Ecology and Environmental Impact of Javan Rusa Deer (*Cervus timorensis russa*) in the Royal National Park

*Andrew James Moriarty B. App. Sc. (Hons.)*

A thesis submitted in fulfillment of the requirements for the degree of Doctorate of Philosophy

College of Science Technology and Environment
School of Science Food and Horticulture
University of Western Sydney

June 2004
“I now suspect that just as a deer herd lives in mortal fear of wolves, so does a mountain live in mortal fear of its deer. And perhaps with better cause, for a while a buck pulled down by wolves can be replaced in two or three years, a range pulled down by too many deer may fail of replacement in as many decades.”

Aldo Leopold

*A Sand County Almanac*

“Let us not change reality to fit ideology”

Graeme Caughley

*The Deer Wars*
Statement of Authentication

The work presented in this thesis is, to the best of my knowledge and belief, original except as acknowledged in the text. I hereby declare that I have not submitted this material, either in full or part, for a degree at this or any other institution.

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Abstract

This thesis examines the ecology and environmental impact of rusa deer, *Cervus timorensis*, in Royal National Park (Royal NP). Wild deer are an emerging pest in many parts of Australia and their biology and impact on both native flora and fauna is largely unknown. This study aims to inform the management of this species.

The study was conducted from September 1999 to December 2001 in Royal NP, 30 km south of Sydney, NSW, Australia. The ecology of rusa deer was divided into two sections, namely movement ecology (encompassing home-range, habitat use and dispersal) and population ecology (encompassing the study of density, rate of increase, reproduction, mortality, the presence of disease and parasites and body condition).

Movement ecology was investigated by fitting radio-collars to a variety of age and sex classes of deer in several areas of the Park and monitoring their behaviour. Home-range size ranged from less than 1 km$^2$ to 8 km$^2$. Most animals showed significant variation in their home-range between seasons, with increases in range most common in winter, perhaps in response to decreased food availability at this time. Analysis of habitat use within home-ranges showed that most animals centred their activity around cleared grassed areas flanked by forest, heath or woodland areas. The size of the home-range and the amount of cleared land in each home-range was highly correlated. Most deer shifted their range seasonally, however only three out of 29 radio-collared animals dispersed. All were sub-adult males between 1 and 2 years of age. All three animals were from high density deer areas and all dispersed to low density deer areas. This result, along with the observation that three other males in this age group from low-density deer areas did not disperse, suggests that dispersal in this population is density dependent.
The distribution, abundance and rate of increase of the rusa deer population in Royal NP was determined by conducting scat surveys of all areas of the Park in three consecutive years. This information along with estimates of deer scat decay rates and defecation rates allowed the density of deer in different areas of the Park and the total number of deer in the park to be determined. Population estimates for the three survey years ranged from 2522 in 1999 to 2877 in 2001. The density of deer was highest in areas where larger cleared, grassed areas were present. Deer numbers did not change significantly over the three survey years. Estimation of the rate of increase for the population showed that in the year 1999/2000 deer numbers increased 1.10 times and in 2000/2001 increased by 1.04 times. The observed exponential rate of increase for the population over the three-year period 1999 to 2001 was estimated to be 10%. These results indicate that the population is relatively stable and likely to be at or close to carrying capacity.

Reproductive parameters, mortality, the presence of diseases and parasites, and the body condition of deer was determined by examining necropsy material taken from shot deer and deer found dead from other causes (e.g. motor vehicle accidents). Analysis of male reproductive material indicated that they first produced sperm at between 1 and 1.5 years of age and around 37 kg body weight. Antler development, testis weight and sperm production were strongly influenced by the timing of the rut, with younger male’s antler, testis and sperm production cycles showing a lag of up to one month behind that of older males. A total of 20 males (24% of males sampled) only had one testicle. Female rusa deer were able to reproduce from 1.5 years of age or from 33 kg to 43 kg body weight, with the youngest lactating female recorded at 2.5 years of age (based on an 8 month gestation period). The season of births for this population peaked
in April and the average frequency of births for rusa deer females ranged from 0.86 to 0.67 pregnancies per year. The sex ratio of fetuses sampled over a two-year period did not differ significantly from parity and the fecundity rate of females peaked at between 0.35 and 0.43 for females between 6 and 7 years of age.

Examination of the cause of deer deaths showed that the most important mortality agents acting on this population were collisions with motor vehicles, followed by dog attacks. Ticks were the only external parasites found on the deer, with low levels of internal parasites found in some animals. Blood samples showed some deer to have low antibody titres to the stock and wildlife diseases, leptospirosis, Q fever, akabane and ephemeral fever. Body condition scores showed a cyclic pattern for both males and females. Males showed a typical fat deposition period before the rut and fat loss period during and after the rut. Females showed a typical pattern of fat deposition and retention during pregnancy and loss during lactation.

The environmental impact of rusa deer in Royal NP was determined by monitoring the diversity of plant species in fenced and control plots at high and low deer density sites over a two year period, by examining the diet of shot and found deer in different areas of the Park and by determining the dietary overlap between deer and the swamp wallaby (Wallabia bicolor). Results of the enclosure experiment showed no differences between the diversity of plant species in fenced plots compared to control plots at individual sites. However, large differences existed between plots located in high deer density locations compared to low deer density locations for the habitats of littoral rainforest (54% less understorey species at high deer density sites), sandstone gully forest (33%
less understorey species at high deer density sites) and sandstone heath (27% less understorey species at high deer density sites).

Analysis of deer diet showed that they consumed a total of 18 native plant genera and 155 native plant species. These plants included a variety of trees, shrubs, climbers, creepers, ferns, orchids, herbs, grasses, rushes and sedges, including two endangered species, nine vulnerable species and 13 regionally uncommon species. Seasonal variation of dietary intake showed that many deer switched from introduced grass consumption to more native plant consumption in winter. Diet modeling showed that the volume of deer rumen increased in winter and that the deer population in Royal NP consumes around 36 million litres of native plant material per year.

Results of four dietary overlap studies between deer and wallabies showed that overlap ranged from 24% in autumn in a heath habitat to 60% in winter in a cleared/mosaic habitat. Modeling of deer and wallaby density as a combined herbivore unit showed that one deer is equal to around 3.88 wallabies (based on stomach and rumen volumes) and that herbivore unit density (including deer) was two to three times greater than the density of other similar sized herbivores along the east coast of Australia.

Interpretation of this research shows that rusa deer impact on both native flora and fauna in some areas. Targeted and strategic management of deer numbers in high impacted sites and follow up monitoring of both deer numbers and vegetation response is recommended. Implications for the removal of large numbers of deer from Royal NP (e.g. fire fuel loads and weed proliferation) should also be considered in future management strategies.