The aims of this review are to summarize the common biological basis of the responses to social stimulus in domestic ruminants and to consider the research still required in order to put this knowledge to practical use on the farm. The mechanisms involved in the stimulation of sheep and goat females, including both the expected ovarian and behavioural responses, are described. In most breeds, the male effect may be used effectively to induce ovulation during seasonal anoestrus. Although good responses have been obtained in most sheep trials, in some experiments using more seasonal breeds of sheep, poor responses were observed. In goats, it seems that this can be partially overcome if teaser bucks are adequately stimulated (by light treatment and melatonin administration). The strategic use of these stimuli to induce fertile ovulations during the postpartum period is also discussed. In cattle, less is known about the physiological mechanisms by which cows respond to stimulation from the bull. Most trials have focused in trying to advance postpartum rebreeding, with very diverse outcomes. The wide variety of interacting factors and the paucity of data make it difficult to draw conclusions regarding the use of social stimuli in postpartum management. The challenge for researchers is to develop social management techniques that will induce oestrus and ovulation whenever farmers require them. Although more research is necessary to improve efficacy in some sheep breeds and in postpartum animals, social stimulation emerges as an inexpensive and hormone-free strategy that may be useful for farmers.

Introduction

Reproduction is a consequence of endogenous neuroendocrine regulating mechanisms and external factors that interact with them. Environmental conditions interact with the endogenous system by either stimulating or inhibiting physiological mechanisms and many of these mechanisms are related to the reproductive axis. In ruminants, social cues may act to either stimulate or inhibit reproductive activity. Social hierarchies or suckling are examples of inhibitory cues, which may be considered in management practice. On the other hand, there is considerable evidence that males may stimulate oestrus and ovulation in anoovulatory females: the so called "male effect". Research on the use of the male effect has been increasing recently (Ungerfeld
2005), probably as a consequence of being described as a “clean, green, and ethical” practice (Martin et al. 2004).

The effects of social stimuli on reproductive physiology have been widely demonstrated in rodents and several farm species. In ruminants, several reproductive responses may be obtained in females following male stimulation (as in the male effect: Table 1). Although there is only preliminary information, male stimuli on female reproductive physiology may also exist in caribou, musk deer and camels (Green 1987; Claus et al. 1999; Adams et al. 2001).

Table 1. Ruminant species in which the male effect has been demonstrated and the main effects on the females.

| Species       | Effect                                      | Reference                        |
|---------------|---------------------------------------------|----------------------------------|
| Sheep         | Induction of oestrus in seasonal anoestrus  | Underwood et al. 1944            |
|               | Shortening of postpartum in ewes            | Geytenbeek et al. 1984           |
|               | Advancement of puberty in lambs             | O’Riordan & Hanrahan 1989        |
| Goat          | Induction of oestrus in seasonal anoestrus  | Chemineau 1985                   |
|               | Advancement of puberty in goats             | Mellado et al. 2000              |
|               | Synchronization of puberty onset            | Amoah & Bryant 1984              |
| Cattle        | Advancement of postpartum re-breeding       | Zalesky et al. 1984              |
|               | Advancement of puberty                      | Rekwot et al. 2000               |
| Red deer      | Advancement of the breeding season          | Moore & Cowie 1986               |
| Eld’s deer    | Advancement of oestrus and the LH peak      | Hosack et al. 1999               |
| Fallow deer   | Advancement of the breeding season          | Komers et al. 1999               |
| Reindeer      | Advancement of onset of breeding season     | Shipka et al. 2002               |
| Moose         | Synchronization of the breeding season      | Whittle et al. 2000              |
|               | Induction of ovulation                      | Miquelle 1991                    |
| Antelope      | Modification of oestrous cycle duration     | Skinner et al. 2002              |
| Oryx          | Advancement of puberty                      | Blanvillain et al. 1997          |
| Impala        | Advancement of the breeding season          | Skinner et al. 1992              |
| Blesbok       | Increase in length of breeding season        | Skinner et al. 1992              |

The female reproductive responses to the male effect have been reviewed before (Walkden-Brown et al. 1999; Delgadillo et al. 2004; Ungerfeld et al. 2004a; Delgadillo et al. 2006). In the present review, information regarding the female reproductive responses to male stimulation of sheep and goats during seasonal anoestrus, and sheep, goats and cattle during the postpartum period are compared and summarized and areas in which further research is needed are proposed. In addition new previously unpublished information on sheep and cattle is included.

Male effect: evolutionary advantages

What is the evolutionary origin of the male effect? Seasonal patterns of reproduction should be a consequence of selective processes related to best environmental conditions for parturition and nursing. To measure the appropriate time for conception, animals would then be forced to use different environmental cues such as photoperiod, temperature, rainfall and nutrition. However, social cues may also trigger the onset of the breeding season in wild and feral ruminants. Domestic animals display some differences in their reproductive physiology compared with their wild ancestors. Wild or feral cattle and swine have short breeding seasons compared to their domesticated counterparts, which have been selected to breed throughout the year (Mauger 1981; Rowlands & Weir 1984; Reinhardt et al. 1986). The reproductive pattern of sheep is a bit different: wild sheep have a short breeding season and even the most developed breeds retain a seasonal reproductive pattern.
The high degree of breeding synchrony observed in wild and feral female ruminants may be at least partially a consequence of male introduction and other social interactions. The social structure throughout the year is similar in wild and feral sheep breeds (such as, Soay, Rocky Mountain Bighorn [Ovis canadensis canadensis], Punjab Urial [Ovis orientalis ssp. punjabiensis] and Mouffon), goats and in farmed breeds (Geist 1965; 1971; Grubb & Jewell 1973; Schaller & Mirza 1974; Knight et al. 1998; McClelland 1991). Outside the rutting period, social groups are comprised of several females with their offspring while males live in small same-sex groups (Stricklin & Mench 1987). When male offspring become mature they disperse from the female group (Shackleton & Schank 1984). Wethers (castrated male sheep) remain together or with females (Jewell 1997), suggesting that the testis (probably through androgens) is involved in segregation. As the time of breeding approaches, males join female groups. Nudging, blocking, rubbing and aggressive behaviours (Jewell 1976; Lincoln & Davidson 1977) by males begins before females come into oestrus, probably as a consequence of the earlier activation of the male reproductive system (including, increased pulsatile LH secretion and increased circulating concentrations of both FSH and testosterone: Lincoln & Short 1980). In sheep, natural joining may trigger, through the ram effect, an earlier onset of the breeding season.

The rut period causes an increase in the energy expenditure of males (Jewell 1997). So what is the significance of beginning the reproductive season before females are cyclic? Moreover, what is the sense of having a mechanism where males trigger the female reproductive system? The mechanism may be especially important in breeds that display a very short breeding season (for example, Soay have 1 to 3 oestrous cycles: Grubb & Jewell 1973). Moreover, late conception in Rocky Mountain Bighorn sheep during the breeding season increases lamb and ewe mortality (Hogg et al. 1992). The male stimuli may also promote an advancement of puberty in females, which may increase their reproductive success throughout their lifetime (Bérubé et al. 1999). The period from joining of males and females until the peak of oestrus may also be useful for males to sort out hierarchical ranks. Oestrous synchronization allows different males to mate different females thereby decreasing the risks of inbreeding and the reduction of genotype variation that would result. Komers et al. (1999) working with fallow deer postulated that the onset of females' cyclic activity in response to males is related to the "quality" of males. If so, females may be able to detect the better quality stimulus emitted by individual males and, if advantages may be obtained, advance their cyclic activity. Overall, the available information suggests that there is an evolutionary mechanism underlying the reproductive response of domestic ewes to the introduction of rams. Understanding this mechanism may allow us to manipulate the breeding activity of farmed breeds.

Considering all this information together, we speculate that most ruminant females would respond to the introduction of males at least 45 to 60 days before the onset of the breeding season. However, the challenge for researchers is to develop social managements to induce ovulation and oestrus whenever it is desired, and not only close to the breeding season onset, as happens in wild ruminants.

**Sheep and goats: the basis of anoestrus and endocrine changes induced by males**

Seasonal anoestrus is associated with reduced LH pulsatility compared to the breeding season and with an absence of preovulatory surges of FSH and LH. Low LH pulsatility is due to two inhibitory mechanisms: (1) an increased negative feedback effect of oestradiol in the hypothalamus; and (2) a direct effect of photoperiod on the hypothalamo-hypophyseal system controlling LH secretion.
The introduction of males induces an increase in the pulsatile secretion of LH in ewes and does (reviewed by Walkden-Brown et al. 1999), which may end with a LH surge followed by ovulation. In ewes, it has been demonstrated that after the introduction of the rams the negative oestradiol-LH feedback switches to a positive, stimulatory feedback but there is also a stimulus independent from oestradiol, acting directly at the hypothalamus-pituitary level (Martin et al. 1983). This response ends with a LH surge, similar to that observed during a follicular phase in cyclic ewes. A silent ovulation occurs, without signs of oestrus. When the corpus luteum (or corpora lutea) regresses after the first ovulation, another ovulation accompanied by oestrus occurs 17 to 19 days after the introduction of the rams. However, in some ewes, the corpus luteum regresses after 4 to 5 days and another silent ovulation takes place. After this ovulation, a corpus luteum of normal life span is formed, followed by oestrus 21 to 25 days after joining ewes and rams. Recently, we observed ultrasonographically other ovarian responses, like delayed ovulations occurring 5 to 7 days after the introduction of rams followed by normal or short luteal phases, or luteinized follicles (Ungerfeld et al. 2002; 2004b).

In goats, the ovarian and behavioural responses differ. An initial ovulation associated with oestrus is observed 2 to 3 days after the introduction of bucks, which is followed in most goats by a short ovarian cycle of 5 to 7 days. Afterwards a second ovulation which is also associated with oestrus occurs and is followed by a normal luteal phase (Delgadillo et al. 2004; 2006). Fig. 1A and 1B illustrates the more common patterns of response in sheep and goats, respectively. In Fig. 1C, a synthesis of the expected periods in which oestrus may be expected to occur in sheep flocks and goat herds is shown.

If ewes or does are primed with progestogens and then stimulated by teasers, all the first corpora lutea will have normal function. Although some attempts have been made to determine the physiological mechanisms producing each response pattern (normal versus short luteal phase) little has been elucidated. Studies determining the relationship between the ovarian response pattern with the follicle status present before the introduction of rams (Ungerfeld et al. 2004b), the follicular development after the introduction of rams (Pearce et al. 1987), the uterine effect on early luteolysis (Lassoued et al. 1997) and the possible existence of spontaneous short luteal phases produced by luteinised follicles or short-lived corpora lutea during the anoestrous season (Ferreria et al. 2005) have all failed to provide a definitive answer. A recently published review provides a working hypothesis of the physiological mechanisms involved (Chemineau et al. 2006).

Apparently in Merino sheep, in response to the introduction of the male a normal oestrous cycle will be induced in approximately 50% of the females while the other 50% will have first cycles with short luteal phases (Martin et al. 1986). However, in several experiments with Corriedale ewes we observed very few ewes in oestrus during the first expected period (days 17-19: Ungerfeld et al. 2003; Ungerfeld & Rubianes 2004). Some factors related to the percentage of ewes that initially respond with normal or short luteal phases are summarized in Table 2. Oldham et al. (1985: see Table 2) in sheep and Luna-Orozco et al. (2005) in goats, observed a higher incidence of short luteal phases in adult compared to young females. However, in sheep this has not been confirmed by other researchers (Thimonier et al. 2000). In agreement with Khaldi (1984) and Thimonier et al. (2000), we observed that Corriedale ewes in poor body condition as a consequence of postpartum status, showed delayed oestrous behaviour compared to control animals (25.8 ± 0.3 versus 24.6 ± 0.4 days after the introduction of the rams, P = 0.03; R Ungerfeld, unpublished data), suggesting that first ovulations were delayed or that a higher percentage of ewes responded initially with short luteal phases.
Fig. 1. Ovarian and behavioural response of A) ewes and B) does to the introduction of males. C) Synthetic scheme of the distribution of oestrus after the introduction of males in doe herds and ewe flocks.
Table 2. Factors that influence the length of the first luteal phase after the introduction of rams. NLP = normal luteal phase; SLP = short luteal phase.

| Factor          | Effect                        | Reference                                |
|-----------------|-------------------------------|------------------------------------------|
| Related to the stimuli |                  |                                          |
| High ram's sexual behaviour | Decreases the incidence of SLP   | Perkins & Fitzgerald, 1994               |
| Related to female status |                  |                                          |
| Percentage of cyclic ewes | Decreases the incidence of SLP   | Lassoued, 1998                           |
| Underfed ewes    | Increases the incidence of SLP  | Khalidi & Lassoued, 1991                 |
| Increase of nutritional level | Decreases the incidence of SLP   | Khalidi 1984; Thimonier et al. 2000      |
| Postpartum interval | Longer postpartum interval decreases the incidence of SLP | Thimonier et al. 2000 |
| Parity           | Maiden have a higher percentage of NLP than adult | Oldham et al. 1985 |
| Breed            | More Dorset than Hampshire ewes seem to have SLP | Nugent III et al. 1988 |

Response to the male effect during the postpartum period in sheep and goats

The physiology of postpartum anoestrus is influenced by different factors; such as suckling, season, nutritional status and age. Although this period has not been studied as much as seasonal anoestrus, the male effect has been used to induce breeding during the postpartum period in both sheep and goats.

The postpartum interval may be reduced if rams are introduced to ewes that have lambed in autumn or spring (Wright et al. 1989; Silva and Ungerfeld 2006). In autumn-lambing Merino ewes, it was observed that the percentage of ewes ovulating during the first 4 days after the introduction of the rams increases progressively from 21 to 45 days postpartum (Geytenbeek et al. 1984). In contrast to what happens in cattle, in autumn-lambing ewes, parity does not seem to influence the response to the ram effect. We have recently compared the response to the introduction of rams of multiparous and primiparous non-cyclic ewes during the breeding season (30 to 60 days postpartum) primed with medroxy-progesterone acetate for 12 days. Although the percentage of multiparous ewes that ovulated, which was determined by ultrasound scanning, tended to be higher than that of primiparous ewes (92.5\% versus 79.3\%, P=0.08), the percentage that came into oestrus (88.8\% versus 75.8\%) was not significantly different (SP González-Pensado, MA Ramos, T de Castro & R Ungerfeld, unpublished results).

In one study performed during the non-breeding season, a similar percentage of postpartum ewes and ewes that had lambed several months before exhibited oestrus after the introduction of rams (Ungerfeld et al. 2004a). However, in agreement with Wright et al. (1990), probably as a consequence of suckling and low body condition, the conception rate was lower in the postpartum ewes. In ewes that had lambed during the non-breeding season Khalidi (1984) observed that the percentage of ewes that ovulated after the introduction of rams was higher at 75 days than at 15, 30, 45 or 60 days after parturition. It is interesting that in several experiments we observed a widespread distribution of oestrus, with ewes coming into oestrus on almost any day until 30 days after the introduction of rams. It remains to be elucidated as to how the range of physiological status between individuals present in a sheep flock affects the pattern of endocrine and ovarian responses to the introduction of rams.

Determinants of the response of sheep and goats to the male effect

In feral or wild populations, when males stimulate anoestrous females early before the onset of the breeding season, males have begun their reproductive recovery at least 40 to 60 days
before. Therefore, females are stimulated by active males, which display their own maximum reproductive capacity. However, at the time of the year that may be of productive interest for farmers to induce ovulation and obtain pregnancies in their female flocks/herds, the males may not have recovered their maximum reproductive capacity from the preceding low capacity period. Thus, both the male and the female, and the stimuli derived from interactions between them, may determine the final response in a sheep flock or a goat herd.

Male condition and stimulating capacity

Stimulating signals

The stimulation of anoestrous females by males involves different cues; such as, odour, sound, visual or behavioural signals (reviewed by Walden-Brown et al. 1999; Delgadillo et al. 2006). The relative importance of each signal has varied in different experiments but this may be a consequence of using females in different states of responsiveness. In both sheep and goats, it has been reported that castrated males treated with androgens may be effective teasers suggesting that the involved cues are at least partially androgen-dependent (Fulkerson et al. 1981; Mellado & Hernández 1996).

The scent of wool and wax from intact rams can be enough to trigger a response, in terms of ovulation, in ewes (Knight & Lynch 1980). Similarly, odours from bucks’ hair have been proven to stimulate LH secretion in does and ewes, and ovulation in anoestrous does (Over et al. 1990; Walkden-Brown et al. 1993). Interestingly, odours produced by the goat buck can also stimulate LH pulse frequency and ovulation in anoestrous ewes (Knight et al. 1983; Over et al. 1990). While Morgan et al. (1972) observed that ewes with impaired smell did not respond to rams, a normal LH response was observed in ewes reported without vomeronasal activity (Cohen-Tannoudji et al. 1989). In agreement, Gelez et al. (2004a) demonstrated that inactivation of the neural projections of the main olfactory bulb (which includes projections from the olfactory epithelium) blocks the endocrine response to male odour, whereas inactivation of the projections from the accessory olfactory bulb (which come from the vomeronasal organ) has no effect. The destruction of the neuroreceptors of the olfactory epithelium blocked the endocrine response to the ram odour (Gelez & Fabre-Nys 2004). A general overview of the neural pathways involved in the ewe’s response to male odours has been recently provided by Gelez & Fabre-Nys (2006). They observed that although male odours activate pathways involving the accessory olfactory bulb, its role seems to be limited compared to that of the main olfactory bulb.

The maximum response of anoestrous ewes to the male was obtained after full ram contact compared with either contact through an open or an opaque fence, or the application of masks containing ram’s wool (odour) (Pearce & Oldham 1988). Similarly, a higher percentage of does ovulated after full contact with bucks than after odour stimulation alone (Walkden-Brown et al. 1993). Moreover, in sheep other authors observed that other sensory signals may completely replace the pheromone stimulus (Cohen-Tannoudji et al. 1986; 1989). Perkins & Fitzgerald (1994) demonstrated the importance of the sexual behaviour of rams: a higher number of ewes ovulated after mixing them with high- than with low-serving capacity rams.

Overall, although the main stimulating cues are known, it seems that we are still far from determining the relative importance of each cue and how to manage them, as happens in swine, in which synthetic pheromones are utilized in production management.

Male characteristics and management

Little is known regarding those characteristics of the ram that may improve the percentage of
anoestrous ewes that respond to teasing. Some authors observed that Dorset rams are better teasers than Suffolk, Romney, Romney X Finn or Coopworth rams (see Table 1 in review: Ungerfeld et al. 2004a).

At least under subtropical conditions, the reproductive activity of bucks is strongly depressed during the non-breeding season: plasma testosterone concentrations, sexual behaviour assessed by ano-genital sniffing, nudging and mounts, sexual odour and vocalizations are all at a low level (reviewed by Delgadillo et al. 2006). However, treatments with artificial long days and melatonin implants improve the biostimulatory effect of males. Therefore, these authors consider the reproductive condition of the buck as the limiting factor determining the response of anoestrous does to the male effect.

Another strategy to improve the stimulus of the male effect is to include a group of oestrous females when teasers are joined with anoestrous females (Rodríguez-Iglesias et al. 1991). Ewes in oestrus also influence the reproductive activity of rams, mainly by inducing an increase in LH pulse frequency and testosterone concentrations (Yarney & Sanford 1983). The increases may continue for at least 4 days if ewes in oestrus are still present (Ungerfeld & Silva 2004). While the increase in testosterone concentrations is similar in adult or yearling teaser rams, as happens during the developmental period (Sanford et al. 1982), LH concentrations reach higher values in yearling rams (Ungerfeld 2003). A possible explanation is that although concentrations are similar, testosterone may be less effective in yearling than in adult rams, as is reflected by a weak effect on the inhibition of pituitary activity. This may be attributed to an increase of feedback inhibition by androgens on the hypothalamo-pituitary axis during the developmental period (Foster et al. 1978) and/or to the maturation of the negative feedback mechanism (Courot et al. 1975). Therefore, as stimulating signals are related to androgen concentration, we compared the response of ewes to adult or yearling teasers. Significantly more ewes came into oestrus and ovulated after teasing with adult rather than with yearling teasers (MA Ramos & R Ungerfeld, unpublished data: Fig. 2). Moreover, significantly more ewes ovulated after being stimulated with masks containing adult than yearling ram’s wool (53.3 versus 29.8%: V Miller, M Cuadro & R Ungerfeld, unpublished data). Therefore, the explanation of the greater effectiveness of adult than of yearling teasers is at least partially explained by quantitative and/or qualitative differences in odour secretion.

The effect of the presence of oestrous ewes is similar if teaser rams had been in contact with oestrous ewes for a short period before being joined with anoestrous ewes (Knight 1985). Rams that have been isolated from ewes and then placed with ewes in oestrus are more effective in stimulating ovulation in anoestrous ewes than are rams that have been in contact with ewes long before the procedure takes place (Knight et al. 1998).

Depth of anoestrus

Several parameters have been used to describe the “depth of anoestrus”: such as, length of time until the ewe would spontaneously begin to cycle; arbitrary percentages of how many animals are cyclic; responsiveness to the introduction of rams; ovulation rate; LH pulse frequency; and basal circulating LH concentrations (Ungerfeld 2003). Thomas et al. (1988) proposed that differences between breeds in the depth of anoestrus could be related to differences in the sensitivity of the hypothalamus to both negative feedback by oestradiol and the direct effects of photoperiod. Overall, LH pulsatility has been consistently proposed as one parameter to assess the depth of anoestrus. We also observed that FSH concentrations before the introduction of rams were significantly higher in ewes that subsequently had a luteal phase than in those that do not (Ungerfeld et al. 2004a).
Socio-sexual stimulus in cattle, sheep and goats

Fig. 2. Percentage of ewes that A) came into oestrus and B) ovulated after a 6-days medroxyprogesterone priming and the introduction of adult rams (AR) or yearling rams (YR) (MA Ramos & R Ungerfeld, unpublished data). The experiment was performed during October (Southern Hemisphere, mid non-breeding season) with Merilin sheep.

The percentage of females that respond to the introduction of males is related to factors such as period of the anoestrous season, parity, previous experience of contact with males and breed (Oldham et al. 1985; Nugent III et al. 1988; Rodríguez-Iglesias et al. 1991; Restall 1992; Gelez et al. 2004b; Gelez & Fabre-Nys, 2006). More ewes from a less seasonal breed (for example, Dorset) than from a more seasonal breed (for example, Hampshire) ovulate and conceive after stimulation with rams (Nugent III et al. 1988). Ewes from more seasonal breeds may not necessarily respond to the ram effect by ovulating even if they display an increase in LH pulsatility (Minton et al. 1991).

Management practices that may improve the effectiveness of stimulation in other breeds may be ineffective in strong seasonal breeds. Three hundred Lincoln ewes, strong seasonal breeders, were stimulated in two consecutive years during January (Southern Hemisphere) joining them with 10 rams from the same breed and twenty ewes in estrus. Forty-eight and 46 ewes were examined laparoscopically 5 days after joining in each year: 2/48 and 0/46 had ovulated (H Irazoqui & RM Rodríguez-Iglesias, personal communication). In another recent experiment using another strong seasonal breed, 46 and 47 Texel ewes were joined during November (Southern Hemisphere) with 6 Texel rams that had been either isolated (n = 3) or kept near oestrus ewes for 3 days before (n = 3), respectively. Fifteen and nine ewes respectively were marked by the rams over the 25 days they were together although none of them
became pregnant (MA Ramos, SP González-Pensado & R Ungerfeld, unpublished data). As we could not discriminate the effects of photoperiod on males and females, it remains to be tested in these breeds whether strategies that are effective with bucks may overcome seasonal inhibition (reviewed by Delgadillo et al. 2006).

Response to the male effect during the postpartum period in cattle

In cattle, less is known about the physiological mechanisms by which cows respond to stimulation by the bull. Most trials have focused in trying to advance postpartum rebreeding, with very diverse outcomes. The diversity of outcomes and paucity of data makes it difficult to draw conclusions about the possibilities of using social stimuli in postpartum management.

As primiparous beef cattle have an especially long postpartum anoestrous period, it is interesting to determine the potential use of social-signals as stimulators of early rebreeding. The postpartum anoestrous interval in beef cows is shortened after bull introduction (Zalesky et al. 1984; Custer et al. 1990; Fernández et al. 1993; 1996; Rekwot et al. 2000; Landaeta-Hernández et al. 2004). Similar results have been also obtained with androgen-treated cows, suggesting (as in rams and bucks) that the bull stimulatory effect is also mediated by androgen stimulation (Burns & Spitzer 1992). A female-female effect, has also been described which may result in ovulation (Wright et al. 1994). In both the bull and cow effect, it has been demonstrated that odours (probably pheromones) are the main stimulating cues (Izard & Vandenbergh 1982; Anderson et al. 2002; Berardinelli & Joshi 2005a). Moreover, it has been recently reported that social interactions between bulls and cows seem not to be necessary to obtain the maximum response (Berardinelli & Joshi 2005a). Bull stimulation has been used to stimulate postpartum rebreeding in zebu and buffalo cattle as well as to advance puberty in beef cattle (Izard & Vandenbergh 1982; Roberson et al. 1987; Bolaños et al. 1998; Roberson et al. 1991; Ingawale & Dhoble 2004).

However, in some experiments cows failed to respond to bull stimulation (Naasz & Miller 1987; Gifford et al. 1989). In the few experiments performed with dairy cattle, no positive response has been observed (Shipka & Ellis 1998; 1999). However, in dual purpose cattle, bull teasing advanced rebreeding (Pérez-Hernández et al. 2002). There is also some contradictory information on the physiological mechanisms by which cows respond to bull stimulation: while Fernández et al. (1996) observed higher LH serum concentrations and pulsatility, this was not consistent with the results of Custer et al. (1990). If the increase of LH pulsatility is slower than that observed in small ruminants, the increase in LH may have not been detected due to the fact that individual animals may show an increase at different times after bull exposure.

The influence of many factors, such as body condition, nutritional status, season and postpartum interval, on the response to bull stimulation has been reported (Alberio et al. 1987; Monje et al. 1992; Stumpf et al. 1992; Larson et al. 1994; Berardinelli & Joshi 2005b). Other factors, like bull familiarity to cows and the bulls’ age (in contrast to what we observed with rams), seem not to affect the response (Cupp et al. 1993; Berardinelli et al. 2005). Considering the previous information, it is possible that when bulls are introduced, the diversity of physiological status present in a herd of postpartum cows, at least under extensive conditions, determines that many of them do not respond to the stimulation. If this happens with a significant percentage of cows, no response may be observed in the herd. Therefore, when cows gradually enter a responsive condition, the acute stimuli of bull introduction may have disappeared. Thus, the greater variation between individuals, compared with ewes or goats during seasonal anoestrus, may explain the lack of consistent and predictable results.
Therefore, one strategy for synchronizing parturition in cattle may be to obtain more homogeneous conditions within the herd. Another strategy may be to prolong the stimuli, allowing cows to respond individually as they develop better physiological conditions. We recently tested this strategy by comparing the time of postpartum rebreeding in two groups of multiparous cows which were extensively managed. At 30-60 days postpartum bulls were introduced to suckling Hereford and Angus cows. In one group, two bulls were changed every week to prolong the stimuli time, while the other group remained continuously with the same two bulls. After 7 weeks 91.1% and 47.8% of the cows from the groups with or without bull rotation, respectively, were cycling (P< 0.001: V Miller, M Rodriguez-Itazoqui & R Ungerfeld, unpublished results).

**Overall view**

Overall, insights into the mechanisms involved in the natural socio-sexual stimulation of wild or feral ruminants will promote the inclusion of these management techniques in domestic ruminant production. Better comprehension of the involved mechanisms, strategies to strengthen the stimuli according to female condition and the use of different stimulating techniques may open interesting perspectives. The challenge for researchers is to develop standardized treatments with predictable results in strong seasonal breeds of sheep and goats and during the postpartum period in the three species. We are still far from developments such as those used in swine, in which the application of synthetic stimulating odours to induce ovulation in females is commonly used in reproductive management.

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