Reprod Dom Anim 39, 315–320 (2004)

ISSN 0936-6768

Social and Breed Effects on the Expression of a PGF2α Induced Oestrus in Beef Cows

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Content

Social organization and breed effects following PGF2α were studied in mature Angus, Brahman and Senepol cows allocated into two groups (each A = 5, B = 5 and S = 5). Variables including interval to oestrus onset (IEO), oestrous duration (DE), total mounts received (TMR), and oestrous intensity (IE) were derived via HeatWatch®. Breed-type influenced IEO (B = 42.6 ± 6.7 h; S = 54.6 ± 6.0 h; and A = 27.8 ± 5.8 h; $p < 0.003$). Within breeds, dominant B (69.4 ± 13.3 h) and S (65.5 ± 7.4 h) cows were slower ($p < 0.05$) to be detected in oestrus than subordinate (38.1 ± 4.4 h) and intermediate (40.6 ± 6.0 h). However, within A, dominant cows (16.4 ± 12.5 h) were detected in oestrus earlier ($p < 0.05$) than intermediate (44.3 ± 9.2 h) and subordinates (32.7 ± 5.1 h). Angus (21.5 ± 2.4 h) and B (22.1 ± 3.0 h) cows had longer ($p < 0.01$) DE than S (9.1 ± 2.8 h). Dominants (20.4 ± 3.0) and intermediates (20.2 ± 2.3 h) cows had longer DE ($p < 0.04$) than subordinates (12.1 ± 2.1 h) although the interaction breed × social order showed that dominant S had shorter DE than dominant A and B (10.1 ± 3.3; 34.8 ± 6.0 h; and 20.0 ± 6.4 h, respectively; $p < 0.001$). Angus cows had less TMR than B ($p < 0.02$) and tended to be less than S cows ($p < 0.06$). Overall, greatest ($p < 0.008$) IE occurred in the first 9 h after onset of oestrus with no breed effect ($p > 0.05$). Dominant cows tended ($p < 0.10$) to have less TMR (3.2 ± 0.7 mounts) than subordinate (4.1 ± 0.4 mounts) and intermediate (4.7 ± 0.6 mounts) throughout, especially 3–6 h after oestrus onset ($p < 0.07$). Breed and social order both influence PGF2α-induced oestrus behaviour.

Introduction

In both, temperate and tropical beef cattle livestock, the rate of genetic progress is limited by a relatively low adoption of artificial breeding technologies such as artificial insemination (Fahey and Boothby 1992). Limitations for a more widespread use of artificial insemination (AI) are primarily associated with problems in oestrus detection (Galina et al. 1994; Howard and Cranfield 1995; González-Stagnaro et al. 2002), despite the increasing availability of new techniques (Lehrer et al. 1992; Cavalieri and Fitzpatrick 1995).

Detection of oestrus strongly relies on its behavioural expression which includes duration and intensity (Van Vliet and Van Eerdenburg 1996; Rae et al. 1999), as well as on human related factors such as time devoted to surveillance (Pennington et al. 1986), housing and floor type (Rodtian et al. 1996; Van Vliet and Van Eerdenburg 1996); factors inherent to cows such as the oestrogen : progesterone ratio (Glencross et al. 1981; Bailey 1997), response to oestrogen (Randel 1994), breed (Rae et al. 1999), age (De Silva et al. 1981; Galina and Arthur 1990), milk yield (Van Vliet and Van Eerdenburg 1996); environmental conditions (White et al. 2002), hoof pain (MacMillan 1992) and social factors such as formation of sexually active groups (SAG) and social hierarchy (Hurnick et al. 1975; Galina et al. 1994).

While breed-type has been suggested to be a factor influencing social organization in cattle (Wagnon et al. 1966; Collis 1976), mixed breed herds are common in both temperate and tropical beef cattle operations. Thus, the combined influence of breed and social organization on oestrus expression seems to be possible although poorly documented. The objective in this study was to determine the effect of social organization and breed-type on the expression of a PGF2α-induced oestrus [e.g. interval to detection of oestrus, its duration, total mounts received (TMR) and intensity] in a mixed breed herd comprising of Angus (A) (*Bos taurus*), Brahman (B) (*B. indicus*) and Senepol (S) (*B. taurus*) cows.

Materials and Methods

The study was conducted at the University of Florida Beef Research Unit, Gainesville, Florida. After being together during a week for acclimatization, 30 mature cows (n = 10 each of A, B and S) from three different herds were allocated into two groups of 15 each (n = 5 each of A, B and S). Each group was separated into different pens of approximately 1.5 hectares each, containing available grass. In addition, cows received *ad libitum* water and Bermuda grass (*Digitaria decumbens*) hay. Moreover, cows were daily supplemented with a mix containing corn, soya and minerals (1 kg/cow/day).

Over a period of 45 days and during 1 h (AM–PM) daily, agonistic social interactions among cows at supplement feeding time were recorded on a win/loss basis (Craig 1986). The number of recorded agonistic interactions (n = 1124) included physical (e.g. displacements, butts) and non-physical (threats, avoidances) interactions. The proportion of herdmates defeated to total herdmates was calculated as raw dominance value for each female. These values were subjected to an arcsine transformation to generate normally distributed arcsine dominance values (Craig 1986). With these, a linear *ad hoc* dominance order containing three categories was obtained as follows: dominants (cows which obtained the highest dominance value, 1.57, by consistently dominating all herdmates), intermediates (cows which obtained intermediate dominance values by dominating some herdmates) and subordinates (cows which obtained the lowest dominance values and were consistently dominated).

Synchronization of oestrus was induced with PGF2α (Lutalyse®, Pharmacia Animal Health, Kalamazoo, MI, USA) using a split dose protocol (e.g. day 0 = 25 mg i.m., day 11 = 12.5 mg i.m. and day 12 = 12.5 mg i.m.). Administration of PGF2α was always initiated at 8:00 AM and the precise time on which each cow received a PGF2α dose was recorded. Permanent surveillance of mounting activity was recorded by using a radio-telemetric system (HeatWatch®, DDx Inc., Denver, CO, USA). A cow was considered to be in oestrus when at least three mounts were recorded by HeatWatch® within a period of 4 h (Rae et al. 1999). When the onset of oestrus was determined, the interval from last PGF2α dose was calculated. End of oestrus was considered to occur when a mount was followed by an elapsed period of at least 6 h with no other mount recorded. The time interval between the onset and the end of oestrus represented the duration of oestrus. Total mounts received comprised the amount of mounts received within the duration of oestrus. Intensity of oestrus was defined as the number of mounts received during each 3-h period comprised across duration of oestrus.

The three dependent variables interval from last PGF2α dose to oestrus onset, duration of oestrus and TMR were statistically analysed by ANOVA using PROC GLM (SAS, 2000). The statistical models included effects of breed, group, social order, Body Condition Score (BCS) and their interactions as independent class variables. Arcsine dominance value and the interaction of arcsine dominance value by breed were also tested on the interval from last PGF2α dose to oestrus onset. Intensity of oestrus was statistically analysed by ANOVA with repeated measures using PROC MIXED (SAS, 2000). Here, the statistical model initially included the effects of breed, group, social order, period and their interactions as independent class variables and cow within social order as the error term. For all dependent variables, no differences as result of group and BCS were found. Thus, data were merged with the independent variables group and BCS being removed from the models. Level for statistical significance was established at $p < 0.05$ and p-values ≤0.10 were considered tendencies. Due to either injures or lack of response to PGF2α treatment, four cows were excluded from the experiment.

Results

Interval from last PGF2α dose to oestrus onset

As shown in Table 1, differences as a result of breed and social order were found in the interval from last PGF2α dose to oestrus onset. Among breeds, A cows were detected in oestrus earlier ($p < 0.003$) than S but not B cows. In general, dominant cows appeared to be detected in oestrus later than intermediate ($p < 0.05$) and a tendency to be detected later than subordinate ($p < 0.08$) was also observed. However, an interaction between breed and social order (Table 2) revealed that after the last PGF2α dose, oestrus onset took longer in dominant B (69.4 ± 13.3 h) and S (65.5 ± 7.4 h) cows compared with their subordinate (38.1 ± 4.4 h) and intermediate (40.6 ± 6.0 h) cows, respectively ($p < 0.05$). Conversely, dominant A cows were detected in oestrus earlier ($p < 0.05$) than intermediate (44.3 ± 9.2 h) and subordinate (32.7 ± 5.1 h) cows of this breed. A third analysis using the arcsine derived dominance value as independent variable showed that the interval from last PGF2α dose to oestrus onset increased in A cows as dominance value decreased. Contrarily, in B and S cows, the interval from the last PGF2α dose oestrus onset increased as dominance value increased (Table 3).

Duration of oestrus

Angus and B cows exhibited longer oestrus duration ($p < 0.01$) than S cows (Table 1). Likewise, dominant and intermediate cows exhibited longer oestrus duration ($p < 0.04$) than subordinate cows did. However, the interaction breed by social order indicated that dominant S cows displayed shorter oestrus duration ($p < 0.001$) than dominant A and B cows (Table 2).

Total mounts received

Total mounts received were influenced by breed but not by social order (Table 1). Angus cows received less mounts than B ($p < 0.02$) and tended to receive less mounts than S cows ($p < 0.06$).

Table 1. Effect of breed and social order on the interval from last PGF2α dose to oestrus onset, duration of oestrus and total mounts received during a PGF2α-induced oestrus in beef cows (LSM ± SE)

Breed	Number	LSM ± SE	Social order	Number	LSM ± SE
Interval from last PGF2α dose to oestrus onset (h)					
Angus	9	27.8 ± 5.8[a]	Dominants	5	55.3 ± 6.8[c]
Brahman	9	42.6 ± 6.7[ab]	Intermediate	7	38.0 ± 6.5[de]
Senepol	8	54.6 ± 6.0[b]	Subordinate	14	38.5 ± 4.9[e]
Duration of oestrus (h)					
Angus	9	21.5 ± 2.4[f]	Dominants	5	20.4 ± 3.0[h]
Brahman	9	22.1 ± 3.0[f]	Intermediate	7	20.2 ± 2.3[h]
Senepol	8	9.1 + 2.8[g]	Subordinate	14	12.1 + 2.1[i]
Total mounts received					
Angus	9	15.2 ± 9.0[j]	Dominants	5	26.0 ± 11.0
Brahman	9	55.0 ± 12.0[kl]	Intermediate	7	37.0 ± 11.0
Senepol	8	39.0 ± 8.0[l]	Subordinate	14	34.0 ± 8.2

(a,b) within a column differ $p < 0.003$.
(c,d) within a column differ $p < 0.05$.
(c,e) within a column tended to differ $p < 0.08$.
(f,g) within a column differ $p < 0.01$.
(h,i) within a column differ $p < 0.04$.
(j,k) within a column differ $p < 0.02$.
(j,l) within a column tended to differ $p < 0.06$.

Table 2. Effect of breed × social order on the interval from last PGF2α dose to oestrus onset, duration of oestrus and total mounts received during a PGF2α-induced oestrus in beef cows (LSM ± SE)

		Social order		
Breed	Number	Dominants	Intermediates	Subordinates
Interval from last PGF2α to oestrus onset (h)				
Angus	9	16.4 ± 12.5[a]	44.3 ± 9.2	32.7 ± 5.1
Brahman	9	69.4 ± 13.3[bc]	–	38.1 ± 4.4
Senepol	8	65.5 ± 7.4[c]	40.6 ± 6.0	–
Duration of oestrus (h)				
Angus	9	34.8 ± 6.0[d]	20.8 ± 4.0	15.3 ± 2.3
Brahman	9	20.0 ± 6.4[de]	–	16.7 ± 2.1
Senepol	8	10.1 ± 3.3[e]	13.9 ± 2.3	–
Total mounts received				
Angus	9	15.0 ± 25	36.0 ± 17	34.0 ± 3.0
Brahman	9	35.0 ± 25	–	34.0 ± 9
Senepol	8	38.0 ± 11	27.0 ± 14	–

(a,b) within a column differ $p < 0.009$; (a,c) within a column differ $p < 0.003$; (d,e) within a column differ $p < 0.001$.

Table 3. Effect of breed × dominance value on the interval from last PGF2α dose to oestrus onset in beef cows (LSM ± SE) [interval to oestrus onset (h) according dominance value (arcsine)]

Breed	Number	Lowest dominance value	Highest dominance value
Angus	9	31.5 ± 9.4[a]	16.2 ± 9.4[c]
Brahman	9	55.5 ± 9.4[b]	76.8 ± 9.4[d]
Senepol	8	35.5 ± 9.4[a]	68.0 ± 5.4[d]

(a,b) within a column tended to differ $p < 0.10$; (c,d) within a column differ $p < 0.001$.

Intensity of oestrus

The period between onset and end of oestrus was the greatest source of variability influencing oestrous intensity (IE) ($p < 0.0001$). Greatest IE ($p < 0.008$) occurred during the first four periods (first 12 h) following oestrus onset (Fig. 1).

Although dominant cows tended ($p < 0.10$) to receive less mounts (3.2 ± 0.7 mounts) per period than subordinate (4.1 ± 0.4 mounts) and intermediate (4.7 ± 0.6 mounts) cows (Fig. 2), the effect of social order on IE seemed to be minimal under the effect of synchronization with PGF2α.

The interaction social order by period showed that, during the second period (3–6 h after onset of oestrus), dominant cows tended ($p < 0.07$) to receive less mounts than intermediate and subordinate cows (Fig. 2). No breed effect ($p > 0.05$) was found on the intensity of oestrus.

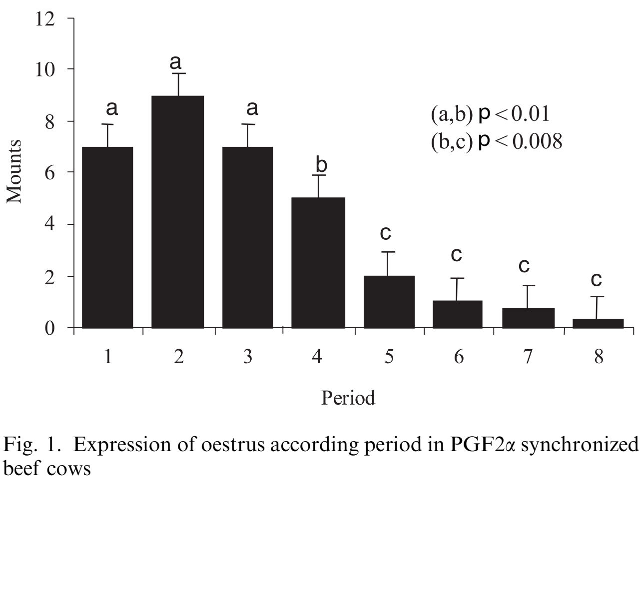

Fig. 1. Expression of oestrus according period in PGF2α synchronized beef cows

Discussion

Interval from last PGF2α dose to oestrus onset

The success rate of oestrus synchronization programmes based on PGF2α protocols is influenced by a number of factors that include day of cycle on which it is applied (Beal et al. 1980; Hardin and Randel 1982) and genetics (Orihuela et al. 1983; Pinheiro et al. 1998). Once a response to PGF2α is obtained, knowing the time of oestrus onset is important because the interval from oestrus onset to ovulation may determine the success of AI (Rae et al. 1999). In this study, differences in physiology and aspects related to social organization among breeds (e.g. A, B and S) arise as possible factors capable of influencing time of oestrus onset following PGF2α administration.

Although receptors to PGF2α on luteal tissue are in place during the whole oestrous cycle (Wiltbank et al. 1995; Mamluk et al. 1998; Skarzynski et al. 2001), cattle are refractory to PGF2α during the first 3–5 days of the cycle (Beal et al. 1980; Hardin and Randel 1982; Pinheiro et al. 1998). Likewise, synchronization of oestrus with PGF2α in *B. indicus* females is often unsuccessful (Orihuela et al., 1983; Pinheiro et al. 1998) because of an apparent reduced sensitivity to PGF2α in luteal tissue from *B. indicus* females compared with *B. taurus* (Cornwell et al. 1985; Santos et al. 1988). Such reduced sensitivity is reflected in the ability of luteal tissue from *B indicus* females to regain functionality, in terms of measurable progesterone, after a single dose of PGF2α (Cornwell et al. 1985; Santos et al. 1988). The

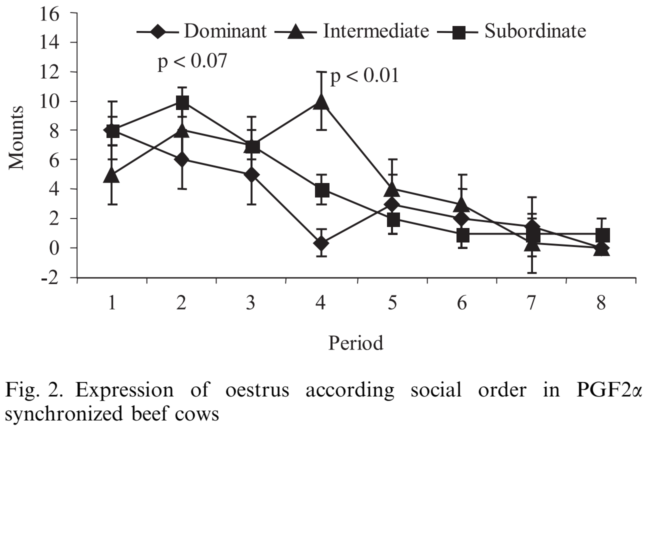

Fig. 2. Expression of oestrus according social order in PGF2α synchronized beef cows

regained functionality of luteal tissue of *B. indicus* may lead to an incomplete luteolysis that result in blood progesterone levels (Cornwell et al. 1985; Santos et al. 1988; Pinheiro et al. 1998) incompatible with expression of oestrus (Glencross et al. 1981; Bailey 1997).

In a comparable study, Rae et al. (1999) found breed differences in the interval from removal of implant to detection of oestrus between A, B and crossbred heifers induced into oestrus using SMB®. More delayed responses in oestrus onset were obtained by Pinheiro et al. (1998) following PGF2α administration to Nelore (*Bos indicus*) heifers and cows (82.5 ± 4.7 h. and 70.5 ± 4.8 h, respectively). Breed differences in oestrus onset following PGF2α may be dependent upon hormonal factors such as differential response to PGF2α between *B. taurus* and *B. indicus* (Tanabe and Hann 1984; Kiracofe et al. 1985; Williams et al. 1999), amount of released oestrogen (Randel 1994; Alvarez et al. 1997) and time-response to oestrogen (Randel 1994). To our knowledge, studies describing either differential response or sensitivity to PGF2α in tropical *B. taurus* breeds such as S are scarce. However, contrary to previous reports, a good response to PGF2α treatment was obtained in our study. Most studies that obtained unsuccessful results with PGF2α used protocols with a single or double dose 11 days apart (Galina et al. 1987; Pinheiro et al. 1998). In our study, a protocol splitting the second dose 24 h apart was used.

Randel (1994) found that B and B-based cows released less oestrogen and needed more time to respond (16–24 h) than European cattle. Comparing A, S and B cows, Alvarez et al. (1997) reported that plasma oestradiol concentration was influenced by the interaction of breed by day. Likewise, an apparent double peak of oestrogen before oestrus onset has been observed in B cows (Glencross et al. 1981; Landaeta-Hernández 1999). Nevertheless, to our knowledge, the relationship between such apparent double peak of oestrogen, response to PGF2α and subsequent expression of oestrus has not received research attention.

Especially in *B. indicus* females, evolutionary differences related to social organization may influence the interval from last PGF2α dose to onset of oestrus. Here, relative hierarchical status may influence the propensity of a given cow to receive mounts during an oestrous period (reviewed by Chenoweth and Landaeta-Hernández 1998). Zebu cows of high social rank appear to avoid being mounted by lower rank cows (Galina et al. 1996). Likewise, in the absence of bulls, dominant zebu cows mounted lower rank cows in preference to allowing themselves to be mounted (Orihuela et al. 1988). With N'Dama cows (a parent breed of S), Kabuga (1992) and Kabuga et al. (1992) also found mounting activity to be associated with social dominance. However, variation in number of mounts given between bulls and dominant cows and the association between dominance order and mounting activity could not be determined in a study with B cows (Orihuela and Galina 1997). None of those findings explain the breed variation observed in our study in which dominant A were detected in oestrus sooner than lower rank cows.

As previously shown by Bouissou (1990) with Holstein females, social hierarchy may be altered by hormonal treatment. If so, PGF2α treatment may have altered social relationships among A females in a manner that facilitated finding partners for mounting activity. However, such an effect did not appear to occur with B and S females of our study. In fact, for these breeds, PGF2α treatment appeared to make it more difficult for them to find a partner for mounting activities. If so, given the differences in time being under controlled breeding and management between A, B and S cattle, we speculate on physiological and evolutionary reasons for such differences in behavioural response. Behavioural and physiological differences have been suggested as reasons for differences in oestrus behaviour between dairy and beef cattle (Miller-Baker and Seidel 1985), with these being probably associated with the sustained effect of different management strategies experienced by both groups of cattle for many years (Miller-Baker and Seidel 1985).

Duration of oestrus

In the present study, breed differences occurred in oestrus duration following PGF2α administration. This is in agreement with previous studies with *B. taurus* (Gulyas 1995; Borger and Green 1997) and *B. indicus* (Rae et al. 1999) cattle. Explanations for these findings are, however, complicated.

Randel (1994) hypothesized that, B and B-based cows experience shorter oestrus duration than cows of European breeds primarily because of physiological reasons. However, in agreement with a previous study using zebu cows (Galina et al. 1996), our findings indicate that social factors also influence oestrus duration, at least when oestrus is induced with PGF2α. It may be surmized that dominant cows would exhibit shorter duration of oestrus as they are less likely to allow mounting compared with subordinate herdmates (Galina et al. 1996). However, in our study, it was only in the S group that dominant cows had shorter oestrus duration than their subordinates.

Total mounts received

Synchronization promotes the formation of SAG by inducing the coincidence of several cows in oestrus. Formation of SAG increases mounting activities in both *B. taurus* and *B. indicus* (Hurnick et al. 1975; Galina et al. 1994). However, according our findings, breed appears to be a factor able to affect the formation of SAG and concomitantly mounting activities in mixed breed herds.

In agreement with our finding, breed differences in TMR were found in a previous study with A, B and crossbred A × B synchronized heifers (Rae et al. 1999). Differences in social interactivity have been observed among some breeds of cattle (Landaeta-Hernández 1999). Such reduced social interactivity may interfere with the expression of oestrus. However, caution is suggested because HeatWatch® only allows to know the individual receiving mounts. Thus, we ignored the magnitude of within breed and between breeds mounting activity. Differences in social interactivity among cattle breeds and its repercussions on expression of oestrus are aspects poorly investigated. Therefore, more research attention on this topic is suggested.

Females of *B. indicus* breeds have been routinely blamed for low expression of oestrus (reviewed by Chenoweth and Landaeta-Hernández 1998). However, in agreement with our finding, B heifers were found to receive more mounts than A and crossbred A × B heifers during a synchronized oestrus (Rae et al. 1999). In a Brazilian study, Nelore females under either norgestomet + oestradiol or PGF2α protocols accepted mounts indistinctly from a bull or other cows. However, under natural oestrus, cows of that study accepted more mounts from a bull than cows (Pinheiro et al. 1998). Thus, synchronizing oestrus may be considered a practical strategy to solve problems for detection of oestrus in *B. indicus* breeds. Regarding S cows, to our knowledge, scientific information on factors influencing the expression of oestrus in tropical *B. taurus* breeds is lacking.

Intensity of oestrus

Oestrous behaviour has been commonly analysed by means of its duration and number of mounts received (Borger and Green 1997; Rae et al. 1999). Meanwhile, dividing number of mounts into the duration of oestrus has been defined as intensity of oestrus (Galina et al. 1982). However, major differences occurring during the expression of behavioural oestrus are not evidenced by using any of these terms. We propose that allocating the number of mounts received per period along the duration of oestrus seems to be a more useful approach to analyse oestrus intensity with both research and practical applications.

Although mounting activity was found to be extended for approximately 24 h, the intensity at which it occurs indicate that best chance and accuracy for detection of oestrus is effective during the first 9 h after its onset. However, if in beef cattle the random distribution of oestrus onset occurs indistinctly around the day as observed in dairy cattle (Dransfield et al. 1998), the usefulness of our finding is limited and reinforce the suggestion for an increased time of surveillance.

It may be possible that the lack of statistical difference observed in the overall IE among breeds and social orders occurred because of the time in which cows were together during a period previously offered for acclimatization. Cattle seem to have short time memory for previous herdmates which provide experience that may reduce a subsequent social interactivity (Collis 1976; Kondo and Hurnick 1990). In addition, the effect of grouping seems to be restricted to a short period of 1–2 weeks (for review see Bøe and Førevik 2003). After such time, changes in social behaviour and locomotor activity as a result of regrouping or introduction of unfamiliar individual normally return to a basic level (for review see Bøe and Førevik 2003). Nevertheless, the interaction of social order by period showed some differences during the third and fourth period that might have an influence on a successful detection of oestrus by visual means, especially with dominant cows. Duration and intensity of oestrus may be reduced by social order because dominant cows are not likely to participate in mounting activities with subordinate herdmates (Galina et al. 1996).

Conclusions

The probability of dominant cows devoting time to perform mounting activities towards lower rank cows appears to be possible especially with B and S cows. However, at least in B cows and independently of social rank, the PGF2α-induced oestrus may be extended once it is expressed. Therefore, synchronization of oestrus may represent a useful tool to mitigate problems related to expression of oestrus, especially in *B. indicus* cattle. Nevertheless, expression of oestrous behavioural patterns in mixed breed herds deserves further investigation.

Acknowledgement

We thank employees of the University of Florida Beef Research Unit for facilities and care of cows during the experiment, the USDA-ARS-STARS at Brooksville for providing the cows and the undergraduate students involved.

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Submitted: 17.10.2003

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