

Research Reflection

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The cow–calf relationship: from maternal responsiveness to the maternal bond and the possibilities for fostering

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Abstract

The relationship between the cow and calf develops over time after birth. The behavioural mechanisms underlying its development are important and comparisons with other species may increase our understanding. In nature the cow will separate herself from the herd to give birth and then the cow–calf relationship will develop with the ability to recognise each other. While twinning levels are low in cows, they do rear their twin calves. If the calf is lost at or after birth the cow can be responsive towards other calves and in specific circumstances the cow can develop a maternal bond with an alien calf, i.e. foster. In this Research Reflection a distinction is made between the development of, on the one hand, maternal responsiveness (the tendency of the cow to care for a calf which occurs before birth) and, on the other hand, the development of the maternal–filial bond or relationship which is reciprocal, occurs after birth and is characterised by the ability to discriminate the mother's own calf from alien calves. These processes can overlap and the relationship between cow and calf in this 'hider' species is more plastic than in some other mammals. For example, a cow might form an attachment with an alien calf before she gives birth. After the cow has given birth the loss of her own calf may result in the state of maternal responsiveness being maintained, such that developing a maternal bond with one or several appropriate alien calves is possible. Viable fostering techniques are possible. If a maternal relationship to the mother's own calf has developed then fostering will be more difficult. If the cow's relationship with her own calf is not exclusive, and she is in a state of maternal responsiveness then fostering of calves of an appropriate age and status can be achieved.

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On modern dairy farms calves are routinely separated from the cow within the first 24 h after birth. This and other matters concerning herd size and cow and calf welfare are of increasing public concern (Broom, 2013; Agenas, 2017; Busch *et al.*, 2017). When the cow and calf are separated on the first, fourth and seventh day after birth the behavioural responses are more intense and last longer if the separation is delayed and is further prolonged and intensified if visual and auditory contact are maintained (Stehulova *et al.*, 2008). Calf rearing conditions do matter and pair housed calves have a higher performance in cognitive tests at three and seven weeks of age (Gillard, 2014). The study of social networks within group reared calves (Koene and Ipema, 2014) is still in its infancy. The feasibility of maintaining calves with the mother cow in a modern dairy herd is of interest (Johnsen *et al.*, 2016). Fostering additional calves could increase productivity, ease management and improve welfare in some farm contexts.

So, the relationship between the cow and calf and the conditions necessary for its development are important. The behaviour of the dairy cow and calf within the first six hours post-partum in housed conditions (Edwards and Broom, 1982; Broom and Fraser, 2015) and in free range environments (Kiley-Worthington and de la Plain, 1983) are well described. On birth the cow licks her new-born calf removing amniotic fluids, a behaviour that is stimulated by the presence of the amniotic fluids (Edwards, 1983). The first few hours after birth were regarded as important for the development of individual specific maternal bonds after which maternal care was limited to the mother's own young and the rejection of other young. This view developed from early studies with sheep and goats Collias (1956), and the first few hours were regarded as a 'sensitive period' for the development of the maternal filial bond (Hersher *et al.*, 1963). Fostering techniques with sheep and goats that had lost their young at birth, and in experimental contexts where their own lambs or kids were removed were studied. Cross fostering of sheep and goat young using a restraining harness attached to a wall were studied (Hersher *et al.*, 1963). Later experimental work with sheep examined the use of hessian coats, amniotic fluids and artificial odours on the lamb in an attempt to facilitate adoption, (Alexander *et al.*, 1985, 1989; Alexander and Stevens, 1985a, 1985b) with varying degrees of success. These issues need to be revisited and are the subject of this Research Reflection short review.

Hider species

Sheep and goats typically isolate themselves from the flock to give birth, and after birth when the new-born kid or lamb has nursed it lies down and sleeps. Then the mother may leave to graze. However, a tendency for the kid but not the lamb to remain immobile until the mother returns is one of the few features that distinguish the behaviour of the two species (Hersher *et al.*, 1963). Goats, similar to cows, are regarded as 'hider' species while sheep are regarded as a 'follower' species (Lent, 1974) though see Geist (1971) for work with mountain sheep. Indeed, Edwards and Broom (1982) found evidence of this hider tendency in housed cows where calves tend to seek a resting place at the perimeter of the calving pen. This 'hiding' trait may have relevance for the development of the maternal filial bond especially in a fostering context. The development of the mother young relationship in hider species should be slower than in follower species, and one can expect the relationship between the lamb and its mother to develop quickly. As a consequence, attempts at fostering may be more difficult with sheep.

Here the focus will be on two aspects of the cow-calf relationship: first, the development of maternal responsiveness or the orientation of the cow to care for her young and second, the development of the maternal bond/relationship between the cow and calf, with the ability to recognise each other. To understand the distinction between the two processes some landmark studies concerning maternal filial relationships in other species will be reviewed.

Imprinting

Young precocial birds and mammals will shortly after birth respond to a wide variety of objects. The process which restricts the social preferences to a specific object has been extensively studied, especially in birds, and is generally referred to as 'imprinting' (Bateson, 1966, 2017; Sluckin, 1972; Bolhuis, 1991). Attention was drawn to this by Lorenz (1935, 1937) who characterised imprinting as a special form of learning, that took place during a 'critical period' early in life of the young, and when complete the preferences formed were 'irreversible'. Later the term 'sensitive period' was used. Imprinting was measured by exposing young precocial birds (species where the young are relatively mature and mobile from birth or hatching) such as chicks or ducklings in the first few days of life to an inanimate object, such as a coloured ball, suspended in its individual rearing pen. Some hours or days later the chicks preferences for that object was measured usually in a simultaneous choice test, with the familiar ball and an unfamiliar object such as a ball of a different colour or an object of a different shape. The chicks chose the familiar. It was later found that the characteristics of the objects used were important, including its colour and movement. The length of exposure to the object, being allowed to follow the object and the role of sound were all extensively studied (for review see Bateson, 1966). While Lorenz (1935) maintained that the biological function of imprinting was to enable individuals to recognise members of their own species rather than particular individuals, Bateson (1966) did point out that visual imprinting may also be concerned with parental recognition in addition to species recognition. Research on filial imprinting progressed in what was effectively a laboratory setting, in the absence of mother hen. This research produced insights into the behavioural and

neural mechanisms underlying the imprinting process (McCabe, 2019).

Predispositions

It was found that young domestic chicks have an innate preference, or a developing predisposition, to approach a model of a stuffed junglefowl (simulating an adult member of its own species) rather than an inanimate objects in a simultaneous choice test (Johnson *et al.*, 1985; Bolhuis, 1991; Johnson and Bolhuis, 1991; McCabe, 2019). When given a choice between an intact junglefowl and a scrambling or degrading junglefowl there was no preference until the chicks had a version of the fowl that lacked a head. Then, they preferred the stuffed junglefowl. When given a choice between the stuffed jungle fowl, a stuffed Gadwall duck (a different species) or a stuffed Polecat (a potential predator) there was no preference, (Johnson and Horn, 1988). Thus, the configuration of features associated with the head or face region were more important than the details of the features themselves (Johnson and Bolhuis, 1991). The predisposition is not species or even class specific (Bolhuis, 1991). The concern was with the development of a predisposition and not with recognition of a parent. It was concluded that there are at least two perceptual mechanisms underlying the development of filial systems in chicks. A predisposition to respond to the general features of the imprinting object and another that recognises the object. The predisposition is independent of training or exposure to the object, and is completed before the birds were 52 h old (for reviews and discussion see Horn, 1985; Hogan and Bolhuis, 2009; Hogan, 2017; McCabe, 2019). Of general interest is the finding that young when first born have an expectation of the world or an *a priori* knowledge, and are prepared to deal with what one might call ecologically appropriate stimuli. In relation to our species of interest, calves are prepared or predisposed to engage in teat seeking and other appropriate behaviours soon after birth to facilitate their survival (Broom and Fraser, 2015). Can these predispositions inhibit or facilitate behavioural change?

Predispositions and the reversibility of imprinting

Bolhuis and Trooster (1988) compared chicks that had been exposed at day one to either a stuffed jungle fowl or a rotating red box for two hours. They soon preferred the object to which they were exposed in a simultaneous choice test. On day 2 they were exposed to the alternative object for two hours. They were then given a preference test. Chicks initially exposed to the red box now preferred the jungle fowl and the chicks initially exposed to the jungle fowl still preferred the junglefowl. Thus, the earlier imprinting preference was reversible in the group exposed to the red box (what we may call the ecologically irrelevant stimuli). Johnson and Bolhuis (1991) distinguished between general predisposition (colour or shape of object) and specific predisposition (clusters of stimuli). In the experiment of Bolhuis and Trooster (1988), these two mechanisms are engaged, leading to the prediction (Bolhuis, 1991) that imprinting should be reversible when two naturalistic stimuli are used, citing the evidence of Kent (1987a) with live hens. In this study chicks hatched by a live hen which remained with her for the first 3 d of life preferred the familiar hen to a novel hen in a simultaneous choice test after 30 min of separation from mother hen. When subsequently exposed to another live hen for 3 d and tested again they preferred the second hen. The chicks' preference was not very stable as only

four hours separation from the familiar hen, at day three of age, was sufficient for them to lose their ability to discriminate between their own mother and an alien hen (Kent, 1987a). Thus the chicks' relationship with their mother is more plastic than earlier laboratory studies might have envisaged. However, the reader will note that the language of the science has changed as we move from 'imprinting' to the study of 'relationships'. It is interesting to note that the chicks' recognition of their mother hen was based on auditory cues (the hens' maternal cluck vocalisation) and not visual cues (Kent, 1987a, 1989, 1993). To complicate matters further, the hens were unable to discriminate between their own brood of chicks and an alien brood of chicks of a similar colour when the chicks were 3 d old (Kent, 1992a). Further, hens when broody, were aggressive and kept at a greater distance from other hens than in the non-broody state. This demonstrated that the socio-ecological context need to be considered when studying the development and maintenance of the maternal-filial relationship (Kent, 1992b) in fowl, and the same is known to be true of other animals.

From imprinting to relationships and attachments

Hinde (1982) pointed out that despite the many studies of 'imprinting', little was known about the chick's attachment to its natural mother, i.e. the 'relationship'. While progress has been made since 1982 the above work gives an indication of the complexity of the developmental processes and also how the developmental processes are more flexible than previously believed. Insights regarding predispositions, and the effects of maternal separation, have relevance for the study of maternal-filial relationship in the cow.

Even in geese (*Anser anser*), the species which inspired early imprinting studies, there is a growing appreciation of plasticity in the developmental process. The finding in geese that broods were larger than can be produced from a single clutch and the evidence of 'adoption' or 'gang broods' (having more than one set of parents) or 'creche' broods (with a mixture of parents, non-breeding adults and subadults) show that the development of parent young relationship is more complex than previously believed, with the mechanisms remaining unexplained (Kalmbach, 2006).

Ecological aspects of recognition

The study of parent-young recognition in bank swallows (*Riparia riparia*), an altricial species (where the young are incapable of moving around on their own soon after hatching) that nest in large colonies in close proximity to each other is insightful. Cross fostering techniques found that the development of signature calls in the young from age 14 d was crucial in facilitating the parents ability to discriminate own from alien young. Before 14 d of age, alien young transferred into the nest were accepted by adult birds as if they were their own (Beecher, 1981; Beecher *et al.*, 1981a, 1981b). More recent work with jackdaws (*Corvus monedula*), also an altricial species, found that nestlings even at 20 and 28 d old were still equally likely to produce vocal and postural begging responses to parents and nonparental calls though there were some indication that older nestlings do discriminate while still in the nest (Zandberg, *et al.*, 2014). Thus, earlier views that imprinting in birds was fixed to a short period early in life have been tempered by experimental and observational findings. Chicks fail to discriminate between mother and an alien hen after only four hours separation on day three post hatching, yet they are prepared to approach another maternal hen

(Kent, 1987a). There is evidence of adoption and gang brooding in geese (Kalmbach, 2006). While in jackdaws and bank swallows, though their 'imprinting' process occurs later in post hatch development, evidence suggests there is potential for considerable flexibility in the 'imprinting' process. The generality of this flexibility is of importance in the applied farm animal context.

The 'sensitive period'

Bateson and Hinde (1987) made the general point that sensitivity to certain types of experience changes throughout life. The term 'critical period' (Lorenz, 1937) in the imprinting context was defined as a phase of susceptibility preceded and followed by a lack of susceptibility. This view was replaced by the term 'sensitive period' implying a phase of greater susceptibility preceded and followed by lower sensitivity, with more gradual transitions (Bateson and Hinde, 1987). They conclude that the processes that underlie the end of the sensitive period for filial imprinting are different from those responsible for its onset. In the case of filial imprinting, social isolation lengthens the sensitive period (Bateson and Hinde, 1987). In birds that are hatched naked, such as jackdaws and bank swallows (see above) the onset is much later post hatch than in precocial birds such as ducklings or chicks. Age from embryonic development rather than chronological age (age from hatching) was found to be a more reliable indicator of sensitivity to an imprinting stimuli in Peking ducklings (Gottlieb, 1961). This distinction between developmental and chronological age was later utilised to explain the lower levels of behavioural interactions between a cow with twin calves and a cow with a single calf. A single calf has a longer gestational period than twin calves and thus twins are developmentally younger than singles at a given post-partum age (Roy, 1980). Thus one could expect twin calves to be less active than a single in the days after birth, and they are less active (Price, *et al.*, 1985, 1986), though such differences in behaviour need not necessarily indicate a difference in the maternal bond/relationship between the cow and her calf (Kent, 1987b). It should be pointed out that 'relationships' have an elusive quality. We infer the existence of relationships using choice tests or carefully designed observational studies. Behavioural measures can indicate the existence of a relationship but measuring the 'strength' of a relationship is a very different matter.

Bateson developed a model referred to as the 'competitive exclusion' model to explain the ending of the sensitive period. It maintains that imprinting is a preemptive, self-terminating process that narrows the social preferences to those that are familiar and, therefore, tends to prevent fresh experience from further modifying those preferences (Bateson, 1979, 1981). Bateson and Hinde (1987) point out that the concept of a sensitive period does not necessarily imply that the behavioural patterns in question cannot be influenced later in life and they cite evidence where trauma and stress have renewed the plasticity of behaviour, even if under limited circumstances. This should be born in mind when considering the cows response to separation from or the death of her own calf. Stockmen and scientists will be aware of circumstances where the cow does not remain with her calf after birth and such events can unwittingly help our understanding of the developmental processes involved in maternal bond formation. Deprivation studies did yield insights into the processes that underlie the development of normal patterns of behaviour. Maternal deprivation of young monkeys resulted in long term behavioural problems (Harlow and Zimmermann, 1959) showing the importance of post birth contact between mother and young.

Maternal responsiveness and lessons from maternal behaviour in rodents

Changes in behaviour before, during and after parturition were intensively studied in rodents (Rosenblatt and Siegel, 1983; Rosenblatt, 1990) and the findings on the development of maternal responsiveness have application in other species. Maternal responsiveness is the orientation by the parent to approach and interact with stimuli of relevance to a maternal relationship, such as the retrieval of nest building material and young pups not necessarily their own. Maternal responsiveness can develop in pregnant and indeed non pregnant females when exposed to pups in a process called 'sensitisation'. The hormonal correlates of this behaviour have been studied (for review see Rosenblatt and Siegel, 1981, 1983). In general, maternal responsiveness appears late in pregnancy, as in the example of sheep accepting lambs that were not her own before she had given birth (Hersher *et al.*, 1963; Poindron and Le Neindre, 1980; Poindron and Levy, 1990). Cervical stimulation at birth stimulated the onset of maternal behaviour in sheep (Keverne, 1988) and additional cervical stimulation about two hours after parturition facilitated the acceptance of alien lambs (Keverne *et al.*, 1983; Keverne and Kendrick, 1990). However, when rodent pups were removed from the dam at birth, maternal responsiveness to pups in terms of retrieving and nest building was extinguished by two and 4 d respectively. On the other hand, if the pups remained with the mother for some hours after birth then the mother maintained her responsiveness, even after 4 d of separation (for review see Rosenblatt and Siegel, 1983). Thus, experience with the pups after birth, and not just the endocrinological state of the mother, is important for the development and maintenance of maternal responsiveness at a later date. The development of maternal responsiveness is a necessary condition for the development of a maternal relationship, even if the two processes should in some circumstances coincide. We can expect animals, both parent and young, to be predisposed towards certain stimuli that are ecologically appropriate. Stimuli features of the young (e.g. amniotic fluid on the calf at birth) will stimulate grooming by the cow and the cow's body features will facilitate teat seeking in the calf (Broom and Fraser, 2015) and these are relevant to the development of the cow-calf relationship. However, being responsive and being predisposed are different.

The development of the maternal filial bond; the necessity of early mother-young contact

Attachment is a special affectionate relationship between two individuals that is specific in its focus and endures over time. The object of the attachment serves psychological functions which others cannot substitute (Hinde, and Stevenson-Hinde, 1976; Gubernick, 1981). The salient features of such attachments are (a) the formation of a special relationship, with (b) a specific individual (c) towards whom certain behaviours are directed rather than towards other individuals. While the bond is not any of the behaviours, it is inferred from the behaviour. Therefore, while the behaviour might change the attachment is more or less constant and enduring. The strength of a bond cannot be directly measured, though its existence can be inferred as described by Gubernick (1981), who defines maternal attachment as '*the preferential responding between parents and offspring as defined by various operational criteria*'. The operational criteria include the preference for one individual over another, seeking

and maintaining proximity to that figure, a response to brief separation from the attachment figure, a response to extended periods of separation, a response to reunion with the presumed attachment figure and, finally, the use of the attachment figure as a secure base to explore the world.

Maternal attachments have been studied in sheep and goats and the sensory mechanisms involved in recognition were identified. Klopfer *et al.* (1964) compared goats that had their young removed at birth (an 'immediate separation group') to a second group who were permitted five minutes *post-partum* contact with one of its young (the 'prior contact group'). The young were then returned after either one two or three hours of separation. The immediately separated group rejected the kids on their return after only one hour separation while in the five minutes of contact group the mother accepted her kids after three hours of separation. Thus early contact is essential for the development of maternal responsiveness – at birth and after separation. Maternal responsiveness is a prerequisite for the development of the maternal bond. Shortly after birth two processes are engaged; the development of maternal responsiveness and the development of the maternal bond. Earlier work maintained that even five to ten minutes contact after birth was found to be sufficient to establish a maternal bond in goats and sheep (Hersher *et al.*, 1963), and Klopfer *et al.* (1964) extended this to show that five minutes contact enabled goats to discriminate between their own and alien kids. Thus, the goats were both responsive and discriminating – a maternal filial bond had been formed. However in these studies (Hersher *et al.*, 1963; Klopfer *et al.*, 1964) simultaneous choice tests were not employed and the acceptance/rejection criterion used did run the risk of confounding effects of the brief post birth experience on the mother and the young, when responsiveness and bond formation were both developing at the same time.

Maternal filial attachment in goats was viewed as specific, rapidly formed and fairly stable. Later studies questioned this certainty. After two hours post-partum separation multiparous domestic goats displayed maternal caretaking of their kids in contrast to first time mother goats. Thus previous maternal experience increased the probability of maternal responsiveness after *post-partum* deprivation of maternal contact in the multiparous goats (Lickliter, 1982). Further, in a detailed study, mother goats given five minutes post-partum contact with their own kid, followed by one hour of separation generally failed to discriminate between her own and an alien kid in a choice test. The alien kid was accepted if it did not have contact with its own mother and that demonstrates maternal 'imprinting' in goats takes longer than previously reported (Gubernick *et al.*, 1979). This also shows that the status of the alien kid (in terms of the kids relationship with its mother) is important. While the development of maternal bonds are more malleable than might be assumed the processes involved must take account of the state of both participants in the relationship. The kid or calf will itself develop with time and its previous experience is important in a fostering context. Relationships are interactive and each participant will respond to the others behaviour, which in turn is dependent on each other's previous experience.

The cow-calf relationship; towards fostering

Rearing calves with their dams in the dairy cow herd is a current issue and there are challenges that need to be addressed (Johnsen *et al.*, 2016). The behavioural mechanisms underlying the development of the cow-calf relationship is of concern here.

Attempts at fostering calves onto nurse cows have included methods such as introducing the calf to be fostered as soon as possible after the birth of the cow's own calf (Hudson, and Mullord, 1977; Le Neindre *et al.*, 1978; Nicoll, 1982). This is an attempt to avoid the differential responding by the cow towards her own calf and her rejection of alien calves. Smearing the calf to be fostered with amniotic fluids while introducing it to the nurse cow as soon as possible after birth (Hudson, 1977), or blindfolding the cow while smearing the calf with neatsfoot oil or amniotic fluids (Crowley and Darby, 1971; Kiley, 1976; Le Neindre and Garel, 1979) have been used in an attempt to manage the sensory mechanisms involved in recognition. Such techniques involved introducing the additional calf when the cow retained her own calf from birth. The cow will in these circumstances be able to discriminate her own from an alien calf.

These techniques focused on acting quickly before a specific bond was formed. The use of substances can reduce recognition cues. Odour transfer techniques involved the use of a cloth covering on the cow's own calf shortly after birth and then 48–96 h later transferring it to an alien calf. Then the alien calf was substituted for the cow's own calf. This method did facilitate fostering though such techniques require much skill and competent personnel (Dunn, *et al.*, 1987). The use of a hessian sack worn by the calf for 4 d and then transferred to an alien calf was assessed in a cross mothering context with beef calves between five and 16 d old (Herd, 1988). This requires considerable amounts of effort on behalf of the assistant.

These fostering techniques reflect an awareness that the relationship between the cow and calf will have already formed. The competitive exclusion model which maintains that imprinting is a preemptive, self-terminating process and narrows the social preferences to those that are familiar, and prevents fresh experience from further modifying those social preferences (Bateson, 1979, 1981) applies here. The cow has already developed a relationship with her own calf and *vice versa* and the windows of the developmental train in Bateson's (1979) model are closing.

In rodents, though an altricial species, the removal of pups for 4 d after some time with her pups resulted in the mother maintaining her responsiveness (Rosenblatt and Siegel, 1983). In goats given five minutes *post-partum* contact with their own kid, and followed by one hour of separation resulted in the mother goat accepting her own and an alien kid after the one hour separation, provided that the alien kid did not have contact with its own mother (Gubernick *et al.*, 1979). This suggests that the so called 'imprinting' is more plastic than previously believed, because in these studies maternal responsiveness was maintained after the relatively brief separation. The period of separation resulted in the loss of recognition, as Kent (1987a) had found with chicks after 4 h of separation from mother hen.

Kent (1984) used a technique to enable cows to foster calves including her own at 4 d *post-partum*. Briefly and in general the dairy cow spent the first 24 h *post-partum* with her calf. The calf was then removed from the cow for three to 4 d whilst the cow was milked in the dairy herd. Then three to four calves were presented to the cow and her own calf could be among them. When this technique was followed, fostering was possible. While the sample size was small the results are best understood in the light of findings described above. The first 24 h cow–calf contact was important for the development and maintenance of maternal responsiveness in the cow after the three to 4 d of cow–calf separation. Maternal bond formation would have taken place during this 24 h of contact with the calf. After the

separation the cow failed to discriminate between her own calf and an alien calf but she was still responsive to calves. Maternal responsiveness was maintained after the separation in the form of a preparedness to accept calves, including alien calves, of an appropriate developmental state.

Future directions

To understand the development of the cow–calf relationship it is wise to first explore the literature on maternal behaviour with other species. Considerable experimental and observational research has taken place over many years and with different species giving insights into the complex behavioural mechanisms that underlie maternal behaviour. These behavioural mechanisms have evolved over millennia and persist despite selective breeding and domestication. Ideas about sensitive periods did yield fruitful research programmes and the results of these studies should improve our understanding, and help prevent making conceptual errors when designing research programmes, in an applied animal behaviour context.

We have seen that animals are predisposed to approach ecologically appropriate stimuli such as facial-like features of the parent and *post natal* experience is necessary to shape the appropriate responses. Research work on the maternal behaviour of the cow could be described as sparse. This is in part due to the size of these animals that give birth once per year constraining what can be achieved in a research context with a limited number of animals. As seen above, experimental work with chicks did help overcome some economic constraints in testing hypotheses on maternal responsiveness and recognition after separation. Much work needs to be done with cows to first understand the behavioural mechanisms involved in the maternal behaviour and to understand behavioural needs of the cow and the calf and explore the development of fostering techniques that would improve the welfare of the cow and calf and indeed the welfare of those who work with and depend on these animals. For example, one would expect the cow's responsiveness to calves would change at oestrus when the cow's endocrinological profile also changes. Carefully designed non-invasive endocrinological work coupled with well-designed observational studies should yield fruitful insights. Such work should help improve the welfare of the cow and the calf.

Conclusions

An understanding of two behavioural mechanisms that underlie the development of the cow–calf relationship is crucial in a fostering context. The development of maternal responsiveness or the orientation of the cow to care for calves is a necessary condition for fostering and is a characteristic of the pre and post birth period. It is not necessarily exclusive to that period. In dairy cows that have the opportunity to spend time with their calves after birth the cow–calf relationship develops to the exclusion of other calves. However, if the relationship between the cow's own calf is not exclusive due to separation especially in the days shortly after birth, then it is possible that the cow will develop a maternal relationship with one or more calves, and she should remain maternally responsive. Contact between the cow and her calf after birth is necessary and indeed crucial for the development of a maternal relationship with her own calf and for the development of a maternal relationship with other calves after a period of separation from her own calf.

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