The importance of social behaviour for goat welfare in livestock farming

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Abstract

The domestic goat is a sociable, inquisitive, and intelligent species, which has been used for its meat, milk, skin, and fur since it was first domesticated c. 10,000 years ago. Although it exhibits a wide range of behaviours, the domesticated goat has been the subject of relatively few behavioural studies. In domestic goats, the opportunity to express certain social behaviours can be limited by captivity and management systems, especially in modern production systems, where goats are reared intensively under high stocking densities, sexual segregation, early separation of kids from their mothers, frequent regrouping, and manipulation during critical periods, including gestation and weaning. To better understand the requirements of this species and to identify possible tools for the detection of early modifications in natural behaviours that might indicate poor welfare and the establishment of positive human-animal interactions, this review provides a detailed description of goat social behaviour. Practical recommendations arising from observations of goat social behaviour are provided in the conclusions.

Keywords: Goat; Welfare; Social behaviour; Social organization; Social dominance; Human-animal relationships.

1. Introduction

Domesticated about 10,000 years ago (Mason, 1984; Zeder and Hesse, 2000), goats were probably the first ruminant livestock species (Hatziminaoglou and Boyazoglu, 2004). Changes in the availability or accessibility of space, food, water, and shelter, exposure to risk of predation, and changes in the social environment often accompany the transition from living free to captivity. Those changes set the stage for the development of the domestic phenotype (Price, 1999). During domestication, many of the behavioural traits of the wild types were replaced by those found in existing domesticated populations

(Mignon-Grasteau et al., 2005) and goats evolved domestic traits that enabled them to live and reproduce in captivity (Gautier, 1990). Present-day domesticated goats are the product of those adaptations, the artificial selection by breeders for specific traits in meat, milk, and fur, and the effect of natural selection for fitness under variable conditions (Galal, 2005).

Small ruminant livestock occur widely, including many developing countries, which use traditional extensive production systems designed to meet the needs of the families. In the more developed countries, to be more efficient and to increase production, the systems are changing from traditional to semi-intensive or intensive conditions (Miranda-de la Lama et al, 2010). With the intensification of animal production systems, the animal's way of life has become progressively artificial. Animal nutrition, reproduction, and diseases have been the subject of considerable research; however, the development of efficient management techniques that optimize production and high standards of animal welfare requires a better understanding of the mechanisms of goat behaviour (Bouissou, 1980).

Behaviour is one of the most important early indicators of the welfare of an individual and its adaptation to its environment and reflects the immediate response to the interaction between the animal and its environment (Metz and Wierenga, 1997). Social behaviour can vary considerably in response to different environmental factors because it evolved to allow adaptations to specific environments (Mattiello, 2001). The social behaviour of small ruminant species has been studied, but much of the research has focused on sheep because, of its ubiquity; however, goat behaviour is quite different from sheep behaviour. In general, goats are more reactive than are sheep, because they are more aggressive (e.g., when they are attacked, goats tend to face the attacker, but sheep usually flee) and they

exhibit more exploratory behaviours, whereas sheep are more fearful and shy (Kilgour and Dalton, 1984; Houpt, 2005). To better understand the specific requirements for ensuring sufficiently good welfare for goats, especially for those in intensive production systems, this review provides a detailed description of the social behaviour of the caprines.

2. Principles of social behaviour

Social behaviour is all of the interactions between two or more individuals in a group that modify the activity of the group (Fraser and Broom, 1990) and that cover the function of intra-specific communication (Immelmann, 1988). The motivation to perform a behaviour depends on the interactions between internal and external factors that involve feedback control mechanisms (Galindo et al., 2000). Physiological, environmental, and behavioural mechanisms that serve to maintain the balance in the relationships within a group that otherwise would be transitory or null regulate social activity (Mendl and Held, 2001).

The social group is part of the complex, dynamic environment of the individual (Mendl and Deag, 1995), in which many strategies have evolved to enhance survival and maintain the viability of the group (Mendl and Held, 2001). Social behaviour serves many purposes, including group cohesion and ecological integration (Fraser and Broom, 1990), and provides a number of advantages (Immelmann, 1988), such as better protection from predators, more efficient foraging, easier potential access to sexual partners, and more successful defence of neonates (e.g., Jarman, 1974; Hunter and Skinner, 1998; Estevez et al., 2007), which is why most ungulate species exhibit a high level of social organization (Mattiello, 2001). However, living in a group can have costs, particularly, competition for

food or access to other resources, which can lower the fitness of individuals (Estevez et al., 2007).

3. Communication

Social relationships among individuals in a group can be conveyed by a variety of communication signals (Immelmann, 1988). Communication plays a key role in the development and maintenance of social behaviours. For example, communication is essential for the recognition of individuals within the group, locating other group members, sending signals intended to establish or maintain an individual's social status, or informing other animals about one’s temporary state (e.g., receptivity to males by fertile females) (Immelmann, 1988). The recognition of a familiar individual and the formation of a social memory are essential to the development of social bonds (Lim and Young, 2006).

In goats, more than in sheep, olfactory signals are important, especially in sexual and maternal behaviour (Levy et al., 2004). For example, the "buck effect" is stimulated mainly through olfactory cues (Gelez and Fabre - Nys, 2004). Urine is one of the main vectors for signals of individual identity and goats frequently urinate, especially when expressing their reproductive status. In addition, they secrete olfactory signals through pedal glands and a tail gland. Typically, volatile odorants are perceived by the olfactory epithelium and non-volatile substances (pheromones) can be perceived with the aid of the vomeronasal organ (or Jacobson's organ) by performing the flehmen behaviour, which is typical of the males of all ruminant species, including goats (Houpt, 2005; Wakabayashi et al., 2002).

An olfactory learning process is the primary basis for the development of the relationship between dam and their kids (Poindron et al., 2007a), although an additional role of visual and/or auditory stimuli during the sensitive period cannot be excluded (Poindron et al., 2007b). Romeyer et al. (1994) found that damage to the main olfactory system before parturition inhibited the formation of selective nursing bonds and Houpt (2005) reported that a week-old kid subjected to open castration was rejected by his mother, possibly because of the smell of the fresh wound. In livestock systems where kids are nursed by their dams, to limit odour contamination, manipulation of newborn or young kids should be performed with caution in order to minimize the risk that a kid will be rejected by its mother, taking into account that visual characteristics of the young are probably not able to compensate for the loss of olfactory cues (Romeyer et al., 1994).

Goats are a vociferous (Lenhardt, 1977) and exhibit a variety of vocalizations including snorts, bleats, and sneezes (Kilgour and Dalton, 1984). Vocal signals (e.g., distress calls and isolation bleats emitted by kids) are important in the establishment of the mother-infant relationship and are helpful to mothers in locating the lying-out site of their kid (Poindron et al., 2003). Vocalisations by goats are indicators of social isolation (Boivin and Braadstad, 1996). Alarm vocalizations consist of high-pitched sneezes, which are often accompanied by visual signals such as stamping, although the latter seem to be of lesser importance to goats (Houpt, 2005). During the season of sexual activity, bucks vocalize more frequently, but there is no evidence that these vocalizations stimulate sexual activity in anoestrous females (Vielma et al., 2008).

Olfactory, vocal, and visual signals from females are important to bucks in detecting oestrus females. Signs that indicate females are in heat are more pronounced in goats than

they are in sheep (Sevi et al., 2009), possibly because: there is sexual segregation among goats and females might have to attract bucks from a distance, whereas in flocks of sheep signals from females can be less obvious.

4. Social organization

Goats are very gregarious, prefer to stay close together, and individuals are rarely seen apart from the group (Ross and Berg, 1956). In goats that have been isolated from their social group, cortisol concentrations are elevated, which reflects an increase in emotional stress (Kannan et al., 2002). Furthermore, in pregnant goats, isolation is stressful and can affect the hypothalamic-pituitary-adrenocortical axis and the sympatho-adrenomedullary system of their offspring (Duvaux-Ponter et al., 2003; Roussel et al., 2005). However, the temporary isolation of individuals from their group is a common practice in goat farm management (Price and Thos, 1980). Whenever it is possible, that practice should be avoided or minimized, especially in pre-parturient goats. If, for the purpose of hygiene, dams have to be isolated from the group just before they are due to give birth, it is better to create small groups (only pre-parturient dams) or to keep isolated dams in individual pens, but allow them the opportunity to maintain olfactory, vocal, and visual contact with other goats in their group, which can will minimize the negative effects of social isolation on dams and their offspring.

Once the structure of goat social groups is established, it persists for several years (Barroso et al., 2000; Rout et al., 2002). As in the studies of other ruminants, those that described the social organization of caprines were based on physical structure, social structure, and group cohesion (Broom, 1981).

4.1 Physical structure

The physical structure of a group includes its size and some of the characteristics of individuals, such as their age, sex, and parentage (Fraser and Broom, 1990). In extensive systems, the size of the herd is influenced by the characteristics of the ecological niche that the animals occupy (Houpt, 2004). In open habitats such as savannas and pastures, ungulate group sizes are generally larger than they are in forested or brush areas (Schaal, 1982; Putman, 1988). Among feral goats, the average group size is about 4 (range = 1-150) (Shakleton and Shank, 1984), and in some European populations, group sizes can vary from 50 to 100 individuals (Alados and Escós, 1996). In Australia, Blackshaw et al. (2003) recorded group sizes of up to 300 individuals. Typically, goatherds are smaller than sheep flocks and are composed of extended family groups (Kilgour and Dalton, 1984). Thus, it advisable to avoid creating large groups of goat, although the most appropriate group size is largely dependent on environmental conditions and the herd management strategies.

The physical structure consists of several minor familiar units composed of two or three adult females and their kids, who remain with their mothers from birth until 11-12 mo of age (Fabre - Nys, 1999), although changes in the mother-infant relationship (e.g., a progressive reduction in the amount of suckling and an increase in kid rejection) can occur much earlier (Bungo et al., 1998). The first 2-4 h after parturition (i.e., the sensitive period) are essential for the establishment of the relationship between a mother and her kid (Poindron et al., 2007a). Results from earlier research (Bordi et al., 1994) showed that maternal selectivity in goats is developed within 4 h after parturition. The mother-offspring relationship can be split into three phases: 1) 0-1 wk: *ad libitum* sucking and complete dependence on the dam; 2) 2-5 wk: the kid remains largely dependent on milk

for food, but the dam starts to reject solicitations to suckle and rejections increase in frequency; 3) > 5 wk: the kid becomes less dependent on milk and begins to eat other foods (Bungo et al., 1998). One potential problem with the early weaning of kids is that they might not have sufficient time to learn appropriate grazing strategies from their dams (Boivin and Braadstad, 1996).

Typically, in the first four weeks after parturition, contact between a kid and its mother is infrequent and, until after this period, mother-kid behaviours are not well synchronised (Lickliter, 1987), which is typical of species that use a "hider" strategy to protect newborns from predators. In contrast, sheep use a "follower" strategy for the defence of newborns and mother and infant behaviours are highly synchronized. Kids tend to associate and form bonds with other kids of the same age, rather than with their mothers (Lickliter, 1987). In goats, the formation of "crèches" is the first sign of a weakening in the mother-young bond (Shackleton and Shank, 1984). A crèche forms when juveniles of different ages and both sexes coalesce into large groups that do not include their mothers (O´Brien, 1984a; 1984b; 1988).

If the practice on a commercial farm is to have the kids suckled by their mother (typical in extensive systems), to allow the proper development of the mother-offspring bond it is important to avoid disturbing the animals during the sensitive period. In those systems, kids are separated from their mothers within the first few weeks, even though under natural conditions kids normally remain with their mothers for a much longer period. As the kids become more independent after the age of 5 wk (Bungo et al., 1998), weaning should not occur before 6-7 wk of age, in order to increase the likelihood of a normal behavioural development and good animal welfare. However, in commercial dairy farms,

the mother-infant bond is interrupted much earlier: in these farms, separation from the dam is usually accomplished soon after birth and, in any case, within the first two days after birth, in order to set aside milk for commercial purposes. In these cases a sudden weaning, consisting of a rapid and complete separation of the couple, is advisable, as the persistence of fragmentary contacts (for example due to restricted suckling twice a day) may be frustrating for the kid, that will continuously look for its nursing mother, sometimes showing evidence of abnormal oral behaviour (Mattiello et al., 2008a). Ramírez et al., 1996a and 1996b demonstrated that an immediate separation, preventing any contact between the dam and the kid, will inhibit all maternal responses, whereas a separation carried out after 5 minutes post-partum seems to be sufficient to allow the establishment of some bond, although maternal responses completely disappear after a separation period of 24 h. However, the kids' behavioural response (consisting of high levels of activity and frequent call rates) can persist for several days after weaning (Boivin and Braastad, 1996). Weaned kids may also experience a reduction in growth rates, often losing body weight; furthermore, chronic responses such as the development of stereotypies and abnormal oral behaviours are common consequences of early removal from the mother (Newberry and Swanson, 2008; Atasoglu et al., 2008). Goat is a "hider" species, and therefore the maintenance of a constant mother-infant relationship early in life is probably less important than in "follower" species; however, both behavioural and productive data indicate that the separation of kids from their mothers is a stressful event for this species, as well as for most other mammal species.

Other aspects of the physical structure of the group can vary in response to several extrinsic factors. For instance, in temperate climates, females and males remain together throughout the year (Côte, 2000; Houpt, 2004), but in the non-breeding period, females are usually segregated from males, which are isolated or form satellite herds (Blackshaw

et al., 2003). Sheep, a more promiscuous species, always tend to maintain mixed-sex groups throughout the year (Sevi and Casamassima, 2009). In feral goats, apparently, the main factor influencing sexual segregation is the difference in the activity rhythms of the sexes, although other factors (e.g., predation, forage quality, and social preferences) probably contribute to this phenomenon (Calhim et al., 2006).

For management purposes, the separation of bucks from does outside the breeding season is advisable and their introduction into groups of females is useful as a stimulus for the onset of synchronised ovulations (Buck Effect). In situations where artificial insemination is used, female contact with bucks is not required, which can have negative consequences for females (because of the absence of the natural Buck Effect and, in some cases, does might have to be induced artificially to enter heat), and males, especially when semen has to be collected in the non-breeding season. In that case, occasional contact with an oestrus doe might be helpful in stimulating sexual activity in bucks (Kilgour and Dalton, 1984). In addition, reproductive factors can influence the composition of groups. Before the breeding season, many small groups of females search for potential mates (O´Brien, 1984a; Fabre - Nys, 1999) and, once a male joins a group, a subgroup of females and their kids is established (Blackshaw et al., 2003).

4.2 Social structure

The social structure of a group is "all of the relationships among individuals in the group and their consequences for spatial distribution and behavioural interactions" (Fraser and Broom, 1990). In small ruminants, several mechanisms of recognition and communication signals maintain the social structure of groups. Short inter-individual distances within a group are essential for maintaining social contact and enabling individual recognition

through those signals and, therefore, intra-group distances are shorter than inter-group distances (Clutton-Brock et al., 1982). For instance, Arnold and Dudzinski (1978) observed that two herds with different origins living in the same pasture formed two distinct groups that grazed in different areas.

Social distances are affected by the quality of social bonds and the ages at which goats are placed in groups. Distances between dyads of amicable goats are shorter than those between dyads of antagonistic goats, and the average distance between dyads of goats that were grouped as juveniles are shorter than the distances between the dyads of goats that were grouped as adults (Aschwanden et al., 2008). Within a group, the activities of individuals often are highly synchronized. Under ideal conditions of social stability and animal welfare, 90% of the individuals in the herd are engaged in the same activity simultaneously (Arnold and Dudzinsky, 1978) because of social facilitation, which is an increase in the frequency or intensity of responses, or the initiation of a particular response, when shown in the presence of others engaged in the same behaviour at the same time (Clayton, 1978).

The social facilitation of reproductive activities occurs in feral goats (Restall et al., 1995): oestrous females can induce anoestrous females to ovulate (the Female–female Effect). Other examples of social facilitation are involved in feeding behaviour: in farmed goats, Van et al. (2007) found that an increase in the number of kids in a pen led to an increase in daily individual DM intake (g/Kg BW), which is interpreted as result of social facilitation (Houpt, 2005). Shrader et al. (2007) observed that, when more goats are in the same pasture, individual intake rates increased, possibly because of an increase in competition for food or the amount of social information. In addition, goats are able to

access social information from other animals and can use it to locate better foraging areas (Shrader et al., 2007), which is evidence that social facilitation can have a strong influence on the likelihood that an individual will sample plants or other foods that are eaten by other members in the group (Ralphs and Provenza, 1999).

4.3 Group cohesion

Group cohesion is reflected in the duration of associations among the members of the group and the frequency of fissions (one or more members leave the group) (Fraser and Broom, 1990), and it can be affected by the degree of kinship and the origin of the animals. Cohesion is a result of all of the forces that act to keep individuals in a group and is a measure of the attractiveness of the group to its members (see review by Taube-Schiff et al., 2007). Schwarz and Sambraus (1997) observed in groups of kid goats a marked sense of group cohesion. In stable groups, goats develop affinity and affiliative relationships, which increase the cohesion of the group and decrease the frequency of agonistic interactions. Miranda-de la Lama (2005) interpreted the behaviour of a goat that interrupted a fight between two group members as an affiliative interaction. Social mediation by a group member appears to be more frequent when the levels of aggression are high (Tønnesen et al., 2008). In addition, Shino (1998) found evidence of post-conflict reconciliation in domesticated goats. Such interactions are interpreted as reconciliatory because they appear to repair relationships that were damaged by conflicts and they help to maintain group cohesion.

5. Intra-specific relationships

Group structure is established and maintained by the agonistic and affiliative social interactions among individuals.

5.1 Agonistic behaviour

In all social species, agonistic behaviour is necessary for the establishment and maintenance of dominance relationships in a group (Blanchard et al., 1993). Agonistic behaviour has the biological function to influences an individual's access to vital resources, such as food, water, shelter, and space. In addition, it can influence access to reproductive partners (although in male goats, levels of aggression do not appear to be related to testosterone levels (Ortiz - de Montellano et al., 2006). Agonistic behaviour is intended to dissuade, injure, cause pain, or reduce the freedom of an individual (Sisto, 2004). In social groups, individuals often experience some type of threat from conspecifics.

In goats, agonistic behaviour can be expressed as aggression with contact, e.g., biting, bumping, or aggression without contact, e.g. threat displays, chases, escapes (Alvarez et al., 2003; Miranda de la Lama, 2005; Alvarez et al., 2007; Tölü and Savaş, 2007; Van et al., 2007). During feeding, aggressive postures in goats can include side-on locking of horns, butting the flank of another feeding goat, and ear biting (Syme and Syme, 1979; Szabo, 2008). When a conflict between goats escalates, the typical aggressive behaviour involves one goat standing up on its hind legs, lowering its head, and striking it against its opponent's head.

In intensive goat production systems, the levels of aggression are higher than they are in semi-intensive or extensive farming systems (Orgeur et al., 1990). Barroso et al. (2000) found that the frequency of aggressive interactions was higher among goats that were kept indoors than among goats in pastures, probably because of differences in the amount of

space available, which was more limited indoors. Thus, the per capita space provided to goats is critical in goat management, especially in systems in which the animals are penned. Recommended stocking densities are influenced by factors such as the age, breed, and class of stock. In general, for adult goats housed indoors, 1.5 m^2/head is appropriate (Kilgour and Dalton, 1984). Loretz et al. (2004) detected a significant reduction in the amount of time that individuals spent feeding when per capita space was reduced from 2 to 1 m^2/head. In addition, a reduction in the per capita feeding space along a feed trough from reduced from 20 to 10 cm/head led to a significant reduction in the amount of time spent feeding. Feed trough length and the frequency of aggressive behaviour are strongly negatively correlated. To avoid unnecessary aggression for competition, per capita trough space should be sufficient to allow all animals' unfettered access to food.

In situations where individual distances were reduced and goats had fewer opportunities to perform butting activity, biting became a more frequent means for goats to maintain individual distances (Tölü and Savaş, 2007). In a study by Pretorius (1970), in groups of goats of heterogeneous weights, the light animals performed very few aggressive acts, but the frequency of aggression among the same animals increased when the weights of the individuals in groups were homogenous.

Typically, just after they are born, kids do not exhibit aggressive behaviour and their relationship with their mothers and their twin usually is quite amicable; however, they can be attacked by adult goats if, for example, they try to approach other mothers or mature bucks (Hafez et al., 1969). Under some circumstances, e.g., when attempting to gain access to desirable food such as Jackfruit (*Artocarpus heterophylllus*), kids can become rather aggressive, and they are more aggressive than are lambs of the same age (Van et al.,

2007). Furthermore, group size can have a significant effect on the expression of agonistic behaviour: This appears to be an effect of density, rather than group size, per se, but group size did not have an effect on growth rate or feed conversion rate (Van et al., 2007).

After repeated regrouping, aggression can increase and feeding and resting times decrease (Andersen et al., 2008). Similarly, when goats were repeatedly regrouped, Sondresen et al. (2008) found evidence of chronic stress, such as increased aggression and reduced production rate. In French Alpine breed, Fernandez et al. (2007) observed an increase in aggressive behaviour whenever goats were regrouped, but milk production decreased after the first regrouping, only, which suggests that goats have a remarkable capacity to adapt to novelty and management practices that are stressful to them. The introduction of an unfamiliar individual into a group of feral goats initially led to an increase in the number of interactions, including exploratory and agonistic behaviours; however, aggressive interactions decreased dramatically 24 h after the introduction of the new individual (Alley and Fordham, 1994). Similarly, Addison and Baker (1982) observed an increase in agonistic behaviours (displacements, threats, and butts) in a goatherd after the introduction of two new animals, which was followed by a progressive reduction in the frequency of these behaviours.

In summary, the common practice of regrouping can have negative consequences for goat welfare because it interrupts the process of individual recognition, which is a basic requirement for maintaining group cohesion and stability (Millman and Duncan, 2001). The introduction of new goats to herds can increase aggression, disrupt the social structure of an established herd, and alter the social hierarchy of the group (Addison and Baker, 1982; Andersen et al., 2008). For those reasons, we recommend against repeated

regrouping in goat management. To minimize the stress on individuals, groups should be kept as stable as possible and the introduction of new individuals should be monitored closely because the integration of unfamiliar animals into a group always is a stressful event for goats (Sevi et al., 2009). Whenever it is possible, to minimize the level of aggression, visual familiarization should precede any opportunity for physical contact (for example, by penning the new individual adjacent to its future group). When unfamiliar animals are added, an increase in the space provided to the group might help to minimize the increase in the levels of aggression.

5.2 Affiliative behaviour

Affiliative behaviours facilitate the establishment of bonds of affinity and association between individuals. In goats, affiliative behaviour improves group cohesion, creates or strengthens bonds between group members, and reduces aggression (Shino, 1998; Miranda-de la Lama, 2005; Tønnesen et al., 2008). Common affiliative behaviours include grooming, sniffing, licking the base of the udder, and resting in pairs. On farms where there are space restrictions, however, Andersen and Bøe (2007) found that goats preferred to rest against a wall, with no body contact with other individuals. Miranda-de la Lama and Galindo (2007) found that high-ranking individuals used affiliative behaviour more often than did low-ranking individuals. Tønnesen et al. (2008) observed that the frequency of affiliative interactions (e.g., social grooming, exploring, and resting with body contact) and group size were negatively correlated, which suggests that affiliative behaviour has an effect on the quality of social interactions within a group. Evidently, allowing and encouraging the animals to perform behaviours that are associated with positive emotions improves their welfare (Špinka, 2006).

5.3 Social dominance

Social dominance is the ability of an individual to have priority over others for access to resources (e.g., food, water, space, mates), with a limited need to fight (Francis, 1988; Mendl and Deag, 1995; Fabre - Nys, 2000). In goats, social dominance is clearly established and quite stable, and a nearly linear hierarchical order exists in a herd (Barroso et al., 2000; Rout et al., 2002; Miranda-de la Lama, 2005). The establishment of the dominance order in goats is influenced by the aggressiveness (Rout et al., 2002; Szabo, 2008), age, size, body weight (Keil and Sambraus, 1996; Shinde et al., 2004), breed, sex, parentage, experience, the presence of horns, horn length (Kilgur and Dalton, 1984; Barroso et al., 2000), and individual differences (Miranda-de la Lama, 2005). The manner in which individuals establish and maintain their hierarchical relationships can differ depending on the individual's hierarchical rank. In one study, Miranda-de la Lama and Galindo (2007) found that low-ranking female goats usually receive, rather than initiate, any type of aggression; i.e., use a passive strategy, while high-ranking goats tended to frequently engage in passive and active affiliative interactions. Usually, males are dominant over females, but a female with horns can dominate a male without horns (Haenlein et al., 1992). In general, horned goats are heavier than and dominant over the others and they occupy more space at the feed trough than do hornless goats (Tölü et al., 2007). Furthermore, horned goats are more aggressive (Loretz et al., 2004). For those reasons, we recommend that horned and hornless goats be housed separately whenever possible.

Dominant goats tend to produce dominant offspring (Haenlein et al., 1992), although mothers always maintain a dominant position over their kids (Kilgur and Dalton, 1984). Ortiz - de Montellano et al. (2006) found that dominant bucks had higher levels of

testosterone than did subordinate bucks, but in the breeding season only. At 6 mo of age, goats first assume their position in the social hierarchy (Orgeur et al., 1990) and, in the absence of the introduction of new individuals, they tend to maintain this position year after year (Syme and Syme, 1979). Apparently, changes in the physical environment do not affect the stability of the dominance hierarchy. In a study of female Saanen goats, the hierarchical order before and after environmental enrichment was highly (98%) correlated (Pinal, 2004).

When new members are introduced into a group, the social structure is altered, temporarily, and the linear social hierarchy of the group is disrupted (Addison and Baker, 1982). In goats, rank is very important for gaining access to resources, e.g., food. Matsuzawa and Hagiya (1991) found that high-ranking goats gained access to more food than did low-ranking individuals. Thus, to insure that all individuals, regardless of rank, attain sufficient access to food, the animals need to be provided with adequate feeding space. In goats, social dominance can be positively correlated with some measures of productivity including body mass gain, fur production (mohair goats), and milk output (Pretorius, 1970; Patón et al., 1995). Repeated aggression and displacements by dominant animals can cause subordinate goats to lose up to 10% of their body mass (Houpt, 2004). Individual milk production can vary with social position, but the relationship is not always linear. In Spanish breeds (Malagueña, Serrana, Granadina), medium-ranking goats produced more milk than did high- and low-ranking goats (Barroso et al., 2000).

Alvarez et al. (2003) observed that high-ranking female spent more time in proximity to the buck and ovulated earlier than did low-ranking individuals. In mountain goats, dominant females had higher reproductive success than did subordinates (Côté and Festa-

Bianchet, 2001). In their study of social dominance and the responses to oestrous synchronisation and superovulatory treatments, Ungerfeld et al. (2007) concluded that social rank did not influence significantly conception rate or litter size. In the non-breeding season, however, hierarchical position can affect the number of *corpus luteum* that developed. In a study of social dominance and susceptibility to disease, Ungerfeld and Correa (2007) showed that gastrointestinal parasitic faecal egg counts increased more slowly in high-ranking females than in medium- or low-ranking individuals, which might have resulted from reduced immune function in subordinate individuals caused by social stress.

5.4. Leadership

Leadership is the ability of an animal to influence the affiliative movements and activities of its group mates (Bouissou et al., 2001). All herding animals show leader-follower behaviour in a variety of social circumstances. Leadership is "social" when it involves controlling aggression and apparent altruism, such as the protection of other members when the group is faced with a threat, and it is "spatial," when it refers to group movements (Syme and Syme, 1979).

A leader should possess three permanent qualities: experience, the confidence of the group, and the ability to lead in the search for resources such as food, water, and shelter. In goats, as in other species, leadership is strongly influenced by experience, and not necessarily by dominance rank (Escos et al., 1993). Gorecki and Wojtowski (2004) evaluated leadership at the entrance of a milking parlour and found that, dominant individuals preceded subordinates through the entrance. Donaldson et al. (1967, cited by Syme and Syme, 1979) reported that younger goats entered the milking shed before older

animals entered. Margetínovà et al. (2003) observed a significant effect of age and level of milk production on the milking order. Indeed, the order of access to the milking parlour seemed to be affected mainly by individual milk yield. Although the relationship between milk yield and age can vary greatly among breeds and regions, milk yield is usually higher in young animals (Crepaldi et al., 1999).

Leadership seems to be less well defined in goats than it is in sheep. Sheep move in a compact flock and follow a single leader, but goat herds move forming a thin line when alarmed or chased and, in a mixed-species herd, goats usually show their higher level of independence by leading sheep (Hafez et al., 1969). The presence of leaders in goat herds is particularly important in extensive grazing systems: some old and experienced goat should always be present to lead the herd to the best feeding sites. In large herds, it is possible that more than one goat assumes the leadership in turn. Leader animals can be provided with bells, which are quite useful for helping the shepherd to find his animals when the visibility is poor and for helping other goats to locate the leaders and, thereby, maintaining good group cohesion (Borelli et al., 1996).

6. Human-goat relationships

As herding animals, goats need to establish some sort of social relationship and, as in many other herding species, they can develop strong bonds with humans. Gentling is a form of positive physical attention that serves to calm the animal and increases the affinity for a healthy animal-human bond, which in turn can have a positive effect on body weight, behaviour, quality and amount of milk produced, and the overall health of the animal (e.g., Hemsworth et al., 2000). Research on various livestock species has shown that gentled animals have shorter avoidance distances (Le Neindre et al., 1996; Lensink et

al., 2000). Boivin and Bradstaad (1996) observed that gentled kids were calmer, more easily approached by humans and, when isolated, were less frightened than were non-gentled kids. In Italy, Mattiello et al. (2008b) observed shorter avoidance distances in goats that were reared in small old farms than in large modern farms. That difference might have been due to the closer relationships between the farmer and each individual goat on the small farm, which was possible because of the smaller number of animals on these farms. Furthermore, the old farms had a very low level of mechanization and, consequently, every operation had to be performed manually by the farmers, which frequently brought them in close contact with the animals. Habituation to humans by goats caused by frequent manipulation of the goats during daily activities might have played a role in improving the quality of the human-animal relationships.

In a study of dairy goats, Jackson and Hackett (2007) found a significant increase in heart girth (a correlate of body weight) in dairy goats after a short gentling treatment (only 10 min/d for 24 d); however, gentling did not have a significant effect on milk quality (fat and protein concentrations). Lyons et al. (1988a) found that goats exhibited marked individual differences in their attitude towards humans. Behavioural and pituitary-adrenal responses provide a means of distinguishing between bold and timid kid goats; however, a goat's experience can influence the attitude of a goat towards humans. The importance of early contact with humans and gentling treatments on the establishment of the human-animal bond has been studied in many ungulate species, and positive, early contact can improve this relationship and result in tamer animals, which exhibit less fear and, therefore, are easier to handle (Hemsworth and Coleman, 1998).

In goats, a taming effect was evident when hand-reared and dam-reared kids were compared and dam-reared goats exhibited greater avoidance distances from humans and were more fearful than were human-reared goats, although these behavioural differences were not accompanied by significant differences in heart rate (Lyons and Price, 1987). Le Neindre et al. (1996) found that young animals that were not exposed to human handling were more fearful and sometimes aggressive towards its caretaker. Lyons et al. (1988b) concluded that genetic factors and early postnatal environments are responsible for individual temperament, including its attitude towards humans, which largely persists throughout the lifetime of the animal. Lyons (1989) observed that adult dairy goats that had been dam-reared were more reactive to novel stimuli and exhibited higher levels of milk ejection impairment (greater residual milk volumes) than did human-reared goats. However, Boivin and Braadstad (1996) reported that artificial feeding is not a sufficient to tame kids goats and if kids are gentled, the age of the kid at the time of gentling seems to play a role in the quality and persistence of the human-animal relationship. Hand-reared kids handled gently for 2 wk from the age of 1 wk (immediately after weaning) were tamer than hand-reared kids gentled in the same manner from the age of six weeks. To facilitate handling practices, increase production, and improve animal welfare, we recommend positive daily contact between the stockperson and the goats, starting when the animals are very young.

7. Conclusions

In domesticated goats, captivity and management practices, especially in intensive production systems, can limit the opportunity to express social behaviours. Limitations of space, changes in feeding practices, regrouping, and animal manipulations during sensitive periods such as weaning and gestation, can prevent animals from expressing

their natural behaviour, which can induce stress-related reactions. Under those circumstances, competition for resources increases and the social structure of the group can become unstable. Based on the observations of goat social behaviour discussed above, we propose the following practical recommendations:

1. Stocking densities should be carefully evaluated, especially in intensive management systems, and animal age, size, and class of stock should be taken into consideration.
2. Group size is largely dependent on environmental conditions and on the experience and ability of the caretaker. In general, small groups should be preferred to large groups.
3. Outside the breeding season, the sexes should be separated. The introduction of a buck into an all-female group can be used to stimulate the onset of synchronised heat.
4. If artificial insemination is used, occasional contact with an oestrus doe might be useful in stimulating sexual activity in the buck.
5. Whenever it is possible, individual animals should not be isolated. If animals have to be isolated for management purposes, it is advisable to provide them with olfactory, vocal, and visual contact with their group members.
6. Groups should be kept stable, repeated regrouping should be avoided, and the introduction of new individuals should be monitored closely, especially in the first 24 h after regrouping.
7. Horned and hornless goats should be kept separate.
8. Feed trough space should be sufficient to guarantee access to food by all individuals, which should limit the amount of aggressive behaviour.

9. If kids are dam-reared, human disturbance and manipulation of the newborn during the sensitive period should be minimised. Weaning is a stressful event and it should not occur before 6-7 wk of age.
10. In extensive grazing systems, an old and experienced goat is beneficial for leading herd movements. To facilitate group cohesion, leaders can be provided with bells.
11. Positive daily contact between humans and goats should be encouraged.

To conclude, we emphasize that, despite the constraints posed by farming systems on the expression of some species-specific behavioural patterns, a thorough understanding of the animal's needs can help farmers to reduce the stress experienced by the animals. The role of the stockperson is extremely important in order to detect early modifications of natural behaviour that might indicate poor welfare (e.g., unusually high levels of aggression, isolated individuals, low levels of activity synchronization) and to help to establish a positive human-animal bond, which can reduce fear and stress-related reactions that may jeopardize animal welfare.

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