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AUSTRALIAN Pork™

Quantitative Genetics R&D: 2006 – 2011

Final Report
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Acknowledgments

This project would not have been possible without the support and enthusiasm of Australian pig breeders, who are willing to share their ideas and provide data for research. The direction of research was developed in consultation with the members of the Pig Genetics Consultative Group which then became APL Specialist Group 2. This support from the Australian pig industry is very much appreciated.

The guidance and support of Dr Brian Luxford, Chair of the APL Specialist Group 2, Dr Ian Johnsson and Dr Darryl D'Souza, General Manager, Research & Innovation, APL and Prof Hans Graser, Director of AGBU is gratefully acknowledged.

A special thank you to my colleagues at AGBU, Mr Rob Jones and Dr Craig Lewis who were both part of this project contributing significantly to the outputs of this project. The extensive collaboration with Dr Kim Bunter at AGBU has been of great benefit for this project. Further support was provided by Ms Marlene Youman, Ms Kathy Dobos, Mr Tony Henzell, Dr Ron Crump and Mr Jim Cook. I would to thank all my colleagues at AGBU for being such a great team to work with.

This project is part of the wider research community in animal breeding and genetics, and pig science in general. The collaborations with Dr Hélène Gilbert (INRA, France), Ms Isabelle Mérour (Institute du Porc, France), Dr Rob Bergsma (Institute of Pig Genetics, The Netherlands) and Dr Wendy Rauw (University of Reno) have been of mutual benefits and have been most enjoyable.

Susanne Hermesch
Senior Research Fellow, AGBU

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Executive Summary

1.1 Overview

This project was established to conduct R&D in genetic improvement of pork production to support the objectives of APL's Strategic Plan. The priorities for specific R&D projects were identified by the Pig Genetics Consultative Group which became APL Specialist Group 2. This group included representatives from all main breeding companies in Australia. Further objectives of this project were to increase the financial viability of PIGBLUP-related genetic services to the extent that APL funding is only required for new R&D projects and to provide commercial fee-based consultancy services to the Australian pig industry to further increase adoption of genetic principles in the Australian pig industry.

During the five-year period of this project, an active research program was developed which attracted numerous visiting scientists from overseas. Further, this research program was the basis for the development of an R&D program to select robust, healthy pig genotypes that is part of the new CRC for High Integrity Australian Pork. The PIGBLUP-related genetic services have been continued at AGBU without receiving any funds from APL. Fee-based consultancy services were provided to the majority of Australian pig breeding companies and two pig breeding companies overseas.

1.2 Inputs

The funds available from Australian Pork Limited for this project were used to support staff at AGBU to conduct research in pig genetics and fund the annual meetings of the Pig Genetics Consultative Group which later became the APL Specialist Group 2. Additional cash contributions were obtained from the Pork CRC for a specific R&D project (3B-102) to investigate selection strategies for iron content in pork. These additional funds were used for recording haemoglobin levels in blood, iron content in pork and meat quality traits at Rivalea (Australia) Pty Ltd.

In-kind contributions were supplied by AGBU, industry and international research organisations resulting from a) contributions by other AGBU staff supporting the work for this project, b) members of the Pig Genetics Consultative Group/APL Specialist Group 2 and c) visits of international scientists from France (INRA and Institute du Porc), The Netherland (Institute of Pig Genetics) and USA (University of Reno). Combined, these researchers spent the equivalent time period of 12 months of a fulltime staff member at AGBU. In addition, all international collaborators provided considerable amount of data for genetic analyses.

Australian pig breeding organisations using PIGBLUP have always been very willing to make their data available for R&D. Data were obtainable for 40 populations from 17 herds containing performance records of approximately 1,000,000 pigs over the period from 1996 until 2010. In addition, five Australian pig breeding companies provided specific new data for this project in regard to feed intake of sows during lactation, sow body composition, muscle depth recorded with alternative measurement devices and weight of primal cuts.

1.3 Outputs

The activities of this project led to the output of 29 scientific and 41 industry publications and presentations. A total of 24 reports, four grant applications and four business plans were prepared for Australian Pork Limited and Pork CRC.

Improving Market Value of the Carcase

It was demonstrated that backfat and muscle depth recorded with the PorkScan™ system had higher heritability estimates than comparable measurements collected on the live pig with real time ultrasound. The economic benefits of a higher weight in the more valuable cuts of the carcase were quantified and outlined to industry. Genetic parameters were obtained for weight of primal cuts and performance, carcase and meat quality traits based on data from the French national pig breeding program. Alternative selection strategies to improve market value of pig carcases were demonstrated to breeders. This information allows breeders to incorporate additional carcase traits in existing genetic evaluations until genetic parameters for weights of primal cuts based on Australian data are available.

Iron Content in Pork

Iron content had moderate to high genetic associations with haemoglobin levels in blood and colour measures of pork. Estimates of genetic correlations between iron content in pork and measures of lean meat growth were not significant indicating that current selection practices do not lead to lower iron content in pork. The use of steel knives to prepare pork samples in the laboratory increased the mean iron content considerably and reduced repeatability of duplicate samples. Future studies should use ceramic knives to prepare pork samples for measurements of iron content in pork.

Sow Performance

The effects of current selection practices with a focus on increasing growth rate and reducing fatness in the growing pig on mature weight and fat reserves of sows were quantified. Alternative measures of feed intake during lactation were evaluated which lead to the development of five- or ten-day measures of feed intake during lactation thereby reducing the costs of recording. Research of this topic benefitted greatly from collaborations with Kim Bunter (AGBU), Hélène Gilbert (INRA, France), Rob Bergsma (Institute of Pig Genetics, The Netherlands) and Wendy Rauw (University of Reno, USA).

Reducing Variability

Factors contributing to variation in performance were identified for key performance traits. Variation in backfat has decreased considerably since the mid 1990s partly due to the lower mean in backfat. The expected increase in variation for growth rate due to the higher mean was not observed. The temporal changes in mean and variability were explored for still born piglets. In addition, genetic and non-genetic factors affecting still born piglets were identified. Genetic analyses revealed limited genetic heterogeneity in residual variation of sires for growth rate and backfat, thereby limiting opportunities for genetic improvement of sires that produce more homogenous progeny groups within the same environment.

Group Performance and Flight Time

It was shown that interactions between pigs housed in the same group affect growth rate. In addition, characteristics of the group in regard to proportion of males, stocking density, proportion of Duroc pigs, and mean flight time of the group can be used to improve performance. The behavioural trait flight time was heritable and had lowly unfavourable genetic associations with backfat. Selection for calmer pigs may be beneficial for performance of pigs housed in groups.

Increasing Genetic Gain and Productivity in the Australian Pig Industry

The framework to deliver research results to industry previously developed at AGBU was extended in this project by providing additional Pig Genetics Information Sheets, preparing two InnovatE issues for APL, using a new format for web-supported seminars (webinars) and organising the AGBU pig

genetics workshops in 2006, 2008 and 2010. The information arising from these extension pathways are available via the AGBU web pages which were re-designed in 2010 and have been updated continuously.

A number of publications and presentations were delivered to industry in regard to the research topics outlined above. In addition, various publications were prepared in regard to improving genetic gain and productivity in the industry. Avenues to increase genetic gain and breeding objectives used in pig breeding program worldwide were presented to industry. The benefits of using estimated breeding values (EBVs) to select replacement stock were demonstrated using examples available from the Australian pig industry. The improvements in performance observed in Australian purebred herds from 1996 until 2010 was summarised and outlined to industry.

AGBU Pig Genetics Services Funded by Industry
PIGBLUP V6.00 was officially released in March 2009 following extensive testing of beta versions by some users. This new version of PIGBLUP provides greater flexibility in trait definitions for 31 production and carcase traits and included a new module to automate analyses (PigSched). Enhancements were made to various modules of the PIGBLUP software package (PBSAMA, FileMerger, PigCheck) and the PIGBLUP manuals received considerable updates.

All PIGBLUP-based genetic evaluation systems (NPIP, PBSELECT) have been working well and required minimal interference of AGBU staff. Data was submitted regularly and information about AI and link boars was regularly updated. Two large international pig breeding companies bought the PIGBLUP license. Support was also required by two Australian PIGBLUP users following the sale of the enterprise.

1.4 Usage and Impact
Research was conducted in collaboration with Australian pig breeding companies which supports the adoption process. Following the outline of first research results in regard to feed intake of lactating sows and selection to improve the market value of pig carcases, breeders used the information to collect data on farm to evaluate management procedures and made some of these data available for further research.

Collaborations with international visitors were useful for the development of a research program for the CRC for High Integrity Australian Pork to develop selection strategies for robust, healthy pigs.
The extension framework to foster adoption on farm includes pig genetics information sheets, webinars and the biannual AGBU pig genetics workshops. These were attended by representatives from all major Australian pig breeding companies since 2006. All of this information is available via the AGBU pig genetics web pages which rank as the first page on the Australian Google search engine for 'pig genetics'. Internationally the AGBU pig genetics pages rank highly in Google search engines in the USA (#4), UK (#4), Canada (#4), China (#4) and India (#6). The Google algorithm 'is thought to correlate well with human concepts of importance' (Wikipedia, Google search) and the high ranking of the AGBU pig genetics web pages indicates the impact of these pages.

In total, 7,311 page loads have been documented since May 2011 for the AGBU pig genetics pages. A snapshot about the demography of users of the AGBU web pages since June 2011 revealed that most were from Australia (39%) followed by the USA (14%). A further dissection of these users in Australia revealed that the pages are used in all states and the frequency of down loads loosely corresponds to the density of pig populations in Australia. There have been 1,238 downloads of

documents since May 2010, with pig genetics information sheets outlining PIGBLUP related topics and describing the benefits of using estimated breeding values for selection being most popular.

Conducting quality research in pig genetics and working closely with industry to implement research results in practical pig breeding programs has always been the primary goal of the AGBU team. This was acknowledged by an Australian breeder following the 2011 AGBU pig genetics workshop who wrote "I would like to again pass on my congratulations to you and the AGBU team at a great conference over the last two days. It was great to be involved in such an interactive group that were forthcoming with their ideas and happy to share them."

2 Background Information

A review of APL-funded quantitative pig genetics in Australia demonstrated the benefits of improving pig genetic evaluation systems and increasing the adoption of enhanced genetic evaluation tools and strategies used in pig breeding programs (Walters, 2006). It was also recognised that close collaboration between researchers and pig breeding companies would enhance the process of developing priorities for new R&D relevant for the pig industry with subsequent benefits for the adoption process on farm. Therefore, a five-year project was established with the following Project Objectives (APL R&D Project Agreement 2133, 2006):

A) "Provide advice to, and conduct R&D projects approved by, the Pig Genetics Consultative Group (established by APL/AGBU as part of this project) that will maximise the contribution that pig genetic improvement can make towards achieving the objectives in APL's Strategic Plan 2005-2010 (the Project Objective)."
B) "Increase the financial viability of PIGBLUP-related services to the extent that APL funding is only required for new R&D projects."
C) "Increase use of PIGBLUP and related genetic improvement products and services by at least 2% per annum (as measured by the % breeding herd influenced) by facilitating adoption by the Australian pig industry and provision of commercial fee-based consultancy services to provide unbiased, independent advice on genetic improvement to individual piggery managers on a confidential basis."

The two main components of this project were defined as a) developing new R&D projects in response to priorities identified by the Pig Genetics Consultative Group and b) the continuation of extension and consultancy activities to ensure adoption of genetic principles in the Australian pig industry. This distinction between R&D and fee-based commercial services was made because it was also recognised that breeding companies may differ in regard to their priorities for commercial applications. Further, commercial application of pig genetic services is a cost of the breeding program and as such should incur a fee paid by breeders who may request confidentiality about the specific genetic services they have received from AGBU.

This distinction between R&D and fee-based genetic services was always maintained and activities for both areas were summarised in two separate progress reports presented to APL each year. In this final report, the components of the Input to Impact Chain Model used by the CRC Association (CRC, 2007) to evaluate R&D programs are used to summarise the Inputs, Activities, Usage, Outcome and Impact of this project in regard to the R&D undertaken. The adoption of R&D is fostered by the provision of fee-based genetic services and an overview of the main activities related to the AGBU pig genetics services is provided to further highlight the impact of this project in the Australian pig industry. However, this overview of commercial application will remain general to ensure that confidentiality of individual pig breeding enterprises is maintained.

3 Inputs

The funds available from Australian Pork Limited for this project were used to support staff at AGBU including operating costs to conduct research in pig genetics and to fund the annual meetings of the Pig Genetics Consultative Group which later became the APL Specialist Group 2. These funds were supplemented by a number of in-kind contributions from AGBU, industry and international research organisations resulting from a) contributions by other AGBU staff supporting the work for this project, b) members of the Pig Genetics Consultative Group/APL Specialist Group 2 and c) visits of international scientists collaborating with AGBU staff. Further, equally important were the in-kind

contributions of Australian pig breeding companies who provided a considerable amount of data used in genetic evaluations for research purposes.

Further cash contributions were obtained from the Pork CRC for a specific R&D project (3B-102) to investigate selection strategies for iron content. These funds were used for recording haemoglobin levels in blood, iron content in pork and meat quality traits at Rivalea (Australia) Pty Ltd.

Pig breeding companies in Australia and overseas pay license and support fees for AGBU's pig genetic evaluation systems (PIGBLUP, NPIP, PBSELECT). Fee-based consultancies were requested from Australian and international pig breeding companies.

In summary, the funds made available by APL were leveraged considerably by using additional in-kind contributions from AGBU, industry and other researchers as well as additional cash contributions from the Pork CRC and pig breeding companies in Australia and overseas.

3.1 People

3.1.1 AGBU Staff

APL funded research. This project supported Susanne Hermesch (80%), Senior Research Fellow, as the Principal Investigator from October 2006 until June 2011. Rob Jones was employed as a Junior Researcher from March 2007 until June 2011 and Craig Lewis, Research Fellow joined the project from February 2011 until June 2011.

AGBU in-kind contributions. The director of AGBU, Hans Graser provided guidance in the management of this project. Further administrative support was provided by Marlene Youman and Kathy Dobos in regard to arranging meetings of the Pig Genetics Consultative Group/APL Specialist Group 2, organisation of the annual AGBU pig genetics workshops and maintenance of the AGBU pig genetics web pages.

Researchers at AGBU benefit from discussions and collaborations among AGBU staff. In particular the collaboration with Kim Bunter on sow body composition and feed intake during lactation was most beneficial. Further, the comments and feedback provided by colleagues working in pig genetics enhanced publications and presentations of research results to industry and the wider scientific community. Collaboration was provided by Ron Crump and Craig Lewis who were working in pig genetics at AGBU.

The AGBU pig genetics services are funded by breeders through license fees and fee-based consultancies and as such are crucial for the implementation of research results in Australian pig breeding programs. Key members of the AGBU team included Tony Henzell, who continued the development of PIGBLUP; Ron Crump, who maintained the services of the National Pig Improvement Program until 2010. This task was subsequently taken over by Jim Cook at AGBU.

The AGBU pig genetics services were coordinated by Susanne Hermesch (20%) who defined the directions of AGBU's pig genetics evaluation systems based on requests for further development obtained from breeders and provided consultancies to pig breeding companies in Australia and overseas.

3.1.2 Collaborators in Australia

All Australian pig breeding organisations using PIGBLUP-based genetic evaluation systems made their PIGBLUP data sets available for general summary of trends over time. In addition, a number of

Australian pig breeding companies provided data for specific genetic analyses, often recording additional traits for research purposes. These are specifically mentioned along with other research collaborators.

Rivalea (Australia) Pty Ltd was a collaborator in the Pork CRC funded project (3B-102) to obtain genetic parameters for iron content in pork, haemoglobin levels and other performance and meat quality traits. Performance data and haemoglobin measures were collected by Kristy Tickle, while Helen Grigg undertook all pork quality measurements and prepared pork samples for further analyses of iron content. Brian Luxford coordinated the project at Rivalea.

Regional Laboratory Services was contracted by Rivalea to measure iron content in pork. David Paynter developed lab procedures to measure iron content in pork reliably.

Eastern Genetics Resources. Brenden McClelland provided data about flight time in pigs and weight of primal cuts.

Premier Pig Genetics. Bruce Trout initiated recording of muscle depth on farm and in the abattoir at Swickers using PorkScan™ equipment.

Woodlawn. Stuart and Tracey Neuendorf provided feed intake data of lactating sows.

UQ Gatton. Mark Bauer made data available for quantifying heterogeneous genetic variation in residual variation.

Australian Pork Limited. Heather Channon managed research projects related to improving iron content in pork and developing new measurement technologies for carcase composition. Research results and the progress of projects were regularly discussed with Heather Channon.

Greenleaf Enterprises. Phil Green, Brenden Hall and Tim Sweet installed the PorkScan™ system at Rivalea to measure light striping and provided guidance in regard to interpreting information available from the PorkScan™ light-striping system.

3.1.3 Pig Genetics Consultative Group/APL Specialist Group 2

The members of the Pig Genetics Consultative Group and the subsequent APL Specialist Group 2 (since 2008) were:

Brian Luxford, Rivalea Australia (Chair)
Ian Johnsson, APL (2006)
Geoffrey Annison, APL (2007)
Darryl D'Souza, APL (since 2008)
Hans Graser, AGBU
Susanne Hermesch, AGBU
Jeff Braun, Myora Farm
Ranald Cameron, (since 2008)
Brenden McClelland, Eastern Genetics Resources
Paul O'Leary, PIC Australia
Walter Osborne, Cefn (since 2010)
Rolf Sokolinski, Cefn (2006-2009)
Bruce Trout, Premier Pig Genetics

3.1.4 International Visiting Scientists and Collaborators

Norwegian University of Life Sciences and Norsvin, Norway. Susanne Hermesch was invited by the Norwegian University of Life Sciences as the opponent to the public PhD defence by Dr Eli Gjerlaug-Enger and is listed as a reference person for two Norwegian research projects investigating structural soundness in pigs and sows, and iron content in pork and salmon.

Hélène Gilbert (INRA; French National Institute for Agricultural Research, France) stayed at AGBU from January 2010 until April 2010 working on the definition and genetic analysis of a new trait describing feed intake of sows during lactation in relation to their nutrient requirements for performance and maintenance.

Isabelle Mérour (Institute du Porc, France). The genetic analyses of performance, carcase and meat quality traits available from the French national pig breeding database conducted by Isabelle Mérour during her six-month visit at AGBU in 2008 – 2009 provided valuable information about genetic avenues to improve the market value of pig carcases, since similar data are not available for the Australian pig industry.

Rob Bergsma (Institute of Pig Genetics, the Netherlands). The response of individual sow genotypes in feed intake during lactation to variation in temperature and humidity was investigated in this joint research project following Rob Bergsma's visit to AGBU for six weeks in 2008.

Wendy Rauw (University of Reno, USA) was a key note speaker for the conference of the Association for the Advancement of Animal Breeding and Genetics in 2007 to outline consequences of selection for productivity on animal physiology and animal welfare.

Combined these researchers spent the equivalent time period of approximately one FTE staff over one year at AGBU contributing directly to the research outputs of this project. The additional time allocated by these researchers to the collaborative research project after their visit to AGBU visit has not been estimated.

3.1.5 Additional Presenters at AGBU Pig Genetics Workshops

Arranging the AGBU pig genetics workshops every two years in Armidale for the Australian pig industry is a real team effort. Each time, between 12 to 14 papers are presented which would not be possible without the contributions of other AGBU researchers as well as geneticists and scientists from overseas and Australia. The following people presented at the AGBU Pig Genetics Workshops from 2006 until 2010 in addition to Susanne Hermesch (2006, 2008, 2010) and Rob Jones (2008, 2010) from AGBU.

Kim Bunter, AGBU (2006, 2008, 2010)
Rex Walters, Livestock Genetics Ltd, UK (2006, 2008, 2010)
Tony Henzell, AGBU (2006, 2008)
Ron Crump, AGBU (2006)
Isabelle Mérour, Institute due Porc, France (2008)
Brian Kinghorn, University of New England, Armidale (2008)
Craig Lewis, AGBU (2010)
Danye Marois, GeneticPorc, Canada (2008)
Sansak Nakavisut, AGBU (2006)
Scott Newman, Genus/PIC USA, USA (2010)
Max Rothschild, Iowa State University, USA (2010)

Matias Suarez, AGBU (2006)
Poasa Tabuarici, AGBU (2010)
Odd Vangen, Norwegian University of Life Sciences, Norway (2010)
Roger Campbell, Pork CRC (2006)
Chris Moran, University of Sydney, (2006)

3.2 Data Provided by Industry and Collaborators

Australian breeding companies using PIGBLUP have always been very willing to provide their data for R&D purposes. Data were available for 40 populations from 17 individual herds. A population is defined as a specific genotype held in one herd. In total, performance records of approximately 1,000,000 pigs and approximately 370,000 litter records were available from 1996 until 2010. These data were used for multiple analyses including review of phenotypic trends and quantifying sources of variation over time.

3.2.1 Improving Market Value of the Carcase

Muscle depth and weights of primal. Muscle depth measurements were available from the PorkScan™ technology installed at Swickers for two herds. These muscle measurements were recorded from June 2009 until December 2009 and linked with backfat depth recorded with PorkScan™ on the carcase as well as backfat and muscle depth information recorded on farm and primal cut weights. Both data sets were small with either 295 or 415 pigs. It was difficult to obtain information from the abattoir and eventually recording of further carcase data was terminated. These data were provided as in-kind contributions.

French National pig breeding database. Isabelle Mérour used the database from the French national pig breeding program to estimate genetic parameters for 36 traits recorded in test stations and on farm including growth, feed intake, carcase and meat quality traits. A number of traits recorded in France are not available in Australia.

French selection lines for residual feed intake. Data from these French selection lines were used by Hélène Gilbert to evaluate the effect of selection for residual feed intake on actual and residual feed intake of sows during lactation, sow performance and sow body condition.

Exploring opportunities to breed for reduced thermal sensitivity. Rob Bergsma used data from the research herd of the Institute of Pig Genetics, the research organisation of Topigs, to develop random regression (reaction norm) models that quantify the genetic variation in the response of sows in regard to feed intake to variation in temperature during lactation.

Feed intake during growth, maturity and lactation in a mouse model. Wendy Rauw has investigated two selection lines of the Norwegian mouse selection experiment. One line had been selected for higher litter size over 104 generations which was compared with a control line. Phenotypic relationship between feed intake during growth, maturity and lactation were obtained for both selection lines. In addition, the association of these feed intake characteristics and the performance of the litter were defined.

3.2.2 Iron Content in Pork

The Pork CRC funded a project to record haemoglobin levels in blood in 5,000 piglets at five weeks of age and in 2,500 pigs at 21 weeks of age. These pigs were subsequently slaughtered and iron content in pork and pork quality characteristics were recorded in 2,500 pigs. Rivalea (Australia) Pty

Ltd was contracted for this project and provided performance records of approximately 60,000 pigs as an in-kind contribution.

3.2.3 Sow Performance

Sow body composition was recorded for about 800 sows along with feed intake from day four to 14 during lactation. These data were combined with sow performance records and traits describing lean meat growth of the pig. The breeder recorded these data specifically for this project and provided the data as an in-kind contribution.

Sow lactation feed intake. Daily feed intake records during lactation were provided by a breeder for about 2,400 lactations. These data were combined with approximately 5,000 farrowing and 35,000 performance records. Approximately 1,000 sows had information about sow longevity available.

3.2.4 Group Performance and Flight Time

Performance records were available for approximately 10,000 pigs along with information about which pigs had been housed in the same group and the behavioural trait flight time. The flight time data was specifically recorded for research purposes as an in-kind contribution following a call from AGBU at a previous pig genetics workshop to investigate flight time (Graser, 2003).

4 Activity

Activities can be attributed to three main areas related to a) research, b) extension for research results to foster adoption and c) full filling the reporting requirements for Australian Pork Limited and Pork CRC including applications for additional research funds.

The provision of AGBU's pig genetics services were funded by industry and included the support and development of PIGBLUP-based genetic evaluation systems and fee-based consultancy services. Although not funded by Australian Pork Limited, these activities are outlined as well, since they are essential for the adoption of research results in the Australian pig industry and relate to the objectives of this project.

4.1 Research

4.1.1 Improving Market Value of the Carcase

The PorkScan™ system. It was demonstrated that backfat and muscle depth recorded with the PorkScan™ system had higher heritability estimates than comparable measurements collected on the live pig with real time ultrasound [Output P11]

A grant application was prepared in collaboration with Rivalea (Australia) Pty Ltd to obtain information from the PorkScan™ light-striping system and to measure weight of primal cuts in the boning room. This information will be used to develop prediction equations involving light-striping information for weigh of primal cuts and to estimate genetic parameters for key traits [Output G4].
PorkScan™ light-striping system was installed at Rivalea under the guidance of Greenleaf staff. Considerable effort was required to make the system operational in a commercial abattoir and malfunctions are still being observed from time to time.

A description of the information provided by the PorkScan™ light-striping technology was prepared for Australian Pork Limited following a webinar with Greenleaf staff [Output R18].

Australian data. Backfat and muscle depth measurements from the PorkScan™ technology as well as on-farm backfat and muscle depth measurements obtained from the Meritronics ultrasound pulse-echo machine were analysed. In addition, weight of primal cuts was retrieved from the boning room for one herd. These data were used to evaluate phenotypic associations between fat or muscle depth and weight of primal cuts and to obtain first heritability estimates for these traits based on Australian data [Output I12, I9].

French national pig breeding database includes information about weight of primal cuts which was used to quantify the additional economic benefits from increasing the weight of more valuable primal cuts for a fixed carcase weight and fat depth [Output I31].

Genetic parameters were estimated for production, carcase and meat quality traits recorded in French test stations and on farm for four breeds [Output P22, P20, P17, P2].

The effects of the Halothane gene on performance, meat quality and carcase traits including weight of primal cuts were evaluated using the French Pietrain breed [Output P16, P4].

Selection strategies for improving carcase value of pig carcases were evaluated in index calculations using genetic parameters obtained from the French data and presented to industry [Output I41].

4.1.2 Iron Content in Pork

The project was completed as scheduled. Genetic parameters were estimated for haemoglobin levels at five and 22 weeks of age and iron content in pork. Genetic associations between these traits and performance, carcase and meat quality traits were estimated highlighting possible selection strategies to improve iron content and pork quality [Output P24, I37, R24].

Haemoglobin levels in blood were recorded for approximately 5,000 piglets at 5 weeks of age and for approximately 2,500 pigs at 22 weeks of age in two Australian terminal sire lines.

The mean iron content in pork and its repeatability were compared for measurements based on steel versus ceramic knives. The use of steel knives increased the mean iron content of pork and reduced repeatability of duplicate samples [Output R24].

The effect of breed and slaughter day on carcase and meat quality traits including iron content in pork were quantified [Output P8].

Susanne Hermesch was invited by the Norwegian University of Life Sciences as one of two opponents to the public defence of the PhD thesis by Eli Gjerlaug-Enger. The thesis presented new methodology to measure fatty acid composition in pork and outlined selection strategies for pork quality. In addition, Susann Hermesch was invited to explore 'Challenges in pig breeding in the coming decade' with emphasis on carcase and pork quality at the international seminar on pig breeding held at the Norwegian University of Life Sciences prior to the defence [Output I16].

4.1.3 Sow Performance

Sow body composition. The effects of current selection practices on sow attributes were quantified by regressing traits describing sow body composition and feed intake during lactation on estimated breeding values (EBVs) of traits used in pig breeding programs; e.g. growth rate, backfat, litter size and average piglet weight at birth. [Output P5, I40].

Sow lactation feed intake. Genetic analyses of daily feed intake records were conducted to evaluate alternative measures of feed intake during lactation for pig breeding programs. In particular, five- and ten-day measures were developed to reduce the costs of recording feed intake of sows during lactation. Genetic associations of sow feed intake during lactation with traits that are commonly available in pig breeding programs to describe sow longevity, sow performance and lean meat growth of the growing pig were estimated [Output P14, P12, P7, I34].

The effect of low feed intake during lactation on total number of piglets weaned per sow over her lifetime was evaluated [P13].

The Pork CRC invited Susanne Hermesch to outline genetic influences on lactation yield [Output I6].

Kim Bunter and Craig Lewis estimated genetic associations between sow body composition, feed intake during lactation and sow performance as part of a project funded by the Pork CRC focusing on sow lifetime performance. Although the Pork CRC project was much more comprehensive, some results obtained for different Australian genotypes could be compared which deepened the understanding of the underlying mechanisms that affect lactation yield [Output P19, P15, P7, P1].

Hélène Gilbert evaluated alternative models to define sow residual feed intake during lactation and quantified the impact of selection for residual feed intake in the growing pig on sow residual feed intake, sow body condition and sow performance. The use of sow residual feed intake in pig breeding programs as an alternative to sow daily feed intake was proposed to select for efficient sows with lower input demands during lactation while maintaining body condition and performance of the litter [Output P26, P6].

Rob Bergsma explored breeding opportunities for reduced thermal sensitivity of feed intake in Dutch lactating sows. There was an effect of temperature on lactation feed intake, even in a climate-controlled environment of the farrowing shed located in The Netherlands. In addition, there was genetic variation in the response of sows in regard to feed intake to variation in temperature. Complex random regression models were developed for these genetic analyses [Output P29].

Wendy Rauw evaluated the relationship between food intake during growth, maturity and lactation in a mouse model following her visit to Armidale where she outlined the consequences of selection for productivity on animal physiology and welfare [Output P27, I1, R20, G1].

4.1.4 Reducing Variability

Factors contributing to variation in performance were identified for key performance traits. Variation for backfat has decreased considerably since the mid 1990s partly due to the lower mean in backfat. The expected increase in variation for growth rate due to the higher mean was not observed [Output P23, P9].

Genetic analyses revealed limited genetic heterogeneity in residual variation of sires for growth rate and backfat, thereby limiting opportunities for genetic improvement of sires that produce more homogenous progeny groups within the same environment [Output P25].

The temporal changes in mean and variability were explored for still born piglets. In addition, genetic and non-genetic factors affecting still born piglets were identified [Output P22, P10].

4.1.5 Group Performance and Flight Time

The effects of pen mates on performance were evaluated for growth rate and backfat in growing pigs. These effects represent social effects and were estimated for the first time in Australian data. Growth rate was affected by the random pen effect indicating that interactions between pigs housed in the same group affect this trait. Different factors affecting the performance of a group of pigs were identified which included the behavioural trait flight time. It was shown that a lower mean flight time of the group was beneficial for growth rate. Flight time was shown to be heritable and it had a lowly unfavourable genetic correlation with backfat [Output P28, P18, I33, I32].

4.2 Adoption and Training

4.2.1 Extension of Research Results

A framework to deliver research results to the Australian pig industry had been developed in a previous APL-funded project (APL 1711). The different vehicles used to deliver research results to industry include short, succinct articles, industry presentations and the AGBU pig genetics workshop. The AGBU pig genetics information sheets are short two or four page documents targeted at either breeders or producers. Other industry articles were prepared for APL's InnovatE and for the AGBU pig genetics workshops. All of these extension documents are available via the AGBU pig genetic web pages which were re-designed in 2010 and are continuously updated by Kathy Dobos at AGBU. A brief summary of extension of research results to industry is provided for each research topic.

Improving market value of the carcase. The impact of selection for residual feed intake on carcase and meat quality traits was highlighted to industry by Hélène Gilbert in March 2010. The seminar is available from the AGBU web pages [Output I15].

The economic value for increased weight in more valuable primal cuts and the genetic variability in these traits were presented to industry at the AAABG Pork CRC industry day in September 2009 [Output I9].

Phil Green from Greenleaf Enterprise outlined the PorkScan™ technology to breeders during the AGBU pig genetics workshop in October 2008.

The additional return from a carcase with higher weights in the more valuable primal cuts was outlined to breeders at the AGBU pig genetics workshop in October 2008. This additional return was defined as the return that was independent from the variation in carcase weight and fat depth. These two characteristics are currently used to determine the market value of pig carcases [Output I30].

Iron content in pork. Measuring haemoglobin levels on farm using the HemoCue® equipment and iron content in pork was described to breeders at the AGBU pig genetics workshop in 2010. Factors affecting haemoglobin levels in weaner piglets and finishing pigs and iron content in pork were identified and first heritability estimates were presented for these traits [Output I36].

Sow performance. The consequences of selection for lean meat growth and prolificacy on sow weight and sow body condition were demonstrated to breeders by quantifying the increase in mature weight of sows and the reduction in fatness levels resulting from selection for increased lean meat growth [Output I39, I38, I35, I33].

Isabelle Mérour initiated the visit of a French purebred herd which had increased the number of piglets weaned from 28 to 32 per farrowed sow in 5 years. This case study was used to prepare an

information sheet for industry to outline changes in management procedures that had led to this improvement in sow performance [Output I23].

The changing requirements of sows in regard to feed intake during lactation resulting from improved productivity were discussed with industry during the pig genetics workshop held in Brisbane in 2007 [Output I4].

Reducing variability. The main factors contributing to variation in performance of growing pigs were outlined to industry in a webinar in June 2011. In addition, two papers have been prepared for APSA 2011 which will be attended by a number of industry personnel [Output P10, P9, I17].

Increasing genetic gain and productivity in the Australian pig industry. Avenues to increase genetic gain and an overview of breeding objectives used in pig breeding program worldwide were presented to industry [Output I34, I25, I24, I3].

The benefits of using EBVs to select replacement stock were outlined to industry using examples available from the Australian pig industry [Output I22, I24, I18]

The improvements in performance observed in Australian purebred herds from 1996 to 2010 was summarised and outlined to industry [Output I41, I27].

AGBU pig genetics workshops have a long tradition to deliver research results to the Australian pig industry. Workshops were organised for 2006, 2008 and 2010 which involved developing a workshop program, liaising with presenters, editing the workshop notes and coordinating the overall organisation of the workshop.

Opportunities for new research directions were outlined to breeders [Output I37, I27].

Liaison with APL's technology transfer managers. Extension of research results was supported by Geogy Philip and Emalyn Loudon at Australian Pork Limited who publicised AGBU's research results and the AGBU pig genetics workshops via the technology transfer program. Articles were prepared for InnovatE, the e-newsletter of APL [Output I19, I20].

4.2.2 Training of Industry Groups and Students

Pork CRC Commercialisation Bootcamp invited Susanne Hermesch to describe the commercialisation process of PIGBLUP as one of the chosen case studies available from the Australian pig industry [Output I13].

Delivery of genetics module for CHM Alliance. A two-day workshop on genetic aspects of pig production was delivered to approximately 20 people working in the Australian pig industry as part of a graduate diploma in pig production offered by the CHM Alliance.

Primary Industry Centre for Science Education (PICSE) encourages High School students to study primary industries at university. This centre is very active at UNE and Susanne Hermesch provided an overview of pig genetics principles applied in the Australian pig industry in 2010 and 2011 to about 50 students in total [Output L3, L1].

Guest lectures at the University of New England were prepared for third and fourth-year students in animal breeding and genetics outlining the genetic evaluation tools used in the Australian pig industry [Output L4, L2].

4.3 Reporting and Grant Applications

4.3.1 Reports for APL and Pork CRC

Progress and final reports were prepared for Australian Pork Limited on a regular basis as defined in the schedule of this project. Separate progress reports were prepared for Australian Pork Limited to summarise the annual achievements in regard to research and AGBU's pig genetics services. These two areas were kept separate to maintain the confidentiality of commercial breeding companies while still fulfilling the reporting requirements in regard to the objectives of this project [Output R8 to R17, R19, R20].

The secretariat of the Pig Genetics Consultative Group which became APL Specialist Group 2, was provided as part of this project. This involved organising the annual meetings, preparing an annual work plan and, since 2008, developing annual business plans for the funds allocated to this project [Output BP1 to BP4].

The iron project funded by the Pork CRC required quarterly progress reports and a final report. In addition, a number of webinars were held with Australian researchers working in this area to discuss research results across Australian studies [Output R1 to R7, R23].

4.3.2 Grant Applications

Research Project Proposal for Program 2 was prepared in collaboration with Brian Luxford as part of the bid of the Pork CRC for the CRC for High Integrity Australian Pork. The proposal outlined the consequences of selection for productivity and described avenues to select for reduced environmental sensitivity and improved disease and stress resistance. A key aspect of this research project was the international collaboration with Iowa State University, USA (Prof Jack Dekkers) and INRA, France (Dr Hélène Gilbert) [Output G3].

Iron content in pork. A research project was developed to estimate genetic parameters for iron content in pork as well as haemoglobin levels in blood, performance and meat quality traits. This project involved collaboration with Rivalea [Output G2].

Weight of primal cuts. A research proposal was initiated to record and characterise light-striping measures of the PorkScan™ technology and to estimate genetic correlations between PorkScan™ light-striping measures and primal cut weights as well as other performance traits. This research project was conducted in collaboration with Rivalea and Greenleaf Enterprises under the management of Heather Channon at APL [Output G4].

4.4 AGBU Pig Genetics Services Funded by Industry

Although these services are funded by pig breeding companies, these activities are crucial for the uptake of research results by the Australian pig industry and therefore complete the adoption process of research results arising from APL funded projects.

4.4.1 PIGBLUP Development

The new PIGBLUP V6.00 was officially released in March 2009 following extensive testing of beta versions by users since April 2007. This version of PIGBLUP provides greater flexibility in trait definitions for 31 production and carcase traits. In addition, a new module was added to automate

analyses, a number of enhancements were made to the PBSAMA module of PIGBLUP and the stand-alone program FileMerger. This program is used to transform data of any format into the specific PIGBLUP format. Enhancements were also made to PigCheck which can be used by clients to identify errors in the data set. The PIGBLUP manuals received substantial updates including specific chapters for PigSched and PigCheck [Output PB1 to PB4].

4.4.2 Maintenance of PIGBLUP-Based Genetic Evaluation Systems

The on-line genetic evaluation systems of the National Pig Improvement Program (NPIP) and PBSELECT have both been working well with minimal interference required by AGBU staff. Users of both systems submit data regularly. The list of AI boars and link boars has been update for the NPIP genetic evaluation system.

4.4.3 Support and Training of Clients

Support of existing clients has traditionally been provided via e-mail, phone and occasional face to face meetings. This support has been enhanced by the use of a commercial web-based facility which allows AGBU staff to view and operate, if necessary, the computer of the PIGBLUP client.

A considerable amount of support was required for data preparation and data transfer between PIGBLUP and the corresponding herd recording system. AGBU staff has liaised regularly with programmers of two commercial herd recording systems in Australia (MIPS, EliteHerd) to outline specific data formats in regard to preparation of data for PIGBLUP analyses and upload of EBVs from PIGBLUP's genetic evaluations into the herd recording system.

The enterprises of two existing Australian PIGBLUP users were sold and the new operators required the equivalent amount of support of a new user to make best use of PIGBLUP by the new business owner.

Enquiries from potential PIGBLUP clients were received from Australia, Argentina, Belarus, Canada, China, Hungary, Venezuela and Zimbabwe. The vast majority of enquiries did not lead to the sale of a PIGBLUP license. However, two large overseas companies have purchased the PIGBLUP license for their genetic evaluation systems following extensive discussions about the use of PIGBLUP in their pig breeding program. These companies employ in-house geneticists who require specific technical support covering all aspects of design of pig breeding programs.

Pham Thi Kim Dung (National Institute Animal Husbandry, Hanoi, Vietnam) was the recipient of the 2007 Crawford Fund Fellowship to receive training in the use of PIGBLUP for genetic improvement of pigs during her three-month stay at AGBU in 2008 [Output R21].

4.4.4 Fee-Based Consultancies

The adoption of research results is facilitated in fee-based consultancies requested by pig breeding companies. Advice is provided in regard to definition and extension of breeding objectives, evaluation of new traits and their use in pig breeding programs followed by the review of phenotypic and genetic trends to audit the success of the breeding program.

5 Outputs

In summary, there were 29 scientific and 41 industry publications and presentations arising from this project. Four lectures were delivered to student groups at the University of New England and students participating in the summer program of the Primary Industries Centre for Science Education (PICSE). A total of 24 reports were prepared for Australian Pork Limited and Pork CRC in addition to four grant application and four business plans to secure existing and additional funding.

5.1 Scientific Publications

5.1.1 Refereed Journal Articles

Published

[P29] Bergsma, R. and S. Hermesch (2011). Exploring breeding opportunities for reduced thermal sensitivity of feed intake in the lactating sow. Journal of Animal Science, published online July 25.

[P28] Jones, R.M., Crump, R.E. and S. Hermesch (2011). Group characteristics influence growth rate and backfat of commercially raised grower pigs. Animal Production Science, 51, 191-197.

[P27] Rauw, W. M., Hermesch, S., Bunter, K. L. and L. Gomez-Raya (2009). The relationship of food intake during growth and food intake at maturity with lactation food intake in a mouse model. Livestock Science 123:249-254.

Forthcoming

[P26] Gilbert, H.; Bidanel, J.P.; Billon, Y.; Lagant, H.; Guillouet, P.; Sellier, P.; Noblet, J. and S. Hermesch. (2011). Correlated responses in sow appetite, residual feed intake, body composition and reproduction after divergent selection for residual feed intake in the growing pig. Journal of Animal Science (submitted).

[P25] Lewis C.R.G. and S. Hermesch. An examination of the genetic heterogeneity of residual variance for production traits in Australian pigs. Journal of Animal Science (submitted).

[P24] Hermesch, S. and R.M. Jones. Genetic parameters for haemoglobin levels in pigs and iron content in pork. Draft manuscript completed for internal review.

[P23] Lewis C.R.G. and S. Hermesch. A dissection of the factors contributing to trait variation in Australian pig populations. Draft manuscript completed for internal review.

[P22] Lewis, C.R.G. and S. Hermesch. Temporal changes in phenotypic and genetic factors associated with still born piglets. Draft manuscript completed for internal review.

5.1.2 Refereed Conference Articles

Published

[P21] Barwick S. A., Swan A. A., Hermesch S. and H.-U. Graser (2011). Experience in breeding objectives for beef cattle, sheep and pigs, new developments and future needs. Proceedings of the 19th Association for the Advancement of Animal Breeding and Genetics, Perth, 19th to 21st July, 2011, pp. Pp. 23-30, invited paper.

[P20] Mérour, I., Tribout, T. and S. Hermesch (2010). Variabilité inter races des poids des pièces de carcasse et corrélations génétiques avec les critères de qualité de la viande chez le porc. 42nd Journées de la Recherche Porcine. February 3. pp.161-166.

[P19] Bunter, K. L., Luxford, B. G., Smits, R. and S. Hermesch (2009). Associations between sow body composition, feed intake during lactation and early piglet growth. Proceedings of the 18th Conference of the Association for the Advancement of Animal Breeding and Genetics. Barossa Valley, South Australia. September 28-October 1. pp.203-206.

[P18] Jones, R. M., Hermesch, S. and R. E. Crump (2009). Evaluation of pig flight time, average daily gain and backfat using random effect models including grower group. Proceedings of the 18th Conference of the Association for the Advancement of Animal Breeding and Genetics. Barossa Valley, South Australia. September 28-October 1. pp.199-202.

[P17] Mérour, I., Hermesch, S., Schwob, S. and T. Tribout (2009). Effect of the halothane genotype on growth performances, carcass and meat quality traits in the Pietrain Breed of the French National Pig Breeding Program. Proceedings of the 18th Conference of the Association for the Advancement of Animal Breeding and Genetics. Barossa Valley, South Australia. September 28-October 1. pp.191-194.

[P16] Mérour, I., Hermesch, S., Jones, R. M. and T. Tribout (2009). Genetic correlations between carcass length, fat and muscle depths and primal cut weights in the French Large White Sire line. Proceedings of the 18th Conference of the Association for the Advancement of Animal Breeding and Genetics. Barossa Valley, South Australia. September 28-October 1. pp.195-198.

[P15] Bunter, K. L., Luxford B. G. and S. Hermesch (2007). Associations between feed intake of growing gilts, lactating sows and other reproductive or performance traits. Proceedings of the 17th Conference of the Association for the Advancement of Animal Breeding and Genetics, Armidale, New South Wales, Australia, 23rd - 26th September 2007, pp. 268-271.

[P14] Hermesch, S. (2007). Genetic analysis of lactation feed intake of sows. Proceedings of the 17th Conference of the Association for the Advancement of Animal Breeding and Genetics, Armidale, New South Wales, Australia, 23rd - 26th September 2007, pp. 61-64.

[P13] Hermesch, S. and R. M. Jones (2007). Low feed intake in lactation reduces lifetime performance of sows. Manipulating pig production XI. Proceedings of the 11th Biennial Conference of the Australasian Pig Science Association (APSA), Brisbane, Australia, 25 - 28 November, p 196.

[P12] Jones, R. M. and S. Hermesch (2007). Season and parity effects on the feed intake of lactating sows in an Australian commercial piggery. Manipulating pig production XI. Proceedings of the 11th Biennial Conference of the Australasian Pig Science Association (APSA), Brisbane, Australia, 25 - 28 November, p 36.

Forthcoming

[P11] Hermesch, S. and R. M. Jones (2011). Higher heritability estimates for fat and muscle depth obtained using the PorkScan™ system. In: Manipulating pig production XIII. Proceedings of the 13th Biennial Conference of the Australian Pig Science Association, Adelaide, 27 - 30 November, accepted.

[P10] Lewis, C.R.G. and S. Hermesch (2011). A phenotypic and genetic analysis of still born piglets. In: Manipulating pig production XIII. Proceedings of the 13th Biennial Conference of the Australian Pig Science Association, Adelaide, 27 - 30 November, accepted.

[P9] Lewis, C.R.G. and S. Hermesch (2011). Phenotypic trends in means and variation for backfat and growth rate of the growing pig. In: Manipulating pig production XIII. Proceedings of the 13th Biennial Conference of the Australian Pig Science Association, Adelaide, 27 – 30 November, accepted.

[P8] Tickle, K.M., Grigg, H., Jones, R.M., Luxford B.G. and S. Hermesch (2011). Breed and slaughter day affects carcase and pork quality. In: Manipulating pig production XIII. Proceedings of the 13th Biennial Conference of the Australian Pig Science Association, Adelaide, 27 - 30 November, accepted.

5.1.3 International Journal and Conference Articles

[P7] Bunter, K. L., Lewis, C. R. G., Hermesch, S., Smits, R. and B. G. Luxford (2010). Maternal capacity, feed intake and body development in sows. Proceedings of the 9th World Congress on Genetics Applied to Livestock Production. Leipzig, Germany, 1-6 August, invited paper.

[P6] Gilbert, H., Billon, Y., Lagant, H., Calderon, J. A., Guillouet, P., Bidanel, J.-P., Noblet, J., Sellier, P. and S. Hermesch (2010). Correlated responses in sow feed intake, body composition and reproduction after divergent selection for residual feed intake in the growing pig. Proceedings of the 9th World Congress on Genetics Applied to Livestock Production. Leipzig, Germany, 1-6 August.

[P5] Hermesch, S., Jones, R. M., Bunter, K. L. and H. Gilbert (2010). Consequences of selection for lean growth and prolificacy on sow attributes. Proceedings of the 9th World Congress on Genetics Applied to Livestock Production. Leipzig, Germany, 1-6 August.

[P4] Mérour, I; Schwob, S; Hermesch, S and Larzul, C (2009). Effet du génotype halothane sur les performances de croissance, qualitiés du carcasse et de viande. TechniPorc 32(6):1-5.

5.1.4 International Presentations

[P3] Hermesch, S and Bunter, K L (2009). "Lactation feed intake of sows – An update of the Australian work." Presentation at Pig Breeders Round Table, Canterbury, UK, 29 April.

[P2] Mérour, I; Hermesch, S; Jones, R M and Tribout, T (2009). "Genetic parameters for carcase traits in the four French national pig breeds." Presentation at Pig Breeders Round Table, Canterbury, UK, 30 April.

[P1] Bunter, KL, S Hermesch, B G Luxford and R M Jones (2008) Feed intake of growing gilts, lactating sows and associations with other traits. Presentation at Pig Breeders Round Table, Canterbury, UK, April 2008.

5.2 Industry Articles

5.2.1 Pig Genetics Workshop Notes

[I41] Hermesch, S. and R. M. Jones (2010). Phenotypic trends for traits of the growing pig and the sow. AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2010, pp 1-8.

[I40] Hermesch, S. and R. M. Jones (2010). Strategies to improve market value of pig carcases. AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2010, pp 39-46.

[I39] Hermesch, S. (2010). Consequences of selection for lean growth and prolificacy on piglet survival and sow attribute traits, AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2010, pp 59-64.

[I38] Hermesch, S. and K. L. Bunter (2010). Busting myths to broaden our horizons. AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2010, pp 73-78.

[I37] Hermesch, S. and B. G. Luxford (2010). Towards healthy, productive genotypes. AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2010, pp 97-100.

[I36] Jones, R. M. and S. Hermesch (2010). First genetic analysis of blood haemoglobin levels and iron content in pork. AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2010, pp 9-16.

[I35] Bunter, K. L., Smits, R., Luxford, B. G. and S. Hermesch (2008). Sow body composition and its associations with reproductive and litter growth performance of the primiparous sow. Pig Genetics Workshop Notes, Armidale, Australia, October 2008, pp 67-82.

[I34] Hermesch, S. (2008). Adoption of further traits to increase genetic gain in the $Index. AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2008, pp 9-14.

[I33] Hermesch, S., Jones, R. M. and K. L. Bunter (2008). Feed intake of sows during lactation has genetic relationships with growth and lifetime performance of sows. Pig Genetics Workshop Notes, Armidale, Australia, October 2008, pp 55-66.

[I32] Jones, R. M. and S. Hermesch (2008). When pigs fly; what does this mean? Pig Genetics Workshop Notes, Armidale, Australia, October 2008, pp 39-46.

[I31] Jones, R. M. and S. Hermesch (2008). Group characteristics influence the performance of individual commercially raised pigs. Pig Genetics Workshop Notes, Armidale, Australia, October 2008, pp 47-54.

[I30] Mérour, I. and S. Hermesch (2008). Variation and trends for weight of individual carcase cuts. Pig Genetics Workshop Notes, Armidale, Australia, October 2008, pp 83-92.

[I29] Bunter, K., Hermesch, S. and B. G. Luxford (2006). Sow feed intake and lifetime reproductive performance. AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2006, pp 35-43.

[I28] Hermesch, S. (2006). First analysis of factors influencing feed intake of sows during lactation. AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2006, pp 44-49.

[I27] Hermesch, S. (2006). From genetic to phenotypic trends. AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2006, pp 59-65.

[I26] Hermesch, S. (2006). Outline of R&D directions for Australian pig genetics. AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2006, pp 79-89.

[I25] Hermesch, S. and R. E. Crump (2006). Tips for making better use of PIGBLUP. AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2006, pp8-15.

[I24] Suarez, M., Braun, J.A. and S. Hermesch (2006). The relationship between reproductive performance of crossbred sows and the EBVs of their purebred dams. AGBU Pig Genetics Workshop Notes, Armidale, Australia, October 2006, pp 30-34.

5.2.2 Pig Genetics Information Sheets

[I23] Hermesch S., Mérour, I., Ligonesche, B. and L. Dartois (2010). From 28 to 32 piglets per farrowed sow per year in 5 years – A case study from France. Pig Genetics Information Sheet. Producer 6.

[I22] Jones, R. M. and S. Hermesch (2009). Comparing AI boar selection strategies. Pig Genetics Information Sheet. Producer 5.

[I21] Hermesch, S. (2008). Towards higher feed intake of sows during lactation. InnovatE, Australian Pork Limited, Canberra.

[I20] Hermesch, S. (2008). AGBU Pig Genetics Workshop. InnovatE Issue 32, Australian Pork Limited, Canberra, November 2008.

[I19] Hermesch, S. (2008). Towards higher feed intake of sows during lactation. InnovatE Issue 30, Australian Pork Limited, Canberra, February 2008.

[I18] Jones, R. M., Brewster, C. and S. Hermesch (2008). Demonstrating Estimated Breeding Values – a case study. Pig Genetics Information Sheet. Producer 4.

5.2.3 Industry Presentations

[I17] Lewis, C. R. G. and S. Hermesch (2011). "Towards more uniform pig performance." AGBU phone webinar, 1 June.

[I16] Hermesch, S. (2011). "Challenges in pig breeding in the coming decade." International Seminar on Pig Breeding, Norwegian University of Life Sciences, 10 March.

[I15] Gilbert, H. (2010). "Selection for residual feed intake in the growing pig – Responses for carcase composition and meat quality traits." AGBU phone webinar, 17 March.

[I14] Bunter, K. L., Hermesch, S., Jones, R. M. and Lewis, C. R. G. (2009). "Sow lactation feed Intake." Invited presentation for Pork CRC Refresher workshop on sow reproductive performance, Melbourne 17-18 August.

[I13] Hermesch, S. and H.-U. Graser (2009). "PIGBLUP – a user-friendly genetic evaluation system for pigs." Invited presentation for Pork CRC Commercialisation Bootcamp, Melbourne 17-18 August.

[I12] Hermesch, S. and I. Mérour (2009). "Exploring variation in saleable meat yield." AGBU phone webinar, 21 January.

[I11] Hermesch, S and K. L. Bunter (2009). "Lactation feed intake of sows – An update of the Australian work." Presentation at Pig Breeders Round Table, Canterbury, UK, 29 April.

[I10] Hermesch, S. (2009). "Flight time – a selection criterion for meat and eating quality in pigs?" Presentation to staff at Institut du Porc, France 5 May.

[I9] Hermesch, S. and I. Mérour (2009). "Improving market value of the Australian pig carcase." AAABG Breeders Day 30 September.

[I8] Jones, R. M. and S. Hermesch (2009). "BLUP selected boars versus non-BLUP selected boars – a comparison." AGBU phone seminar, 26 August.

[I7] Jones, R. M. and S. Hermesch (2009). Comparing selection of strategies of AI boars – BLUP selection is superior." AGBU phone seminar, 16 December.

[I6] Hermesch, S. and K. L. Bunter (2008). Genetic influences on aspects of lactation performance. Invited presentation at Pork CRC "Increasing Lactation Yield" workshop, Melbourne, 11 - 12 September.

[I5] Hermesch, S. (2007). "Choosing the pig genotypes that are best for your herd". Electronic Seminar Series. PigLink 2007 Program of the National Centre for Pork Industry Training and Education, Roseworthy, South Australia, 15 August.

[I4] Hermesch, S. and K. L. Bunter (2007) Exploring feed intake of lactating sows. Presentation at pig genetics workshop, Brisbane, 25 November.

[I3] Hermesch, S. (2007). Increasing genetic gain and reducing genetic slippage. Presentation at pig genetics workshop, Brisbane, 25 November.

[I2] Hermesch, S, Jones, R. M. and K. L. Bunter (2007). The importance of recording feed intake in lactating sows. Recorded AGBU pig genetics presentation.

[I1] Rauw, W. M. (2007) Physiological consequences of selection for increased performance in pigs. Phone seminars to Australian pig breeders. 20 & 27 September.

5.2.4 Guest Lectures

[L4] Hermesch, S. (2011). Pig genetics for the Australian pig industry, January 2011, Primary Industries Centre for Science Education (PICSE), University of New England.

[L3] Hermesch, S. (2010). Introducing the science of genetics in pigs. January 2010, Primary Industries Centre for Science Education (PICSE), University of New England.

[L2] Hermesch, S. (2010). Pig breeding – overview of Australian tools for genetic evaluations, modified September 2010, guest lecture for Gene351, University of New England.

[L1] Hermesch, S. (2007). Pig breeding – overview of Australian tools for genetic evaluations, September 2007, guest lecture for Gene422, University of New England.

5.3 Reports and Applications

5.3.1 Final Reports

[R24] Hermesch, S. and R. M. Jones (2010). Genetic parameters and breed differences for iron content in pork. Pork CRC Project 3B-102. Final Report, August 2011, pp 23.

[R23] Mérour, I and S. Hermesch (2009). Genetic parameters for production, carcase and meat quality traits in the four French national breeds. Confidential report to IFIP and AGBU, March 2009, pp 76.

[R22] Pham Thi, K. D. and S. Hermesch (2008). ATSE Crawford Fund Fellowship 2007 Report. Final Report. June 2008, pp 64.
[R21] Hermesch, S (2007). Distinguished visitor award – Dr Wendy Rauw, APL2200.04, Final report for Australian Pork Limited, pp 5.

5.3.2 Progress Reports and Confidential Reports

[R20] Hermesch, S (2011). Quantitative Genetics R&D 2006-2011. 5th Annual Progress Report for Australian Pork Limited. August 2011, pp 66.

[R19] Hermesch, S. (2011). AGBU Pig Genetics Services, Confidential annual report for Australian Pork Limited. September 2011, pp 2.

[R18] Hermesch, S. (2011). General description of information contained in data file from PorkScan™ recordings. Confidential report for Australian Pork Limited, Project 2010-2321.05, pp. 3.

[R17] Hermesch, S. (2010). Quantitative Genetics R&D 2006-2011. 4th Annual Progress Report for Australian Pork Limited. September 2010, pp 53.

[R16] Hermesch, S. (2010). AGBU Pig Genetics Services, Confidential annual report for Australian Pork Limited. September 2010, pp 3.

[R15] Hermesch, S. (2009). Quantitative Genetics R&D 2006-2011. 3rd Annual Progress Report for Australian Pork Limited. September 2009, pp 66.

[R14] Hermesch, S. (2009). AGBU Pig Genetics Services, Confidential annual report for Australian Pork Limited. July 2009, pp 6.

[R13] Hermesch, S. (2008). Quantitative Genetics R&D 2006-2011. Papers for the 4th PGCG Meeting. 2nd Annual Progress Report for Australian Pork Limited. September 2008, pp 49.

[R12] Hermesch, S. (2008). 3rd Progress Report, AGBU Pig Genetics Services, Confidential annual report for Australian Pork Limited. August 2008, pp 13.

[R11] Hermesch, S. (2008). 2nd Progress Report, AGBU Pig Genetics Services, Confidential progress report for Australian Pork Limited. September 2007, pp 4.

[R10] Hermesch, S. (2007). Quantitative Genetics R&D 2006-2011. Papers for the 3rd PGCG Meeting. Progress Report for Australian Pork Limited. September 2007, pp 24.

[R9] Hermesch, S. (2007). Quantitative Genetics R&D 2006-2011. Papers for the 2nd PGCG Meeting. Progress Report for Australian Pork Limited. April 2007, pp 19.

[R8] Hermesch, S. (2007). 1st Progress Report, AGBU Pig Genetics Services, Confidential progress report for Australian Pork Limited. April 2007, pp 4.

[R7] Hermesch, S and Jones R M (2011). Genetic parameters and breed differences for iron content in pork. PorkCRC Project 3B-102. Quarterly Progress Report Q1, 2011; submitted April 2011.

[R6] Hermesch, S. and R. M. Jones (2011). Genetic parameters and breed differences for iron content in pork. PorkCRC Project 3B-102. Quarterly Progress Report Q4-2010; submitted January 2011.
[R5] Hermesch, S. and R. M. Jones (2010). Genetic parameters and breed differences for iron content in pork. PorkCRC Project 3B-102. Quarterly Progress Report Q3-2010 submitted October 2010.

[R4] Hermesch, S and Jones R M (2010). Genetic parameters and breed differences for iron content in pork. PorkCRC Project 3B-102. Quarterly Progress Report Q2-2010; submitted July 2010.

[R3] Hermesch, S and R. M. Jones (2010). Genetic parameters and breed differences for iron content in pork. PorkCRC Project 3B-102. Quarterly Progress Report Q1-2010 submitted April 2010.

[R2] Hermesch, S. and R. M. Jones (2010). Genetic parameters and breed differences for iron content in pork. PorkCRC Project 3B-102. Quarterly Progress Report Q4-2009; submitted January 2010.

[R1] Hermesch, S. and R. M. Jones (2009). Genetic parameters and breed differences for iron content in pork. PorkCRC Project 3B-102. Quarterly Progress Report Q3-2009 submitted October 2009.

5.3.3 Grant Applications and Business Plans

[G4] Hermesch, S. and B. G. Luxford (2010). Measurement of primal cut weights using the PorkCan™ technology. Grant application for Australian Pork Limited.

[G3] Hermesch, S. and B. G. Luxford (2010). Breeding healthy, robust pig genotypes. Research Project Proposal of Program 2 as part of the bid of the Pork CRC for the CRC for High Integrity Australian Pork.

[G2] Hermesch, S. (2009). Genetic parameters and breed differences for iron content in pork. Grant application for Pork CRC and Australian Pork Limited.

[G1] Hermesch, S. (2007). Distinguished visitor award – Dr Wendy Rauw. Grant application for Australian Pork Limited.

[BP4] Hermesch, S. and B. G. Luxford (2011). 2011-2012 Business Plan, Genetics, genetic modification and genetic transfer (SG2), Confidential Business Plan prepared for Australian Pork Limited, February 2011, pp 10.

[BP3] Hermesch, S., Luxford B. G. and R. Cameron (2010). Research & Innovation Specialist Group 2 Business Plan, Genetics, genetic modification and genetic transfer, 2010-2011,Confidential Business Plan prepared for Australian Pork Limited, February 2010, pp 10.

[BP2] Hermesch, S., Luxford, B. G. and R. Cameron (2009). Research & Innovation Specialist Group 2 Business Plan, Genetics, genetic modification and genetic transfer, 2009-2010, Confidential Business Plan prepared for Australian Pork Limited, February 2009, pp 10.

[BP1] Hermesch, S., Luxford, B. G. and R. Cameron (2008). Research & Innovation Specialist Group 2 Business Plan, Genetics, genetic modification and genetic transfer, 2008-2009, Confidential Business Plan prepared for Australian Pork Limited, February 2008, pp 16.

5.4 Other Industry-Funded Outputs

5.4.1 PIGBLUP Manuals

Crump, R. E., Henzell, A. L., Hermesch, S. and K. J. Dobos (2009). PIGBLUP version 6.00 User Manual. Animal Genetics and Breeding Unit, University of New England, Armidale, Australia, pp119.

Crump, R. E., Hermesch, S. and K. J. Dobos (2009). PIGBLUP Selection and Mate Allocation (PBSAMA) & Marker (PBMARKER) Modules User Manual, PIGBLUP V6.00. Animal Genetics and Breeding Unit, University of New England, Armidale, Australia, pp26.

Henzell, A. L., Hermesch, S. and K. J. Dobos (2009). FileMerger version 2.00, distributed with PIGBLULP version 6.00. Animal Genetics and Breeding Unit, University of New England, Armidale, Australia, pp37.

Henzell, A. L., S. Hermesch and K. J. Dobos (2005). FileMerger version 1.00, distributed with PIGBLULP version 5.20. Animal Genetics and Breeding Unit, University of New England, Armidale, Australia, pp35.

6 Usage and Impact

6.1 Improving Market Value of the Carcase

The economic weight for more valuable primal cuts at a given carcase weight is the price difference with other less valuable primal cuts. This simple concept can be used by pig breeders to incorporate aspects of saleable meat yield in pig breeding programs.

Genetic parameters for weight of the ham, shoulder, loin and belly and their genetic associations with growth performance, feed efficiency and meat quality traits can be used by Australian pig breeders to consider these traits in genetic evaluations until genetic parameters are available for these traits based on Australian dissection methods.

It was shown that backfat and muscle depth had higher heritabilities based on PorkScan™ measures in comparison to measures on the live animal. The more accurate information available from the PorkScan™ technology can be used to calibrate on-farm measures and allow further genetic improvement of these traits.

The description of PorkScan™ light-striping information is useful for the development of prediction equations for weight of primal cuts and identification of key parameters for estimation of genetic parameters.

The very low heritability for muscle depth recorded with Meritronics ultrasound pulse-echo machine indicates that this measure of muscle depth on farm is not very useful for pig breeding programs.

6.2 Iron Content in Pork

More accurate measures of iron content in pork arising from the use of ceramic versus steel knives in the laboratory during preparation of meat samples will aid development of industry policies in regard to the desired levels of iron content in pork.

A more accurate measure of iron content in pork will be beneficial for any research project that aims to identify factors affecting iron content in pork. Most research trials are considerably smaller than the number of records available for genetic analyses and more accurate measurements of iron will reduce the measurement error and therefore improve the scope of future research to identify factors affecting iron content in pork.

Iron content in pork is heritable and can be improved by considering it in pig breeding programs. Haemoglobin levels at 22 weeks can be used as a selection criterion for iron content in pork and some colour measurements. However, further refinement of measuring haemoglobin levels in blood is required.

High genetic correlations between colour measures and iron content in pork will be useful for pig breeding companies that are able to retrieve information from the abattoir for their breeding program.

Current selection practices focussing on productivity are not expected to affect iron content in pork, since no genetic associations were found between performance traits and iron content in pork. This implies that other changes in husbandry practices have contributed to the lower iron content in pork observed over time.

The on-farm measure of haemoglobin levels in blood can be used to identify the haematological status of sows and pigs with potential benefits for sow longevity and piglet survival.

6.3 Sow Performance

Breeders used the outline of the importance of a higher feed intake of sows during lactation for sustained productivity and sow longevity to evaluate actual feed intake levels of sows during lactation on farm. This highlighted some management issues of feeding sows during lactation on some farms which were subsequently rectified with positive outcomes for sow performance. In addition, the outline of results from the data investigated initially, led to the availability of a second data set that also had sow body composition traits in addition to feed intake of sows during parts of lactation. This was then used to demonstrate the effects of selection for productivity on mature weight and fat levels of sows.

A five-day measure of feed intake during lactation was demonstrated as a selection tool for feed intake during lactation. This is useful for breeders, since it reduces the costs of recording feed intake during lactation.

Sows have the genetic potential for a 30-kg higher body weight resulting from a genetic gain of 100 grams in lifetime growth rate of the growing pig. This estimated increase in mature weight of sows resulting from selection for higher growth rate can be used by industry to plan the changes required in husbandry practices and housing conditions to accommodate the changing needs of sows.

Similarly, it was estimated that selection for lower backfat in the growing pig reduces fat depth in sows by 1.5 mm for every one mm genetic gain in backfat during the growth period. This information is useful for industry to develop strategies that balance the nutrient requirements of the sow and the growing litter with the nutrients available from body reserves and feed intake during lactation of sows.

This project provided avenues via the AGBU pig genetics workshop to make results from a Pork CRC project on sow lifetime performance more widely available to industry.

6.4 Reducing Variability

The identification of factors that contributed to trait variation in Australian pig populations demonstrated that little variation is due to factors that cannot be influenced on farm (season, parity) and most of the variation is from factors that can be manipulated (weight, choice of sire, early maternal environment). Producers can use this information to reduce variability on farm by reducing the variation in weight at point of measure for backfat, utilizing more genetically homogenous boars and reducing variation in key sow attributes that affect lifetime growth rate.

Also evident was the need to further define environments so that fixed effects can model the animals' individual performance more precisely with further opportunities for producers to reduce variation on farm. Current models were able to explain 26 to 33 of the variation for performance traits and 11 to 26 of the variation observed for reproductive traits of the sow demonstrating the magnitude of potential improvement arising from more precise definition of the environment which is one of the aims of Program 2 of the CRC for High Integrity Australian Pork.

The residual variance is defined as the variance not explained by the model. There was limited genetic heterogeneity in residual variation of sires for growth rate and backfat. Therefore, breeders

have limited opportunities to breed sires that produce more homogenous progeny groups within the same environment.

The improvement in mean performance in backfat and growth rate achieved since the mid 1990s due to genetic and non-genetic factors has been accompanied by favourable changes in the variation in these traits. Variation in backfat has decreased, partly due to the lower mean in backfat. The expected increase in variation in growth rate due to the higher mean was not observed.

The number of still born piglets has increased during the last 15 years and selection as well as husbandry practices need to be modified to prevent further increase in this trait.

The number of still born piglets had a similar heritability than litter size and breeders can incorporate this trait in pig breeding programs using genetic parameters available from this project.

Producers should evaluate the specific effects of parity, gestation length, total born and sow attributes on still born piglets on farm to implement husbandry practices that prevent a further increase in still born piglets over time.

6.5 Group Performance and Flight Time

Performance of pigs housed in groups has been shown to be lower than performance of pigs housed individually. This study identified characteristics of the group a pig belongs to that can be manipulated by husbandry practices to improve performance of individual pigs.

Breeders can use flight time to breed calmer pigs which are beneficial for the performance of pigs housed in groups.

The random effect of the grower group accounted for 15% of the variation in growth rate highlighting the need for breeders to record this piece of information for future research. This random effect represents the social interactions between pigs within a group which may provide further avenues to improve performance of animals within groups.

6.6 Contributions of International Visitors

The collaboration with Hélène Gilbert from INRA was invaluable for the development of the research program for the CRC for High Integrity Australian Pork (HIAP). International collaborations are beneficial for the CRC for HIAP when it is possible to combine resources. In particular the selection lines available at INRA will be explored for potential future collaborative research.

Rob Bergsma (Institute of Pig Genetics and Wageningen UR, the Netherlands). The investigations on the response of sows to variation in temperature in regard to feed intake during lactation were part of Rob Bergsma's PhD thesis at Wageningen UR. Reaction norm models were used by Rob Bergsma for these analyses, providing AGBU staff with first experiences in the use of these models for genotype by environment interactions that describe environmental conditions on a continuous scale. These models will also be used for extensive data analyses planned for the CRC for High Integrity Australian Pork to develop selection strategies for less environmentally sensitive pig genotypes.

The review about consequences of selection for productivity on animal physiology and animal welfare by Wendy Rauw was used for the application of the CRC for HIAP. It was the basis of many discussions among AGBU staff and breeders which heightened awareness of some unfavourable associations that had received less attention in the past.

6.7 AGBU Pig Genetics Workshops

The 2006, 2008, 2010 biannual AGBU pig genetics workshops were attended by 29, 23, 29 people, respectively. Participants provided feedback to the presentations at each workshop in regard to a) interest and relevance of the topic presented, b) likelihood of implementing the information and c) interest in further information about the topic.

The topics that were regarded as most interesting and relevant were:
2006 workshop:

- Sow feed intake and lifetime reproductive performance (Kim Bunter, AGBU)
- PIGBLUP update (Tony Henzell, AGBU)
- Tips for making better use of PIGBLUP (Susanne Hermesch, AGBU)
- Prospects for genetic improvement of meat and eating quality – where do we go from here? (Rex Walters, UPB World, UK)
- The relationship between reproductive performance of crossbred sows and the EBVs of their purebred dams (Matias Suarez, AGBU)
- Outline of R&D directions for Australian pig genetics (Susanne Hermesch, AGBU)

2008 workshop:

- Carcase measurements of PorkScan™ (Phil Green, Greenleaf Enterprise)
- Feed intake of sows during lactation – growth and sow lifetime performance (Susanne Hermesch, AGBU)
- Sow body composition and reproductive and litter growth performance of gilts (Kim Bunter, AGBU)
- Adoption of further traits to increase genetic gain in $Index (Susanne Hermesch, AGBU)

2010 workshop:

- Genetic and genomic technologies from A – Z (Max Rothschild, Iowa State University, USA)
- Consequences of selection for lean growth and prolificacy on piglet survival and sow attribute traits (Susanne Hermesch, AGBU)
- Mate selection in pigs: a porcine match.com (Scott Neman, PIC USA, USA)
- Sow development, reproductive performance and longevity (Kim Bunter, AGBU)
- Heat stress: the effects of temperature on production and reproduction traits (Craig Lewis, AGBU)
- Improving piglet survival: traits for piglet vitality at birth (Poasa Tabuaciri, AGBU).

Participants rated the likelihood of implementing or using parts of the information as highly:
2006 workshop:

- The relationship between reproductive performance of crossbred sows and the EBVs of their purebred dams (Matias Suarez, AGBU)
- PIGBLUP update (Tony Henzell, AGBU)
- First analysis of factors influencing feed intake of sows during lactation (Susanne Hermesch, AGBU)
- Sow feed intake and lifetime reproductive performance (Kim Bunter, AGBU)
- NPIP and PBSELECT (Ron Crump, AGBU)

2008 workshop:

- PIGBLUP update (Tony Henzell, AGBU)
- Sow body composition and reproductive and litter growth performance of gilts (Kim Bunter, AGBU)
- Carcase measurements of PorkScan™ (Phil Green, Greenleaf Enterprise)
- Feed intake of sows during lactation – growth and sow lifetime performance (Susanne Hermesch, AGBU)
- Variation and trends for weights of individual carcase cuts (Isabelle Mérour, Institute due Porc, France)
- Adoption of further traits to increase genetic gain in $Index (Susanne Hermesch, AGBU)

2010 workshop:

- Genetic and genomic technologies from A – Z (Max Rothschild, Iowa State University, USA)
- Prolificacy and survival (Kim Bunter, AGBU)
- Sow development, reproductive performance and longevity (Kim Bunter, AGBU)
- Strategies to improve market value of pig carcases (Susanne Hermesch, AGBU)
- Improving piglet survival: traits for piglet vitality at birth (Poasa Tabuaciri, AGBU).
- Heat stress: the effects of temperature on production and reproduction traits (Craig Lewis, AGBU)

Participants were interested in further information about:
2006 workshop:

- Body length and its genetic relationships with production and reproduction traits in pigs (Sansak Nakavisut, AGBU)
- Sow feed intake and lifetime reproductive performance (Kim Bunter, AGBU)
- First analysis of factors influencing feed intake of sows during lactation (Susanne Hermesch, AGBU)
- Prospects for genetic improvement of meat and eating quality – where do we go from here? (Rex Walters, UPB World, UK)
- The relationship between reproductive performance of crossbred sows and the EBVs of their purebred dams (Matias Suarez, AGBU)

2008 workshop:

- Carcase measurements of PorkScan™ (Phil Green, Greenleaf Enterprise)
- Sow body composition and reproductive and litter growth performance of gilts (Kim Bunter, AGBU)
- Feed intake of sows during lactation – growth and sow lifetime performance (Susanne Hermesch, AGBU)
- Genomic selection (Brian Kinghorn, University of New England)
- Adoption of further traits to increase genetic gain in $Index (Susanne Hermesch, AGBU)

2010 workshop:

- Genetic and genomic technologies from A – Z (Max Rothschild, Iowa State University, USA)
- Improving piglet survival: traits for piglet vitality at birth (Poasa Tabuaciri, AGBU).
- Have we forgotten about inherited diseases (Rex Walters, UPB Genetic World)

6.8 AGBU Web Pages

The AGBU web pages were updated in May 2010 implementing a new design which is based on a cover page outlining AGBU's involvement in research, extension, genetic evaluation systems and consultancy services. Different sections are then provided for Research, Workshops, Information Sheets, Presentations, PIGBLUP and the National Pig Improvement Program (NPIP). A 'What's New' section highlights the latest and upcoming events. In order to monitor the use of the AGBU pig genetics pages a software package was installed which provides information about page loads, download of documents and information about visitors.

The pages are accessed following standard internet searches. The analyses of keywords revealed that 31% of recorded visits were based on the search term 'pig genetics'. For this search term, the AGBU pig genetics pages are listed as the first web page in the Australian Google search engine. Web pages are ranked by Google based on a patented algorithm that 'is thought to correlate well with human concepts of importance.' (Wikipedia, Google search). Internationally, the AGBU pig genetics pages rank highly in the USA (#3), UK (#4), Canada (#4), India (#6) and China (#4) as well as various other countries that use different languages (e.g. Philippines, #2; France, #1; Ukraine, #1 and Spain, #2).

In total 7,311 page loads have been documented since May 2010. Further distinctions were made between different sections of the AGBU pig genetics pages in September 2010. Since then, 980 page loads have been documented for the PIGBLUP section. The number of page loads was 750 for the pig genetics workshop section, 622 for the section showing the pig genetics information sheets and 430 for the section outlining previous presentations. On average there were over 450 page loads per month highlighting the use of these web pages.

Information about the location of each visitor was logged since June 2011 providing a snapshot about the demography of users of the AGBU pig genetics pages. Most users were from Australia (39%) followed by the USA (14%), Philippines (6%), China (3%), Canada (3%) and The Netherlands, Peru, South Africa, United Kingdom with 2% each. These main countries accounted for over 70% of the page loads. Overall, there were over 50 countries represented in this log of visitors.

A further dissection of these users revealed that most were from New South Wales (17% including 6% from Armidale) followed by Queensland (7%), Victoria (5%), South Australia (4%), Western Australia (2%) and Australian Capital Territory (2%). This overview demonstrates that the pages are used in all states and the frequency of down loads loosely corresponds to the density of pig populations in Australia.

The summary also provides information about the number of downloads of each document. In total, there have been 1,238 downloads of documents since May 2010 highlighting the wide use of the documents related to pig genetics available on the AGBU web pages. In comparison to other categories of information, the pig genetics information sheets were downloaded most with 449 downloads. In addition, 198 downloads were documented related to AGBU's PIGBLUP-based genetic evaluation systems. These documents are also shown in the format of the pig genetics information sheets further demonstrating that short, succinct two- or four-page documents are a useful tool to disseminate information to industry. Finally, there was considerable interest (227 downloads) in the presentations shown on the web pages.

The top 20 documents in regard to the number of logged downloads are shown in Table 1, highlighting that information about AGBU's genetic evaluation systems based on the PIGBLUP engine were of most interest. Most of the pig genetics information sheets outline information about the

concept and use of estimated breeding values (EBVs), further demonstrating that this type of information remains important to industry, since it does have direct practical implication on the selection of replacement stock.

Table 1: Number of recorded downloads (N) since May 2010 of documents shown on the AGBU pig genetics web pages.

Category*	N	Document
PIGBLUP	81	Hermesch, S; Crump, R.E. and A. H. Henzell (2005) Genetic evaluation systems for pigs used in Australia. AGBU Pig Genetics Information Sheets, PIGBLUP 1.
PGI	72	Hermesch S., Mérour, I., Ligonesche, B. and L. Dartois (2010). From 28 to 32 piglets per farrowed sow per year in 5 years – A case study from France. Pig Genetics Information Sheet. Producer 6.
PRES	64	Jones, R.M. and Hermesch S. (2009) Comparing selection strategies of AI boars – BLUP selection is superior.
PGI	63	Hermesch, S; Crump R E; Henzell, A and H.-U. Graser (2004). Benefits of using PIGBLUP in pig breeding programs. Pig Genetics Information sheet, Breeder 1.
PIGBLUP	62	Hermesch, S and Crump R E. (2006) PBSELECT: The online PIGBLUP service. Pig Genetics Information sheet, PBSELECT 1.
PGI	60	Hermesch, S. (2005). Selection strategies for increased litter size and reduced litter mortality. Pig Genetics Information sheet. Breeder 2.
PRES	53	Rauw W. M. (2007). Physiological consequences of selection for increased performance in pigs. Pig Genetics Presentation.
PGI	45	Hermesch, S. (2005). Sow reproductive performance - Selection for litter size only is not enough. Pig Genetics Information sheet, Breeder 3.
PRES	45	Hermesch, S. (2011). Challenges in pig breeding in the next decade.
PRES	39	Hermesch, S., Jones R.M. and K. L. Bunter (2008). The importance of recording feed intake in lactating sows.
PGI	35	Jones, R.M., Brewster, C. and S. Hermesch (2008). Demonstrating Estimated Breeding Values – a case study. Producer 4
PGI	33	Hansson, A., Bunter, K. and S. Hermesch (2005). Boar EBVs predict differences in average progeny performance better than the boar's own performance. AGBU Pig Genetics Information Sheets, Breeder 4.
PGI	33	Jones, R.M. and S. Hermesch (2009). Comparing AI boar selection strategies. Pig Genetics Information Sheet. Producer 5.
PIGBLUP	32	Hermesch, S and R. E. Crump (2002). The National Pig Improvement Program. Pig Genetics Information sheet. NPIP 1.
PGI	32	Hermesch, S. (2003). EBVs are a better predictor of genetic differences between pigs than performance records. Pig Genetics Information sheet, Producer 1.
PRES	32	Gilbert, H. (2010). Selection for residual feed intake in the growing pig – responses for carcase composition and meat quality traits.
PGI	27	Hansson, A., Hermesch, S. and R. E. Crump (2005). Evaluating trial designs for a proof of EBVs demonstration. AGBU Pig Genetics Information Sheets, Breeder 5
PGI	27	Hermesch, S (2003). Using EBVs to select replacement stock improves profitability. Pig Genetics Information sheet, Producer 3.
PRES	27	Hermesch, S. and I Merour (2009) Exploring variation in saleable meat yield.
PGW-Notes	26	Mérour, I. and S. Hermesch (2008). Variation and trends for weight of individual carcase cuts. Pig Genetics Workshop Notes, Armidale, Australia, October 2008, pp 83-92.

* Category: PIGBLUP: topic related to genetic evaluation systems based on the PIGBLUP engine; PGI: Pig genetics information sheets; PRES: Presentation; PGW-Notes: Pig genetics workshop notes.

6.9 Specific Feedback from the Australian Pig Industry

Improving the understanding of genetic principles and their effective use in pig breeding to increase the profitability of sustainable pork production has always been the overall goal of this project. In order to achieve this goal, special efforts have been made to disseminate information about research outcomes to industry via a number of avenues outlined in this report. This support was acknowledged by a number of people working in the Australian pig industry.

In January 2008, the importance of recording feed intake in lactating sows was outlined in phone seminars. An InnovatE article was prepared for Geogy Philips from APL at the same time, who provided feedback about this issue of InnovatE mentioning that "Ian Parish (an APL Board member) was highly complementary of this issue and the statements in the e-mail that accompanied it. To the point of letting Enzo Allara, Emily Mackintosh and Andrew Spencer know about ... how scientific information should be presented."

Industry personnel may contact Susanne Hermesch asking for general information about pig genetics and past research projects. The veterinarian of a large Australian pork producer provided the following feedback: "Thanks for the time this morning. I have found the publications & conversations on the SB, PBA, TB, PWM saga very useful. I have been prompted by your work to extract large data sets and look at the risk factors around perinatal mortality. The success of the initial work (multiple regressions of 30,000 farrowings at 1 site) has demonstrated perinatal deaths are largely a function of litter size which has increased over time due in part to better mating shed management and selection of heavier gilts. There are many housing related issues which are being teased out by other techniques. The net effect is, I was able to present some sensible options based on fact - we now have some supervisors looking at perinatal mortality with new eyes." (e-mail 21 July 2008).

Following the 2011 AGBU pig genetics workshop, an Australian breeder wrote "I would like to again pass on my congratulations to you and the AGBU team at a great conference over the last two days. It was great to be involved in such an interactive group that were forthcoming with their ideas and happy to share them."