)	0% (0)
Agricultural Sciences	2	7	8	3.5	0.84	0% (0)	0% (0)
Engineering	2	60	14	30.0	4.28	100% (2)	0% (0)
<b>all fields</b>	<b>75</b>	<b>933</b>	<b>720</b>	<b>12.4</b>	<b>1.48</b>	<b>19% (14)</b>	<b>1% (1)</b>

### 3.3 Demonstrable marks of recognition - Marks of recognition from peers

Table 3.3. Most important prizes, keynotes etc. of staff (max 6 per category). For remaining achievements see mini CVs (Separate file called mini CVs).

Science awards, Scholarly prizes, Research grants awarded to individuals		
Year	Prize description...	Person
2009	Dutch Zoology Prize	D. Lentink
2010	Academic Annual Award (Academische Jaarprijs), National Outreach competition, The Netherlands	D. Lentink, S.W.S. Gussekloo, P. de Cocq, A.W. Fiaz.

2012	Marie Curie International Incoming Fellowship (7th Framework Programme)	B. Pollux
2013	Perspectief grant 'iMIT', STW/NWO	J.L. van Leeuwen (co-applicant of successful 6 M€ grant)
2014	NWO VENI personal grant	F.T.Muijres
2015	NWO VIDI personal grant	B. Pollux

**Plenary/Keynote\* Lectures at major conferences**

Year	Person	Conference
2012	Van Leeuwen	4e International Conference on Smart materials Structures, Systems, Montecatini Terme, Italy
2014	Lankheet	Bernstein Conference, Göttingen, Germany
2010	Schulte-Merker	European Zebrafish PI Meeting, Padua, Italy

**Organisation of International Scientific Conferences**

Year	Person	Conference
2009	S. Schulte-Merker	Workshop on Zebrafish in the study of development & disease, EMBO
2010	J.L. van Leeuwen	International Board 6 <sup>th</sup> World Congress of Biomechanics (Singapore), responsible for Biomechanics in Nature Track.
2011	S. Schulte-Merker	European Workshop: 'Zebrafish: an animal model in biomedical research'
2014	J.L. van Leeuwen	World Congress of Biomechanics, Boston, responsible for Coordination of biofluidynamics of locomotion (Swimming and Flight)

**Editorships and editorial boards**

Person	Editorship from... until...
J.L. van Leeuwen	Associate editor: <i>Proceedings Biological Sciences, R. Soc. Lond.</i> 2008-2013
S. Schulte-Merker	Editor: <i>Biological Cybernetics</i> (2013-present) Editorial Board of <i>Development</i> (2009-present) Editorial Board of <i>Angiogenesis</i> (2011-present)
M. Muller	Editor <i>Animal Biology</i> (2001-2012)
B. Pollux	The open Marine Biology Journal (2007-present) <i>Freshwater Biology</i> (2012-present)
D. Lentink	Guest Editor <i>Biomimetics &amp; Bioinspiration</i> , 2010

**Memberships of academies, a.o.**

Person	Member of... from... until...
D. Lentink	Young Academy of the Royal Netherlands Academy of Arts and Sciences (2011-present)
J.L. van Leeuwen	World Council of Biomechanics (2005-present) Academic Board Wageningen University (2008-2013) Board member and previous convenor Biomechanics Group, Society for Experimental Biology
S. Schulte-Merker	Treasurer and a board member of the International Society of Developmental Biology

#### 4. Relevance to Society

Our alumni have pursued careers in (inter)national universities (e.g. Stanford), research institutes (e.g. Imares), industry (e.g. micro-air vehicles, dairy, offshore, biomedical equipment), professional schools (e.g. director at Agricultural Professional University Den Bosch), teaching, and scientific journalism. Our main targets of societal relevance are **human and animal health, bioinspired technologies** and **scientific outreach**.

##### *Human and animal health:*

Mastitis and claw diseases are a major problem at dairy farms. Our patented mechanism for milking of cows and other livestock reduces mechanical load and aims to reduce mastitis. We collaborate with Livestock Research and the dairy industry to improve milking efficacy and cow health on an international scale. We published on beneficial effects of soft flooring on claw health, and strive for wide implementation of the results.

Mosquitoes are vectors of many diseases (e.g. malaria), killing more than a million people per year. We published on host seeking in malaria mosquitoes in response to human odour and heat, which helped to improve mosquito traps (currently tested in Africa by the Entomology group). We intensified our research efforts in this area (several MSc projects; Muijres (Veni grant): biomechanics of mosquito dispersal). Our 3D-tracking software for mosquito flight was commercialized by Noldus Information Technology, and sold world-wide to institutes involved in insect-flight behaviour. Tracking software for fish swimming was made available as open source to other researchers.

##### *Bioinspired technologies:*

For the Dutch National Police (KLPD), we developed an unmanned micro-air vehicle with (swift-based) morphing wings. With TU-Delft, we constructed an Unmanned Underwater Vehicle (UUV) with undulating fins for underwater inspections (subsidized by Delphi consortium). We have begun work (2014) on steerable needles based on ovipositor steering by parasitic wasps, which should enable drug delivery and sampling of small biopsies at difficult-to-reach locations with minimal damage and discomfort in patients. With support from STW and three companies, we initiated work on gentle gripping of slippery tissues (2014), with the goal reduce tissue damage during minimally invasive surgery. We hired a PhD student in 2015.

##### *Scientific outreach:*

We won the 2010 Academic Year Prize, the national outreach competition. In this two-year project, we made high-speed cameras available to about 600 people for filming birds, bats and insects under natural conditions. We provided high-speed video training, supported by dedicated manuals. The videos (stored on our servers) are publically available (e.g. via YouTube). This work attracted extensive worldwide media attention. Several members of the group presented their scientific work for the general public (e.g. Lentink: Ted-Amsterdam; Henrion: NWO, Bessensap PhD outreach; Van Leeuwen and Kranenbarg: WU Child University (2014), primary school outreach).

##### *Targets for the coming 5–10 years:*

- We will expand work on mosquitoes, and collaborate in multidisciplinary teams to study host-seeking and dispersal mechanics because vector-borne diseases will continue to be life threatening.
- We will examine how stressors (pesticides and parasites) affect flight and pollination performance of bees. Pollination is important for worldwide food production, but bee populations (including wild species) are declining.
- We will continue work with the Livestock Research on cow health.
- We will continue to develop bio-inspired flying robots, biomimetic work on steerable needles, and gentle grippers for wet and slippery human tissues.

#### 4.1 Demonstrable products - Research products for societal target groups

*Table 4.1 - Main categories of output for societal target groups.*

Year	Output
<b>I. Professional publications and products</b>	
2009	Roboswift, biomimetic unmanned aerial vehicle (with TU Delft).
2009	In Dutch: Haazelager MB, Muller M, Timmerman M, <u>van Leeuwen JL</u> (2009) The effect of

- trimming of the frog on the impact accelerations of the equine hoof during walk and trot *Science Shop Wageningen UR, (Rapport / Wetenschapswinkel 255) - 14.*
- 2011 Track 3D, software package for automatic spatial insect tracking (sold by Noldus Information Technology).
- 2012 In Dutch: Pollux BJA, Korosi A & Pollux PMJ (2012) Verspreiding van de bittervoorn langs de Maas in Noord-Limburg: Indicaties voor een regionale metapopulatiestructuur. *Natuurhistorisch Maandblad* 101, 116-121.
- 2013 Patent Biomechanical Milking.
- 2013 Biomimetic underwater vehicle with undulating fins (with TU Delft).
- 2014 In Dutch: Henrion S, Pieters RPM, Gussekloo SWS, ter Veld M. (2014) Het zeepaard: model voor onderwaterrobots. *Biotechniek* 53(3): 9-14.
- 2014 In Dutch: Pollux BJA, Reznick DN (2014) Onderzoek naar het voortplantingsgedrag bij levendbarende vissen in de family Poeciliidae – Een verzoek om hulp! *Poecilia Nieuws - Levendbarende Tandkarpers* 31(3):10-13.
- 2014 In Dutch: Boedeltje G, Spanings T, Flik G, Pollux BJA, Sibbing F & Verberk W (2014) Wat de vis eet zal hij zaaien. *Visionair* 34: 28-31.

## II. Publications for the general public

- 2011 Training manuals for Casio ExF1 high-speed video camera
- 2011 Training manual for Phantom high-speed video camera

## III. Other research output

- 2010 S. Henrion: Inspector Gadget goes under water (NWO, 'bessensap') (public lecture).
- 2010 D. Lentink: "Ideeën uit de natuur geven microrobotjes vleugels" Kennis op Zondag in science center NEMO, October, 2010, Amsterdam, The Netherlands. (public lecture)
- 2010-2013 Dutch Academic Year Prize Activity: Lentink team: 'Vliegkunstenaars' (Flight Artists). More than two year guidance of general public for high-speed filming of flying animals.
- 2011 Lentink team, Flight Artists: Two different courses on high-speed video for the general public (>600 participants).
- 2011-2013 High-speed video equipment made available for general public: Professional Phantom v710 (Vision Research) camera (up to 7500 frames/s), and several Casio Ex-F1 amateur camera's.
- 2011 D. Lentink: TEDxAmsterdam: Nature Inspired Flight: Beyond the Leap (public lecture)
- 2013 Pollux BJA. De evolutie van placentas en superfetatie in de levendbarende vissenfamilie Poeciliidae. Meeting of the Dutch Livebearer Association, Poecilia Nederland, 25 May 2013, Maarn, the Netherlands. (public lecture).
- 2014 J.L. van Leeuwen & S. Kranenbarg: Public lecture 'Elastiek in het Dierenrijk' (Elasticity in the Animal Kingdom) on WUR TV about for children (in Dutch; primary education). 'Kinderuniversiteit Wageningen University' (Children University).

## 4.2 Demonstrable use of products - Use of research products by societal groups

Table 4.2: Examples of use of research products by societal target groups of EZO.

Patents by members of EZO in the review period	
	<ul style="list-style-type: none"> <li>WO 2013/137735: Inventors J.L. van Leeuwen, P.H. Hogewerf, A.H. Iepema, C.J.A.M. de Koning, J.G.M. van den Boogaart &amp; M.C. van Turnhout. Method of Mechanically Milking an Animal and Teat Cup Liner, International Publication date 19 September 2013.</li> <li>WO2010056123A1: Inventors S. Schulte-Merker &amp; B.M. Hogan. Methods for identifying modulating compounds of lymphangiogenesis, means therefore, compounds and uses thereof. International Publication date 19 June 2014</li> </ul>

<b>Participation in training courses and use of research facilities by societal groups</b>	We trained more than 600 people to make high-speed movies of flying animals. They subsequently used our high-speed video equipment to film flying animals under natural conditions (as part of the Academic Year prize activity).
<b>Contract research</b>	For Delphi Consortium: Development of an underwater vehicle with fin propulsion.

#### 4.3 Demonstrable marks of recognition - Marks of recognition by societal groups

Table 4.3: Examples of marks of recognition by societal target groups of EZO.

<b>Actual achievements:</b>	Academic Year Prize 2010
<b>Funding by:</b>	Dutch National Police (KLPD): roboswift DELPHI consortium: underwater robot GEA: development of milking system for dairy industry based on acquired patent.
<b>Media exposures:</b>	Newspapers and magazines (selection only): AD (2009); BBC News (2014); BioNieuws (2014, 2010, 2009); De Ingenieur (2009); LA Times (2014); Livescience (2010); MailOnline (2014); National Geographic (2014); New Scientist (2014); New York Times (2009); NRC (2009, 2010, 2014); NRC Next (2010); Parool (2014); Popular Science (2009); Quest (2010); Reuters (2014); Volkskrant (2014); <i>Science</i> (news section) (2010, 2014); Washington post (2010); Wired online (2009)  Television (selection only): ABC Science (2010); Discovery Channel (2010); Discovery Channel Canada (2013); Discovery Channel 'Daily Planet' (2014); Labyrint (2010); NPO/EO ('Melk en honing') (2014); De Wetenschapsquiz (2010); Vroege Vogels (2010); Noorderlicht (2008)  YouTube: Flight artists Academic Year Prize outreach project (many movies)

## 5. Viability

### 5.1 Benchmark

The Biomechanics Team of Concord Field Station of Harvard University and the Biomechanics group of the Zoology Department of Oxford University (UK) are leading groups that overlap with our research area (we cover a slightly wider field). The universities are nr. 2 and 3 in the 2014-2015 world university ranking (Thomson Reuters). The WIAS survey shows the following figures. The Harvard group of Professor Biewener and Dr Combes, with studies on animal flight, terrestrial locomotion and biomimetics, produced 51 peer reviewed papers over 2008–2014, published in 20 different journals with a mean IF of 4.29 (three papers with IF > 9.5), one (comment) paper in *Science* and two *PNAS* papers. The Oxford group on animal flight and biomimetics currently has 3 PI's, one having left in 2013. According to the publication list on their WEB site, they produced 18 peer reviewed papers from 2008–2014, with one publication in *Science* (IF: 31.447) and one in *PLoS Biology* (IF: 11.77). All other publications have journal IFs below 4. Their preferred outlet is the interdisciplinary *J. Roy. Soc. Interface* with 7 papers. Their mean Journal IF is 4.94. Given our mean journal IF of 5.66, productivity (78 papers), 9 papers with a journal IF > 10, 22 papers with an IF > 5 and additional scores (see table), we conclude that we are on par with these renowned biomechanics groups. With only 2 PIs, the Harvard group seems to be most productive (productivity is hard to compare because of different time available per capita in the three research groups). The Oxford group has the highest number of citations per publication, while EZO has the highest Field-Weighted impact factor. In the 2011 national Biology peer review, we were highly ranked among other Biology groups.

*Table 5.1. Results of SciVal survey by WIAS (2008-2013). CFS=Concord Field Station; FG=Flight Group.*

	Number of publications						
	2008	2009	2010	2011	2012	2013	Overall
EZO (WU)	8	7	12	13	14	10	<b>64</b>
CFS (Harvard)	8	6	5	8	4	6	<b>37</b>
FG (Oxford)	0	6	2	1	2	2	<b>13</b>
	Citations per publication						
	2008	2009	2010	2011	2012	2013	Overall
EZO (WU)	27	34.9	8.2	18.9	5.4	12	<b>15.6</b>
CFS (Harvard)	16	14.3	11.2	9.1	5	3.7	<b>10.4</b>
FG (Oxford)	-	46.3	7	4	2.5	3.5	<b>23.7</b>
	Field-Weighted Impact Factor						
	2008	2009	2010	2011	2012	2013	Overall
EZO (WU)	1.75	2.36	0.7	1.44	0.88	2.68	<b>1.51</b>
CFS (Harvard)	1.46	0.98	1.27	0.97	0.98	1.81	<b>1.26</b>
FG (Oxford)	-	2.17	0.58	0.79	0.34	1.21	<b>1.39</b>

## 5.2 SWOT-analysis

Internal organisation	Strengths	Weaknesses
	<ul style="list-style-type: none"> <li>• Strong international position in Animal Mechanics, in particular animal locomotion, as is evident from the number of papers in high-impact journals.</li> <li>• Strong partnerships with leading national and international universities and institutes on Animal Mechanics.</li> <li>• Excellent match of experimental and theoretical approaches.</li> <li>• Unique niche for high impact research (top journals and media exposure).</li> <li>• Multidisciplinary team (biology, biophysics and engineering) that can solve complex interdisciplinary problems.</li> <li>• Strong position in teaching (quality and quantity).</li> </ul>	<ul style="list-style-type: none"> <li>• Complex nature of the research limits the numbers of PhD students.</li> <li>• Large percentage of budget goes into expensive experimental set ups, which puts available fte support staff under some pressure.</li> <li>• Focus on high-quality research, and development of unique experimental set ups, limits the sheer number of papers (although output is on par with biomechanics groups in top-10 universities).</li> <li>• Funding obtained from companies is relatively low (but interactions with companies have grown).</li> </ul>

To safeguard our strengths for the coming years, we have attracted talented young scientific staff with complementary backgrounds; they have brought personal grants and display high potential to raise external funds for PhD students. To maximize success of the group, we emphasize not only a challenging research environment, but also one that is genuinely collaborative. We have furthermore expanded our lab space and technological infrastructure.

To tackle the weaknesses, we have taken the following steps. We continue to be very selective in the appointment of PhD students, which raises overall quality and maximizes the number of students that can be successfully supervised. We aim for grants that provide not only support for PhD students and post-docs but also for technical support. This strategy has worked well in our recently funded biomimetic STW projects, which gave us access to the high-tech mechanical workshop of Delft University of Technology in addition to our own well-equipped workshop. Our state-of-the-art experimental facilities attract (inter)national cooperation, which is expected to raise the yearly number of papers. Our collaboration with (inter)national companies is currently growing, in particular through our biomimetic projects.

External context	Opportunities	Threats
	<ul style="list-style-type: none"> <li>• Focus of WUR on global health and resilience.</li> <li>• Rising societal concern for animal health and welfare.</li> <li>• Work on animals that are either a threat to human health or have societal benefits.</li> <li>• Rapidly expanding field of biomimetics with applications in medical instruments and small unmanned vehicles.</li> <li>• Increase effectiveness by collaboration in B&amp;AR cluster and by exploiting our strength in Animal Mechanics.</li> <li>• National Science Foundation (NWO) puts more emphasis on interdisciplinary</li> </ul>	<ul style="list-style-type: none"> <li>• Basic science depends largely on diminishing funds from our National Science Foundation (NWO), for which competition is stiff. Funding policies of NWO are lowering priority of fundamental research.</li> <li>• Relatively few funding opportunities for research in Animal Mechanics due to current focus on molecular research.</li> <li>• Biomechanics is not (yet) generally considered an important issue in animal health and welfare (in contrast to human orthopaedics).</li> </ul>

In recent years, we have taken effective steps to profit from new opportunities. This led to a steep increase in the percentage of externally financed research (up from 30% in 2011 to an expected 80% by the end of 2015). The interdisciplinary nature of our team gives us a head start to benefit from the new strategic plan of the National Science Foundation (NWO).

Over the last three years, we have anticipated and counteracted several threats to our research program. We were not negatively affected by the pressure put on funding for basic research; on the contrary, the success rate of our NWO proposals increased significantly as a result of adjustments of our overall strategy. We have been able to put Animal Mechanics on the national agenda (Academic Year Prize 2010) and have attracted prominent media attention. Mechanical overload is key to many health problems in animal husbandry. The rising societal awareness of these problems guarantees the relevance of our work in the future.

Below, we connect the SWOT analysis to our strategy for the future in the light of a (concise) environmental analysis.

### 5.3 Strategy for the future

*Expected changes in research environment:*

The WUR strategic plan 2015–2018 calls for more multidisciplinary overlap between knowledge areas, viz. (1) food, feed and biobased production, (2) society and well-being, and (3) natural resources and living environment. “Global One Health” (including disease vector control) and “Resilience” are focus areas within the general mission “to explore the potential of nature to improve the quality of life”. NWO, the major Dutch funding source for fundamental research, is shifting its funding balance from fundamental research to directly applicable projects, with a stronger focus on interdisciplinary work. The preference for immediate economic impact is visible on a European scale and seems irreversible. As a Zoology group we take these trends into account as we continue to aim for excellent fundamental research with societal relevance related to human and animal health.

*Key scientific competence in relation to an adaptive response (see also our SWOT):*

To maximize our viability we emphasize the aims of the WUR strategic plan and we adapt to (inter)national changes in research funding. To this end, we (1) expand our strengths, (2) exploit opportunities and (3) prioritize interdisciplinary work. We select research projects within the preferred WUR domains, with clear practical applications (disease vectors, health, resilience), and promote interdisciplinary collaborations.

(1) Success in obtaining personal- and open grants from NWO and at a European scale requires research of highest quality. Therefore, we continue to aim for quality papers in high-impact journals. We combine fundamental research with applicability in areas with societal relevance, and we aim to create an environment that attracts talented students from different disciplines. To further strengthen

the infrastructure for biomechanics research we continue to invest in challenging experimental set-ups, in world-class high-speed video, and flow visualization equipment. In cooperation with the Hubrecht Institute and other groups in Wageningen, we now combine biomechanics with genomics and proteomics to analyse tissue development and differentiation.

- (2) Our research lines already combine societal relevance with top-quality fundamental research and are therefore highly viable. In selecting research topics and species, we take relevance to human and animal health, and resilience into account. This resulted in research on cows, zebrafish, mosquitoes, and bees (section 4). To emphasize resilience of aquatic systems, we co-founded the cluster on Biology & Aquatic Resilience, in which we work with CBI on the dynamics and resilience of the developing immune system (PhD position granted), and with AFI on invasive species.
- (3) A strong interdisciplinary team has been our back-bone for solving zoological problems (section 1). The interdisciplinary nature of our work matches the mission of WUR and the paradigm shift for future NWO funding, and therefore strengthens our viability. It has resulted in a flourishing line of biomimetic research (with STW/NWO as current major funder) that we aim to expand in the coming years. To strengthen our strategy, we attracted young researchers (Muijres, Pollux) with strong research lines on animal flight and fish biology.

*Conclusion:*

We are an international key-player in the highly competitive area of biomechanics, a position we intend to capitalize upon in the years to come. There is an increasing awareness of major animal health issues due to mechanical overload. This, together with new industrial contacts for bioinspired designs, gives us a competitive advantage for projects that combine fundamental and applied research, match the WUR mission, and reflect the national and European research agendas.

## **6. Research Integrity**

*Integrity and ethics.* Maintaining the highest possible standards of integrity and ethical principles is a priority within the group. Frequent progress meetings with our PhD and MSc students and detailed discussions of work within the group support an open atmosphere in which scientific quality and rigor are optimally guarded.

*Research culture.* We have weekly open research discussions in which work in progress is presented for the whole group, including models, experimental data sets and manuscripts. We have a flat hierarchical culture to maximally facilitate discussions based on scientific arguments. Contributions of authors to publications should be made clear explicitly (we reject authorships based on just management and hierarchy).

*Data storage.* We have dedicated servers to store the huge amount of data that we generate especially with our high-speed video systems. One problem that we face is that the cost of data storage by the ICT facilities offered by WU are beyond the economic capacity of our chair group. We therefore had to install our own server systems to store data. We have a general data-storage plan for the chair group and each PhD student has to write his/her own data storage plan that is verified by the supervisors and is submitted to WIAS for approval.

**Appendix 1** - Research staff Experimental Zoology group

Table 1 - Research staff input at Chair Group level

<b>Name staff</b>	<b>Funding 1, 2, 3*</b>	<b>2009 FTE**</b>	<b>2010 FTE</b>	<b>2011 FTE</b>	<b>2012 FTE</b>	<b>2013 FTE</b>	<b>2014 FTE</b>
<i>Full professors</i>							
Prof dr ir J.L. van Leeuwen (1 fte)      Tenured	1	0.3	0.3	0.3	0.3	0.3	0.3
<i>Special chairs</i>							
Prof Dr S. Schulte-Merker (0.2 fte)      1-7-2008/1-07-2013	1	0.08	0.08	0.08	0.08	0.08	0.04
<i>Associate professors</i>							
Dr Ir M.J.M. Lankheet (1 fte)      Tenured	1	0.13	0.3	0.3	0.3	0.30	0.3
Dr M. Muller (1 fte)      Tenured/retired 2013	1	0.4	0.4	0.4	0.4	0.20	
Dr F.A. Sibbing (1 fte)      Tenured/retired 2010	1	0.2	0.1				
<i>Assistant professors</i>							
Dr S.W.S. Gussekloo (1 fte)      Tenured	1	0.15	0.15	0.15	0.15	0.2	0.2
Dr ir S. Kranenbarg (1 fte)      Tenured/0.8 fte in 2013	1	0.2	0.2	0.2	0.2	0.1	0.1
Dr ir D. Lentink (1 fte)      Tenured/left in 2012	1	0.1	0.5	0.5	0.17		
<i>Post-docs</i>							
Dr.ir. F. Muijres (1 fte)      1-8-2014	2						0.33
Dr. B.J. Pollux (1 fte)      01-01-2012/31-12-2014	2				0.9	0.9	0.9
<i>Visiting fellows</i>							
Dr. U.K. Muller					0.05	0.05	
<b>Total scientific staff</b>		<b>1.56</b>	<b>2.03</b>	<b>1.93</b>	<b>2.55</b>	<b>2.13</b>	<b>2.17</b>
<i>Support staff</i>							
Dr. K. Leon (0.7 fte)      Tenured	1	0.5	0.5	0.5	0.5	0.5	0.5
H. Schipper (1 fte)      Tenured	1	0.7	0.7	0.7	0.7	0.7	0.7
Ir. R. Pieters (1 fte)      Tenured	1				0.7	0.7	0.7
J.G.M. van den Boogaart      Tenured	1	0.8					
<b>Total staff</b>		<b>3.56</b>	<b>3.23</b>	<b>3.13</b>	<b>4.45</b>	<b>4.03</b>	<b>4.07</b>

\* Funding scores: 1= direct funding by University; 2= funding obtained in national scientific competition (e.g. grants from NWO, KNAW) ; and 3= funding obtained from external organisations, such as industry, governmental ministries, European Commission and charity organisations.

\*\* FTE reported in this table regards the research appointment part of the total appointment (e.g. tenured staff has 40% available for research, postdocs have 60% available for research).

**Appendix 2** - Scientist for benchmark Experimental Zoology group**Table II.** *Scientist selected at Harvard University (Harv), and Oxford University (Oxf) for benchmarking EZO.*

<b>EZO</b>	<b>Harv</b>	<b>Oxf</b>
Gussekkloo, S.W.S.	Biewener, A.A.	Taylor, G.K.
Kranenbarg, S.	Combes, S.A.	Thomas, A.L.
Lankheet, M.J.M.		Walker, S.M.
Lentink, D.		
Müller, M.		
Sibbing, F.A.		
Van Leeuwen, J.L.		



## Host-Microbe Interactomics (HMI)

Programme leader(s): Jerry Wells 2009-2014

For a full staff survey see appendix 1.

### 1. Objectives and Research Area

#### 1.1 Vision, Mission and Objectives

**Our Vision** “our vision is to deliver mechanistic and fundamental insight in the molecular interactions of microbes and hosts that can be exploited for the benefit of human and animal health, and in parallel train and educate young scientists to become the future knowledge leaders in the field”

**Our Mission** is to provide high quality multidisciplinary research, education and innovation in host-microbe interactions and explore and support new strategies for preventing and treating disease in humans and animals.

#### Core Objectives

##### Host-pathogen interactions

- Provide fundamental knowledge and understanding of the biology and virulence mechanism of bacterial pathogens or pathobionts. Focus is on *Streptococcus suis*
- Work with societal stakeholders to translate our research into novel strategies for pathogen detection disease prevention and treatment.

##### Host-microbiota Interactions in the intestinal tract

- Provide fundamental knowledge and understanding of the mechanisms underlying intestinal homeostasis and the interplay between microbes and the gut mucosa that impact on host physiology in health and disease.
- Work with societal stakeholders to translate our research into microbe or microbial consortia-based interventions for prevention and treatment of diseases. Focus is on *Lactobacillus spp.* *Faecalibacterium prausnitzii* and combinations of colonic anaerobes.
- Understand and exploit the mechanisms underlying natural processes of horizontal gene transfer between microbial cells, with the intent to harness and exploit microbial genome diversity for the generation of improved biotechnologically applicable microbes.

#### 1.2 Main Research Areas

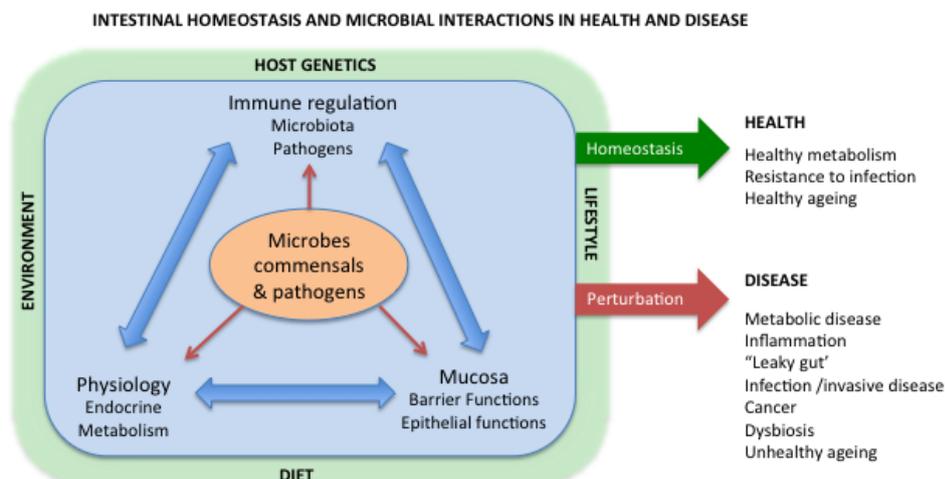


Figure 1. Microbes are central to intestinal homeostasis and can impact on host physiology, immunity and epithelium functions. Our two main research lines are: 1). Host-pathogen interactions and 2). Intestinal microbes/microbiota interactions. These research lines share core technological approaches strengthening

*the exchange of knowledge and the group learning approach to bioinformatics and omics methodologies. The pathogen focus is on Streptococcus suis a major pathogen of pigs worldwide and cause of zoonotic infections. We also work on pathobionts that can trigger immune-mediated diseases in animals and humans with predisposing genetic defects and/or environmental factors.*

### **1. Host-pathogen interactions (FTE input = 6.5)**

Development and application of advanced genetic approaches, techniques, and models to enhance our understanding of *Streptococcus suis* virulence mechanisms, including the extensive strain variability in virulence and the recent emergence of more virulent zoonotic infections with *S. suis* in humans and pigs. Knowledge to underpin the development of strategies to prevent and treat infections, including development of novel antimicrobials. Understanding of the mechanisms and conditions leading to increased abundance and pathogenic potential of pathobionts (B2 phylotype *E. coli*).

### **2. Microbiota-Host Interactions in the intestinal tract (FTE input = 8.8)**

Enhance our understanding of the interplay between the gut microbiome and specific species/groups on post-natal development and the establishment/maintenance of energy/immune homeostasis in humans and animals. Research on the molecular host interaction of specific bacterial species (e.g. *F. prausnitzii* and probiotic lactobacilli), bacterial consortia and/or bioactive molecules from bacterial origin that profoundly impact on host physiology and have therapeutic and/or prophylactic use against diseases. Gain mechanistic knowledge to underpin microbiota-based strategies for the management of health and combat negative consequences of the microbiota imbalance (dysbiosis) observed in many (gut) disorders.

#### **1.3 Strategy**

##### **Major achievements in host-pathogen interactions (2009-2014)**

We have made some landmark discoveries concerning *S.suis* including (i) a peptide pheromone system for inducing competence for highly efficient DNA transformation and genome recombination, (ii) transposon mutagenesis approach enabling genotype-phenotype and gene-fitness relationships to be investigated rapidly (even *in vivo*) by applying new generation sequencing methods for mapping transposon insertion frequencies, (iii) identification of novel virulence mechanisms, (iv) transcriptomics studies showing that different carbohydrates found in the host niches differentially influence virulence gene expression in *S. suis*, (v) a model for regulation of gene regulation at different stages of infection, (vi) bacteria that inhibiting *S. suis* through production of novel bacteriocins and antibiotic compounds and colonize the same niches in the pig, (vii) identification of essential genes in *S. suis* and identification of novel antibacterial compounds through virtual screening against a validated target and (viii) identification of novel virulence mechanisms in *E. coli* pathobionts

**Next Five Years:** specifically we will (i) unravel novel mechanisms contributing to virulence and transmission of different strains and serotypes of *S. suis* in pigs and humans, (ii) provide fundamental knowledge to underpin the development of markers for the identification and epidemiology of emerging strains with high virulence potential (iii) investigate new intervention strategies to prevent *S. suis* infections in piglets based on microbial antagonism and carbohydrate regulation of *S. suis* virulence and (iv) initiate research employing transcriptomics approaches to gain a better understanding of the challenges to the intestinal system elicited by enteric pathogens in pigs and humans.

##### **Major achievements in microbiota-host interactions in the intestinal tract (2009-2014)**

We have (i) further expanded our expertise in network biology and pathway analysis of host-microbiota interactions in the intestine using human volunteer studies and mouse models of infection and colitis, resulting in publications in several high impact publications, (ii) established intestinal organoid models from intestinal biopsies and optimized protocols to generate 2D cell monolayers for mechanistic and infection studies (iii) identified and patented an anti-inflammatory effector molecule of *F. prausnitzii* that protect against experimental colitis *in vivo*, (iv) a surface exposed protein of *Lactobacillus plantarum* that contributes to attenuation of inflammation by this microbe, (v) differential immune activation capacities of small intestinal streptococci of human origin (vi) proposed the “bandwidth of health” concept which intends to harness (multivariate) variability among individuals to define and decipher the boundaries of health and disease, using a framework of novel data-mining strategies.

**Next Five Years:** specifically we will (i) identify other bacterial strains and species as well as defined consortia of gut bacteria that have beneficial effects on the host physiology *in vivo* and (ii) investigate the mechanisms underlying the protective effects that these bacteria or their effector molecules can elicit *in vivo*, (iii) utilize this knowledge for disease prevention or treatment, (iv) Explore the “bandwidth of health” concept for health stratification of individuals in human cohorts or animal breeding lines, and advancement of customized therapies.

#### 1.4 Research environment and embedding

The HMI group is made up of high-profile international scientists that are strongly embedded in national, European, and international networks, and collaborating with partners in large disciplinary and interdisciplinary research projects. Our group contributes to the high-ranking (18) of Wageningen University for Life Sciences among the top 100 universities in the world<sup>1</sup>.

**Within Wageningen University** HMI research themes are at the centre of the University 5-year strategic plan<sup>2</sup> and we collaborate in research projects within the **ASG Research Cluster** (HMI, ABG and QVE), with Chair groups ADP and CBI and with 4 Chair groups outside in other Departments (HNE, MIB, FQD, FCH). HMI scientists are members of the WIAS and VLAG Graduate Schools and PhD students are roughly divided between the two graduate schools on basis of research topic.

**Collaboration with industry** enables us to stay tuned to the knowledge barriers to innovation and demonstrate impact of our research through knowledge transfer and exploitation of our IPR. We have active research project collaborations with 4 global companies in the food and pharmaceutical sectors, (i.e. Nestec, Christian Hansen and Friesland Campina and Zoetis), collaborations and small projects with a number of smaller food, feed, animal breeding and ingredients companies (e.g. PROBI AB, ToPigs; Elanco, Greenway) and contract research organizations in the private sector (e.g. Schothorst Feed Research, and NIZO food research). Via Mari Smits there is also a strong interaction with Dutch Animal Nutrition Industries in the Topsector Public Private Partnership (PPS).

HMI staff hold a variety of key influential **management positions in national research centres and programs** (i) Board of Wageningen Centre for Systems Biology, (ii) Theme Director and PIs in the Top Institute for Food and Nutrition, (iii) Chair of the TopSector PPS Feed4Foodure and (iv) Centre for One Health & Theme on Antimicrobial Resistance.

The group participates in several European and global research programmes and cooperates with several **leading international universities and research organizations worldwide**. The research embedding and environment facilitates our research through access to different expertise, technologies and staff /PhD student exchanges. JW has a guest scientist appointment at University of Cambridge School of Veterinary medicine in Cambridge U.K. The group participates in important European Consortia working on host microbe interactions (e.g. projects METAHIT, Fibrebiotics, Crosstalk, and coordinates the STARS European Training Network for 9 PhD students.

#### 1.5 Reference to previous assessments

HMI was not evaluated in the previous peer review (2009) as the Chair group was only formed towards the end of 2007. This was a cold start with no funding, research equipment or personnel (except for the salary of Chair holder from University), so it was not until 2009 that the group began to expand with the award of new research grants for funding PhD students and post-docs.

In the mid-term review (2012) the WIAS International Advisory Board and four international experts commented that:

*" The topic of infectious diseases and microbiota has great potential and is of high societal importance."*

*"The output is very good and increasing; publications are in high impact journals"*

*"The scientific quality is rapidly increasing in the last few years and points to a high potential of the group."*

<sup>1</sup> See Times Higher Education ([www.timeshighereducation.co.uk/world-university-rankings/](http://www.timeshighereducation.co.uk/world-university-rankings/)), and Academic Ranking of World Universities (<http://www.shanghairanking.com/>).

<sup>2</sup> Wageningen University (2010), Strategic plan 2011-2014, Wageningen WUR. The university had three strategic areas: Food and food production; Environment and natural resources; Lifestyle, livelihood and health. Our research contributes strongly to two of these areas.

It was recommended that we:

1. "Continue the growth and publication strategy" Actions - this we have done very successfully (see section 3).

2. "The maintenance of a good balance between number of staff and PhD students is important and deserves attention" Actions - Growth has to be balanced with income and associated workload and since then we have appointed two more staff (endowed Chair and personal Chair 1.0 FTE since 2015) enabling expansion of the group while maintaining research quality (see sections 2 and 3 below)

## 2. Resources and Facilities

### Research staff strategy:

In the groups first five years the size, visibility and opportunities for research funding have increased steadily. Growth has been controlled to manage workload and maintain a good balance between number of staff and PhD students. Education income for PhD graduations started in 2013 and will provide financial resources to fund a new tenure track position from 2015.

### 2.1 Researchers

Table 2.1. Research input: number<sup>1</sup> and FTE<sup>2</sup> of Scientific staff, Post-docs and PhD candidates by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff <sup>4</sup>	1	0.4	2	0.7	4	0.8	4	0.9	4	0.9	4	0.9	3	0.8
Post-docs <sup>5</sup>	3	2.7	2	1.0	2	1.0	3	2.5	3	2.6	2	1.8	3	1.9
PhD candidates <sup>3,6</sup>	5	3.0	6	4.2	11	6.4	10	6.2	10	6.6	11	6.2	9	5.4
<b>Total research staff</b>	<b>9</b>	<b>6.1</b>	<b>10</b>	<b>5.9</b>	<b>17</b>	<b>8.2</b>	<b>17</b>	<b>9.6</b>	<b>17</b>	<b>10.1</b>	<b>17</b>	<b>8.9</b>	<b>15</b>	<b>8.1</b>
Lab Technicians	1	0.8	2	1.6	2	1.6	3	2.4	3	2.4	3	2.4	2	1.9
Visiting fellows	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<b>Total staff</b>	<b>10</b>	<b>6.9</b>	<b>12</b>	<b>7.5</b>	<b>19</b>	<b>9.8</b>	<b>20</b>	<b>12.0</b>	<b>20</b>	<b>12.5</b>	<b>20</b>	<b>11.3</b>	<b>17</b>	<b>10.0</b>

<sup>1</sup> Total number of staff and PhD candidates

<sup>2</sup> Available research time in full time equivalent (FTE)

<sup>3</sup> All PhD categories, except external PhDs

Standards for Research Capacity (in case of part time appointment adjustment is applied):

<sup>4</sup> Professor, Assistant Professor and Associated Professor: Research Capacity = 40% of the appointment

<sup>5</sup> Post-doc: Research Capacity = 90% of the appointment

<sup>6</sup> PhD candidate: Research Capacity = 75% of the appointment (all categories)

### 2.2 Research Funds

**Funding trends and targets:** funding has steadily increased over the five years commensurate with new staff appointments and increasing visibility of the group. In the first 3-4 years of this starting group our research funding came from competitive international grants e.g. EC and the Dutch Ministry for innovative research in cooperation with industry. In the past year we increased applications for competitive national research grants (category 2). Thus in 2015, 5 new research grants (5 FTE) will start including 2 national research grants i.e. grants from NWO or ZonMv in cat. 2. We are awaiting the outcome of 4 other grants including 2 from national funding calls. Thus as of this year we have a more balanced portfolio of funding sources.

Table 2.2. Funding of Scientific staff, Postdocs and PhD candidates by year and Expenditure of Chair group by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
<i>Funding:</i>	<b>FTE</b>	<b>%</b>	<b>FTE</b>	<b>%</b>	<b>FTE</b>	<b>%</b>	<b>FTE</b>	<b>%</b>	<b>FTE</b>	<b>%</b>	<b>FTE</b>	<b>%</b>	<b>FTE</b>	<b>%</b>
Direct funding <sup>1</sup>	1.5	25	2.7	45	3.0	36	2.8	30	3.7	37	2.9	33	2.8	34
Research grants <sup>2</sup>	0.0	0	0.0	0	0.0	0	0.0	0	0.5	5	1.2	13	0.3	3
Contract research <sup>3</sup>	4.6	75	3.2	55	5.2	64	6.7	70	5.9	58	4.8	54	5.1	63
<b>Total funding</b>	<b>6.1</b>	<b>100</b>	<b>5.9</b>	<b>100</b>	<b>8.2</b>	<b>100</b>	<b>9.6</b>	<b>100</b>	<b>10.1</b>	<b>100</b>	<b>8.9</b>	<b>100</b>	<b>8.1</b>	<b>100</b>
<i>Expenditure<sup>4</sup>:</i>	<b>K€</b>	<b>%</b>	<b>K€</b>	<b>%</b>	<b>K€</b>	<b>%</b>	<b>K€</b>	<b>%</b>	<b>K€</b>	<b>%</b>	<b>K€</b>	<b>%</b>	<b>K€</b>	<b>%</b>
Personnel costs	546	56	653	44	715	51	890	50	1,089	55	1,099	61	832	53
Other costs	435	44	821	56	691	49	896	50	876	45	716	39	739	47
<b>Total expenditure</b>	<b>981</b>	<b>100</b>	<b>1,473</b>	<b>100</b>	<b>1,406</b>	<b>100</b>	<b>1,786</b>	<b>100</b>	<b>1,965</b>	<b>100</b>	<b>1,815</b>	<b>100</b>	<b>1,571</b>	<b>100</b>

<sup>1</sup> Direct funding by the University

<sup>2</sup> Research grants obtained in national and international scientific competition (e.g. grants from NWO, KNAW)

<sup>3</sup> Research contracts for specific research projects obtained from external organisations, such as industry, governmental ministries, European Commission (including ERC), charity organisations

<sup>4</sup> Expenditure from financial system of Wageningen University which not only includes research but also teaching and other activities

### 2.3 Research facilities

HMI has excellent facilities and equipment for molecular biology, tissue culture (ML2) and pathogen containment (ML2). Additionally the group shares and maintains a human tissue culture laboratory, histology lab, flow cytometer and confocal microscope with CBI and or EZO. Additionally HMI hosts a high throughput high content imaging system available in only in a few centres across Europe.

## 3. Research Quality

### 3.1 Demonstrable products - Research products for peers in science

Table 3.1. Categories of research output by year.

Category:	Year							Total	*Average 2011-2014
	2009	2010	2011	2012	2013	2014			
<b>Academic publications</b>									
a. Refereed articles	3	13	21	34	53	19	143	32	
b. Non-refereed articles	0	0	2	0	0	0	2	1	
c. Books	0	0	0	0	0	0	0	0	
d.1. Refereed book chapters	0	0	4	0	0	1	5	1	
d.2. Non-refereed book chapters	0	0	0	0	0	0	0	0	
e. PhD Theses	0	0	1	3	5	3	12	3	
f. Conference papers	0	0	1	3	0	1	5	1	
<b>Total academic publications</b>	<b>3</b>	<b>13</b>	<b>29</b>	<b>40</b>	<b>58</b>	<b>24</b>	<b>167</b>	<b>38</b>	

\* In 2009-2010 this was a starting Chair group with only one employee at the beginning and no research grants, the last 4 years were averaged

**In the past 5 years the group members have published original research papers in leading journals with high impact factors (IF) including Nature (3 papers IF 42), PNAS (3 papers IF 9.8), Gut (2 papers IF 13.3), IBD (1 paper IF 6), Mucosal Immunology (2 papers and 1 in press IF 7.5) ISMEJ (5 papers IF 9.2). We have published several invited reviews in highly impact review journals, including Nature Reviews**

Microbiology (2), FEMS Microbiology reviews, Trends in Immunology, Nature Reviews Immunology, Current Opinion Microbiology (3), Current Opinion Biotechnology (3) and PNAS.

**Theses.** As the group has grown the number of PhD graduations has increased and we are maintaining 10-12 PhD students per year, which is a compatible with total research staff. In the next period we expect this to increase to 12-15 with a new tenure track appointment and increased number of post-docs from 2015. **PhD graduations** in the HMI group were all evaluated in the top 20% category for the thesis and oral defence.

**Patents** (not included in Table 3.1). Members of HMI are named inventors on 5-filed patents (2009-2014), 2 of which have been filed with WU-HMI as owner or co-owner; 3 are owned by TIFN. One of the patents co-owned by WU has been licenced to a large company. Two other patent filings are in progress (2015).

### 5 selected publications (research articles 2008 to 2014) representing the breadth of our research

- Wells J.M, Rossi O, Meijerink M and van Baarlen P. (2011). Epithelial Crosstalk at the Microbiota-Mucosal Interface. *Proc Natl Acad Sci U S A*. 2011 Mar 15;108 Suppl 1:4607-14
- Loonen LM, Stolte EH, Jaklofsky MT, Meijerink M, Dekker J, van Baarlen P, Wells JM. REG3 $\gamma$ -deficient mice have altered mucus distribution and increased mucosal inflammatory responses to the microbiota and enteric pathogens in the ileum. *Mucosal Immunol*. 2014 Jul;7(4):939-47
- Le Chatelier E et al., Richness of human gut microbiome correlates with metabolic markers. *Nature*. 2013 Aug 29;500(7464):541-6. doi: 10.1038/nature12506.
- El Aidy S, Merrifield CA, Derrien M, van Baarlen P, Hooiveld G, Levenez F, Doré J, Dekker J, Holmes E, Claus SP, Reijngoud DJ, Kleerebezem M The gut microbiota elicits a profound metabolic reorientation in the mouse jejunal mucosa during conventionalisation. *Gut*. 2013 Sep;62(9):1306-14. doi: 10.1136/gutjnl-2011-301955. Epub 2012 Jun 21.
- van Baarlen P, Troost F, van der Meer C, Hooiveld G, Boekschoten M, Brummer RJ, Kleerebezem M. Human mucosal in vivo transcriptome responses to three lactobacilli indicate how probiotics may modulate human cellular pathways. *Proc Natl Acad Sci U S A*. 2011 Mar 15;108 Suppl 1:4562-9.

### 3.2 Demonstrable use of products - Use of research products by peers

Table 3.2.1. Bibliometric indicators for HMI over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	2	222	53	111.0	5.17	50% (1)	50% (1)
2009	3	170	44	56.7	3.35	33% (1)	33% (1)
2010	10	368	117	36.8	3.60	50% (5)	30% (3)
2011	20	510	185	25.5	3.21	40% (8)	15% (3)
2012	32	394	214	12.3	1.89	19% (6)	3% (1)
2013	48	718	125	15.0	6.16	35% (17)	8% (4)
<b>all years</b>	<b>115</b>	<b>2382</b>	<b>740</b>	<b>20.7</b>	<b>4.14</b>	<b>33% (38)</b>	<b>11% (13)</b>

\* **Relative impact (RI) classification based on relative impact at the level of chair groups**

RI  $\leq$  0.8 below world average impact

0.8 < RI  $\leq$  1.2 world average impact

1.2 < RI  $\leq$  2.0 above world average impact

2.0 < RI  $\leq$  3.0 very good average impact

RI > 3.0 excellent average impact

We strive for high quality in our research, and for many papers a lot of research months were (and are) invested. **The average relative impact for HMI is excellent (> 4 fold world average) based on average number of citations per research field divided by the world average in that field. HMI has a very high proportion of peer-reviewed articles in the top 10% and 1% cited publications in our field.** Furthermore, our total number of publications and citations are relatively high considering we were a starting group in the period of the peer review.

Table 3.2.2. Bibliometric indicators for HMI per research field over the period 2008-2013. The rows are ordered in descending number of publications (N). The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

research field	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Microbiology	46	1193	312	25.9	4.02	37% (17)	15% (7)
Biology & Biochemistry	19	147	106	7.7	1.28	21% (4)	0% (0)
Clinical Medicine	15	509	71	33.9	11.94	40% (6)	20% (3)
Immunology	11	138	85	12.6	2.00	27% (3)	0% (0)
Molecular Biology & Genetics	8	116	95	14.5	1.35	25% (2)	0% (0)
Agricultural Sciences	7	211	29	30.1	5.79	57% (4)	43% (3)
Plant & Animal Science	4	23	22	5.8	1.08	0% (0)	0% (0)
Chemistry	2	4	6	2.0	0.68	0% (0)	0% (0)
Environment/Ecology	2	31	10	15.5	2.22	50% (1)	0% (0)
Pharmacology & Toxicology	1	10	2	10.0	4.50	100% (1)	0% (0)
<b>All fields</b>	<b>116</b>	<b>2390</b>	<b>754</b>	<b>20.6</b>	<b>4.14</b>	<b>33% (38)</b>	<b>11% (13)</b>

The most important research fields for HMI publications are Microbiology and Clinical Medicine (Health Related Research) (Table 3.2.3), which are internationally highly competitive. Overall 72% of the HMI articles are published in quartile 1 journals and 23% in quartile 2 journals. Publications in quartile 1 journals have an excellent average relative impact of more than 5, the share of 38% within the top 10% most cited publications in their field and the share of 16% within the top 1% most cited publications in their field.

### 3.3 Demonstrable marks of recognition - Marks of recognition from peers (in review period)

Table 3.3. Most important prizes, keynotes etc. of staff. For remaining achievements see mini CVs (Separate file called mini CVs).

Science awards, Scholarly prizes, Research grants awarded to individuals		
Year	Prize description...	Person
2014	Individual European Fellowship (submitted in 2014)	N. Velikova
2013	Young Researcher Prize at Seeon Microbiota Host Conference Munich, (2013)	B. Sovran
2012	WIAS Publication Prize (2012)	M. Meijerink
Plenary/Keynote* Lectures at major conferences		
Year	Conference	Person
2014	Plenary: Rowett-INRA 2014 9th Gut Microbiology Symposium	J. Wells
2009	Keynote: 5th International Yakult Conference "The Gut and More"	J. Wells
2012	Keynote: AgResearch/Fronterra Symposium, Palmerston North, NZ.	J. Wells
2014	Keynote: Innate Host Defence Mechanisms in Infections, Utrecht	J. Wells
2014	Keynote: ALW Genetics, Lunteren	J. Wells
2011	Keynote: 10th Lactic Acid Bacteria Symposium, Egmond aan Zee, NL	J. Wells
2014	Keynote: ILSI Conference Brussels, Belgium	J. Wells
2012	Plenary: Welcome Trust Microbiome Conference, Cambridge, UK	M. Kleerebezem
2012	Keynote: Microbes for Health Conference, Madrid, Spain	M. Kleerebezem
2013	Keynote: Kluyver Centre open conference, Noordwijk aan Zee	M. Kleerebezem
2013	Keynote: Lactic Acid Bacteria Conference, Egmond aan Zee	M. Kleerebezem
2014	Plenary: Pharmabiotics Conference, Paris, France	M. Kleerebezem
2014	Plenary: Microbiome Business and Science Conference, San Diego, USA	M. Kleerebezem
2014	Plenary: Herrenhausen Conference, Frankfurt, Germany	M. Kleerebezem
2014	Keynote: Dutch Dermatology Annual Meeting, Lunteren	M. Kleerebezem
2014	Keynote: KNMG Symposium, Den Haag	M. Kleerebezem

2008-14 More than 20 invited lectures at international conferences - J. Wells  
P.van Baarlen, M. Kleerebezem, M. Smits, M. Meijerink, & L. Loonen Several staff

#### Organisation of International Scientific Conferences

Year	Conference	Person
2010	Chair Scientific Committee: Beneficial Microbes NL	J. Wells
2014	Chair Scientific Committee: Beneficial Microbes, NL	J. Wells
2012	Scientific Organizer of Antimicrobial Drug Discovery Conference, Madrid Spain	J. Wells
2010	Microbes for Health 1 <sup>st</sup> edition, Paris	M. Kleerebezem
2011	Lactic Acid Bacteria Conference, 10th edition, Egmond aan Zee	M. Kleerebezem
2014	Lactic Acid Bacteria Conference, 11 <sup>th</sup> edition, Egmond aan Zee	M. Kleerebezem
2010	International Symposium on Animal Genomics for Animal Health	M. Smits
2009	Genomics for Animal Health: Outlook for the Future	M. Smits

#### Editorships and editorial boards

Guest Editor Current Opinion in Microbiology 2014	J.Wells
Guest Editor Microbial Cell Factories 2010 and 2011	M. Kleerebezem
Guest Editor Current Opinion in Biotechnology 2014 and 2015	M. Kleerebezem
Editorial Board of Journal Biomedicine and Biotechnology 2008 to date	M. Smits

#### Peer-Review Committees, consultancy and Advisory Boards/Panels

Member of Alimentary Pharmabiotic Centre, science review panel (2011)	M. Kleerebezem
Member of Science Advisory Board of 3G multicentre project coordinated by Tine Rask Licht of DTU, Copenhagen (since 2010)	M. Kleerebezem
Consultant for Danone Research Palaiseau (since 2013)	M. Kleerebezem
Invited member of the Science Foundation Ireland (SFI) Science Evaluation Board - (3 times since 2011)	M. Kleerebezem
Expert member of ILSI Prebiotic taskforce (2012-2014)	M. Kleerebezem
Expert member of ILSI Microbiota taskforce (since 2013)	M. Kleerebezem
Academic co-chair of ILSI Probiotic taskforce (since 2014)	M. Kleerebezem
Invited vice Chair evaluations (2014), European Commission	J. Wells
Research Quality Evaluation Panel, Cork University, Ireland (2012)	J. Wells
Invited member of the Science Foundation Ireland Science Evaluation Board (2011)	J. Wells
Consultant Fronterra, New Zealand (2011)	J. Wells
Advisory Panel Danone Research, Paris (2011)	J. Wells
Peer-Review Panel, INRA Animal Health Division, France (2014)	J. Wells
Invited expert panel member of the European Science Foundation, "gene environment interactions", Barcelona, Spain (2010)	J. Wells
Habilitation Committee Member, Thomas Clavel (2013)	J. Wells
Committee pool NGI Horizon program	M. Smits
Evaluation committee NWO Enabling technologies	M. Smits
Scientific advisor Carnot Institute (France)	M. Smits
Scientific advisor Agreenskills (France)	M. Smits
Scientific advisor ICSA (France)	M. Smits

#### 4. Relevance to Society

##### Examples of societal relevance and impact for each of our main research lines

Our scientific achievements are already showing strong signs of having a considerable health and economic impact on society. Examples are given for each our two Research Areas as follows:

**1. Patenting, licencing and dialogue with stakeholders in the field of "Host-Microbiota interactions and therapeutic microbes".** We have recently shown that a specific strain of the colonic anaerobe *Faecalibacterium prausnitzii* can protect against colitis in the DNBS mouse model of chronic relapsing inflammatory bowel disease (IBD) and identified a contributing antiinflammatory factor with considerable promise as a treatment for IBD, a chronic life long condition, which severely affects the quality of life for around 2.5 million Europeans. We filed a **patent** on the therapeutic strain and immunomodulatory factor and a **second patent filing** on a different anti-inflammatory colonic anaerobe with therapeutic potential. The patents and strains were recently licensed to the leading global ingredients supplier to the food and feed industry. We have received funding as part of a large international R&D project <http://www.chr-hansen.com/news-media/singlenews/chr-hansen-accelerates-efforts-within-human-microbiome.html>. The first royalties are anticipated in 3 years.

Our achievements in the domain of mechanisms of probiotic interaction in the human gut (publications in PNAS 2009 and 2011) attracted a lot of attention from the national and international press, including more than 50 news publications related to this work (only some were included in Table 4.1.1), and 3 national news-radio interviews. As a consequence we have recently initiated an industrially funded project with one of the fast-growing probiotic producing companies in Europe (PROBI AB, Lund, Sweden). This collaboration intends to harness our previous work and establish a science based probiotic product backed-up with a scientific dossier that will be approved by EFSA and other international legislation bodies.

The examples described above have led to many demonstrable outputs listed in the Tables below and are a clear illustration of the recognition of the societal relevance of the scientific work performed by the HMI group.

**2. Patenting, licencing and dissemination to stakeholders in the field of "Combating Antimicrobial Resistance and zoonotic infections".** Food security and sustainability in food production is one of the global challenges for the coming decades. There is already widespread clinical resistance to some first-line choices of antimicrobials in veterinary medicine causing considerable productivity and financial losses in the industry. We participate in 2 large European Training Consortia seeking solutions to these problems ([www.stas-itn.eu/](http://www.stas-itn.eu/) and [www.train-asap.eu/](http://www.train-asap.eu/)); the later coordinated by the Chair of HMI). Within the STARS project one tangible impact has been the **discovery of inhibitors of bacterial two-component systems** (bactericidal at low  $\mu\text{M}$  concentrations) through *in silico* virtual screening (with InhibOx Ltd, Oxford, UK) of target crystal structures (with Institute of Biomedicine in Valencia). **A patent has been filed on the novel inhibitors under a co-ownership agreement.** We are currently progressing with the "hit-to lead" development of these drugs through an award of a prestigious European Individual Fellowship to Nadya Velikova. Future cooperation and exploitation is under discussion with a global pharmaceutical. Additionally, we have discovered non-pathogenic organisms from the porcine nasopharyngeal cavity and small intestine that produce **non-ribosomal synthesized novel antibiotic compounds** inhibiting *Streptococcus suis* (**patent filing in progress**), which is an exciting development with broader application potential. We are currently testing the efficacy of microbial antagonism on *S. suis* colonization of young pigs with industry partners. Our research projects in this domain are now embedded in the **newly formed Dutch National Centre for One Health** and the section on Future Antimicrobial Strategies. This national centre can enhance and facilitate the future impact of our work through government funding and by bringing us into contact with groups with complementary expertise.

The EU projects involve training of 23 PhD students and engage in a range of dissemination measures targeted to specific societal groups. One example is that HMI has prepared two movies about the development of novel antimicrobials (above) (<http://www.stars-itn.eu/everyone/1271/7/0/32> and <http://www.stars-itn.eu/everyone/1273/7/0/32>) and these are disseminated through multiple websites.

**Targets for next 5 years:** we aim to exploit our filed patents through licencing agreements and explore potential for further IPR. We anticipate the therapeutic microbes and microbial consortia mentioned in the example above to have gone through safety studies and evaluation in humans. Intervention studies to prevent or reduce risk of *S. suis* infections in pigs will have been performed. We anticipate partnering with pharmaceutical partner(s) for licensing of IPR for the "hit-to-lead" development of novel antimicrobials and the further development of novel antibiotics produced by commensal bacteria.

#### 4.1 Demonstrable products - Research products for societal target groups (excluding submission of microarray datasets to public databases)

Table 4.1.1. Overview of output for societal target groups by year.

	Year						Total
	2009	2010	2011	2012	2013	2014	
Professional publications and output	16	1	1	4	2	5	29
Publications for the general public	8	1	1	3	1	1	15
Other research output	1	4	1	8	7	9	30

Table 4.1.2. Examples of output for societal target groups by HMI.

Year	Output
<b>I. Professional publications or products</b>	
<b>-Refereed Book Chapters</b>	
	In total 5 peer-reviewed contributions to book chapters were published in the period of review for example, a recent contribution to the 4th Edition of Mucosal Immunology i.e. Chapter 8 "Gnotobiology and study of complex interactions between the intestinal, microbiota, probiotics. Mucosal Immunology is the only comprehensive reference covering the basic science and clinical manifestations of mucosal immunology. It is the most comprehensive text on mucosal immunology from internationally recognized experts in the field."
<b>-Contributions to professional journals</b>	
	In total 29 contributions to professional publications were written in the period of the review to general practitioners and pharmacists, scientists in the feed and food industry, laboratory and process chemists, nutritionists, veterinary doctors and health-care professionals.
	A few examples to different target groups are listed below (titles translated from Dutch when required):
	Verschenen in De Molenaar Oktober (feed industry), 2013: Empowerment through improving feed."
	Agrarisch Dagblad (agricultural science), February 6, 2009: "Probiotics increase resistance."
	Elsevier, voedingsmiddelen industrie (food industry), February 13, 2009: "TIFN proves how probiotics activate immune system."
	Arts en Apotheker.nl (doctors and pharmacists), February 4, 2009: "Clear effect of probiotics in the intestines of healthy humans."
	News-medical.net (medical professionals), 2012: "FibeBiotics aims to prove benefits of polysaccharides in clinical trials."
	C2W, February 10, 2009: "Probiotics do something."
	Nutritionhorizon.com, February 16, 2009: "Clear effect of probiotics demonstrated in gut of healthy adults."
	21food.com: February 13, 2009: "probiotic bacteria's immune enhancing mechanism reported."
	Veearts (veterinary doctors): April 2014: "Starch makes <i>Streptococcus suis</i> killers!"
<b>- Organization of Scientific Conferences</b>	
	Scientific Committee: International Symposium on Animal Genomics for Animal Health, June 2010 (M. Smits)
	Scientific Committee: Genomics for Animal Health: Outlook for the Future, October 2009 (M. Smits)
	Chair Scientific Committee: Beneficial Microbes, Noordwijkerhout, NL, 2010 (J. Wells)
	Chair Scientific Committee: Beneficial Microbes, Den Haag, NL, 2014 (J. Wells)
	Scientific Organizer of Antimicrobial Drug Discovery Conference, Madrid Spain, 2012 (J. Wells)

Scientific Committee: Microbes for Health 1st edition, Paris, France, 2010 (M. Kleerebezem)  
 Scientific Committee: Lactic Acid Bacteria Conference, 10th edition, Egmond aan Zee, 2011 (M. Kleerebezem)  
 Scientific Committee: Lactic Acid Bacteria Conference, 11th edition, Egmond aan Zee, 2014 (M. Kleerebezem)

#### - **Electronic newsletters to industry**

Ten electronic newsletters relating to the work in European projects coordinated by or involving HMI were sent out to relevant companies and made available on websites. This includes EC funded projects TRAIN-ASAP, STARS, Fibrebiotics and Crosstalk (see websites below).

## **II. Publications for the general public**

### - **Public pages of websites for projects coordinated by or involving HMI**

<http://www.wageningenur.nl/nl/Onderzoek-Resultaten/Projecten/Feed4Foodure.htm>

<http://www.stars-itn.eu/everyone/1271/7/0/32>

<http://www.stars-itn.eu/everyone/1273/7/0/32>

<http://www.fibrebiotics.eu>

<http://www.cross-talk.eu>

### - **Newspaper articles**

Volkskrant (frontpage national paper): Friday February 6, 2009: "bacterial drink boost immune defence."

Volkskrant (science section of national paper): Saturday February 7, 2009: "bacterial drink puts body on code orange"

Het Parool Friday February 6, 2009: "bacterial drink really helps"

Volkskrant (science section), March 6, 2010: "In our bodies are more foreign genes than genes from ourselves."

NRC (science section), April 21, 2011: "There are only three types of gut flora."

### - **Radio interviews**

Radio 1: February 6, 2009: interview with Michiel Kleerebezem live on national radio 1, in "nieuwe wetenschap"

Radio 5: February 20, 2009: 20 minute interview with Michiel Kleerebezem live in "wat de wetenschap brengt"

### - **Social Media**

Staff and group members have linked in pages and some use twitter to share publications and scientific statements that are interesting to an audience with general interest in host-microbe interactions, microbiomes, -omics and antibiotics resistance; @pvbaarden has several hundred followers on twitter

### - **Movies**

Movies describing antimicrobial research projects coordinated by HMI for the layperson were made and posted on multiple organizational and personal web sites and some additionally on www.youtube.com For example see:

<http://www.stars-itn.eu/everyone/1271/7/0/32>

<http://www.stars-itn.eu/everyone/1273/7/0/32>

<http://www.fibrebiotics.eu/index.php/videos>

## **III. Other research outputs**

### - **Reports (for the sake of policy making)**

Report 800: Nutritional intervention in animals: benchmarking of strategies, monitoring biomarkers and immune competence (M. Smits, 2014)

<https://www.wageningenur.nl/en/Publication-details.htm?publicationId=publication-way-343738313730>

Commissioned Report 859: Impact on gut development of an early life oral antibiotic intervention in broilers (M. Smits) <http://www.wageningenur.nl/nl/Expertises-Dienstverlening/Onderzoeksinstituten/livestock-research/show.htm?publicationId=publication-way-343836363337>

Contribution to White Paper on antibiotics in farming (Policy document for Government) (M. Smits and J. Wells)

<http://www.government.nl/issues/antibiotic-resistance/documents-and-publications/leaflets/2014/02/28/reduced-and-responsible-use-of-antibiotics-in-food-producing-animals-in-the-netherlands.html>

J. Wells and M. Kleerebezem are appointed experts for the International Life Science Institute, (ILSI) Brussels and work on scientific panels to write publication reports for the industrial members of ILSI (3 reports in period of review).

#### **- Instruments, infrastructure**

HMI maintains a high content bioimager - BD Pathway™ 855 in its own laboratories and provides access and training to researchers from universities, research institutes and companies. The equipment was funded by the by CAT-AgroFood to provide researchers access to advanced research equipment. This high throughput high-content cell analyser combines superior image quality, flexible image capture, and live-cell analysis. It provides fluorescence intensity measurements, kinetic imaging, and morphological analysis, including subcellular imaging.

#### **- Datasets, software tools, or designs developed**

Peter van Baarlen contributed to the testing and refinement of a transcriptomics database and analysis pipeline, MADMAX (Lin K, Kools H, Muller MR, Leunissen JA: MADMAX - Management and analysis database for multiple omics experiments; J Integr Bioinform 8(2):160 (2011)), that was developed at Human Nutrition, WU. This database has been operational and in use by researchers internal and external to Wageningen University since 2007 and is still being used heavily for transcriptome data storage, rigorous quality control and statistics.

10 microarray datasets (data from around 600 individual microarrays) have been deposited in public databases ArrayExpress and NCBI as well as MADMAX.

2 protein structures have been deposited in NCBI

#### **- Projects in cooperation with societal groups (European Union, governments, international funds)**

In the period of the review HMI staff have participated in 5 European funded projects: Initial Training Network (ITN) "Cross-Talk" ITN "TRAIN-ASAP", ITN "STARS" coordinated by HMI (J. Wells), ITN Cross-Talk. R&D project "Fibrebiotics"

#### **- Outreach activities for a general audience (lectures, exhibitions)**

6 Lectures to the general public e.g. "Nederlandse Vereniging van Dietisten", the "Dutch association of physicians, region Overijssel and the "Dutch Dairy Association" public exposure day.

#### **- Activities with respect to primary and secondary education**

Talk and demonstration of bacteria used in the dairy industry for making cheese and yoghurt at a secondary school (Dr Ellen Kranenbarg, HMI).

## **4.2 Demonstrable use of products - Use of research products by societal groups**

*Table 4.2. Examples of use of research products by societal target groups of HMI.*

### **Contract research (including consultancies)**

The group performs contract research for Friesland-Campina, Nestle, Chr Hansen and as a sub-contractor for NIZO. J. Wells and M. Kleerebezem are appointed experts for the International Life Science Institute, (ILSI) Brussels and work on scientific panels to write publication reports for the industrial members of ILSI (3 reports in period of review).

M.K has provided regular paid consultancy to Danone since 2013 and J.W has provided paid *ad hoc* consultancy to Yakult and Fronterra and Danone.

### **Overview first jobs/present jobs of alumni (domains)**

All PhD students were employed in research positions related to host-microbe interactions or antimicrobial research at the time of graduation, except one who took maternity leave before resuming her career. One PhD student was awarded a Marie Curie individual Fellowship.

### Participation in training courses

Dr Peter van Baarlen co-organizes and participates in a PhD-level course on Advanced Visualization of -Omics Data supported by the graduate school VLAG (WU) and an afternoon training session on network biology at the PhD course "Gene expression data analysis using R: How to make sense out of your RNA-Seq/microarray data", taught at the Erasmus University Medical Centre, Rotterdam, and organized by the graduate school Molecular Medicine (Erasmus U). In these courses, and at HMI transcriptomics work group meetings, PhD students are coached to work with their transcriptome data and display results such that researchers from different disciplines can intuitively interpret the gist of large datasets and get the "take-home" messages. The combination of group discussions, network biology and creative visualizations makes both the group work and courses very attractive for researchers at PhD and post-graduate levels.

JW, MK and PvB contribute to 2 VLAG graduate courses. In EU Training Network STARS J. Wells (coordinator) organized 4 training workshops for graduate students on complementary skills and specific research topics; these were open to outside participants. In addition M. Kleerebezem and J. Wells contributed to Cross-Talk training courses and J. Wells to TRAIN-ASAP and STARS training courses.

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### 4.3 Demonstrable marks of recognition - Marks of recognition by societal groups

*Table 4.3. Examples of marks of recognition by societal target groups of HMI.*

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#### Valorization/Technology Transfer funding

5 patents were filed in this period with HMI members as named inventors. WU-HMI is co-owner of 3 of the 5 patents, one of which was licensed in 2014 to a major company (see above). Licensing of a second patent is current under discussion to an animal health care company.

Ruud Albers (Guest Scientist) and J. Wells were selected to participate in the Dutch Venture Challenge Competition in 2014.

#### Positions paid by societal groups

Dr Annick Mercenier is seconded from Nestec to work at HMI for 1 day per week (2012- to date)

#### Prizes

Poster prizes, travel awards and 1 young scientist award have been given to several PhD students by conference organizers (e.g. *Lancefield International Symposium on Streptococci and Streptococcal disease*, *Seeon Conference on Microbiota, Probiotics and Host*), Scientific Societies (e.g. *DGHM - The German Society for Hygiene and Microbiology*) and the WIAS Graduate School (WIAS).

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## 5. Viability

### 5.1 Benchmark

We requested to be benchmarked against (i) the well-renowned European group of Nutrition and Immunology; at the Technical University of Munich Headed by Prof. Dr. rer. nat. Dirk Haller, (ii) Utrecht University, Veterinary Medicine, Department of Infectious Diseases and Immunology - Molecular Host Defence Group Headed by Prof. Henk Haagsman and (iii) The therapeutic microbiology group of Prof. Robert Brittan at Michigan State University USA (Table 1). These groups we considered to be very good to excellent on the basis of their visibility and reputation of the staff in our fields/networks and publications in high impact journals. The data was generated independently using SciVal. The publications of Michiel Kleerebezem were omitted from the analysis unless they included co-authors of HMI staff members because it was not possible to include only the period he was employed in the group.

Table 5.1.1. Research groups for benchmarking.

Group	Research Domains	Staff and group size *
Nutrition and Immunology at the Technical University of Munich. Head: prof. Dirk Haller	1. Microbiome and gut health 2. Inflammation and immune function 3. Bioactivity of food and microbes	32 group members: comprising group Head, 2 staff members, 14 PhD students, 7 post docs and 8 technicians
Utrecht University Veterinary Medicine, Department of Infectious Diseases and. Head: Prof. Henk Haagsman	Molecular Host Defence Group with a focus on intestinal health and zoonotic/animal pathogens	10 group members: comprising Group Head, 2 staff members. 1 post doc, 5 PhD students and 2 technicians
Michigan State University, Microbiology and Molecular genetics, therapeutic microbiology laboratory. Head: Robert Britten	1. Microbiome and gut health 2. Inflammation and immune function	12 group members: comprising Group Head, 2 staff members, 4 Research Associates and 6 PhD students and several undergraduate students
Host Microbe Interactomics Group, Animal Science Department, Wageningen University	1. The role of intestinal bacteria in health and disease	16 group members: comprising Group Head, 2 staff members #, 2 post-docs, 9 PhD students, 3 technicians

# MK not included except as co-author because it was not possible to include only the period he was employed in the group.

Table 5.1.2. Benchmarking: output

Year	Number of Publications (N)				Citations per Publication (CPP)				Field Weighted Citation Impact (RI)			
	HMI	Mi	Mu	Utr	HMI	Mi	Mu	Utr	HMI	Mi	Mu	Utr
2008	10	2	1	3	35	141	33	40	1.6	2.2	2.2	2.2
2009	5	1	3	5	36	39	26	14	1.5	1.3	2.2	1.0
2010	12	1	5	3	104	27	21	13	5.0	2.2	1.3	0.9
2011	17	3	2	4	20	10	36	12	2.1	1.1	3.9	1.2
2012	22	0	5	2	14	-	13	5	2.0	-	1.4	1.5
2013	30	1	4	2	18	8	2	5	6.7	2.2	0.5	1.2
<b>All</b>	<b>96</b>	<b>8</b>	<b>20</b>	<b>19</b>	<b>32</b>	<b>48</b>	<b>18</b>	<b>16</b>	<b>3.8</b>	<b>1.7</b>	<b>1.6</b>	<b>1.3</b>

HMI = Host-Microbe Interactomics, WU

Mi = Michigan State University USA

MU = Technical University of Munich, Germany

Utr = Utrecht University, The Netherlands

**HMI has an excellent average relative impact score (3.8)** for the publications analysed in SciVal and its associated database. Publications have increased to around 30 to 50 per year since 2010 although this is not evident here because the publications of MK that do not include other HMI members were omitted because it was not possible to include only the period he was employed in the group. For all groups the relative impact varies a lot from year to year. The US group has small number of highly cited papers one in 2008 which increases their average citation rate. The comparator groups are well above world average (av. = 1.0) in some years and regularly publishing in high impact journals (IF>9) but the average performance of HMI is higher in terms of numbers of publications and average impact despite being a starting group in 2008.

## 5.2 SWOT-analysis

HMI is a very viable and vital group, with senior faculty who all have a high reputation in their specific fields of research and who are highly active in national and international networks (Table 3.3). Our research domains are high on the agenda of Wageningen University<sup>3</sup>, the Dutch government<sup>4</sup>, One Health Initiative<sup>5</sup> international organisations (e.g. EU<sup>6</sup>, WHO) and the private sector (both profit and not-for-profit). We have demonstrated our ability to increase PhD students, staff and funding in a controlled manner while maintaining excellent scientific output and impact compared to international standards. HMI will take on 5 new funded positions in 2015 with potentially 5 more positions from recently submitted grants. HMI has a proven record in innovation and licencing, earning capacity, and consultancy. Together with the increasing numbers of PhD students (currently 10-12 per year) and >12 MSc theses annually, we have a strong financial outlook and significant pool of talented young individuals to recruit future PhD students and post-doc researchers. We identified excellent opportunities for strengthening our financial position and key alliances with other international centres/groups to counteract relatively minor threats and weaknesses identified in the SWOT analysis.

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>• Complementarity of staff expertise (<u>mini CVs</u>)</li> <li>• Multidisciplinary staff and team (bioinformatics, 'omics, immunology, molecular microbiology, infection biology)</li> <li>• Excellent scientific output and impact (<u>Table 3.2.1</u>)</li> <li>• Performance very strong compared to other internationally renowned groups in our field (<u>Table 5.1.2</u>)</li> <li>• Good relationships with industry (secondments, research contracts and consultancy) (<u>section 4</u>)</li> <li>• Excellent visibility: many measures of esteem and recognition for staff members (<u>Table 3.3</u>) (evaluation/advisory panels, conference organization, keynote &amp; plenary lecture)</li> <li>• Research domain growing in importance and increasingly recognized (<u>publication trends in PubMed</u>)</li> <li>• Innovative and entrepreneurial team (<u>5 patents filed one licensed with good potential for revenues</u>)</li> <li>• Collaborators are world leaders in our field (e.g. INRA, Univ. Cambridge)</li> <li>• Founding group of the National One Health Centre -subgroup on antimicrobial resistance</li> </ul>	<ul style="list-style-type: none"> <li>• High costs of overhead and infrastructure at WU (compared with international level)</li> <li>• Few funding opportunities to purchase or replace advanced equipment</li> </ul>

<sup>3</sup> Wageningen University (2010), Strategic plan 2011-2014, Wageningen WUR. The university had three strategic areas: Food and food production; Environment and natural resources; Lifestyle, livelihood and health. Our research contributes strongly to two of these areas.

<sup>4</sup> <http://www.nwo.nl/en/about-nwo/media/publications/nwo/strategy-memorandum-2015-2018.html>

<sup>5</sup> <http://www.onehealthinitiative.com/index.php>

<sup>6</sup> <https://ec.europa.eu/programmes/horizon2020/>

Opportunities	Threats
<ul style="list-style-type: none"> <li>• Strengthen mutually beneficial alliances with University of Cambridge UK, Copenhagen University, DK and INRA, France with joint research to strengthen position in European and international calls for funding (e.g. Horizon2020 and JPI) and share costly infrastructure</li> <li>• Appoint new tenure track in 2015 or early 2016</li> <li>• Strategic funding from Government through the National One Health Centre.</li> <li>• Staff will apply for ERC grants and post-docs for career advancement grants such as Veni Vidi and ERC starter grants strengthening our financial position and potential for growth</li> </ul>	<ul style="list-style-type: none"> <li>• Uncertain long-term future for small animal research facilities at WU</li> <li>• Increasing gap between funding provisions and full economic costs (applies to both national and international funding bodies)</li> <li>• Increasing move toward funding of large thematic programs comprising mostly of applied research</li> </ul>

### 5.3 Future strategy

The Dutch Government has aligned its future funding strategy for innovation and technology to the global challenges embodied in the European Horizon2020 programme; these themes are also globally recognized as strategically important areas for science and innovation. Our research strategy is well aligned to 2 of the 7 main challenges concerning health, prevention and treatment of diseases, in humans and animals. Our research impacts on strategies for combating infectious endemic and zoonotic diseases that reduces the health and welfare of animals farmed for food production in the NL and elsewhere and is thus important in an economic and food security context. Our other priority area is host-commensal interactions underpinning homeostasis and health. To date most research has been performed in mice or humans and there is considerable potential to apply this knowledge to production animals (and pets) with the aim of maintaining health and reducing the need for veterinary/medical intervention. This domain includes our research on probiotics and exploiting the microbiome, which is conducted in collaboration with food and feed industries.

Moreover our own strategy fits perfectly with the global "One Health" initiative that aims to unite research in veterinary and medical fields; this is one of the main focuses of the Strategic Plan of Wageningen University. Furthermore we are a one of the founding Chair groups of the National Centre for One Health. The strategic fit of our research domains with the national, international and global initiatives mentioned above provide excellent funding opportunities for our group.

To strengthen our position in the field of microbiota and health we have developed mutually beneficial collaborations with strong academic groups and strategic alliances with two major food companies (0.1 FTE secondment of Dr Annick Mercenier from Nestec Research Centre to HMI 2012 to date) and a major (programme of sponsored research on "exploiting the microbiome" with Chr Hansen (2014 to 2018)). In addition, we recently initiated a PhD project that is fully funded by industry with the Swedish probiotic company PROBI AB. In the animal food production sector we have established new collaborations with industry ToPigs, Elanco, DenkaVet through applications to national grant calls and sponsored research. The goal is to perform research that will inform development of industry strategies or government policies that will lead to the prevention and control of animal diseases. Additionally we work closely with the Central Veterinary Institute (CVI) and other animal testing facilities at Scotthorst Feed Research.

The domains in which we work are broad in scope, so we will continue to ensure our research expertise is embedded in a team with sufficient critical mass and focus. We aim to increase the number of post-doc researchers to share the supervision of projects and PhD students. Expansion of the group has been controlled but now we have regular education income for PhD graduations and have increased FTE of staff in 2014, we aim to appoint another early stage tenure track staff member in 2015 or 2016. This will mean in 2016 we will have two full time Professors, one part-time (0.2FTE) endowed Professor (MS), an Associate Professor (PvB) and new tenure track appointment at level of Assistant Professor (new 1 FTE). This is our first step toward succession planning in 10 years from now.

In 2015, 5 new research grants (5 FTE) will start including 2 from research grants obtained in national scientific competition i.e. grants from NWO or ZonMv). We are awaiting the outcome of 7 others as follows: NWO (1), Horizon2020 ITN Program (2), Industry funded investigator grant (1), JPI HDHL Microbiomics (3). In conclusion HMI is a viable and vital Chair group and further expansion of the group is foreseen.

## **6. Research Integrity**

HMI is dedicated to the highest standards of research integrity. It expects all staff and students, and those who are not members of the University but who are conducting research in our University facilities as a guest, to observe the highest standards in the conduct of their research as outlined in the section on Research Integrity in the WIAS Self-Evaluation Report. Failure to comply with the WU Integrity code and the guidelines above may give rise to an allegation of Misconduct in Research. Misconduct in Research may be a ground for disciplinary action, and if serious, for dismissal

The Group has developed its practices in data management in line with recommendations from the WIAS Graduate School (see WIAS policy statement)

We ensure data is:

- Identifiable (printed data directory of hard drive folders), retrievable, and available when needed;
- Secure and safe (archived data storage devices in fire safe); MADMAX and public repositories for omics data
- Kept in a manner that is compliant with legal obligations and, where applicable, the requirements of funding bodies and project-specific protocols approved Committees for Medical-Ethical Conduct of Research Involving Human Participants and Personal Data.

**Appendix 1** - Research staff Host-Microbe Interactomics group

Table 1 - Research staff input at Chair Group level

<b>Name staff</b>		<b>Funding 1, 2, 3*</b>	<b>2009 FTE**</b>	<b>2010 FTE</b>	<b>2011 FTE</b>	<b>2012 FTE</b>	<b>2013 FTE</b>	<b>2014 FTE</b>
<i>Full professors</i>								
Prof. Dr. J.M. Wells (1 fte)	Tenured	1	0.4	0.4	0.4	0.4	0.4	0.4
<i>Special chairs</i>								
Prof. M. Kleerebezem (0.6 fte)	01-09-2011/	1			0.1	0.1	0.1	0.1
Prof. M.A. Smits (0.2 fte)	01-11-2011/	3			0.02	0.1	0.1	0.1
<i>Assistant professors</i>								
Dr. ir. P. van Baarlen (1 fte)	Tenured / 01-01-2014	1		0.3	0.3	0.3	0.3	0.3
<i>Post-docs</i>								
Dr. ir. P. van Baarlen (1 fte)	1-7-2008/01-12-2010	3	0.9					
Dr. J. Karczewski (0.8 fte)	1-4-2008/1-10-2013	3	0.9	0.9	0.9	0.9	0.75	
Dr. S. Fuentes Enriquez de Salamanca (1 fte)	1-9-2007/1-1-2010	3	0.9	0.1				
Dr M. Meijerink (1 fte)	1-11-2011/1-1-2016	3			0.1	0.9	0.9	0.9
Dr L. Loonen	1-4-2012/1-4-2016	1				0.67	0.9	0.9
<b>Total scientific staff</b>			<b>3.10</b>	<b>1.70</b>	<b>1.82</b>	<b>3.37</b>	<b>3.45</b>	<b>2.70</b>
<i>Support staff</i>								
N. Taverne	1-1-2009	1	0.8	0.8	0.8	0.8	0.8	0.8
A. Thiele	1-1-2012	3				0.8	0.8	0.8
E. Kranenbarg	1-11-2010	2		0.8	0.8	0.8	0.8	0.8
<b>Total staff</b>			<b>3.90</b>	<b>3.30</b>	<b>3.42</b>	<b>5.77</b>	<b>5.85</b>	<b>5.10</b>

\* Funding scores: 1= direct funding by University; 2= funding obtained in national scientific competition (e.g. grants from NWO, KNAW) ; and 3= funding obtained from external organisations, such as industry, governmental ministries, European Commission and charity organisations.

\*\* FTE reported in this table regards the research appointment part of the total appointment (e.g. tenured staff has 40% available for research, postdocs have 60% available for research).

**Appendix 2** - Scientist for benchmark Host-Microbe Interactomics group**Table II.** *Scientist selected at Michigan State University (Michigan), University of Munich (Munich), and Utrecht University (Utrecht) for benchmarking HMI.*

<b>HMI</b>	<b>Michigan</b>	<b>Munich</b>	<b>Utrecht</b>
Wells, J.M	Auchtung, J.M.	Clavel, T.	Coorens, M.
Van Baarlen, P Smits, M.A.	Schaefer, L.K.	Hörmannsperger, G.	Veldhuizen, E.J.A.



## Human and Animal Physiology (HAP)

**Programme leader(s):** Prof.dr.ir. Jaap Keijer (2008 - present)

*For a full staff survey see appendix 1.*

### 1. Objectives and Research Area

#### 1.1 Vision, Mission and Objectives

##### *Vision*

Inadequate metabolic capacity and flexibility, with a central role for mitochondrial functioning, characterizes impaired metabolic health. This poses an increasing burden on society. Foods may help to relieve this burden. To do this it is necessary to know the mechanisms underlying metabolic capacity and flexibility and how metabolic capacity and flexibility is best targeted by nutrition. We address this through quality research and training in order to contribute essentially to sustainable long term strategies to improve human and animal health.

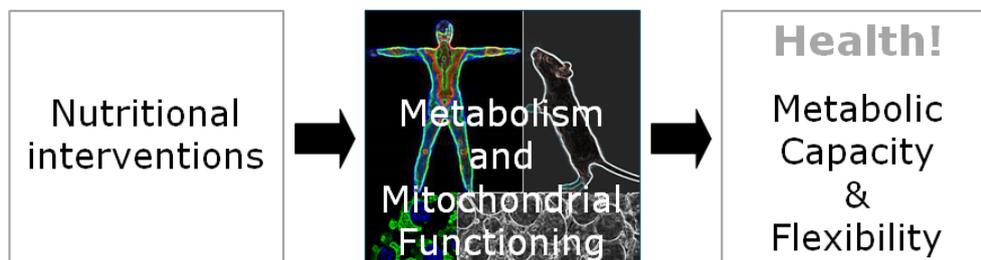
##### *Mission*

To improve metabolic health of humans and animals by molecular physiological research and academic training in nutritional targeting of metabolic capacity and flexibility.

##### *Objectives*

To be an internationally recognized and competitive research group in:

- Elucidation of mechanisms that underlie impaired metabolic capacity and flexibility, the role of mitochondria therein, and its functional consequences.
- Substantiation of the efficacy of foods to improve metabolic capacity and flexibility.
- Providing stimulating academic teaching and training in human and animal physiology to fulfil the demand for well-trained (molecular) nutritional physiologists.



#### 1.2 Research Area / research line(s)

##### *Expertise*

HAP has extensive expertise in performing controlled dietary intervention studies and in the integrated metabolic, functional genomic and immunohistochemical analysis of such studies. We perform detailed mechanistic studies in (model) animals and efficacy studies in humans. Cell studies are used for mechanistic support. We focus on diets and functional food-components that affect mitochondrial functions, substrate metabolism and energy metabolism. Recent expertise includes non-invasive, indirect calorimetry-based challenge tests for metabolic flexibility, substantiating our research theme.

##### *Research area*

Our research aims for nutritional improvement of diet-related (e.g. obesity, diabetes, negative energy balance) and age-related (e.g. fatigue, Alzheimer's disease) metabolic health problems. We do this in one central research theme: **Improvement of health by nutritional targeting of metabolic capacity and flexibility**. This positions us in the domains of health improvement and food functionality. Our mitochondria-centred approach and emphasis on white adipose tissue, muscle and other metabolic organs underlines our focus on metabolic health. By examining reproduction organs from the perspective of metabolism, we have integrated this topic in our research theme, allowing us to capitalize on our unique reproduction expertise.

*Research lines*

Mitochondrial functioning emphasis:

*dr.* Dorien van Dartel (mitochondrial capacity),

*dr.* Jessica Hegeman (redox balance);

Substrate and energy metabolism emphasis:

*dr.* Arie Nieuwenhuizen (functional responses in humans),

*dr.ir.* Evert van Schothorst (molecular responses);

Metabolism and reproduction emphasis:

*dr.* Katja Teerds (reproductive organ function).

Note: See appendix 2 for staff changes early 2015.

**1.3 Strategy***General research strategy*

Key to our strategy is to focus our efforts on our research theme. Our nutrition and mitochondria centred approach, our infrastructure and inherent research quality, as well as our expertise and ability to directly translate from rodents to humans, provide us with a strong integrated package to do so. To maximize critical mass, we will continue to work as a group and to collaborate internationally. To maintain a technological edge, we will invest in our molecular physiological capabilities and cement alliances with key (inter)national partners for reciprocal use of methodology. Together, this will facilitate sustainable growth in terms of competitiveness and impact.

*Achievements*

When the current chair was appointed in 2008, the position of HAP was meagre (see 1.5). Since then, we employed new staff, defined one central research theme and now we operate as one collaborative research group. We have continued to invest in existing capabilities (e.g. functional genomics) to remain state-of-the-art and we have newly invested in indirect calorimetry, first for rodents, now for humans. The number of PhD students has increased from 1 in 2008 to 8 in 2014. Our publications, co-funding<sup>[1]</sup> and full-funding<sup>[2]</sup> by industry are evidence for increased visibility. In addition, we have established a transparent, well organized teaching infrastructure, with relevant courses and capable teachers, evidenced by the external international peer review of our education (2013) and our high student evaluations.

*Adjustments*

Metabolic capacity and flexibility was chosen as our focus on health. Our successful research line on beta-carotene and lung cancer was discontinued, because it diluted our efforts away from our research theme. For the same reason, we have decided to study only those food components that are directly relevant to our research theme.

*Future outlook*

Increases in obesity and aging and the growing recognition that nutrition is important for health underscores that we have chosen a sustainable theme in which we have a solid and growing position and a distinct profile that allows us to contribute relevantly.

[1] e.g. STW (programming), AgNL (sugar), PIDON (hypoxia and obesity), UCF (carnitine), Oost-NL (challenge test model); [2] Danone, FrieslandCampina

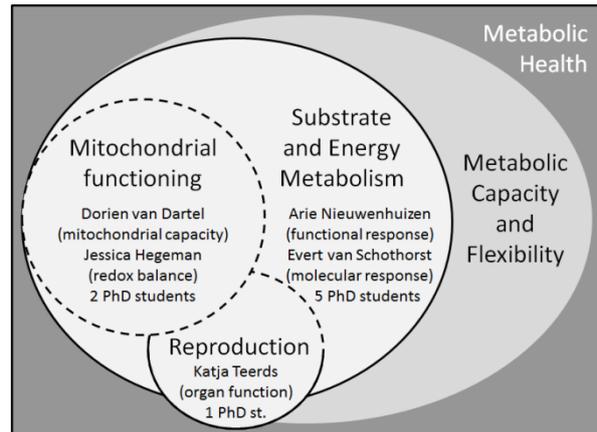
**1.4 Research environment and embedding***Graduate School*

HAP participates in the graduate schools WIAS (animal sciences) and VLAG (human nutrition and health) to optimally facilitate training of PhD students, depending on their research focus. With experimental emphasis on model animals, HAP is well embedded in the Animal Science Group (for details see 1.5).

*National and international position*

Our nutrition-and-health focus bases us ideally at Wageningen University, where 'healthy and safe food for healthy lives' is a priority area in the new strategic plan. As physiology group we have a central position, reflected by the strategic theme 'resilience', by joint research throughout WageningenUR and our broad teaching portfolio. We are nationally and internationally recognized in molecular nutritional

Research lines of Human and Animal Physiology (HAP)



physiology. Major network activities have contributed to this. We co-initiated NuGO, an EU-FP6 NoE (2003-2010) that continues to this date as an independent entity (22 partner institutes), and co-ordinated the EU-COST Action Mitofood (2007-2011) with 43 partners from 23 countries. We are invited management committee members of two ongoing COST Action networks (Zinc-Net and Positive). Our research network in molecular nutritional physiology is strengthened by several long term collaborations with excellent European groups and by international research projects (e.g. EU-FP7 Bioclaims, 2010-2015). We also have an extensive (inter)national network in male and female reproduction physiology, established through memberships in the boards of various relevant national and international societies (e.g. European and North American Testis Workshops, Royal Netherlands Zoological Society) and through projects (e.g. EU-FP7 Reproforce (2010-2012), Nuffic/CAPES (2012-2016)). Our extensive network(s) will allow us to maintain and strengthen our international funding for research and for training.

### 1.5 Reference to previous assessments

#### *Response to the 2009 peer review recommendations*

In 2008, when the current chair was appointed, the position of HAP was meagre (fragmented research, little organization, small size, no external funding). The 2009 committee was presented with a vision, that was well-received.

*'The new chair is commended for .... focusing on one central research theme.'*

We established and delineated a central research theme: 'Improvement of health by nutritional targeting of metabolic capacity and flexibility', with emphasis on the role of mitochondria.

*'Increase funding by increasing contacts with industry, particularly in the area of functional foods and the influence of bioactives on animal performance.'*

First, we have invested in building a solid scientific foundation. Our attempts directed at the animal production sector were not successful due to lack of track record and, in fact, have diluted our efforts. We have adapted our strategy early 2012 and have focussed our efforts on our strengths: experimental molecular nutritional physiological research in model organisms for health improvement, addressing human health, and for substantiation of food functionality. From the 2007/2008 position with no external funding, we now have projects partially and fully funded by industry. We have extended our research to humans and we are part of the Metabolic Health Unit with other WU chairgroups and the regional hospital.

*'Can this group be turned around?'*

Our initiatives to obtain funding have gained substance. We are well organized, have a strong education portfolio, are financially healthy, have increased the number of PhD students and have improved our scientific output, now aligned with our research focus. We are in a very good position.

#### *Response to 2012 midterm recommendations*

The midterm advisory committee praised HAP with the progress since 2009 and gave the following recommendations:

*'Find niche that is different from other groups working on mitochondrial functions.'*

Our focus on metabolic capacity and flexibility and on nutrition and the fact that we are specialists in functional genomics based analysis is what distinguishes us.

*'Build bridges to animal science groups.'*

We provide mechanistic expertise to production animal groups as evidenced by joint publications with ADP(2), ANU (1), HMI (1) and ABG (2). Together with ADP, ANU, APS and BHE, HAP forms the cluster Adaptive Animals and Systems, where we develop joint research initiatives on adaptation of animals to challenges in their environment. This has resulted in a recently awarded NWO/WIAS PhD project with ADP on pig reproduction, using our complementary expertise. The cluster members represent and help each other, share research facilities and are a sounding board to increase opportunities and effectiveness and to minimise risks. In addition, HAP has initiated a task-force 'energy metabolism', with ANU, AFI and ADP. We have joint courses with EZO, CBI, HMI and BHE. In addition to WIAS, we are well embedded in VLAG with teaching and research projects (with TOX (2), HNE/FBR and HNE/SB).

*'Obtain funds for graduate students and continue to increase research output.'*

The number of PhD students has substantially increased, which will contribute to research output and capacity.

*'Chair should be able to use financial reserve for investment.'*

We still agree.

## 2. Resources and Facilities

### *Personnel and funding trends*

We have substantially increased our effective critical mass (academic staff , technicians) and the number of PhD students (from 2 to 8). Our funding has diversified and our efforts towards industry start to pay off.

### *Future funding targets*

We focus on projects for PhD students and Post-docs and on projects for improvement of research capabilities. We aim at a mix of funding, in particular NWO (fundamental research), TIFN and STW (industry participation), EU (ERC, collaborative research, infrastructure and training and direct funding by industry).

### *Research facilities*

Since 2008, we have established our facilities that are state-of-the-art equipped for molecular biology (including functional genomics and associated bioinformatics), biochemistry and immunohistochemistry and for physiological assessment of substrate and energy metabolism in animals, humans, individual cells and mitochondria. We have particularly invested in non-invasive body composition analysis and in indirect calorimetry for rodents. Our 12 cage indirect calorimetry system, with automatic detection of food and drink intake and physical activity, is extended for oxygen restriction, a relatively unique feature. A recently acquired STW project will allow us to further extend this with <sup>13</sup>CO<sub>2</sub>, CH<sub>4</sub> and H<sub>2</sub> sensors. We have started to upgrade our human indirect calorimetry facilities.

### 2.1 Researchers

Table 2.1.1. Research input: number<sup>1</sup> and FTE<sup>2</sup> of Scientific staff, Post-docs and PhD candidates by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	#	FTE												
Scientific staff <sup>4,9</sup>	3	1.2	3	1.2	3	1.2	4	1.3	4	1.3	4	1.4	4	1.2
Post-docs <sup>5</sup>	1	0.2	0	0.0	2	0.6	2	0.6	3	0.8	2	0.7	2	0.5
PhD candidates <sup>3,6</sup>	3	1.1	4	3.0	4	3.0	7	3.4	8	4.1	6	3.8	5	3.1
<b>Total research staff</b>	<b>7</b>	<b>2.5</b>	<b>7</b>	<b>4.2</b>	<b>9</b>	<b>4.8</b>	<b>13</b>	<b>5.3</b>	<b>15</b>	<b>6.2</b>	<b>12</b>	<b>5.8</b>	<b>11</b>	<b>4.8</b>
Lab Technicians <sup>7</sup>	4	1.8	4	2.2	5	1.8	3	1.6	3	1.6	4	1.6	4	1.7
Visiting fellows <sup>8</sup>	8	2.3	4	0.5	8	1.2	4	0.1	6	2.2	8	1.8	6	1.4
<b>Total staff</b>	<b>19</b>	<b>6.6</b>	<b>15</b>	<b>6.8</b>	<b>22</b>	<b>7.8</b>	<b>20</b>	<b>7.0</b>	<b>24</b>	<b>9.9</b>	<b>24</b>	<b>9.2</b>	<b>21</b>	<b>7.9</b>

<sup>1</sup> Total number of staff and PhD candidates

<sup>2</sup> Available research time in full time equivalent (FTE)

<sup>3</sup> All PhD categories, except external PhDs

Standards for Research Capacity (in case of part time appointment adjustment is applied):

<sup>4</sup> Professor, Assistant Professor and Associated Professor: Research Capacity = 40% of the appointment

<sup>5</sup> Post-doc: Research Capacity = 90% of the appointment

<sup>6</sup> PhD candidate: Research Capacity = 75% of the appointment (all categories)

<sup>7</sup> Technicians: Research capacity = 55 % of the appointment

<sup>8</sup> Research and training

<sup>9</sup> Tenured research staff decreased from 1.3 in 2003 to 0.7 in 2007. There was no non-tenured staff in same period. Both categories increased with appointment of current chair.



*5 key publications (for future directions)*

[1] [van Schothorst EM](#), [Bunschoten A](#), Schrauwen P, Mensink RP, [Keijer J](#) (2009) Effects of a high fat, low versus high glycemic index diet: retardation of insulin resistance involves adipose tissue modulation. *FASEB J* 23:1092-1101. IF 5.4

❖ Basis for recent grant on nutritional programming by carbohydrates as functional ingredients.

[2] [Teerds KJ](#), de Rooij DG, [Keijer J](#) (2011) Functional Relationship between Obesity and Male Reproduction: from Humans to Animal Models. *Human Reproduction Update*, 17(5):667-683. IF8.7

❖ Shows our linking of reproduction with metabolic health.

[3] [Hoek-van den Hil EF](#), [van Schothorst EM](#), [van der Stelt J](#), [Swarts HJM](#), Venema D, Sailer, M, Vervoort JJM, Hollman PCH, Rietjens IMCM, [Keijer J](#) (2014). Quercetin decreases high-fat diet induced body weight gain and accumulation of hepatic and circulating lipids in mice. *Genes and Nutrition* 9:418. IF3.4

❖ Shows expertise in analysis of energy metabolism and molecular mechanisms to assess functional ingredients (bioactives) for metabolic health improvement.

[4] [Duivenvoorde LPM](#), [van Schothorst EM](#), [Swarts HJM](#), [Keijer J](#) (2015) Assessment of metabolic flexibility of old and adult mice using three non-invasive, indirect calorimetry-based treatments. *Journal of Gerontology Series A Biological Sciences*. 70:282-293. IF4.9

❖ Shows extended indirect calorimetry (OxR) assess metabolic flexibility.

[5] Ost M, Keipert S, [van Schothorst EM](#), Donner V, [van der Stelt J](#), Kipp AP, Petzke K-J, Jove M, Pamplona R, Portero-Otin M, [Keijer J](#), Klaus S (2014) Muscle mitohormesis promotes cellular survival via serine/glycine pathway flux. *FASEB J*, doi: 10.1096/fj.14-261503. IF5.4

❖ Shows expertise in functional genomic analysis of energy and substrate metabolism.

### 3.1 Demonstrable products - Research products for peers in science

Table 3.1. Categories of research output by year.

Category:	Year						Total	Average 2009-2014
	2009	2010	2011	2012	2013	2014		
<b>Academic publications</b>								
a. Refereed articles	18	12	10	6	13	17	76	13
b. Non-refereed articles	0	0	0	0	0	1	1	0
c. Books	0	0	0	0	0	0	0	0
d.1. Refereed book chapters	0	1	2	0	0	0	3	1
d.2. Non-refereed book chapters	0	0	0	0	0	0	0	0
e. PhD Theses	0	0	0	0	1	1	2	0
f. Conference papers	0	0	2	1	0	0	3	1
<b>Total academic publications</b>	<b>18</b>	<b>13</b>	<b>14</b>	<b>7</b>	<b>14</b>	<b>19</b>	<b>85</b>	<b>14</b>

### 3.2 Demonstrable use of products - Use of research products by peers

Table 3.2.1. Bibliometric indicators for HAP over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication	Bibliometric indicators						
	N*	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	11	238	209	21.6	1.16	18% (2)	0% (0)
2009	18	369	252	20.5	1.77	22% (4)	0% (0)
2010	11	104	138	9.5	0.84	0% (0)	0% (0)
2011	10	115	108	11.5	1.22	20% (2)	0% (0)
2012	6	39	36	6.5	1.13	17% (1)	0% (0)
2013	12	38	26	3.2	1.59	25% (3)	0% (0)
<b>all years</b>	<b>68</b>	<b>903</b>	<b>768</b>	<b>13.3</b>	<b>1.35</b>	<b>18% (12)</b>	<b>0% (0)</b>

\*N=16 in 2014; N=73 all years 2009-2014; N=47 all years 2003-2008 (from 2009 peer review report)

Table 3.2.2. Bibliometric indicators for HAP per research field over the period 2008-2013. The rows are ordered in descending number of publications (N). The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

research field	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Clinical Medicine	20	284	197	14.2	1.54	30% (6)	0% (0)
Agricultural Sciences	16	197	98	12.3	1.86	25% (4)	0% (0)
Biology & Biochemistry	11	140	145	12.7	1.01	0% (0)	0% (0)
Molecular Biology & Genetics	11	157	228	14.3	0.63	0% (0)	0% (0)
Pharmacology & Toxicology	4	82	33	20.5	2.13	50% (2)	0% (0)
Plant & Animal Science <sup>2</sup>	4	37	38	9.3	1.01	0% (0)	0% (0)
Chemistry	1	4	6	4.0	0.62	0% (0)	0% (0)
Neuroscience & Behavior <sup>2</sup>	1	2	23	2.0	0.09	0% (0)	0% (0)
<b>all fields</b>	<b>68</b>	<b>903</b>	<b>768</b>	<b>13.28</b>	<b>1.35</b>	<b>18% (12)</b>	<b>0% (0)</b>

<sup>2</sup>Discontinued research.

### Publication trends

#### Quantity

Our 2009-2014 research output increased with 55 % compared to the previous review period. Research initiated after 2008 took some time to generate output, hence the 'dip' in 2012. We are now on track and are confident that we can increase our publication record, as the number of PhD students is increasing and research lines are maturing. Importantly, our recent publications reflect our current research focus.

#### Citations

We are pleased that the large majority of publications are in Q1 (73% Q1, 94% in Q1+Q2), that most publications relevant to our current research focus have very good CCP, and that 18 % of our publications are top 10% most-cited. We are confident that our impact, which is well above average (especially in priority fields), will increase by maintaining our (mitochondrial) research focus and by maturation of our research lines, with special promise for implementation of new tools, for our research on humans and for reproduction from the perspective of metabolism.

#### Other research output

We have deposited 23 independent, high quality, large transcriptome datasets in the open access public database GEO/Array Express. These datasets have been used by others.

### 3.3 Demonstrable marks of recognition - Marks of recognition from peers

Table 3.3. Most important prizes, keynotes etc. of staff (max 6 per category). For remaining achievements see mini CVs (Separate file called mini CVs).

Science awards, Scholarly prizes, Research grants awarded to individuals		
Year	Person	Description
2009	EM van Schothorst, J Keijer	TIFN publication prize.
2012	DAM van Dartel	Elsevier Award best paper published in Reproductive Toxicology.
2012	DAM van Dartel	Joep van den Bercken award. Dutch Society of Toxicology.
2012	MA Hegeman	European Respiratory Society 3 month fellowship.
2014	AG Nieuwenhuizen	Shortlist teacher of the year (top 5); reflecting training.
2014-	KJ Teerds	Permanent visiting professor Bulgarian Academy of Sciences.
Plenary/Keynote Lectures at major conferences		
Year	Person	Conference
2009	J Keijer	4 <sup>th</sup> International Conference on Polyphenols and Health, UK.
2010	J Keijer	Cellular Radical Stress and Related Biomarkers Conference, GR.
2011	J Keijer	11 <sup>th</sup> European Nutrition Conference FENS, SP.
2011	K Teerds	36 <sup>th</sup> Annual Meeting of the American Society of Andrology, CAN.

2011	MA Hegeman	28 <sup>th</sup> Annual Congress of the European Society of Intensive Care Medicine, DE.
2014	J Keijer	Experimental Biology 2014, San Diego, USA (debate).

#### Organisation of International Scientific Conferences

Year	Person	Conference
2009	J Keijer	Mitofood Symposium, SP; Mitochondrial Physiology Symposium, PL.
2010	J Keijer	Dietary interventions for healthy aging, UK; Xenobiotics and Mitochondria Symposium, PT.
2011	J Keijer	International Conference: Bioactive food components, energy metabolism and health, NL.
2011	J Keijer	Nutritional Physiology Symposium; constraints of flexibility in protein and energy metabolism', NL.
2013	J Keijer	International Phenotypic Flexibility Conference, SP.
2011→	KJ Teerds	Member of the organizing committee of the North American Testis Workshop

#### Editorships and editorial boards

Person	Editorial board (year)
KJ Teerds	Biology of Reproduction (2003-2014).
KJ Teerds	Reproductive Biology and Endocrinology (2004-2012).
KJ Teerds	Journal of Andrology (2004-2013).
KJ. Teerds	Andrology (2013-present).
J Keijer	Genes and Nutrition (2005-present).

#### Relevant scientific board positions

Person	Membership (year)
KJ Teerds	Treasurer of the Royal Dutch Zoological Society (2008-2014).
KJ Teerds	Treasurer of the Dutch Endocrine Society (2001-2010).
KJ Teerds	Member of the Permanent Scientific Committee of the European Study Group for Molecular and Cellular Endocrinology of the Testis (2000-present).
J Keijer	Chair of the Centre for Human Nutrigenomics (2001-2010).
J Keijer	Chair of Cost Action FA 0602: Mitofood (2007-2011).
J Keijer, EM van Schothorst, MA Hegeman (substitute)	Management Committee Members of COST Actions TD1304: ZincNet (2013-present) and FA1403: Positive (2014-present): Positive.

#### 4. Relevance to Society

Impaired metabolic health poses an increasing burden on society; socially and economically<sup>[1]</sup>. While medication primarily focuses on symptom relief, nutrition and life style provide sustainable long term solutions to improve health. Development of such solutions is the core of our research and training, directly addressing a major societal issue. We do this i) by developing tools, concepts and research outcomes<sup>[example below and 2]</sup> that can be used in efficacy testing and health improvement, ii) by delivering well trained students<sup>[3]</sup>, iii) by developing advanced research capabilities open for joint research<sup>[4]</sup>.

##### *Example of relevance: Tools for assessment of health status*

To improve health by nutrition, tools are needed to quantify health status. Health status is usually determined in steady state conditions. We have proposed<sup>[5]</sup> that health status is better assessed under conditions that challenge homeostasis, addressing capacity and flexibility. This can be done invasively and non-invasively. We have non-invasively<sup>[6]</sup> assessed fasting-refeeding responses in indirect calorimetry to substantiate health beneficial effects of marine long chain n-3 PUFAs<sup>[7]</sup> and we have shown that challenge tests can discriminate in health status where static biomarkers could not<sup>[8]</sup>. Non-invasive tests can potentially also be applied to children, which motivated a food industry<sup>[9]</sup> to fully fund a PhD position to further develop this and other tests to assess ingredient functionality in humans, with the ultimate aim to also apply this in infants.

We have also developed an oxygen restriction (OxR) test. A unique nutrient-independent challenge test, that assesses the metabolic response to reduced oxygen availability and thus targets mitochondria. Healthy adult and old mice responded differently to the OxR test<sup>[10]</sup>, confirming the challenge test concept. OxR, applied after short term (5 day) feeding of different diets, showed diet dependent differences in response in various tissues and in serum, revealing it as a novel method to test food products on potential health beneficial effects<sup>[11]</sup>. We have promising results with OxR in humans and have interest from a large US company. Together, this shows that we develop relevant challenge tests to be used as scientific tools, but also as practical tools for assessment on individual health status in humans. As early adaptors (since 1998), we have become specialists in transcriptome analysis of dietary intervention studies<sup>[e.g. 12]</sup>. We use our expertise to develop transcriptome-based biomarkers to be used as practical tools. For example, we have selected and tested a metabolic biomarker profile for *in vitro* developmental toxicity testing<sup>[13]</sup>. Furthermore, we have shown that blood cells, which are accessible in humans, are a relevant target tissue to assess nutritional efficacy using transcriptome biomarkers<sup>[14]</sup>. We have now obtained funding to apply this in a nutritional intervention study in elderly.

#### *Future targets.*

We will continue with our training efforts and our development of advanced research capabilities open for joint research. For the coming 5-10 years, we particularly aim to contribute to:

- improved use of animals,
- functional assessments in both sexes,
- translation of data from model species to target species, and
- development of tools for end-users.

[1] Over 40 % of the Dutch population is overweight, of which 10 % is obese, predisposing to e.g. CVD, type II diabetes and hypertension; Individuals over 65 will increase from 16% to 25 % of the Dutch population in the coming 15 years

[2] We store datasets (study designs, transcriptome, physiological and biochemical data) in the NuGO/TNO nutritional phenotype database for international data integration (Kelder 2015 Genes Nutr 10:439 (IF3.4) ; Darous 2015 Genes Nutr, Accepted (IF3.4))

[3] Our students are in demand and readily find jobs in a variety of sectors; research (44 %), pharmaceutical and food industry (33 %), education (17%) and government (6%)

[4] We received 35 international guests from 11 countries, increasing their market value

[5] Ommen 2009 Mol Nutr Food Res 53:795 (IF 4.9)

[6] contributes to improved use of animals

[7] Horakova 2012 PlosOne 7:e43764 (IF3.5)

[8] Duivenvoorde 2015 PLoSOne, Accepted (IF3.5)

[9] FrieslandCampina

[10] Duivenvoorde 2015 J Gerontol A 70:282 (IF 5.0)

[11] Duivenvoorde 2014 Pflugers Arch 467:1179 (IF3.1)

[12] Keijer 2010 Mol Nutr Food Res. 54:240; van Helden 2010 Cell Molec Life Sci 67: 2039 (IF5.8). Hoek-van den Hil 2013 PLoS One e51588 (IF3.5)

[13] van Dartel 2014 Toxicology 324:76 (IF3.7)

[14] Díaz-Rúa 2015 J Nutr Biochem. 26:398 (IF4.6); Sánchez 2014 Genes Nutr 9:417 (IF3.4); Konieczna 2014 Genes Nutr 9:366 (IF3.4); Caimari 2010 OMICS 14:129 (IF-); Caimari 2010 J Nutr Biochem 21:1127 (IF4.6); Caimari 2010 Int J Obes 34:831 (IF 5.4); Pagmantidis 2008 Am J Clin Nutr. 87:181 (IF6.9)

#### **4.1 Demonstrable products - Research products for societal target groups**

*Table 4.1. Main categories of output for societal target groups.*

<b>Societal relevant output</b>	<b>year</b>	<b>Output</b>
<b>Selected professional publications</b>		
- JK, Senate Commission on Food Safety of the Deutsche Forschungsgemeinschaft Symposium, Kaiserslautern, DE.	2009	Lecture and publication
- JK, Chronic stress reversal therapists conference, Driebergen, NL.	2009	Lecture and reader

- KJT, Chronic stress reversal therapists conference, Driebergen, NL.	2010	Lecture and reader
- VVAMS, Nutrafoods.	2010	Publication
- JK, Biovitaal conference (neutraceutical), Ede, NL.	2012	Lecture and reader
- JK, Fresenius conference (lawyers), Mainz, DE.	2012	Lecture and reader
- JK, Innovision (Nutreco R&D), Scheveningen, NL.	2012	Lecture and reader
- MAH, Frontlines of Thoracic Surgery, INT.	2012	Book chapter

#### Selected publications for general public

- JK, Hoe, Zo! (national radio).	2009	Live interview
- KJT, TV Gelderland (regional television).	2010	Live interview
- EMvS, University Insights (features).	2012	Article
- JK, NRC Handelsblad (national newspaper) (research highlight).	2013	Article
- EMvS, <a href="http://www.smarthealth.nl/2014/03/27/healbe-gobe-fitness-bloedglucosewaarde/">http://www.smarthealth.nl/2014/03/27/healbe-gobe-fitness-bloedglucosewaarde/</a> (expert contribution).	2014	article
- KJT, Reformatorisch Dagblad (quality national newspaper).	2014	Article
- KJT, Volkskrant (quality national newspaper).	2014	Article
- KJT, Trouw (quality national newspaper).	2014	Article

#### Selected other research output

- Deposited 23 GEO /Array Express transcriptome datasets.	2009-2014	Dataset
- Coordination of Cost Action Mitofood (23 countries).	2007-2011	International network
- MC member of Cost Actions Zincnet and Positive.	2013-2018	International network
- EU-FP7 Bioclaims (2010-2015) (international research project).	2010-2015	Research project
- EFSD European Diabetes Foundation (international research project)	2010-2012	Research project
- EU-FP7 Reproforce (Bulgaria).	2010-2012	Research development
- Joint research projects with industry, including SME (8).	2009-2014	Research with industry
- Joint research projects for industry, including SME (4).	2012-2014	Research for industry

#### 4.2 Demonstrable use of products - Use of research products by societal groups

'My molecular physiology expertise proved essential to be able to advise the Ministry of Social Affairs and Employment on health risks of night work which concerns 1 million workers in the Netherlands.'  
*Dr. Wendy Rodenburg, Project Leader, National Institute of Public Health, a former PhD student.*

Table 4.2. Memberships of professional societies and use of products.

#### Memberships

Name	Year	Society
J Keijer	1985-present	Netherlands Society of Biochemistry and Molecular Biology.
J Keijer	2001-present	Netherlands Association of the Study of Obesity.
J Keijer	2003-present	Mitochondrial Physiology Society.
J Keijer	2004-present	Netherlands Academy of Nutrition.
EM van Schothorst	2002-present	Netherlands Association for the Study of Obesity.
EM van Schothorst	2014-present	European Association for the Study of Diabetes.
MA Hegeman	2010-2012	European Society of Intensive Care Medicine.
MA Hegeman	2010-2012	American Thoracic Society.
MA Hegeman	2010-2012	European Respiratory Society.
KJ Teerds	1990-present	Dutch Endocrine Society.
KJ Teerds	1993-present	Society for the Study of Reproduction.
KJ Teerds	2007-present	American Society of Andrology.
KJ Teerds	2008-2014	Royal Netherlands Zoological Society.
KJ Teerds	2008-present	American Physiological Society.

**Use of products**

*The societal use of products comes from our research (see narrative), but also reflects our strong position in education, our interest in training and our international focus.*

<b>Demonstrations</b>	Lectures, practicals and demonstrations at secondary schools, demonstrations during events (Museum Night, Open Days)
<b>PhD courses</b>	E.g. VLAG courses Energy Expenditure (organizer), Nutrigenomics (lecturer), Toxicology (lecturer); Annual international PhD summerschool in Molecular Nutrition (lecturer, 2012-present)
<b>Training</b>	Research training project with Brasil (CAPES/NUffic), proposal for an European joint doctorate in Molecular Nutritional and Physiology (Molnuph). 35 international guests (PhD students, Staff, Post-Docs) from a variety of countries (Spain, Brazil, Bulgaria, Poland, Czech Republic, Germany, France, Mongolia, Turkey) were hosted for training and joint research
<b>MSc training</b>	We have a solid reputation among students, which is also reflected by increasing numbers of MSc students (annual number completed 2009-2014: 14, 16, 14, 15, 14, 38, 29 (+ 26 started, not yet completed). The job perspective of our MSc students is excellent; All (100 %) of our 2009-2013 students that could be traced have a position. research (44 %), pharmaceutical and food industry (33 %), education (17%) and government (6%); We lecture in (inter)national Masters (e.g. Nutrigenomics and personal nutrition, Spain, 2008-2012)
<b>Infrastructure</b>	Our infrastructure is available for joint research and as such is being used by third parties. We are a beta test-site for physiology Apps (Samsung)
<b>Research collaboration</b>	We actively collaborate (inter)nationally (85 % of our publications are with multiple groups, the majority international), evidenced by our research projects and our participation in Network projects (NuGO, COST Actions) and research development project (ReproForce)
<b>Science support</b>	We are active (nationally and internationally) as reviewers of grants, research proposals and research programs and participate in international Appointment Advisory committees and Thesis Evaluation committees (all staff members)

'The MSc students rated HAP's teachers to be even more dedicated than teachers from other chair groups. They have a high appraisal of the open and friendly atmosphere in the chair group, feel welcome to share their lab experiences and progress (or lack thereof), are very positive about the quality of supervision'  
*Quote from the 2013 Education international peer review report concerning training of MSc students.*

#### 4.3 Demonstrable marks of recognition - Marks of recognition by societal groups

*Table 4.3. Demonstrable marks of recognition.*

<b>Selected relevant societal board positions</b>		
Name	year	Result
KJ Teerds	2007-2009	Secretary of the Dutch Persian Cat Society.
KJ Teerds	2012-	Chair of the Education Program Committee 'Biology'.
J Keijer	2014-	Chair of the Education program Committee 'Animal Sciences'.
AN Nieuwenhuizen	2012-	Member of the Education program Committee 'Nutrition and Health'.
J Keijer	2014-	Chair of the Scientific Advisory board of CAT-Agrofood.
EM van Schothorst	2011-2015	Member of the WIAS Board.

## 5. Viability

### 5.1 Benchmark

For benchmarking we compared ourselves to 3 internationally reputed European groups of roughly similar size (research FTE) and with a similar focus. Like us, all groups strive for scientific excellence coupled to societal relevance. We reflect on their performance and choices for future directions relative to ours.

*Table 5.1.1. Benchmarking output total and average 2008-2013.*

<b>2008-2013</b>	<b>HAP</b>	<b>UBI</b>	<b>ASCR</b>	<b>DifE</b>	<b>AVG</b>
Number of publications (N)	103	100	27	36	66.5
Citations per publication (CPP)	21.7	14.8	21.0	16.9	18.6
Field Weighted Citation Impact (RI)	1.7	1.3	2.1	2.1	1.8
%age Top 10% (T10%)	35	22	41	33	32.8

*HAP Human and Animal Physiology, Wageningen University, The Netherlands.*

*UBI Nutritional Biochemistry, University of the Balearic Islands, Spain.*

*ASCR Adipose Tissue Biology, Academy of Sciences of the Czech Republic, Czech Republic.*

*DIFE Physiology of energy metabolism, German Institute of Human Nutrition, Germany.*

*Analysis was done by WIAS based on 2009-2014 publications as appear in SciVal (see appendix 3 for the names that were used in the Scival analysis). The UBI group is longer in the same composition than the other groups. The UBI group has more senior staff members compared to HAP; the ASCR and Dife groups have fewer staff members, but do not have teaching duties, which are substantial for UBI and HAP.*

*Table 5.1.2. Benchmarking: output*

Year	Number of Publications (N)				Citations per Publication (CPP)				Field Weighted Citation Impact (RI)			
	HAP	UBI	ASCR	Dife	HAP	UBI	ASCR	Dife	HAP	UBI	ASCR	Dife
2008	18	17	3	3	33.4	22.2	19.7	16.3	1.7	1.2	1.0	0.6
2009	30	18	5	3	30.2	15.2	43.4	14.7	2.0	1.1	2.6	1.1
2010	21	23	4	9	15.2	20.2	11.5	34.6	1.4	1.6	0.7	2.9
2011	18	11	5	3	16.8	13.2	20.2	10.7	1.8	1.6	2.5	1.2
2012	5	15	7	11	8.6	9.7	15.0	10.8	1.5	1.5	2.5	2.0
2013	11	16	3	7	5.3	4.3	13.0	7.9	1.6	0.9	3.0	2.6
<b>All</b>	<b>103</b>	<b>100</b>	<b>27</b>	<b>36</b>	<b>21.7</b>	<b>14.8</b>	<b>21</b>	<b>16.9</b>	<b>1.72</b>	<b>1.31</b>	<b>2.14</b>	<b>2.1</b>

The core research of the comparator groups is mechanistic physiological research on nutritional improvement of metabolic health in rodents as model organisms. All employ cellular, biochemical and molecular tools as well as whole body physiology, including indirect calorimetry. All are internationally highly competitive (EU projects). These groups develop and remain competitive by gradually adding new expertise to their core competences. They also increasingly aim for translation to humans. These points all apply to HAP, underscoring our choices and the fact that we operate in a relevant field.

From table 5.1.1, we can conclude that we perform very well. Our number of publications is relatively high, our CPP is above par and RI and T10% are on par. To further improve, we particularly aim to increase our impact (as described in 3.2).

Of course, each group has its own specific strengths and key points for innovation. These are summarized in table 5.1.3.

Our choices for increased competitiveness are:

- i) Continued focus on our research theme.
- ii) To strengthen our mitochondrial profile (see 5.3)
- iii) To invest in maintaining our very high level of lab infrastructure.
- iv) To invest in further extending our indirect calorimetry system.
- v) To increase our capacity to perform and assess human interventions. Of these research groups, we are the only one doing human interventions ourselves.

Table 5.1.3. Benchmarking: competence and innovation.

	Core issue	Strengths	Innovation
<b>HAP</b>	Metabolic health	Functional ingredients, Transcriptomics	Extended InCa (OxR), 'human' capacity
<b>UBI</b>	Obesity	Nutritional programming, Claims	Blood cell-based biomarkers
<b>ASCR</b>	Diabetes	Food-pharma, n-3 LC marine PUFA	Metabolomics, lipid biology
<b>DIFE</b>	Energy metabolism	Diet, Functional ingredients	Extensive phenotyping

## 5.2 SWOT-analysis

Strengths	<ul style="list-style-type: none"> <li>• <i>Distinct profile.</i> Our focus on improvement of health by nutritional targeting of metabolic capacity and flexibility, from a mitochondria-centred perspective, linked to our capabilities in physiological and functional genomic assessment and our ability to directly translate from rodents to humans (and other target species) provides us with a distinct, competitive profile.</li> <li>• <i>International network.</i> We have a strong and widespread international network (EU projects). We published with more than 84 groups, including 46 international groups in all continents.</li> <li>• <i>Embedding.</i> Wageningen University augments our nutritional research profile. Sharing WIAS facilities and participation in Metabolic Health Unit increases our research capacity.</li> <li>• <i>State-of-art facilities.</i> Our lab is top-notch. CAT-Agro provides easy access to high-end equipment.</li> <li>• <i>Teaching portfolio.</i> Our teaching portfolio facilitates appointment of tenured staff, translation of research to state-of-art teaching and research training of a growing number of MSc thesis and internship students (tripled).</li> <li>• <i>Financially sound.</i> We have a substantial financial reserve.</li> </ul>
Weaknesses	<ul style="list-style-type: none"> <li>• <i>Risk of dilution of focus and efforts.</i> Maintaining focus, given our key expertise and external (human centred) demand, conflicts with ASG-push to pursue a profile in the production animal domain.</li> <li>• <i>Visibility and research capacity.</i> Not all research lines are yet mature.</li> </ul>
Opportunities	<ul style="list-style-type: none"> <li>• <i>Research focus fits EU policy and societal interest.</i> Our research focus fits demographic trends as well as the EU research policy (nutrition and lifestyle for metabolic health improvement) and is of societal relevance (health improvement, substantiation of food functionality, training).</li> <li>• <i>Revival of interest in mitochondria.</i> Our research emphasis on mitochondria fits the increasing awareness that mitochondria are an important target for health strengthening.</li> <li>• <i>EU network.</i> Our EU network provides us with research funding opportunities.</li> <li>• <i>Increased visibility to industry.</i> Our increased visibility for industry provides us with research funding opportunities (e.g. STW).</li> <li>• <i>Relatively unique capabilities.</i> We perform research on rodents and humans and have advanced physiological (extended indirect calorimetry) and molecular (functional genomics) capabilities, which are used in an integrated manner focused on metabolic health analysis; Expertise in metabolism and reproduction.</li> </ul>
Threats	<ul style="list-style-type: none"> <li>• <i>Funding for basic research.</i> The political appreciation for basic research, and hence the funding, is decreasing.</li> <li>• <i>Vocal societal groups against research with animals.</i> This may result in political and industrial disinclination for research with animals.</li> <li>• <i>Decreased funding for infrastructure.</i> Competitive research in our field depends on state-of-the-art infrastructure, which is expensive, difficult to fund and faced with decreased institutional support, including support for animal experimentation.</li> <li>• <i>Non-core business demands.</i> Increased number and diversity of non-research, non-education demands</li> </ul>

### 5.3 Future strategy

#### *Critical mass*

We have formulated a policy to focus on core-business (research and teaching/training) and only selectively engage in other activities, for personal development. Alignment of research within our research theme maximizes efficiency and effective critical mass. This is enhanced by our embedding at Wageningen University and by development of long term alliances with selected partners for reciprocal use of advanced methodology (e.g. metabolomics and quantitative mitochondrial imaging). We have recently expanded our staff, attracting a scientist with high impact publications on mitochondria. We are in a good position to target various sources of funding (basic, European, with B-to-B industries and high-tech companies) to further increase our research capacity. Together, this will facilitate the development towards high impact publications.

#### *The outside world*

In the Netherlands, funding is progressively dependent on co-funding from industry. Food industry is interested in our preclinical mechanistic capabilities and increasingly in research in humans and tools to be used in humans. We are therefore investing in our human expertise, in development of tools to be used in humans and in translation of mechanistic knowledge obtained in model species to target species (humans and production animals). We have advanced capabilities (e.g. transcriptome analysis and extended indirect calorimetry for rodents and humans) which are open for joint research. This facilitates collaborative research and satisfies an industrial need for access. Our expertise will allow us to significantly contribute to improved use of animals, currently an important political issue. We enjoy training, are good at it and will continue our training efforts for students and guests to fulfil the demand in well-trained molecular physiologists.

#### *Sustainability of our research theme*

Decreased metabolic capacity and flexibility underlie the health problems associated with obesity and aging. The demographic increase in obesity and age and the growing recognition that nutrition can significantly contribute to health underscores that we have chosen a sustainable research theme. We will therefore continue to adhere to and invest in our central research theme.

#### *Sustainability of key scientific competence*

Our key competence is advanced integrated physiological, immunohistochemical and omics-based assessment of rodent (and human) nutritional interventions for health improvement. Our research is essential to underpin the efficacy of functional ingredients. This fits the new strategic plan of Wageningen University and positions us in the core of the European Agrofood policy, with 'nutrition and lifestyle research' being marked as key to combat metabolic and age-related diseases. We can continue to be successful by strongly linking our research in model species to target species and by firmly establishing our mitochondrial focus. Hence our investments and strategic choices. We will enhance our mitochondrial profile by using mouse models with adapted mitochondrial function (tissue specific SIRT3KO/SIRT5KO), by developing new assessment tools (e.g. extension of indirect calorimetry, signatures for mitochondrial functioning, microsensors) and by focusing on ingredients that target mitochondrial functions.

#### *Conclusion*

Working as a group, we will invest in our central research theme and in our molecular physiological capabilities. Together with maintaining inherent research quality and continuing international collaboration, this will allow us to remain an attractive and increasingly competitive research partner with relevant output.

## 6. Research Integrity

HAP adheres to the Netherlands code of conduct for scientific practice (2012 revision).

#### *Ethics*

All animal and human experiments are being submitted to the relevant ethical committees, after extensive discussion of the protocols within HAP, and are only conducted with approval. We care for our animals and human subjects.

#### *Research culture and manner of interaction*

HAP has an open atmosphere where people feel at ease to comment on data and attitude.

#### *Data storage*

HAP has a protocol for handling and storing of raw and processed data and of samples and adheres to this. We store data in public (e.g. GEO) and joint research databases (e.g. Nutritional Phenotype).

*Data*

HAP adheres to international procedural standards (e.g. MIAME). We respect the data and define and maintain quality criteria for experimental procedures (e.g. PCR).

*Deviating research outcomes*

When our results are against the prevailing lines of thought, we will try to confirm and publish, which often takes additional work. Increased intestinal permeability by FOS is an example of initial scepticism and current acceptance.

*Confidentiality*

We strive for open discussion of all data during weekly work discussions. To facilitate this students and staff sign an internal confidentiality agreement. For projects with external partners, sensitive issues are identified and by addressing them in an appropriate manner (e.g. use polyphenol rather than the specific compound) we have been able to maintain our open culture. Our contracts guarantee our scientific independence and freedom to publish.

*Publications*

For authorship a real scientific contribution is required.

**Appendix 1** - Research staff Human and Animal Physiology group

Table 1 - Research staff input at Chair Group level

<b>Name staff</b>		<b>Funding 1, 2, 3*</b>	<b>2009 FTE**</b>	<b>2010 FTE</b>	<b>2011 FTE</b>	<b>2012 FTE</b>	<b>2013 FTE</b>	<b>2014 FTE</b>
<i>Full professor</i>								
Prof dr ir J. Keijer (1 fte)	Tenured	1	0.40	0.40	0.40	0.40	0.40	0.40
<i>Associate professor</i>								
Dr K.J. Teerds (1 fte)	Tenured	1	0.40	0.40	0.40	0.40	0.40	0.40
<i>Assistant professors</i>								
Dr ir E.M. van Schothorst (0.92fte)	Tenured	1,3	0.36	0.36	0.36	0.36	0.36	0.40
Dr A. Nieuwenhuizen (1 fte)	Tenured	1				0.10	0.16	0.16
<i>Post-docs</i>								
Dr Ir G.J. Geerse (1 fte)	1-4-2007/31-03-2009	1						
Dr R. Piga (1 fte)	1-04-2011/1-4-2013	1			0.27	0.40	0.10	
Dr D. van Dartel (1 fte)	1-2-2011/31-01-2014	1			0.33	0.24	0.32	0.26
Dr R.J.R.J. Janssen (1 fte)	1-10-2008/12-06-2009	3	0.20					
Dr V.V.A.M. Schreurs (0.5 fte)	Tenured/1-12-2011							
Dr I. Palm (0.8 fte)	1-1-2008/31-12-2013							
Dr. M.A. Hegeman (1 fte)	18-02-2013/17-02-2016	1					0.34	0.40
<i>Visiting fellows</i>								
Yvonne van Helden	01-01-2009/31-12-2009		0.75					
Dagdaa Batsaikhan PhD	01-04-2009/01-10-2009		0.50					
Dasa Medrikova MSc	19-10-2009/19-12-2009		0.17					
Sabina Diaz Martinez MSc	19-01-2009/19-04/2009		0.25					
Sabina Diaz Martinez MSc	17-06-2009/03-07-2009		0.04					
Eddy Rijntjes PhD	17-12-2013/31-12-2013		0.04					
Hatice Reyhan MSc	19-01-2009/19-04-2009		0.25					
Tereza Krausova MSc	18-08-2009/01-01-2010		0.30					
Tereza Krausova MSc	18-10-2010/19-12-2010			0.17				
Joana Sanchez Roig PhD	03-10-2010/23-10-2010			0.08				
Desislava Abadzhieva MSc	07-06-2010/02-07-2010			0.08				
Ruben Diaz Rua MSc	15-11-2010/15-02-2011			0.13	0.13			
Elgin Lichtenauer PhD	01-11-2011/30-11-2011				0.08			
Joana Sanchez Roig PhD	04-07-2011/22-07-2011				0.08			
Anja Voigt PhD	07-08-2011/19-08-2011				0.04			
Dasa Medrikova MSc	14-02-2011/10-04-2011				0.17			
Jadwiga Konieczna MSc	16-07-2011/16-10-2011				0.25			
Laure Herreman MSc	25-07-2011/25-08-2011				0.08			
Desislava Abadzhieva MSc	29-08-2011/30-12-2011				0.40			
Elena Stoyanova MSc	01-05-2012/29-05-2012					0.04		
Dimitrina Kacheva PhD	07-05-2012/12-05-2012					0.02		
Elena Kistanova PhD	07-05-2012/12-05-2012					0.02		
Mario Ost MSc	10-05-2012/17-05-2012					0.02		
Marli Do Carmo Cupertino MSc	01-01-2013/31-06-2013						0.50	
Verena Donner	05-08-2013/29-11-2013						0.25	
Tereza Krausova MSc	18-03-2013/30-09-2013						0.50	
Hatice Reyhan MSc	22-04-2013/23-08-2013						0.33	
Laure Herreman MSc	24-08-2013/31-12-2013						0.33	
Marcos De Lucca Moreira	01-08-2013/01-08-2014						0.33	0.67
Ruben Diaz Rua MSc	02-02-2014/03-05-2014							0.25
Barbara Reynes Miralles MSc	05-06-2014/15-07-2014							0.25
Barbara Reynes Miralles MSc	01-09-2014/22-10-2014							0.25
Jana Hansikova MSc	10-02-2014/22-02-2014							0.04
Akhtar Hussain MSc	11-05-2014/26-05-2014							0.04
Miguel Vasques Velasco PhD	14-04-2014/15-07-2014							0.25
Desislava Abadzhieva MSc	26-06-2014/27-07-2014							0.08
<b>Total scientific staff</b>			<b>3.66</b>	<b>1.62</b>	<b>2.99</b>	<b>2.00</b>	<b>4.32</b>	<b>3.85</b>

*Support staff*

S. Snaas-Alders	01-09-2009/21-08-2011	1,3	0.18	0.55	0.14				
M. Grovestein-Bekkenkamp	01-01-2009/31-01-2011	1,3	0.55	0.55	0.05				
M. Grovestein-Bekkenkamp	22-12-2014/31-12-2015	1,3							0.01
I. Romijnders-van der Stelt	01-01-2011/Tenured	1,3				0.55	0.55	0.55	0.55
H. Swarts	Tenured	1,3	0.55	0.55	0.55	0.55	0.5	0.5	0.5
A. Bunschoten	Tenured	1,3	0.5	0.5	0.5	0.5	0.5	0.5	0.5
<b>Total staff</b>			<b>5.44</b>	<b>3.77</b>	<b>4.78</b>	<b>3.60</b>	<b>5.87</b>	<b>5.41</b>	

\* Funding scores: 1= direct funding by University; 2= funding obtained in national scientific competition (e.g. grants from NWO, KNAW) ; and 3= funding obtained from external organisations, such as industry, governmental ministries, European Commission and charity organisations.

\*\*FTE reported in this table regards the research appointment part of the total appointment (e.g. tenured staff has 40% available for research, postdocs have 60% available for research, technicians have 55 % available for research).

**Appendix 2 – Notes on Research staff Human and Animal Physiology**

Dr. Dorien van Dartel announced a career change early 2015. She is replaced by Dr.ir. Vincent de Boer (June 2015), with an excellent publication record in mitochondrial research (e.g. 2x Cell (IF 32)). Our staff is further strengthened by Dr. Sander Grefte (May 2015), an expert in mitochondrial metabolism.

Staff bibliometric indicators<sup>1</sup> (WoS)

Name	Born	H-index	publications	CPP	citations	IF>8
Jaap Keijer	1959	33	128	29.2	3732	5
Katja Teerds	1959	27	77	20.1	1749	2
Evert van Schothorst	1968	18	43	17.4	794	3
Arie Nieuwenhuizen	1969	17	46	18.1	833	2
Dorien van Dartel	1983	12	24	14.0	337	0
Jessica Hegeman	1981	6	12	14.3	171	0
Sander Grefte	1980	7	17	16.7	284	0
Vincent de Boer	1977	15	23	39.6	830	4

<sup>1</sup>For further information see mini curricula vitae. Born: year of birth for age distribution staff; H-index: Hirsch-index; CPP: citations per publication; IF>8: lifetime publications in journals with impact factor larger than 8. The average journal impact factor of our 2009-2014 publications is 4.1.

**Appendix 3** - Scientists for benchmark Human and Animal Physiology

**Table II.** Scientists selected at the Department of Adipose Tissue Biology, Czech Academy of Sciences – Czech Republic (ASCR), the Laboratory of Molecular Nutrition, University of the Balearic Islands – Spain (UBI), and Section Energy Metabolism, German Institute of Human Nutrition – Germany (DIfE) for benchmarking HAP

<b>HAP</b>	<b>ASCR</b>	<b>UBI</b>	<b>DIfE</b>
Keijer, J.	Flachs, P.	Bonet, M.L.	Klaus, S.
Nieuwenhuizen, A.G.	Kopecký, J.	Oliver, P.M.	Schumann, S.
Teerds, K.J.	Kuda, O.	Palou, A.M.	Voigt, A.
Van Dartel, D.A.M.	Rossmeisl, M.	Picó, C.	
Van Schothorst, E.M.		Sánchez, J.M.S.	
		Serra, F.	

## Quantitative Veterinary Epidemiology (QVE)

**Programme leader(s):** Mart C.M. de Jong 2009-2014

*For a full staff survey see appendix 1.*

### 1. Objectives and Research Area

#### 1.1 Vision, Mission and Objectives

Vision: Infectious diseases are important for every biological system, because they can have an enormous impact on the utilisation of biological systems and the infection can also directly affect human health.

Mission: We are concerned with infectious diseases of animals in animal production systems including the links both to natural systems and to human health. As humans, wildlife, and production animals do share infectious agents (for examples see below) infections in natural ecosystems and in humans are closely linked with those in animals in animal (production) systems.

Objectives: Our goal is to understand the factors, including any of the control measures applied to animal populations, that determine the transmission and virulence of infectious agents in these linked biological systems.

Our goal can be further specified in that we want to understand (i) the population dynamics and virulence changes of infectious agents and the factors that influence those and (ii) the evolutionary (genetic) changes in hosts and pathogens. We especially focus on the methods to quantify these processes by combining mathematical modelling and statistical approaches.

#### 1.2 Research Area / research line(s)

1. The research focus in the case of infectious disease epidemiology is for our group on measuring transmission parameters and the impact of control measures on the transmission. We developed methods that can be used for controlled experiments (including the experimental design) and for quantification based on observational (field) data. Classical epidemiological approaches (risk factor analysis, survival analysis) are used to generate hypotheses for the factors to be studied. The team consists of Mart de Jong, Klaas Frankena, Lisette Graat, and (as of June, 1<sup>st</sup> Ynte Schukken) and PhD students.
2. Genetic information both on host and pathogens become more readily available and this has an impact on our research. First of all changes in the genetic make-up of the pathogen populations is potentially an important tool to understand the transmission of the pathogens but its role in quantification of transmission has to be developed further. To that end we study pathogen adaptation which could be adaptations to new host species, changes in virulence, and control escape. Finally, host genetic differences may result in difference in tolerance, susceptibility, and infectivity and these differences may be used in animal breeding. The team consists of Mart de Jong with Piter Bijma (ABG) and PhD students.

#### 1.3 Strategy

Research is conducted in cooperation with other groups and funded by several governments because of their interest in disease management. The ongoing number of PhD projects has been approximately 12 throughout QVE's existence (since 1999). As part of improvements in our strategy (based on previous evaluations) we aim at and have obtained NWO funding in this evaluation period.

The research in the past 6 years has increased in quality resulting in more and more publications in higher profile journals (PNAS, Plos One), a higher RI (see below), and increasing h-factors for the group and its members (the sequence of h-factors for 2009,2012, 2015 is for QVE 27,32,39).

- Under Goal 1 we published about risk factors for MRSA (Broens et al., 2011a; Broens et al., 2011b) and E.coli with ESBL genes (Huijbers et al., 2013) and found out about the important contribution of environmental transmission (Broens et al., 2012a). An important development is therefore that we do consider more the environmental compartment in the transmission of infectious agents. Previously, unexplained observations have become more clear considering that contamination of the

environment takes time and leads to delays in transmission (van Bunnik et al., 2014). This has had also applications for coccidiosis (Velkers et al., 2012) and FMDV (Bravo de Rueda et al., 2015).

- With respect to goal 2 we have used sequence differences of HPAI (i.e. the pathogen) to reconstruct and quantify transmission routes (Ssematimba et al., 2012). Also we have been studying antigenic distances between influenza viruses and the effect on vaccine escape (Sitaras et al., 2014). For the host traits we have looked at how selection against disease would affect these host traits and concluded that selection will lead to increase tolerance or reduced susceptibility but not reduced infectivity. Which leads to the prediction that there is considerable genetic variance in infectivity (and some in susceptibility!) that is not used and measured currently (Anche et al., 2014).

The strategy is to build upon these research developments described and increase the group's size with an extraordinary professor (Schukken starts June, 1<sup>st</sup>) and a postdoc which also will make more PhD's possible. Also the planning is to obtain more competitive research grants (NWO, EU etc).

#### 1.4 Research environment and embedding

PhD's active in the period 2009-2014: QVE is part of WIAS and has had cooperation with several chair groups in this graduate school: ABG (3 PhD), AFI (2 PhD), APS (1 PhD), and within the University but outside this graduate school: Mathematics (1 PhD), and Virology (3 PhD). Nationally, we have important research cooperation with FD-UU (1 PhD), WLR(1 PhD), CVI(5 PhD), and RIVM (3 PhD). Internationally, with the Irish government on bovine TB (2 PhD) and with Vietnam on WSSV in shrimp (3 PhD). Furthermore, there are currently sandwich PhD with Nigeria (WU funded), and Ethiopia (Nuffic funded).

Nationally, the chairholder is part of official national advisory boards for the government on animal welfare (Raad voor Dieraangelegenheden) and on the control of infectious disease (Commissie deskundigen dierziektenbestrijding). Internationally, we have the cooperation with the Irish government and this work also has led to the membership of the Scientific Oversight Group of DEFRA (Department for Environment, Food & Rural Affairs) for making a plan to investigate cattle vaccination against Bovine TB in the UK. Also de Jong has been part of a working group of EFSA (European Food Safety Authority) on modelling infectious diseases in production animals.

During the period of this report the International Society for Veterinary Epidemiology and Economy has had its international congress in The Netherlands and de Jong has been member of the scientific committee. Also a meeting has been held in Cambridge celebrating the 20 year anniversary of 1994 programme on Mathematical Epidemiology (half year) at the Isaac Newton Institute on Mathematical Epidemiology (Brooks-Pollock et al., 2015; De Jong et al., 1995)

#### 1.5 Reflection to previous assessments

The previous evaluation was Quality=4.5, Productivity=4, Relevance=5, Vitality=3.5 (at a 0-5 scale) which made us the fourth best chair group of WIAS. Remarks of the committee and our response:

- *"The Chair group has an excellent national and international reputation and is at the forefront of his field."*

We strengthened that further by publishing in high profile journals. This was successful see bibliometric indicators and the increase in h-indexes. Also we have participated in national and international advisory boards on animal disease management as detailed below.

- *"Its long term viability could be strengthened by recruiting more early or mid career researchers and by strengthening internal links."*

Cooperation with ABG (1 PhD), AFI (2 PhD), WIS (1 PhD) and VIR (3 PhD) were established. Further investments in postdoc personnel are supported by the newly formed cluster (ABG,HMI & QVE) and are discussed with ASG management. Also our improved financial position and the new extraordinary chair will help in this.

- *Budget-wise the Chair still counts as a half-time position, which means that the group has half of the basic WU funding compared to other Chairs.*

Thanks to efforts of the management of ASG this has been (almost) repaired since the January 1st 2010. As a consequence our financial position has improved and we plan to use that to strengthen the group.

## 2. Resources and Facilities

### 2.1 Researchers

Table 2.1. Research input: number<sup>1</sup> and FTE<sup>2</sup> of Scientific staff, Post-docs and PhD candidates by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff <sup>4</sup>	3	1.0	3	1.0	3	1.0	3	1.0	3	1.1	3	1.1	3	1.0
Post-docs <sup>5</sup>	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
PhD candidates <sup>3,6</sup>	10	5.7	10	6.5	11	4.7	6	3.2	7	2.3	5	3.0	8	4.2
<b>Total res. staff</b>	<b>13</b>	<b>6.7</b>	<b>13</b>	<b>7.4</b>	<b>14</b>	<b>5.7</b>	<b>9</b>	<b>4.2</b>	<b>10</b>	<b>3.3</b>	<b>8</b>	<b>4.1</b>	<b>11</b>	<b>5.2</b>
Lab Technicians	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Visiting fellows	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<b>Total staff</b>	<b>13</b>	<b>6.7</b>	<b>13</b>	<b>7.4</b>	<b>14</b>	<b>5.7</b>	<b>9</b>	<b>4.2</b>	<b>10</b>	<b>3.3</b>	<b>8</b>	<b>4.1</b>	<b>11</b>	<b>5.2</b>

<sup>1</sup> Total number of staff and PhD candidates

<sup>2</sup> Available research time in full time equivalent (FTE)

<sup>3</sup> All PhD categories, except external PhDs

Standards for Research Capacity (in case of part time appointment adjustment is needed):

<sup>4</sup> Professor, Assistant Professor and Associated Professor: Research Capacity = 40% of the appointment

<sup>5</sup> Post-doc: Research Capacity = 90% of the appointment

<sup>6</sup> PhD candidate: Research Capacity = 75% of the appointment (all categories)

The scientific staff for all task is 2.7 FTE of which approximately one FTE is for research, see above. The ambition has been for a long time to expand the group by more postdoctoral staff to allow for more research to be carried out and more PhD students to be supervised. In the years to come there will be for the first time a good possibility to do so. First of all, as per June, 1<sup>st</sup> Prof. Dr. Ynte Schukken DVM (now Cornell University and recently became director Animal Health Service) will join QVE as an extraordinary chair bringing in additional PhD students and 0.2 fte research capacity.

### 2.2 Research Funds

Table 2.2. Funding of Scientific staff, Postdocs and PhD candidates by year and Expenditure of Chair group by year.

	Year												Average	
	2009		2010		2011		2012		2013		2014		2009-2014	
	FTE	%												
<i>Funding:</i>														
Direct funding <sup>1</sup>	3.9	58	4.0	54	2.6	46	2.1	49	2.0	60	2.2	54	2.8	54
Research grants <sup>2</sup>	0.0	0	0.0	0	0.0	0	0.0	0	0.2	6	0.8	19	0.2	4
Contract research <sup>3</sup>	2.8	42	3.4	46	3.1	54	2.1	51	1.1	35	1.1	28	2.3	42
<b>Total funding</b>	<b>6.7</b>	<b>100</b>	<b>7.4</b>	<b>100</b>	<b>5.7</b>	<b>100</b>	<b>4.2</b>	<b>100</b>	<b>3.3</b>	<b>100</b>	<b>4.1</b>	<b>100</b>	<b>5.2</b>	<b>100</b>
<i>Expenditure<sup>4</sup>:</i>														
Personnel costs	532	71	574	66	553	78	479	69	423	65	445	69	501	70
Other costs	219	29	295	34	152	22	212	31	229	35	204	31	218	30
<b>Total expenditure</b>	<b>750</b>	<b>100</b>	<b>869</b>	<b>100</b>	<b>705</b>	<b>100</b>	<b>691</b>	<b>100</b>	<b>651</b>	<b>100</b>	<b>649</b>	<b>100</b>	<b>719</b>	<b>100</b>

<sup>1</sup> Direct funding by the University

<sup>2</sup> Research grants obtained in national and international scientific competition (e.g. grants from NWO, KNAW)

<sup>3</sup> *Research contracts for specific research projects obtained from external organisations, such as industry, governmental ministries, European Commission (including ERC), charity organisations*

<sup>4</sup> *Expenditure from financial system of Wageningen University which not only includes research but also teaching and other activities*

The goal to obtain more PhD's from competitive funding (NWO etc.) seems to be well on its way with one PhD from NWO (started 2013 see table 2.2) one other PhD project in a STW programme in its second round, and one other STW proposal is currently being written with CVI. Instrumental in these first two of these PhD's has been the productive cooperation with Dr. Piter Bijma (ABG) on the subject of host genetics related to infectious diseases. This cooperation started as part of the cooperation within the cluster of ABG, HMI en QVE. A further PhD from this cooperation and one from a cooperation originally started by CVI (Olga Haenen) are foreseen, financed by EU funding (Marie Curie).

### 3. Research Quality

QVE focusses on the development and application of mathematical techniques and statistical methods that contribute to a better management of infectious diseases in (production) animal populations. We have developed methods to quantify transmission and the effect of intervention measures on this transmission. In this we are quite exceptional as there are groups that model infectious diseases and groups that study interventions at the individual animal level but few that combine this. Key high impact journals or pivotal papers in this period where:

- (Broens et al., 2012b) VetMic Looking at factors that influence the transmission of MRSA on the farm.
- (Azhar et al., 2011) VetMic Field trial for evaluation of vaccination against bovine TB in badgers,
- (van Bunnik et al., 2014) PNAS Experiments and modelling showing environmental dissemination of infectivity,
- (Anche et al., 2014) Heredity Defining concepts and evolutionary trends for heritable host traits with respect to infectious diseases
- (Sitaras et al., 2014) PlosOne Antigenic distances between virus isolates used to study impact on transmission in subsequent paper.

As can be seen by any indicator the impact of QVE has increased again e.g. RI now: 1.85 2009:1.70

#### 3.1 Demonstrable products - Research products for peers in science

Table 3.1. Categories of research output by year.

Category:	Year						Total	Average 2009-2014
	2009	2010	2011	2012	2013	2014		
<b>Academic publications</b>								
a. Refereed articles	15	19	31	20	15	15	115	19
b. Non-refereed articles	0	0	1	0	0	0	1	0
c. Books	0	0	0	0	0	0	0	0
d.1. Refereed book chapters	0	0	0	0	0	0	0	0
d.2. Non-refereed book chapters	3	0	0	0	0	0	3	1
e. PhD Theses	1	1	3	3	2	2	12	2
f. Conference papers	2	0	6	1	0	0	9	2
<b>Total academic publications</b>	<b>21</b>	<b>20</b>	<b>41</b>	<b>24</b>	<b>17</b>	<b>17</b>	<b>140</b>	<b>23</b>

#### 3.2 Demonstrable use of products - Use of research products by peers

Table 3.2.1. Bibliometric indicators for QVE over the period 2008-2013. The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

year of publication	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
2008	11	228	153	20.7	1.79	27% (3)	0% (0)
2009	15	350	144	23.3	2.60	40% (6)	7% (1)
2010	19	214	183	11.3	1.64	11% (2)	5% (1)
2011	30	366	197	12.2	1.87	23% (7)	0% (0)
2012	20	87	77	4.4	1.21	10% (2)	0% (0)
2013	14	37	25	2.6	1.82	7% (1)	7% (1)
<b>all years</b>	<b>109</b>	<b>1282</b>	<b>780</b>	<b>11.8</b>	<b>1.79</b>	<b>19% (21)</b>	<b>3% (3)</b>

Table 3.2.2. Bibliometric indicators for QVE per research field over the period 2008-2013. The rows are ordered in descending number of publications (N). The bibliometric indicators are explained in paragraph 2.7 of the Bibliometric Analysis.

research field	Bibliometric indicators						
	N	C	Wavg	CPP	RI	%T10 (#T10)	%T1 (#T1)
Plant & Animal Science	66	684	398	10.4	1.63	20% (13)	0% (0)
Agricultural Sciences	9	70	46	7.8	1.32	11% (1)	0% (0)
Microbiology	8	98	85	12.3	1.06	13% (1)	0% (0)
Social Sciences, General	7	232	37	33.1	6.78	71% (5)	43% (3)
Immunology	6	46	88	7.7	0.71	0% (0)	0% (0)
Biology & Biochemistry	4	19	41	4.8	0.58	0% (0)	0% (0)
Clinical Medicine	4	55	36	13.8	1.67	25% (1)	0% (0)
Chemistry	2	25	19	12.5	1.35	0% (0)	0% (0)
Psychiatry/Psychology	2	22	15	11.0	1.12	0% (0)	0% (0)
Molecular Biology & Genetics	1	31	16	31.0	1.95	0% (0)	0% (0)
<b>all fields</b>	<b>109</b>	<b>1282</b>	<b>780</b>	<b>11.8</b>	<b>1.79</b>	<b>19% (21)</b>	<b>3% (3)</b>

### 3.3 Demonstrable marks of recognition - Marks of recognition from peers

Table 3.3. Most important prizes, keynotes etc. of staff (max 6 per category). For remaining achievements see mini CVs (Separate file called mini CVs).

Plenary/Keynote Lectures at major conferences		
Year	Person	Conference
2014	Mart de Jong	Isaac Newton institute Cambridge "20 year after the 1994 meeting"
Organisation of International Scientific Conferences		
Year	Person	Conference
2012	Mart de Jong	International Society for Veterinary Epidemiology, scientific committee XIII international meeting Maastricht
Editorships and editorial boards		
Klaas Frankena	2009-now Associate Editor Preventive Veterinary Epidemiology	
Mart de Jong	-now Committee of experts on animal disease (Dutch ministry of Economic Affairs) -now Committee on animal affairs (RDA) 2013 EFSA working group 2014 DEFRA Scientific Oversight Group for the vaccination in cattle against bTB 2015 DEFRA working group on transmission experiments for testing vaccination against bTB in cattle	

## 4. Relevance to Society

The management of infectious diseases is important for any biological system. We study populations of (production) animals where infections occur that can be important for the animal production, for other animal species or for humans. These issues attract a lot of attention nowadays as it becomes clear that such problems are often difficult to manage. Our research helps to find good intervention strategies. The research projects are concerned with the application of mathematical and statistical methods to quantify the transmission and the impact of control measures on this transmission. We have done this for many of the most important animal diseases. One example was the eradication of pseudorabies virus (Aujeszky's disease) in Netherlands where selection of the correct vaccine (De Jong and Kimman, 1994) and modelling of the eradication programme (Bouma et al., 1995; Bouma et al., 1996; Bouma et al., 1997) has led to a successful eradication by vaccination only (Stegeman et al., 1997). Now the two examples will be discussed with probably the largest societal impact in the past 6 years.

**HPAI:** Highly pathogenic avian influenza in poultry can be managed by vaccination. However vaccination is not considered a good strategy by many as it will not result in eradication and new variants of the virus will appear that cannot even be mitigated by the vaccination. We had shown previously that vaccination can result in stopping the transmission of HPAI (van der Goot et al., 2005) so at least initially the vaccine should work fine and lead to eradication. We then asked whether adaptation of the virus in few poorly vaccinated chickens can lead to vaccine escape mutants that would evade the vaccination and make that it does not work. We selected for escape mutants by exposing HPAI to diluted antiserum which "kills" most of the virus but not all and indeed that led to antigenically different viruses (Sitaras et al., 2014).

Next, we did experiments to see whether those mutant viruses when used as vaccine would still be effective against the original virus. Thus we tested the effect of antigenic distance and these experiments showed us that the differences between virus and vaccine have a much smaller effect on the transmission than e.g. the dose of the vaccine. The failure to eradicate HPAI by vaccination in countries like e.g. Indonesia is not because of virus evolution but because vaccination in the field is not as good as the vaccination under controlled circumstances (in the laboratory). We showed that if all vaccinated chickens have HI titres above 8 transmission will be stopped ( $R < 1$ ) and this almost entirely due to a change in infectivity. So now more research is needed in the factors that make vaccination in the field less effective than in the laboratory.

**Bovine TB** The eradication of Bovine TB in the republic of Ireland (ROI) and South-West United Kingdom (Wales and England) is not progressing (in fact the situation has got worse in SW UK) and that failure is considered to be due to wildlife reservoirs maintaining the bacterium and reintroducing it into the cattle population. We have looked at many aspects of the eradication of bovine TB including the diagnostic methods used and the quality of the diagnostic tests ((Frankena et al., 2007; Olea-Popelka et al., 2012), Frankena et al., in prep.). We used here a mathematical tool called the Next Generation Matrix (Diekmann et al., 2010) to model the transmission in badgers (the wildlife reservoir in ROI) and cattle. We also designed the experiment to estimate the effect of vaccination in badgers (Aznar et al., 2011; Aznar et al., 2013) and are currently doing the calculation on the real trial that has been done in ROI based on this design.

#### 4.1 Demonstrable products - Research products for societal target groups

Table 4.1. Overview of output for societal target groups by year.

	Year						Total
	2009	2010	2011	2012	2013	2014	
Professional publications and output	1	1	1	0	0	1	4
Publications for the general public	0	0	1	0	0	0	1
Other research output	15	5	11	9	2	0	42

In december 2014 de Jong was interviewed at the Dutch national radio NPO "de kennis van nu" on avain influenza outbreak.

#### 4.2 Demonstrable use of products - Use of research products by societal groups

- Contract research (including consultancies)

In many issues regarding the control of infections in the Netherlands we are involved in research done by either Central Veterinary Institute of WUR, Animal Health Service, or RIVM (the public health institute) through MSc research projects. Occasionally we do contract research ourselves (i.e. get paid ourselves) when it fits in the line of our own research questions (often PhD projects).

In the past years this was done for:

- Bovine TB development of a new standard tuberculin because that is used as diagnostic preparation in bTb eradication (2014, Prionics)
- Test and removal strategy calculations for *Leptospira* Hardjo to improve certification programme for this disease. (2014, with Animal Health Service for the Cattle Product Board).
- Design transmission experiment for cattle vaccination against bTB with Cambridge University (2015, for DEFRA).

- Overview first jobs/present jobs of alumni (MSc and PhD / only in general terms when referring to the domains)

*Table 4.2. Year of finalising QVE thesis 2010-2015 (n=52)*

Jobs MSc	n	%
Back to home country	13	25%
PhD	8	15%
Research	4	8%
Industry	11	21%
Consultancy	8	15%
Miscellaneous	8	15%
Total	52	

Graduated PhD students in 2010-2015 (n=10) all remained in research either at universities or institutes.

#### 4.3 Demonstrable marks of recognition - Marks of recognition by societal groups

See memberships of advisory boards.

### 5. Viability

#### 5.1 Benchmark

The best other groups that work specifically on veterinary epidemiology are used for comparisons (see Appendix 2 for composition of research groups). Benchmarking we have done comparing to the group of Prof. Arjan Stegeman (h-index: 27) faculteit diergeneeskunde (FD) in Utrecht and as we are not in a veterinary department we compare also to another type of group led by Prof Nils Toft (h: 15) technical university (TU) in Denmark who is also focussing more on methodology. The best researchers in veterinary epidemiology e.g. Prof. Ynte Schukken (h:55) , Prof Herman Barkema (h: 43) and Prof. Nigel French (h: 32).

*Table 5.1. Benchmarking: output.*

Year	Number of Publications (N)			Citations per Publication (CPP)			Field Weighted Citation Impact (RI)		
	QVE	TuD	FD UU	QVE	TuD	FD UU	QVE	TuD	FD UU
2008	11	8	11	20.3	30.0	13.5	2.1	2.2	1.5
2009	11	14	24	19.1	19.8	18.0	2.3	2.0	2.0
2010	13	8	30	11.1	10.0	10.8	1.2	1.8	1.8
2011	25	18	25	13.4	8.0	8.4	2.8	1.6	1.8
2012	18	20	25	5.4	6.0	4.2	1.8	1.5	1.3
2013	14	24	17	3.0	2.6	2.9	1.5	1.5	1.5
<b>All</b>	<b>92</b>	<b>92</b>	<b>132</b>	<b>11.4</b>	<b>10.0</b>	<b>9.6</b>	<b>2.04</b>	<b>1.65</b>	<b>1.66</b>

### 5.2 SWOT-analysis

Internal organisation	Strengths	Weaknesses
	<ul style="list-style-type: none"> <li>• Excellent staff which will be further strengthened by extraordinary chair (see benchmarking),</li> <li>• Embedding in a cluster of chairgroups (ABG,HMI,QVE) that strengthens the position of the group in the department and university,</li> <li>• Good financial position,</li> <li>• Infectious diseases is WUR strategic theme for the coming period.</li> </ul>	<ul style="list-style-type: none"> <li>• The capacity available to in initiate further growth is at first small</li> <li>• There is a need for mathematical modelling expertise to ensure continuity of the group.</li> </ul>
External context	Opportunities	Threats
	<ul style="list-style-type: none"> <li>• As a research group we link the modelling (ecological) research with the high impact research on production animals,</li> <li>• Quantification of transmission related to actual management issues is not researched by that many groups.</li> <li>• Global one health is a priority theme.</li> </ul>	<ul style="list-style-type: none"> <li>• Closed communities around veterinary, medical, microbiological, and ecological questions,</li> <li>• The motivation for and methods to study transmission are not always understood by funding authorities.</li> </ul>

### 5.3 Future strategy

The societal challenges originating from the impact on human health (zoonoses, one health) and from the animal welfare consequences make that the field of research of QVE is seen as very relevant by society. Thus, animal infectious diseases are more and more seen as a difficult and relevant problems: this can be outbreaks of highly pathogenic influenza recently (H5N8) but also “old” problems that will not go away like Bovine Tuberculosis in cattle and wildlife. Thus with more capacity we will increase the efforts of QVE on these issues. Our unique selling point is the combination of measurements and modelling that allows us to have an impact on real world decisions. In terms of the internal organisation we profit from the cluster as a sounding board for new ideas and for mutual cooperation.

For example QVE and ABG have played a role for example to help HMI to obtain position in the curriculum in Wageningen and QVE represents the cluster in the WIAS board and life science exam board. ABG has helped QVE to start a research project regarding the genetic host traits that are associated with infectious disease by investing in a PhD student and co-supervision and this has been profitable to both groups resulting in an additional NWO funded PhD student and two more applications under way.

## **6. Research Integrity**

For QVE it is important that there is a high quality supervision of PhD students (and undergraduate students of course) and that those the supervise PhD students get credits for that. The university policy on co-promotors (max 2) can sometimes be restrictive to give due credits to external supervisors and also the internal supervisors. Our strategy is that we try to agree upon these issues beforehand so that those involved know what the revenues will be from their efforts.

We are happy with the more clear guidelines with respect to co-authors but it can be difficult to uphold these standards with co-workers in the projects from outside the university. Again here it is important to make agreements beforehand.

**Appendix 1** - Research staff Quantitative Veterinary Epidemiology group*Table 1 - Research staff input at Chair Group level*

<b>Name staff</b>	<b>Funding 1, 2, 3*</b>	<b>2009 FTE**</b>	<b>2010 FTE</b>	<b>2011 FTE</b>	<b>2012 FTE</b>	<b>2013 FTE</b>	<b>2014 FTE</b>
<i>Full professors</i>							
Prof. dr. ir. M.C.M. de Jong (1 fte)      Tenured	1	0.30	0.30	0.30	0.30	0.40	0.40
<i>Associate professors</i>							
Dr ir K. Frankena (1 fte)                      Tenured	1	0.40	0.40	0.40	0.40	0.40	0.40
<i>Assistant professors</i>							
Dr ir E.A.M. Graat (0.75 fte)                  Tenured	1	0.32	0.25	0.25	0.25	0.25	0.25
<b>Total scientific staff</b>		<b>1.02</b>	<b>0.95</b>	<b>0.95</b>	<b>0.95</b>	<b>1.05</b>	<b>1.05</b>
<i>Support staff</i>							
<b>Total staff</b>		<b>1.02</b>	<b>0.95</b>	<b>0.95</b>	<b>0.95</b>	<b>1.05</b>	<b>1.05</b>

\* Funding scores: 1= direct funding by University; 2= funding obtained in national scientific competition (e.g. grants from NWO, KNAW) ; and 3= funding obtained from external organisations, such as industry, governmental ministries, European Commission and charity organisations.

\*\* FTE reported in this table regards the research appointment part of the total appointment (e.g. tenured staff has 40% available for research, postdocs have 60% available for research).

**Appendix 2** - Scientist for benchmark Quantitative Veterinary Epidemiology group**Table II.** *Scientist selected at the Technical University of Denmark (TuD), and Utrecht University (VM) for benchmarking QVE.*

<b>QVE</b>	<b>TuD</b>	<b>VM</b>
De Jong, M.C.M.	Boklund, A.	Bouma, A.
Frankena, K.	Bødker, R.	Koop, G.
Graat, E.A.M.	Græsbøll, K.	Nielen, M.
	Halasa, T.	Stegeman, J.A.
	Kirkeby, C.	Velkers, F.C.
	Lind, P.	
	Toft, N.	



## List of Abbreviations

ABG	Animal Breeding and Genetics Group
ABGC	Animal Breeding and Genetics Centre
ABIES	Doctoral School Agriculture, Food, Biology Environment, Health, AgroParisTech
ADP	Adaptation Physiology Group
AFI	Aquaculture and Fisheries Group
AHCI	Arts & Humanities Citation Index
ANU	Animal Nutrition Group
APS	Animal Production Systems Group
ASG	Animal Sciences Group
BHE	Behavioural Ecology Group
BSc	Bachelor of Science
CAN	Centre for Animal Nutrition
CBI	Cell Biology and Immunology Group
CVI	Central Veterinary Institute
DLO	Contract research part of Wageningen UR
ECTS	European Credit Transfer System
EPS	Experimental Plant Sciences graduate school
ERC	European Research Council
ESI	Essential Science Indicators
EU	European Union
EZO	Experimental Zoology Group
FAO	Food and Agriculture Organisation of the United Nations
FP7	Seventh Framework Programme
FTE	Full Time Equivalent
FWCI	Field-Weighted Citation Impact
HAP	Human and Animal Physiology Group
HMI	Host-Microbe Interactomics Group
IMARES	Institute for Marine Resources & Ecosystem Studies
INRA	Institut National de Recherche Agronomique, France
INREF	Interdisciplinary Research and Education Fund of Wageningen University
IP/OP	Strategic research programme of Wageningen UR
ITN	Initial Training Network
JCR	Journal Citation Reports
KNAW	Royal Netherlands Academy of Sciences
MAS	Masters in Animal Sciences
MAM	Masters in Aquaculture and Marine Resource Management
MIF	Median Impact Factors
MNCS	Mean Normalized Citation Score
MSc	Master of Science
NC	Not Cited
NIOO	Netherlands Ecology Institute
NOVA	Nordic Forestry, Veterinary, and Agricultural university network
NUFFIC	Netherlands University Organisation for International Cooperation in Higher Education
NWO	Netherlands Organisation for Scientific Research (Netherlands Research Council)
NWO-ALW	Earth and Life Sciences Foundation
NWO-STW	Technology Foundation
NWO-WOTRO	Netherlands Foundation for the Advancement of Tropical Research
PE&RC	C.T. de Wit Graduate School for Production Ecology and Resource Conservation
RMV	Research Master Variant
RMC	Research Master Cluster
PhD	Doctor of Philosophy

PNAS	Proceedings of the National Academy of Sciences
PRI	Plant Research International (contract research institute of Wageningen UR)
Q	Quartile
QANU	Quality Assurance Netherlands Universities
QVE	Quantitative Veterinary Epidemiology Group
RI	Relative Impact
SCI	Science Citation Index
STARS	Scientific Training in Antimicrobial Research Strategies
T1	Top percentile publications
T10	Top Decile publications
T&T	Talents & Topics
TNO	Netherlands Organisation for Applied Natural Sciences
TSP	Training and Supervision Plan
UK	United Kingdom
USA	United States of America
VLAG	Graduate School of Food Technology, Agrobiotechnology, Nutrition and Health Sciences
VSNU	Association of Cooperating Universities in the Netherlands
Wageningen UR Livestock Research	Institute for Animal Science in Lelystad, part of the ASG
Wageningen UR IMARES	Institute for Marine Resources and Ecosystem Studies (contract research institute of Wageningen UR)
Wageningen UR	Wageningen University and Research centre
WACA	Centre for Animal Welfare and Adaptation
WaCASA	Centre for Agroeconomic and Systems Analysis
WASS	Graduate School for Social Sciences, Wageningen
WAPS	WIAS associated PhD Students
WGS	Wageningen Graduate Schools
WIAS	Graduate School Wageningen Institute of Animal Sciences
WIMEK	Wageningen Institute for Environment and Climate Research
WoS	Web of Science
WU	Wageningen University