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DEER FARMING TECHNIQUES AND DISEASES OF DEER IN QUEENSLAND

edited by

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Contents

FOREWORD

The genesis of the Australian deer industry in the late 1970s was due to a combination of three factors. The high prices paid for velvet antler, particularly by South Korea, automatically set a high price for deer, notwithstanding that we neither had an industry nor market outlets at the time. Australia had a small feral population of deer to breed from and the techniques for feral deer capture and farming had been established by New Zealand farmers.

The major concentration of feral Red deer in Australia is in south-east Queensland. Thus farmers in this area with sufficient capital to meet the high costs of establishment diversified by adding deer to their existing cattle enterprises. Business interests wishing to diversify were also attracted to farming deer.

As this fledgeling industry got under way, two State Government Departments became involved. Feral deer in Queensland are protected under the Fauna Conservation Act which is administered by National Parks and Wildlife Service (NPWS). Farmed deer are the responsibility of the Department of Primary Industries (DPI) under the Deer Farming Act and the Stock Act. NPWS saw its role as a source of information and a custodian of the feral population. DPI saw its role predominantly to monitor disease status and to advise on legislation particularly on standards of confinement outside the feral area.

Much has been published on technical, historical and social aspects of deer and deer farming from countries where these animals have been utilised by man to a much greater extent than in Australia. This publication should be a useful document for all involved or interested in this new industry in Queensland.

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1 DEER FARMING

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DEER SPECIES

Red deer (Cervus elaphus), the main species farmed in Queensland, were released at 'Cressbrook' Station in the Brisbane Valley in 1873. They have since spread into the watersheds of the Brisbane, Mary and Stanley Rivers and surrounding areas, which are now known as the feral range. Before the commencement of deer trapping in 1978 the Queensland National Parks and Wildlife Service estimated the red deer feral population at between 8 000 and 10 000 head. It is felt that live capture has had little influence on the total feral population. The major limiting factors to population growth are probably dingo and wild dog predation as well as illegal shooting. A large part of the red deer feral range lies within state forests where trapping and shooting are prohibited.

Red deer, which are among the largest and easiest of all species to domesticate, are suitable for both venison and velvet production.

Moluccan rusa deer (Cervus timorensis), a tropical species originating from the Indonesian archipeligo, are present on a number of Torres Strait Islands. The main population is on Prince of Wales Island where deer were originally released in 1912. A helicopter survey of the population during capture operations in 1980 estimated that there may be up to 3 000 head on Prince of Wales Island. Moluccan rusa deer are very tractable to deer farming but are smaller than the Javan rusa which are the predominant farmed species in Victoria. The Javan rusa farm population was derived from deer culled from the feral population in the Royal National Park south of Sydney during the mid 1970s.

Fallow deer (Dama dama) which are feral in an area west of Stanthorpe provide the basis for most of the Australian deer industry. The feral population is scattered but it is estimated that up to 1 000 head may be present in this area.

Fallow deer are not as easy to handle as the other species, but can be farmed for their venison, their by products being not as lucrative as for red deer.

Chital deer (Axis axis) are present in the wild on several grazing properties north-west of Charters Towers. The majority of the population estimated at up to 10 000, is on 'Maryvale' Station where they were originally released in 1867. They are a tropical species originating from India and are suited to our climate, but are extremely difficult to handle. A considerable number of chital deer have been exported to New South Wales deer farms. Chital deer need specialised yarding facilities, and higher deer fences especially in pressure areas, because of their

flightly temperament. Compared to other species, chital are small and suitable only for venison production.

GOVERNMENT CONTROL OF DEER FARMING

In Queensland, feral deer are 'protected fauna' and come under the jurisdiction of the Queensland National Parks and Wildlife Service (QNPWS). QNPWS issues permits to trap deer only to people farming in the red deer feral area. In 1978 QNPWS first issued permits for twelve property owners in the Brisbane and Mary Valleys to trap and keep red deer for farming purposes.

A royalty of $55/head is payable to the Crown for all feral deer taken from the wild. The maximum number of deer allowed to be taken yearly from the wild from all permits are 1 000 for red deer and 500 each for fallow and chital deer.

When new legislation is enacted in the Queensland Parliament, the Queensland Department of Primary Industries (QDPI) will assume responsibility for the regulation and supervision of deer farming. Feral deer will remain fauna under the control of QNPWS who will continue to issue trapping permits.

The draft legislation prepared covering the farming of deer deals with the identification of farmed deer, the requirements for fencing outside the normal feral range, the keeping of inventories and the issue of permits to farm on specific locations.

There are some areas of Queensland where deer farming is not permitted. There is a buffer zone of 20 km along the Queensland-New South Wales border within the cattle-tick-infested area to comply with the New South Wales tick control measures.

When the QDPI issues farm permits, preference will be given to producers in the more closely-settled areas where deer husbandry measures can be practised more effectively. Deer farming is restricted north of Cairns due to the danger of deer escaping from farms, and establishing feral populations in Cape York Peninsula. Prospective deer farmers should contact their QDPI Divisional Veterinary Officer or local stock office for more information.

DEER FENCING AND YARDS

Before farming permits are issued, yards and external boundary fences must be erected. Deer farms within the feral range have no regulations governing fencing requirements, but farms outside the feral area of the species being farmed are required to have specially constructed fences. Adequate fencing is vital to ensure deer don't escape and form new feral colonies which could damage natural ecosystems, or compete for food with already established stock such as cattle or sheep. Boundary fences must be 2.13 m high. Special fencing may be required under certain conditions, such as when the species of deer confined (including chital and fallow) are noted for their jumping ability. K wire or New Zealand Cyclone Tight-lock netting are the only fencing

materials approved for deer fencing outside the feral range.

Specialised deer yards are essential to allow handling of individual deer with safety to both deer and handlers without the use of tranquilisers. Yards should have solid-boarded walls at least 2.6 metres high and if possible the main working area should be circular and roofed to permit darkening. Deer quieten rapidly and handle more easily in semi-dark conditions.

LIVE CAPTURE

Initially the emphasis in establishing the Queensland deer industry was on live-capture methods. Trapping is permitted from mid April to the end of October. The most successful method of capturing red deer has entailed using deer-fenced traps. The fenced area strategically located near deer habitats is usually planted with oats. The area fenced can vary from 1 to 15 hectares. The deer are run into a corner enclosure of the trap and then transported to the deer farm. Trapped deer are usually kept in a small enclosure or deer yards for a few days until they settle down. This period enables the deer to become accustomed to eating supplementary feeds, especially pelletised feeds, and stags are usually handled to remove their hard antlers.

During the past two trapping seasons (1982, 1983) very few red deer have been captured mainly due to unsuitable seasonal conditions. Thus the build-up of farm numbers has become more dependant on stock increases from breeding on farms. Queensland has the only significant feral population of red deer in Australia available for trapping. Most interest in deer farming in Queensland has centred on red deer due to their suitability for deer farming, their velvet production and the good access to the feral population for most deer farmers. At present most deer farmers in Queensland are graziers within the red deer feral area who entered the industry by trapping on their own or nearby properties. Before 1984, wild-trapped red deer were not allowed to be moved out of the feral range, although progeny of these red deer and other species of deer could be farmed outside their feral range and were allowed to be moved interstate. Wild-trapped red deer will now be allowed to leave the feral range after being held 12 months behind wire.

DEER NUMBERS

Current limitations on deer farming in Queensland lie in the limited availability of suitable animals, their relatively high price and the sustantial cost of adequate deer-proof fencing.

The current estimate (1984) is that there are about 3 500 red deer being farmed on 50 deer farms most of which are located in the red deer feral area. Unfortunately, the limited availability of moluccan rusa from Torres Strait has limited their farming in Queensland as they are very suited to our climatic conditions. A few Javan rusa deer have been imported from interstate but they

have not been compared with Moluccan rusa under the same farming conditions. There are about 600 Moluccan rusa behind wire with less than 100 Javan rusa farmed.

Chital and fallow deer are also farmed - about 500 head of each species.

NUTRITION

As red deer trapping is permitted only by farmers within the feral area, most red deer are still farmed within this area. Many deer are being farmed on poor forest type country under low stocking rates. Supplementary feeding of grain rations has been necessary during the dry season under such grazing conditions.

A major economic factor in deer farming is the high cost of deer-proof fencing and there is an obvious economy in fencing only fertile land capable of carrying high stocking rates. Future growth of the industry will probably involve considerable transfer of deer farming outside of feral areas. Most deer in south-east Queensland are being farmed on improved sub-tropical pastures such as Rhodes, setaria and kikuyu grasses. The tropical legume Siratro is grown on the steeper country but does not persist if it is subjected to continual high stocking rates. Slashing is generally employed to keep summer pastures short and attractive to deer. Stags are being fattened on irrigated rye grass-clover pastures during the winter-spring period. Dryland oats are also grown as winter crops in areas that experience winter frosts.

The availability of irrigation can considerably increase the carrying capacity of the deer farm. Stags are being run on irrigated pastures at carrying capacities of 15 red stags to the hectare. Without irrigation, stocking rates of 3 to 5 deer to the hectare are usually achievable depending on the fertility of the land and the amount of fertilisers used.

New Zealand research has established that a mature red deer hind has about twice the metabolisable energy requirements of a ewe rearing one lamb to weaning. Red deer stags have a considerable and unavoidable weight loss during the rut in the autumn, followed by a slight weight loss in winter. Adult hinds show weight gains in late pregnancy and during lactation, with some weight loss during winter. Weaners show a low rate of gain over the autumn-winter period with a high rate of gain during spring-summer between 9 and 15 months of age.

The periods of high energy demand in red deer are in the winter for stags and during the summer lactation for hinds. In Queensland, the seasonal pattern of pasture production which is usually characterised by a high rate of summer pasture growth is more favourable for red deer breeding than velvet production which is more dependant on good winter-spring nutrition.

DEER HUSBANDRY

The usual forms of animal husbandry which apply to cattle also apply to farm deer.

Red deer

Red deer are of temperate zone origin and are adversely affected by hot summer conditions. They require access to both shade and water at all times during summer. Deer species of temperate zone origin such as red and fallow deer are not suited to farming in tropical areas of this state. The tropical Asian species rusa and chital deer are better suited to the tropical climate of North Queensland.

Red deer breed seasonally. The calving season normally starts in late November and lasts until February. Calves can be born as late as March or April if hinds are left running with a stag. Hinds tend to seek isolation prior to calving. Some farms have lost significant numbers of newly-born calves, especially those born during heatwave conditions, and most farms have reported hind deaths due to dystocia. This is often exacerbated by overfeeding hinds during late gestation.

Natural or artificial shelter should be available to newly-born calves. Rank grass or dead branches provide adequate shelter. Disturbance of calving hinds should be minimised. Mismothering or hinds attacking and killing other calves are signs of excessive stress. Calf mortalities up to 20% have been experienced with most deaths occurring within a few days of birth.

Some deer farms wean their red deer calves before mating. This allows the hind to increase live weight and level of condition because she no longer has to divert energy into lactation. Weaning early also makes it easier to tame and hand-feed young stock. Some small deer farms are not able to wean due to lack of subdivision. Yarding hinds with calves for weaning requires considerable care. Calves should be drafted off as soon as the hinds settle. Ideally calves should be kept in the yards for several days at weaning. The weaning paddock should be one paddock removed from any hinds to prevent fence-pacing.

The mating time (rut) for red deer usually commences about the end of March and continues for about 2 months. Most farmers mate two or three stags with up to 50 hinds. The dominant stag is usually removed before the end of the rut to allow other stags to complete mating, and insure against possible infertility in the dominant stag. Some farmers are using single-sire mating in order to identify the sire of progeny. Yearling hinds achieve high calving percentages as 2-year-olds provided they are well grown at mating. Red deer hinds are regularly achieving over 80% calving percentages on Queensland deer farms. However some farms have experienced lower calving percentages down to 50% in some years.

Some deaths of red deer running on Queensland deer farms have been attributed to excessive cattle tick (Boophilus microplus) burdens. Most of these losses occured when deer farmers trapped red deer before constructing adequate deer yards. When red deer are sick or suffer nutritional or lactational stress they appear to lose some of their tick resistance. Most red deer farmers within the cattle-tick-infested area have had to use acaricides to control cattle ticks by regularly plunge-dipping or spraying their deer. Strategic treatments commence in mid-October and continue until the start of the calving season in late November. Further handling of calving hinds is not recommended until the end of the calving season usually in late February when further treatments are recommended.

Moluccan rusa deer

Moluccan rusa deer have been farmed in south-east Queensland since 1980. These deer have proved more heat-tolerant and resistant to cattle ticks than red deer and have not required tick treatments on farms in south-east Queensland.

The unrestricted breeding programme adopted with the moluccan rusa farmed in south-east Queensland has resulted in a continuation of the unseasonal breeding pattern observed in the wild in Torres Strait with calves born throughout the year. The evidence suggests that the rusa's breeding season is probably determined by food availability at the time of mating rather than by daylight length. As rusa calves are born throughout the year there may be an advantage in being able to turn off stags for venison throughout the year.

However, with moluccan rusa at a considerably high altitude on a farm that experienced severe winter conditions in 1982 the mortality rate was high in calves born during heavy winter frosts. These calf deaths occured despite the provision of shelters for newly-born calves. Rusa deer can be farmed in sub-tropical areas with an unrestricted breeding pattern provided newly-born calves are not subjected to weather conditions likely to cause severe hypothermia.

VELVETING

Most red deer farmers in Queensland harvest velvet from their mature stags. The older stags commence casting their antlers in September and the velvet is harvested after 65-70 days growth with the aim to maximise the yield before calcification occurs. The removal of antlers reduces the risk of injury to both stock and handler when deer are yarded. If stags are not velveted, the hard antler should be removed before the rut as stags are dangerous during the rut, and should be treated cautiously.

ANIMAL HEALTH

QDPI disease surveys of farm deer have shown them to be relatively disease free during the early years of deer farming in Queensland.

Disease prevention is more important with deer than traditional livestock because deer are easily stressed by yarding, handling or under-feeding. Most diseases in deer seem to be associated with stress. Animals should be watched for abnormal behaviour which may be a sign of disease. No serious disease outbreaks have occurred on Queensland deer farms and most deaths of red deer behind wire have occured in recently captured animals and are often related to capture myopathy or trauma associated with capture handling.

There is little evidence that leptospirosis is an important disease of deer but with more intensive husbandry of deer it could reveal its full potential. Thus vaccination against clostridial diseases and leptospirosis is recommended and vaccination regimens as for other domestic livestock are recommended.

Newly-born red deer calves have been found abandoned and paralysed due to scrub tick (Ixodes holocyclus) infestation but have recovered after antiserum treatment. Some deaths of newly-born calves considered due to mismothering may have been caused by tick paralysis. Confirming this by finding affected calves is generally not possible. Although it is very necessary to have good shelter for calves in calving paddocks, care should be taken to ensure that habitats favourable to scrub ticks are not present.

INDUSTRY VIABILITY

Deer farming is not restricted to one form of production. Income can be derived from venison, velvet, sale of livestock and by-products from slaughter such as eye teeth, hides and pizzles.

Demand for Queensland red deer progeny is high in southern states because their local supply is limited. The current price of red deer progeny is $1 000 for red deer yearling hinds (1984 values).

Consumer demand for venison is increasing rapidly, but local supply is unable to meet Queensland demand and venison has to be imported from New Zealand. The current price for venison is $4.75/kg nett for deer carcasses. Prime venison is a low-fat product and what fat it does have is 50-55% polynsaturated. The higher production efficiency and killing-out percentage of deer suggest a bright long-term future. However, there are now in excess of 2 000 deer farms in New Zealand with a population now approaching 300 000 and estimates for a farmed deer population of over 3/4 million by 1990. A Game Industry Board was recently established to control the export and marketing of deer products and in the future competition from New Zealand venison could influence venison returns to Queensland farmers.

Velvet from deer antlers can also provide excellent returns. Red deer A Grade velvet is currently returning about $100/kg. The average weight of velvet from a red deer stag is about 1.5 kg.

For a deer farmer entering the industry it is generally envisaged that initial development could involve a small herd of about 10 hinds with a development period of up to 5 years. These units would be in association with some other enterprise, either livestock or cropping, which would be required to provide working capital and establishment costs during the stock build up period.

Deer farming has high capital costs with deer fencing costing an average of $6/m, but current returns are high and in line with the amount of risk involved. Once fences and yards are constructed, deer farming is a low labour-input industry.

2 SEROLOGICAL SURVEY OF RED DEER

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INTRODUCTION

The first release of red deer (Cervus elaphus) into southeast Queensland was during 1873-4. Fewer than 20 animals from the United Kingdom were freed into forests in hilly terrain around the Brisbane river valley. Further small numbers were released between 1903 and 1909 (Roff 1960; Bentley 1978). Today, about 10 000 red deer live about 10 000 km^2 in the catchments of the Brisbane and Mary rivers (Couchman 1980).

The habitat of the feral red deer is used mainly for forestry and the grazing of cattle. Some goat herds are maintained on the margins of this area. The feral deer are used as stock for a newly-begun deer farming industry (Couchman 1980). They may carry pathogens of domestic livestock, including those exotic to Australia (Murray and Snowdon 1976). No information on the infections of local red deer is known to us. To provide some such information we undertook a survey of red deer serums for antibodies against several bacteria and viruses from cattle.

MATERIALS AND METHODS USED

Deer

Between August 1977 and April 1982, blood samples were collected from 677 red deer (586 female, 91 male), 628 of which were obtained in the last 10 months from 1 June 1981. Mature deer (over 2 years old) comprised 532 of those sampled. The deer were from 20 localities, all within the feral range. They were bled either at the time of capture or up to 18 months afterwards.

Serology

Blood samples were collected aseptically from deer in the field and sera were separated from the clot 24-48 h later. Sera were tested for antibodies against 4 bacterial and 26 viral antigens. In some cases, serum volume was insufficient for all tests. The standardised complement fixation test (CFT) was used for Brucella abortus (Anon. 1977). The microscopic agglutination test (Winks 1962) was used for leptospires, any serum having 50% agglutination at a dilution of 1/100 or greater being considered positive. A microtitre neutralisation test (Cybinski et al 1978) was used for the viruses. The strains of the viruses which were

TABLE 2.1
Strains and sources of viral antigens used for testing red deer sera

Antigen	Strain	Source
Family Herpetoviridae		
Bovid herpesvirus 1	-	Snowdon (1964)
Bovid herpesvirus 2	-	St. George *et al* (1980b)
Family Togaviridae (Pestivirus)		
Mucosal Disease Virus	C24V	French and Snowdon (1964)
Family Rhabdoviridae		
Bovine ephemeral fever	BB7721	Doherty *et al* (1969)
Kimberley	CSIRO368	Cybinski and Zakrzewski (1983)
Tibrogargan	CSIRO132	Cybinski *et al* (1980)
Family Reoviridae (Orbiviruses)		
Palyam Group		
D'Aguilar	B8112	Doherty *et al* (1972)
CSIRO Village	CSIRO11	Cybinski and St. George (1982)
Bunyip Creek	CSIRO58	" " "
Marrakai	CSIRO82	" " "
Bluetongue Group		
Serotype 1	CSIRO156	St. George *et al* (1980a)
Serotype 20	CSIRO19	St. George *et al* (1978)
Serotype 21	CSIRO154	St. George *et al* (1980a)
BT AGDP	-	Della-Porta (1979)
Epizootic Haemorrhagic Disease of Deer Group		
Serotype CSIRO 157	CSIRO157	St. George *et al* (1983)
Serotype CSIRO 439	CSIRO439	" " "
Serotype CSIRO 753	CSIRO753	" " "
Serotype CSIRO 775	CSIRO775	" " "
Serotype DPP59	DPP59	" " "
Eubenangee (2 serotypes)	CSIRO20 CSIRO23	Standfast and St. George (pers. comm.)
Family Bunyaviridae (Simbu Group)		
Akabane	B8935	Doherty *et al* (1972)
Aino	B7974	" " "
Peaton	CSIRO133	St. George *et al* (1979)
Douglas	CSIRO150	" " "
Tinaroo	CSIRO153	" " "

used and their sources are given in Table 2.1. An agar gel diffusion precipitin (AGDP) test was used with a bluetongue group antigen (Della-Porta 1979).

RESULTS AND DISCUSSION

The results of the serological tests are given in Tables 2.2 and 2.3. The 677 deer sampled comprised about 7% of the estimated red deer population in the region. Sufficient sera were tested

against all antigens to estimate the prevalences in the whole population to within 5% at the 95% confidence level (Cannon and Roe 1982).

TABLE 2.2

Serological prevalence of infections with Brucella abortus and leptospires in red deer from south-eastern Queensland

Antigens	Number examined		Prevalence	
	Total	Sero positive	%	CL*
Brucella abortus	677	0	0	-
Leptospira interrogans serovar. hardjo	677	98	14.5	12.0-17.5
Leptospira interrogans serovar. pomona	677	4	0.6	0.1-2.6
Leptospira interrogans serovar. tarassovi	677	2	0.3	0.1-1.8

* 95% confidence limits of prevalence in the whole population (Cannon and Roe, 1982)

Brucella abortus

B. abortus infection of ruminants causes worldwide concern. This is currently emphasised in Australia by a national eradication campaign in cattle (Anon. 1982). The red deer feral range is in an area where the bovine brucellosis prevalence is now less than 0.22%. Our negative findings were consistent with those in surveys of red deer for brucellosis in England (McDiarmid and Matthews 1974) and New Zealand (Daniel 1966). The reason for this dearth of red deer reactors is unclear. It may stem from limited contacts between feral deer and cattle or indicate an innate resistance to Brucella infection. From our data, 44 positive reactors is the maximum that could be expected with 95% confidence in a population of 10 000 (Cannon and Roe 1982). These results suggest that deer are no threat to the brucellosis status of cattle in the region.

The CFT was the most efficient (85%) of 4 serological tests at detecting reactors in elk (Cervus canadensis) in a Wyoming study (Thorne et al 1978). Serological evidence of brucellosis in North America has been found in several deer species, namely elk, moose (Alces alces), white-tailed deer (Odocoileus virginianus), mule deer (O. hemionus) and caribou (Rangifer tarandus) (Moore and Schnurrenberger 1981). Reactors have been found in fallow (Dama dama) and sika deer (C. nippon) in England (McDiarmid 1951). No reactors have been found in small numbers of fallow, rusa (C. timorensis), sambar (C. unicolor) or hog (Axis porcinus) deer in Victoria, Tasmania (Presidente and Westbury 1979) and New South Wales (England 1982).

Leptospires

The prevalences of reactors to leptospiral serotypes were much less than those found in cattle in southeastern Queensland, namely 40% to Leptospira hardjo and 12% to L. pomona (Spradbrow 1964; Elder and Ward 1978). This suggests that while red deer are susceptible to leptospiral infection and could act as carriers, they are probably more at risk of infection from cattle than the reverse. Cattle were the most likely original source of infection for the deer in this study, but deer-to-deer transmission is not ruled out. Studies on cattle-deer-leptospira interactions in the United States have suggested that the maintenance of infection in deer does not depend on the presence of infected cattle (Andrews 1964).

The differences in prevalence between serotypes which we found in deer parallel those in the local cattle (Elder and Ward 1978). Smaller surveys of rusa and fallow deer in southern states have found similar prevalences (Presidente and Westbury 1979; Milner et al 1981; English 1982). Leptospirosis is an unimportant disease of deer (English 1982). The intensive husbandry of deer farming may reveal its full potential. One case of haemolytic leptospirosis (L. pomona) has been diagnosed in a farmed New Zealand red deer hind (Anon 1980a).

Bovid herpesviruses

Naturally-occurring infections of any deer with bovid herpesviruses 1 and 2 are rate (Lawman et al 1978). Clinical disease in animals other than cattle only occurs experimentally (Chow and Davis 1964; Westbury 1981). Our failure to detect antibodies is consistent with reports for small numbers of fallow, rusa and hog deer in southern states (Munday 1966; Presidente and Westbury 1979; English 1982). Bovid herpesvirus 1 (BHV1), the cause of infectious bovine rhinotracheitis, is widespread in Australian cattle (St. George 1982). The prevalence of BHV1 antibodies in cattle from the feral red deer range is about 20% (Queensland Department of Primary Industries unpublished data). Antibodies against bovid herpesvirus 2 have been detected in 65% of 1 514 cattle tested in regions of Australia north of the 20th parallel of latitude, and in 9% of 1 322 cattle to the south of it (St. George 1982). The feral red deer range lies in the latter area.

TABLE 2.3

Serological prevalance of infections with some viruses in red deer from southeastern Queensland

Antigen	Number examined		Prevalence	
	Total	Sero positive	%	CL†
Family Herpetoviridae				
Bovid herpesvirus 1	405	0	0	-
Bovid herpesvirus 2	193	0	0	-
Family Togaviridae (Pestivirus)				
Muscosal Disease Virus	405	16	4	2- 7
Family Rhabdoviridae				
Bovine ephemeral Fever	432	184	43	38-48
Kimberley	432	0	0	-
Tibrogargan*	432	0	0	-
Family Reoviridae (Orbiviruses)				
Palyam Group				
D'Aguilar*	432	370	86	82-89
CSIRO Village*	432	329	76	72-80
Bunyip Creek*	432	343	79	75-83
Marrakai	193	0	0	-
Bluetongue Group				
Serotype 1	396	32	8	6-11
Serotype 20	396	0	0	-
Serotype 21	396	51	13	10-17
BT AGDF	396	190	48	43-53
Epizootic Haemorrhagic Disease of Deer Group				
Serotype CSIRO 157*	432	216	50	45-55
Serotype CSIRO 439*	432	81	19	15-23
Serotype CSIRO 753*	432	200	46	41-51
Serotype CSIRO 775*	432	188	44	39-49
Serotype DPP59	432	130	30	27-35
Eubenangee (2 serotypes)**	193	0	0	-
Family Bunyaviridae (Simbu Group)				
Akabane*	396	356	90	87-93
Aino*	396	136	34	30-39
Peaton*	396	341	86	82-89
Douglas*	396	140	35	31-40
Tinaroo*	396	176	44	40-49

* Suspected vector is Culicoides brevitarsis

** Suspected vectors are Culicoides marksi, Anopheles farauti and Culex annulirostris

† 95% confidence limits of prevalence in the whole population (Cannon and Roe, 1982)

Mucosal disease virus

Antibodies against mucosal disease virus (MDV) have been found in small numbers of several deer species both in Australia (Munday 1972; Slee and Presidente 1981; English 1982) and elsewhere (Lawman et al 1978; Anon 1980b, 1981) and the results of this survey were similar.

Antibodies to MDV were found in 60% of over 5 000 Australian cattle surveyed by St. George et al (1967) but overt disease is uncommon (Beveridge 1981). The one report in deer in North America of a mucosal disease-like syndrome (Richards et al 1956) was unsubstantiated by virological or serological studies.

Arboviruses

Antibodies, frequently at high prevalences, were found against 17 of 23 arbovirus antigens in this survey. This contrasted markedly with the results of surveys with fewer antigens of much smaller numbers of fallow, rusa and sambar deer (Presidente 1978; Slee and Presidente 1981; English 1982) in the southern states with a more temperate climate and insect vectors of different species.

The arboviruses to which antibodies were found can be considered most conveniently in their serological groups.

Bovine ephemeral fever virus commonly infects cattle in the region where the red deer are found (Uren et al 1982). The present study indicates that these deer can also become infected. The younger deer (less than 18 months old) were free of antibodies which suggests that infection had occurred in the last epidemic in cattle in 1979, or earlier. Tibrogargan and Kimberley viruses are also found in the same area in cattle as judged by unpublished surveys of Cybinski and St. George, but no reason can be advanced at present for the lack of evidence of infection of deer.

The Palyam group viruses, D'Aguilar, CSIRO Village and Bunyip Creek have been found to infect sentinel cattle in southeast Queensland (St. George and Cybinski, unpublished data), but Marrakai virus antibody has not been found within 3000 km of the area. Thus the deer serology results for these viruses are consistent with those from cattle.

Similarly, antibodies to bluetongue virus serotypes 1 and 21, but not serotype 20, have been found in cattle in southeastern Queensland (St. George and Cybinski, unpublished data), although an objective survey has not been carried out in the red deer range. The 48% prevalence of bluetongue group antibody in deer revealed by the AGDP test in this study greatly exceeds the combined prevalences for serotypes 1 and 21 of 8 and 13% respectively. It is not known if this excess resulted from the infection of deer by other bluetongue virus serotypes or by a combination of cross-reacting viruses such as those of the epizootic haemorrhagic disease of deer (EHD) group which were very prevalent in the deer we have examined. The EHD group

viruses isolated locally from cattle have been separated into 5 serological groupings by St. George et al (1983). Other EHD group viruses cause major mortalities in North American deer (Frank and Willis 1975). No such disease has been seen in Queensland red deer.

The remaining orbivirus tested for was Eubenangee virus. Unlike each of the preceding arboviruses, no significant evidence of neutralising antibody has been found in cattle or deer in this survey but is present in marsupials (Muller et al 1982). This may reflect a difference in vector susceptibility.

All 5 Simbu group viruses associated with livestock were detected with prevalences between 34 and 90%. These viruses tend to be teratogenic given suitable circumstances (McPhee et al 1982). The chance of a feral deer calf with congenital defects surviving predators is very small. Both dingoes and feral pigs occur in the feral deer range. Farm-born deer may be affected in future if their dams are infected for the first time during pregnancy, however the high prevalences found in this survey may indicate enzootic stability with infection and immunity occurring early in life before breeding age.

Of the 19 viruses isolated from the biting midges Culicoides spp. in Australia, 11 have come from C. brevitarsis (Muller et al 1982). Antibodies to 10 of the 11 viruses isolated from C. brevitarsis were detected at moderate to high prevalence (34-90%) in deer in the present study (Table 2.2), suggesting that C. brevitarsis attacks deer. C. brevitarsis breeds in the dung of large herbivores (Cannon and Reye 1966) and occurs in the study area (H.A. Standfast, personal communication). Laboratory studies have shown that C. brevitarsis can be infected with the three serotypes of bluetongue virus known from Australia (Muller et al 1982). It is the only representative of the group of insects infected (Standfast et al 1979) known to occur in the area which could have transmitted the bluetongue viruses. The more efficient bluetongue vector Culicoides fulvus has not been recorded south of Mackay (Dyce and Standfast 1979). Culicoides marksi is widespread in Australia (Murray 1975) and occurrs in the area (H.A. Standfast, personal communication). However no antibody was detected to Eubenangee virus, the only virus isolated from this insect (Muller et al 1982), for which tests were done in this study.

CONCLUSIONS

Our results suggest that red deer, though of restricted geographical distribution, must now be considered in the epidemiology of arboviruses. It must be emphasised that no disease has been observed in either farmed or free-living deer which could be attributed to any of these viruses. In fact the farmed red deer population at present is essentially very healthy, but their increasing numbers may provide conditions for sub-clinical infections to become manifest as overt disease.

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3 PARASITES OF RED DEER IN SOUTH-EASTERN QUEENSLAND

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INTRODUCTION

About 10 000 feral red deer (Cervus elaphus) inhabit the Brisbane and Mary river catchments of south-east Queensland, an area mostly used for forestry and cattle grazing. The recently established deer farms in the area have drawn on this feral population for breeding stock (Couchman 1980). This activity has prompted the small survey reported here for potentially pathogenic parasites of these deer.

MATERIALS AND METHODS USED

Deer and Specimens Examined

Between 1 July 1979 and 31 August 1981, 12 female and 11 male red deer were necropsied and examined for parasites. Seven deer were shot and necropsied in the field and 16 were submitted to the laboratory after death in traps or on deer farms. The time in captivity of the latter 16 was from 1 day to over 2 years with 8 captive for less than 1 month. Mature deer (over 2 years old) comprised 18 of those examined. Whole alimentary tracts (ruminoreticulum, abomasum and intestines) were available from 19 deer. The organs examined are indicated in Table 3.1. Ticks were obtained from 8 deer. Faeces were examined from 20 deer.

Parasitological methods

Alimentary tracks were opened, visually inspected, washed out and the contents collected and sieved to recover helminths. The helminth burdens were estimated by individual counting or by the method of aliquots. Bile ducts were opened and examined for trematodes. Lungs were palpated and airways opened and searched for nematodes. Fascial planes and epimysia (and cranial meninges of carcases submitted to the laboratory) were searched for Elaphostrongylus cervi adults. Faeces were examined for nematode egg and coccidial occysts by saturated sodium chloride flotation and the McMaster technique, for trematode egg by the methods of Happich and Boray (1969) or Breca and Corba (1973), and for lungworm larvae by the Baermann technique. Faeces were cultured for nematode larvae by the standard technique. Boophilus microplus were examined for acaricide resistance by the method of Stone and Haydock (1962).

RESULTS

The identity of the helminths and ticks recovered, their prevalences and their sites of infection are given in Table 3.1.

TABLE 3.1

Helminths and ticks recovered from red deer from south-eastern Queensland

Parasite	No. of deer		No. of parasites
	Examined	Infected	Mean (range)
Trematodes			
Orthocoelium (Ceylonocotyle) streptocoelium (R)*	19	5	2 900 (4-10 800)
Fasciola hepatica (Li)	23	1	- (5)
Cestodes			
Echinococcus granulosus (Li)	22	1	- (1)
Nematodes			
Capillaria sp. (IS)	22	4	18 (5-40)
Cooperia sp. (IS)	22	3	9 (1-15)
Dictyocaulus viviparus (Lu)	21	2	7 (1-12)
Elaphostrongylus cervi	23	0	-
Haemonchus placei (A)	22	6	70 (1-198)
Oesophagostomum venulosum (IL)	22	12	10 (1-31)
Spiculopteragia asymmetrica (A)	22	15	243 (11-774)
Spiculopteragia boehmi (spiculoptera) (A)	22	18	322 (20-1 806)
Ticks			
Boophilus microplus	23	7	Not recorded
Haemaphysalis bancrofti	23	1	- (1)
Ixodes holocyclus	23	1	- (1)

* Location in host: (A) Abomasum, (IS) Small intestine, (IL) Large intestine, (Li) Liver, (Lu) Lung, (R) Ruminoreticulum.

No striking contrasts were seen between burdens in deer older and younger than 2 years. *Haemonchus placei* occurred almost exclusively in captive deer, only 1 worm being found in 1 feral deer. The faecal nematode egg counts were very low, the highest being 240 epg with 17 of the 20 samples containing 40 epg or less. Larvae were obtained from 4 samples and were mainly *Spiculopteragia* spp. No coccidial oocysts were detected in any faecal sample. The 5 samples containing paramphistome eggs yielded from 1 to 54 epg (mean 24 epg).

Seven deer were infected with B. microplus. One which died from trauma during capture carried about 200 engorged females on one side of its body with 710 ticks (comprising 299 males, 224 females and 187 nymphs) on the ear. A second deer carried a similar burden which was not counted. It died after 6 months in captivity. Its tissues were very anaemic at necropsy. No other disease was detected. Biarra-type acaricide resistance was found in 1 batch of ticks, and mixed Biarra-Mt. Alford with the former predominant in 4 other batches examined.

DISCUSSION

General

The parasites detected were a mixture of those confined to deer (Spiculopteragia spp.) and those which infect the local domestic ruminants. The number of deer examined and the parasite burdens found were considered too small to allow valid broad conclusions to be drawn on the effects of age or time of captivity on parasite burdens. There is nothing substantial to be gained from a detailed comparison of the results of parasite surveys of deer species in the temperate south of Australia (Presidente 1979; Presidente and Draisma 1980; Slee and Presidente 1981) and New Zealand (Wilson 1979; Mason 1981) with this one from a subtropical habitat. As could be expected from the climatic difference, we record here substantial numbers of H. placei, Cooperia sp. and B. microplus for the first time in deer in Australia. The numerous rumen flukes and the few Dictyocaulus viviparus also reflect climatic differences.

Pathogenic potential of helminths found

Only the rumen fluke Orthocoelium (Ceylonocotyle) steptocoelium and the abomasal nematodes Spiculopteragia spp. were found in numbers sufficient to be potentially life-threatening or a possibly significant facet of natural selection pressure for feral red deer. For deer in captivity, any or all of the helminths found could become significant pathogens given appropriate conditions. H. placei and Cooperia spp. in particular may cause concern in the summer rainfall zone in which deer are farmed in Queensland. Experience in New Zealand (Charleston 1980) and Scotland (Corrigall et al 1980) with severe infections of farmed red deer with D. viviparus prompts vigilance against this threat as well, although cattle in south-eastern Queensland rarely display clinical lungworm infections.

Trematodes

O. streptocoelium has been found previously in sheep and cattle in Australia (Albiston 1967), and in sambar deer (Cervus unicolor) and water buffalo (Bubalus bubalis) in the Northern Territory (Keith and Keith 1969). Their occurrence in red deer in south-eastern Queensland contrasts with the Calicophoron calicophorum infections commonly found in cattle in the area.

Fasciola hepatica has a very limited distribution in Queensland, being confined to small areas in the southeast (Dixon 1963) some of which include feral deer range. The single infection we found may reflect this limited exposure of deer to infection or a relative resistance of deer to infection with this fluke (Wilson 1979).

Echinococcus

Much of Queensland is inhabited by dingoes (Canis dingo) infected with Echinococcus granulosus and the prevalence of hydatid cysts in cattle viscera can approach 50% (Durie and Riek 1952; F.C. Baldock unpublished data). As dingoes are commonly associated with feral red deer as predators of their calves, ample opportunity for infection was likely. The single nonviable cyst found in our deer is consistent with the previously-observed resistance of red deer to hydatid infection (Sweatman and Williams 1962).

Elaphostrongylus cervi

No evidence of the metastrongylid nematode E. cervi (adult worms, larvae or inflammatory lesions) was found in the carcases which we examined. Further, over 150 red deer have been processed through commercial abattoirs in south-eastern Queensland without any evidence of E. cervi being seen (A.R. Mackenzie, personal communication 1982). E. cervi has not been found in any deer in Australia to date (1983). As low stock numbers and a restricted gene pool are important limiting factors for the Australian deer farming industry, the importation of E. cervi- free deer from New Zealand would be beneficial. E. cervi is present in up to 50% of farmed red deer and 45% of feral red deer in some areas of New Zealand (Watson 1980/1). During larval migration it may cause lesions in the central nervous system of red deer (Watson 1981) and possibly more severe lesions in other deer (Presidente 1979). This possibility and the potential effects of E. cervi on carcase quality, have been the basis for refusal of entry to Australia for live deer from New Zealand. Recent promising work with anthelmintics in Europe may enable deer to be freed of infection (Duwel et al 1979; Kutzer and prosl 1979). Demonstration of the absence from Australia of terrestrial molluscs capable of transmitting E. cervi could serve to allow import, but this is unlikely as many genera of molluscs have this capacity (Watson 1981).

Ticks

Experimentally, 10 female Ixodes holocyclus induced paralysis in 2-3 week old bovine calves weighing up to 40 kg (Doube et al 1977), and red deer are as susceptible as cattle to this tick (English 1979). Bandicoots, which are its host (Doube 1975), are found in the feral deer range. The period of increasing female tick activity (Doube 1975) coincides with the deer calving season, making it conceivable for tick paralysis to kill sufficient feral red deer calves to affect the population growth. Confirming this by finding affected calves would be made very

difficult by dingo and feral pig predation.

The acaricide resistance which was found in B. microplus was consistent with results for B. microplus from cattle in the area (Roulston et al 1981). Queensland deer farmers have used acaricides to control B. microplus by regularly plunge-dipping or spraying their deer. The introduction of the tropical Asian species of deer to the B. microplus-infested northern areas of Australia would certainly lessen and possibly eliminate the need for acaricides for tick control. Rusa (Cervus timorensis), chital (Axis axis) and sambar deer are all present in Australia (Couchman 1980) and are better suited to the tropical and subtropical climate than the red and fallow (Dama dama) deer of European origin. Rusa deer are more resistant to B. microplus than British breed cattle (Owen 1977), and chital and sambar probably have the same ability.

CONCLUSIONS

In general, this study suggests that red deer in south-eastern Queensland are not troubled by parasite infections at present. The major exception to this is B. microplus. To maintain this situation, deer farmers and their advisors will need to pay attention to good husbandry practices.

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4 NECROPSY FINDINGS IN RED, FALLOW AND RUSA DEER FROM SOUTH-EASTERN QUEENSLAND

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INTRODUCTION

The recently-established deer farms in south-eastern Queensland have relied almost totally on the capture of local feral red deer (Cervus elaphus) for stock. A few feral rusa deer (C. timorensis) from Prince of Wales island in Torres Stait and feral fallow deer (Dama dama) from the southern border region of Queensland have also been included on some deer farms (Couchmann 1980). This paper complements previous observations by reporting the principal necropsy findings from deer obtained dead or moribund during capture operations, from farms and from fauna parks in south-eastern Queensland during 1979-1982.

MATERIALS AND METHODS USED

Deer and Specimens Examined

Necropsies were performed at this laboratory on 16 red deer (11 female; 5 male), 4 male fallow deer and 1 female rusa deer, and specimens were received for examination from a further 11 red deer (8 female; 3 male), 2 fallow deer (1 female; 1 male) and 5 rusa deer (1 female; 4 male) necropsied in the field. The deer originated from 15 different farms. The maximum from any 1 farm was 6.

Laboratory methods

Necropsies were performed by standard techniques for ruminants. Specimens collected or received from field necropsies were examined as appropriate by histopathology, chemical analysis for toxins or culture for microbial pathogens using routine methods.

RESULTS AND DISCUSSION

General

Death among farmed deer in Queensland have been few and sporadic, and no disease causing serious losses has been reported. This is reflected in the few deer necropsied from an estimated farm population of 3,000 red deer and fewer than 300 of each of fallow and rusa deer (A. R. Mackenzie, personal communication 1982).

Trauma

Deer which have died rapidly as a direct result of mishaps while being trapped, transported or immobilised by drugs were

TABLE 4.1

Main Necropsy Findings in Red, Fallow and Rusa Deer from southeastern Queensland, 1979-1982.

Causes of Death or Disease	Number of Deer Examined		
	Red	Fallow	Rusa
Mishaps during capture			
Trauma			
Affecting the neck	6		
Affecting other sites	2		
Suffocation during transport	1		
Metabolic disorders			
Ketosis (pregnancy toxaemia)	2		
Acidosis (grain overload)	2		
Abdominal fat necrosis			4
Intoxications			
Trema aspera poisoning		1	
Infectious diseases			
Parasitic			
Boophilus microplus	3		
Microbial			
Salmonellosis		1	
Pneumonia	2		
Pyelonephritis/Metritis	3		
Unknown or Undetected Causes			
Hepatic fibrosis	1		
Polycystic kidneys (congenital)	1		
Lymphosarcoma		1	
Haemorrhagic enteropathy	1	2	
Muscular degeneration	1		
No significant lesions	2	1	2
	27	6	6

not submitted for necropsy by the farmers involved. Thus cases of trauma and other capture-related diseases were under-represented in this study. Those cases of trauma which were submitted (Table 4.1) were usually paralysed or recumbent and remained alive for various periods after the traumatic incidents which were not always observed by the farmer. The complete absence of cases of exertional rhabdomyolysis or 'capture myopathy' (Harthoorn 1981) was surprising given the initial inexperience of the captors.

Cases of trauma to the neck probably all resulted from the head-on impact of deer attempting to escape through the wire netting fences of traps. These fences provide a solid physical

barrier but, if some form of visual barrier is not present, they may not be recognised by deer in flight. The neck lesions sustained by different deer included luxation of the intervertebral joint (IVJ) between cervical vertebrae 1 and 2 (C1-2), fracture of the dens and spinous process of C2, avulsion of the ajoining epiphyses of the bodies of C4 and C5, rupture of the IVJ C6-7 and subluxation of IVJ C6-7. These affected the spinal cord by constriction, subdural and internal haemorrhage, laceration or a combination of these.

Another red deer suffered avulsion of one tuber coxae with strangulation of herniated small intestines through an associated rent in the abdominal muscles. A further red deer died during surgery to reduce a luxated hock joint.

Metabolic disorders

The 2 cases each of pregnancy toxaemia from inadequate feeding and of acidosis from excessive grain feeding appeared to result from the failure of farmers to apply standard principles of ruminant nutrition for prevention of these metabolic disorders (Blood et al 1979). The extensive fat necrosis of abdominal fat depots seen in rusa stags at routine slaughter was consistent with such lesions (lipomatosis or primary lipogranulomatosis) in cattle and pigs which is thought to result from rapid lipid mobilisation from adipose tissue (Vitovec et al 1975). Its occurrence in these deer was surprising as they were thought to be well fed.

Intoxication

Trema aspera (Poison peach) ingestion by a 3 month-old fallow buck resulted in rapid death from severe centrilobular necrosis and haemorrhage in the liver and its sequellae. This case was consistent with the known effects on ruminants of this plant which is common in coastal south-eastern Queensland (Seawright 1982).

Infectious diseases

Three probable cases of fatal Boophilus microplus infestation were necropsied. All were severely anaemic, and one had subcutaneous oedema. The deer-B. microplus relationship has been discussed by Green (Chapter 3).

The only serious mortality seen occurred in October 1981 when 7 of 30 mature fallow bucks imported from Victoria died with a haemorrhagic enteropathy between 2 and 6 days of arrival. Laboratory necropsy of the last 3 bucks to die failed to demonstrate any pathogens (including Yersinia spp.) in 2 but Salmonella typhimurium was isolated from many tissues of the third. The small and large intestinal lesions (congestion and haemorrhage) were similar in all 3. No histological evidence of malignant catarrhal fever was seen in any tissues. The apparently 'non-infectious' cases may have been the post-stress haemorrhagic enteropathy described in red deer in New Zealand (McAllum 1981).

Severe necrotising fibrinous pleuropneumonia was seen at necropsy in the field of 2 mature red hinds recently introduced to one farm. No material was received for culture but Pasteurella spp. are a possible cause of such lesions (Jubb and Kennedy 1970). Three cases of severe urinogenital tract infection occurred in red hinds from different farms. Two had chronic vaginal discharges. At necropsy, purulent bilateral pyelonephritis, cystitis, metritis and vaginitis were found in these 2 and purulent endometritis in the third. A mixture of bacteria was seen in tissue sections (fusiforms, diphtheroids, cocci) and pseudomonads and coliforms were variously isolated from the lesions.

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5 LIVER COPPER CONCENTRATIONS IN RED DEER IN SOUTH-EASTERN QUEENSLAND

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INTRODUCTION

Copper (Cu) deficiency of cattle is recognised in several parts of south-eastern Queensland, essentially on alluvial coastal plains (Gartner et al 1980). This type of terrain includes the sites of some deer farms. Clinical Cu deficiency has not been reported in farm deer in Queensland to date. In red deer in Europe and New Zealand, ataxia and posterior paresis in mature animals, similar to enzootic ataxia, has been tentatively linked with Cu deficiency (Barlow et al 1964; Terlecki et al 1964; Wilson et al 1979). These reports prompted the analysis of local red deer liver samples for Cu to provide a basis for evaluation of any putative Cu deficiency which may occur in farm deer in future.

MATERIALS, METHODS USED AND RESULTS

Liver tissue from 15 of the red deer whose necropsies were reported in Chapter 7 and from a further 10 normal red deer, either shot in the field or collected at slaughter, was submitted for Cu analysis. Liver samples were analysed for Cu by the method of Clare et al (1945).

Thirteen hinds and 11 stags, all greater than 1 year old, had a mean liver Cu concentration of 95 ± S.D. 50.7 mg/kg dry matter with a range of 18-198 mg/kg which was comparable with that in similar deer from New Zealand (132 mg/kg measured by Reid et al 1980) but higher than values from Scotland (51 mg/kg measured by McTaggart et al 1981; 24 mg/kg measured by Cowie 1976). Three deer had concentrations of less than 30 mg/kg, the level below which cattle are regarded as Cu deficient (Blood et al 1979). A 4-week-old stag calf had 970 mg Cu/kg liver dry matter. Young deer have much higher concentrations than adults (Reid et al 1980).

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