REPRODUCTION IN TROPICAL SPECIES

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The Acclimatisation Societies in Australia, introduced at least 17 species or subspecies of deer in the last century. Six species became established in the wild in Australia: fallow, red, chital, hog, rusa and sambar deer. These wild populations provided the base stock for deer now held on farms.

Rusa and chital deer are the main tropical species farmed in Australia. A small number of sambar deer are held on farms, being used largely to hybridise with rusa deer to produce a larger, fertile F1 hybrid. Hog deer are found in the wild in southern Victoria with only a few in captivity.

The tropical species of deer (Table 1) do not have the well-defined breeding season of temperate species such as red and fallow deer. They do however display a degree of seasonality but differ from the temperate species in that they can reproduce year round.

Table 1. Liveweights for tropical species of deer

Class of Animal	Birthweight (kg)	Yearling LW (kg)	Mature LW (kg)
Javan rusa			
Stag	5 ± 2	70–80	120–160
Hind	4 ± 0.5	40–60	65–85
Moluccan rusa			
Stag		45–60	80–100
Hind		30–50	50–60
Chital			
Stag	3.6 ± 0.35	30–35	70–90
Hind	3.4 ± 0.5	25–30	45–55
Hog			
Stag	3.5	28–35	40–50
Hind	3	20–25	30–35

CHITAL REPRODUCTION

Chital deer (*Axis axis*) are indigenous to India and Sri Lanka, an equatorial region in which they are able to reproduce year round.

In the wild, there are regional variations in the timing of the antler cycle and the season of births, with chital stags in the north of their range exhibiting a seasonal antler cycle

(Schaller, 1967; Mishra, 1982), while in the south of the range there is little synchrony in the antler cycle or birth season (Phillips, 1928; Morris, 1935).

Chital translocated to temperate regions continue to breed during all months of the year, although some may exhibit a degree of seasonality in their reproductive and antler cycles (Graf and Nichols, 1966; Loudon and Curlewis, 1988; Chapple, 1989) similar to that seen in tropical regions. Thus it appears that photoperiod does not influence reproduction in chital deer.

FEMALE REPRODUCTION

Female chital deer in the wild and in captivity are reported to calve during all months of the year (Asdell, 1964; Graf and Nichols, 1966; Mishra, 1982; Loudon and Curlewis, 1988; Chapple, 1989;). Hence it has been thought that chital hinds are capable of conceiving during any month of the year.

In a study at the Deer Research Unit (DRU), at Camden, a group of 5 chital hinds were run with a crayon-harnessed vasectomised stag for a 12 month period to assess annual cyclicity. Progesterone concentrations were measured every 3-4 days to assess ovarian activity. Results from this study showed that hinds are polyoestrus and cycle throughout the year (Figure 1), when not mated. It is interesting to note that the teaser stag mated hinds during all stages of his antler growth.

Chital hinds are invariably monovular and have an oestrous cycle length of 19.3 ± 1.3 days (Chapple, 1989; Mylrea, unpubl.).

Mean gestation length is 240 ± 1.7 days. At Camden, NSW, in a mixed-sex herd, calves were born in every month of the year when mating was unrestricted. However, there was a seasonal pattern of parturition with the majority of calves being born in the second half of the year (peak August/September). This peak in calving corresponds to the time of the year (January-June) when the majority of chital stags are in hard antler and most fertile.

Studies on chital populations in both equatorial and temperate regions have reported seasonal patterns of calving (Asdell, 1964; Graf and Nichols, 1966; Mishra, 1982; Loudon and Curlewis, 1988; Chapple,1989), although calves were born in all months of the year. Calving patterns varied widely between these populations. It appears that it is the male that determines the mating and hence calving time, as peaks in calving corresponded with the time of year when there was a peak in males in hard antler.

Parturition/maternal behaviour

Parturition/maternal behaviour is similar to other deer species. Signs of parturition are expressed in restlessness of the hind, with repeated licking of the vulva and udder, frequent lying down and then rising for short walking or grazing periods. Hinds usually withdraw from the herd to give birth but will calve near other females when in small paddocks. Duration of labour, time to standing and first suckling of the neonate have not been reported. Chital calves exhibit a 'freezing' reflex for 24-48 hours and remain in a hiding phase until 10-14 days old. By day 25 they were constantly with their mother in the herd (Chapple, 1989).

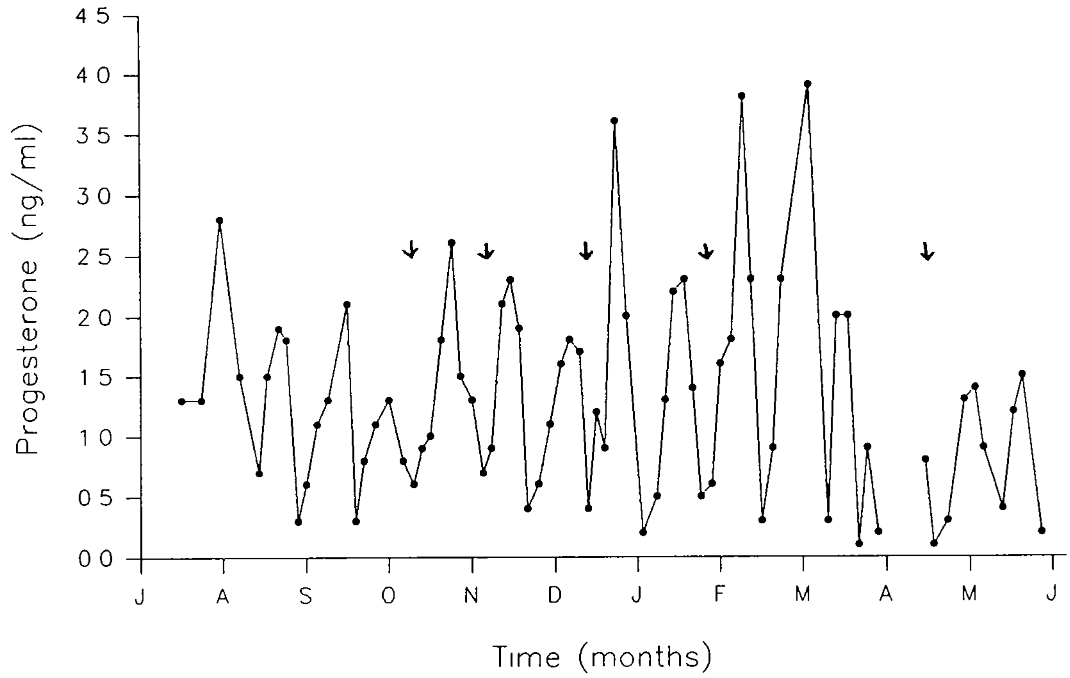

Figure 1. Plasma progesterone profile of a chital hind run with a vasectomised stag (arrows indicate behavioural oestrus).

Table 2 Necropsy results for perinatal mortality in farmed chital deer, 1980–1990 (Mylrea and English, 1990).

Diagnosis	Chital n (%)
Parturient death	5 (11)
Exposure/starvation	13 (28)
Hyperthermia	–
Mismothering	5 (11)
Misadventure	7 (15)
Infections	–
Malformation	1 (2)
Predation	15 (33)
Dystocia	–
Total	46

The average birthweight of male and female chital calves is 4.0 ± 0.4 and 3.6 ± 0.4 kg respectively (Mylrea, unpub.). A twinning rate of 2.5% has been recorded in a herd at Camden (Chapple, 1989).

Perinatal mortality

A study over 10 years reported perinatal mortality to be the major cause of death in farmed deer in the Camden region of New South Wales; accounting for 41% of deaths in chital deer (Mylrea and English, 1990). Perinatal mortality was defined as death before, during or within 7 days of birth.

Table 2 shows the necropsy results of perinatal deaths recorded from 1980–1990 at Camden, New South Wales. Causes of death have been classified into 9 categories.

Predation, exposure/starvation, mismothering and misadventure were the major causes of calf mortality in chital deer. It is important to appreciate that deaths in any one of these categories is likely to be multifactorial, the result of an interaction between one another i.e. one may predispose to the other.

Foxes were the major predator of chital calves at Camden, with predation being the major cause of perinatal mortality (33%). Predation was most frequent in September/October when foxes were hunting for feed for their young. When restricted mating is timed so that calving occurs in spring, when fox predation is at its peak, it is vital that preventative measures against fox predation are in place. Good fencing (including the use of electric fencing) is essential to minimise predation losses.

Weather stress (hypothermia) has been identified as a major factor causing deaths. Where unrestricted mating is allowed, a large number of calves will be born during the cold, wet winter months (peak calving August/September), when climatic conditions are not very conducive to calf survival. It is during these periods that perinatal mortality is high. It appears that the time of calving is the critical factor with regard to chital calf mortality. If mating is restricted so that calving occurs only during spring and summer when climatic conditions are more favourable, there is a much higher rate of calf survival.

Unlike the situation in red and fallow deer, chital calf mortality does not appear to be directly related to birthweight. Weights at autopsy were distributed over a wide range. Also the incidence of perinatal mortality was similar in both primiparous and multiparous hinds (Chapple, 1989).

The majority of losses due to misadventure were preventable with good management, the provision of good fencing and adequate shelter in calving paddocks.

Management strategies which seek to minimise deaths during the perinatal period will result in improved reproductive performance and increased profitability.

Post Partum Oestrus

Chital are capable of ovulating and conceiving soon after parturition, while lactating (Graf and Nichols, 1966; Chapple, 1989). The interval from parturition to conception in a captive population of chital ranged from 18 to 118 days, averaging 48 ± 28 days (Chapple, 1989). 39% of hinds conceived within 33 days of calving, 25% between 34–51 days and

36% between 52–118 days. The inter-calving interval averaged 283 ± 28 days (Chapple, 1989).

This ability to conceive soon after calving means that chital hinds are capable of producing 3 calves in 27 months, provided they are joined with a fertile male soon after calving.

Weaning

Weaning, as a management practice is recommended in chital deer for the same reasons outlined for fallow deer (English, 1990).

The threshold weaning weight has been set at 13 kg at around 3 months of age – it would be unwise to separate a calf smaller than this from its mother. At 3 months, most calves will be 14–16 kg. Animals should also be sexed, weighed, eartagged and vaccinated at weaning.

Mating management

If mating is not restricted, at any one time there will be females at all stages of gestation, very young deer, as well as antlered stags. It is quite impossible to handle such large, mixed groups of chital deer without losses of animals due to trauma or mismothering.

By restricting the mating to a 6–8 week period, as is often practised in the temperate species, there are the advantages of:

- tight calving period and therefore easier management
- uniform groups of animals makes handling easier
- stags can be kept separately most of the year, enabling easier velvet harvesting without having to yard the hinds and calves.

The use of restricted mating will ensure that a group of chital hinds of known reproductive status can be managed in the appropriate fashion, with calving occurring in the selected period. All the calves in the group will then be of a similar age, and can eventually be yarded with their dams for vaccination, weaning etc., with minimal risk of injury or mismothering.

The period selected for the calving season will be determined by several factors. The first factor is likely to be related to the seasonal conditions of weather and climate on the farm in question. It has become apparent that chital deer have some problem in coping with extreme changes in winter weather, with the deer most at risk being heavily pregnant and recently calved hinds, and very young calves.

The other seasonal factor which determines the choice of calving season concerns the pasture growth pattern for the region. Calving should be timed to occur when pasture is plentiful and of high quality.

MALE REPRODUCTION

The antler and reproductive cycles were studied in 10 farmed chital deer over an 18 month period at DRU, Camden, run as a bachelor group. At monthly intervals stags were anaesthetised and electroejaculated to collect a semen sample. Semen samples were evaluated for volume, colour, wave motility (WM), progressive motility (PM), % live, % abnormal and concentration. Liveweight (LW), neck girth, scrotal circumference, antler stage and testosterone were also measured.

Figure 2 shows the results from a representative stag in the group. Testis size reached a nadir shortly after the casting of the old antler and increased gradually during the period of antler growth. Maximal testis size occurred 4-5 months after antler casting when stags were in hard antler. Serum testosterone concentrations were undetectable around the time of antler casting but coincident with the period of hard antler and maximal testis size, testosterone levels reached maximal concentration. Thus, in this species, as in the temperate species, there is a close correlation between changes in testis size, testosterone secretion and growth and development of the antler (red deer: Lincoln, 1971; fallow deer: Asher *et al.*, 1987). Similar results have been reported in a herd of chital stags at Bedfordshire in the United Kingdom (UK) were there was little evidence of a clear seasonal synchrony in the antler cycle (Loudon and Curlewis, 1988). These authors also found that changes in bodyweight and neck circumference occurred in association with changes in testis size, independent of the time of year.

Seasonal changes in neck girth and coat colour were more pronounced in the Australian study than in the UK study. Neck girth of the mature chital stags was correlated with liveweight and testosterone levels, with all paramcters declining during antler growth (Figure 2).

In the bachelor group of males, a 5-10 % loss in liveweight between hard antler and velvet antler stages was observed in the mature stags. A study in a group of stags run with hinds (Loudon and Curlewis, 1988) observed a 20% loss in LW. The greater weight loss in the mixed sex group may have been due to increased rutting activity. A similar variation in weight loss depending on mating status is seen in fallow deer (Asher, 1986) where fallow bucks in bachelor groups during the rut may lose 9% of prerut LW compared with up to 30% in bucks used as sires (Asher, 1986).

Successful electroejaculation of motile spermatozoa has been achieved both during antler growth and the hard antler phase. Motile spermatozoa were electroejaculated at all stages of the testis cycle and sperm counts ranged from 1×10^7 - 571×10^7 spermatozoa per ml. There did not appear to be a correlation between sperm density in the ejaculate and testis size, perhaps indicating that electroejaculation does not always enable the collection of a representative semen sample. %live, WM and %PM fluctuated throughout the collection period. There did appear to be a fall in WM immediately after antlers were cast, but this was not reflected in decreases in %PM. There appeared to be a strong correlation between % abnormal spermatozoa and antler stage, with % abnormal spermatozoa rising from a low level (1-10%) during hard antler to a high (60-75%) just after antler casting.

Histological evidence from testes removed during early velvet antler growth indicated that limited spermatogenesis occurs at the nadir of the testis cycle (Loudon and Curlewis, 1988; Chapple, 1989). Hence, fertile matings may take place when males are in velvet antler. The occurrence of such matings have been observed at the DRU, at Camden.

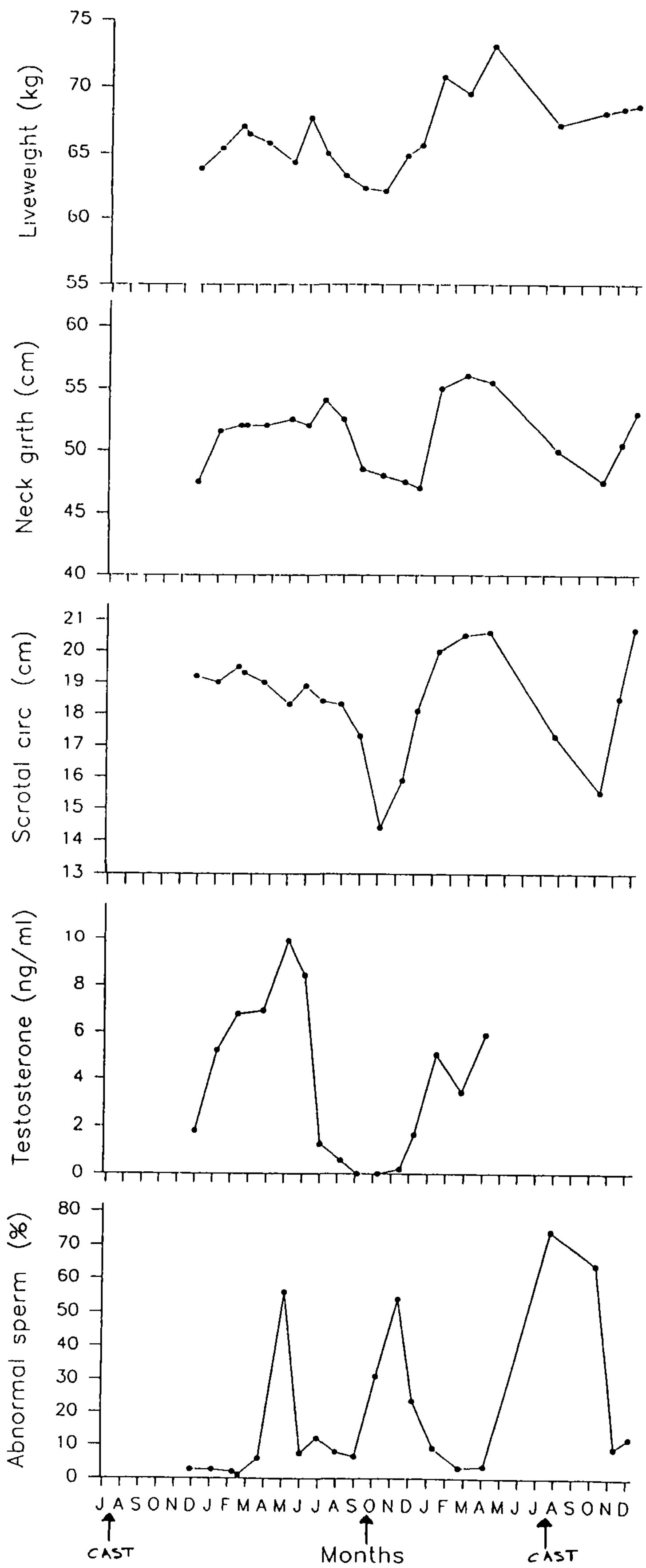

Figure 2. Changes in liveweight, neck girth, scrotal circumference, testosterone concentration and abnormal spermatozoa in ejaculate of a mature chital stag from December 1988 to December 1990

ANTLER CYCLE

Antler cycles at Camden, NSW are synchronised to a high degree, with all stags over the last three years casting antlers within 4 months of each other. Other localities throughout Australia (NSW, Queensland and Western Australia) reported antler castings at a similar time of year, between August and November. This is the first report of such a high degree of synchrony of males in a chital population.

Other chital populations in temperate regions do exhibit a degree of synchrony in timing of antler maturation, however, the degree of synchrony varies widely between these populations. Studies in Hawaii and Texas (Graf and Nichols, 1966; Schaller, 1967), observed the majority of stags to be in hard antler between April and August. While a study in the UK (Loudon and Curlewis, 1988) reported that the antler cycles of chital males showed poor synchrony with one another, although the majority of animals cleaned their velvet in the summer months.

The mean interval from casting to casting was reported to be 48.4 weeks (Chapple, 1989) and 53 weeks (Loudon and Curlewis, 1988) in chital stags, with a range of 45–60 weeks. Individual stags usually replace their antlers every year at approximately 12–monthly intervals (Goss and Rosen, 1973), but not necessarily in synchrony. An exception to this has been observed in the dominant stag in both bachelor and mixed sex groups at the DRU, Camden. Four different stags carried their antlers for 18 (August to February), 24 (September to September), 25 (August to September) and 16 month (October to February) periods.

The poor synchrony of antler growth between males in one temperate region and synchrony in a different temperate region (Graf and Nichols, 1966; Ables, 1977; Loudon and Curlewis, 1988) suggests that photoperiod is not involved in controlling the antler cycle in this species. Melatonin treatment (Loudon and Curlewis, 1988) of chital stags failed to have any effect on the growth of the testis and antler, in contrast with work done on temperate species (Bubenik, 1983; Lincoln *et al.*, 1984; Asher *et al.*, 1987). This contrasts with seasonally breeding deer in which photoperiod has been shown to drive the reproductive and antler cycles (Jaczewski, 1954; Goss, 1969).

The question then arises as to what drives their reproductive and antler cycles. Whatever the annual environmental event, it must vary between individuals, and be independent of latitude.

Puberty

A study at Camden observed that date of birth does affect age at which puberty is reached. Females born in spring/summer reached puberty in late summer/early autumn at 15–16 months of age, at 30–32 kg LW, while those born in autumn reached puberty in late summer/early autumn at 10–12 months of age at 28–30 kg LW.

Males born in spring/summer reached puberty in late summer/early autumn at 12–16 months of age, at 35–41 kg LW. No comparative studies have been performed on males born in autumn. Chapple (1989) reported that chital stags reached puberty around a similar time of the year and hence a wide variation in ages, depending on date of birth.

Thus it would appear that the age at which puberty occurs in chital deer is determined by date of birth. What influences this synchrony in the timing of puberty is still unclear.

RUSA REPRODUCTION

There are two subspecies of rusa deer being farmed in Australia, the Javan rusa (*Cervus timorensis russa*) and the Moluccan rusa (*Cervus timorensis moluccensis*).

In Australia rusa deer have acquired a degree of seasonality, although some calves can be born in any month of the year. Rusa deer in Victoria and NSW show a peak in rutting activity from late winter (July) into early summer (October) resulting in calving during autumn/winter.

FEMALE REPRODUCTION

Calves may be born at any time of the year, although the majority are born between March and July, with a peak in April coinciding with the peak in rutting activity in August/September (van Mourik and Stelmasiak, 1986). Hamilton (1984) observed a similar rutting period in a wild population in NSW, but reported a longer calving period between April and September (peak April to June), with occasional births as late as January, indicating an extended period of mating activity in that population.

As hinds may calve at any time of the year, it is thought that females cycle throughout the year, with the male determining the mating and hence calving time. Detailed endocrine studies are required to confirm this hypothesis.

A study over 3 years on farmed rusa deer (van Mourik and Stelmasiak, 1986) reported pregnancy rates of 94, 90 and 91% respectively, indicating that rusa hinds are highly fertile, like other deer species.

The gestation period is 249 ± 13 days (van Mourik and Stelmasiak, 1986). Twinning is rare. In an unrestricted mating system, the intercalving interval was 366±7 days (van Mourik and Stelmasiak, 1986).

Parturition

Rusa hinds exhibit a similar calving behaviour to other cervids. Labour lasts for 15–145 min. Time to first standing and first suckling in neonates ranges from 20–45 min and 69–195 min respectively. After cleaning and suckling the calf the hind leaves it in a hiding place and rejoins the herd. She will return to the calf for nursing periods until the calf is 4–5 days old. Thereafter the hind and calf remain on the periphery of the herd.

Rusa calves, like other hider species remain in an immobile posture when approached. This prone response is observed for up to 72 hours.

The incidence of dystocia in rusa hinds can be quite high (Mylrea and English, 1990). It is occasionally seen in hinds that have an obstructed pelvic canal due to a large fatty/bony mass. The aetiology of this phenomenon is not known, although most cases have been ascribed to 'fat necrosis'.

Perinatal mortality

As in other species of farmed deer, perinatal mortality can account for major losses. Until recently a large number of rusa deer were farmed in Victoria and southern NSW where the calving period coincided with wet, cold weather. The major cause of perinatal losses in rusa calves in these areas has been due to the problems associated with hypothermia and weather stress. Under these conditions any degree of mismothering is likely to precipitate fatal hypothermia. Also low birthweight calves have very poor chances of survival if they are born in the colder months.

The rusa, being of tropical origin, do not tolerate the cold well and so it is vital that calving paddocks have good shelter from winds and rain. In a group of 42 calves born in April–May, in Victoria, 18 (33%) died prior to weaning due to hypothermia and weather stress in a paddock devoid of any shelter (van Mourik, 1983).

To minimise these losses hinds should be in good condition (but not over–fat) throughout pregnancy, so that they give birth to a good sized calf. The hinds should be offered plenty of good quality feed during lactation, so that the calves have a good source of nutrition. Ideally, rusa deer should be under a restricted mating system or be farmed in the northern, warmer parts of Australia.

Puberty

van Mourik and Stelmasiak (1986) reported Javan rusa hinds in Victoria conceiving at 18–20 months of age, at an average liveweight of 46 ± 4.5kg. Woodford and Dunning (1989) reported rusa hinds in Queensland calving at 16 months of age, at 45–50kg (Javan) and 35–40kg (Moluccan). Thus 45–50kg appears to be the critical LW for puberty in Javan rusa. Differences in planes of nutrition and hence growth rates may explain the differences between ages at which puberty was reached in these two populations.

MALE REPRODUCTION

Rusa stags exhibit maximal testosterone concentrations, presence of hard antler and an increase in rutting activity directly after the winter solstice, indicating that the majority of rusa deer have adopted a long day breeding pattern (van Mourik *et al.*, 1986). However, unlike temperate species they are able to reproduce outside of the rutting period.

In contrast to the temperate species which exhibit a short well–defined rutting and antler growth period, rusa deer exhibit an extended rutting period from late winter (July) to the start of summer (October), as well as a different antler growth pattern.

During the rutting period rusa stags exhibit similar behaviour patterns to the temperate species, with stags spending a major part of the day involved in social activities such as grooming, wallowing, fighting, chasing and mating hinds compared to other times of the year when few of these activities were observed (van Mourik and Stelmasiak, 1985). An increase in grazing during autumn, followed by a significant decline during the rut has also been observed.

The relationship between testosterone levels and antler stage is similar to the temperate species, with testosterone secretion rising when velvet is shed and peaking during the rut (van Mourik *et al.*, 1986). Hence, the antler cycle in rusa stags is probably dependent on testosterone levels, irrespective of the time of year.

Antler Growth

The antler cycles of rusa deer have similar phases and lengths to those of the temperate species, but are not as well synchronised as the temperate species. The majority of rusa stags will be at a similar stage of antler growth at any one time, indicating that their antler growth pattern does show a degree of synchrony.

Antlers are usually cast between October and February. New growth continues into autumn from which time the dry velvet begins to shed. The velvet shedding takes several weeks and velvet pieces may still be attached to the antlers when they are cast. The antlers gradually ossify and are hard in time for the winter rut, with the majority of stags in hard antler during July–December (the rut).

Stags usually cast their antlers every 12 months at about the same time each year, however occasionally a stag will retain his antlers for a 24 or 36 month period as if he missed the signal to cast.

Rusa stags may produce viable spermatozoa during all stages of the antler cycle and hence all year round. At Camden a calf was conceived within one week of when both stags in the group had cast their antlers. Rusa stags probably undergo cyclic changes in testicular growth and spermatogenesis related to their antler cycle, similar to that seen in chital stags.

The unusual nature of the reproductive cycle of rusa deer (long–day breeders) as compared with temperate cervidae (short–day breeders) illustrates the differences in sensitivity to photoperiodic stimulation and indicates that the endogenous mechanisms regulating the gonadal functions may differ between species.

Mating Management

There are good reasons for manipulating the date of calving, to avoid the months June–August, at least in colder southern areas. This can be achieved by removing breeding stags from the hinds between late October and January, and therefore restricting calving to a warmer period between September and May. As well as manipulating breeding so that calving occurs in the warmer months, calving should also coincide with times when pasture availability is high, e.g. spring.

SUMMARY

The tropical species of deer do not have the well–defined breeding season of the temperate species of deer. They do however display a degree of seasonality but differ from the temperate species in that they can reproduce throughout the year. The degree of seasonality is quite marked in the rusa deer which have adopted what is essentially a long–day breeding season. In contrast, the seasonal pattern seen in chital deer in Australia is more like the temperate species, with most stags in hard antler in late summer/autumn.

What endogenous mechanisms drive the reproductive cycles of tropical species is unclear,

but it would appear that the mechanisms regulating gonadal function differ between tropical and temperate deer and even between tropical species of deer.

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