Calving environments for farmed red deer: a review of current knowledge and a pilot study on soil quality

J.C. Pollard and J. Drewry

Abstract

In the wild, red deer seek isolated sites with vegetative cover for parturition. Intensive deer farms often allow limited isolation from other deer or humans, and little vegetative cover. These are probably reasons why hinds pace fencelines at calving time, and the failure to provide an appropriate environment almost certainly contributes to perinatal mortality. Part A of this paper reviews studies of behaviour at calving time and evidence that farm calving environments influence mortality. Solutions for providing more suitable environments in the intensive farming situation are discussed, and include (i) increased knowledge of how to provide suitable environments (two-way interaction with farmers is desirable), and (ii) quantification of the costs and benefits of improving calving environments. Such benefits would be expected to include reduced mortality rates, and reduced fenceline damage from pacing.

Part B of this paper then describes a pilot study on soil damage due to fenceline pacing in calving paddocks on Invermay deer farm. Results showed that the soil in tracked fenceline areas of the calving paddocks was very compact, with an overall mean macroporosity of 4.4% compared to 16.3% for pasture (SED 0.90%; $P<0.001$), and a mean bulk density of 1.25 Mg m^{-3} compared to 0.86 Mg m^{-3} for pasture (SED 0.020 Mg m^{-3}; $P<0.001$). The values for macroporosity and bulk density in the tracked areas are of concern as losses of soil and nutrients through overland flow may increase with increased soil compaction.

Keywords: *red deer, calving, farming, mortality, behaviour, soil quality*

Part A: Calving environments for deer

Introduction

Substantial neonatal losses and high frequencies of fenceline pacing by hinds are experienced on many intensive deer farms at calving time (Asher & Pearse, 2002). There is much evidence that these problems can be reduced by providing appropriate environments and management at calving. This section reviews this information, beginning with a description of calving environments, behaviour and causes of neonatal mortality in wild deer. Following this, behaviour and mortality observed in farm situations are described, then recommendations for providing suitable calving environments on farms are summarised.

Calving environments for wild deer

Knowledge of the calving behaviour in wild red deer comes mainly from two Scottish studies, one carried out on the mainland (Darling, 1937) and one on the Isle of Rhum (Clutton-Brock & Guinness, 1975), both of which provided similar observations. Hinds became isolated from their matriarchal groups between two and 12 hours before calving, although some animals left their groups several days before. The hinds tended to move to high ground, which was sometimes outside of their normal ranges. Previous offspring followed some hinds but were driven off by the mother when the new calf was born. The hinds chose long heather and sheltered areas for calving. Guinness *et al*. (1979) also considered that poor feeding areas were chosen, possibly as a means of avoiding other deer. After giving birth the hinds licked and suckled the calves, remaining within 50 m of the neonate for the first few hours, but thereafter spent most of their time much further away (often over 1 km away in the study by Clutton-Brock & Guinness (1975)), only returning to suckle 2-4 times a day. Following suckling the calf moved away from its dam and selected a hiding site within long vegetation.

Calf hiding sites tended to be raised above the surrounding ground and sheltered from sight on at least one side, and were often within a gully or dip on a hillside (Clutton-Brock & Guinness, 1975). Calves that were marked by observers were normally moved to a higher altitude level during the next 24 hours (Clutton-Brock & Guinness, 1975). After a few days the calves started to accompany the hinds, and both mother and offspring joined other hinds by about three weeks following birth (Darling, 1937; Clutton-Brock & Guinness, 1975).

A study on red deer in English parks provided further information on the selection of calving sites. Low vegetation such as ragwort or rushes were favoured, while open grassland, and in one park woodland, was avoided (it was thought that the woodland may have been avoided because of the hinds' need to monitor disturbance by humans (Birtles *et al*., 1998)).

In a study and review of calving habitats for wild elk in North America, it was concluded that in general calving habitats provided trees or shrubs for cover, and that an essential component was a hidden bedding site for the calf, for instance among rocks, logs, vegetation, hollows or fallen branches (Wallace & Krausman, 1990).

Causes of neonatal mortality in wild deer

In a study of calf mortality on the Isle of Rhum, 14 % of calves died within a week of birth (Guinness et al., 1978). These deaths were attributed to stillbirth, suckling difficulties, lactation/suckling difficulties, misadventure, predation, and desertion or beating by the mothers following marking by the observers. It was thought that exposure or infection may have aggravated effects of the other factors (Guinness et al., 1978).

In Darling's (1937) study, predation of the neonates during hiding was a major source of mortality. In natural populations of elk in North America, high losses of neonates were associated with poor winter nutrition of the cows, as well as predation (Taber et al., 1982).

Calving environments for farmed deer

On intensive deer farms, there is often little opportunity for hinds to become isolated from other deer and people, and shelter is often lacking. For the calves, there can be little in the way of low cover for hiding. Nevertheless there is recognition that cover is important to calves, evident in a survey of farmers in which 95 % of respondents considered that cover improved calf survival (Pollard *et al*., in prep).

Causes of neonatal mortality in farmed deer

Recent estimates of average mortality rates of farmed deer calves during the perinatal period were 10 % for adult hinds and 12 % for yearlings (Asher, 2000). Post-mortem studies indicated that the most common causes of perinatal mortality were dystocia, starvation and misadventure (Asher & Adam, 1985; Gill, 1985; Audigé, 1995; Pearse, unpublished data). An investigation of mortality of farmed elk calves in North America found that more than half of the calves that died did so during the first 24 hours following birth, and many of these had been assisted during birth (Allen, 2000).

Behaviour observed in the farm environment at calving

Pacing

The first observed pre-parturient behaviour of intensively farmed hinds is fence pacing. This behaviour is common in animals in inadequate environments (Hediger, 1964). Pacing occurs at relatively low levels during the week or so before parturition, possibly starting seven days before the hind gives birth (Cowie *et al*., 1985). Two days beforehand it increases markedly, then on the day of parturition there is a peak (Cowie *et al*., 1985; Pollard *et al*., 1998, Wass *et al*., in prep.). For example, Wass *et al*. (in prep.) observed that the proportion of observations in which individual adult hinds were pacing during the periods more than two days, two days and one day prior to parturition rose from 3 to 28 and then 42 %. Pacing carried on at moderate or low levels following birth (Wass *et al*., in prep; Deighton, unpubl.). While pacing normally ceased during parturition itself, it was sometimes resumed by hinds that were disturbed from the birth site (Cowie *et al*., 1985).

The reasons for pacing have been the subject of some speculation and investigation. Pacing in general was thought to reflect "the urge to move freely", and was prevalent at particular times of the year including calving (Moore *et al*., 1985). Pacing at calving was seen as a reflection of the hinds' need for isolation (Cowie *et al*., 1985), while Asher & Pearse (2002) wrote that it reflected a desire to move away from sources of disturbance, and Fletcher (2000) felt that it reflected a desire for seclusion and a need for cover. Pacing was also seen in calves that were apparently seeking hiding places or attempting to re-join their mother on the other side of the fence (Cowie *et al*., 1985).

In a study of hind groups calving in four paddocks, pacing was directed at specific fencelines but the factors responsible for this choice were not obvious. The exception was a tendency for the group nearest a set of yards to pace with a particularly high frequency, and with a strong preference for the furthest fence from the yards (Pollard *et al*., 1998). Pacing in the paddocks also increased markedly with human presence (with an increasing frequency from humans being in the yards, to humans visible, to humans in the paddock (Pollard *et al*., 1998)). In a comparison of groups of 12 hinds calving in two paddocks with different environments (one a relatively flat 1.8 ha, near a deer yards and below a hide containing observers, and the other a 4.2 ha hillside with some topographical and vegetative cover, more distant from human activities), considerably more pacing was seen in the former paddock (Deighton, unpubl.).

Isolation

Although their opportunities are limited, intensively farmed hinds show some degree of isolation from the rest of the herd prior to and during parturition (Cowie *et al*., 1985; Wass *et al*., in prep.; Deigton, unpubl.). Wass *et al*. (in prep.) observed an increase in isolation of hinds (defined as being >20m from other hinds) from >two days prior, one day prior and the day of parturition, from 3, to 11, to 40 % of observations, with adult hinds spending more time isolated during 24-48 hr prior to parturition than yearlings. Similarly, Deighton (unpubl.) found that isolation began two days before parturition then peaked on the day of birth. In that study, on the day of birth hinds in the smaller paddock were on average 61 m from the centre of the herd, and hinds in the bigger paddock were 134 m from the herd (Deighton, unpubl.). Following parturition the frequency of isolation declined to 24 % then 12 % of observations during the periods 0-24 h and >24 h (Wass *et al*., in prep.), although different patterns in different groups were observed by Deighton (unpubl.).

Calving sites

Observations of the sites chosen for calving were made on the Invermay deer farm by Cowie *et al*. (1985). Sites away from the normal resting area of the herd, and human disturbance, were favoured. Some sites provided cover for calves while others were on open hillsides. Hinds that were disturbed during calving sometimes rejoined the herd or resumed pacing, then either returned to the birth site or found a new one. If the calf was born during disturbance the mother sometimes failed to attend to it, instead returning to the birth site (especially if the mother was primiparous). It was considered that hinds attempted to lead their calves away from the birth site after the first suckling (which usually began ½ to ¾ hour after parturition), then the calf would move away and hide, with the hind resting and grazing close to the calf for the next four or five hours (Cowie *et al*., 1985). Movement from the birth site was also studied by Wass *et al*. (in prep.), who observed that hinds reached 10m from the site on average 112 minutes following the birth, and calves had reached 6 m from the site on average 130 minutes after birth.

Hiding

In addition to the lack of isolation opportunities, the calving environment on intensive farms also often fails to provide hiding places for calves. Cowie *et al*. (1985) observed that following each suckling, the young calf left its dam and sought a suitable place to hide. Farmed calves were found hiding in patches of thistles or long grass, or beside fence posts (Kelly & Whateley, 1975). Those with little cover available were observed to walk along fence lines and push through netting in search of a hiding place (Cowie *et al*., 1985; Fletcher, 2000). It was thought that the lack of cover in paddocks contributed to the incidence of calf entanglement in fences, and loss of contact with the dam after pushing through a fence (Cowie *et al*., 1985). Nevertheless, calves aged less than 24 hours were sometimes found in the open, even though scattered shelter was present (Kelly & Drew, 1976). In that study, young calves were more easily disturbed when they were hidden within manuka scrub with little understory, compared with when they were hidden in low shelter provided by felled pine tree branches (Kelly & Drew, 1976).

Adding extra netting to fences in an attempt to reduce mortality was found to be successful in some paddocks, but was associated with increased mortality in others (Beatson *et al*., 2000). This was possibly because of other confounding factors or because calves were unable to escape attacks from alien hinds, or managed to get through the fences in search of cover but not back again.

Hiding behaviour of the calf began to diminish when it was three to four days old (Cowie *et al*., 1985). Calves joined the herd by the time they were 7-12 days old (Kelly & Whateley, 1975; Cowie *et al*., 1985).

Interactions between unrelated deer

It was suggested that bonding of the hind to the calf occurs when the dam licks the calf immediately following birth (Cowie *et al*., 1985), whereas the calf appears to only slowly learn to recognise its dam (Clutton-Brock & Guinness, 1975; Guinness *et al*., 1979; Cowie *et al*., 1985). When other neonates and adults are present at calving there are opportunities for calves to approach alien hinds and for hinds to become bonded onto alien calves. For instance, 44 % of adult and 60 % of yearling hinds were observed to experience some form of interference from other hinds during calving (Wass *et al*., in prep). Not surprisingly, genetic analysis of farmed deer pedigrees showed that hind-calf mismatching was widespread, whereas similar tests on a feral population in the United Kingdom did not detect any mismatching (Sigsgaard *et al*., 1998).

Alien hinds can also be intolerant of calves and attack them (Cowie *et al*., 1985; Harboard, 1999). For example, calves observed pacing along fencelines apparently seeking cover, or mistakenly approaching an unrelated hind, were sometimes attacked by alien hinds, or frightened into pushing through the fence (Cowie *et al*., 1985). Some particularly aggressive hinds that attacked calves that were lying down were observed by Kelly & Whateley (1975). This behaviour was attributed later to a sudden change from an extensive to an intensive environment, just prior to calving (Kelly & Drew, 1976).

Disturbances

Disturbance of calving hinds was sometimes observed to cause the hinds to abandon the site where the amniotic sac had burst, and rejoin the herd or resume pacing (Cowie *et al*., 1985). This could lead to loss of contact with the calf if it was born away from the original site (Cowie *et al*., 1985). It has been suggested that disturbance may prolong the birth period (Arman, 1974), thus contribute to mortality from dystocia (Asher & Pearse, 2002). This possibility was supported by observations of pigs, in which stress led to delays in parturition and also inhibition of milk production (Bostedt & Rudloff, 1983). Human interference with newborn calves (for instance for tagging) can also lead to problems, with the calf subsequently following the person or vehicle, or being deserted by the hind (Kelly & Drew, 1976; Cowie *et al*., 1985).

Recommendations for improving calving environments

The behavioural responses to disturbance, lack of isolation and cover, and lack of hiding sites for calves all have the potential to lead to calf mortality through loss of contact with the mother and physical harm. Recommendations (Kelly & Whateley, 1975; Kelly & Drew, 1976; Cowie *et al*., 1985; Moore *et al*., 1985; Harboard, 1996; Pollard *et al*., 1998; Fletcher, 2000; Asher & Pearse, 2002; Pollard *et al*., in prep., M. Bell, pers. comm.) for improving farm environments for calving, based on research and farmer observations include:

- minimising stocking density and human disturbance,
- providing large paddocks with topographical and vegetative cover,
- habituating hinds to the calving environment and any routine disturbances,
- establishing social groups well before calving,
- avoiding calving hinds with similar parturition dates in close confinement,
- using calf-proof fences, and mowing the pasture on the outside of the fence,
- eliminating hazards such as mud wallows, and
- providing cover for calves throughout the paddock in the form of cut branches, large haybales, rough terrain, scrub, tussocks, long pasture, weedy areas, allowing calves access to tree lanes, or temporarily fencing off a margin around the paddock that still allows access to calves.

Many of these recommendations were made a long time ago. Nevertheless fence pacing and substantial levels of mortality persist on intensive farms. Reasons for this may include lack of understanding and application of factors affecting the suitability of calving environments, lack of information reaching farmers, the costs of providing appropriate environments (such as time and production losses from overgrown or rough pastures), and management difficulties with achieving such ideals as low stocking densities and minimal human disturbance on intensive farms.

Conclusions

Achieving improved calving environments may come about through (i) increased knowledge of how to provide suitable environments (two-way interaction with farmers is desirable), and (ii) quantification of the costs and benefits of improving calving environments. Such benefits would be expected to include reduced mortality rates, and reduced fenceline damage from pacing. The latter may result in increased soil quality and therefore less soil erosion.

Part B: Soil compaction associated with deer pacing at calving

Introduction

Fenceline pacing by deer creates bare tracks and considerable areas of bare ground and compacted soil contributing to soil erosion. However, the effects of deer pacing on soil and water quality have not been scientifically quantified. There is very little information in New Zealand and the literature specifically relating to deer farming and soil quality, compaction and erosion.

To investigate effects of pacing on soil quality, it is useful to assess soil compaction. Soil compaction research (particularly for the dairy industry) shows that a good indicator of soil compaction is soil macroporosity. This is the proportion of large pores in the soil (greater than 30 microns) responsible for soil aeration and drainage, which is important for plant growth (Drewry and Paton 2000; Drewry *et al*. 2002). In general, macroporosity values of less than 10% can indicate that a soil is compact enough to reduce plant growth. Soil bulk density is also a common indicator of soil physical condition. Soil physical conditions can also dictate the magnitude of sediment and nutrient (such as phosphorus) loss via overland flow, and thus the potential for environmental damage to waterways (e.g. by eutrophication).

The aims of this brief study at the AgResearch Invermay deer farm were to quantify the extent of soil compaction on deer tracks and within deer farmed pasture, and measure any effect of increased deer pacing on soil compaction during calving.

Methods

Four paddocks on the AgResearch Invermay deer farm (used in a behavioural study of calving (Wass ***et al***., in prep.)) were monitored for soil compaction. The soil is a Warepa silt loam classified as a mottled Fragic Pallic Soil (Hewitt 1998). Four macroporosity soil cores were taken from a fence line track area at the top of each paddock, and a further four samples from tracks at one side of each paddock. In general, the side track areas had a greater slope than at the top of each paddock. An additional 8 samples were taken from non-tracked pasture areas within each paddock. All soil cores were collected by inserting a foot-sampler (0–5 cm) with metal rings inserted into soil with minimal distortion. The sampler consisted of three 47 mm diameter rings that fitted on top of each other: two 15 mm deep spacer rings, which fit above and below the sample ring (20 mm deep; soil depth 1.5–3.5 cm). All three rings are held together by tape. A total of 64 samples were collected pre-calving on 7 November 2001 and a further 64 samples collected post-calving on 10 December 2001.

In the laboratory, any worms were removed using a dilute formalin solution. The middle sample ring was removed for analysis. Macroporosity was then measured using pressure plates and established techniques for water release at –10 kPa (Smith & Mullins 1991). Bulk density was determined using standard techniques (McLaren & Cameron 1996). All samples were analysed by Celentis Analytical Ltd, Ruakura. Further details of the routine macroporosity/compaction test are outlined by Roberts ***et al***. (2000) and Drewry ***et al***. (2002).

The macroporosity and bulk density results were analysed by ANOVA, with paddock as the block structure and date (pre- or post- calving), location within paddock (side or top track or pasture) and their interaction as treatment effects.

Results and discussion

The soil in the tracked areas was very compact, with an overall mean macroporosity of 4.4% compared to 16.3% for pasture (SED 0.90%; $P<0.001$; Table 1). There was no significant difference between top and side tracks, no significant effect of date nor interaction between the date and location within paddock. In contrast, soil under the pasture areas of the paddock was considered not to be compact at either sampling date (macroporosity 15.5–17.2%) and were therefore unlikely to be limiting pasture production at that particular time.

There were similar trends in bulk density. The soil in the tracked areas was more compact (mean bulk density 1.25 Mg m^{-3}) than in the pasture area (mean of 0.86 (SED 0.020) Mg m^{-3}; $P<0.001$). For bulk density there was no significant difference between top and side tracks, no significant effect of date nor interaction between the date and location within paddock.

The very low values and reduction in macroporosity post-calving on sloping side tracks, is likely to be a concern as losses of soil and nutrients through overland flow may increase with increased soil compaction. For sheep and cattle hill country, Nguyen ***et al*** (1998) found treading damage reduced water infiltration and macroporosity causing increased sedimentation and nutrient losses. Deer pacing at other times of the year may also influence soil compaction and hence water quality although there have been no studies to quantify this. The results of this study suggest that future research is required to quantify fenceline and pasture soil quality, erosion and subsequent water quality, on both paddock and catchment scales.

Table 1. Macroporosity (%) of tracked and pasture areas sampled pre- and post-calving on the Invermay deer farm.

Date & location	Side track	Top track	Pasture	SED
Pre calving	5.2	4.3	15.5	0.89 date
Post calving	2.7	5.5	17.2	1.09 location
				1.6 interaction

Conclusions

The small study in Part B showed that although there was no difference detected in soil physical status pre- and post-calving, the tracked areas were considerably more compact than pasture. This is likely to be of concern as loss of soil and nutrients through overland flow may increase in tracked areas. Further research is required to quantify fenceline and pasture soil quality, erosion and subsequent water quality, on both paddock and catchment scales. It is desirable that future studies include measurement of behavioural, production and environmental variables.

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