AGRICULTURAL SCIENCE AND THE ACADEMIES OF SCIENCE IN AUSTRALIA

by Graham **Faichney**[1]

Introduction

In Australia, there is no peak body for the agricultural sciences that is the exact equivalent of the French Academy of Agriculture. However, for the physical and biological (including medical and agricultural) sciences and their applications, the peak body to which a scientist may be elected is the Australian Academy of Science. For the applied sciences and engineering, the peak body is the Australian Academy of Technological Sciences and Engineering. The two Academies overlap to some degree in their coverage of the applied sciences and it is not unknown for a person to be elected to each Academy.

The Australian Academy of Science

The Academy of Science was founded in 1954 by Australian Fellows of the Royal Society of London. It was granted a Royal Charter which established it as an independent body but with government endorsement. The Academy's Constitution was modelled on that of the Royal Society of London. It receives government grants towards its activities but has no statutory obligation to government.

Objectives and Functions

The objectives of the Academy are to promote science through the recognition of outstanding contributions to science, improving education and public awareness, contributing to science policy debate and maintaining international relations. The Council, which is elected by the Fellows of the Academy, manages the business of the Academy to implement its objectives. The decisions of the Council are carried out by the secretariat in Canberra, supervised by the Executive Committee. The objectives of the Academy are met through a range of activities, not least of which is the contribution of scientific advice to government for the purposes of policy development through submissions to government ministers and parliamentary inquiries. In providing that advice, the Academy’s Fellowship assists government not only to formulate evidence-based policy and inform decision-making, but also assists to inform domestic and international public debate. The President of the Academy is, by virtue of that position, a member of the Prime Minister's Science, Engineering and Innovation Council. The Council advises the Prime Minister on important scientific issues. The Academy has published many reports on public issues such as national research policy setting, stem cell research, human cloning, pesticides, ecological reserves, food quality, genetic engineering, space science and climate change.

Fellowship – election of Fellows

The Fellowship of the Academy is made up of just under 450 of Australia's top scientists, distinguished in the physical and biological sciences and their applications. Each year twenty scientists, judged by their peers to have made an exceptional contribution to knowledge in their field, are elected to

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Fellowship of the Academy. Election is subject to a searching examination of the candidate's published works, including reference to leading scientific researchers around the world. This examination is undertaken by one of thirteen committees of Fellows called Sectional Committees. The Sectional Committees are arranged so that the Academy encompasses the many specialised fields of science within broad subject areas. Three of these Committees cover agriculture and its plant and animal sciences. Also, no more than two Fellows may be elected every three years on the basis of distinguished contributions to science by means other than personal research. A small number of distinguished foreign scientists with substantial connections to Australian science are elected as Corresponding members. The strict limitation imposed on the number of new Fellows elected each year is one of the instruments that assist in ensuring the scientific standing of Fellows. Upon election, a scientist is designated as a Fellow of the Academy and may use the post-nominal FAA.

Programs and activities

Fellows contribute to the Academy in an honorary capacity by serving on Council, committees and as advisors. In addition to the Sectional Committees, the Academy maintains National Committees which are widely representative of its disciplines. The broad aims of these Committees are to foster a designated branch or theme of natural science in Australia and to serve as a link between Australian scientists and overseas scientists in the same field. Each Committee may have up to eight members including its chairman, who is a Fellow, and representatives of its corresponding scientific societies. The aims of the Committees are to liaise with the appropriate national and international bodies and societies, to propose and encourage scientific activities in Australia, to ensure the maximum participation by Australian scientists in relevant activities of the international body and to keep the international body informed at appropriate times of Australian opinions and plans. Their activities may include discipline reviews, forums, conferences and workshops and the preparation of submissions to government enquiries. They provide advice to Council and contribute to science policy issues.

The Academy has a program of international scientific and technological collaborations which aim to improve Australian access to science and technology and to increase awareness of Australian research. The program gives Australian researchers the opportunity to collaborate with foreign colleagues, to widen research perspectives and experience, to exchange ideas, to be recognised in the international arena, to gain information and knowledge of techniques that will stimulate and advance Australian research, and to be involved in large international projects. The Academy manages international programs with countries in Europe, North America, China, Japan, Korea and Taiwan.

The Academy produces an on-line education web-site for schools and has programs to support the teaching of science in Australia. It produces reference books, works on the history of science in Australia and a variety of reports and conference proceedings. The Academy shares editorial responsibility with CSIRO for the twelve Australian Journals of Scientific Research and each year awards a series of medals, lectures and prizes to early-career and career scientists.

The Australian Academy of Technological Sciences and Engineering

Founded in 1976 as the Academy of Technological Sciences, it was renamed the Academy of Technological Sciences and Engineering in 1987.

Objectives and Functions

The Academy was established to foster excellence in technological sciences and engineering to enhance Australia's competitiveness, economic and social well-being and environmental sustainability and to recognise and promote the achievements of Australian scientists, engineers and technologists. It provides a national forum for discussion and debate of issues critical to Australia's future. It aims to selectively provide robust, independent and informed advice to government, industry and the community, to improve education in the technological sciences and engineering, to promote technological sciences and engineering linkages globally, to foster technology transfer and to champion excellence in technological sciences and engineering. It maintains a strong interest in major policy areas including Climate Change Impact, Water, Energy and Education. The Academy also has working groups discussing a number of key themes such as Health & Biotechnology and Information & Communication Technology. It also maintains links with a wide variety of international bodies and worldwide expertise in technological sciences and engineering through active international programs and exchanges.

Fellowship – election of Fellows

The Academy is made up of some 800 members who are elected to Fellowship in recognition of their impact and excellence of achievement. Fellowship of the Academy is by peer nomination. Fellows annually nominate potential Fellows and, after a rigorous process, successful candidates are elected to Fellowship. Upon election, a Fellow may use the post-nominal FTSE.

Programs and Activities

The Academy maintains international networks through exchange programs and workshops. Recent programs have involved Japan, China, Korea and India. Nationally, it has State Divisions whose committees manage the Academy's affairs in each State. The Academy seeks to contribute to regional, state and national debate and to this end it undertakes projects and organises forums in its priority areas. Currently, these are Climate Change Impact, Water, Energy and Education. These forums provide a platform for Fellows with similar and related interests to update their knowledge, assist in their professional development and to debate issues. They identify areas where the Academy should become involved, through initiating projects, preparing advice to governments or others, or raising awareness through symposia, publications, etc. This would require identifying the niche where the Academy would be seen as relevant, authoritative and being capable of mustering the required resources. They provide independent advice for the Academy, providing input in developing the scope and terms of reference for new projects, advice to project directors in the course of the work and comment on draft reports prior to publication. The forums assist in the preparation of submissions to inquiries and other forms of advice that the Academy is periodically requested to provide or chooses to prepare. The Academy presents each year the ATSE Clunies Ross Award for the application of science and technology for the economic, social or environmental benefit of Australia. This Award recognises the achievements of scientists, technologists and innovators across Australia.

Conclusion

Australian scientists who achieve eminence in the agricultural sciences may be recognised by election to Fellowship of either Academy. In this field, the Australian Academy of Science tends towards the more basic disciplines and the Australian Academy of Technological Sciences and Engineering has its emphasis on the more applied and technical aspects of agricultural science.

Despite the importance of agriculture to Australia's culture and economy, it has not been an area of priority for the Federal and State governments. However, although relatively few of the Fellows of both Academies are agricultural scientists, both Academies are now focussing more attention on the key areas of climate change and its likely effects, land use, food security and water resources.

Acknowledgements

The information in this note was taken from the web sites of the Australian Academy of Science (www.science.org.au) and the Australian Academy of Technological Sciences and Engineering (www.atse.org.au).

AN INTRODUCTION TO THE LARGE KANGAROOS OF AUSTRALIA

by Graham **Faichney**[1]

Kangaroos are herbivores belonging to the marsupial subfamily Macropodinae and range in size from about 3 to 80 kg. They are adapted to open forest, woodland and grassland habitats. The smaller species are nocturnal but the larger species are crepuscular. Two of the four species of well-known large kangaroos, the red kangaroo (*Macropus rufus*) and the euro (*M. robustus erubescens*) live in the arid and semi-arid regions of the country and two, the eastern grey kangaroo (*M. gigantea*) and the western grey kangaroo (*M. fuliginosus*) live in woodland and open forest areas of the east and south.

Reproduction

It is the anatomy of the female reproductive tract which is the defining characteristic of marsupials, first recognized by de Blainville in 1816 (cited by Tyndale-Biscoe, 2005). In marsupials, the female has two vaginas and two uteri. The young are born very small after a short gestation, about 33 days in red kangaroos, passing through a median birth canal which is effectively a third vagina. Newborn kangaroos weigh less than 0.01% of maternal weight whereas newborn eutherian mammals weigh about 5% of maternal weight. Upon emergence from the mother's urogenital opening, the cloaca, the newborn makes its way to the mother's pouch where it attaches to a teat. Its life in the pouch is the equivalent of gestation in eutherian mammals. During the first third of pouch life, the joey (as the infant kangaroo is called) remains attached to the teat and develops its immune and nervous systems. The second third of pouch life, during which its physiological functions develop, begins when it relinquishes the teat and lasts until it begins to venture out of the pouch and nibbles grass. During the final third of its pouch life, the joey completes its physical growth to independence, taking milk from the same teat but eating more and more grass until it is too big to re-enter the pouch and is finally weaned, at about 235 days for red kangaroos. The composition of the milk the joey sucks from the teat changes during its development. While attached to the teat during the first phase, the milk secreted by the gland is a dilute fluid high in sugars and low in fat. By the time the joey is weaned, the milk is rich in proteins and fat but contains little sugar.

A feature of reproduction in kangaroos is embryonic diapause. The desert dwelling species, the red kangaroo and the euro, ovulate and mate shortly after parturition. The resulting embryo remains in diapause until the previous offspring leaves the pouch, at which time it resumes development and is born about 32 days later. The female mates again and the cycle is repeated so that, in good conditions, she may have a suckling at foot, an attached young in the pouch and a quiescent embryo in a uterus. If conditions deteriorate so that milk secretion stops and the joey dies, another will be born and enter the pouch, mating will occur and a new embryo will enter diapause. This enables these species to adopt an opportunistic breeding strategy that ensures that the female is always ready to start breeding unless conditions become so bad that she becomes anovulatory. By contrast, the eastern grey kangaroo and the western grey kangaroo are seasonal breeders and give birth in early summer. The eastern grey, whose range extends north into the dry tropics, may mate again in late lactation when conditions there are very favorable. The embryo then will remain dormant until its older sibling leaves the pouch. Thus it retains the capacity for diapause. However, the western grey, which is confined to the winter rainfall regions across southern Australia, does not ovulate during lactation and has lost the capacity for diapause.

Nutrition

The body temperature of marsupials, including kangaroos, is about 2°C lower than that of eutherian mammals. Their basal metabolic rate (BMR) is also lower, being about 70% of the BMR of eutherians so

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that their maintenance requirements and voluntary feed intakes are lower. However, summit metabolism is similar in marsupials and eutherians so their lower BMR does not restrict their ability to cope with low environmental temperatures. The low BMR is associated with a relatively low maintenance requirement for protein which is an advantage when available feed is low in protein. As in ruminants, kangaroos have evolved a forestomach fermentation system to manage the digestion of fibrous plant material. Its superficial resemblance to the rumen misled early observers to think of its functions in the same terms as for ruminants. In fact, the anatomy and function of the kangaroo stomach is more like the colon of monogastric animals such as the horse than the rumen of sheep and cattle. It has a small sacciform section and an enlarged tubiform section for fermentation which leads to the hind-stomach where acid and enzyme secretion occurs in a gastric pouch proximal to the pylorus.

In ruminants, food swallowed after initial mastication mixes in the rumen with residues from previous meals. Thereafter, residues are regurgitated, remasticated and swallowed in a co-ordinated process, rumination, which progressively reduces feed particles to less than a critical size for passage from the rumen. In kangaroos, food is masticated more thoroughly than in ruminants and there is no critical size for the passage of particles to the small intestine. Food entering the stomach is not mixed throughout the contents, particles from separate meals tending to remain separate as mixing is radial rather than axial. Although regurgitation, called merycism, does occur occasionally, it is not a co-ordinated activity like rumination and is not needed for particle comminution. Its role in digestion is not known but it has been suggested that it may aid digestion by stimulating saliva flow and buffering the acids produced by fermentation in the forestomach. In ruminants, reducing equivalents released during the fermentation of feed are converted to methane by methanogenic archaea in the rumen and methane emissions may account for more than 8% of the gross energy intake of sheep and cattle. However, kangaroos emit very little methane, usually not more than 1-2% of their gross energy intake. The passage of particulate matter through their tubiform stomach is relatively more rapid than through the rumen and may prevent the maintenance of an effective population of methanogenic archaea there. The most likely pathway for the removal of reducing equivalents is through reductive acetogenesis. The more rapid rate of passage of particles means that, unlike sheep, kangaroos can maintain their food intake as its fibre content increases. Although digestibility decreases, they are better able to survive on poor quality diets than sheep. Kangaroos share with ruminants the ability to utilize non-protein nitrogen compounds in the diet and in urea recycled from the blood by their incorporation in microbial cells during fermentation in the forestomach. This process enables them to conserve nitrogen when dietary sources are limited and also water as less is needed for urea excretion.

Locomotion

In the field, kangaroos are notable for their large hind legs and their bipedal hopping gait. Their movement is less efficient energetically than the quadripedal gait of other mammals at low speeds when kangaroos use their tail as a fifth leg while bringing their large hind legs forward while walking. However, when speed of movement is greater than 10 km/h, hopping is more efficient as its energy cost remains constant from 10 to 30 km/h while, for quadrupeds, the energy cost of running increases progressively as speed increases. Kangaroos achieve this efficiency by recovering the energy stored in the tendons of the hind legs which are stretched as the legs bend at the end of each stride, more energy being stored at each stride as speed increases. Kangaroos cannot walk backwards and always move their hind legs together when walking or hopping but appear to kick their hind legs independently when swimming.

Population and distribution

The population of large kangaroos is estimated annually by aerial survey and varies widely with seasonal conditions. Nationwide, values from 35-50 million have been reported in recent years. Plant growth is a function of rainfall and, in the arid regions, its unpredictability means that the amount of feed available is variable to which conditions the red kangaroo and euro are well adapted. Modifications brought about since European settlement began in 1788 by the provision of watering points, land clearing and pasture improvement for sheep and cattle husbandry in all regions have resulted in increases in kangaroo populations well beyond the numbers pre-settlement. The red kangaroo is distributed throughout the better watered plains of the arid zone across the continent. The distribution of the euro includes the areas occupied by the red kangaroo but it lives in the hills and ranges rather than on the plains. Its range also extends into the tropics and a sub-species of the euro, the eastern wallaroo (*M. robustus robustus*), extends its distribution to the east coast. The grey kangaroos are found in the eastern and southern parts of Australia where rainfall is seasonal and predictable. The eastern grey kangaroo lives in Queensland, New South Wales, Victoria and Tasmania. The western grey kangaroo, the least numerous of the four species, occurs only where there is winter rainfall. It does not occur in eastern Victoria or Tasmania but is found from western Victoria and western New South Wales through South Australia to Western Australia. The ranges of the four species overlap in western New South Wales.

Competition with livestock and population management

As kangaroos are found in association with domestic livestock, there is a perception that they compete for the available feed. Their food selection differs from that of cattle but is quite similar to that of sheep. Studies have shown that direct competition between kangaroos and sheep is insignificant when the available biomass exceeds 200 kg of dry matter per hectare but the perception of competition remains. Such low levels of available biomass can occur in the dry pastoral regions due to their low and variable rainfall and both kangaroos and sheep suffer. As well as apparently competing for feed, kangaroos can damage fencing and crops in their early growth stages in the higher rainfall regions, reinforcing the perception that kangaroos are agricultural pests. Community concern for native animals has increased in recent decades to challenge this perception leading to continuing discussions on what measures if any should be implemented for kangaroo management. Such measures could be aimed at total protection, mitigation of damage or harvesting as a renewable resource. Total protection is impractical in view of the widely held perceptions of kangaroos as pests and would probably be unenforceable. Damage mitigation would require estimates of likely future damage which would be impossible in the pastoral zones given the unpredictability of rainfall. Attempts to reduce local impacts would not have a lasting impact because of the mobility of kangaroos but harvesting for population control is now managed on a broad scale by several State governments. Kangaroos have been hunted for fifty thousand years and are a traditional part of the diet of indigenous Australians. The sale of kangaroo meat for human consumption was illegal in Australia for many years but was legalized in South Australia in 1980 and in all other States in 1993. Kangaroo meat is sold as a game meat. It has a strong flavour, is low in fat and has a high concentration of conjugated linoleic acid compared to other foods. The kangaroo industry is well established and has developed export as well as local markets. The meat has been exported since 1959 and some 70% of it is exported now, much of it to France and Germany. Although harvesting by licensed shooters is controlled so that not more than 10-15% of the population can be taken each year, the variation of kangaroo populations due to fluctuating seasonal conditions is such that continuity of supply cannot be guaranteed. It is important that the harvesting of kangaroos continues to be controlled to ensure that they remain as the iconic faunal symbol of Australia.

Acknowledgements

Information for this note was drawn from works by Hume (1999) and Tyndale-Biscoe (2005). More details can be found in these works, for other marsupials as well as for kangaroos. Caughley, Shephard and Short (1987) report studies in western New South Wales of kangaroos and sheep on the rangeland property, Tandau, compared to kangaroos on the contiguous sheep-free Kinchega National Park.

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