Factors controlling maternal behaviour and mutual mother-young recognition in the parturient goat

P. POINDRON (1), H. HERNÁNDEZ (1), M.L. NAVARRO (2), J.A. DELGADILLO (3)
(1) Centro de Neurobiología, UNAM, AP 1-1141, Querétaro, 76 001, QRO, México
(2) FESC, UNAM, Carretera Cuautitlán-Teoloyucan Km. 2.5, Cuautitlán-Izcalli 54 700, Edo México.
(3) Departamento de Ciencias Médico Veterinarias Universidad Autónoma Antonio Narro, Periférico y Carretera a Santa Fe, Torreon, Coah. México.

RÉSUMÉ

Les chèvres donnent naissance à des jeunes qui initialement ne suivent pas leur mère, mais se cachent en attendant son retour périodique, à l'inverse des ovins. Cependant, les mécanismes d'activation du comportement maternel et d'établissement d'un lien sélectif sont similaires dans les deux espèces. Le comportement maternel s'établit pendant une période sensible, indiquant l'existence d'une activation de la motivation maternelle par des facteurs physiologiques associés à la parturition. Si le rôle des stéroides ovariens reste à démontrer, des résultats récents suggèrent que la stimulation vaginocervicale causée par l'expulsion du foetus est un facteur important. Elle facilite également la formation du lien maternel sélectif grâce à la mémorisation de l'odeur individuelle du chevreau. Il est bien établi que le marquage olfactif du chevreau par sa mère n'est pas nécessaire pour son allaitement sélectif. Enfin, les chèvres sont capables de reconnaitre leur jeune par d'autres sens que l'olfaction dès le premier jour postpartum, et le chevreau nouveau-né est aussi capable de reconnaître sa mère dès 12 hrs après sa naissance. Il en découle une relation mère-jeune exclusive caractérisée pendant la lactation par des rythmes d'allaitement similaires à ceux décrits chez les ovins.

SUMMARY

Although goats give birth to young that initially show a phase of hiding behaviour, the factors controlling the onset of maternal behaviour at parturition and the formation of a selective bond with their kid appear similar to those reported in sheep, that give birth to follower neonates. Maternal behaviour is established during a sensitive period, which indicates the existence of an activation of maternal behaviour by physiological factors associated with parturition. While the role of ovarian steroids still remains to be demonstrated, there is growing evidence showing that the vaginocervical stimulation caused by foetus expulsion is an important factor. It also facilitates the formation of a selective bond with the neonate through memorisation of its individual smell. It is now well established that maternal olfactory labelling is not a requisite for recognition or selective acceptance of the kid at nursing. Finally, we have found that mothers can recognise their kids by other means than olfaction on the first day postpartum, and also that kids are able to recognise their dam within 12 hrs after birth. This leads to the development of an exclusive mother-young relationship characterised during lactation by suckling rhythms very similar to those reported in sheep.

BACKGROUND

Most domestic ungulates rapidly develop a strong and exclusive maternal bond with their young within a few hours after parturition. The presence of such a bond is generally considered as an important element to ensure survival of the progeny, a fact that has been well documented in sheep (Stevens *et al.*, 1982; Alexander *et al.*, 1983; Nowak and Lindsay, 1992). However, bonding is a secondary event in the development of maternal behaviour at the time of parturition, and is conditioned by a more general behavioural state, that is maternal responsiveness or receptivity towards any neonate. The failure to show this initial step of maternal behaviour can also by itself lead to early postnatal mortality (Putu *et al.*, 1986; Poindron *et al.*, 1993). A good understanding of the factors that activate maternal behaviour and control the establishment of an exclusive mother-young bond can therefore be useful to reduce the risks of early postnatal mortality and promote better management and fostering techniques. But while a number of studies have been carried out in sheep, very little data is available in the goat and results are sometimes contradictory. Early studies (Hersher *et al.*, 1963; Klopfer *et al.*, 1964; Klopfer and Gamble, 1966) suggested that the factors controlling the onset of maternal behaviour were quite similar in both species. Nevertheless, it is only in sheep that extensive studies have been carried out (Poindron *et al.*, 1993; Lévy *et al.*, 1996), probably partly because in most western countries goats are used exclusively for dairy purposes and therefore are separated from their kid immediately after parturition. However, this was not sustained by later studies about the mechanisms of maternal behaviour activation (Rosenblatt and Siegel, 1981). Similarly, it has been proposed that mother-young recognition could depend on processes different from those reported in sheep (Gubernick, 1981; Lickliter and Heron, 1984), possibly in relation with the fact that newborn lambs and kids have different locomotion strategies in the first days of their life (Lent, 1974; O'Brien, 1983, 1984). Now, the comparison of the literature with more recent results (Romeyer and Poindron, 1992; Romeyer *et al.*, 1993, 1994a,b; Navarro, unpublished) allow us to propose a more integrative vision of the factors that control the activation of maternal behaviour and the development of mutual recognition in goats.

THE ACTIVATION OF MATERNAL BEHAVIOUR AT PARTURITION.

Goats are not spontaneously maternal when presented with a neonate. Non-pregnant non-lactating goats generally show rejection towards alien kids (Rosenblatt and Siegel, 1981). In addition, after parturition their ability to show maternal behaviour (assessed by the presence of licking, maternal bleats, acceptance at the udder and absence of aggression) disappears rapidly if they are not maintained in contact with the neonate (Hersher *et al.*, 1963; Klopfer *et al.*, 1964). By contrast, a short contact with the kid immediately after its birth allows the mother to maintain her receptivity, indicating that a sensitive period exists at that time, during which the presence of the neonate is critical for the later maintenance of maternal behaviour. In addition, the duration of this sensitive period is shorter in primiparous inexperienced mothers than in multiparous ones (Lickliter, 1982). Considering these results together with those existing in sheep and other mammals (Rosenblatt and Siegel, 1981; Poindron *et al.*, 1993), the presence of such a sensitive period is a strong indication that some internal factors associated with parturition are involved in the activation of maternal behaviour in goats.

Nevertheless, intents to induce maternal behaviour in non-pregnant non-lactating goats with ovarian steroids have failed (Rosenblatt and Siegel, 1981), contrary to what has been found in sheep (Poindron and Le Neindre, 1980). Whether this is due to an absence of action of estradiol, or to an inadequate hormonal treatment is not known. To our knowledge, attempts to investigate the importance of the sequence of administration of progesterone and estradiol, or the participation of additional hormonal factors reported in other mammals (e.g. oxytocin, prolactin, opiates), have not been carried out so far.

On the other hand, recent studies in our laboratory have provided evidence that the vaginocervical stimulation caused by the expulsion of the foetus may be an important factor in the immediate activation of maternal behaviour at parturition. The onset of maternal behaviour was compared in parturient Nubian and Alpine goats receiving a peridural anaesthesia either at the first signs of labour (Experimental group; 6 primiparous and 3 multiparous), or at the end of the parturition process, just before expulsion (control group; 6 primiparous and 6 multiparous). The methodology was similar to that used in previous studies in sheep (Krehbiel et al., 1987; Lévy *et al.*, 1992). No clear-cut effect was found on the overall proportion of mothers showing maternal behaviour during the first 30 min. after expulsion (56% vs.

75% for early and late peridural respectively, Fisher exact $p > 0.05$). Nevertheless, the frequency of maternal bleats was lower in the early peridural group than in the late peridural group (median and inter-quartile range: 8, 2-24, vs. 33, 8-246 respectively, $p = 0.05$, Mann-Whitney test). Also, the median for the onset of licking tended to be higher in the experimental group (750 sec., 310-1801 vs 78 sec., 1-1300; $p = 0.08$, Mann-Whitney). Finally, the strongest evidence for a facilitation of maternal behaviour by vaginocervical stimulation (VCS) came from the effect of artificial VCS applied after recovery of the peridural anaesthesia in some mothers that had failed to show maternal behaviour at parturition. This stimulation was carried out in non-maternal dams, after they had regained motor control of their hinge legs, between one and three hours after the anaesthesia. Out of the 7 dams stimulated (5 min. of artificially VCS), 4 showed maternal behaviour within 30 minutes following the stimulation ($p = 0.06$, Sign test). All variables indicative of maternal behaviour (latency and duration of licking, emission of maternal bleats, frequency and duration of nursing) were significantly higher or tended to be so following VCS than during the equivalent period of time immediately preceding the stimulation. In one dam, the effects of VCs were quite spectacular, the mother starting to emit low pitched bleats before the end of the VCS, licking the kid less than 2 min after being released and nursing it within 20 min., whereas she was aggressive towards it before the stimulation. In summary, these results indicate that VCS is probably an important determinant of maternal behaviour at parturition, but that the experimental design we used is not the best to demonstrate this effect. Interestingly, the same appears to apply to the control of selectivity (see below).

MOTHER-YOUNG RECOGNITION AND SELECTIVE NURSING

Recognition of the kid and selective nursing by the mother. It is well established that mother goats are rapidly able to discriminate their own young from alien ones. Indeed, it has been proposed that 5 to 10 min. of contact are sufficient for dams to reject alien kids when presented one hour later (Hersher *et al.,* 1963; Klopfer *et al.,* 1964; Gubernick, 1981). Although these results have to be taken with caution, due to the rather artificial situation in which they have been obtained (a very short contact at birth followed by one-hour separation), they illustrate the strong tendency of the mother to spontaneously bond to her young. In a more natural situation (continuous mother-young contact) selective nursing is clearly established within 2 hrs postpartum, even when the alien kid is also a newborn (Romeyer and Poindron, 1992; Romeyer *et al.,* 1994a). The establishment of selective nursing depends on the perception of some olfactory cues provided by the kid, since suppressing the sense of smell in the dam before parturition results in sustained acceptance of alien kids at the udder (Klopfer and Gamble 1966; Romeyer *et al.,* 1994b, Hernandez *et al.,* 1999). On the other hand, there has been some controversy about the nature of the odour used by the dam to recognise her kid(s). Work by Gubernick (1981) suggested that the mother labelled her kid through licking and colostrum, thus accepting kids labelled with her own odour or kids that are not labelled, and rejecting kids labelled with odours of alien does. Nevertheless, more recent studies have demonstrated that labelling is not necessary for maternal acceptance of the own kid. Furthermore, alien unlabelled kids are not accepted by a mother that had 2 hours of continuous contact with her own young (Romeyer *et al.,* 1993). Rather, the mother learns the individual smell of each kid of her litter, as in sheep (Romeyer *et al.,* 1994c). This is also congruent with the fact that in goats selective nursing is controlled by VCS (Romeyer *et al.,* 1994a), which in sheep has been shown to facilitate memorisation of the smell of the young (Lévy *et al.,* 1996). Nevertheless, as for the action of peridural anaesthesia on the onset of maternal behaviour, it seems that artificial VCS does not result in effects as clear-cut as those reported in the ewe.

While olfaction plays a major role in selective nursing, this does not exclude that dams are probably also able to recognise their kid using visual or acoustic cues, even on the first day postpartum. We have found for example that mothers are able to show a significant preference for their own kid in a two choice test already at 12hrs after parturition, as also do sheep (Poindron *et al.,* 1998; Terrazas *et al.,* 1999). This is true even though the mothers cannot get closer than one meter from the kids, a distance which is known to be sufficient to impede perception of the individual smell of the young, at least in sheep (Alexander and Shillito, 1977). According to a preliminary study comparing sonograms of kids' bleats, it would be unlikely that does are able to discriminate their young on the basis of vocalisations, since individual differences do not appear before the 4th day of the kid's life (Lenhardt, 1977). Nevertheless these results would need to be confirmed on a larger number of cases, as well as by performing play back experiments.

Recognition of the dam by the kid. Data concerning the capacity of the kid to recognise its dam is scarce. Lickliter and Heron (1984) found that 2-days old kids already showed a significant preference for their dam against an alien female of the same flock in a double choice situation. As no similar results had been reported in sheep at the time, it was thought this could be related with the fact that new-born kids hide and wait for their mother to return during the first days of their life, while lambs follow her from the very beginning. More recently, using also a double choice situation between two mothers of about the same postpartum "age" (see Nowak *et al.,* 1987 for details of procedure), we have even been able to show that kids spend significantly more time with their dam already at 12 hrs postpartum. But such a performance is probably not related to the early hiding behaviour of the young, since similar results have also been reported in sheep (Nowak *et al.,* 1987; Nowak, 1991). At this stage, the sensory cues involved in early recognition of the doe by the kid remain unknown, even though individual differences in the sonograms of dams have been reported (Ruiz-Miranda et al., 1993) and pelage pigmentation appears of some importance at later stages of the relation (Ruiz-Miranda, 1993).

CONCLUSIONS

Overall, the factors that control the onset of maternal behaviour in goats appear quite similar to those previously reported in sheep. Vaginocervical stimulation is likely to be responsible for the immediate manifestation of maternal care following expulsion of the foetus. The greater variability of the effects due to the suppression of VCS compared to those found in the ewe could be due to differences in the relative importance of this factor in the two species. However, this would not explain the large variation found between individual goats. This may be better explained by a greater variability in the innervating of the genital tract in goats than in sheep, a fact that has been also reported for the innervating of the mammary gland (Labussière, 1993). As the effects of VCS are generally influenced by gonadal steroids, it is likely that these hormonal factors are also involved in the control of maternal behaviour activation, even though this remains to be established. Also, the factors controlling maternal selectivity and mutual recognition between the dam and her young are similar in both species, which may be interesting for the realisation of adoptions in meat producing flocks, taking advantage of the knowledge available in sheep. This also raises the question of whether the selectivity of maternal behaviour may be a factor limiting milk production, as it seems to be the case in some beef or double purpose breeds of cattle. From the first studies we carried out in dairy goat breeds (see Hernandez et al., this congress), it does not seem to be the case. Nevertheless, it would be interesting to investigate this point in traditional systems using non-dairy or double purpose breeds.

ACKNOWLEDGEMENTS

Part of the investigation results mentioned here was obtained with the help of DGAPA PAPIIT Grant IN212796 (UNAM). H. Hernandez was supported by a Ph.D. Scholarship from CONACyT, Mexico.

Alexander G., Shillito, 1977 Appl. Anim. Ethol. 3: 127-135
Alexander G. *et al.*, 1983. Appl. Anim. Ethol. 10: 301-317
Gubernick, D.J., 1981. Anim. Behav. 29: 305-306
Hernandez H. *et al.*, 1999. Proc. XIV Nat. Meet. Caprinocultura, Montecillo, México, pp 153-158.
Hersher L. *et al.*, 1963. In "Maternal Behavior in Mammals", Rheingold HL Eds., J. Wiley N.Y., pp203-232
Klopfer P.H. and Gamble, 1966. Zietschr. Tierspsych. 23: 588-592
Klopfer P.H. *et al.*, 1964. Proc. Nat. Acad. Sci. USA, 52: 911-914
Krehbiel D. *et al.*, 1987. Physiol. Behav. 40: 463-472
Labussière J., 1993. In "Biologie de la Lactation", J. Martinet and L.M. Houdebine Eds., INRA/INSERM, Paris. pp. 259-318
Lenhardt M.L., 1977. Appl. Anim. Ethol. 3: 211-220.

Lent P.C., 1974. In "The behavior of Ungulates and its relation to management", Volume 1, V. Geist and F. Walther Eds., IUCN, New series, 24: 14-55
Lévy F. *et al.*, 1992. Behavior. Neurosci. 106: 1-6
Lévy F. *et al.*, 1996. Adv. Stud. Behav. 25: 385-473
Lickliter R.E. 1982. Appl. Anim. Ethol. 8: 537-542
Lickliter R.E. and Heron J.R., 1984. Appl. Anim. Behav. Sci. 12: 187-192.
Nowak R., 1991. Anim. Behav. 42: 357-366
Nowak R. and Lindsay D.R., 1992. Appl. Anim. Behav. Sci. 34: 61-74
Nowak R. *et al.*, 1987. Appl. Anim. Behav. Sci. 17: 263-271
O'Brien P.H., 1983. Appl. Anim. Behav. Sci. 10: 325-339
O'Brien P.H., 1984. Appl. Anim. Behav. Sci. 12: 233-243
Poindron P. and Le Neindre P., 1980. Adv. Stud. Behav. 11: 75-119
Poindron P. et al., 1993. Oxford Rev. Reproductive Biol. 15: 311-364
Poindron P. *et al.*, 1998. Proc. XIII Nat. Cong. Caprinocultura, San Luis Potosi, Mexico, pp.48-66
Putu G.I. *et al.*, 1986. Proc. Austr. Soc. Anim. Prod. 16: 315-318
Romeyer A. and Poindron P., 1992. Behavioural Processes 26: 103-112
Romeyer A. *et al.*, 1993. Anim. Behav. 46: 705-712
Romeyer A. *et al.*, 1994a. Physiol. Behav. 55: 395-400
Romeyer A. *et al.*, 1994b. Physiol. Behav. 56: 693-700
Romeyer A. *et al.*, 1994c. Behaviour 127: 119-139
Rosenblatt J.S. and Siegel H.I., 1981. In "Parental Care in Mammals", D.J. Gubernick and P.H. Klopfer Eds. Plenum Press, N.Y. pp. 13-76
Ruiz-Miranda C.R., 1993. Appl. Anim. Behav. Sci. 36: 317-326
Ruiz-Miranda C.R. *et al.*, 1993. Bioacoustics 5: 99-116
Stevens D. *et al.*, 1982. Appl. Anim. Ethol. 8: 243-252
Terrazas A. *et al.*, 1999. Behavioural Processes 47: 19-29