Preface

At the 16th AAABG conference in 2005, a proposal was launched to organise a symposium to examine advances in understanding of "adaptive fitness, both in managed populations being conserved and domestic animal species being utilised for food and agriculture production". After discussion about the term "adaptive fitness" some of us decided we should organise a symposium "Adaptation and Fitness in Animal Populations – Evolutionary and breeding perspectives on genetic resource management" to be held at the 2007 AAABG meeting in Armidale.

The term 'adaptive fitness' in itself is somewhat a tautology, but fitness and adaptation are both relevant concepts when one is concerned with the long term sustainability of animal breeding programs and animal production systems in a broader sense. Fitness of farm animal populations is clearly becoming a concern, especially in programs that have achieved substantial genetic change for 'production traits' or where environmental stressors are intense. Adaptation is required to maintain fitness in new or changing environments. Adaptive mechanisms are very important in animal production systems where genotypes are used globally without being explicitly tested in all the environments where they are kept. Adaptability is also important within animal production systems experiencing large between-year variability in the environment. Understanding such mechanisms and their relationships with the production traits may help to more successfully realise sustainable productivity gains.

Evolutionary geneticists are continuously exploring the genetic mechanisms that surround fitness and adaptation in natural populations. Consequently it seemed appropriate to have a debate among animal geneticists and evolutionary biologists. The chapters from this book are a reflection of the symposium papers that were presented in September 2007 in Armidale. The book is divided into four sections, corresponding to the different sessions that we identified for the symposium. Each of these sessions addressed specific questions that we had posed before the symposium. We asked the chair of each session to summarise the discussion and this discussion summary completes the set of papers for each section of the book.

Prof. Stuart Barker's primary life's work has been directed at understanding fitness and the evolution of natural populations. He begins the book by reviewing developments over time in the definition of fitness and its components. This assisted us in arriving at a uniform set of terms for use in addressing these components.

Animal breeders have clearly been very successful in achieving selection goals. In high-input production systems in particular, dairy cows are now much more productive, sheep produce more and better wool, and cattle, broilers, and pigs grow faster and have improved meat quality. Fitness, in the sense of general health, wellbeing and reproductive ability, is commonly perceived to have declined in farm animal populations particularly of developed country production systems. Why? One straightforward model is to consider fitness as just another quantitative trait. There appears to be a negative genetic correlation with production traits and if fitness as such is not selected for, one would expect a decline. The problem could then be resolved by simply measuring fitness and including it in the selection objective. However, fitness appears to encompass complexes of characters – do these fitness characters behave like other quantitative traits? And why is the correlation with production traits negative? Can we trust that the simple quantitative genetic model will work? At this symposium, Prof. Dick Frankham explores the genetic architecture of fitness characters and shed some light on those questions. Prof. Mike Goddard discusses the same issues in the context of animal breeding programs and makes suggestions for accommodating fitness in breeding objectives.

When considering long term consequences of selection (in the farm animal context more than 10–20 generations), the main question is how genetic variation can be maintained as well as exploited, particularly for fitness traits. We are somewhat surprised by the amount of genetic variation that is still observed for traits after many generations of artificial selection. In natural populations, considerable variation exists for fitness even after millions of years of natural selection. Prof. Bill Hill and Dr. Xu-Sheng Zhang review the mechanisms that determine genetic variation and the implications for maintenance of variation in long term (artificial) selection programs. Prof. Mark Blows and Prof. Bruce Walsh discuss the constraints to selection response and adaptation, and explore whether within a multi-dimensional selection space all points are equally attainable. Dr. Piter Bijma addresses the question of how to best utilise genetic variation for fitness traits in selection programs. A relatively new approach in animal breeding is the use of a genetic model that includes effects of interactions between individuals within populations. Such models can be used to select against aggressiveness in livestock populations, an aspect that is clearly linked to fitness and animal welfare.

Adaptation is a key principle for individuals to survive in the environment they are managed in. With the possibility of environmental changes, e.g. due to global warming and perhaps increased variability of climate events, the ability to adapt to such changes has become a key issue. Dr. Kathleen Donohue discusses the ability of organisms to affect, or rather determine their environment, and how this can form a basis for genotype by environment interaction and how it can determine response to selection for phenotypic performance in different environments. Prof. John James presents principles and examples that are used in animal breeding literature to model genotype by environment interaction and interprets the meaning of different modelling approaches. An important question is how to assess fitness in different environments In *Drosophila*, fitness has been measured extensively under laboratory

conditions, and Prof. Ary Hoffman explores to what extent such assessments can be extrapolated to natural conditions.

Maintaining enough variation and diversity in genetic resources is an essential component of animal breeding programs as it is a key for maintaining fitness. Prof. Brian Kinghorn et al. give an overview of the concepts and proposed strategies for maintaining genetic diversity in breeding programs. The objective of directional selection for increased merit needs to be balanced with the objective to maintain diversity. International bodies such as FAO have made considerable investments in developing strategies to assist the countries of the world to better manage their farm animal genetic resources. Dr. Louis Ollivier and Dr. Jean-Louis Foulley review measures of between and within population diversity, demonstrating also the strengths and weaknesses of this information when trying to establish conservation tactics and population adaptability. Prof. John Gibson gives an outline on the possible roles for the different institutional entities that have a responsibility to implement sustainable utilisation and conservation policies for farm animal genetic resources.

Finally, to celebrate the contributions over 55 years by Professor Stuart Barker to the research, development and teaching of population and quantitative genetics, we dedicated the symposium to him. Stuart's passion is "genetics". Fitness and adaptation have been important keywords in his research career. He has been instrumental in translating these fundamental concepts to applications in animal breeding and to the characterisation and conservation of genetic resources. This symposium brought together scientists in evolutionary genetics and animal breeding in the hope that lessons can be learned about the relevance of fitness in domesticated breeding populations and how fundamental questions about fitness and adaptation can be addressed through experimental results and observations in natural populations. Stuart has always been a strong advocate of such interactions and this book creates a unique opportunity for mutual benefits for both groups.

We thank all authors of this book for their contributions and for reviewing the contributions of their colleagues. We thank the chairpersons of the symposium for summarising the session discussions for this book. We thank Dr. Keith Hammond for raising the original idea of the symposium and the book, and his tireless efforts in keeping us on track in many ways. In relation to the program, we thank Professor Stuart Barker for his succinct and effective suggestions, Professor Frank Nicholas for his cheerful and thoughtful contributions and Professor Bill Hill for his advice on topics and speakers. We are very grateful to Kathryn Dobos who did a tremendous and meticulous job in fixing up errors in the 'final version' of the manuscript. Finally we acknowledge the financial support of the Federal Department of Agriculture, Fisheries and Forestry (DAFF) and Meat and Livestock Australia (MLA).

Armidale, NSW Australia

J. van der Werf
H.-U. Graser
R. Frankham
C. Gondro