BIOLOGY OF DEER REPRODUCTION: A COMPARISON BETWEEN TEMPERATE AND TROPICAL SPECIES: A REVIEW

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ABSTRACT

One principle differences between temperate and tropical deer is that calving and antler cycle in stags in temperate deer are linked closely to the season, whereas in tropical deer current data indicate in an opposite way. However, both species have similar duration of oestrus with the length of oestrous cycle in tropical deer tends to be shorter than in temperate deer. Since data on the hormonal profiles of tropical deer is limited, little is known on the relationship between the environmental factors and the activities of the hormones. This review indicates the needs of a comprehensive study on the basic and on applied studies of tropical deer reproduction.

(Keywords: Deer, Red deer, Javan rusa deer, Sambar deer, Oestrous.)

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BIOLOGI REPRODUKSI RUSA: PERBANDINGAN DIANTARA RUSA TEMPERATE DAN RUSA TROPIK

INTISARI

Satu perbedaan utama antara rusa asal daerah temperate dan rusa asal tropik adalah kelahiran dan siklus pertumbuhan tanduk di pejantan pada rusa temperate sangat erat hubungannya dengan pergantian musim, sedangkan pada rusa asal tropik data sementara menunjukkan tidak adanya keterikatan dengan musim. Walau demikian, kedua jenis rusa tersebut memiliki beberapa kesamaan diantaranya panjang estrus, dengan siklus estrus pada rusa tropik cenderung sedikit lebih panjang dibandingkan dengan rusa temperate. Mengingat data mengenai profil hormon rusa tropik masih sangat terbatas, sedikit sekali untuk diketahui bagaimana hubungannya dengan lingkungan. Dari review ini menunjukkan bahwa penelitian yang menyeluruh baik dari ilmu dasar dan terapan untuk reproduksi rusa tropik masih perlu dilakukan.

(Kata kunci: Rusa, Rusa merah, Rusa Jawa, Rusa sambar, Estrus.)

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Introduction

To adapt to a changing temperate climate, temperate deer have a pronounced yearly physiological seasonality. Seasonal cycles present are voluntary feed intake (VFI) and body growth, velvet antler stripping and casting, replacement of coat and colour changes, fasting metabolic rate, and reproduction (Kay and Ryder, 1978; Lincoln, 1985; Barry *et al.*, 1991; Domingue *et al.*, 1991a&b). With red deer (*Cervus elaphus*), elevated feed intake and growth rate occur in spring and summer, decreasing to low values in winter (Suttie *et al.*, 1989; Domingue *et al.*, 1991a), with antler casting occurring in spring (Fennessy and Suttie, 1985). The reproductive activity in both sexes is high during autumn/early winter (Kelly *et al.*, 1985; Fennessy and Suttie, 1985). All these seasonal cycles are regulated by hormonal changes, whilst daylength entrains the cycles (Barrell *et al.*, 1985; Lincoln, 1985; Suttie and Simpson, 1985). Thus, the seasonal rhythms in red deer are endogenous (Loudon and Brinklow, 1992).

Comprehensive studies of biology and physiology of captive tropical deer is in its infancy, with most work being conducted in non-tropical environments (Kelton, 1981; van Mourik, 1985; Chapple, 1989; Mylrea, 1992). However, to a certain degree, the biology of wild tropical deer in their natural habitat has been documented (Ngampongsai, 1978; Rice, 1986; Santiapillai *et al.*, 1981). At equatorial latitudes, ungulates are believed to have day-length-dependent rhythms which are controlled by environmental factors such as rainfall and nutrition (Skinner, 1978). Loudon and Brinklow (1992) argue that some deer species living at lower tropical latitudes also show an inherent rhythmicity which could be associated with the seasonality of feed intake and reproduction cycles. A transition latitude between seasonal and aseasonal reproductive cycle deer lies between latitudes 14^{0}N and 18^{0}S (Goss, 1983). Rusa stags (*Cervus timorensis*) in Victoria, Australia, are reported to have acclimatized to the local environment (van Mourik & Stelmasiak, 1985), as have tropical Burmese brow-antlered hinds (*Cervus eldi thamin*) in North America (Monfort *et al.*, 1990). Sadleir (1987) argues that environmental factors are more important than photoperiod in regulating the tropical deer reproductive cycle. A comparative study between rusa and red stags under Australian sub-tropical environments indicates that rusa show no seasonal trend in their growth until at least 15 months of age (Suttie *et al.*, 1992a). Similar results were also found with chital deer (*Axis axis*, Chapple, 1989).

This review is aimed to present current research on the biology reproduction of tropical deer with the comparison to temperate deer, as the latest has been intensively studied.

Hind Maturity And Oestrous

In most temperate deer species, hinds become sexually mature between 15-18 months (Bentley, 1978; Couchman, 1978; Anderson, 1984). This may be influenced by liveweight and food availability (Putman, 1988). Chital hinds are reported mature at 9-10 months (Chapple, 1989), while others suggest 14-17 months of age (Acharjyo and Mishra, 1980). Farmed rusa hinds show their first sign of puberty at eight months of age (Woodford and Dunning, 1992), providing the body weight is greater than 40 kg (Woodford, 1991).

TABLE 1. DURATION OF OESTRUS (h) AND LENGTH OF OESTROUS CYCLE (DAYS) IN SEVERAL TEMPERATE AND TROPICAL DEER.

Species	Length of oestrus (h)	Length of oestrous cycle (days)
Temperate deer		
Alces alces	-	25-30
Cervus elaphus	16-24	17.5-18.3
Odocoileus hemionus	-	22-29
Odocoileus virginianus	37.5-42.3	28
Rangiferus tarandus	50	24
Dama dama	-	24-26
Tropical deer		
Cervus eldi thamin	12-24	19
Axis axis	-	12-23
Cervus timorensis	6-25, 48	10-18, 20-22
Cervus unicolor	-	17

Data compiled from Bemmer (1950, in Syarief 1974), Bentley (1978), Couchman (1978), Sadleir (1987), English (1988), Clutton-Brock & Albon (1989), Chapple (1989), Monfort *et al.* (1990), Woodford (1991) and Mylrea (1992).

Table 1 shows that, in general, both temperate and tropical deer species have a similar duration of oestrus (26.3 v. 26.6 h), but the length of the oestrous cycle in tropical deer tends to be shorter than in temperate deer (20.3 v. 24.4 days).

Calving time, calving interval and calving rate

Although tropical deer living within or outside their natural habitat show year round calving (Amir, 1978; Couchman, 1978; Mishra, 1982; Ali, 1985; Woodford and Dunning, 1992) little is known about their reproductive seasonality. Peak calving of sambar (*Cervus unicolor*) in tropical regions is reported to be close to the monsoon season (Santiapillai *et al.*, 1981; Mishra, 1982), although there are reports of regional differences (Syarief, 1974; Putman, 1988).

The gestation period between tropical and temperate deer is somewhat closer, but the calving interval varies in tropical deer as the calving is not influenced by the season as occurred in temperate deer (Table 2). Because of the irregularity of the breeding season and its independence from photoperiod effects, Bentley (1978) assumed that wild sambar hinds might produce two calves within 510-545 days. Calving rate for farmed red deer averages 70-90% to weaning at three months of age (Couchman, 1978). Calving rate of rusa in Mauritius is reported between 80-100% (Lalouette, 1985), and in Australia 97% (Woodford, 1991), while

TABLE 2. THE GESTATION PERIOD (days) AND CALVING INTERVAL (days) IN TROPICAL AND TEMPERATE DEER.

Species	Gestation period (days)	Calving interval (days)	Author
Tropical deer			
Axis axis	238-242	281-285	Mylrea 1991
Cervus timorensis	215-225		Bentley 1978
Cervus timorensis	217-277	359-372	van Mourik 1986
Cervus timorensis	248-258	280-400	Woodford & Dunning 1992
Cervus timorensis	253	271-281	Woodford 1991
Cervus timorensis	236-262		Mylrea 1991
Cervus unicolor	240		Bentley 1978
Temperate deer			
Cervus elaphus	231		Clutton-Brock *et al.* 1982

Mylrea (1991) reports 90-94%. In their native habitat, rusa wean their offspring at 4-7 months of age (Mackenzie, 1985). No data are available on calving rate and weaning time for sambar.

In contrast to tropical hinds, red hinds are regarded as short day breeders, because of a breeding season during autum, when daylength is short (Asher *et al.* ,1989; Duckworth and Barrell, 1991). The breeding season can be delayed if long daily photoperiod in autum are also delayed (Duckworth and Barrell 1991), but there is no evidence under natural breeding conditions that the calving season comes earlier as latitude increases (Fletcher, 1974). Under farmed conditions in New Zealand (NZ), red deer calved from early November to late December, with mating taking place between mid-March and late May. Red stags become fertile in summer when testes secrete testosterone and produce spermatozoa (Asher *et al.*, 1989). The rut in red deer can last for six weeks (English, 1988).

Stag maturity

No comprehensive study of reproduction has ever been conducted on tropical deer. In India, wild sambar stags are reported to come to their first rut at 19 months of age (Bentley, 1978). Rusa stags are fertile at 12 months, with an average body weight of 45-50 kg (Anderson, 1984). Red stags are fertile at about 18 months (Couchman, 1978), while Wilson (1984a) gives 14-15 months as the age at puberty. Spermatocytes were seen at nine months of age, indicating reproductive tract function, and at 12 months of age elongated

spermatids were present. At 12-15 months of age, the seminiferous tubules were mature and fully developed (Webster *et al.*, 1992).

Antler

Observations of tropical deer either in their natural habitat or after relocation to non-tropical regions, indicate that stags in hard antler can be found at any time of the year (Thom, 1934; Riney, 1957; Amir, 1978; Shea *et al.*, 1990), suggesting a less pronounced reproductive cycle. Anecdotal reports of wild sambar carrying their hard antlers for more than one year have been questioned by Mishra and Wemmer (1987). Woodford and Dunning (1992) report that on rare occasions farmed rusa in Queensland, Australia, as well as chital (English, 1992) can retain hard antlers for more than a year.

With studies of antler development in tropical deer being conducted outside of the tropical native habitat, results are often contradictory. A study with chital in Texas, USA (lat. 27:3 N), concluded that the stag population had a relatively well synchronized antler cycle within herds (Bubenik *et al.*, 1991), but this did not occur in Great Britain (Loudon and Curlewis 1988). Rudd (1978) concludes that wild sambar in NZ have adapted to a seasonal antler growth pattern. Pedicle growth in Indonesian sambar is reported as early as 4-6 months of age (Schroder, 1976), close to pedicle growth of rusa at 5-9 months of age (Woodford and Dunning 1992). Since the reproductive cycles of tropical stags appear to be independent of photoperiod (Lincoln ,1985), a different approach in trying to understand the role of the antler cycles in tropical deer was conducted by Woodford (1991) through an examination of the interaction between male-male and male-female deer. The hypothesis of Woodford (1991) is that pheromone could play a major role in initiating antler growth and casting. Several studies show that tropical stags are fertile at any stage of antler development (chital, Mylrea, 1992; rusa, Asher, personal communication).

Antler cycles (velvet antler growth, velvet stripping, hard antler and casting) of temperate deer are closely related to their reproductive cycle and are therefore under the influence of reproductive hormones (Wilson, 1984b; Fennessy *et al.*, 1988, Lincoln, 1992). Stags commence antler growth in spring, harden during summer and cast early in the following spring (Wilson, 1984b). These activities are closely related to photoperiod (Goss, 1983; Suttie *et al.*, 1992b).

Full antler growth in red deer takes about 164 days, of which 52-73 days is the process of ossification (Muir *et al.*, 1987). Early pedicle growth is initiated by increasing levels of plasma testosterone, which is stimulated by increasing luteinizing hormone pulse frequency. Pedicle growth in red deer may also be liveweight dependent, requiring a minimum of 56.3 kg (Suttie *et al.*, 1991).

Hormonal profile

Studies of the reproductive hormonal profiles of tropical deer are limited. In temperate deer, the reproductive hormonal secretions is seasonal and have been associated with seasonal cycles in liveweight, voluntary feed intake (VFI), metabolic rate and the breeding season.

Luteinizing hormone

Luteinizing hormone (LH) is secreted in episodic rhythm from the anterior pituitary gland, and is regulated by

luteinizing hormone releasing hormone (LHRH), secreted from the hypothalamus (Lincoln, 1985). A limited study of chital stags indicates that they exhibit little seasonal variation of plasma LH concentrations when relocated to northern latitudes (27:30N) (Bubenik *et al.*, 1991). A study of rusa in Victoria, Australia, showed that the animals responded to the decreasing daylength by increasing concentrations of plasma LH (van Mourik *et al.*, 1986). This was the first report to indicate that after spending time away from the tropics, the animals became entrained to a new photoperiod.

In red deer, LH secretion is associated with antler development in the stags and the reproductive cycle in both sexes (Lincoln, 1985). The seasonal pattern of both plasma LH concentrations and LH responses during antler development is marked, being low whilst stags are in hard antler and high during velvet antler growth (Fennessy *et al.*, 1988). In both sexes, daylength regulates the frequency of LH secretion, being low during short day and high during long day (Suttie *et al.*, 1989). The pattern of LH pulse frequency in red deer changes according to age. At six months, LH pulse frequency increases; between 6-8 months pulse frequency intensifies before decreasing between 8-12 month of age (Suttie *et al.*, 1991). In red hinds, during early and mid-pregnancy, plasma LH concentrations are frequently undetectable (Kelly *et al.*, 1982).

Testosterone

The pattern of plasma testosterone (T) release in red stags reflects the interrelationship between antler condition and sexual cycles. Very low plasma levels of T occur at antler casting and during velvet growth, while high plasma levels of T are associated with a high degree of fertility and antler in hard condition (Fennessy and Suttie, 1985; Bubeni *et al.*, 1991), and coincides with the mating season. Testosterone is also known as a stimulator for pedicle growth in temperate deer (Suttie *et al.*, 1991). In white-tailed deer (*Oodocoileus virginianus*), maximal concentrations of plasma T is not required for the process of spermatogenesis and stripping of velvet (Bubenik, 1982, as quoted by van Mourik and Stelmasiak, 1990). Under NZ conditions, red stags exhibit low levels of plasma T throughout winter (May) and spring (November), followed by an increase during late December, which eventually reaches peak levels in the April breeding season (Fennessy and Suttie, 1985). There is also a relationship between the seasonal T cycles and VFI in red stags, with low levels of feed intake occurring during decreasing photoperiod, when plasma T concentrations is increasing towards peak levels (Suttie and Kay, 1985).

A study of chital stags in the USA indicates a similar pattern of T release. As in temperate deer stags, a low levels of plasma T is associated with antler casting and a high levels of plasma T with hard antler (Bubenik *et al.*, 1991). Rusa stags in Australia have elevated T concentrations in autumn (May), but the main rutting period does not start until the end of July (winter), and extends to October (spring) (van Mourik and Stelmasiak 1990).

Prolactin

Studies show that in temperate deer, plasma prolactin (PRL) concentrations are correlated with feed intake patterns (Curlewis *et al.*, 1988), and are responsive to change in photoperiod (Adam *et al.*, 1992) via the pineal hormone melatonin

(Curlewis, 1992). Recent studies show that photoperiodic information can also be detected in utero by the foetus, judging from the levels of plasma PRL in new born deer calves (Adam *et al.*, 1992). Low winter plasma levels of PRL rise in spring prior to hard antler cast, and peak in midsummer (Barrell *et al.*, 1985; Curlewis, 1992). As plasma PRL concentrations decline in late summer, plasma T concentration increase and reach peak levels during the breeding season in April (Barrell *et al.*, 1985).

In red hinds there is a possible relationship between PRL secretion during the breeding season and pelage growth. Red hinds treated with bromocriptine during the breeding season show a delay in the seasonal rise in PRL secretion, which reduces the amplitude of the peak plasma PRL levels causing a delay in the onset of seasonal anestrous (Curlewis *et al.*, 1988). Prolactin is undetectable during early and mid-pregnancy, but the concentrations of plasma PRL in either pregnant or non-pregnant hinds is high in early summer (Kelly *et al.*, 1982).

Plasma PRL concentrations in chital and rusa stags show a similar response to photoperiod, to that shown by temperate deer (Bubenik *et al.*, 1991; van Mourik and Stelmasiak, 1985), but the relationship between plasma PRL and T levels are believed to be weaker in tropical deer (van Mourik and Stelmasiak, 1985).

Conclusions

The present review indicates there is limited data available on the reproductive physiology of tropical deer. Data on the gestation period show a wide variations, thus needs to be clarified. As most studies of the physiology of tropical deer are concentrated in non-tropical environments, the data available are more concerned with those deer which are acclimatized to non-tropical environments.

With the advent of deer farming, there has been interest in the farming of tropical deer species by several tropical countries. The need for a more complete set of reference pertaining the reproduction will grow as the number of farmed tropical deer species increases. It will be necessary to conduct comprehensive studies of tropical deer species in a range of environments since data in a non-tropical environment may be different from those recorded in their native tropical environment.

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