KEEPING THE YOUNG ALIVE TO STIMULATE MILK PRODUCTION? DIFFERENCES BETWEEN CATTLE AND SMALL STOCK

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Summary

Opinions diverge on how milk exploitation in prehistoric times should be reflected in mortality profiles of dairy species. The debate has focused on whether the slaughter of the offspring would have enhanced or reduced milk availability for human consumption. This article aims at explaining why, due to differences in the physiology of lactation, the answer may be different for cattle and caprines. The fraction of cisternal milk, available by simple pressure on the udder, compared to alveolar milk, which has to be actively expelled by induction of the ejection reflex, is considerably higher in caprines than in cattle. Induction of milk let down is primordial in cattle to insure both the quantity and quality of milk production, and to maintain lactation, whereas consequences on milk production of inhibition of milk let down are less important in caprines. Moreover, stimulation of caprine females requires considerably less effort than stimulation of a cow, in which the presence of the calf is still necessary in modern poorly improved breeds to initiate milk ejection. This suggests that removal of the young would have seriously compromised the milking of cattle, whereas it would not have precluded it in caprines.

Key Words

Milking, Cattle, Caprines, Cisternal/alveolar milk, Milk ejection reflex.

Résumé

Maintenir le jeune en vie pour stimuler la production laitière? Différences entre les bovins et les caprinés.

Les opinions divergent sur les indices témoignant de l'exploitation du lait à la Préhistoire, dans les profils de mortalité des espèces laitières. La question se pose particulièrement de savoir si l'abattage du jeune aurait augmenté ou au contraire réduit la part du lait disponible pour la consommation humaine. Cet article tente d'expliquer pourquoi, étant donné des différences dans leur physiologie de lactation, il se peut que la réponse à cette question soit différente pour les bovins et les caprinés. La part du lait citernal, disponible par simple pression du pis, par rapport au lait alvéolaire, qui doit être expulsé par déclenchement du réflexe d'éjection, est considérablement plus grande chez les caprinés que chez les bovins. Le déclenchement de la descente du lait est primordial chez la vache pour assurer à la fois la quantité et la qualité de la production de lait, et pour maintenir la lactation, tandis que les conséquences sur la production laitière de l'inhibition du réflexe d'éjection du lait sont moindres chez les caprinés. Par ailleurs, la stimulation des femelles de caprinés demande considérablement moins d'effort que celle de la vache, chez laquelle la présence du veau est encore nécessaire de nos jours chez les races rustiques pour initier le réflexe d'éjection du lait. Tout cela suggère que l'enlèvement du jeune aurait sérieusement compromis la traite de la vache, tandis qu'il n'aurait pas empêché celle des caprinés.

Mots clés

Traite, Bovins, Caprinés, Lait citernal/alvéolaire, Réflexe d'éjection du lait.

Archaeozoological recognition of milk exploitation in the mortality pattern of dairy species has been forcefully debated. A question most frequently raised is whether the slaughter of the young would have enhanced or reduced milk availability for human consumption. Payne's mortality model for optimized milk production in sheep and goat (Payne, 1973), based on the assumption that the young, who competes with the herder for milk consumption, should not be kept alive, has been widely applied not only to caprines, but also to cattle. Against application of this model to cattle, it has been argued that in primitive breeds, the slaughter of the young might have seriously compromised removal of milk by the herder, due to inhibition of milk let down (Clutton-Brock, 1981, 1989; Entwistle & Grant, 1989; McCormick, 1992; Peske, 1994; Tresset, 1996; Balasse *et al.*, 2000).

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The negative effect of removal of the young immediately after birth on establishment of lactation has been observed by physiologists and herders (Halstead, 1998; Marnet & McKusick, 2001): rupture of the mother-young bond has a very strong effect on regulation of hormones involved in lactation. The necessity of preserving this bond at least for a short period after birth is widely acknowledged, although the duration of this period is still debated (Halstead, 1998). The necessity of keeping the young once lactation has been established remains questioned (Halstead, 1998). It is striking to observe that a clear distinction has not been made between the three dairy species most frequently involved in the debate: cow, sheep and goat. The consequences of early slaughter of the young on milk production might not be the same for cattle and small stock, whose physiology of lactation, especially the mechanisms of storage of milk in the mammary gland, differs.

In this paper I would like to address the following questions: (1) why is it important to induce the milk ejection reflex, *i.e.* what would be the consequences for milk production of inhibition of the reflex, and *would the consequences be the same in cow, sheep and goat?* (2) How easy is it to induce milk let down when the young has been removed, *and is it equally easy in cow, sheep and goat?*

Storage of milk in the mammary gland: the cisternal and alveolar fractions of milk

Full understanding of the importance of induction of the milk ejection reflex implies basic knowledge of the mechanisms of storage of milk in the mammary gland. The secretory unit of the mammary gland, the alveolus, consists of a cluster of lactocyte cells specialized in milk synthesis, surrounding a cavity, the lumen, in which milk is temporarily stored before transfer to larger storage regions near the teat (Labussière, 1999; Caja *et al.*, 2000). Transfer of milk via the lactiferous ducts occurs only during suckling in certain species like rat, rabbit or pig, whereas in species with large cisterns, including ewe, goat and cow, transfer occurs also between suckling or milking sessions and can be stored in the teat (Labussière, 1999). Milk stored in the lumen is referred to as alveolar milk. Milk stored in the gland and teat cisterns is referred to as cisternal milk.

Cisternal milk is obtainable immediately by action of suckling or milking. Alveolar milk is retained in the mammary gland by capillary forces and has to be actively expelled from the lumen by induction of the milk ejection reflex. In response to a nervous stimulus in the teat by the suckling of the offspring, or by milking, the hormone oxytocin is released and transported to the mammary gland, where it causes contraction of the cells surrounding the alveoli. The alveolar lumen is flattened and milk is ejected to the cistern (Labussière, 1999; Lollivier *et al.*, 2002).

In the natural conditions of the feeding of the offspring, milk let down is induced by the suckling and butting action of the young. Visual and auditory contacts have also been shown to be important stimuli in the ewe and the cow (Labussière, 1999). Oxytocin release is highly influenced by environmental factors. Inhibition of the milk ejection reflex is observed in case of stress (fright). Adrenaline injection has been shown to cause suppression of oxytocin release and the milk ejection reflex in cows (Davis *et al.*, 1998).

Importance of induction of the milk ejection reflex for the quantity, quality and maintenance of milk production

Failure to initiate milk ejection does not preclude collection of cisternal milk, but leads to the loss of the alveolar fraction of milk production. Partitioning of milk accumulation between alveolar and cisternal fractions, and the dynamics of the filling of the cisterns, have been the subject of intense research related to dairy production, in order to determine optimal milking intervals, and to improve the effectiveness of machine removal of milk (Peaker & Blatchford, 1988). From this research it emerged that there is a marked difference in milk partitioning between cows and caprines. The relative proportion of cisternal milk is higher than 75% in goats (Peaker & Blatchford, 1988; Marnet & McKusick, 2001), varies from 40 to 75% in ewes (Caja *et al.*, 1999; Rovai *et al.*, 2000; Marnet & McKusick, 2001; McKusick *et al.*, 2002), and is less than 20% in cows (Knight *et al.*, 1994; Bruckmaier *et al.*, 1994; Pfeilsticker *et al.*, 1996; Davis *et al.*, 1998). These figures, obtained on dairy breeds, vary with the breed (Rovai *et al.*, 2000) and lactation phase (Knight *et al.*, 1994), and get higher with lactation number (Bruckmaier *et al.*, 1994). Establishment of the milk ejection reflex is therefore of primordial importance especially in cattle, in which failure to collect the alveolar fraction of the milk would cause the loss of 80% of the total production. This loss would represent 25 to 60% of milk production in sheep and less than 25% in goat.

The partition between alveolar and cisternal milk also corresponds to a partition in milk quality. Alveolar milk is fatter than cisternal milk. As much as 70 to 75% of milk fat is contained in the alveolar fraction in small ruminants (Labussière, 1988; McKusick *et al.*, 2002). Alveolar milk has been shown to be three times as fat as cisternal milk in cattle (Davis *et al.*, 1998). However, partitioning does not affect the protein percentage of milk. The large fat glob-

ules have to be expelled actively from the alveoli, whereas the smaller casein micelles presumably pass freely to the cisterns (McKusick *et al.*, 2002). Non-removal of the alveolar fraction of milk production implies, therefore, the loss of an essential quality of milk: its lipid content.

Inducing milk ejection is also important for maintenance of lactation. To avoid over-production, milk synthesis is regulated by milk removal. Prolonged absence of milk ejection, meaning prolonged incomplete removal of milk from the udder, can have a negative feedback action on milk secretion and eventually reduce milk production (Knight *et al.*, 1998; Marnet *et al.*, 2001; Lollivier *et al.*, 2002). Consistent absence of the reflex has been shown to induce a loss of 35% of total milk yield in ewes (Labussière, 1988). The consequences, however, are not as serious in small stock as in cattle, due to differences both in the relative size of cisternal versus alveolar compartments and in the dynamics of the filling of the cistern. In sheep and goat, non-ejected alveolar milk will soon be removed by passive transfer to the emptied cistern: Peaker & Blatchford (1988) have shown that, in the goat, cisternal filling occurs immediately after emptying. In the case of repeated non-ejection of milk, part of the production can be lost, but the risk of inhibition of secretion is less. In cattle, due to the high proportion of milk stored in the alveoli versus milk stored in the cistern (80: 20), only a small fraction of non-ejected milk will eventually be transferred to the cistern. Moreover transfer will not be really effective until 4 hours after emptying of the cistern (Knight *et al.*, 1994). Stagnation of milk in the alveoli will seriously disturb milk secretion, and eventually provoke cessation of secretion.

Inducing milk ejection is therefore of fundamental importance to insure both the quantity and the quality of milk production, and to maintain lactation. However, marked differences do exist between cattle and small stock. Failure to provoke milk ejection would seriously compromise exploitation of the milk of cattle, whereas the consequences would be more limited in small stock. In the former, the amount of milk available at milking would be dramatically reduced, and repeated incomplete emptying of the udder would even lead to cessation of milk secretion; in the latter, the proportion of production lost would be less, especially in goat, and might even be negligible compared to the part otherwise reserved for the raising of the young if this one was to be kept alive.

Even if they apply to a lesser extent to caprines, the negative consequences of inhibition of the milk let down cannot be denied. The question now arises of the herder's ability to induce the milk ejection reflex when the young has been removed.

Is the herder as good as the offspring in inducing milk ejection in cattle and small stock?

In modern dairy breeds, the milk ejection may be facilitated by milking routine: the ejection reflex is conditioned by entry into the milking parlour, distribution of food, drinking, or the sound of buckets (Labussière, 1999). In these days of automated milking, however, physiologists are still working on the best way to assure maximum removal of milk from the udder and are facing some difficulties especially with cattle. Milking in unfamiliar surroundings has been shown to block oxytocin release in dairy cows (Bruckmaier *et al.*, 1994). Any change in the milking routine, including change in housing or pasture, or mixing with another herd, might provoke a considerable drop in milk yield in cattle (Labussière, 1999). This underlines how sensitive the environmental conditions are, in which removal of milk can be processed without the presence of the offspring. It is true that milking performance is related to housing and feeding conditions (Halstead, 1998). Rather than demonstrating how easy it is to initiate milk ejection when environmental conditions are good, however, this tends to show how much more difficult it can be when conditions are poor, even today with modern dairy breeds. Stimulation by allowing the calf to suckle before machine milking is still required in certain cases to induce milk let down, for example in *Bos indicus* x *Bos taurus* crossed breeds in the tropical American lowlands (Combellas *et al.*, 2003). Caprines more readily give their milk to the machine than cattle, which generally require a greater effort for stimulation (Marnet, pers. comm. 2003).

Automated milking may not be the best example of the herder-animal bond during milking. Traditional manual milking of poorly improved breeds is still performed in France. In the case of the Salers and Aubrac cattle breeds, it is simply impossible to get the milk without the presence of the calf (Bonal *et al.*, 1985; Bruhnes Delamare, 1987; Bouvier, 1993). The presence of the calf during milking of the cow is observed nowadays in Africa, Europe, Asia and South America (Balasse *et al.*, 2000). The practice has been described in great detail for African pastoral societies (Huntingford, 1953; Krige, 1957; Dupiré, 1962; Klima, 1970; Goldschmidt, 1976; Boutrais, 1978; Bernus, 1981; Touré & Arpaillange, 1986; Bernardet, 1988; Evans-Pritchard, 1994). Most of the time the calf is first allowed to suckle for a while, then visual contact between the female and offspring is maintained during milking (milk ejection is not complete with induction of the reflex at the start of milking; stimulation is required throughout the entire process to continue milk

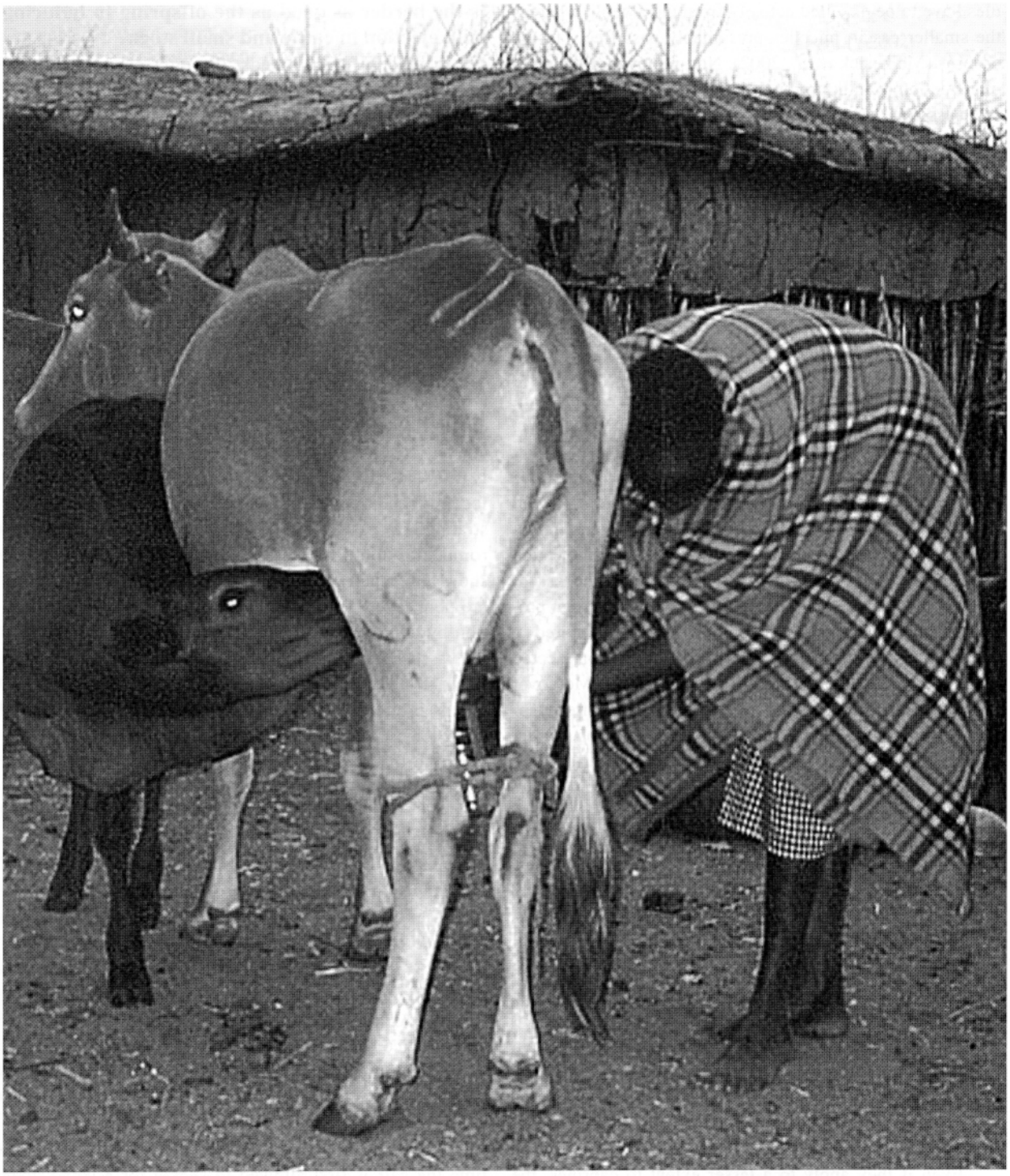

Fig. 1 : Morning milking of a cow by a Maasai woman in the Central Rift Valley of Kenya (Olengoluo, June 2001). Milking and suckling occur at the same time. Presence of the calf is required to initiate the milk ejection reflex (©Marie Balasse).

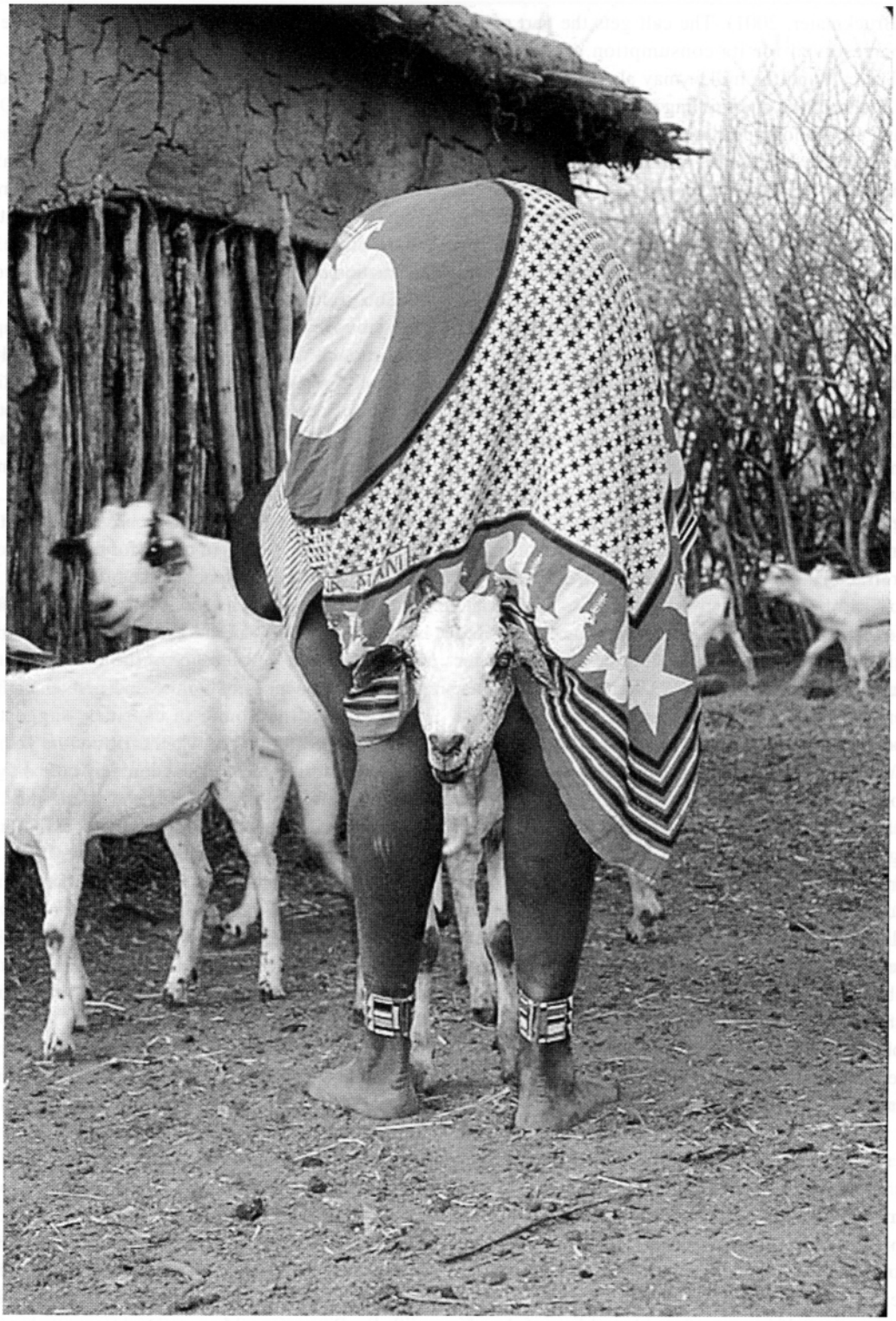

Fig. 2 : Milking of a goat by a Maasai woman in the Central Rift Valley of Kenya (Olengoluo, June 2002). Presence of the kid is not required to initiate the milk ejection reflex (©Marie Balasse).