ABSTRACT

This paper will start with briefly outlining the recent domestication history of red deer (Cervus elaphus) and fallow deer (Dama dama), followed by a description of the present status of modern deer farming. It will then review the main welfare issues of deer farming. The following aspects will be considered: accommodation and housing, management and handling, nutrition (feed and water provision), transport and slaughter, plus a short mention of velvet harvest. As a summary, the following practices can be recommended to ensure animal welfare in modern deer farming: the adoption of suitable housing systems and of adequate management techniques (e.g. specific handling pens and drop-floor cradles or crushes) and the respect of specific needs (e.g. provision of protection and shelter from predators as well as from climatic extremes, such as cold winds or direct solar radiation). Handling and yarding operations will be easier when they occur in dim light. Special attention must be paid to the manipulation of the newborns. At the slaughterhouse, facilities must be designed specifically for deer. The presence of well trained stockpersons, with a sound knowledge of deer physiology and behaviour, is also a key-factor for improving welfare levels in deer farms. To achieve these aims, training of the managers and stockpersons and the adoption of specific codes of conducts are highly recommendable.

Key words: Red deer, Fallow deer, Deer farming, Welfare, Behaviour.

RIASSUNTO

PROBLEMATICHE DI BENESSERE NEI MODERNI ALLEVAMENTI DI CERVIDI

Nel presente lavoro viene inizialmente brevemente illustrata la recente storia di domesticazione di alcune specie di cervidi allevati, ed in particolare del cervo (Cervus elaphus) e del daino (Dama dama), e viene fornita una descrizione della situazione attuale nei moderni allevamenti di cervidi. Vengono poi passati in rassegna i principali aspetti relativi al benessere in tali allevamenti. Gli aspetti trattati si riferiscono prevalentemente alle strutture, alla gestione e manipolazione degli animali, agli aspetti nutrizionali (fornitura di alimento e di acqua) ed infine agli aspetti più specifici di trasporto e macellazione, oltre che a un breve cenno sulla raccolta del “velluto”. Al fine di garantire sufficienti livelli di benessere negli allevamenti di cervi, viene evidenziata la necessità di adottare strutture e sistemi di gestione adeguati (quali ad esempio appositi recinti di cattura e sistemi di contenzione degli animali con fondo apribile e facilità di accesso a
tutti i lati dell’animale). E’ inoltre essenziale che vengano rispettate tutte le necessità specifiche dei cervidi al pascolo, quali ad esempio un’adeguata protezione dai predatori e dagli eventi meteorologici avversi (e.g. vento e forte irraggiamento solare diretto). Altri accorgimenti, quali l’effettuare le operazioni di manipolazione degli animali in condizioni di semi-oscurità, contribuiscono a migliorare il livello di benessere. Particolare riguardo va prestato alla manipolazione dei piccoli, per evitare fenomeni di abbandono da parte delle madri. Anche al macello, le strutture devono essere progettate specificamente per i cervidi. Un altro fattore chiave per una gestione rispettosa del benessere animale è la presenza di personale preparato, che abbia una profonda conoscenza della fisiologia e del comportamento dei cervidi. In conclusione, l’organizzazione di corsi di preparazione e la stesura e adozione di linee guida specifiche per queste specie è altamente auspicabile.

Parole chiave: Cervo, Daino, Allevamenti di cervidi, Benessere, Comportamento.

Introduction

Apart from reindeer, Rangifer tarandus, which has been the most widely bred deer species in many Northern Countries for the last two thousand years (Clutton-Brock, 1987), the most widespread deer species in modern deer farms are red deer, Cervus elaphus, and fallow deer, Dama dama (Reinken, 1990; Bartoš and Šiler, 1993). Deer farms are present nowadays on a large scale in New Zealand and, to a lesser extent, in Europe, North America, Australia and even in tropical regions, such as Mauritius and New Caledonia, and deer are farmed under a variety of conditions, ranging from extensive to intensive systems (Bartoš and Šiler, 1993; Fletcher, 2002). Deer are farmed mainly for the production of venison or for being sold to hunting preserves, or being used directly for tourist farms and, in non European countries, also for velvet production. In Italy, the last survey on deer farms indicated the presence of about 10,000 fallow deer and 2000 red deer dispersed into 400 small farms, most of which are semi-extensive, mainly concentrated in marginal hilly areas of Central Italy (Salghetti, 1991). These numbers, which include animals from state parks and from small farms for hobby purposes, probably have to be reconsidered by now, as some farmers have discontinued their activity (FEDFA, 2007).

The present situation of Italian deer farms has been described by Diverio et al. (1997). The degree and the nature of the relationship between deer and men show considerable variations, depending on geographic, economic, social or cultural conditions (Putman, 1988). This relationship developed through several intermediate stages, ranging from bare hunting exploitation, to management of wild or semi-wild populations, to sporadic taming attempts, to more recent deer farming enterprises. At present, red deer and fallow deer can, in several aspects, be regarded as newly domesticated species (Mattiello, 2005). Because of their quite recent domestication history, their coping mechanisms with farming conditions are likely to be more pronounced than those of the traditional domestic species, and their adaptive processes to the radical environmental changes to which animals are subjected when they move from the wilderness to farming conditions are still in progress. This may jeopardize their welfare. For example, Hanlon et al. (1994) found that calves deriving from wild red deer hinds are more sensitive to stress caused by intensive housing conditions than calves derived from farmed hinds, as indicated by their poorer immune response to a foreign antigens and by their different behavioural patterns. Stress in deer may have even more severe consequences, and may
eventually lead to death. This may happen for example in the case of postcapture myopathy, which is associated with the stress related to capture operations of wild species (McAllum, 1985).

The main welfare issues in deer farming are related to accommodation, housing, management, handling, transport, slaughter and velvet harvest (Burton, 1993; English, 1993; Matthews, 1993; Goddard, 1998). These aspects will be reviewed in the present paper.

**Accommodation and housing**

Deer are usually kept in groups at pasture in large fenced areas. A survey carried out in European countries revealed that, depending on climatic conditions, in some geographic areas (e.g. Czech Republic, Denmark, France, Great Britain) it is a common practice that weaned red or fallow deer calves are wintered indoors from September to the following spring, in order to protect them from aversive weather conditions, to reduce expenses for winter feeding and to encourage taming of the animals (Bartoš and Šiler, 1993).

Experiments of indoor winter housing have been carried out in adult red deer hinds, but the results suggest that this practice should not be recommended for adult animals. In fact, although there was a positive effect on weight gain, indoor confinement increased aggression and skin damage (Pollard and Littlejohn, 1998).

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Stocking rates are important for guaranteeing a good level of welfare both in outdoor and in indoor conditions (see indoor winter housing for weaned calves). For animals at pasture, they are obviously strictly dependent on the availability of resources and on the use of supplementary feeding. As a general rule, in deer farms the recommended stocking rate under ideal grass growing conditions ranges from 6 to 8 red deer breeding hinds per hectare (or up to twice as many for fallow deer; FEDFA, 2007). In Italy, animals are usually kept at much lower densities (2.2 and 0.3 heads/hectare for fallow and red deer, respectively; Mattiello et al., 1993). Space allowance must also take into account the age, sex and weight of the animals (DEFRA, 2006). High densities may induce social stress and modification of grazing patterns, especially in subordinate individuals (Blanc and Thériez, 1998). Furthermore, high densities induce the animals to form larger groups (Putman, 1988) in which the nearest neighbour distance tends to decrease, thus producing an increase of aggressive interactions (Clutton-Brock et al., 1982). This is evident also in indoor housing conditions. Significant differences in the number of agonistic encounters have been observed in housed red deer calves penned at different stocking densities: the higher the stocking density, the higher the amount of aggressive interactions (Mattiello, 1994). Pollard and Littlejohn (1996) also suggest that larger pens are less aversive to temporarily confined young stags, as shown by greater inter-individual distances and reduced fence line pacing, but they recorded the effect of seasonal variation on the frequency and nature of aggressive behaviour and other activities: small pens seem to be favoured in spring and large pens in summer. Detrimental effects on production parameters, such as growth rates (Blanc and Thériez, 1998) and reproductive performance (Benoit and Brelurut, 1996) have been recorded in response to increasing stocking rates. The possibility of forming groups with various configurations of individuals is essential in deer farms both for rational management and for facilitating the formation of aggregations that correspond to the social needs of these species. Fallow deer and red deer are highly social species, living in large
groups in sexual segregation during most of the year and forming mixed-sex groups during the breeding season (Putman, 1988). Even under very intensive conditions, they tend to maintain their typical sexual segregation during the birth season. However, in over-crowded conditions mixed-sex groups become the most common type of social aggregation, especially at feeding sites (Mattielo et al., 1997b). Under extensive conditions, in a fallow deer population kept in a park, it has been observed that aggressions are more likely to occur between individuals of similar rank (Mattiangeli et al., 1998), which usually corresponds to similarities in body masses. In contrast with these findings, the farmers’ opinion is that in calves kept in indoor situations, groups of similar-sized individuals show a reduced level of aggressive behaviour and, when the animals are of different size, the lightest deer receive the most aggression (Pollard and Littlejohn, 1998).

Fences are one of the most important facilities on deer farms. Besides preventing the animals from escaping, they should guarantee adequate protection from predators. Therefore, they need to be of suitable height (minimum 1.8-2 metres), well buried into the ground and they should be regularly inspected in order to detect possible breaks (Diverio et al., 1997). Protection from predators is an important welfare issue for animals at pasture. A survey in Italian deer farms pointed out that predation by foxes and stray dogs is the main cause of mortality, especially for young animals, and it has been recorded in 50% of the surveyed farms (Mattielo et al., 1994). Another cause of mortality related to fences is the accidental entangling of frightened calves (Mattielo et al., 1994), which may occur when nets are not elastic and the mesh size is not correct. Meshes should be wide enough to make the net flexible, and close enough to prevent the passage of animals inwards or outwards. The use of nets with increasing mesh size from the bottom to the top is highly recommended (Reinken, 1990; Langridge, 1992; Diverio et al., 1997). An adequate distance between posts will also contribute to give sufficient flexibility to the nets. Barbed wire has to be avoided, as it might cause severe injuries in the case of frightened deer trying to jump out of the fenced area (Kilgour and Dalton, 1984). Electric fences have been successfully used in some cases and they are recommended by several authors (Kilgour and Dalton, 1984; Clift et al., 1985; Reinken, 1990).

As deer are not well insulated, protection and shelter from climatic extremes should be provided (DEFRA, 2006). If natural vegetation is not present along the fence, windbreaks should be placed in order to protect animals from cold winds, which are one of the most aversive meteorological factors, and some shade must also be present to protect from direct solar radiation (Blackshaw, 2003). Shade and shelter seem to be beneficial for deer thermoregulation, and contribute to their well being (Pollard and Littlejohn, 1999). Visual cover may have additional benefits for deer, for example reducing aggressive behaviour (Whittington and Chamove, 1995) or by preventing disturbance reactions (Herrmann, 1995). The provision of sheltered areas is particularly important during the birth season in paddocks where parturitions occur, as fallow deer and red deer are “hider” species (Putman, 1988). It has been shown by Mattielo and Bianchi (2003) that, in the absence of an adequate number of suitable areas, more than one newborn may be dropped down in the same few suitable places, thus altering the normal hiding behaviour of the species. Alternatively, when the few suitable areas become overcrowded, mothers may choose to give birth in suboptimal areas, such as along the fences or in completely open ar-
eas, thus exposing the newborns to excessive direct solar radiation during the summer (Mattiello and Bianchi, 2003). Hodgett et al. (2002) confirmed that the presence of shelters contributes to improve calf welfare and suggest that their shape and location are also important: as calves mature, they tend to prefer tunnel shaped to simple wall designed shelters, possibly located in the centre of the paddock. The presence of quiet areas, far from road disturbance, is required by females for giving birth and for suckling (Mattiello et al., 1997b).

Another behavioural need that must be satisfied is the possibility for wallowing (Kilgour and Dalton, 1984), which requires the presence of a sufficient amount of water in the paddocks. Wallowing is particularly important for red deer for cleaning up external parasites and for finding some refreshment during the hot season. Stags also use wallowing for marking their territory during the rut (Clutton-Brock et al., 1982).

Management and handling

Management practices that require physical restraint, visual isolation or human proximity, are stressful for novel farm species like deer (Diverio et al., 1993; Grigor et al., 1998a), and it is important to try to minimise their impact on welfare. The design of facilities for capture, handling and manipulation of the animals must be done by keeping in mind the behaviour of the species and taking into account the perception that deer have of the surrounding environment and of human beings (Bradshaw, 2003). For example, corridors should be large enough to avoid overcrowding when the animals are run to restraint facilities; they should have solid walls and they should be clearly visible to the deer, in order to prevent animals from jumping against them (Kilgour and Dalton, 1984).

Corners should be avoided, as deer tend to crush into a corner when yarded (Bradshaw, 2003). The use of specific handling pens and cradles or crushes for restraining the animals is recommended (Langridge, 1992). Specific additional information on handling and restraint systems for deer can be found, for example, in Kilgour and Dalton (1984), Reinken (1990), Langridge (1992), Diverio et al. (1997), Bradshaw (2003).

Deer should be handled gently and never rushed (DEFRA, 2006). Handling and yarding operations will be easier when they occur in dim light, as darkness seems to make the animals quieter (Pollard and Littlejohn, 1994). The tendency of deer to move from a dark place to the light can be useful for gently encouraging the animals towards the direction desired (Langridge, 1992).

Deer can progressively become accustomed to human presence in response to regular contact during farming practices, as indicated for example by the decrease in the percentage of heart rate peaks associated with human presence in the barn or in the pen from the beginning to the end of the indoor period in red deer calves (Mattiello et al., 1997a). For this reason, regular moving of the animals through the corridors to the handling facility can help to reduce stress when handling is required (Kilgour and Dalton, 1984).

As fallow and red deer are social species (Putman, 1988), isolation is a stressful event for them, and if they are left alone in a pen they may panic (Bradshaw, 2003). Therefore, they should not be confined alone for long periods, except for quarantine or management purposes (DLGRD, 2003). When animals have to be segregated, visual contact with their fellows is still advisable to minimise stress (DEFRA, 2006). Another form of social stress can be induced by mixing unfamiliar groups of animals together (Pollard et al., 1993).
Human interference at calving has proved to represent a source of disturbance, as shown by avoidance behaviour and increased pacing along the fence line observed in red deer hinds (Pollard et al., 1998). In the presence of disturbance, the normal mother-infant bonds might be altered and this can be shown, for example, by the increased occurrence of fallow deer mothers suckling two or three unrelated fawns at the same time (Mattiello et al., 1994). Human intervention at calving may eventually result in females abandoning their calves (Kilgour and Dalton, 1984). In these cases, or in case of death of the mother, hand rearing of orphan calves is sometimes required. This may lead to abnormal behaviour in adult hand reared animals, which will often stay apart from the rest of the group and, in the case of males, may become extremely aggressive against man during the rut (Kilgour and Dalton, 1984).

Weaning is obviously a stressing procedure for farmed deer. It seems that weaning stress can be reduced by moving weaned calves to indoor pens (Pollard et al., 1992). Visual separation between mothers and weaned calves can be useful in order to avoid injuries to the calves while they are trying to overcome physical barriers to rejoin their mothers (Kilgour and Dalton, 1984).

Finally, when talking about management and handling, the role of well trained stockpersons, with a deep knowledge of deer behaviour and physiology, is of extreme importance for carrying out the management practices in the best possible way (Kilgour and Dalton, 1984; Hemsworth and Coleman, 1998).

**Feed and water provision**

Fulfilling of the nutritional requirements must be carefully considered, especially in extensive farming conditions, where feed supply might be limited by environmental constraints, such as abundant snowfalls in winter or water deficiency in warm summers. In these cases, supplementary feed must be provided. Detailed information about nutritional requirements of farmed red (Thériez, 1988, 1989) and fallow deer (Reinken, 1990) can be found in the existing literature. A body condition score system specifically adjusted for farmed red deer is currently available and may represent a useful tool in order to check that animals are in good condition (Audigé et al., 1998).

As animals are usually kept at pasture, attention must be paid to the presence of toxic plants which may have deleterious effects on deer health (DLGRD, 2003). If the animals are wintered indoors, the administration of some roughage source and/or tree trunks for chewing seems to improve their welfare (Pollard and Littlejohn, 1997).

When deer are kept under intensive farming conditions, supplementary feed must be provided all year round. Special regard must be paid to the growth requirements of young animals and to seasonal requirements, such as protein and energy requirements of females at the end of pregnancy and during lactation and the mineral requirements of males during antler growth (Thériez, 1988). Sex differences in food preference must also be considered (Mattiello et al., 1997b; Heroldová et al., 2005). It is important that all animals can have contemporary access to food, otherwise aggression will increase (Mattiello, 1994) and subordinate animals might not be able to satisfy their nutritional requirements.

Colostrum must be provided to the newborns from their dams. Some roughage source and, possibly, some palatable feed, must also be accessible to them from an early age (DEFRA, 2006).

Changes in diet, for example for young animals passing from indoor wintering to
pasture, should be gradually introduced (DLGRD, 2003).

Deer must have access to abundant fresh and clean water for drinking (DEFRA, 2006). Daily requirements must always be satisfied, even in the case of lactating females, which in summer may need between 10 (fallow deer) and 20 litres (red deer) of fresh drinking water per day (DLGRD, 2003). If natural water sources are not present in the paddock, artificial sources must be provided and regularly inspected for normal function. This is particularly important and should be more frequent during the summer. In the case of natural water sources, attention must be paid in order to minimise faecal contamination (DLGRD, 2003).

**Transport and Slaughter**

Transport and slaughter are among the main welfare issues in deer farming, and a considerable amount of research has been carried out on these topics (e.g. Smith and Dobson, 1990; Grigor et al., 1997, 1998a, 1998b, 1998c, 1999; Jago et al., 1997; Waas et al., 1997). Reviews (Matthews, 1993; Weeks, 2000; Pollard and Wilson, 2002; Bornett-Gauci et al., 2006) and scientific reports (FAWC, 2003; AHAW, 2006) on the same subjects are also available.

**Transport**

When animals are transported, they undergo stress caused by handling procedures (see “Management and handling”) and by transport. Although carcass damage due to transport procedures is usually infrequent (Grigor et al., 1997; Jago et al., 1997), Selwyn and Hathaway (1992) recorded a very high incidence of traumatic lesions in red and fallow deer slaughtered after transport. In order to improve welfare levels during transport, it is advisable to load the animals on the trucks by using non-steep ramps (Smith and Dobson, 1990). Providing subdued lighting inside the trailer does not seem to facilitate loading operations (Grigor et al., 1998c). Welfare during transport may be improved by keeping the animals in the darkness (Mattiello, 1997), driving carefully, and by avoiding steep and winding roads, which may induce loss of balance, especially at the beginning of the journey (Jago et al., 1997). During long journeys, deer should have the possibility of lying down, while during short journeys a higher animal density may be preferred, as it reduces loss of balance (Jago et al., 1997). In any case, pen size in the truck must allow the animals to orient themselves to the direction of travel (Pollard and Wilson, 2002). The duration of the journey seems to affect deer welfare. Waas et al. (1997) reported that stress increased linearly with transport duration; however, Grigor et al. (1998c) suggest that the animals may become accustomed to transport with time, as they start to show signs of behavioural adaptation within the first two hours of the journey. Weeks (2000) reports that the New Zealand codes suggest that deer should not be transported for more than 12 hours without water and that journey breaks are not desirable, as animals become stressed by being unloaded in an unfamiliar environment. At environmental temperatures ranging from 1.0°C to 15°C, live weight losses occur proportionally with transport duration and hunger increases with time, but little evidence of dehydration following transport is found in red deer, regardless of journey length (Grigor et al., 1998c).

As a general rule, only animals in good condition should be transported, and during transport they should be segregated into groups of the same species, sex and age; transport of males with velvet antlers must be avoided and hard antlers must be removed before transport, otherwise males should be transported individually (DLGRD, 2003). Transport of males during the
rut is also not advisable (Jago et al., 1996). Otherwise, seasonality does not seem to produce remarkable effects on stress during transport (Grigor et al., 1997).

**Slaughter**

As an alternative to stunning and slaughtering in a slaughterhouse, in order to avoid the stress of transportation, deer can be either shot in the field, or stunned and slaughtered in on-farm facilities (not feasible in most cases due to economic reasons). Smith and Dobson (1990) showed that cortisol levels of deer shot in the field are significantly lower than those of deer captured, transported and then slaughtered at the slaughterhouse and pointed out that muscle pH can be negatively affected by pre-slaughtering stress, being higher in animals that are more stressed. Pollard et al. (2002) confirmed that deer commercially slaughtered at the slaughterhouse were more stressed than the ones shot in the field, although differences were not marked. Although it has been demonstrated that shooting deer in the field is less stressful to the animals, it must be pointed out that this procedure should be performed by an experienced marksman. Further research is needed in order to determine how many deer can be shot in one field slaughter session without agitating the rest of the herd (Bornett-Gauci et al., 2006).

At the slaughterhouse, facilities must be designed specifically for deer (FAWC, 2003). Proper lairage pens where deer can stay in the darkness must be present (Pollard and Littlejohn, 1994), at adequate stocking densities, avoiding repeated mixing of unfamiliar animals, which may be an additional cause of stress (Hanlon et al., 1995). Measures should be taken in order to prevent animals from jumping out of the holding pens, bearing in mind that fallow deer are generally more flighty and jumpy than red deer (FAWC, 2003). In multi-species slaughterhouses, attention must be paid to the proximity to other species, as negative responses have been observed in deer penned close to pigs or cattle (Abeyesinghe et al., 1997; Abeyesinghe and Goddard, 1998). In any case, it is recommended to slaughter the animals as soon as possible after downloading (Weeks, 2000). In some cases, lairage time has been observed to be correlated with the occurrence of bruising (Jago et al., 1996). Raceways should be designed in order to minimise stress when animals are moved around the lairage (FAWC, 2003).

For stunning, it is recommended that deer be effectively restrained, which can be achieved in specifically designed drop-floor crates (FAWC, 2003). Captive-bolt stunning is usually adopted, as it is considered a human safety factor, and the use of penetrating stunner is recommended instead of the concussion stunner (DLGRD, 2003). If deer heads are well restrained, head-only electrical stunning seems to be an effective and humane stunning method (Blackmore et al., 1993).

**Velvet harvest**

This procedure consists of cutting the deer antlers during their growth phase, when they are still covered by a particular soft skin called “velvet”. During this phase, the antlers are innervated and have an intense blood circulation, and are therefore sensitive organs. Their removal is a really stressful event and, if not properly managed, it will cause pain to the animals. Antler removal for velvet production is a common practice in many countries, especially in New Zealand, due the high value of velvet in East Asian countries (e.g. Korea, China) that import it for the preparation of a wide range of traditional remedies (Putman, 1988).

In spite of its high impact on deer welfare, this topic will not be dealt with in detail in the present review because of its very
sporadic occurrence in European deer farms (Bartoš and Šiler, 1993) due to the scarce market opportunities for exportation from Europe to the Asian market. The main welfare issues of antler removal and the methods which have been used in order to reduce pain have been recently reviewed by Wilson and Stafford (2002).

Criteria for welfare evaluation

Unfortunately, no specific indication exists as to on-farm welfare evaluation for deer. The use of physiological parameters (such as heart rate, body temperature, plasma cortisol level with or without ACTH challenge, etc.) can be effective for welfare monitoring in domestic species and several examples of their use are available also for deer, where these parameters have been investigated either in experimental conditions or during yarding and transport (e.g.: Abeyesinghe et al., 1997; Grigor et al., 1997, 1998b, 1998c; Waas et al., 1997). However, these parameters are more difficult to be measured in wild species that are very susceptible to stress caused by capture and handling, and this may jeopardize the reliability of the results. The development of automated techniques now offers a possibility to monitor physiological stress levels in undisturbed conditions. For example, heart rate has been successfully recorded in reindeer using telemetric heart rate monitoring systems fitted on the animals (e.g.: Eloranta et al., 2002). In red deer, heart rate and body temperature were measured by means of subcutaneous surgically implanted transmitters (Giacometti et al., 2001), while the measurement of plasma cortisol levels close to basal concentrations has been achieved by using automatic blood sampling equipments (e.g.: Goddard et al., 1998; Säkkinen et al., 2004).

Direct indicators based mainly on animal behaviour seem to be the most appropriate tools in order to detect poor welfare conditions. Fear reactions, alteration of social behaviour (e.g. excessive aggressive behaviour, abnormal group composition, isolation, etc.), modification of feeding activity, excessive vocalization, alteration of maternal behaviour and the presence of abnormal behaviours (e.g. fence line pacing) can be considered as clear signs of poor welfare. In addition, the presence of lesions due to injuries or accidents can be used in order to monitor welfare levels.

Conclusions

The adaptation of deer to farming conditions is still in progress. Deer can cope quite well with a number of restrictions deriving from captive situations, and they seem to adapt rather well to human presence, but they still need a remarkable amount of space and some specific environmental characteristics for performing their activities and maintaining normal behaviour. If their requirements are not fulfilled, their social and anti-predatory behaviours will become frustrated or affected and the animals will experience a situation of poor welfare. The adoption of suitable housing systems and of adequate management techniques that are specifically designed for deer, as well as the presence of well trained stockpersons, with a sound knowledge of deer physiology and behaviour (Kilgour and Dalton, 1984), are particularly important for guaranteeing sufficient welfare levels to farmed deer. To achieve this aim, training of the managers and stockpersons and the adoption of specific codes of conduct are highly recommendable (Burton, 1993; DLGRD, 2003; DEFRA, 2006).

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REFERENCES

Abeyesinghe, S.M., Goddard, P.J., 1998. The preferences and behaviour of farmed red deer (*Cervus elaphus*) in the presence of other farmed species. Appl. Anim. Behav. Sci. 56:59-69.

Abeyesinghe, S.M., Goddard, P.J., Cockram, M.S., 1997. The behavioural and physiological responses of farmed red deer (*Cervus elaphus*) penned adjacent to other species. Appl. Anim. Behav. Sci. 55:163-175.

AHAW, 2006. Scientific Report: The welfare aspects of the main systems of stunning and killing applied to commercially farmed deer, goats, rabbits, ostriches, ducks, geese and quail. EFSA Journal 326:1-18.

Audigé, L., Wilson, P.R., Morris, R.S., 1998. A body condition score system for farmed red deer hinds. N. Z. J. Agric. Res. 41:545-553.

Bartoš, L., Šiler, J., 1993. Survey of game farming in Europe. FAO Ed., Roma, Italy.

Benoit, M., Brelurut, A., 1996. Elevage du cerf (*Cervus elaphus*) dans l’Ouest de la France. Résultats techniques et économiques. INRA Prod. Anim. 9:121-131.

Blackmore, D.K., Cook, C.J., Devine, C.E., Gilbert, K.V., Tavener, A., Langdon, S., Isaacs, S., Maasland, S.A., 1993. Electrical stunning of red deer. New Zeal. Vet. J. 41:126-130.

Blackshaw, J.K., 2003. Notes on some topics in applied animal behaviour. School of Veterinary Science. Home page address: http://www.animalbehaviour.net

Blanc, F., Thériez, M., 1998. Effects of stocking density on the behaviour and growth of farmed red deer hinds. Appl. Anim. Behav. Sci. 56:297-307.

Bonnin-Gauci, H.L.I., Martin, J.E., Arney, D.R., 2006. The welfare of low-volume farm animals during transport and at slaughter: a review of current knowledge and recommendations for future research. Anim. Welfare 15:299-308.

Burton, B., 1993. Welfare of farmed fallow deer - a Canadian's perspective. pp 209-224 in Proc. 1st World Forum on Fallow Deer Farming (G.W. Asher ed.), Mudgee, Australia.

Clift, T.R., Challacombe, J., Dyce, P.E., 1985. Electric fencing for fallow deer. In : P.F. Fennessy and K.R. Drew (eds.) Proc. Int. Conf. on Biology of Deer Production, Wellington, New Zealand, R. Soc. NZ Bull. 22:363-365.

Clutton-Brock, J., 1987. A natural history of domesticated mammals. Cambridge University Press, Stockbridge, UK.

Clutton-Brock, T.H., Guinness, F.E., Albon, S.D., 1982. Red deer: behaviour and ecology of two sexes. Edinburgh University Press, Edinburgh, UK.

DEFRA, 2006. Code of recommendations for the welfare of farmed deer. Home page address: http://www.defra.gov.uk/animalwelfare/farmed/othersp/deercode.htm

Diverio, S., Goddard, P.J., Gordon, I.J., Elston, D.A., 1993. The effect of management practices on stress in farmed red deer (*Cervus elaphus*) and its modulation by long-acting neuroleptics: behavioural responses. Appl. Anim. Behav. Sci. 36:363-376.

Diverio, S., Mattiello, S., Viliani, M., Beghelli, V., 1997. L’allevarimento di unguali selvatici: quali strategie per il futuro? pp 73-88 in Proc. 14th Nat. Conf. Game Farming Working Group, Bastia Umbra (PG), Italy.

DLGRD, 2003. Code of practice for farming deer in Western Australia. Home page address: http://www.dlgrd.wa.gov.au

Eloranta, E., Norberg, H., Nilsson, A., Pudas, T., Säkkinen, H., 2002. Individually coded telemetry: a tool for studying heart rate and behaviour in reindeer calves. Acta Vet. Scand. 43:135-144.

English, A.W., 1993. Fallow deer farming - animal welfare issues in Australia. pp 225-228 in Proc. 1st World Forum on Fallow Deer Farming (G.W. Asher ed.), Mudgee, Australia.

FAWC, 2003. Report on the Welfare of Farmed Animals at Slaughter or Killing. Home page address: http://www.fawc.org.uk/reports/pb8347.pdf

FEDFA, 2007. Deer farming in Italy. Home page address: http://www.fedfa.com/index2.html

Fletcher, T.J., 2002. The domestication and husbandry of deer in tropical regions. Trop. Agric. Assoc. News. 22:3-7.
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Giacometti, M., Janovsky, M., Fluch, G., Arnold, W., Schober, F., 2001. A technique to implant heart-rate transmitters in red deer. Wildl. Soc. Bull. 29:586-593.

Goddard, P.J., 1998. The welfare of deer. Acta Vet. Hung. 46:395-404.

Goddard, P.J., Gaskin, G.J., Macdonald, A.J., 1998. Automatic blood sampling equipment for use in studies of animal physiology. Anim. Sci. 66:769-775.

Grigor, P.N., Goddard, P.J., Cockram, M.S., Rennie, S.C., Macdonald, A.J., 1997. The effects of some factors associated with transportation on the behavioural and physiological reactions of farmed red deer. Appl. Anim. Behav. Sci. 52:179-189.

Grigor, P.N., Goddard, P.J., Littlewood, C.A., 1998a. The relative aversiveness to farmed red deer of transport, physical restraint, human proximity and social isolation. Appl. Anim. Behav. Sci. 56:255-262.

Grigor, P.N., Goddard, P.J., Littlewood, C.A., 1998b. The behavioural and physiological reactions of farmed red deer to transport: effects of sex, group size, space allowance and vehicular motion. Appl. Anim. Behav. Sci. 56:281-295.

Grigor, P.N., Goddard, P.J., Littlewood, C.A., Macdonald, A.J., 1998c. The behavioural and physiological reactions of farmed red deer to transport: effects of road type and journey time. Appl. Anim. Behav. Sci. 56:263-279.

Grigor, P.N., Goddard, P.J., Littlewood, C.A., Warris, P. D., Brown, S.N., 1999. Effects of preslaughter handling on the behaviour, blood biochemistry and carcasses of farmed red deer. Vet. Rec. 144:223-227.

Hanlon, A.J., Rhind, S.M., Reid, H.W., Burrells, C., Lawrence, A.B., 1995. Effects of repeated changes in group composition on immune response, behaviour, adrenal activity and liveweight gain in farmed red deer yearlings. Appl. Anim. Behav. Sci. 44:57-64.

Hanlon, A.J., Rhind, S.M., Reid, H.W., Burrells, C., Lawrence, A.B., Milne, J.A., McMillen, S.R., 1994. Relationship between immune-response, liveweight gain, behaviour and adrenal-function in red deer (Cervus elaphus) calves derived from wild and farmed stock, maintained at two housing densities. Appl. Anim. Behav. Sci. 41:243-255.

Hemsworth, P.H., Coleman, G.J., 1998. Human-livestock interactions: the stockperson and the productivity of intensively farmed animals. CAB International, Oxon, UK.

Heroldová, M., Homolka, M., Kamler, J., Ghezzi, C., Andreoli, E., Redaelli, W., Mattiello, S., 2005. Autumn diet of red deer (Cervus elaphus) in alpine environment evaluated by diet analysis of rumen content. Page 59 (abstr.) in Proc. 4th Int. Symp. on Wild Fauna (M. Trávníček and A. Kočišová eds.), Stará Lubovňa, Slovakia.

Herrmann, H.J., 1995. Environmental enrichment and the behaviour of farmed red deer (Cervus elaphus). Appl. Anim. Behav. Sci. 44:263-264.

Hodgetts, B.V., Waas, J.R., Matthews, L.R., 2002. Use of different artificial shelter types by farmed red deer (Cervus elaphus) calves. Appl. Anim. Behav. Sci. 79:43-52.

Jago, J.G., Harcourt, R.G., Matthews, L.R., 1997. The effect of road type and distance transported on behaviour, physiology and carcass quality of farmed red deer (Cervus elaphus). Appl. Anim. Behav. Sci. 51:129-141.

Jago, J.G., Hargreaves, A.L., Harcourt, R.G., Matthews, L.R., 1996. Risk factors associated with bruising in red deer at a commercial slaughter plant. 1. Meat Sci. 44:81-191.

Kilgour, R., Dalton, C., 1984. Livestock behaviour. A practical guide. Granada Publishing Limited, Bungay, UK.

Langridge, M., 1992. Establishing a fallow deer farm: basic principles. pp 79-94 in Proc. 1st World Forum on Fallow Deer Farming (G.W. Asher ed.), Mudgee, Australia.

Matthews, L., 1993. Deer handling and transport. In: T. Grandin (ed.) Livestock Handling and Transport. CAB International, Wallingford, UK, pp 253-272.

Mattiangeli, V., Mattiello, S., Verga, M., 1998. Factors affecting the duration of fights in fallow deer (Dama dama) during the rut. Ethol. Ecol. Evol. 10:87-93.
Mattiello, S., 1994. L'allevamento di ungulati selvatici: studio di alcuni aspetti produttivi, fisiologici e comportamentali. PhD Diss., Università di Milano, Italy.
Mattiello, S., 1997. Benessere dei cervidi allevati: il trasporto. Obiettivi Doc. Vet. 10:56-58.
Mattiello, S., 2005. From the wild to the farm: a history of domestication. The example of deer. pp 37-44 in Proc. 4th Int. Symp. on Wild Fauna (M. Trávníček and A. Kočišová eds.), Stará Lubovňa, Slovakia.
Mattiello, S., Bianchi, L., 2003. Alterazioni del comportamento materno nei cervidi allevati. Obiettivi Doc. Vet. 24:39-44.
Mattiello, S., Bianchi, L., Canali, E., Verga, M., 1994. Suckling behaviour of fallow deer in enclosure. Page 161 (abstr.) in Proc. 28th Int. Congr. ISAE, Foulum, Denmark.
Mattiello, S., Littlewood, C., Hamilton, W.J., 1997a. Heart rate as an indicator of adaptation to farming practices in Red deer calves. Page 184 (abstr.) in Proc. 31st Congr. ISAE, Prague, Czech Republic.
Mattiello, S., Mattiangeli, V., Bianchi, L., Carenzi, C., 1997b. Feeding and social behavior of fallow deer (Dama dama L.) under intensive pasture confinement. J. Anim. Sci. 75:339-347.
Mattiello, S., Sulpizio, B.M., Olivieri, O., 1993. Indagine sugli allevamenti di ungluti selvatici in Umbria. Economia Montana 5:25-31.
Mattiello, S., Sulpizio, B.M., Olivieri, O., Rambotti, F., 1994. Aspetti tecnici e gestionali degli allevamenti di cervidi in Umbria. pp 163-175 in Proc. 13th Nat. Congr. Game Farming Working Group, Nocera Umbra (PG), Italy.
McAllum, H.J.F., 1985. Stress and postcapture myopathy in red deer. In: P.F. Fennessy and K.R. Drew (eds.) Proc. Int. Conf. on Biology of Deer Production, Wellington, New Zealand, R. Soc. NZ Bull. 22:65-72.
Pollard, J.C., Grant, A., Littlejohn, R.P., 1998. Fence line pacing in farmed red deer hinds at calving. Anim. Welfare 7:283-291.
Pollard, J.C., Littlejohn, R.P., 1994. Behavioural effects of light conditions on red deer in a holding pen. Appl. Anim. Behav. Sci. 41:127-134.
Pollard, J.C., Littlejohn, R.P., 1996. The effects of pen size on the behaviour of farmed red deer stags confined in yards. Appl. Anim. Behav. Sci. 47:247-253.
Pollard, J.C., Littlejohn, R.P., 1998. Effects of winter housing, exercise, and dietary treatments on the behaviour and welfare of red deer (Cervus elaphus) hinds. Anim. Welfare 7:45-56.
Pollard, J.C., Littlejohn, R.P., 1999. Activities and social relationships of red deer at pasture. New Zeal. Vet. J. 47:83-87.
Pollard, J.C., Littlejohn, R.P., Asher, G.W., Pearse, A.J.T., Stevenson-Barry, J.M., McGregor, S.K., Manley, T.R., Duncan, S.J., Sutton, C.M., Pollock, K.L., Prescott, J., 2002. A comparison of biochemical and meat quality variables in red deer (Cervus elaphus) following either slaughter at pasture or killing at a deer slaughter plant. Meat Sci. 60:85-94.
Pollard, J.C., Littlejohn, R.P., Suttie, J.M., 1992. Behaviour and weight change of red deer calves during different weaning procedures. Appl. Anim. Behav. Sci. 35:23-33.
Pollard, J.C., Littlejohn, R.P., Suttie, J.M., 1993. Effects of isolation and mixing of social groups on heart rate and behaviour of red deer stags. Appl. Anim. Behav. Sci. 38:311-322.
Pollard, J.C., Wilson, P.R., 2002. Welfare of farmed deer in New Zealand. 1. Management practices. New Zeal. Vet. J. 50:214-220.
Putman, R.J., 1988. The natural history of deer. Comstock Publishing Associates. Cornell University Press, New York, NY, USA.
Reinken, G., 1990. Deer Farming: a practical guide to German Techniques. Farming Press, Ipswich, UK.
Säkkinen, H., Tornberg, J., Goddard, P., Eloranta, E., Ropstad, E., Saarela, S., 2004. The effect of blood sampling method on indicators of physiological stress in reindeer (Rangifer tarandus tarandus). Domest. Anim. Endocrinol. 26:87-98.
Salghetti, A., 1991. Elementi strutturali ed economici degli allevamenti di ungluti selvatici in Italia. Annali della Facoltà di Medicina Veterinaria, Università degli Studi di Parma, 11:87-156.
Selwyn, P., Hathaway, S., 1992. Diseases and defects of slaughtered farmed deer. Proc. Deer Course for Veterinarians, Methven, New Zealand, 9:13-18.

Smith, R.F., Dobson, H., 1990. Effect of preslaughter experience on behaviour, plasma cortisol and muscle pH in farmed red deer. Vet. Rec. 126:155-158.

Thériez, M., 1988. Elevage et alimentation du cerf. 1) Caractéristiques physiologiques, besoin alimentaires et élevage des adultes. INRA Prod. Anim. 1:319-330.

Thériez, M., 1989. Elevage et alimentation du cerf (*Cervus elaphus*). 2) Elevage des jeunes et production de viande. INRA Prod. Anim. 2:105-116.

Waas, J.R., Ingram, J.R., Matthews, L.R., 1997. Physiological responses of red deer (*Cervus elaphus*) to conditions experienced during road transport. Physiol. Behav. 61:931-938.

Weeks, C.A., 2000. Transport of deer: A review with particular relevance to red deer (*Cervus elaphus*). Anim. Welfare 9:63-74.

Whittington, C.J., Chamove, A.S., 1995. Effects of visual cover on farmed red deer behaviour. Appl. Anim. Behav. Sci. 45:309-314.

Wilson, P.R., Stafford, K.J., 2002. Welfare of farmed deer in New Zealand. 2. Velvet antler removal. New Zeal. Vet. J. 50:221-227.