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Advances and Challenges in Deer Biology

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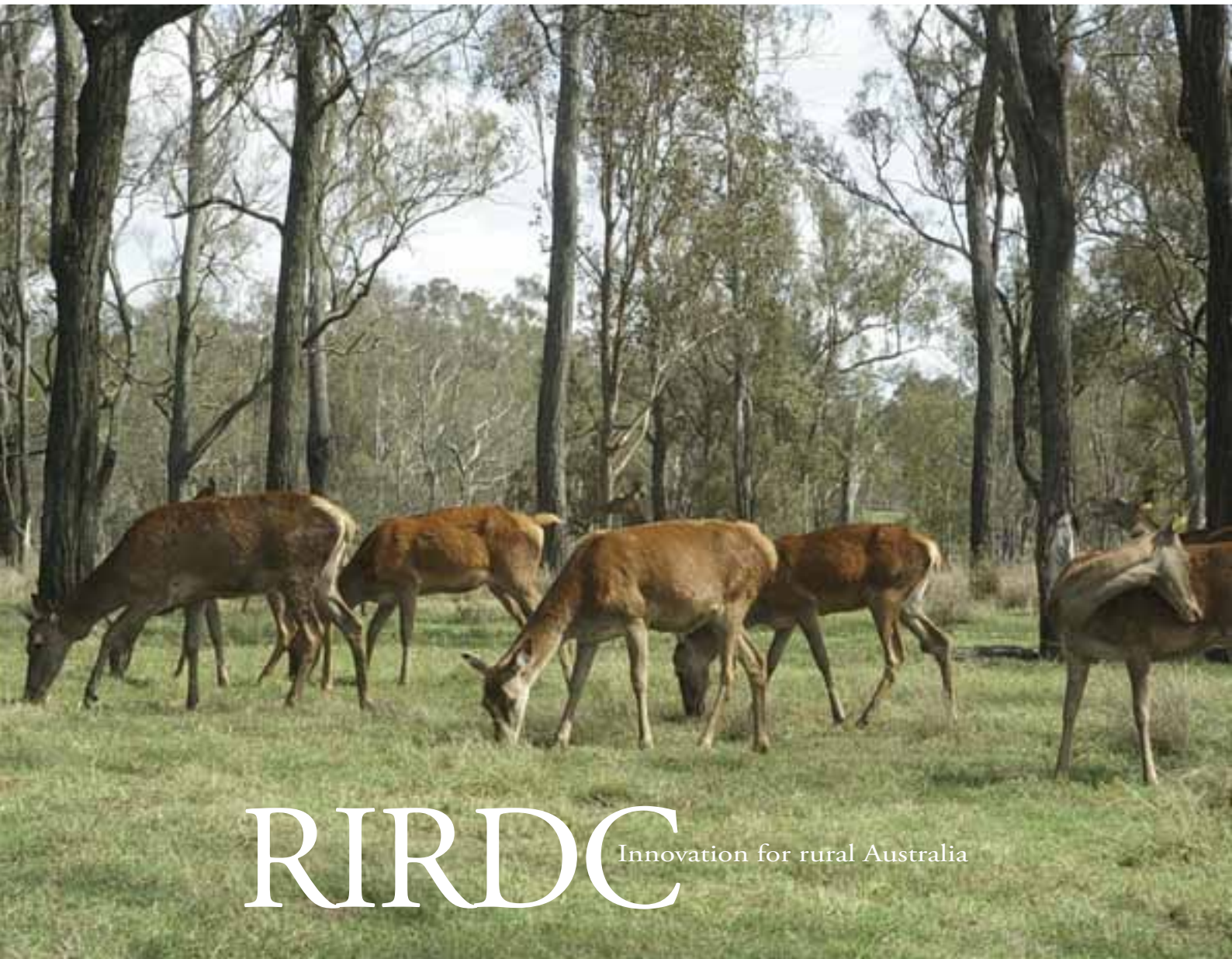

RIRDC Innovation for rural Australia

Advances and Challenges in Deer Biology

7th International Deer Biology Congress, Huilo Huilo, Chile

1 – 6 August, 2010

by Gordon Dryden

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Foreword

This report outlines the information presented at the 7th International Deer Biology Congress (IDBC), and discusses some of the implications of this information for Australian deer farming and wild deer management.

Deer in Australia, both farmed and wild, contribute to the nation's economy and regional diversity. But there are challenges. Wild deer must be managed so as to avoid overabundance and unwanted effects on the natural environment, while continuing to provide a recreational and commercial resource. Deer farming contributes to regional diversity and to rural incomes but it is a small industry which faces a continual challenge to attain a critical mass and to keep pace with international technological developments. Many of these problems can be solved by appropriate research. Good research answers real questions relevant to the needs of the industries it serves, and it can and should build on the work that is done to solve similar problems in other countries. That is why conferences such as the IDBC are important – they provide a means of new information exchange.

Farmers, ecologists, those involved in formulating policy, and scientists will find this report a useful summary of the IDBC proceedings, and a guide as to where further information on these topics can be found.

Deer scientists from Europe, China, North and South America, New Zealand and Australia contributed to the information reported at the Congress. There were new ideas and technologies about all aspects of deer biology, but in particular about genetics, ecology, nutrition and the conservation of endangered populations.

Many of the techniques described at the Congress can be applied immediately towards the resolution of some of the issues which farmers, managers and policy-makers presently face. This information will serve as a basis for planning research programs, farm management practices, and wild deer management policies.

This project was funded from industry revenue which is matched by funds provided by the Australian Government.

This report is an addition to RIRDC's diverse range of over 2000 research publications and it forms part of our New Animal Products R&D program, which aims to accelerate the development of viable new animal industries

Most of RIRDC's publications are available for viewing, free downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Craig Burns
Managing Director
Rural Industries Research and Development Corporation

About the Author

Gordon Dryden was senior lecturer in animal nutrition at the University of Queensland, Gatton. He is now the principal of Dryden Animal Science, a consultancy specializing in animal nutrition research, training and extension. He holds honorary positions at The University of Queensland and Curtin University of Technology.

He led the deer research program at UQ Gatton between 1990 and 2010, and has researched the nutrition of grazing animals in Queensland, Norway, New Zealand, and The Netherlands. He has provided consultancies on animal nutrition and animal science education in the Solomon Islands, New Zealand and Pakistan, and recently visited the Qinghai Academy of Animal and Veterinary Sciences in China under the Chinese expert visitor program. He was a member of an Australian Centre for International Agricultural Research team to rehabilitate the National University of Timor Lorosae in 2000 to 2004. He is still involved with projects in East Timor.

He is a member of the International Union for the Conservation of Nature Deer Specialist Group and of the Scientific Steering Committee (SSC) for the 7th and 8th International Deer Biology Congresses.

He has published a textbook *Animal Nutrition Science*, and many scientific publications including 12 invited papers to national and international conferences.

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Executive Summary

What the report is about

This report summarises the information exchanged at the 7th International Deer Biology Congress (IDBC), and places it in an Australian context. The Australian deer industry is challenged by a variety of external factors, such as unseasonal weather and lack of control of export markets. The industry will be enhanced by a greater awareness of current techniques and ideas in deer science and management.

Deer scientists at the 7th IDBC exchanged new information on deer health, breeding and nutrition, and methods of controlling over-abundant deer.

Who is the report targeted at?

The audience for this report is the community of Australian deer scientists, farmers and administrators. The IDBC meetings typically cover a wide range of topics, of relevance to those who need up-to-date information on, for example, the health, breeding and nutrition of deer, or methods of controlling over-abundant deer, or of deciding on research priorities and the extension of research findings to deer farmers and managers.

This information will help Australian deer farmers and managers of wild deer.

Where are the relevant industries located in Australia?

The deer farming industry is currently concentrated in the south-eastern and southern Australia, especially in southern and central New South Wales, Victoria and South Australia. At present, there are about 200,000 farmed deer. The industry processes about 15,000 animals annually to yield venison worth about $1.5 million. Some 20 tonnes annually of raw velvet antler is produced. Most of these products (about 85%) are exported – venison to Europe, North America and southeast Asia, and velvet antler to Korea, Hong Kong and mainland China.

Environmentalists who have responsibilities in the management of wild deer are located in all Australian states, especially Queensland, New South Wales, Victoria, South Australia and Tasmania. These people have two, rather different, jobs. Deer over-abundance is becoming a widespread problem (just as it is in North America) and techniques for accurately identifying its magnitude, and for managing it, are urgently needed. At the same time, there is a thriving safari hunting industry, of which wild deer are a key resource, and which caters for domestic and international hunters. Thirdly, Australia is a refuge for at least two deer species which are endangered in their native ranges: the hog deer (*Axis porcinus*) and the sambar deer (*C. unicolor*). These species are confined mainly to Victoria and South Australia.

Background

The International Deer Biology Congresses are a series of meetings of scientists who are involved in research into the physiology, conservation, behaviour, health, management and production of deer. The 7th Congress was the first to be held in South America, and was an opportunity to showcase the work of Latin American deer scientists and to describe the South American deer species and their conservation status.

Aims/objectives

The objective of this project is to make available to the community of Australian deer farmers, scientists and administrators the information exchanged at the 7th International Deer Biology Congress.

Key findings

In relation to the objectives of the report:

The Congress provided a forum for the exchange of recent knowledge of deer biology. Areas of special interest were: quantitative nutrition of deer, management of wild populations and the re-introduction of deer into regions from which they had been extirpated, methods of recognising and controlling over-abundant deer, antler biology, intraspecific variation in biology and ecology of deer, and deer behaviour.

If adopted, how will this research benefit your identified industry?

The new information about disease, methods of controlling overabundant deer populations, methods of predicting the population dynamics of wild deer, and deer behaviour that was provided in this Congress will help to better define the status of wild deer in Australia and develop ways of controlling their numbers and of managing populations so as to optimise their economic benefit and minimise impacts on the environment. New information on deer genomes, physiology, nutrition and behaviour can be applied in deer farming, and will help in the formulation of breeding programs, nutritional management, and general husbandry of Australian farmed deer.

New information about disease, methods of controlling overabundant deer populations, methods of predicting wild deer population dynamics, and deer behaviour.

Implications for relevant stakeholders for:

Industry:

The application to the Australian deer farming industry of the developments in genomics, animal behaviour, physiology, nutrition, and animal health and diseases which were discussed in this Congress may improve deer management systems and deer farmers' abilities to operate profitably and sustainably.

Policy makers:

The management of wild deer, especially when these are considered to be overabundant, can be improved by adopting techniques developed overseas, especially Canada, Spain, the USA and New Zealand. Models to predict the dynamics of wild populations are now available and should be used to monitor Australian wild populations.

Recommendations

Agencies responsible for the management of wild deer:

- use the approaches described by Parkes (overabundant deer workshop) to determine acceptable numbers and locations of wild deer in Australia
- predict wild deer population dynamics with the models used to predict the outcomes of new releases and/or population management in Israel and Spain
- re-evaluate the use of recreational and commercial hunting of wild deer as a means of controlling population sizes, with regard to the experiences with this method in New Zealand, North America, Argentina and Spain

- implement education programs as used in Canada and the USA to make the Australian public aware of the effects of wild deer, especially in peri-urban areas.

Deer farmers and the Deer Industry Association of Australia (DIAA):

- identify, from the information presented at this Congress (and from other appropriate sources, such as the recent 5th World Deer Congress, held in China and the forthcoming Antler Science and Technology conference) techniques which can be applied in Australian deer farming and which are likely to yield immediate, positive financial results
- the DIAA and Australian deer scientists should assist RIRDC to identify those avenues of research which may in the longer term contribute to the sustainability of the deer industry.

Introduction

The International Deer Biology Congresses are a series of meetings of scientists who are involved in research into the physiology, conservation, behaviour, health, management and production of deer. Meetings are held every four years and are organised by the Scientific Steering Committee (SSC) and a local Organising Committee. The first congress was held in New Zealand in 1985; subsequent congresses have been held in North America and Europe.

The 7th Congress was the first to be held in South America, and was an opportunity to showcase the work of Latin American deer scientists and to describe the South American deer species and their conservation status. The Congress was attended by about 230 people.

Like most scientific conferences, the IDBC format includes a number of plenary presentations where speakers invited by the SSC describe the current status of selected topics in deer biology. The plenary papers are supported by contributed short papers and posters. The 7th Congress also included two Workshops organised by scientists who are involved in particular disciplines.

The IDBC series is one of three series of international conferences on deer; the others are the World Deer Congress (WDC) and the Antler Science and Product Technology series. Although the attendees at these conferences tend to overlap, there is a difference in their aims. The WDC meetings emphasise the application of scientific information to deer farming, while the IDBC meetings, like the ASPT meetings, are a venue for the exchange of current information on deer biology, and attract scientists and university research students rather than deer farmers. However, this in by no means an absolute rule, and recent conferences in Europe have been attended by farmers, estate managers and hunters, who have been attracted by the wide range of topics discussed at the IDBC meetings.

Objectives

The objective of this project is to make available to the community of Australian deer farmers, scientists and administrators the information exchanged at the 7th International Deer Biology Congress. The 7th IDBC program included topics which are of immediate value to the Australian deer industry, and easy access to this information will benefit the industry:

Itinerary

My itinerary and the associated activities are described in Table 1.

Table 1. Itinerary and activities

Date	Departures and destinations	Activities
29 July	Leave Brisbane for Santiago via Auckland	
29 July	Arrive Santiago	Overnight in Santiago
30 July	Leave Santiago for Temuco; Temuco to Huilo Huilo Biological Reserve	By car from Temuco to Huilo Huilo
31 July	Huilo Huilo	Conference preparation
1 August	Huilo Huilo	Registration, initial meetings
2 August – 6 August	Huilo Huilo	Attend Congress, including: (i) Attend IUCN Deer Specialist Group meeting (establishing priorities for the 2010/2011 year) (ii) Attend IDBC Scientific Steering Committee meeting (initial planning for the 8th Congress) (iii) Present plenary presentation "Nutrition of Deer – A Quantitative Approach" (iv) Chair Deer Nutrition session (contributed papers) (v) Present initial bid for the 8th IDBC to be held in Australia.
7 August	Leave Huilo Huilo for Brisbane via Santiago	

Plenary papers

Six plenary papers were presented. The topics were chosen by the SSC to provide overviews of the present status of research in deer conservation, management and biology.

The six plenary papers were:

- reintroducing the Persian fallow deer – a chronology of ups and downs
- deer over-abundance revisited: recent advances, challenges, and opportunities
- stem cells, stem cell niche and antler development
- intraspecific variation in biology and ecology of deer: magnitude and causation
- nutrition of deer – a quantitative approach
- relationships between rank related behaviour and antler growth in deer.

These papers will be published in a special issue of *Animal Production Science*.

Reintroducing the Persian fallow deer – a chronology of ups and downs

David Saltz (Ben Gurion University, Israel)

Persian (or Mesopotamian) fallow deer (*Dama mesopotamica*) were exterpated in Israel by the end of the Second World War. A small number of animals were obtained from Iran and introduced into a breeding facility in Israel in 1976. Twenty years later, these (by now 40 females) animals were used as the nucleus of an adaptive release program intended to re-establish these deer in Israel. Questions which had to be answered before this program could be successful were: how frequently should animals be released? how many at each time? should releases be in one or more locations? how should habituation enclosures be designed? In 1996 there were twice-yearly releases of six females each time into a single reserve. They were monitored to determine if animals raised in captivity would successfully adapt to "range" conditions, and to monitor their effect on the environment. The program was delayed in the north by perceptions that their effect on agricultural lands was unacceptable. The project was moved to central Israel, but with less success so far as the deer were concerned. More recently, successful releases have been made again in the northern region.

Implications for Australian deer management: population modelling was used successfully to predict the viability of these releases. This suggests that, with appropriate re-parameterisation, these models can be used to predict the size and growth of wild deer populations, their sustainability, and the effects of urban sprawl on deer × human interactions.

Deer over-abundance revisited: recent advances, challenges, and opportunities

Robert Warren (University of Georgia, USA)

Deer over-abundance, especially of white-tailed deer, has become a widespread problem in the USA. Since 1997 research has been carried out in the USA which has characterised the ecological consequences of chronically over-abundant deer populations. These include effects on other animals (ranging from invertebrates to carnivores) and plants, and also on humans. Some of these include changes in predator animal behaviours which have assisted in the control of excess deer in some regions, and consequent changes in the abundance of these animals. The impact of excess deer on humans, and the human response to this, varies. Governments have had to change their attitudes

towards control measures in ways which were not previously considered acceptable. These include sponsoring public hunts, using sharpshooters, and use of fertility control. The use of this type of control measures was illustrated by reference to two scenarios in Georgia.

Implications for Australian deer management: there are some 80,000 wild deer in Australia, occurring mainly in the southern and eastern mainland states and Tasmania. Perceptions of their effects on the environment varies, with some graziers accusing deer of spreading cattle ticks and destroying crops, while others appreciate the aesthetic contribution deer make on their properties. The attitudes of people living in peri-urban areas vary according to their experience – car/deer collisions or entry of deer to gardens can be intimidating. Others feel that only native Australian animals are acceptable in Australian environments. Approaches used in the USA are directly relevant to Australia. These include selective hunting (often by professional hunters), education programs to teach people how to live with wild deer (e.g. the Quality Deer Management Association programs) and perhaps fertility control drugs (e.g. the recently- licensed drug Gonacon ®).

Stem cells, stem cell niche and antler development

Chunyi Li, Fuhe Yang and Jimmy Suttie (AgResearch Invermay Agricultural Centre, New Zealand; Chinese Academy of Agricultural Sciences, China)

Antlers regenerate annually from the pedicles of deer. Understanding of this process began in the 1970s when the antlerogenic periosteum (AP) was described, and later by work which culminated in the *in vitro* cultivation of AP cells. Regenerating antlers (as distinct from the first antlers grown by spikers) grow from cells in the pedicle periosteum (PP). These cells are antler stem cells (ASC) and they contain the markers (genes and enzymes) which are present in embryonic stem cells. ASC can be made to differentiate into a variety of bone, muscle and nerve cells.

Implications for the Australian deer industry: antlers grow and are cast in an annual cycle of initiation, growth, ossification and casting. This is a natural process which is not affected by the removal of immature (velvet) antler. However, many lay people do not understand this and some even believe that the animal has to be killed to harvest velvet antler. Deer farmers need to recognise that these misunderstandings can affect the way that the community views their industry and should take immediate steps to disseminate accurate information. A better understanding of the physiology of antler growth may lead to the development of new methods in regenerative medicine.

Intraspecific variation in biology and ecology of deer: Magnitude and causation

Rory Putnam and Werner Flueck (Ardgour, Scotland; National Council of Scientific and Technological Research, Argentina)

Although each deer species has its own particular characteristics which can be used to differentiate that species, within the species there are genetically and phenotypically based differences in social and reproductive behaviour, morphology, diet, population demography and structure, etc. These are often over-looked when scientists and managers consider the “characteristics” of deer.

Implications for Australian deer management and the deer industry: an improvement in the economic performance of Australian deer farming may be depend on breeding programs which identify and use the type of intra-specific variation described in this paper. It is clear, for example, that the red deer genotype includes the ability to produce weaners and yearlings with a greatly enhanced capacity to grow. This could markedly improve farm productivity if coupled with adequate feeding management. Similarly, a knowledge of the genetic or phenotypic variations in herd structure and breeding dynamics

which occur in Australian wild deer could help in designing effective management programs for these animals.

Quantitative nutrition of deer: Energy, protein and water

G.McL. Dryden (Dryden Animal Science, Australia)

The quantitative requirements of deer for energy, protein and water were reviewed, using where possible a factorial approach to defining requirements. Deer may be more efficient than cattle and sheep in metabolising digested energy and in utilising metabolisable energy as a source of net energy. The average metabolisable energy requirement for maintenance (ME_m) is 0.46 MJ/W(kg)$^{0.75}$ per day. Temperate species have a higher requirement in spring/summer, and tropical species in a subtropical environment have a greater requirement in winter. ME_m declines with age, and is less for males than for females. ME requirements and efficiencies of use for production are reviewed.

Diet protein contents that are adequate for maintenance and production are approximately 4 to 9% and 16 to 22%, respectively. It is difficult to use a factorial approach to describing deer protein requirements because of a lack of information on basal endogenous N excretion rates, the outflow of metabolisable protein from the rumen and the efficiencies of utilisation of metabolisable protein. Differences in digestive function between deer and other ruminants mean that data for cattle and sheep may not be applicable to deer.

Guides to drinking water consumption by deer are a water:dry matter intake ratio of about 3.5:1 and 139 g drinking water/W(kg)$^{0.75}$ per day; but ambient temperature, physiological state and diet composition greatly affect water requirements. The salinity tolerances of cervine and rusine deer, and of fallow deer, are approximately 8000 and 12000 mg/kg drinking water, respectively.

The concepts needed to formulate nutritional models for deer are understood, but we need more data if we want to develop reliable expert systems for nutritional management or to predict the nutritional condition of wild populations. Cattle and sheep data does not necessarily apply to deer because deer differ in key aspects such as the metabolisability of dietary energy, the rate of passage of feed through the digestive tract and its effect on protein and organic matter degradability, and in seasonal differences in nutrient use.

Seasonal effects are very important for deer. There are seasonal differences in N retention and seasonal changes in the SMR, but the physiology of these, and their implications for feeding management, are not well understood. The effects on feed intake and energy requirements of the autumn rut in temperate species stags, and the winter rut in tropical species in temperate and subtropical Australia, are not yet fully understood. Accurate prediction of the nutrient requirements of growing deer requires an accurate knowledge of their growth paths and the accompanying changes in body composition. This information is surprisingly scarce. Further, feeding standards which are based on currently available data may fail to correctly describe the requirements of modern deer which have been bred for extremely fast weaner and yearling growth, or to produce antlers which are five or six times larger than those grown by males only one or two decades ago.

Implications for the Australian deer industry: successful deer farming demands an accurate knowledge of nutrient requirements. This paper reviews our current knowledge of the energy, protein and water requirements of deer, and presents this information as a series of relationships which can be used to develop feeding standards. Currently, the only feeding standards for deer are the NRC (2007) publication. Deer farmers have also relied on recommendations made for sheep and cattle. The recommendations in this paper extend those in the NRC publication to include tropical deer, and give a more complete survey of energy, protein and water requirements.

Relationships between rank related behaviour and antler growth in deer

Luděk Bartoš (Institute of Animal Science, Czech Republic)

Studies over 30 years, involving red, fallow, pudu, white-tailed and reindeer, have shown that antler growth is influenced by the social status of the male deer at the time that the antlers are growing. If his dominance status changes (in either direction) during antler growth, the development of his antlers at that time reflects this change. In those species where dominance changes during the rutting season (e.g. white-tailed deer – and possibly rusa deer, although these were not investigated in these reported experiments) antler growth does not reflect social status as closely as it does in, e.g. the red or fallow deer. Testosterone was originally considered to be hormone responsible for stimulating antler growth, but work in the 1980s suggested that IGF-1 was responsible. The work described in this paper reinforces the view that testosterone is the most important antler-stimulating hormone.

Implications for the Australian deer industry: for many years, the factor(s) which stimulate antler growth (and thus the velvet antler harvest) have been unknown, although it has been accepted that there is a good relationship between antler size and body size. The role of specific nutrients (e.g. protein) has been unclear. These results suggest that another factor influences antler growth and it is possible that social dominance effects will obscure or override any nutritional effect. Stag management is always difficult and removal of immature antlers is recommended in the Deer Code of Practice to reduce injuries to other deer and to humans. This work adds considerably to our understanding of how to manage male deer – to reduce fighting and possibly to grow larger antlers.

Workshops

Three workshops were held, organised by specialists in those disciplines.

Policies and management of overabundant deer (native or exotic) in protected areas

1. Pest or resource: Management of introduced wild deer in New Zealand

Graham Nugent (Landcare Research, New Zealand)

Deer in New Zealand are viewed as a valuable economic resource (farming and hunting) and an environmental pest. The wild deer population is kept in check by unrestricted hunting (e.g. from helicopters) and there is little need for conservation-directed control. However, there is conflict between hunting and conservation interests requiring new policy initiatives which were developed in 2008.

2. Management of deer in Australia

John Parkes (Landcare Research, New Zealand)

The legal status of wild deer varies between jurisdictions. The policy issue "how should managers set management targets for deer populations?" is discussed in this presentation. It is suggested that this depends on the status of deer as native or exotic species. If exotic, then their impact on biodiversity and the social values placed on deer by hunters as well as their ability to harvest deer, are important. Exotic deer should be managed so that their density is zero (local extirpation) or at some level which has an acceptable impact on the environment. The extent to which control is needed determines the method(s) used.

3. The concept and consequences of deer overabundance in the United States with suggestions for management prescriptions

William O'Shea (Smithsonian Institute, USA)

High densities of white-tailed, elk wapiti), and sika deer are now common in areas of the USA, e.g. peri-urban areas and national parks. The expected effect on plants of high deer densities is to encourage a population richer in mature individuals, leading to ultimately the senescence of the plant population. Hunting, the reintroduction of predators, and contraception are suggested as means of controlling overabundant deer.

4. Policy on management of hyperabundant wildlife in Canadian national parks

Stephen Woodley and John Waithaka (National Parks Directorate, Canada)

Hyperabundance is a problem in some of Canada's national parks, especially smaller ones in the south. A policy introduced in 2007 established the criteria for declaring overabundance, and the ways in which this must be controlled. The process is adaptive, and based on the best available scientific information. It involves Aboriginal Canadians and other interest groups, and public consultation and education.

5. Monitoring deer population size in Lugar Neuvo and Selladores-Contadero South Spain: Evaluating efficiency of management culls for reducing density

Javier Moro Valverde, R Gutierrex and Concepcion Azorit Casas (Ministry of the Environment and Rural and Marine Affairs, Spain; University of Jaén, Spain)

Deer populations (red and fallow) increased to about 55/km^2 and there several thousand animals died in droughts in the early 1990s. Culling by hunting is now used to control numbers. Emphasis is on retaining the "emblematic" animals in a sustainable environment.

6. Exotic red deer (Cervus elaphus) in national parks: A natural resource that harmonises conservation and production.

Fernando Mendez Guerrero (Administración de Parques Nationales, Argentina)

Hunting is used to control red deer numbers in two national parks. Hunters must be trained or supervised by trained guides. Local farmers who are allowed to farm animals in these parks must link the number of domestic animals that they keep to their rights to hunt deer commercially.

7. A review of introduced cervids in Chile

Werner Flueck and JoAnne Smith-Flueck (National Council of Scientific and Technological Research, Argentina; Universitad Atlantida, Argentina)

Four deer species were introduced to Argentina and Chile in the early 20th century, with red deer spreading the most widely (at about 1 km/year) and their presence is referred to as an "invasion". Of concern is that they may out-compete the endangered native huemul (*Hippocamelus bisulcus*). The existence of about 100 captive deer enclosures in Chile is considered a possible threat to native species.

Implications for Australian deer management: overabundance is a widespread and long-standing problem in North America, particularly with white-tailed deer and in those north-eastern states where hunting has become less popular. It is also a problem in Europe and Australia, but in those countries it is more restricted to particular species, e.g. the sika deer in the UK; or regions, e.g. peri-urban areas near Sydney and Brisbane in Australia. Poor management decisions, e.g. supplementing deer in winter or enclosing deer in estates, may contribute to local overabundance. Like Australia, introduced deer in South America are viewed as either pests or as an economic resource, but in both cases it is considered that their numbers must be controlled. It is interesting that commercial or recreational hunting is used, in all the jurisdictions described in this Workshop, as a way of controlling deer numbers. This is probably the most economic way of attempting to control deer numbers, but there are several caveats. Some interest groups in Australia (including governments) feel that hunting introduces important welfare considerations. Australian hunting associations attempt to deal with this by holding hunter training courses, and there are legal requirements about welfare which hunters must meet. In some areas, the harvest is too small, or directed too exclusively at males, or intended to leave a self-regenerating population, for it to effectively control numbers. The QDM program implemented in Tasmania goes a long way towards dealing with this issue. Intentional release of deer in regions which were previously deer-free has occurred in eastern mainland Australia. This is counter-productive and irresponsible because it reduces any likelihood of a consensus between those who support a (small, controlled) deer population, and those who would prefer to eradicate all deer.

Measuring the acoustic properties of vocalisations

Description, demonstration and hands-on session of how to use Praat

David Reby (University of Sussex, UK)

Vocalisation in red and fallow deer is used to attract oestrus females and intimidate males. Stags and bucks use vocalisations to assess the size of other males. Females also do this, but prefer higher-pitched roars.

Implications for Australian deer management: although not canvassed in this presentation, a better understanding of vocalisation may lead to methods of "confusing" oestrus hinds and/or males and thus reducing the frequency of successful matings in wild deer.

Genomics of Rangifer and other deer species

Genomics solutions on developing reference genomes in BGI

Zhuo Li (BGI Americas, USA)

The BGI company has developed a new way of assembling genomes from short-read sequences. The application of this to describing the genomes of 1000 commercially important organisms, including deer, was discussed in this presentation.

Implications for Australian deer farming: it is axiomatic that understanding an organism's genome will lead to improved understanding of its biology, with better ways of manipulating it to achieve desired outcomes.

Symposium: Conservation of neotropical deer

The SSC organised a symposium on South American deer to bring participants up-to-date with their conservation status, and to summarise the current work in this area. Seventeen oral presentations and 11 posters contributed to these two symposia.

Advances in the conservation and ecology of the genus Hippocamelus

There are about 1000 - 1500 huemul (*Hippocamelus bisulcus*) in South America, with populations mainly in Argentina and Chile. The species is endangered. Low reproduction rates and a high incidence of disease, exemplified by antler malformations, may be responsible for this species' demise. They have been forced to move away from the more fertile lowlands along the foot of the Andes into higher, less fertile regions. Deficiencies of I and Se have been implicated. These may be prime causes, with predation by dogs, illegal hunting, etc. being additional contributors. Similar causes may be responsible for the vulnerability of the taruka (*H. antisensis*). Conservation efforts are being undertaken in Peru and Bolivia.

Marsh deer (*Blastocerus dichotomus*; in a related genus) are the largest South American deer and are also endangered. Causes are loss and fragmentation of habitat, and illegal poaching.

Advances in the conservation and ecology of pudu

The pudu (*Pudu* spp.) is a small (<15 kg), solitary forest dweller which is declining throughout its home range. Causes appear to be predation by puma and domestic dogs, and loss of habitat to agriculture. When bred in captivity they are susceptible to bacterial diseases. Nevertheless, 28 animals are kept successfully in a colony in southern Chile and some will be released soon. In northern Chile and Peru the species competes with other dwarf deer (e.g. the brocket deer, *Mazama* spp.). The historical fragmentation of the pudu's home range has divided this genus into several species and subspecies (this has been confirmed by recent genomic analysis). This division increases the difficulty of conserving this genus, as it can be argued that each species and subspecies (all vulnerable) require separate conservation.

The oral presentations were supported by 13 posters: pampas deer inventories in Brazil, genetics of South American deer, the role of protected areas in huemul conservation.

Supporting sessions

Management

Thirteen oral presentations: all dealing with the management of wild populations in China, India, Taiwan, UK, Czech Republic, Lapland, Argentina, Japan, USA.

Eight posters: habitat and distribution, and condition assessment of white-tailed deer; ecology of Odocoileini deer; capture, restraint and performance in captivity of South American deer.

Deer production

Four oral presentations: effect of carcass treatments and meat quality (of reindeer, fallow and red deer); the use of sub-alpine regions of New Zealand for breeding red hinds; adaptive management in reindeer husbandry; irruptive behaviour of sika deer

Two posters: adaptive management for reindeer, suspension hanging and meat quality of reindeer.

Antler biology

Two oral presentations: nutritional management effects on the structure and properties of ossified antler.

Ten posters: genetics of antler growth; hormonal control of antler growth; casting synchrony in Reeve's muntjac.

Health and disease

Eleven oral presentations: paratuberculosis in NZ and southern Europe; internal parasites in South American red deer; disease in free-ranging deer in Patagonia and Mexico; internal parasites in red, roe and fallow deer in Hungary; mechanisms of prion spreading in the US.

Five posters: parasites in pampas deer (*Ozotoceros bezoarticus*); rickettsia in marsh deer; periodontal disease due to F deficiency in red deer; blood chemistry of the pudu.

Reproductive physiology

Five oral presentations: ovarian follicular dynamics; methods and effects of semen storage; manipulation of puberty in red hinds using melatonin.

Nine posters: the red semen of brocket deer; faecal progestins and glucocorticoids; semen characteristics of pampas and red deer; ovarian structure of pampas deer; seasonal changes in the rennin-angiotensin system of red and fallow deer.

Nutrition

Three oral presentations: purine derivatives in Chinese moose and roe deer; habitat enrichment effects (use of supplements) on foraging by white-tailed deer; nutritional ecology of the huemul.

Two posters: protein nutrition and antler growth; seasonal variation in the diets of red and fallow deer in Spain.

Behaviour: free-ranging and captive deer

Four oral presentations: behaviour of pampas deer and Eld's deer challenged by exotic species or humans; socio-mapping to analyse behaviours of red stags; pre-orbital gland as a stress indicator.

Seven posters: habitat selection by sympatric red deer and sheep, Mazama deer species; mating bonding in Eld's deer; circadian rhythms of pampas deer; allogrooming by brocket deer.

Communication in deer

Three oral presentations: vocal and chemical communication in red, fallow and brocket deer; role of vocalisation in the hybridisation of red and sika deer.

Two posters: vocalisation and phylogeny.

Evolution and conservation genetics

Four oral presentations: developments in elucidating the genomes of caribou, brocket deer and the *Mazama* spp.

Thirteen posters: genetics of the pampas deer, phylogeography of brocket deer, genetics of Chinese deer, hybridisation of sika and red deer and of cervids and marsh deer, genetics of red deer in Argentina.

Implications

Assessment of the impact of the outcomes on industry in Australia (where possible provide a statement of costs and benefits)

Implications for industry:

The application to the Australian deer farming industry of the developments in genomics, animal behaviour, physiology, nutrition, and animal health and diseases which were discussed in this Congress may improve deer management systems and deer farmers' abilities to operate profitably and sustainably.

However, farmers can not be expected to take up these innovations without help from professionals to identify useful techniques and interpret these scientific presentations into useful farm practices.

Implications for policy makers:

The management of wild deer, especially when these are considered to be overabundant, can be improved by adopting techniques developed overseas, especially Canada, Spain, the USA and New Zealand. Models to predict the dynamics of wild populations are now available and should be used to monitor Australian wild populations.

The Australian deer farming industry has survived since its inception in the late 1970s in an environment of severe drought, variable and uncontrolled prices for products, and a lack of a domestic market for its products. It has done this with little government support (the valuable contributions of RIRDC excepted). However, in a suitable physical, policy and technical environment, deer farming can be profitable and sustainable. The key issues for Australian deer farming are (i) to be able to process its output (venison and velvet) profitably and conveniently; (ii) to sell its products to a receptive domestic market, while retaining existing export markets; and (iii) to match the advances in technology which are being made in New Zealand, China and other countries through targeted (and often purposely-commissioned) research.

Recommendations

Agencies responsible for the management of wild deer:

- Use the approaches described by Parkes (Overabundant Deer Workshop) to determine acceptable numbers and locations of wild deer in Australia.
- Predict wild deer population dynamics with the models used to predict the outcomes of new releases and/or population management in Israel and Spain.
- Re-evaluate the use of recreational and commercial hunting of wild deer as a means of controlling population sizes, with regard to the experiences with this method in New Zealand, North America, Argentina and Spain.
- Implement education programs as used in Canada and the USA to make the Australian public aware of the effects of wild deer, especially in peri-urban areas.

Deer farmers and the Deer Industry Association of Australia:

- Identify, from the information presented at this Congress (and from other appropriate sources, such as the recent 5th World Deer Congress and the forthcoming Antler Science and Technology conference) techniques that can be applied in Australian deer farming and which are likely to yield immediate, positive financial results.
- The DIAA and Australian deer scientists should assist RIRDC to identify those avenues of research that may in the longer term contribute to the sustainability of the deer industry.

Advances and Challenges in Deer Biology

by Gordon Dryden

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This report outlines the information exchanged at the 7th International Deer Biology Congress (IDBC), and places it in an Australian context.

The Australian deer industry is challenged by a variety of external factors, such as unseasonal weather and lack of control of export markets. The industry will be enhanced by a greater awareness of current techniques and ideas in deer science and management.

The IDBC meetings typically cover a wide range of topics, of relevance to those who need up-to-date information on, for example, the health, breeding and nutrition of deer, or methods of controlling over-abundant deer, or of deciding on research priorities and the extension of research findings to deer farmers and managers.

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