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Reproductive productivity of young red deer hinds

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ABSTRACT

Reproductive productivity of rising-two-year old red deer hinds on New Zealand deer farms has been a prominent issue over the last 10 years. On average, 16% of young hinds fail to establish pregnancy in their second year, although this figure masks wide between-farm variation. A growing body of ultrasound scanning data implicates failure of ovulation and/or conception at 16 months of age as the main influence on pregnancy rate. While such puberty failure in red deer has often been attributed to poor nutrition and failure of hinds to attain a critical threshold live weight of 65 – 70 kg at 16 months, data on growth rates of young hinds from numerous farm monitoring programmes around the country largely debunk this concept. This paper reviews the potential causes of reproductive failure in young red deer, including the putative and actual influences of seasonal, social, stress and genetic factors on puberty failure. An emerging theme is the strong interplay of various environmental and genetic factors in determining the incidence of puberty.

Keywords: red deer; wapiti; reproduction; puberty; conception; ovulation.

INTRODUCTION

Deer farming in New Zealand is based upon pastoral management of the red deer (*Cervus elaphus*), particularly the Scottish (*C.e. scoticus*) and Eastern European (*C.e. hippelaphus*) subspecies. More recently, introgression of the larger North American wapiti subspecies (*nelsoni, roosevelti, manitobensis*) has been facilitated from locally derived and imported studstock.

Females of the European subspecies generally attain puberty (first ovulation) at 16 months of age, conditional upon surpassing a critical liveweight threshold equivalent to 65-70% of ultimate mature bodymass (Asher & Pearse, 2002). For the Scottish subspecies, this equates to 65 kg by 16 months of age (Kelly & Moore, 1977; Hamilton & Blaxter, 1980; Fisher & Fennessy, 1985). However, this threshold is likely to be proportionally higher for the Eastern European subspecies due to its larger mature mass (100 kg vs 130 kg for *scoticus* and *hippelaphus*, respectively). North American wapiti are considerably larger than either of the European strains, with mature cows having livemasses of 210-250 kg (Haigh & Hudson, 1993). Under normal range conditions in North America, wapiti cows seldom attain puberty before their third year, although, under exceptionally good nutritional environments, earlier puberty can occur (Haigh & Hudson, 1993). Thus, wapiti are often regarded as slower-maturing than red deer.

Reproductive productivity of young red deer hinds on New Zealand deer farms has been a prominent issue over the last 10 years, driven largely from the outcomes of several farm monitoring programmes (Audigé *et al.*, 1999a; Deer Industry Manual, 2000). Essentially, wide variation has been recorded between farms and years in the proportion of rising-two-year old hinds calving at 24 months of age. On average, 16% of young hinds fail to establish pregnancy in their second year (Table 1). A growing body of ultrasound scanning data implicates failure of conception, probably reflecting failure to attain puberty (i.e., ovulate) or to conceive at 16 months of age for a significant proportion of the national herd (Asher & Pearse, 2002).

TABLE 1: Generalised breakdown of the causes of reproductive wastage among farmed red deer in NZ 1980-2000* (expressed as % of breeding hinds).

	Ovulation and conception	Embryonic and fetal loss	Perinatal and postnatal calf mortality	Total %
Adult hinds (>2 years old)	4%	1%	10%	15%
First calvers (2 years old)	16%	2%	12%	30%

* after Asher (2000)

Audigé *et al.* (1999b) provided an analysis of multivariate data from 700 young red deer hinds across 15 farms in central New Zealand, with particular emphasis on identifying risk factors associated with conception rate and conception date (based on early pregnancy scanning). Factors seemingly improving conception rate (i.e., early pregnancy rate) included optimisation of body condition score at around 2.5 (scoring range: 1-5) and minimisation of the amount of tree cover in mating paddocks. However, factors having a more subtle influence on productivity via conception date (based on foetal aging) included high body weight and height, joining early with pubertal stags, exclusion of adult hinds from mating groups, limiting human disturbance, and limiting trees and gullies in mating paddocks to increase the incidence of early conceptions (Audigé *et al.*, 1999b).

As can be expected from multivariate analyses, some factors appear somewhat counter-intuitive to accepted management practice (e.g., low body condition score; negative effect of tree cover). This may be due to the presence of spurious correlations or an inability to tease out the true cause and effect from confounded data sets. However, there is little doubt that various environmental (and genetic) factors highlighted by Audigé *et al.*, (1999b) have had a profound effect on yearling hind conception rates.

The purpose of this paper is to review potential causal factors implicated in reproductive failure of rising-two-

year-old red deer hinds on New Zealand deer farms.

Seasonal effects

While being liveweight dependent, the ability of young hinds to enter puberty around 16 months of age, is driven by photoperiod responsiveness (Sadlier, 1969; Webster & Barrell, 1985), this broadly aligning their breeding season with that of the rest of the population and, ensuring summer calving. However, it has been demonstrated that, despite generalised synchronisation of ovulation in autumn, pubertal hinds generally exhibit first oestrus/ovulation (and hence, conceptions) about two weeks later on average than older hinds (Asher & Pearse, 2002). Consequently, most adult hinds are mated before any pubertal hinds are mated. Given the intense hyper-sexual nature of the rutting stags, situations may arise whereby sires are incapable of servicing young hinds late in the mating period due to physical exhaustion. This was observed in a recent study at the Invermay Agricultural Centre in which stags were joined with mixed-aged groups of hinds (G.W. Asher, unpublished. data). Furthermore, early removal of sire stags to ensure highly synchronised calving patterns may compromise opportunities for young hinds to be mated.

It is clear that seasonality issues are really management issues in terms of establishing and maintaining mating groups. For example, recognition of the desirability of separating young hinds from older cohorts for mating (Yerex, 1982) partly reflects differences in the timing of mating.

Social effects

Red deer are a gregarious species with strongly delineated hierarchal structures within the herd. This is particularly so of hind groups in which the older and larger hinds are clearly dominant (Clutton-Brock *et al.*, 1982). Younger, smaller hinds, in contrast, sit low in the "pecking order". Farm management practices almost invariably destroy the natural matriarchal lineages (mother, daughter, granddaughter groupings) commonly seen in wild herds (Clutton-Brock *et al.*, 1982), and replace them with large groupings of unrelated hinds subject to repeated change. This leads to re-establishment of hierarchies, often to the detriment of younger, smaller hinds. This is manifest as constant aggression by dominant hinds towards subordinant hinds. Again, recent studies of mixed-aged hind mating groups at Invermay clearly identified pubertal hinds as subordinant, with some animals repeatedly driven from older hind mobs at mating time (G.W. Asher unpublished. data). It is, therefore, easy to speculate that young hinds may be prevented access to stags and/or be socially inhibited from attaining puberty (i.e., ovulate). Again, the desirability of separating young hinds from older cohorts has the added benefit of reducing social stressors around puberty.

There has been some speculation that older (>2 year) sire stags may actively avoid mating pubertal hinds, or, conversely, young hinds are socially inhibited by older stags. The merits of these contentions are debatable, as there are no supporting data for either. However, it has now become accepted practice on NZ deer farms to mate yearling hinds with yearling stags at relatively high sire:hind ratios (i.e., 1:10 vs. 1:40-50 for older stags) to ensure adequate hind coverage (Asher & Pearse, 2002). Interestingly, although based on unproven premises, most farmers report improved reproductive performance of young hinds under this system (Deer Industry Manual, 2000). It has now almost become an industry standard. Clearly, research is needed to establish how this system works, as there is a very limited understanding of the social interactions involved and of the mating behaviour of pubertal stags.

Stress effects

Apart from social stressors, consideration of the mitigating effects of other environmental stressors on reproductive performance of young hinds warrants consideration. The assumption is that young deer are relatively naïve to the farming environment and may be subject to perturbing effects of acute and chronic stress on the pubertal processes. Evidence for this is scarce, as any subtle effects on the reproductive axis of females are not outwardly obvious. Furthermore, some farmers argue that successive generations of farm-raised red deer become habituated to farm conditions earlier, and are generally very well adapted within their first year of life. Extensive, low-input systems may be the exception to this, as deer are not subjected to high levels of human contact within the first year.

It is generally recommended that farmers minimise the frequency of yarding of young hinds in the weeks leading up to the rut, to lower putative stress effects on ovulation incidences (Asher & Pearse, 2002).

Liveweight threshold theory: wapiti introgression

The well established paradigm of liveweight threshold theory for attainment of puberty in female red deer requires careful reconsideration given the wide phenotypic variation in mature hind body mass through introgression of genetically disparate genotypes.

It is apparent from numerous farm monitoring statistics that few farm-reared hinds in New Zealand fail to exceed the puberty threshold of 65 kg at 16 months of age for the Scottish red deer subspecies. Average herd weights for yearling hinds generally range from 80-100 kg (Deer Industry Manual, 2000). However, despite general attainment of such live weights, a significant proportion of yearling hinds fail to become pregnant in their second autumn (Asher & Pearse, 2002). One factor largely overlooked until recently is genetics. Over the last two decades, the New Zealand deer-farming industry has imported and incorporated into the herds other subspecies of larger mature body mass. For North American wapiti in particular, introgression into the national herd through purposeful and inadvertent hybridisation has occurred since the early 1980s (Yerex, 1982). The large mature body mass of wapiti (> two-fold greater than *C.e. scoticus*) has been commercially attractive for the production of fast-growing, high body weight hybrid offspring for venison production. This was often based on the premise of energetically efficient "terminal sire" programmes using large wapiti bulls over

small red deer hinds to generate the hybrid for slaughter (Fennessy & Thompson, 1988). However, hybrid females were seldom slaughtered and were generally retained for breeding purposes. The retention and indiscriminant trading of hybrid females (sometimes marketed as well-grown red deer) has facilitated rapid introgression of wapiti genes into the national herds and, arguably, the line between red deer and hybrid has become blurred. Many red deer breeding herds, particularly large herds derived from various farm sources, are clearly phenotypically heterogeneous, with hinds exhibiting a wide range of body size/shape, and pelage colour characteristics, indicative of genetic introgression. Other breeding operations have purposefully incorporated a certain percentage of wapiti breeding in order to increase average hind weights. The overall extent to which introgression of wapiti has occurred within the national herd is unknown, and some farmers even argue that few "pure" red deer presently exist on New Zealand deer farms.

An obvious consequence of genetic introgression of a larger subspecies is to alter the average mature body mass of hinds, and thus, the puberty liveweight threshold (Asher & Pearse, 2002). Furthermore, in the particular case of North-American wapiti, numerous studies of the various subspecies within their native environments indicate that most females do not attain puberty until their third year (Haigh & Hudson, 1993), suggesting that they are relatively slow maturing by contrast to European subspecies.

A recent study, funded through DEEResearch Ltd (a joint venture between Deer Industry New Zealand, AgResearch and various Universities) is presently investigating the potential influence of wapiti introgression on poor reproductive performance of rising-two-year-old hinds (G.W. Asher, unpublished data). The study aims to test the following hypotheses:

1. Morphological phenotypic variability among yearling red deer hinds within given herds reflects various levels of wapiti hybridisation.
2. Within any given herd, the proportion of wapiti genes within individuals is negatively correlated with the attainment of puberty at 16 months (i.e., pregnancy at 18 months).
3. There is an interaction between genotype (% wapiti genes) and live weight/body condition score (BCS) on the attainment of puberty at 16 months of age (i.e., pregnancy at 18 months), with threshold live weights increasing with increasing wapiti influence.

The study to date (February 2003) has monitored the early pregnancy status (i.e., ultrasound scanning in May/June) of ~3600 rising-two-year-old hinds across five farms in Otago/Southland. Measurements of body weight, size and shape, as well as scores for the presence of obvious wapiti features (e.g., pelage colour) and body condition, were obtained. Hair samples were collected for retrospective DNA analysis (14 microsatellite markers that differentiate red deer vs wapiti).

Results to date have conclusively supported the above hypotheses. Although the level of wapiti influence varied between farms, all showed significant negative relationships between increasing wapiti score (and/or percent wapiti from DNA analysis) and pregnancy status. Furthermore, there was a significant interaction between wapiti score (% wapiti) and live weight on pregnancy status, indicating a strong involvement of a critical threshold live weight that increased with increasing wapiti influence. Interestingly, DNA analysis revealed that the percentage of wapiti genes detected for individual hinds ranged from 0 to 50% on two of the farms. Both farmers were aware of wapiti introgression within their herds but were surprised at the magnitude of wapiti influence. Pregnancy rates measured across the farms ranged from 97% for one farm where managers had actively avoided incorporating wapiti genes in the herd (average yearling hind weight at mating = 87 kg), to 75% for another farm that purposefully incorporated wapiti genetics to increase hind size (average yearling hind weight = 110 kg).

These preliminary data highlight a potentially significant cause of reproductive failure in a high proportion of yearling hinds in NZ and indicate a need to establish clear guidelines for managing wapiti influence in breeding herds.

CONCLUSION

It is clear that no single factor accounts for the high level of reproductive failure of young red deer hinds. An emerging theme is the strong interplay of various environmental and genetic factors. Of particular relevance are the social environment around mating and the influence of wapiti introgression on the incidence of puberty.

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