MANAGING REPRODUCTIVE PERFORMANCE OF FARMED DEER: THE KEY TO PRODUCTIVITY

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Summary

Annual reproductive productivity is a major driver of on-farm profitability. At its simplest and most realistic, it is expressed as the number (or weight) of surviving offspring produced annually per breeding female (i.e. "weaning rate"). However, this figure hides an array of lost opportunities expressed as "reproductive wastage". The key to improving reproductive productivity is to identify and remove the source of wastage at the point it occurs in the annual reproductive cycle. Key areas of focus are female fertility (ovulation), fertilization (mating management), embryonic mortality, fetal mortality (resorption/abortion), neonate mortality, and lactational insufficiency. Using farmed red deer in New Zealand as an example, the main areas of wastage consistently occurring are fertility of pubertal hinds (i.e. first calving 2 year olds) and perinatal calf mortality. There are strong indications how these forms of wastage can be minimised on individual farms.

Introduction

The reproductive productivity of farmed deer is the major driver of on-farm profitability and both biological and economic efficiency. Modern deer farm systems identify this as an area where the most improvement can be achieved in a short time-frame with relatively low-impact management inputs. While venison and velvet antler are the main financial outputs of deer farming, these are essentially themselves the products of the female reproductive herds, which probably account for at least 50% of all farmed deer (e.g. 1.66 million of NZ's total farmed deer population of 2.56 million animals are breeding hinds). In simple terms, overall reproductive efficiency can be expressed as the number or weight of surviving offspring produced annually per breeding unit (hind/doe). More often, this is expressed as the "weaning rate" or "weaning percentage", defined as the number of surviving offspring at weaning (usually 3 months of age) per 100 hinds/does for breeding. This is the key measure of productivity and profitability of the breeding herd … however, hidden beneath this figure is an array of lost opportunities. What happened to those offspring that were not present at weaning time but should have been? How and when were they lost? Answering these seemingly simple questions is the key to improving and maximising reproductive potential of breeding herds.

The most logical way of identifying lost reproductive opportunities is to focus on components of reproductive success and/or wastage from the start of the overall process (i.e. ovulation) to the final endpoint (i.e. weaning).

Components of reproductive success/wastage

Successful achievements in all the following areas culminate in the maximal production of live calves/fawns:

(1) Estrus and ovulation

(2) Mating, fertilization and conception

(3) Embryonic implantation

(4) Fetal survival and growth

(5) Parturition and neonate survival

(6) Lactation and calf/fawn growth

Failure at any one of the points will disrupt the reproductive process, and represent the point at which "wastage" occurs. This term is commonly used by scientists and, although negative in connotation, is a useful means of viewing and defining the area of lost productivity. Thus, in terms of wastage, the previous list reads as follows:

(1) Anestrus and anovulation (failure to express estrus and to ovulate)

(2) Fertilization and conception failure

(3) Embryonic mortality

(4) Fetal retardation and/or abortion

(5) Perinatal and neonatal calf/fawn mortality

(6) Lactational insufficiency; retarded calf/fawn growth

While it is possible to experience all these forms of wastage within a breeding herd, it is more likely that only one or two factors account for most of the lost reproductive potential on any given farm. Causes of wastage can vary between years according to climatic situations. However, even given uncontrollable extrinsic variable such as weather, a significant proportion of reproductive wastage is preventable given knowledge of the underlying causes and implementing appropriate management necessary to circumvent the conditions leading to the wastage.

Much of the following discussion relates to numerous studies on farmed red deer (*Cervus elaphus* spp), wapiti (*Cervus elaphus* spp) and fallow deer (*Dama dama*) in New Zealand and Australia. These species are of northern temperate origin and characterised by highly seasonal breeding patterns invariably aligned to early summer calving. Furthermore, their maximum annual reproductive potential is 100% given the species trend towards singleton births (i.e. twinning is very rare at <1:200 births). This does contrast with a number of other farmed species such as white-tailed deer (*Odocoileus virginianus*) which can exhibit high rates of twinning, and various species of tropical origin such as Rusa deer (*Cervus timorenis*), Sambar deer (*Cervus unicolor*) and Chital deer (*Axis axis*) which exhibit considerably less seasonality in their annual reproductive cycles. Despite such differences, the principles of assessing causes of reproductive wastage are much the same for all species.

A general picture of reproductive wastage in farmed red deer

A number of studies on the reproductive performance of farmed red deer in New Zealand have been conducted over the last 20 years. This provides an interesting backdrop for considering other farmed deer species around the world. If one considers the New Zealand data in an overall and generalised context, the "weaning rate" of adult hinds averages ~85% and of first calving (2-year-old) hinds averages ~70%. While these approximations mask the considerable between-farm variation, overall performance across the industry has not essentially changed over twenty years (Asher, 2000). In fact, a slight decline may be more truthful.

Further consideration of the overall causes of reproductive wastage from these studies (Table 1) indicate some interesting features.

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

	Ovulation/conception failure	Embryonic/fetal loss	Peri-natal/post-natal calf mortality	Total %
Adult hinds (>2 years old)	4%	1%	10%	15%
First calvers (2 years old)	16%	2%	12%	30%

* after Asher (2000)

The salient features of this analysis are ...

(1) Ovulation/conception failure are relatively minor features for adult hinds but very important sources of wastage in pubertal hinds.

(2) Embryonic/fetal loss have been minor causes of wastage in red deer (i.e. pregnancy is very robust in this species). Emerging disease trends (e.g. leptospirosis) may pose a future issue.

(3) Calf mortality is a major source of wastage in both adult and first-calving hinds.

In essence, the two issues most pertinent to improving reproductive performance of red deer in New Zealand are those of fertility enhancement at puberty (16 months of age) and improved calf survival at and around birth.

Causes of reproductive wastage

Anestrus/anovulation

Failure of hinds/does to enter into a reproductive condition each year essentially means failure to exhibit ovarian cycles leading to estrus and ovulation (termed anestrus and anovulation). Such infertility is often thought to be the underlying cause of low reproductive performance of farmed deer. However, infertility in adult (i.e. greater than 2 years of age) red deer and fallow deer is uncommon, and appears to seldom account for more than 1-2% of overall reproductive wastage on NZ and Australian deer farms. Exceptions to this on individual farms in some years may relate to extremely harsh environmental conditions during the preceding months (i.e. over lactation) that severely compromise the body condition of females just prior to the rut. Such conditions may cause occasional catastrophic effects on individual farms, but are generally not universal across farms. Recent farm monitoring programmes in NZ have highlighted the value of supplementary feeding of lactating red deer hinds during summer drought conditions.

This is aimed at preventing substantial body condition loss induced by the high energy demands of lactation when pasture quality is severely limiting to performance. Furthermore, early weaning of calves at least 4-6 weeks before the mating period facilitates appropriate nutritional management of hinds to improve their body condition leading into the rut. Such management will generally circumvent infertility problems in mature females during harsh summers.

Young hinds/does entering their first breeding season at 16 months of age (i.e. pubertal females) are more likely to exhibit anovulation than adult hinds. Failure of red deer hinds to attain puberty at 16 months of age has been reported widely around the world, and generally relates to poor nutritional conditions that have compromised prepubertal growth. If insufficient body mass has been attained by their second autumn, puberty is generally delayed by a further year.

For red deer of western European origin (i.e. *Cervus elaphus scoticus*) the critical threshold body mass required for puberty is about 65kg at 16 months (Kelly and Moore, 1977; Hamilton and Blaxter 1980). However, this threshold undoubtedly increases with the increasing mature weight of the more eastern genotypes such as Eastern European red deer (*C. elaphus hippelaphus*), Asiatic wapiti (*C. elaphus xanthopygus*) and North American wapiti (*C. elaphus nelsoni, roosevelti, manitobenisis*). Limited studies of European fallow deer indicate the puberty threshold is about 28kg (Asher, 1993). Essentially, female deer must attain 65-70% of the genotype's/species overall mature body mass before puberty can occur.

In reality, puberty threshold weights of red deer are easily surpassed on well managed farms. Average weights of 16 month old red deer hinds in NZ are generally around 80-90 kg (Asher, 2000). However, in marginal nutritional and climatic environments, consideration must always be given to optimising growth of young replacement breeder stock to ensure that puberty is not compromised.

Fertilization/conception failure

Apart from failure of ovulation, a number of other factors can contribute to failure of some females to successfully establish a pregnancy. These are essentially factors pertaining to mating/insemination. While behavioural estrus (i.e. sexual receptivity of the female) just prior to ovulation is an essential prerequisite for mating, it does not guarantee that it will occur. In this respect, the structure and management of the herd during the annual rut (mating period) are of paramount consideration.

The rut is a complex social phenomenon of most deer species in which males actively and aggressively compete for access to estrous females during a very short and defined period of the year. The rut is often characterised by intense sexual and aggressive displays by the males in order to hold dominant social rank, secure exclusive access to prime rutting territory and/or maintain harem cohesion. Typically, rutting male deer drastically reduce feeding activity for 2-3 weeks, during which time they will lose 25-40% of their body mass. The physiological and social burdens of rutting, and the social interactions of males and females during the period, place certain constraints on mating success.

In red deer, for example, the following factors are considered to be important determinants of mating (hence, conception) success.

(a) Appropriate "joining" dates for males and females

This obviously varies for species. However, in red deer, stags initiate rutting activity (e.g. roaring vocalisations, harem formation) several weeks before any hinds exhibit estsrus. In fact, these behaviours may actually serve to initiate and synchronise estrus/ovulation in hinds (McComb 1987). In New Zealand, stags start rutting in late February/early March, but mating does not generally occur until late March/early April (and up to 2 weeks later in pubertal hinds). Most stag: hind joining occurs in early March, although there seems to be an emerging trend for even earlier joining dates on many NZ deer farms. Early joining ensures that sires are "conditioned" for mating and do not invest too much effort in establishing the boundaries of their territory during the actual mating period. There are also considerations of breed or strain type in joining date. Eastern strain red deer and North American wapiti commonly initiate mating activity 8-12 days before that of western red deer strains. Early joining for these genotypes is necessary to capitalize on the earlier calving seasonality.

(b) Appropriate ratio of males:females

Whether using single-sire or multi-sire mating management practices on the farm, correct judgement of sire:dam ratios is important. Sires must be able to adequately service all hinds during their brief period of first estrus.

Excessively high number of males to females (e.g. 1 male:<10 females), particularly in multisire groups with high animal densities, can lead to excessive energy investment in aggressive interactions between males fighting for limited resources. Exhaustion and injury in sires will invariably reduce mating success.

Conversely, excessively low numbers of males to females (e.g. 1 male:100 females) places considerable burden on individual sires to service all estrous hinds. This is a reflection of the high level of estrous synchrony between hinds (i.e. 10-12 days) and the necessity of sires to service many hinds in a single day. While some red deer stags seem capable of this early in the mating period, they may not be so virile a few days later. Other stags appear to have lower libido throughout the mating period.

For red deer, the recommended ratio of males to females is between 1:35 to 1:50 hinds. However, ratios of 1:25 to 1:35 are generally established when using less virile younger sires (<3 years old). There has recently been some discussion in NZ about successfully using high genetic merit stags at ratios of 1:120 hinds (Deer Industry Manual New Zealand, 2000). While this may have been successful for some proven sires, it carries a very high risk and the consequences of stag failure are catastrophic for individual farms. Lower ratios of females balance the risk of failure against the desire to obtain maximal numbers of offspring from top sires. It may be that the emerging success of new procedures of cervical AI with minimal interference and well-defined synchrony will supersede the desire to extend the use of leading sires through high hind ratios.

Multisire management practices need particular attention to ensure that excessive competition between sires is minimised. In particular, providing adequate resources of space and topography will enable sires to establish non-overlapping territories and, thus, reduce aggressive interactions. However, there is always the possibility that the dominant sires will "hoard" the majority of females to the detriment of overall mating success (Moore *et al*, 1985).

(c) Risk of infertile sires

The use of infertile stags/bucks as sires can have catastrophic consequences on herd performance. While such cases are relatively uncommon, they have been documented occasionally on red deer farms in NZ. It is generally not practical to test the fertility of potential sires. Instead, many red deer farmers opt to reduce the risk of catastrophe by replacing single sires immediately after the first or second estrous period. At worst, hinds failing to conceive to the primary sire will "return to estrus" and be inseminated by the "chaser" sire. This will invariably lead to a delayed calving pattern but the consequences are less severe than complete reproductive failure.

The practice of using "chasers" also lessens the risk of reduced calving rates due to early exhaustion of the primary sire. Such cases have been observed for both red deer and fallow deer, in which sires have succumbed to fatigue during the mating period and have "deserted their post".

(d) Mating management practices for pubertal hinds

In NZ, a significant proportion of 16-month-old hinds fail to become pregnant despite having attained sufficient liveweight to exhibit puberty. It is possible that social and physiological factors during the rut may inhibit either ovulation or mating in young hinds. Firstly, pubertal hinds are almost invariably later to exhibit first estrus of the season than older hinds. This can be by as much as 2-3 weeks. We have recently observed cases whereby sire stags, being physically exhausted after mating adult hinds, were unwilling to service pubertal hinds later in the season.

Secondly, older hinds tend to dominate younger hinds, often repeatedly chasing them to the periphery of the herd. Not only may this place considerable physiological stress on the younger animals but may also prevent access to the stag.

Thirdly, many farmers consider that older stags may shun young hinds or, conversely, young hinds are overly intimidated by large stags. This may inhibit or prevent mating in some cases.

One or all of these factors may contribute to the relatively poor pregnancy rates of pubertal hinds observed on some NZ deer farms. Presently, the general management practices include mating pubertal hinds separately from adult hinds. Furthermore, early joining (e.g. February) with stags of the same age at relatively high ratios (1 stag:20 hinds) in low-density, multisire groups appears to improve the overall pregnancy rate of young red deer hinds (Deer Industry Manual New Zealand, 2000).

From limited data available from farms in New Zealand and Australia, these issues pertaining to female age do not appear to apply to fallow deer. Pregnancy rates of rising-two-year old fallow deer does seldom differ from those of adult does (Asher and Adam, 1985; Mulley, 1989).

Embryonic mortality

Embryonic mortality has been a major issue with sheep farmers for many years, as there is generally a high discrepancy between ovulation rate and early pregnancy rate. However, the situation in farmed deer appears to be different; at least for monovulating species such as red deer and fallow deer. While it is very difficult to assess the influence of early embryo loss (i.e. with 30-40 days of conception) on overall reproductive wastage in deer, some studies indicate that the rate of retention and subsequent implantation of embryos is unusually high. Accordingly, embryonic mortality is not considered a significant problem in red deer and fallow deer.

Fetal mortality

Fetal mortality, more often termed resorption or abortion (depending on whether or not the fetus is expelled), is often overlooked as a source of reproductive wastage on deer farms. This is probably because few aborted fetuses are ever observed in the field due to resorption, scavenging or dam ingestion. Fetal loss estimates of 1-2% for red deer in New Zealand are generally based on observed differences between the number of pregnancies confirmed by ultrasound scanning at about Days 40-80 from mating, and the actual number of calves born (Audigé *et al*, 1999).

While this loss rate seems small in the overall picture of wastage, there are a number of important considerations.

- This figure is a crude estimate based on a limited amount of data across relatively few farms. It may mask individual catastrophic cases in which fetal mortality is a significant factor in annual reproductive performance on a farm.
- Species differences are apparent. Fetal abortion was widely reported for farmed fallow deer in NZ during the 1980's. In some farm cases it accounted for the termination of >10% of pregnancies. Casual links between the abortion incidence and clinical manifestations of leptospirosis were speculated. Subsequent treatments of herds with antibiotics and ongoing vaccination programmes have been associated with a dramatic reduction in abortion rate (Asher, 1993). No links between leptospirosis and abortion have been verified for red deer.

Bovine brucellosis has been implicated in late term abortions of wild wapiti in some regions of North America. However, bovine brucellosis has been virtually eliminated from NZ and it seldom considered a threat to farmed deer there.

- There is growing evidence that hybridisation between cervid taxa increases the incidence of fetal wastage. However, for closely related taxa (e.g. red deer x wapiti), the incidence of abortion appears to still be relatively low (i.e. <4%). Conversely, for taxa with wider genetic distance (e.g. red deer x Pere David's deer), the abortion rate appears to be considerably higher (e.g. >25% of pregnancies). This indicates that genetic incompatibility is a factor in fetal wastage.
- Abortion "storms" (i.e. sudden and widespread onset of abortions within a herd) are not widely reported for deer, but have been known to occur. In one such case with fallow deer, clinical evidence linked a severe "storm" in late gestation to the ingestion of the desiccated prunings of *Cupressus macrocarpa* hedge.

While the available evidence indicates that fetal wastage is not a major contributor to overall reproductive performance of farmed deer, it is clear that catastrophic cases can occur occasionally. Rapid identification of the causal factor is essential to prevent further occurrences.

Perinatal calf/fawn mortality

There is little doubt that perinatal calf/fawn mortality is a significant cause of lost productive potential in most, if not all, species of farmed deer. While its causes are many and varied, numerous studies on farmed red deer in New Zealand (Asher and Adam, 1985; Gill, 1985) indicate the majority (>90%) of calf losses can be attributed to the following causes:

- Starvation/dehydration ("mismothering")
- Dystocia (birth injury)
- Misadventure
- Non-viability (low birth weight)

- Infectious agents

(a) Starvation/dehydration

Most studies to date highlight the significance of "starvation/dehydration syndrome" as the leading cause of calf loss in red deer. Typically, calves die within three days of birth through failure to suckle and ingest milk. Therefore, we tend to view this "syndrome" as a euphasism for mismothering/calf desertion. It is disturbing, to say the least, that after 25+ years of deer farming in NZ, high levels of mismothering still exist (i.e. 35-45% of calf mortalities; or 5-8% of calves born). However, the loss rate is not uniform across farms, indicating that management practices can be implemented to minimise calf desertion.

The fundamental key to minimising calf desertion is removing management and environmental barriers to dam: calf bonding that occurs within the first hour or two of birth. A strong bond between the hind and her newborn calf is essential for the survival of the calf. Factors that cause disturbance of the hind within 2 hours of calving can potentially cause a disruption in the maternal bonding process.

There are strong arguments that trends towards intensification of deer production (e.g. high stocking rates; frequent paddock rotations) introduce greater opportunities for disturbance of parturient hinds and lead to higher levels of calf mortality. While this maybe the case, economic imperatives mitigate against more "natural" extensification of deer farming in most cases, necessitating careful consideration of the calving environment within intensive management systems. Despite the pressures of high stocking rates, there are a number of key management principles pertaining to calving that have emerged to optimise the calf:dam bonding process. These have been based on a sound understanding of the birthing behaviour of hinds.

While red deer are clearly gregarious, hinds seek and require isolation from herd mates (and other potential disturbances) during the parturition period. In the wild, hinds will typically move well away from the herd and find a quiet, isolated birthing site. High stocking rates, small paddocks, low levels of natural cover and human disturbances are all known to induce high levels of anxiety in parturient hinds. This anxiety is manifest as fervent fence-pacing behaviour prior to and during birth. Fence-pacing simply reflects a desire to move away from sources of disturbance, and high levels of pacing are a strong indication to the farmer that all is not well with the hind. Recent studies at the Invermay Agricultural Centre demonstrated that paddock size and stocking rate strongly influenced fence-pacing in parturient hinds, with animals confined to small paddocks exhibiting 2-3 times the level of such activity than those in paddocks of twice the size. Furthermore, proximity to human disturbances also increased such behaviours. Therefore, the implication for farmers are quite clear ... *manage for a better calving environment*. Options include:

- establishing calving groups well before calving starts to allow hierarchies to be established.
- reducing stocking rate of hinds prior to onset of calving.
- providing more area by opening gates between paddocks.
- establishing calving areas around natural topographic features (e.g. hills, gullies, vegetative cover) that provide safe birthing sites.
- siting birthing paddocks away from human disturbances.
- avoiding unnecessary disturbances within calving paddocks (e.g. dogs, vehicles, etc)
- or alternatively, ensuring hinds are fully habituated to certain situations (e.g. human presence, motorcycles, etc) well before calving starts.

Special consideration should be given to the calving environment of first calving hinds, as these animals are likely to be more sensitive than adults to calving disturbances.

(b) Dystocia

Dystocia has been, and still is, a significant cause of calf (and hind) mortality for farmed red deer in NZ. Early studies indicated that birth injury accounted for 34% of all calf mortalities. This figure may have reduced over the last 25 years, but dystocia still ranks as an important cause of reproductive wastage (15-25% of calf mortalities). Typically, in such cases, the calves are born dead (stillborn) or died within several hours of birth without having walked or suckled. Occasionally, hinds cannot complete the birth process and require assistance to expel the calf.

There has been much discussion over the years about the causes of dystocia in red deer, and the following themes have repeatedly emerged:

- small, poorly grown hinds that are habitual offenders (i.e. anatomical constraints).
- overfeeding leading to excessive hind body condition in late pregnancy.
- overfeeding leading to excessive calf birth weight.
- low levels of physical exercise/fitness on intensive units.
- sire effects on excessive birth weight and/or calf limb size (e.g. hybridisation).
- disturbance around parturition.
- subliminal stressors (overcrowding, unstable herd structures, etc) that create behavioural instability and poor farming temperament.

Over the last decade, large numbers of poor performing hinds have been culled from the NZ herd. This may account for the apparent reduction in the overall incidence of dystocia. Many farmers now routinely cull hinds known to exhibit calving difficulties. However, the other factors need closer evaluation if this trend is to continue.

Perhaps the most controversial discussions on the causes of dystocia centre around the "fatness/fitness" conundrum. This has led to polarised views on management of hinds in late pregnancy. Some farmers advocate strict controls of food intake by hinds, while other farmers prefer luxury feeding. Such disparate management strategies still persist, although most farmers take more balanced approaches and manage pregnant hinds within a moderate range of body condition scores (a visual assessment of fatness). Variations in feeding policy largely reflect perceptions of the role of maternal nutrition on inducing dystocia through excessive hind fatness and/or excess calf birth weights. Neither situation has been convincingly demonstrated. The pragmatic farmer view is increasingly to maintain hinds at reasonably high body condition over all seasons of the year, regardless of sire size or management focus. These managers regard fitness as a critical issue but believe, from experience, there are few risks to hinds loss through dystocia from overfatness, and significant advantages. Hinds have strength and persistence to expel a mispresented calf in the rare case of difficult birth; milking ability is substantially enhanced through strong development of udder tissue; and hinds in good body condition have substantial reserves for lactation. In turn, maintaining a high body condition score through lactation has perceived benefits at mating through advanced cycling and concise conception patterns.

Recent studies involving various controlled levels of feeding to hinds during late pregnancy found that hinds exhibit a high degree of control over birth weight by adjusting gestation length to compensate for variation in fetal growth. Furthermore, excessively fat hinds (maximum body condition score) that had experienced little exercise prior to calving, all calved with ease (Asher *et al*, 2000). This throws into doubt previous assumptions about the role of nutrition in dystocia, although it is fair to say that the "jury is still out" on the issue.

Sire effects on birth weight have been demonstrated, especially with hybridisation favouring larger sires (e.g.wapiti) over smaller dams (e.g. red deer). Consequently, increased incidences of dystocia have been a historical problem with some hybridisation programmes. However, such problems are now generally kept to a minimum by selective use of breeding hinds capable of delivering larger calves (e.g. well-grown red deer hinds and hybrid hinds). In the case of wapiti x red deer hybridisation, dystocia problems seem to arise more from excessive fetal limb length than from birth weight *per see*. Farmers adopting hybridisation options seem prepared to accept some increased risk of dystocia over that of pure red deer systems, on the basis that the benefits (faster growing calves) outweigh the costs (higher calf losses). The use of restricted feeding management during late pregnancy for hybrid-bearing hinds seems to be still common practice in New Zealand, although the benefits of such have yet to be evaluated for hybridisation programmes.

The issue of disturbance-induced dystocia is also a little contentious due to lack of quantification. However, given that disturbance during parturition can undoubtedly lead to mismothering, any additional benefits from reducing disturbance on dystocia incidences would be welcomed by farmers.

There has always been considerable debate amongst red deer farmers on when or if to intervene in the calving process if a hind appears to be having difficulty expelling the calf. Horror stories during the early 80's of farmers having to assist 10-20% of their hinds during calving sound unbelievable ... but it happened occasionally. However, one wonders if their paranoia didn't actually create the problem. Normal calving is often a protracted process (2-5 hours) and it is often hard to make a judgement call on whether a hind is birthing naturally or is in trouble. The actual process of yarding the hind for assistance may further compound the situation, as well as disturb other parturient hinds in the paddock. By the same token, many farmers would consider it unethical to leave an obviously distressed hind to suffer when calf expulsion is unlikely. Often, such hinds will completely separate from the herd and may be easily yarded without disturbance from other hinds. Experience is an important tool here.

The issue of reducing the incidences of dystocia is a complex one shrouded in contrasting perceptions and misinformation. The main summary messages are ...

- cull problematic hinds from the herd.
- manage the nutritional environment of the pregnant hind within sensible boundaries, avoiding extremes in feeding strategies.
- be aware of potential sire effects on calf birth weight and limb size when adopting hybridisation programmes. Select breeding hinds capable of bearing larger calves.
- reduce levels of disturbance during calving, taking particular care when intervening to assist individual hinds in difficulty.
- establish routine and familiar observation patterns, ideally from vehicles so that intervention, if needed, can be implemented quietly and effectively.

(c) Misadventure

Calf losses through accidental causes are always going to occur, and some cases are just plain bad luck. However, many misadventure cases are caused by bad management and poor facilities, and as such are completely avoidable.

Without a doubt, the most significant causes of misadventure in young deer are fences … in particular, poorly constructed or inappropriately placed fences. Newborn calves naturally seek shelter to hide. In the absence of suitable cover they will wander great distances and seek shelter outside the birth paddock. From here it is often only a matter of time before they get lost and starve, or get hung up in the fencing wire. Many such losses go unnoticed as the calves often die well away from the herd.

There are two important issues here … (1) ensuring that fences around calving areas are calf-proof (this is largely a function of mesh size) and (2) reducing the incentive for calves to wander by providing adequate low-level ground cover within the calving area. The latter point is often one of contention, as farmers on highly intensive units also seek to maximise pasture area and feed quality, being unwilling to sacrifice large tracts for ground cover (synonymous with "weeds" in some eyes). However, there are many forms of cover attractive to calves, including strips of pasture left to mature:

- natural topographic features (rocks, logs)
- planted cover (pampas)
- tree branches
- hay bales, etc.

It is important to note, however, that placement of shelter belts and plantings on the outside margins of calving paddocks may look attractive but will likely lure calves through the fences. In such circumstances, losses may be avoided by lifting the bottom wires of the fence about 30 cm above ground level during calving. This will allow calves, but not hinds, to move freely to and from the cover.

There are numerous other potential causes of calf misadventure that should be identified for each farm. These may include physical features such as potholes, large mud wallows, discarded fencing wire, etc, or be associated with normal management practices such as "topping" and haymaking (I need not draw a mental picture here). Forms of disturbance that panic calves into fences should be avoided, as many losses in older calves result from impact injuries. The overall message is clear and simple … identify the causes and eliminate them (or at least modify them into something less lethal).

(d) Non-viability syndrome

In essence, non-viability refers to low birth weight. In such cases, calves are unable to walk or suckle after birth, and soon succumb to dehydration, hypothermia, etc. In the case of red deer, calves below 5.0 kg seldom survive more than a day from birth. For fallow deer the viability threshold lies around 2.5 – 3.0 kg (Asher and Adam, 1985; Mulley, 1989). The occurrence of such low birth weights indicates fetal developmental aberrations that may be related to various factors during pregnancy.

Non-viability syndrome has been a major issue for fallow deer farmers in Australia and New Zealand, and has been linked to under-nutrition of the doe during the last third of pregnancy (Mulley 1989). While not as prevalent in red deer, non-viable calves are occasionally observed. Recent studies involving mild nutritional constraints to hinds during late pregnancy failed to establish an effect of nutritional status on birth weight, with hinds on lower planes of nutrition simply extending gestation length to accommodate reduced fetal growth rate (Asher *et al*, 2000). Other studies on wild red deer and wapiti indicated that severe undernutrition during late pregnancy has serious consequences on birth weight and calf survival (Albon *et al*, 1983; Thorne *et al*, 1976). The sporadic occurrence of non-viable red deer calves on New Zealand farms indicates the influence other causal factors affecting individual hinds within a herd.

(e) Infectious agents

As deer farming grows, so too does the list of potential pathogens that potentially cause mortality in young deer. Again, this may reflect a growing trend toward intensification (e.g. high stocking rates) and the integration of deer with other livestock species. While the overall incidence of calf/fawn mortality through infectious agents may seem relatively low on a regional or national basis (2-5% of calf losses of red deer in New Zealand), the sporadic nature of specific infections can have disastrous consequences on reproductive productivity of individual farms. In many cases in which disease outbreaks have occurred on individual farms, they have arisen with no prior history of infection on the farm and have caused mortality rates as high as 30% of calves born in that season. Such has been the case of recent *Cryptosporidia* outbreaks on some farms in the Otago/Southland region of New Zealand (Gill, 1998).

Once an unexpected infection problem becomes evident, the key to immediate control lies in rapid identification of the causal agent. Subsequent treatments to curtain the outbreak may require a high level of intervention during calving ... something that may not sit well with farmers who prefer a "hands-off" approach to calving. However, the benefits often far outweigh the risks in these situations. Longer-term control of disease generally best lies with vaccination of hinds (if a vaccine is available). Hinds will confer protective immunity to newborn calves via immunoglobulins in their colostrum. Some diseases may be spread by certain environmental situations (e.g. *Salmonella* in infected water supplies) or management practices (contamination of summer calving sites with *Cryptosporidia* by hinds/calves) that may need to be addressed before calving starts.

Infectious agents that have been observed to cause sporadic mortality problems in young red and fallow deer in New Zealand include ...

- *Cryptosporidia*
- *E. coli*
- *Fusiformis* (particularly in fallow deer)
- *Leptospira*
- Cattle tick (*Hemophysalis longicornis*)
- *Salmonella*

However, this list will not necessarily apply to other countries or other species of farmed deer. Again, the key to control is rapid identification of the causal agent, rapid intervention with prophalaxous and prevention of future occurrences (e.g. vaccination). In all cases, veterinary expertise is critical.

(f) Lactational insufficiency

This is often overlooked as a prime source of reproductive wastage. However, it is an extremely common source of wastage that reflects the level of nutritional management to the female while rearing her offspring. The growth of calves/fawns from birth to weaning is directly related to milk intake ... and milk intake is directly related to milk yield ... and milk yield is a function of food intake by the dam. It sounds simple but is easily overlooked because lactational insufficiency on deer farms is generally at a level that retards calf growth but does not necessarily cause any obvious increase in calf mortality. Ultimately, it is the total weight of calves at weaning (i.e. a function of both "weaning rate" and average weaning weight) that determines financial returns from breeding operations (weaners are often bought and sold on a liveweight basis).

Because most cervid species produce their offspring during summer months, the vagaries of summer rainfall patterns often determine feed production outcomes in many regions of the world (especially in pastoral environments). This necessitates management planning of "worst'case scenarios" to offset the effects of drought conditions on hind/doe nutrition.

Supplementary feeding of red deer hinds during lactation has become an accepted and common practice in many regions of New Zealand that are subject to drought conditions (e.g. Canterbury, Central Otago). Not only does this optimise milk yields but also minimises weight loss in the hind ... and may have flow-on effects on subsequent reproductive performance at the next breeding season (Deer Industry Manual New Zealand, 2000).

Summary

While this paper has focussed largely on reproductive performance of red deer on New Zealand pastoral farms, the principles of identifying and eliminating sources of reproductive wastage apply to all species. Particular emphasis should be placed on accurate assessment of pregnancy establishment, pregnancy maintenance (i.e. fetal survival), neonate survival and neonate growth (lactational performance of dam) when attempting to maximise annual reproductive performance of the female breeding herd.

In many situations, relatively simple adjustments to management and the animals' physical environment may lead to dramatic improvements in the numbers of calves/fawns successfully reared within the herd.

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