DEEResearch Ltd
~ A Review~

Review of Deer Welfare

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1. Executive summary

- The DEEResearch Board requested this review of deer welfare as a means of establishing research priorities for funding in this area. The review was prepared with input from researchers from AgResearch and Massey University, as well as two leading members of the deer industry. The review focuses on red and wapiti deer as they predominate in the New Zealand deer industry, although relevant work on fallow deer has been included.

- In the wild, red deer and wapiti live in a range of physical environments that provide suitable vegetation for grazing, browsing, cover and shelter from the weather. Adults live in sexually segregated groups, with hinds/cows tending to remain with related females, and young males remaining with their dams for a year or more. During the rut, males compete for and mate with a harem of hinds/cows.

- Some degree of husbandry has been imposed on deer for thousands of years. Modern farming practices in New Zealand have broadly diverged into extensive breeding units, and finishing units on intensively farmed lands (with stud and velveting operations seen in association with either type of operation). Trophy hunting is also carried out, on large tracts of enclosed mountain terrain.

- On farms, common social interventions are early weaning at 3-4 months, sexual segregation at about 10 months of age, group sizes of 50-400, and breaking down mobs into smaller groups for mating and calving, while common handling practices are mustering into deer yards, ear-tagging, administration of health treatments (such as drenching and vaccination), mechanical restraint, velvet antler removal from stags, transport in deer crates, and slaughter at Deer Slaughter Premises (DSPs). A range of artificial reproductive techniques has been developed for deer and pregnancy scanning using ultrasound is relatively common. Hybridisation of red deer with wapiti is used frequently to generate fast-growing offspring for venison production.

- Deer farm sizes are increasing rapidly, and there is divergence into specialised systems, assisted by crossbreeding and selection of suitable stains of deer. There is a challenge to provide continuity in venison supply. Consumer concerns are stimulating the uptake of quality assurance systems (QA) and consideration of land use capabilities.

- National Animal Welfare Advisory Committee Codes of Recommendations and Minimum standards cover transport, slaughter and sale of general livestock and specific codes and guidelines have been written for velvet antler removal in deer. A draft code of welfare for deer is currently being written.

- The New Zealand deer industry has developed a set of QA programmes that have a substantial animal welfare component and cover all phases of production of venison and velvet. Uptake of the programmes has been extensive. Five processing/venison export companies have adopted the DeerQA On-Farm operating standards as a minimum requirement to their own standards.

- Research on social environments has invariably concluded that to minimise problems, stocking density should be low, but this is incompatible with intensive farming. There is currently no information on the social effects of a current trend towards large mob sizes, or the effects of social perturbations such as dividing hind groups up for calving. Techniques for reducing social stress such as providing visual cover, increasing opportunities to forage, and avoiding division of established groups need to be investigated.

- There are indications that at times (especially at calving) deer have a high requirement for cover, and that shade and shelter help create suitable environments for deer. However there is no objective data on the consequences to welfare of not providing these features, or on the requirements of deer for wallowing.

- Research has shown that indoor wintering systems can create social stress and there are many other factors that can make this environment aversive. Systems that incorporate good shelter from the weather and avoid stress from confinement deserve investigation.

- Studies on handling of deer have concluded that any form of interaction with humans can be stressful to deer. Techniques to reduce stress include taming, habituation, selection for temperament, training handlers in appropriate techniques, and modifying handling environments. Research is required to advance knowledge in all of these areas.

- Pre-slaughter handling involves multiple stressors and this is reflected in the physiology of deer at slaughter. Each component of pre-slaughter handling needs to be examined to determine where improvements can be made. Studies have indicated that welfare would be improved by minimising transport and lairage times. Thermal conditions during transport warrant further study.

- Mechanical restraint has been shown to be stressful, and it is likely that reducing stressful components (e.g. noise and isolation from other deer) would reduce restraint stress. Of the physical manipulations carried out on deer, only analgesia for velvet removal has been extensively researched. There is still a need to identify methods of providing analgesia for velvet removal, and the consequences to welfare of leaving antlers to harden should be explored. Other manipulations such as ear tagging and electroejaculation deserve attention.

- Trophy hunting creates opportunities for welfare problems. There is a need to monitor this activity and identify welfare issues.

- Research could also be carried out to identify effective techniques to stimulate the uptake of knowledge on animal welfare by stock handlers. There may also be a need to identify optimal techniques for ensuring compliance with QA standards.

- Techniques to quantify acute stress have been extensively studied in deer. Advances have been made in chronic stress assessment but techniques have had little use in evaluating husbandry practices. A better understanding of the relationships between chronic stress, behaviour, and the adrenal and immune systems is vital to identifying improved husbandry systems for deer.

- Assessment of pain in deer currently relies heavily on behavioural measures. Improved knowledge of physiological responses to pain is required so that techniques for carrying out manipulations such as velvet antler removal and ear tagging can be evaluated more effectively.

- One major threat to overseas markets is the harvest of velvet antler. This threat emphasises the need for advances in knowledge on providing analgesia for velvet removal, and the welfare and management issues arising from leaving antlers to harden. A second threat is the issue of whether deer in New Zealand are naturally or factory farmed, therefore research into practical alternatives to winter housing is vital.

- Contributors to the review were asked to rate potential research areas highlighted by the review as being of high, medium or low priority. Topics favoured as high priority were pre-slaughter stress, techniques for improving calving environments, and minimising stress during handling and restraint. Assessing welfare, effects of manipulating social environments, and velvet removal techniques also were given several “high” ratings but opinions were more diverse on these topics. Research areas receiving the greatest number of “low” ratings were ear-tagging, effects of genetic selection, cross-breeding and artificial reproduction techniques, selection and taming for amenability to farming, assessing market connections and management of stags in hard antler or during the rut. Nevertheless for most of these topics there was diversity of opinion with some “high” ratings.

- Results from the priority-ranking exercise need to be interpreted with caution, as some topics may not have been represented fairly by their descriptions or by grouping them with others. Furthermore two contributors warned against using a piecemeal approach to research that attempted to address issues without first assessing the broader picture, which encompassed the natural behaviour of deer and sound techniques of assessing welfare.

2. Introduction and scope of the review

The DEEResearch Board requested this review on the topic of deer welfare as a means of establishing research priorities for funding in this area. Deer Health and Welfare is one of seven research goals identified by the DEEResearch Board. Health is to be addressed separately. This review was prepared with input from researchers from AgResearch and Massey University, as well as two leading members of the deer industry.

The review provides a background to the topic of farmed deer welfare by briefly discussing the natural history and domestication of deer, current practices used in deer production in New Zealand, and future trends. The current state of knowledge is then described with a review of scientific and farming literature on physiological and behavioural stress responses of deer to production practices. Codes of practice and quality assurance systems that implement knowledge on deer welfare are described. Gaps in knowledge are identified through a comparison of current practices and research on these practices, and through issues identified in the literature. Current research on deer welfare in New Zealand and internationally is described and research capabilities within New Zealand are identified. Research priorities emerging from the review have been ranked by contributors from research institutions and within the deer industry.

Red deer and red x wapiti hybrid deer predominate in the New Zealand deer industry and are the focus of this review, although a section on relevant work on fallow deer has been included. Red deer and wapiti have extensively interbred within New Zealand. In this review no attempt has been made to distinguish between research findings from studies of red deer, wapiti and their hybrids.

3. Background on deer farming

3.1 Natural history

3.1.1 Red deer

Populations of wild red deer (*Cervus elaphus*) extend from western Europe to central Asia. Their physical environment varies widely, with the general locality of populations, and also factors such as season, the weather, sex and age. Some localities appear to be more favourable than others, because the deer in the Scottish uplands have relatively small body and antler sizes that are thought to result from the harsh, mineral-poor environment (Clutton-Brock *et al*., 1982).

Within general locations, the size of home ranges can be a few hundred or several thousand hectares (Staines, 1969). Red deer were originally a forest animal (Lockie, 1969), and the presence of vegetation for food, cover and shelter is one of the major determinants of the distribution of wild red deer (Darling, 1937; Langbein, 1988; Challies, 1990). They browse from trees, fallen leaves and shrubs as well as eating herbs and grasses (Darling, 1937; Challies, 1990; Nugent *et al*., 2001). Trees, particularly conifers, are also used for rubbing (Darling, 1937). The natural habitat of red deer provides shelter from chilling conditions (Staines, 1969), wind (Clutton-Brock *et al*., 1982), temperature change and sun (Darling, 1937), and cover when the animals are disturbed (Langbein, 1988). Cover is particularly important at calving time, when hinds are found in areas of weedy or scrubby vegetation (Darling, 1937; Birtles *et al*., 2001) and during the early post-parturient period when the calves remain hidden except when suckling (Darling, 1937; Clutton-Brock *et al*., 1982). Another feature of red deer habitat is wallows, which are used by both hinds and stags (Darling, 1937). Wallowing is a component of rutting behaviour in stags, and is thought to assist with metabolic cooling and avoidance of biting flies in both sexes (in the northern Hemisphere) (Darling, 1937; Geist, 1982).

Social conditions for wild red deer vary widely according to sex, age, season and environmental conditions. During most of the year, adult stags and hinds are sexually segregated and live in small, loosely associated hierarchical groups. Hinds isolate themselves from herdmates during the day or so before giving birth, then take a week or more to rejoin the herd. Juveniles stay with their mothers for 2-3 years (stags), or remain associated with their matrilineal group (hinds). During the rut, individual stags attempt to establish and defend a group of hinds (Darling, 1937; Clutton-Brock *et al*., 1982).

3.1.2 Wapiti

North American Elk, commonly known as wapiti (*Cervus elaphus nelsoni, roosevelti and manitobensis*) originated in North America where they were historically found in a wide range of habitats. Aside from human influences, critical limiting factors to their distribution (as with red deer) are the availability of thermal cover, forage, or both, especially in winter. While found on prairies feeding on grasses and rushes in summer, they favour river valleys with trees and undergrowth for browse during the winter (Bryant & Master, 1982). In summer, ranges can be limited by the availability of water (Skovlin, 1982). The need to adjust their habitat seasonally is reflected in the tendency of some populations to migrate between summer and winter grounds (Adams, 1982).

Like red deer, wapiti use trees for rubbing and vegetation is used for cover, particularly when resting or disturbed by people. Calving habitats usually but not always provide covering vegetation. Wallows are primarily used by mature rutting bulls (Skovlin, 1982).

Adult wapiti form hierarchical, sexually segregated clusters for most of the year, although bulls tend to be more solitary than cows (especially in areas with vegetative cover). As with red deer, bulls defend and mate with a harem during the rut, and cows seek isolation for calving. Dispersal of young bulls at one year of age is common, while the female calves remain associated with their dams (Geist, 1982).

3.1.3 Fallow deer

European fallow deer (*Dama dama dama*) populations are found over a wide geographical spread, largely due to artificial introductions by humans. They inhabit a wide variety of climatic conditions and vegetation types, including temperate forests, tropical seasonal forest, grasslands and savannah. They are primarily grazers but also consume browse and are highly adaptable to available food resources (Chapman, 1993).

The social system of fallow deer differs from that of red deer and wapiti in that bucks do not always establish a territory and defend a harem of does, but sometimes adopt a “lekking” strategy whereby a number of bucks each hold a small territory in very close proximity to each other (Chapman, 1993).

3.2 Overview of current deer farming practices in NZ

3.2.1 Domestication and species

Deer (especially red deer) have been husbanded for several thousand years, and for many centuries there has been a practice of population management to limit numbers and to enhance the number of “superior” animals, traditionally defined by antler size. This practice has continued up to and through Victorian times in the United Kingdom (Fletcher, 2002). The pursuit of excellence in deer breeding through forestry and deer management has always been influenced by the demands of the nobility for hunting and exclusive access (Haigh, 2002).

Most of the deer farmed in New Zealand are red, with some degree of hybridisation with wapiti to increase body size, growth rates and antler weights. Increasingly, farmers are mixing recently imported so-called “elite” strains to produce a composite farm deer type that has the attributes of good temperament and superior antler and body growth rates. Fallow deer comprise a small but variable proportion of the national herd (currently about 2.5%).

3.2.2 Production strategies and physical environment

Modern production systems have either expanded on traditional game ranching, or more commonly have been adapted from intensive pastoral farming techniques (Pearse & Drew, 1998). Two divergent production systems have evolved. Breeding units tend to be large, extensive hill and range operations, while finishing units favour highly productive, intensively farmed lands. Stud and velveting units may be seen in association with either type of operation.

In extensive operations, group sizes are large (400-800 hinds per mob) and intervention is minimal. The deer are grazed on native grasses, often with oversown legumes and improved grasses, with flat areas used most intensively for crops. Yarding is infrequent and requires large facilities. Intervention by humans is often restricted to pregnancy scanning, weaning in winter (with tagging and removal of breeding stags), velvet removal, Tb testing, transport and slaughter. The need for efficient handling of large mobs has led to culling on temperament.

Intensive operations are predominant in New Zealand deer farming. Pastures are often highly developed and improved, with subdivisional fences for grazing control and stock management. Strict culling and sale criteria based on performance are applied. The calving period is condensed and weaning is predominantly early, at 3-4 months of age.

The most intensive systems are finishing properties in fertile foothill and flat lands, that buy in weaner deer and achieve maximal growth rates through specialised crops and pastures. Winter pen feeding is sometimes used, particularly in the colder, wetter regions and where photoperiodic manipulation is used to increase winter growth rates. However this type of farming is not now condoned by the deer industry or acceptable to any venison exporters. In the cold, wet regions stock are also sometimes overwintered on “sacrifice” paddocks or brassica crops.

Trophy hunting is at the other end of the scale, ideally being carried out on large tracts of enclosed mountain terrain. Suitable trophy stags are released in the hunting season for harvest. The hunts are specifically managed by outfitters whose services include accommodation, tourism experiences and access to hunting in other areas for other sought-after species in New Zealand (e.g. thar, chamois). All types of hunting/harvest can be accommodated (black powder, bow and arrow, and (most commonly) high-powered rifle). Animals are selected on a specific basis in negotiation between hunter and guide. Recently a Code of Practice including humane killing has been developed with trophy park operators. The New Zealand Game and Forest Foundation has also recently been formed to be involved in feral hunting, forest management and establishing credible trophy park operations and a sustainable trophy industry.

There is recognition that the simple harvest of aged sire stags on deer farms is not an appropriate part of the trophy hunting industry. However deer farmers themselves are taking a keen interest in selection and breeding specific animals and antler styles for the trophy industry, which returned an estimated $5 million to the operators last season.

3.2.3 Social environments

The level of social intervention by humans varies with the scale of intensity of the farming operation. In general calves are weaned at 3-4 months of age, then kept in mobs of 50 to 400 or more (often with social segregation on the basis of origin and body size). Sexes are usually separated at 10 months of age, to form separate grazing mobs of hinds and stags. Group sizes at this age vary from 50 to 400 or more. For mating and then again at calving it is common to break down hind mobs to 40-50 individuals. Stags raised for venison and/or velvet are generally retained in their large mobs for overwintering. However management considerations for velvet or venison harvest require that individual age or weight groups are established in spring/summer for efficient production.

3.2.4 *Handling environments*

Yarding and restraint

Techniques and facilities used for handling deer were reviewed recently (Matthews, 2000). The industry has a robust on-farm quality assurance (QA) system that defines good yarding practices and minimum standards in materials and construction. Deer yards are usually purpose-built with solid plywood or slatted wooden walls (or a combination of both), about 3m high. Part or all of the building is usually covered with a roof, and the floor may be a variety of substrates. The handling areas contain large and small pens as well as a circular drafting pen in a central location. Many yards have an enclosed individual weighing area and it is usual to have some means of controlling the deer for hands-on work, such as a wooden or railing chute, or more commonly a crush (or handling cradle). Crushes are usually made of a padded vinyl holding area supported on a metal or wooden frame, and capture the animal by either dropping the floor or by moving one side of the crush towards the other using an hydraulic mechanism. Loading ramps for incoming and out-going stock are usually wooden. The lead-in area to deer yards usually provides visual barriers along fencelines that help the deer see and avoid the fence (Haigh & Hudson, 1993).

Transport

Techniques used for transporting deer were reviewed recently (Matthews, 2000). The industry's on-farm QA system extends to transport (as part of a pasture-to plate QA strategy). All accredited deer transporters use purpose-built deer crates, which are specifically designed to allow for freedom of movement, unimpeded flow of ventilation, ease of handling, security and safety for both the animals and their handlers (drivers). Ceilings are usually 1.8 - 2 m high but in many trucks this height can be varied according to the class of stock. Flooring in the crates must provide for safe and secure footing and allow for the drainage of effluent. Normal flooring is of 19 mm^2 woven mesh. Other surfaces that meet QA requirements can be approved. Maximum pen sizes have been established for the cartage of all deer on a loading density criteria based on deer being a liveweight of 100 kgs. The maximum number of deer per pen under this criteria is 8 (100 kg deer). However pens are normally designed for and used to carry 6 (100 kg) deer. Many new deer crates being commissioned recently have opted to install water sprinkler systems for use when deer become unsettled, which is normally attributed to overheating.

Slaughter

Deer slaughter plants (DSPs) vary greatly in scale and design, with some plants being purpose-built and others modified from facilities used to process other livestock. In the yard area, floors are made of concrete or wire mesh gratings. Walls, gates and handling races are variously constructed from solid or slatted wood, galvanised pipes and wire netting.

DSPs commonly have a lairage area where stock are held individually (if sent in alone, or detained for veterinary reasons) or in groups of up to about 20, with many plants avoiding mixing different lines of stock. Lairage usually begins in the afternoon, with the deer held overnight prior to slaughter in the morning. During lairage the deer are not fed but water is provided in corner recesses or rubber troughs attached to the wall.

Most plants spray the deer with overhead mist washes on arrival and thereafter for varying times. Mist washes are thought to settle and cool the deer. They also soften dirt, reduce dust and avoid a buildup of faeces on the floor. On the morning before slaughter, the deer are washed extensively using jets of water from underneath and various arrangements of side and overhead washing equipment.

For slaughter, individual deer are removed from a single file, and held briefly in an enclosed area before stunning with a captive bolt pistol. Electrical stimulation and bleeding out follow within 2 minutes of stunning.

3.2.5 Manipulations

Ear-tagging

Animal Health Board (AHB) regulations require that all farmed deer over the age of one month must be tagged if they are leaving the property. The exact tagging requirements differ depending on whether the animals are being moved for sale (or between farms) or for slaughter. Animals being moved for sale must have two tags:

1. A permanent primary tag, which is yellow plastic and has printed on it the AHB logo, the herd number, herd bar code and individual animal number.
2. A secondary tag of metal or plastic with the herd number and AHB logo.

Animals being moved for slaughter must have at least a primary tag (as above) or a special slaughter tag. Some owners also use a plastic or brass identification tag for their own purposes. Tags are usually applied with a specific applicator.

Velvet removal

There are two different reasons for removing antlers in velvet and methods can differ accordingly. For harvesting velvet for sale to premium markets, methods currently in use are chemical restraint with xylazine or mixtures of xylazine and fentanyl, carfentanyl or ketamine, or physical restraint in a pneumatic or mechanical cradle device, followed by analgesia with lignocaine administered in either a ring or nerve block fashion.

The second reason for velvet antler removal is to facilitate the safe transport and handling of year-old “spiker’ stags, prior to slaughter for venison. For this purpose an additional method of antler removal is also available. This uses a rubber ring, applied around the pedicle to produce analgesia, enabling velvet to be removed between 1 and 2 hours later.

In some cases the antlers are allowed to mature and strip to hard antler stage, and these are usually sawn off to reduce risk of injury between stags and to farm workers. There is no requirement for analgesia because the hard antler is not innervated. Some stags are allowed to remain in hard antler for show, demonstration or trophy hunting purposes. This requires a high level of management to minimise the risks to operators and other animals.

Animal health treatments

Most deer farmers maintain the health of their animals by implementing a variety of animal health measures, and these range from minimal *ad hoc* treatments to a fully integrated programme. Most farmers administer anthelmintic treatments in the form of oral drenches or “pour-ons” to young weaners periodically in their first year of life. Weaner deer may be vaccinated by subcutaneous injection against yersiniosis, clostridial diseases and leptospirosis, and adult hinds may receive an annual booster vaccination against clostridial diseases and leptospirosis. Trace element supplementation with copper, iodine and/or selenium may be given by oral drench, oral bolus, injection or pour-on treatments. Veterinary assistance may be required to treat other clinical diseases, misadventure or calving difficulties.

Chemical restraint

In addition to chemical restraint used for velveting, drugs may also be administered by veterinarians to allow animals to be examined, tested, sampled, treated or to facilitate reproductive manipulations.

Artificial reproductive techniques (ARTs)

A range of ARTs have been developed specifically for red deer/wapiti, either for implementation of genetic improvement programmes (e.g. semen collection, artificial insemination, multiple ovulation and embryo transfer) or for general herd management (e.g. pregnancy scanning and breeding season advancement).

Semen collection from elite sires is performed almost exclusively by electroejaculation (EE). Initially, rectal placement of probes and deployment of low amperage current through reproductive glands was performed only while stags/bulls were heavily sedated/anaesthetised. However, commercial operators now opt for EE of conscious animals physically restrained in a crush. Given the degree of involuntary muscle contraction generally induced by EE, some concerns have been raised as to the welfare of conscious stags/bulls. These concerns are often offset by the putative risks of chemical restraint of such valuable animals.

Artificial insemination (AI) is currently performed on 5,000-10,000 hinds/cows annually. Laparoscopic intrauterine AI, involving heavy sedation/anaesthetisation of females, has been almost completely replaced by less invasive techniques of transcervical AI. The latter technique requires special operator attributes (including very small hands to perform rectal palpation of uteri!) but is generally cheaper, faster and kinder to hinds/cows than laparoscopic techniques.

Multiple ovulation-embryo transfer (MOET) programmes are performed on 100-200 donors (elite hinds) and 500-1000 recipients (surrogates) annually. Embryo recovery from multiple-ovulated donors has generally been performed by laparotomy under general anaesthesia. However, some practitioners now employ non-surgical (transcervical) flushing techniques, eliminating some of the risks to valuable donors. However, there are increasing concerns that the techniques of repeatedly inducing multiple ovulation may be compromising the long-term fertility of donor hinds/cows (possibly an immunological response to repeated injections with exogenous gonadotrophin). Embryo transfer to recipient hinds is normally performed by “keyhole” (laparoscopy-assisted) surgery for direct placement of the embryo in the oviduct. Full anaesthesia of these (less valuable) hinds is a pre-requisite for such procedures.

Pregnancy diagnosis is currently performed annually for a relatively high proportion of hinds (probably 20-30%). This is invariably performed by rectal ultrasonography (within the first 80 days of conception) or flank ultrasonography (> 80 days from conception). Specialist operators service a wide range of clients within a geographical area. There are few welfare concerns about the scanning process (even rectal ultrasonography is relatively safe as long as hinds are physically restrained). However, the efficiency of some operators is questionable, as varying percentages of “scan negative” hinds presented for slaughter prove to be pregnant. The false negative rate has been particularly high (i.e. > 50%) for some operators working outside optimum scanning dates. There seems to be no regulation of operators in New Zealand.

Breeding season advancement can be achieved by a number of techniques, including melatonin treatment of both sexes and progesterone CIDR treatment of hinds before the onset of the natural breeding season. Issues of hind/calf welfare arising from aseasonal births have received little attention as few farmers have yet to instigate such breeding season advancement programmes within their herds. Issues around early calving relate to (i) lactogenesis in aseasonal hinds (i.e. ability to initiate lactation) and (2) survival of calves born in a thermally challenging environment (i.e. potential hypothermia of neonates).

Hybridisation

The hybridisation of red deer and wapiti is commonly practiced in New Zealand to generate fast growing hybrid offspring (mainly for venison production). The biological efficiency of the system is based on using a large terminal sire genotype (wapiti) over a small breeding unit dam (red deer) to produce a fast-growing offspring while minimising energy expenditure on the breeding herd. Welfare considerations of this system include:

1) consequences of sire effects on the birth weight of hybrid calves, leading to an increased incidence of dystocia (birthing difficulties).
2) additional energy drains on red hinds lactating to support the rapid growth of hybrid calves
3) recruitment of hybrid females into the national breeding herd, leading to increased energy expenditure on the reproductive herd, and putative consequences of lower reproductive performance of hybrid animals.

3.3 Future trends

Deer farm sizes are increasing rapidly in terms of both number of animals farmed and scale of operation. Consumer requirements for high standards of food safety, animal welfare and environmental care are stimulating the uptake of QA systems and stratification of production systems according to land use capabilities. There is also a challenge to provide continuity in venison supply. Organic venison production may gain momentum. Divergence of specialised systems will be assisted by genetic selection and crossbreeding to create suitable strains of deer and fine-tuning of husbandry techniques to maximise performance.

4. Current state of knowledge and its implementation

4.1 Past research on the welfare of red deer and wapiti

4.1.1 Pasture environments

Social conditions

The patterns of forced association and segregation on deer farms have not resulted in major problems from a management perspective (Moore *et al*., 1985). Nevertheless welfare problems have been indicated in instances of victimisation of individuals within stag and hind groups, and fence pacing of deer attempting to join others in adjacent paddocks (Moore *et al*., 1985). Observed patterns of attachment between some individuals and avoidance of social contact by others (Pollard & Littlejohn, 1999) have supported the possibility that certain conditions imposed by management, such as high stocking densities and segregation, can create aversive social conditions for individuals. Subordinate hinds suffered the most in a comparison of high (150 hinds/ha) and low (37 hinds/ha) stocking densities, in which social stress (increased vigilance and aggression), disruption of grazing patterns, and lower average growth rates were seen in the high density treatment (Blanc & Theriez, 1998). In a subsequent study of hinds and ewes confined together or separately, similar effects of space allowance were seen, and these were intensified in the mixed-species situation (Blanc *et al*., 1999).

Fence pacing activity increases during weaning, calving and mating (Moore *et al*., 1985). From a welfare perspective, social and/or physical conditions may be least suitable at those times. Research and recommendations concerning each of these periods are outlined below.

Weaning

Weaning calves at 3-4 months of age created stress, evident in poor post-weaning calf growth rates, pacing along fencelines, calling between the hind and calf, and impaired immunocompetence (Griffin *et al*., 1988; Pollard *et al*., 1992; Pollard and Littlejohn, 2000; Beatson *et al*., 2000a). Not only social stress but also nutritional stress was likely, as calves of this age were still highly dependent on their mothers' milk (Arman *et al*., 1974; Loudon *et al*., 1983; 1984).

Techniques to reduce weaning stress have been identified through experimentation and farmer innovation (summarised in Pollard, 2001a). These include confinement indoors for a few days, hand-feeding, weaning in good weather and providing shelter, minimising handling, using remote or adjacent paddocks for the separated hinds and calves, addition of unrelated adults to the calf group, gradual weaning by removing successive groups of hinds, maintaining social and environmental familiarity, and providing high quality familiar feed (Moore *et al*., 1985; Griffin *et al*., 1988; Pollard *et al*., 1992; Milne, 1993; Haigh *et al*., 1997; Church & Hudson, 1999; Beatson *et al*., 2000b; Pollard & Littlejohn, 2000). Delaying weaning until winter improved autumn-winter growth rates (Pollard *et al*., 2002) but no attempt to quantify welfare was made in that study.

Mating

Intense social interaction between stags occurs during the autumn rut. It was recommended that to minimise fighting, group size and stocking density be reduced to the lowest possible level in non-breeding stags, adjacent paddocks for breeding stags should be avoided, and only one breeding stag should be kept in paddocks less than one hectare in area (Moore *et al*., 1985). It was also suggested that particularly aggressive stags should be removed from groups, and that sufficient food in multiple sites should be provided to minimise competition (Suttie, 1985). Vegetative cover between paddocks containing rutting stags was considered to reduce antagonistic behaviour between them (Fullerton-Smith, 1996).

Calving

Recent estimates of mortality rates of calves during the perinatal period were 10% for offspring of adult hinds and 12% for offspring of 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; Pearse, unpublished data).

On intensive deer farms, hinds are often unable to express their natural tendency to isolate themselves from the herd to give birth, and vegetative cover normally sought by the pre-parturient hind and newborn is often absent. Lack of these features, and human presence, were considered to be factors underlying the fenceline pacing commonly seen in hinds during the 24 hours before giving birth (Cowie *et al.*, 1985; Pollard *et al.*, 1998). “Anxiety” created by the inability to locate an appropriate environment was suggested to contribute to dystocia (Asher and Pearse, 2002). Furthermore, fence pacing hinds were likely to encroach on the birth areas of others, leading to interference with parturition, bonding and suckling (Wass *et al*., in prep.). Some hinds have been observed to be intolerant of alien calves, attacking or even killing them (Kelly & Whateley, 1975; Harboard, 1999).

In newborn calves, absence of cover was thought to cause them to go through fences in search of hiding places (Moore *et al*., 1985; Fletcher, 2000). The importance of cover for young calves was highlighted in a deer farmer survey, in which 95% of respondents considered that cover aided calf survival (Pollard *et al*., in prep.).

Recommendations for improving farm environments for calving, based on research and farmer observations, have included 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, keeping yearling and adult hinds in separate groups, using calf-proof fences, eliminating hazards such as mud wallows, and providing cover for calves in the form of cut branches, weedy areas, allowing calves access to tree lanes, or temporarily fencing off a margin around the paddock that still allows access to fawns (Kelly & Whateley, 1975; Kelly & Drew, 1976; Cowie *et al*., 1985; Moore *et al*., 1985; Harboard, 1996; Pollard *et al*., 1998; Asher & Pearse, 2002; Pollard *et al*., in prep.).

Shade and shelter

In a survey of farmers, a strong belief in shelter being beneficial to the health of farmed deer was expressed (92% of respondents; Pollard, 2001b). Young deer calves were considered particularly likely to benefit from shelter as they were susceptible to chilling, due to relatively poor insulation of the coat, skin and subcutaneous fat in relation to other types of livestock (Moen, 1985; Webster, 1997). Consistent with this, a study of newly weaned calves showed that in poor weather, immunocompetence was suppressed (Griffin *et al*., 1988) and 78% of respondents in the farmer survey felt that growth of deer calves aged 3-12 months was enhanced by shelter (Pollard, 2001b). Furthermore, 80% of farmers believed that shelter reduced fenceline pacing, which is an indicator of welfare (as discussed in Section 4.1.8. The need for shelter may differ with the time of day, as rain was most likely to be associated with pacing behaviour when it occurred at dusk rather than at dawn or midday (Pollard & Littlejohn, 1999).

There is sparse information on the effects of shade, or cover for hiding, on the welfare of farmed deer. Shade is most critically needed in regions where deer are prone to facial eczema as affected deer become highly photosensitive. In the deer farmer survey, 78% of the respondents rated shade as beneficial to deer health, and respondents considered that adult deer (rather than juveniles aged three months or more) were particularly likely to seek shade (Pollard *et al*., in prep.). Sixty-nine percent of farmers believed that shade reduced fence pacing.

Cover for hiding or shade was thought by farmers to be very important at calving, with 95% of respondents to the deer farmer survey believing that this aided calf survival (Pollard *et* *al*., in prep.). Hodgetts *et al.,* (in prep.) showed that a high proportion of calves used artificial cover/shade/shelter (made from wind break), provided that cover was provided on two sides, or one side and the top. Information based on deer farmers' experience and previous literature on providing plants for shade, shelter and cover has been summarised (Pollard, 2001b). In adult hinds, visual cover in the form of wind-break and black plastic was thought to reduce aggression and reactivity to stimuli (Whittington & Chamove, 1995). Hermann (1991, cited in Matthews, 2000) showed a similar benefit of shelter but Hodgetts *et al.* (1998) found that cover did not have much beneficial effect in reducing reactivity.

Nutrition

Basic feed requirements for different stock classes have been outlined for red, wapiti and hybrid deer (Beatson *et al*., 2000b; Feist, 2000). There may be welfare advantages in providing dietary variety, such as mixtures of pasture species or tree leaves to browse through netting fences, as foraging has been shown to be an effective antidote to boredom in intensive production systems (Marsden and Wood-Gush, 1986; Beattie *et al*., 1995). Furthermore, it was shown that grasses were less preferred by deer than legumes and herbs (Hunt & Hay, 1992).

4.1.2 Indoor housing

In 1996, a paper on welfare issues arising from indoor housing was prepared for the Game Industry Board (GIB) (Matthews *et al*., 1996). Deer confined indoors are sheltered from the weather, but there is evidence that social conditions in particular can be aversive for housed deer. Housed deer have shown higher levels of aggression and skin damage between individuals than those confined in paddocks (Hamilton & Soanes, 1994; Walton, 1994; Matthews, 1995; Pollard & Littlejohn, 1998). In another study, confinement in isolation had the undesirable effects of reducing weight gain and general activity levels, and the calves made repeated attempts to view animals in neighbouring pens (Hanlon *et al*., 1997).

Space and group size were thought to be important determinants of the level of aggression in group housed deer (Hamilton & Soanes, 1994), although this effect was not observed in a comparison of red deer calves housed in groups of five at densities of 1.8 or 4.5 m^2 per head (Hanlon *et al*., 1994). The deer at the lower density spent more time lying than those at the higher density (Hanlon *et al*., 1994). In a different study, groups of nine hind calves were housed at 1.50, 2.25 or 3.00 m^2 per calf. The same trend for lying time to increase with space allowance was observed, and the deer with more space ate more and grew more rapidly (Milne, 1994). Group sizes of 18 gained more weight than larger or smaller groups (Milne, 1994), supporting casual observations that large group sizes should be avoided (Cutt, 1989; Pearse & Fennessy, 1989).

Within a group, the lightest (and presumably smallest) deer tended to receive the most aggression (Pollard & Littlejohn, 1998) and farmers have recommended grouping similar-sized individuals together (Walton 1994; Matthews 1995). Social mixing of housed deer was associated with increased aggression and physiological indicators of stress (Hanlon *et al*., 1995), and it was recommended that once groups were established, they were best left intact (Pearse & Fennessy, 1989).

Housing with concentrate feeding limits the amount of time the deer can spend foraging. Ample roughage (such as hay) was required to reduce chewing of non-food items (such as the walls of the pen; Pollard & Littlejohn, 1998). It was recommended that care was taken to adapt the deer gradually to the diet to be fed indoors (Suttie *et al*., 1996), and it was considered necessary to maintain a high level of fibre in the diet to allow the animals' digestive systems to function normally (Jones, 1990). According to Suttie *et al*. (1996), sufficient trough space was required to allow all of the deer to feed at once, regardless of whether the deer were on restricted or *ad libitum* diets.

A further welfare concern is the limitation on locomotory behaviour. High levels of activity occurred whenever housed deer were temporarily allowed more space (interestingly, daily exercise resulted in slightly higher weight gains during winter confinement; Pollard & Littlejohn, 1998). Depending on specific husbandry practices, additional welfare concerns for housed deer include high ammonia levels, lack of clean dry resting areas, enforced light/dark conditions, boredom and lack of access to drinkable water. Many welfare concerns might be overcome by housing in a barn with an outdoor fenced area so that the deer had access to both indoors and outdoors (Suttie *et al*., 1996).

4.1.3 Yarding

Responses of deer to yarding were reviewed by Matthews *et al*. (2000). The mere presence of handling facilities has been shown to unsettle deer (Diverio *et al*., 1993; Pollard *et al*., 1998). Moving the deer into handling facilities was shown to increase heart rate, stress and muscle damage indicators, as well as unsettled behaviour following release back to pasture (Diverio *et al*., 1993; 1996; Carragher *et al*., 1997).

Mustering stags into yards had the obvious effect of reducing individual distances below those found at pasture, and increased the frequency of aggressive interactions (Pollard & Littlejohn, 1999). The frequency and type of aggressive activities, and effect of pen size on the level of aggression, varied between seasons (Pollard & Littlejohn, 1996). Short-term confinement, especially in the small pens, seemed aversive as the deer paced and made repetitive up-and-down head movements along the walls of the pen (Pollard & Littlejohn, 1996).

Darkening unfamiliar pens was thought to reduce the aversiveness of yarding, as deer in darkened pens grouped together less and showed less reaction to human presence, compared with deer in well lit pens (Pollard & Littlejohn, 1994). Deer also showed a preference for dim lighting over bright lighting (Pollard & Littlejohn, 1995a). Sound-deadening features were thought to be desirable in handling facilities, as noises from slamming doors and banging walls elevated the heart rates of deer in yards (Price *et al*., 1993).

A study on social conditions during yard confinement showed that deer in small groups stayed closer to an adjacent pen when it contained unfamiliar deer than when it was empty (Abeyesinghe & Goddard, 1998). Other studies showed that both social isolation and mixing with unfamiliar deer were aversive (based on measurements of heart rate, pacing and head movements) and that mixing lead to increased aggression (Pollard *et al*., 1993; Price *et al*., 1993).

Human presence was avoided during yard confinement, indicating that this probably added to the aversiveness of the environment (Pollard *et al*., 1991; 1995b; Pollard & Littlejohn, 1994). Other indications that human presence was aversive were increases in heart rates of deer approached by a person (Price *et al*., 1993), and the greater stress responses seen in deer that underwent mustering into yards plus drafting, compared with deer mustered into yards only (Carragher *et al*., 1997).

The effects of race width (0.5m or 1.5m), shape (straight or curved) and lighting (bright or dim) on the ease of movement of deer have been studied (Grigor *et al*., 1997). The deer entered curved or wide races more readily than straight or narrow races, and moved faster down the wide races than the narrow ones. Lighting was not found to affect the movement of the deer (Grigor *et al*., 1997).

4.1.4 Withdrawal of feed and water

Under pasture conditions (where herbage provided up to 60% of water intake), deer drank 2-4 litres of water per day (Barrell & Topp, 1989; Alexander & Segiura, 1990). In deer experimentally deprived of feed and water for 2 or 20 hours, 75% of the 2 hour deprived deer, and all but one of the 20 hour group drank in a further 6 hour observation period in a pen with an unfamiliar trough. Most of the drinking was done in the 2 hours following the deprivation period, and it was concluded that water should be provided in lairage (Hargreaves & Matthews, 1995).

A study in which feed and water were withheld from deer for either 3 or 6 hours showed no significant increase in feeding or drinking in a subsequent recovery period, possibly because the rumen provided a reservoir of food and water that reduced the effects of short-term deprivation (Grigor *et al*., 1997a). Nevertheless, deer in held in lairage with straw or hay, following three hours' transportation, started to eat within a further period of three hours (Grigor *et al*., 1997b). Observations of red x wapiti hybrid bulls in lairage indicated that they lost about 80% of their gut contents in 16 hours (K. Drew, pers. comm.).

4.1.5 Transport

Research on transport of deer, with particular reference to red deer, was reviewed recently (Matthews, 2000; Weeks, 2000). As with most farmed species, transport has been demonstrated to decrease liveweight and increase levels of physiological stress indicators in deer (Waas *et al*., 1997; Grigor *et al*., 1998a). Nevertheless, according to Weeks (2000), experimental studies on group size, stocking density, road conditions and duration of transport (Jago *et al*., 1993; Matthews *et al*., 1995; Jago *et al.,* 1997; Waas *et al*., 1997; Grigor *et al*., 1998b) indicated that deer travelled well with few welfare problems, provided current guidelines (NAWAC and GIB) were followed, care was taken on winding roads, and pen size allowed the animals to orientate to the direction of travel.

Increasing journey time increased liveweight loss (Grigor *et al*., 1998a), bruising (Jago *et al*., 1996), muscle damage indicators (Jago *et al*., 1997), cortisol (indicative of stress) and sodium levels (indicative of dehydration; Waas *et al*., 1999). The frequency of bruising also varied between deer carriers (Jago *et al*., 1993; Pollard *et al*., 1999).

Concern was raised in the review by Weeks (2000) that thermal conditions during summer transport of deer were largely unknown, and that the experimental studies on which recommendations were based and assessed may not have simulated commercial conditions adequately. Some knowledge on thermal conditions during transport was gained in a study of 15 red deer hinds transported during summer when the mean temperature at pasture was 25 ^{o}C and mean relative humidity was 60% (Matthews *et al*., 1996). On most days temperature and humidity inside the transport crate during transport were higher than ambient conditions, and rear pens were hotter than front pens. Individual deer varied in their responses to transport, but in general handling and loading were associated with an increase in body temperature. Few animals showed signs of heat stress, but there were indications that spraying the pens with water might reduce body temperature in such individuals (Matthews *et al*., 1996). An additional welfare concern arising from transport was excessive wear on the soles of the feet, arising from abrasive surfaces and/or excessive movement or pushing of the deer (Wilcockson, 1986).

Casual observations indicated that deer that were held in yards overnight (with access to water) were more settled during loading and transport than those mustered just prior to transport (J. Tacon, pers. com.). However this effect was not observed in an experimental situation (Grigor *et al*., 1998c). Similarly, providing subdued lighting (taking care to avoid creating shadows that can cause stock to balk) inside the trailer was thought to improve the ease of loading (J. Tacon, pers. com.) but this effect was not observed when tested experimentally (Grigor *et al*., 1998c). Differences between simulated and commercial conditions, and the relatively small number of stock observed during experiments compared with commercial experience, could account for this disparity. Physiological indicators of stress increased during loading, and to a lesser extent unloading, then recovered to near basal values soon after unloading (Waas *et al*., 1999).

4.1.6 Slaughter

Pre-slaughter handling involves multiple stressors including human presence, transport, fasting, dehydration, close confinement, novel environments and lack of rest. Studies on deer have shown that, similar to other livestock, pre-slaughter handling depleted muscle glycogen reserves, resulting in increased muscle pH at 24 hours post-slaughter (pH_u; Kay *et al*., 1981; MacDougall *et al*., 1979; Smith & Dobson, 1990).

A survey carried out in 1988-1989 in three New Zealand DSPs found that wounds, bruises and related lesions were a major cause of downgrading (Selywn & Hathaway, 1990). Subsequently a study at one DSP found that 7% of carcasses were downgraded for bruising, and seasonal effects on bruising were apparent, with a peak in October (Jago & Matthews, 1993; Jago *et al*., 1996). Bruising was negatively related to hot carcass weight and GR measurement, and varied according to the sex of the deer (Jago *et al*., 1996).

In a further study, in 3856 deer killed at an Otago DSP, 19% of carcasses had shoulder muscles with pH_u values >/= 5.8, the level at which deleterious effects on meat quality arise (Pollard *et al*., 1999). In that study, bruising (including minor bruises) was recorded in 24% of carcasses, a high level of fighting during lairage was observed, and unsettled behaviour occurred in the final handling race before slaughter (for instance, 17% of deer reared up on their hind legs in this race). It was concluded that advances could be made to improve welfare in slaughtered deer. Effects of farm of origin and transporter on the variables measured indicated that improvements could be made during these phases, as well as in the DSP (Pollard *et al*., 1999).

A subsequent experiment at the same Otago DSP, comparing the physiology of paddock-shot and DSP-killed red deer, concluded that pre-slaughter handling created at least moderate stress and a high level of muscular exertion or damage (Pollard *et al*., 2002). Ecchymosis (due to ruptured blood vessels) in slaughtered deer may also indicate that they undergo stress before slaughter (Wilson, 1999). A further indication of welfare problems during the pre-slaughter period was the high frequency of recent damage to hides, that was considered to occur during transport and/or lairage (Dickson, 1993; Baird & Walton, 2001).

The lairage component of pre-slaughter handling has been investigated in several studies, with mixed results. Jago *et al* (1993) found a greater frequency of bruising in deer held overnight than in those slaughtered on the day of arrival, but in the latter deer (which were held for a short time only: mean = 16, SE 1.9 minutes) there was a negative relationship between lairage time, and plasma glucose and carcass pH, suggestive of recovery from the effects of transport. Grigor *et al.* (1997) studied deer held in lairage with hay, water and straw bedding, for 0, 3, 6 or 18 hours. In that study there was an increase in antagonistic behaviour and a decrease in liveweight over 18 hours of lairage, but an increase in liver glycogen and a decrease in plasma creatine kinase activity indicating recovery from transport. The lowest pH values were seen in the deer held for 6 hours. It was concluded that because behaviour was unsettled, the deer should be slaughtered as soon as possible after arriving at the plant (Grigor *et al*., 1997). Experimental work reported in confidential documents to the GIB made similar conclusions (Matthews *et al*., 1994a; 1994b; 1996). On the basis of physiological stress indicators and unsettled behaviour it was recommended that lairage time should be minimised, disturbance of the lairage pens should be minimised, and that a lower density (0.7 deer/ m2) was preferable to a higher density (1.46 m2) of deer in lairage pens (Matthews *et al*., 1994a; 1994b; 1996). A further study on lairage indicated that keeping deer in a pen adjacent to other species (cattle and pigs) had an unsettling effect (Abeyesinghe *et al*., 1997).

In the early days of the deer industry, a mobile slaughter plant was trialed (Yerex, 1979) but proved economically impractical (Seamer, 1986). Such a plant would have reduced pre-slaughter handling markedly. More recently, mobile plants for deer have operated in Canada (Diversified Animal Management, 1997), and the UK (Anon, 1993). A different approach to reducing pre-slaughter stress was the provision of electrolytes, which appeared to improve carcass yield and reduce a stress-related elevation in temperature in farmed wapiti (Renecker *et al*., 1995).

The welfare of deer subjected to head-only electrical stunning at slaughter has been investigated. It was concluded that provided the heads of the deer were adequately restrained, head-only stunning could be incorporated into a humane method of slaughter for deer (Blackmore *et al*., 1993).

4.1.7 Physical manipulations

Physical restraint

The topic of physical restraint of deer was reviewed recently (Matthews, 2000). Restraint is normally accompanied by the additional stressors of yarding, human presence and social isolation. Studies have shown that restraint is a stressful experience in itself. Crush restraint for 2 minutes in a drop-floor crush was shown to create greater perturbations in physiology and behaviour than just yarding or drafting (Carragher *et al*., 1997). In a different approach using preference testing, brief (5 seconds) restraint in a drop-floor crush was demonstrated to be more aversive than just walking through the same type of crush (Pollard *et al*., 1994). In a comparison of several treatments (restraint alone in a crush, individual transport, human proximity and visual isolation) deer were slowest to enter a raceway down which they were treated with restraint or individual transport (Grigor *et al*., 1998). Darkness during crush restraint appeared to be effective in reducing stress as heart rates were lower compared with restraint under brightly lit conditions (Pollard & Littlejohn, 1995).

Electrical restraint

Head-to-tail electroimmobilisation was assessed in red and red x wapiti hybrid deer and concluded to be stressful, as indicated by open-mouth breathing following treatment, and probably painful, as indicated by vocalisation during treatment (Stafford & Mesken, 1992).

Chemical restraint

In an evaluation of chemical restraint techniques used for deer, it was concluded that neither xylazine or Fentazin provided sufficient analgesia for potentially painful techniques (such as velveting) to be carried out, therefore local anaesthetic was also required (Wilson *et al*., 1993, Wilson *et al.,* 1996a; b). In contrast, carfentanyl was stated to provide good analgesia (Key, 1995). A comparison of the physiological stress responses to chemical (xylazine) and physical restraint was confounded by possible physiological effects of xylazine (Matthews *et al*., 1990).

Ear-tagging

In the only study of ear-tagging in deer to date, three yearlings were tagged under mechanical restraint. Their behavioural reaction was rated as "strong" and heart rate was elevated (Matthews & Cook, 1991).

Velvet removal

Many studies have been carried out on the welfare of stags during velvet removal. During the early 1990's evidence emerged that that the technique of restraining stags mechanically and applying local anaesthetic as a ring or regional nerve block did not always provide full analgesia for antler removal or following velveting. Lack of adequate analgesia was evident in struggling and increased heart rates during velveting (Matthews & Cook, 1991; Matthews *et al*., 1992; Pollard *et al*., 1992), and aversion to the procedure was evident in an increase in the heart rate of velveted stags when they were re-exposed to the treatment area on the following day (Pollard *et al*., 1992). Behaviour at pasture following velveting differed from control deer that were mechanically restrained only (Pollard *et al*., 1992).

More recently, analgesic techniques and the time required for the anaesthetic to become effective were examined, and it was recommended that a high-dose (1 ml lignocaine hydrochloride per cm of pedicle circumference) ring block with a two minute wait produced the most effective and rapid analgesia, although the occasional stag still responded to antler cutting using this technique (Wilson *et al*., 1999; Wilson *et al*., 2000). Unexpectedly high levels of response to analgesic tests have sometimes occurred following high doses of local anaesthetic administration (Matthews *et al*., 2001). On-going work in this area has included a study on stress responses to velvet antler removal in elk (Cook & Schaefer, 2002) and further refinement of techniques for application of anaesthetic (Bartels *et al*., 2001).

Because of concerns about chemical residues in velvet, electroanaesthesia has been evaluated as an alternative to local anaesthetic, but studies concluded that this technique was less effective in achieving analgesia (Matthews *et al*., 1999a; Matthews & Suttie, 2001; Woodbury *et al*., 2001). A technique that uses high pressure compression around the pedicle to achieve a nerve block of the antler has been investigated recently and results are promising (Matthews & Suttie, 2001; Cook *et al*., in prep.; Matthews *et al*., in prep.).

Since 1996, many studies have been carried out by the Animal Behaviour and Welfare Research Centre on techniques for providing analgesia, with the results presented in confidential reports (Matthews & Carragher, 1996; Matthews & Bagshaw, 1997; Matthews, 1998; Matthews *et al*., 1998; Morrow & Matthews, 1998; Matthews, 1999; Matthews & Morrow, 1999; Matthews & Pearse, 1999; Matthews *et al*., 1999b; 1999c; 1999d; Matthews & Pearse 2000; Matthews *et al*., 2000a; 2000b; Matthews *et al*., 2001).

Disbudding of red deer calves as an alternative to velveting has been investigated. The operation was carried out using a standard cattle disbudding iron, under mechanical restraint and local anaesthesia, and successfully prevented antler growth while not impairing liveweight gain to slaughter age (Hamilton *et al*., 1993). However in a study carried out in New Zealand, disbudding did not prevent antler growth (Carragher *et al*., 1995).

Concerns have been raised that questionable techniques were sometimes used to remove antlers in venison stags. Observations at slaughter plants indicated welfare problems due to inadequate analgesic techniques, polling, tourniquets being left on, injection site lesions, poor hygiene leading to infection, and skull injuries apparently due to the forceful removal of hard antler (Killorn, 1993).

4.1.8 Measurement of stress

Physiology

The usefulness of eleven blood hormones and metabolites for quantifying handling stress in deer were reviewed recently (Pollard *et al*., 2000; 2002). Plasma cortisol has been extensively used and the time course of elevations and clearance in response to stress has been tracked (Ingram *et al*., 1994; Carragher *et al*., 1997; Ingram *et al*., 1999), although variation in baseline levels and between individuals, sexes and animal backgrounds have been observed (Pollard *et al*., 2000). Lactate, packed cell volume (PCV) and enzymes indicative of muscle damage (creatine kinase, lactate dehydrogenase and aspartate aminotransferase) have also been reasonably well studied and appeared useful in quantifying handling stress, although lactate and PCV were less useful for quantifying handling stress in slaughtered deer as levels were probably elevated by stunning or slaughter (Pollard *et al*., 2000). Difficulties with either insufficient knowledge of background physiology or confounding influences (especially nutrition) were considered problematical with using glucose, progesterone, protein, albumin and creatinine to quantify handling stress (Pollard *et al*., 2000). The development of remote blood sampling techniques has allowed quantification of responses to various procedures without confounding effects of handling and restraint for sampling (Ingram *et al*., 1994; 1997; 1999; Carragher *et al*., 1997; Ferre *et al*., 1998). Non-invasive assessment of cortisol responses to stress has also been carried out using cortisol metabolite levels in faeces (Berger *et al*., 1998)

Heart rate has been used in many studies to quantify acute handling stress in deer, and has the advantages of being relatively non-invasive and able to be monitored remotely (Gedir, 2001). A difficulty with this measure is the confounding effect of muscular activity on any psychological responses to stress (deer often increase their activity levels when exposed to a stressor). An attempt to circumvent this problem was made by Price *et al*. (1993) who estimated the elevation in heart rate associated with various levels of activity.

A further non-invasive technique for assessing stress that has been investigated is infrared thermography (IRT). Wapiti that were assessed using IRT as having higher temperatures prior to slaughter had higher muscle pH at 24 hours post-slaughter (Renecker *et al*., 1995).

Effects of acute stress on immunocompetence have been studied in deer (Griffin *et al*., 1992). The research showed that the level of stress (simulated by injections of ATCH, adrenocorticotrophic hormone) and the temperament of the animal (aggressive or placid) interacted to either inhibit or enhance immunologic function.

For assessing chronic stress, such as long-term confinement indoors, possible effects on cortisol regulation have been investigated using ACTH tests (Goddard *et al*., 1994; Hanlon *et al*., 1997; Ingram *et al*., 1996; Pollard & Littlejohn, 1998; Ingram *et al*., 1999). Interpretation of findings has proven difficult, leading to the suggestion that this test would need to be combined with other physiological and behavioural measures to be useful (Goddard *et al*., 1994). Nevertheless the use of remote infusion and blood sampling technology has advanced knowledge of patterns in cortisol secretion and responsiveness to ACTH, opening the way for further investigation of chronic stress using this technique (Ingram *et al*., 1996; 1999). Chronic stress in deer has also been evaluated using measures of the immune system, in particular antibody and cellular immune responses to novel antigens (Griffin *et al*., 1988; Hanlon *et al*., 1997). The combined stressors of transport, fasting and relocation increased susceptibility to disease, and reduced specific antibody production and non-specific mitogenic activity (Griffin *et al*., 1992).

Behaviour

Three main techniques have been used to assess stress and aversiveness of procedures and environments in deer: observations of activities, preference testing and aversion testing. Disruptions in normal activity cycles, inter-animal distances, and specific activities such as aggression and pacing along fencelines have been used to assess the degree to which handling treatments or environments have affected the deer (e.g. Matthews *et al*., 1990; Pollard *et al*., 1992; Diverio, 1993; Berger *et al*., 1998; Blanc & Theriez, 1998).

Stereotyped pacing along fencelines (or enclosure walls) has been observed in a wide variety of situations and probably reflects motivation to escape from something aversive or gain access to something lacking (Moore *et al*., 1985). Stereotyped pacing behaviour has long been considered to be an indicator of an inadequate environment (Hediger, 1964). Play behaviour, as an indicator of good welfare, was used in one study (Pollard *et al*., 1993).

For assessment of analgesia in restrained deer prior to and during velvet removal, assessments of avoidance behaviour during electrical stimulation or cutting of the antler have been used (Matthews *et al*., 1992; Wilson *et al*., 1999; 2000). Such behaviour has been quantified by reference to a scale developed with repeatable aversive stimuli (Matthews *et al.* 1992) or with pressure recorders (Thierman *et al*., 1999).

The animals' own choice of environments and handling treatments has been assessed using preference testing. In a y-maze, deer rapidly learnt the consequences of entering left or right handling races and showed a consistent preference for the least intensive treatment (Pollard *et al*., 1994). Preferences for dark over light conditions (Pollard & Littlejohn, 1994) as well as for specific social environments (Abeyesinghe & Goddard, 1998) have also been measured by allowing the deer free choice in a pen that offered a gradient between contrasting treatments.

Aversion testing (in which the time taken for deer to move down a raceway into a treatment area was recorded) was used in assessments of velvet removal (Pollard *et al*., 1992) and electroimmobilisation (Stafford & Mesken, 1992). However results were not consistent with other indications of aversiveness and it was concluded that this type of testing may not be suitable for use with deer. More recently the time taken to *re-enter* a race preceding a treatment area differed between a range of treatments and it was thought that this measure allowed an effective measure of the relative aversiveness of the treatments (Grigor *et al*., 1998).

4.2 Past research on the welfare of farmed fallow deer

Comments on suitable physical environments for farmed fallow deer in Canada were made by Burton (1993), who considered that they were highly reactive to stimuli and found changes in their environment (such as a new paddock) stressful. According to Burton (1993) they had a high requirement for shade in summer, and protection from winter cold, rain and snow, and readily used artificial shelter after an initial period of avoidance.

Aspects of the social behaviour of fallow deer were studied using 110 does and bucks in a 3.5 ha enclosure during fawning (Mattiello *et al*., 1997). Does and bucks tended to use different areas of the enclosure, possibly due to different food preferences, although mixed-sex groups were observed at times. Does with fawns showed a strong preference for an area furthest from human activities (Mattiello *et al*., 1997). Bucks have been observed to be highly aggressive towards other deer at pasture, and it was thought that a high stocking rate and lack of size differentiation within the group were contributing factors (Asher, 1986).

Experience with fallow deer showed that they required very careful, slow handling as they were highly strung and readily panicked. Yard walls needed to be higher 2.3 m, handling pens darkened, and sources of light covered to prevent the deer jumping at them (Moore *et al*., 1985; Vigh-Larsen, 1988). Movement of the deer from one area to another was facilitated by providing lighting in the direction of movement (Vigh-Larsen, 1988).

A tendency for aggressive behaviour in bucks has lead to the practice of polling, particularly for future sire animals (Asher, 1986). A different method of controlling antler growth is the application of tight rubber rings around the pedicles. Deer treated with rubber rings showed behavioural responses for six hours following treatment, and some in some bucks the antlers remained on the deer or regrew (Weilburg, 1996). Castration has also been used as a means of improving the manageability of bucks (Mulley & English, 1991). Entire animals were particularly difficult to handle during the breeding season and extreme bruising damage was observed in those commercially slaughtered at this time (Mulley & English, 1991).

Responses of fallow deer to handling have been investigated in a few studies. Levels of LDH and its skeletal-derived isoenzyme LDH-5 were studied in park deer that were driven by a line of people then captured in nets. LDH-5 was correlated with the duration of the driving period, but not with plasma cortisol, and it was considered that LDH-5 was a useful indicator of acute to medium term stress (Jones & Price, 1992). In a different study, levels of plasma catecholamines, cortisol and progesterone were measured during restraint of does and fawns (von Borell & Fisher, 1998). There were indications that manual restraint created more stress than mechanical restraint, and of a positive relationship between catecholamine levels and behavioural responses (struggling and vocalising) during restraint (von Borell & Fisher, 1998).

Pre-slaughter stress was investigated in fallow deer either shot at pasture, transported in small groups in wooden boxes and left overnight until shooting, or transported and held in lairage with food and water then moved to a slaughter area and shot. A range of physiological stress indicators was measured and it was concluded that field slaughter was the least stressful treatment (despite those in the field trotting or running prior to being killed) (Diverio *et al*., 1998). In a different study of physiological stress indicators at slaughter, there was evidence of a greater response to four hours of transport compared with two hours, despite a subsequent period of 36 hours in lairage (Diverio *et al*., 1998). In a New Zealand study, a small number of fallow deer killed at a commercial plant in Otago showed very high levels of movement during lairage, and mean pH_u level of the carcasses was high (5.89) (Pollard *et al*., 1999).

4.3 QA systems and welfare codes in NZ

4.3.1 Relevant welfare codes and their status

Codes of recommendations and minimum standards for the welfare of animals, and guidelines for the welfare of animals were previously prepared under the Animals Protection Act 1960, and are voluntary with no legal status. The Animals Protection Act 1960 was replaced by the Animal Welfare Act 1999. All voluntary codes will gradually be reviewed and replaced by new codes of welfare issued under the Animal Welfare Act, which will have legal status.

The following codes and guidelines pertaining to deer were endorsed by the Animal Welfare Advisory Committee (AWAC, now NAWAC, the National Animal Welfare Advisory Committee).

Guidelines for the Welfare of Yearling Fallow Deer During the Use of Rubber Rings to prevent Antler/Pedicle Growth.

Guidelines for the Welfare of Red and Wapiti Yearling Stags During the Use of Rubber Rings to Induce Analgesia for the Removal of Spiker Velvet.

Code of Recommendations and Minimum Standards for the Welfare of Deer During the Removal of Antlers.

The GIB has begun to draft a code of welfare for deer. The writing group is chaired by John Tacon. There are also general codes concerning the welfare of animals during transport, sale, slaughter and the use of animals in research, testing and teaching that are relevant to deer. These are:

Code of Recommendations and Minimum Standards for the Welfare of Animals at the Time of Slaughter at Licensed and Approved Premises.

Code of Recommendations and Minimum Standards for the Emergency Slaughter of Farm Livestock.

Code of Recommendations and Minimum Standards for the Welfare of Animals at Saleyards.

Code of Recommendations and Minimum Standards for the Welfare of Animals Transported Within New Zealand. (A new code has been drafted but put aside due to other codes being given higher priority.)

Code of Recommendations and Minimum Standards for the Care and Use of Animals for Scientific Purposes.

4.3.2 Quality Assurance systems

The New Zealand deer industry has developed a set of QA programmes, initiated by the Game Industry Board, that cover all phases of production of venison and velvet. These programmes are as follow (from Loza, 2002).

DeerQA On-Farm: covering standards relating to facilities, animal health, animal welfare, food safety, recording systems, and farm and animal management.

DeerQA Transport: covering standards relating to the design of transport equipment, documented procedures, driver training and animal handling and welfare.

DeerQA Sale yards: covering standards relating to facilities, procedures and animal handling and welfare.

DeerQA Stock and Station Agents: covering standards relating to industry and product knowledge and animal handling and welfare.

National Velveting Standards Body ("NVSB") Velvet Removal Programme: an Approved Programme under New Zealand animal welfare and animal remedies legislation covering farmer training and accreditation for velvet removal techniques, veterinarian supervision and the facilities required.

DeerQA Venison Processors: covering standards relating to food safety, documented procedures, animal handling and welfare, product specifications, packaging and environmental issues.

Two quality marks are currently used in the New Zealand Deer Industry. One is *Zeal*®, which is used on venison products conforming to the DeerQA Venison Processors Standard. The Zeal quality mark is also the quality standard to which Cervena® products must comply, and appears on Cervena® packaging. (The differences between these two marks is that an animal age of 3 years or less is a requirement for Cervena®, and that processors and exporters of Cervena® are franchise holders of the Cervena® appellation and its product standards.)

Individual companies have recently developed their own extensions to the on-farm codes of practice and some product specifications. This is in response to their individual customers' marketing specifications. For example there are marketing groups in the United Kingdom that will not market product from stags if velveting has been involved.

The incentive for producers to enrol in an additional company QA system is both financial (with good incentives) and access to contracted slaughter supply that suits the farming property. The customers often have very specific requirements of animal welfare, appropriate health treatments and management systems on farm. These within-house schemes use third-party audit and personalised communication with their farmers to develop constant improvement, excellent and auditable record-keeping and long-term relationships.

The second quality mark is *New Zealand Deer Velvet*™, which is used on velvet products that meet industry agreed standards, including being sourced from a DeerQA accredited farm (or equivalent programme), removed under the NVSB Velvet Removal Programme, and processed in Ministry of Agriculture licensed and inspected premises.

4.3.3 Uptake of QA systems by farmers, transport operators and meat processors

There has been substantial uptake of The DeerQA On-Farm programme. Five processing/venison export companies have adopted the DeerQA On-Farm operating standards as a minimum requirement to their own QA programmes. With incentives being offered to deer farmers to become accredited to these company programmes, the total number of QA accredited deer farms is now well over 50% of the national total (J. Tacon, pers. com.).

A total of 128 transport companies are currently accredited to the DeerQA transport programme. These companies range from one man, one truck organisations through to some of the biggest transport companies in New Zealand. Only accredited transport operators are eligible to carry deer to most processing plants. To qualify for accreditation, companies must have approved deer crates (crates that meet the operating standards), approved drivers (drivers who have attended and passed the industry training programme, which includes a written test) and also have documented procedures in place to show how the company meets the criteria required. These procedures are also required for any audit purposes. Over 600 drivers have passed through the training course since the DeerQA programme was implemented. Training courses are held throughout the country for new and existing drivers on an as-required basis.

The stock agents' DeerQA programme is based on the transport training programme and covers industry requirements as well as animal welfare issues, farmers' needs, transport needs, processor needs, documentation and marketing issues. Stock & Station companies also have their own procedure manuals for their operations.
This programme requires all participants to undergo a pass in a written test to become accredited stock agents within the DeerQA programme. All of the major Stock & Station companies in New Zealand have become accredited to this programme and training courses for new agents are regularly held in various locations throughout the country.

4.4 Current research programmes

Research and personnel addressing deer welfare topics, within AgResearch, other institutions in New Zealand, and internationally are listed in Table 1.

Table 1: Current deer welfare research programmes in New Zealand and internationally

Institution	Research providers	Topic
AgResearch (AgSystems)	G. Asher J. Pollard T. Pearse	Calving and mating management
AgResearch (AgSystems, Food Systems and Technology)	J. Pollard J. Stevenson-Barry	Factors affecting behaviour, bruising and pH in deer at slaughter
AgResearch (Nutrition and Behaviour, AgSystems)	J. Webster L. Matthews T. Pearse	Non-chemical techniques for velvet removal
Massy University: Institute of Veterinary Animal and Biomedical Sciences, and Centre for Animal Welfare Science and Bioethics	P. Wilson K. Stafford D. Mellor	Analgesia for velveting
Macaulay Land Use Institute, Aberdeen	I. Gordon A. Duncan G. Lason A. Sibbald	Deer grazing management, dietary preferences and habitat assessment
Dept. Zoology, University College, Dublin	T. Hayden	Evolution and ecology of deer
Agriculture and Agrifoods, Canada	A. Schaefer N. Cook	Non-chemical techniques for velvet removal, pre-and post-velveting analgesia, reducing velveting stress, pre-slaughter handling, meat quality
University of Saskatoon, Canada	M. Woodbury N. Caulkett	Analgesia for velveting
Halle University, Germany	E. Borell	Stress assessment and behaviour management
Institut National de la Recherche Agronomique Clermont-Ferrand, France	A. Brelurut M. Dehnhard J. Streich M. Rohleder	Social stress

4.5 Gaps in knowledge

4.5.1 Social and physical environments

Social environments

Work on social environments has invariably concluded that to minimise problems, especially at calving, mating and during indoor wintering, stocking density should be minimised. This is impractical on intensive deer farms. There are some indications that one means of reducing social stress is to provide visual cover. More information on this technique and other means of reducing social stress (for instance by increasing opportunities to forage) in intensive situations is required.

The trend towards increasing mob sizes in some operations has unknown consequences for welfare and productivity. Information on desirable mob sizes and stocking densities and their interaction is required. A related issue is the number and placement of fences on deer farms (a relevant observation is that territories of wild deer end in open areas between topographical features (Darling, 1937)).

Few studies have addressed the consequences of social perturbations such as dividing hind groups up for calving, although it is considered that this creates stress. There is no information on systems that minimise mixing and dividing of social groups, including avoiding separating offspring from mothers (for instance a few farmers don't wean, or only wean male calves).

One technique of overcoming social stress in deer may be to selectively breed strains that are amenable to intensive farming. This would require definition or identification of the characteristics that constitute amenability. The heritability of such characteristics (for instance the propensity to pace fencelines) is unknown.

Physical environments

There is very little information on the welfare consequences of not providing shelter from cold, wet, windy conditions (especially on muddy substrates when conductive losses into the ground would be substantial), hot, dry conditions, or hot, humid conditions. There is also no information on the welfare benefits (such as in thermoregulation or parasite control) of wallowing. While it has been recognised by farmers that cover improves calf survival, the best techniques for providing this have not been identified (for instance a strip of long vegetation around paddock margins may provide cover but increase entanglement in fences).

Indoor wintering environments may create severe welfare problems, if mismanaged, through social stress, ammonia levels, buildup of faeces, lack of exercise, boredom and disease. However indoor systems provide good shelter from winter weather. Alternative systems such as the provision of good shelter and an exercise area have not been investigated.

Studies of yarding and handling have concluded that any form of human intervention is stressful. Therefore options to improve welfare include minimising handling (as in extensive production systems); altering the animals' responses through habituation to handling, taming of young stock or selection for amenability to intensive systems; and providing training and guidelines to handlers on appropriate techniques for handling deer. Attempts to reliably quantify desirable qualities such as lack of fear of humans or novelty have been made (Pollard *et al*., 1994; Pollard & Littlejohn, 1995). Further work in this area is required followed by evaluation of taming procedures and/or heritability of desirable traits. Techniques likely to reduce the stressfulness of handling, such as eliminating noise and allowing visibility between animals, and the influence of handler behaviour on the responses of the deer, need quantifying so that recommendations to farmers are soundly based.

There is good evidence, from studies of bruising, skin damage, behaviour, physiology and muscle pH that deer experience substantial stress before slaughter. The evidence shows that stress occurs at all phases of pre-slaughter handling. Components of each of these phases need to be examined to determine where improvements can be made. Minimising the time in confinement (on the farm and at the plant) and transport time is likely to reduce stress levels. Providing electrolytes or hay (e.g. Gregory *et al*., 2000) may improve welfare during pre-slaughter handling (at present, feed and water are likely to be withheld for at least 30 hours in deer confined overnight before transport to slaughter). Heat stress may occur during transport in summer, and cold stress may occur in winter where extensive mist spraying is used. The effects of pre-slaughter washing practices on stress levels are unknown. From a welfare perspective, it would be preferable to avoid current pre-slaughter procedures altogether. Alternative systems (such as mobile slaughter plants) could be investigated.

4.5.2 Physical manipulations

Mechanical restraint is known to be stressful and there are techniques such as minimising noise and isolation from other deer that could be explored to make it less aversive. The welfare advantages of chemical restraint over physical restraint for some procedures are unknown (but difficult to quantify due to effects of chemicals on stress physiology).

Ear-tagging is now carried out extensively due to AHB tagging requirements. Preliminary observations of behaviour and heart rate indicate that ear-tagging is painful. Research to define the most humane way of carrying out ear tagging is required, and alternative identification systems could be investigated.

There is good evidence that local anaesthetic does not always provide full analgesia for velvet removal and the requirements for post-treatment analgesia are unknown. Velvet removal systems that are painless (both during and after removal) and chemical free (for velvet production) are desirable. Reasons for the lack of reproducibility and repeatability of analgesia, regardless of the technique used, are needed, and alternative systems to local analgesia are required. The consequences to welfare of leaving antlers intact until they have hardened also need to be examined.

Trophy hunting of farmed stags is becoming increasingly popular and there is potential for serious welfare problems to occur. There is a need for monitoring the range of practices used. Recent moves to provide guidelines for operators will assist in protecting welfare. A recent study on the welfare implications of culling deer may be helpful in defining the issues (Bradshaw & Bateson, 2000).

Research has not been carried out the welfare effects of many of the manipulations that deer are subjected to. These include techniques used in artificial reproduction (electroejaculation techniques, artificial insemination, embryo recovery, embryo transfer, elective caesarean deliveries), assisted births, Tb testing and health treatments (injections, pour-ons, oral dosing and boluses). Other practices that may affect welfare are small-framed hinds bearing large calves (with cross-breeding of red hinds and wapiti stags), limitations on the use of conventional health treatments in organic farming, and minimal supervision of deer in extensive systems.

Regardless of the state of knowledge of husbandry techniques that optimise animal welfare, individual handlers have a major influence on the level of welfare actually imposed on the animals. Research could examine the most effective techniques for stimulating the uptake of this knowledge and encouraging high quality stockmanship. There may also be a need to identify optimal techniques for ensuring compliance with QA standards.

4.5.3 Quantifying welfare

Physiological and behavioural responses to acute stress have been extensively studied in red deer and this type of stress can be evaluated with reasonable confidence. Less is known about the assessment of chronic stress, for evaluation of the effects of long-term exposure to social and/or environmental conditions. Behavioural indicators of chronic stress in deer seem to include pacing behaviour and aggression but have not been studied in their own right. Physiological studies have investigated relationships between chronic stress, the adrenal system, and the immune system in deer but as yet these relationships are not well understood. Multidisciplinary studies of the effects of chronic stress on behaviour and physiology would improve knowledge in this area.

A second area in which knowledge is lacking is the assessment of pain. This is a difficult area because pain is a subjective, personal experience and not readily quantified, even in humans. It was cautioned that behavioural responses of “game” animals were not always related to the degree of injury; for instance deer with massive injuries were observed to behave normally (Burton, 1993). Additional techniques to assess pain (rather than relying heavily on behaviour) would help in identifying improved velvet removal techniques and in assessing other procedures such as electroejaculation and ear-tagging. Better knowledge of the relationship between pain and physiological variables (such as endogenous opioids) would improve our understanding.

4.5.4 Market connections/relationships

The major role of the GIB is to assist in the orderly marketing of deer and deer products. The industry funds the GIB to be involved in the individual markets, with the aim of receiving signals about the needs and attitudes of the markets, so that the deer industry can respond accordingly with appropriate faming practices. Issues of on-farm practice (for example wintering systems, animal health treatments, and the expression of the Five Freedoms) that influence the image of deer products are identified so that market expectations can be met, and assurance systems put in place. The GIB meets with deer farming organisations in other counties as well as the distributors and customers to increase the understanding of consumer trends, perceptions and expectations of the New Zealand system. This information is published in the GIB’s Formal General Meeting reports, which also include keynote addresses from invited speakers that define international trends and issues in the area of customer perception. Animal wellbeing and food safety are always key components of this information.

Two major threats to overseas markets are the harvest of velvet antler and the issue of whether New Zealand deer are naturally or factory farmed. If velvet is not harvested, the care, management and slaughter of deer with growing and hard antler become major issues on animal welfare grounds. The natural farming issue becomes complex with consideration of intensive overwintering systems, either indoors or on feedpads, as there is a compromise between providing good shelter and other perceived needs of the animals.

5. Capability summary

New Zealand research personnel with capabilities in assessing deer welfare are presented in Table 2.

Table 2: New Zealand Deer welfare research capability summary

Institution	Principal research personnel	Specific capabilities
AgResearch (AgSystems)	J. Pollard G. Asher T. Pearse D. Stevens	Identifying and implementing management systems that assure/improve welfare
AgResearch (AgSystems)	M. Fisher	Ethics of farming
AgResearch (Food Systems and Technology)	J. Stevenson-Barry	Evaluating effects of pre-slaughter treatments on meat characteristics
AgResearch (Nutrition and Behaviour)	L. Matthews A. Fisher J. Webster N. Roberts M. Stewart	Assessment of public perception, input to QA schemes, developing and implementing techniques to assess welfare during handling and manipulations, identifying technology transfer techniques
Massey University	P. Wilson, K. Stafford, D. Mellor, C. Johnson, P. Chambers	Assessment of pain and analgesia, deer farm management and environmental issues, animal behaviour, bioethics
Lincoln University	A. Nicol G. Barrell	Behavioural, physiological and immune responses to stress
HortResearch	C. Cook C. Devine	Stress neurophysiology
Otago University (Deer Research Lab.)	F. Griffin	Relationship between stress and immunity
Dexcel	J. Jago G. Verkerk	Assessing pre-slaughter stress, assessing thermal stress, intensive management systems
NAWAC	D. Mellor	Perspective of welfare issues, setting policy
MAFPolicy	D. Bayvel	Assessing market concerns, setting policy

6. Research priorities

Research priorities for 20 topics identified in Section 4.5 (Gaps in knowledge) and by contributors were assessed by asking each contributor to rate the priority of the topics as low, medium or high. The number of ratings in each category, and the number of contributors rating each topic, are given in Table 3.

Topics receiving the greatest number of “high” ratings, and fewest “low” ratings, were minimising pre-slaughter stress, techniques for improving calving environments, and minimising stress during handling and restraint. Assessing welfare, effects of manipulating social environments, and velvet removal techniques also were given several “high” ratings but opinions were more diverse on these topics.

Research areas receiving the greatest number of “low” ratings were ear-tagging, effects of genetic selection, cross-breeding and artificial reproduction techniques, selection and taming for amenability to farming, assessing market connections and management of stags in hard antler or during the rut. Nevertheless for most of these topics there was diversity of opinion with some “high” ratings.

Results from this priority rating exercise need to be interpreted with caution, as some topics may not have been represented fairly by their descriptions or by grouping them with others (for example one contributor commented that while they had welfare assessment as “medium”, the topic of pain assessment on its own would have been given a “high” rating). Furthermore two contributors warned against using a piecemeal approach to research that attempted to address issues without first assessing the broader picture, which encompassed the natural behaviour of deer and sound techniques of assessing welfare.

Table 3: The number of ratings of "low" (L), "medium" (M) or "high" (H) priority given by contributors, and the number of contributors rating each topic, for potential areas for research

Topic	No. of responses			No. of people rating
	L	M	H	
Effects of manipulation of social environments (e.g. mob size, stocking density, social composition)	3	4	6	13
Physical techniques to reduce social stress (e.g. visual cover, fence placement)	4	5	4	13
Selection and taming for amenability to farming	8	3	2	13
Techniques for minimising stress during handling and restraint	2	4	7	13
Techniques for communicating knowledge on welfare and encouraging good stockmanship	2	9	2	13
Need, and effective techniques, for providing shade	1	9	3	13
Need, and effective techniques, for providing shelter	1	8	4	13
Need, and effective techniques, for providing wallows	5	7	1	13
Techniques for improving calving environments	0	7	6	13
Winter management	4	6	3	13
Minimising transport stress (e.g. long-distance cartage, temperature and humidity, and density requirements for specific stock types)	3	6	4	13
Minimising pre-slaughter stress	0	4	8	12
Ear-tagging	10	0	3	13
Adult and spiker velvet removal techniques	5	2	5	12
Management of stags during the rut	8	2	2	12
Management of stags in hard antler	8	4	1	13
Identifying welfare issues in emerging specialist production systems (e.g. trophy hunting, organic farming, extensive farming and intensive farming)	3	6	4	13
Effects of genetic selection, cross-breeding and artificial reproduction techniques	9	4	0	13
Assessing welfare (including acute stress, chronic stress and pain)	4	3	6	13
Assessing market connections/relationships	8	3	2	13

7. Popular summary article

DEEResearch requested a review of deer welfare as a means of identifying research priorities for funding in this area. The review was prepared with input from researchers from AgResearch and Massey University, as well as two leading members of the deer industry. It focussed mainly on red deer and wapiti, as they are the main types of deer farmed in New Zealand.

The review begins with descriptions of the behaviour and environment of wild deer, and common practices used on farms, so that the differences and similarities between farming practices and what deer naturally do can be appreciated. In the wild, deer live in a range of environments, which provide suitable vegetation for grazing, browsing, cover and shelter from the weather. Adults live in sexually segregated groups, with females tending to remain with related females, and young males remaining with their mothers for a year or more. During the rut, males compete for and mate with a harem of females.

Deer have not been farmed intensively for long but have had a certain amount of husbandry in game parks for thousands of years. In New Zealand, deer farms range from extensive high country properties to intensive farms on fertile lowlands. Trophy hunting is also carried out, on large tracts of enclosed mountain terrain. On farms, deer are generally weaned early, sexually segregated at about 10 months of age, then kept in groups of 50-400. The larger mobs are broken into smaller groups at mating and calving time. Commonly, the deer are subjected to handling practices that include mustering into deer yards, ear-tagging, health treatments (such as drenching and vaccination), mechanical restraint, velvet antler removal from stags, transport in deer crates, and slaughter at Deer Slaughter Premises. A range of artificial reproductive techniques has been developed for deer. Crossing of red deer with wapiti is often used to generate fast-growing offspring for venison production. Deer farm sizes are increasing rapidly, and productions systems are becoming more specialised.

The industry is in touch with consumer concerns, which are stimulating people involved in all phases of production to adopt the industry's quality assurance systems (that have a large welfare component) and fostering awareness of the need to avoid practices that damage the environment. Guidelines to protect the welfare of deer (during transport, sale, velvet removal and slaughter) are also provided in the Welfare Codes prepared by the National Animal Welfare Advisory Committee. A draft code of welfare for deer is currently being written.

The review presents findings from scientific research on deer welfare and highlights areas where knowledge is lacking. There has been research on how social conditions affect deer welfare, which tends to conclude that social problems are best alleviated by giving the animals as much space as possible. This is impossible on intensive farms, so other techniques of alleviating stress such as providing more cover in paddocks, and more interesting and natural food need to be investigated. Other possible causes of social stress are an increasing tendency to keep deer in very large groups, and the practice of breaking up established social groups.

There has not been much research on providing shade, shelter, cover for hiding, and wallows for deer, but there are indications that at times (especially at calving) deer do have a high requirement for some sort of cover. Objective studies are required to determine when these features are most likely to be needed and what the advantages are to the animals.

Indoor wintering systems can create social stress and there are many other factors that can make this environment unpleasant for the animals. Alternative systems that incorporate good shelter from the weather and avoid stress from confinement deserve investigation. Indoor wintering can be interpreted as “factory farming” by overseas consumers, and is not condoned by the New Zealand deer industry.

Studies have shown that in general deer find the presence of people, and being mustered and handled, quite stressful. Handling stress might be reduced through taming of young deer, culling deer that were particularly stressed, training people to handle the deer appropriately, and making changes to the handling environment (e.g. reducing noise and avoiding isolating the deer from each other). Research is needed to find the most effective ways of carrying out these modifications. Pre-slaughter handling involves many factors that deer find stressful such as strange environments, people, transport and close confinement with other deer. Each component of pre-slaughter handling needs to be examined to determine where improvements can be made. Studies have indicated that stress would be reduced if transport and waiting times were minimised.

Of the physical manipulations carried out on deer, velvet removal has been researched most extensively. There is still a need to identify methods of providing analgesia for velvet removal. Not harvesting velvet creates its own set of problems, as the deer can damage each other and people with their antlers, and ways to manage deer with hard antler need to be explored. This is particularly important as some overseas consumers consider velveting to be unacceptable on animal welfare grounds. Other common manipulations have not been studied and deserve attention. Trophy hunting creates opportunities for welfare problems. There is a need to monitor this activity and identify welfare issues. Research could also be carried out to identify effective techniques for stimulating the uptake of knowledge on animal welfare by stock handlers. There may also be a need to identify optimal techniques for ensuring compliance with QA standards.

Techniques to quantify short-term stress have been extensively studied in deer. Techniques for assessing long-term stress have not been applied to many aspects of the practical farming situation. A better understanding of the relationships between chronic stress, behaviour, and animal physiology is vital to identifying improved husbandry systems for deer. At present, pain in deer is largely assessed by measuring how much the animal moves when the potentially painful stimulus is applied. Improved knowledge of how deer respond physiologically to pain is required.

Contributors to the review were asked to rate potential research areas highlighted by the review as being of high, medium or low priority. Topics favoured as high priority were pre-slaughter stress, techniques for improving calving environments, and minimising stress during handling and restraint. However two contributors warned against using a piecemeal approach to research that attempted to address issues without first assessing the broader picture, which encompassed the natural behaviour of deer and sound techniques of assessing welfare.

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