5. Effects of 48-hour calf removal on conception rates of *Bos indicus* cows and calf-weaning weights in extensive production systems

(Published in the Journal Tropical Animal Health and Production, 2012, DOI 10.1007/s11250-012-0137-x)

Summary

The current study aimed to determine if 48-hr calf removal prior to the breeding season affects (1) ovarian steroids, cortisol, urea and creatinine; (2) improves the conception rates; and (3) influence the calf-weaning weights of *Bos indicus* cattle in extensive production systems. Sixty multiparous Brahman-type cows were randomly selected in the early post-partum period and equally allocated into a calf removal group (RG) and a non-removal group (NRG). Calves from cows in the RG were removed for 48 hr prior to the breeding season and returned afterwards, whereas in the NRG the calves remained with their dams until weaning. BW and BCS of cows were recorded at the beginning of the breeding season, mid-breeding season and just after pregnancy diagnosis.

Pregnant cows were monitored throughout the gestation period and calving dates were accurately recorded. The calving season was divided into early, mid and late, corresponding conceptions occurred in the early, mid and late part of the breeding season, respectively. Calves were weighed at birth and at weaning. Weaning weights were corrected to 205 days. BW and BCS were similar throughout the experimental period. Conception rates (CR) were 76% for RG and 55% for NRG but did not differ significantly between the groups. However, differences ($p<0.05$) between the groups were observed for conception rates in the early and late part of the breeding season. CR was correlated with CBI and BCS at the onset of the breeding season. Product-limit survival curves Vs CCI differed significantly ($p<0.05$) between treatment groups. It was estimated with 95% certainty that 50% of the cows in the RG would conceive within the

first 19 days of the breeding season while for the NRG within the first 38 days of the breeding season. Weaning weights were 135.2 ± 22 kg for the RG and 135.5 ± 19 kg for the NRG. In the RG estradiol concentrations increased with sampling time, contrary to progesterone. Cortisol decreased with sampling time for both groups but with higher concentration in the RG. It was concluded that 48-hr calf removal prior to breeding enhances the conception rates with the majority of cows conceiving in the early part of the breeding season. It was also concluded that 48-hr calf removal increases plasma concentration of cortisol without adversely affecting reproduction and does not affect calf weaning weights of *Bos indicus* beef cattle in extensive production systems.

5.1 Introduction

In a beef cow-calf operation the optimum calving percentage can be attained if the first post-partum oestrus and the reestablishment of oestrous cycle occur prior to the breeding season. Walters *et al*. (1982) and Odde *et al*. (1986) found that 48-hr calf removal preceding the onset of the breeding season increases the number of cows in oestrus in the early breeding season. Salfen *et al*. (2001) observed an increase in oestrus rate of cows synchronised at 25 days post-partum following a 48-hr calf removal. Better results in interval to first oestrus and conception rates were related to restricted suckling combined with 48-hr calf removal or only the latter, when these were implemented prior to the breeding season (Odde *et al*., 1981; Walters *et al*., 1982a, Walters *et al*., 1982b; Meirelles *et al*., 1994) or in synchronisation protocols using GnRH and $PGF_{2\alpha}$ with 48-hr calf removal (Yelich *et al.,* 1995; Gear *et al*., 2001; Vasconcelos *et al.,* 2009). There is, however, a lack of information on the effects of 48-hr calf removal on the rebreeding performance of *Bos indicus* cows in extensive production systems.

In Mozambique, the breeding season is used to better manage reproduction in a few extensive beef cattle farms but conception rates are yet relatively low (<60%). The

current study aimed to determine if 48-hr calf removal prior to the breeding season: (1) affects ovarian steroids, cortisol, urea and creatinine in *Bos indicus* cows in extensive production systems; (2) improves the current conception rates of *Bos indicus* cows in extensive production systems and (3) affects the calf-weaning weights.

5. 2 Materials and Methods

The study was carried out at the same location as described in 4.2.1.

Sixty multiparous Brahman-type cows were randomly selected in the early post-partum period and assigned to two groups of 30 cows: a calf removal group (RG) and a non-removal group (NRG). Calves from cows in the RG were removed for 48-hr prior to the breeding season and returned afterwards, whereas calves from cows in the NRG remained with their dams until weaning. BW and BCS of cows were recorded at the beginning of the breeding season, mid-breeding season and just after pregnancy diagnosis using the methods as described by Escrivão *et al.* (2009). Satisfactory classified bulls (Hopkins and Spitzer, 1997) were used at a ratio of 1:20 cows for a breeding season of 90 days (January to March).

Cows from both groups were submitted to the breeding season at the same time. Pregnancy diagnoses were done by rectal palpation 60 days after the end of the breeding season. Calves from both groups were weighed approximately 48-hr after parturition and again at weaning. Weaning weights were corrected to 205 days (Escrivão *et al.*, 2009). The interval from calving to the onset of the breeding season was calculated and defined as calving to breeding interval (CBI). Pregnant cows were monitored throughout the gestation period and calving dates were accurately recorded, while non-pregnant cows were re-bred in the follow-up breeding programme. The calving season was divided into early-calving season (ECS) (first 21days of the calving season), mid-calving season

(MCS) (second 21 days of the calving season) and late-calving season (LCS) (third 21 days of the calving season and above) and corresponding conceptions in the early, mid and late parts of the breeding season, respectively.

5.2.1 Blood sampling

Blood samples were collected by caudal venepuncture at 24 and 36 hours after calf removal (24 and 12 hours prior to breeding season) from all cows in the RG and NRG using sterile vacuum tubes containing EDTA and centrifuged immediately after collection. Plasma was harvested and stored at - 20ºC until hormone analysis. Collection of blood samples at time zero (t_0 = time of calf removal) was not considered due to the fact that cow-calf management from both groups was similar by the time of calf withdrawal. In addition, reports on *Bos taurus* beef cows in intensive production systems indicate that when 48-hr calf removal is performed the first LH peak is observed approximately 24 hr after calf removal (Walters *et al*., 1982; Edwards, 1985; Whisnant *et al*., 1985).

5.2.2 Hormonal assay

Estradiol, progesterone, creatinine, cortisol and urea were assayed using ADVIA Centaur Assay and SYNCRON LX Systems, while creatinine was assayed by Cobas Modular P, as described in 3.2.4.

5.2.3 Statistical analysis

Data were analysed by means of the analysis of variance (ANOVA) in the GLM procedure of SAS by including treatment group, sampling time as fixed factors, as well as the corresponding interactions in the model. The variables measured included BW and BCS at the onset of the breeding season, pregnancy data, CBI, CCI, and corrected weaning weight, progesterone, estradiol, cortisol, creatinine and urea. When appropriate the BW of the cows at the start of the breeding season and CBI were included as covariates. Differences between factors were assessed at the level of $p<0.05$ (95% accuracy). All results were expressed as least square means (LSmeans) ± standard deviation (SD) and multiple comparisons of means were done by means of the Bonferroni method in order to correct for unbalanced data, where the number of observations differed. Pregnancy status of treated and control cows were compared by Chi-square analysis (SAS, 1996). To compare the survival distributions (in the time before conception) the Log-rank test (Nathan, *1966*) was applied to the two experimental groups. Cows that did not conceive were included in the analysis as censored data with a weighting factor to compare conception rates between treatment groups. The Kaplan-Meier estimator was used to estimate and graphically display the survival functions (Kaplan and Meier, 1958).

5.3 Results

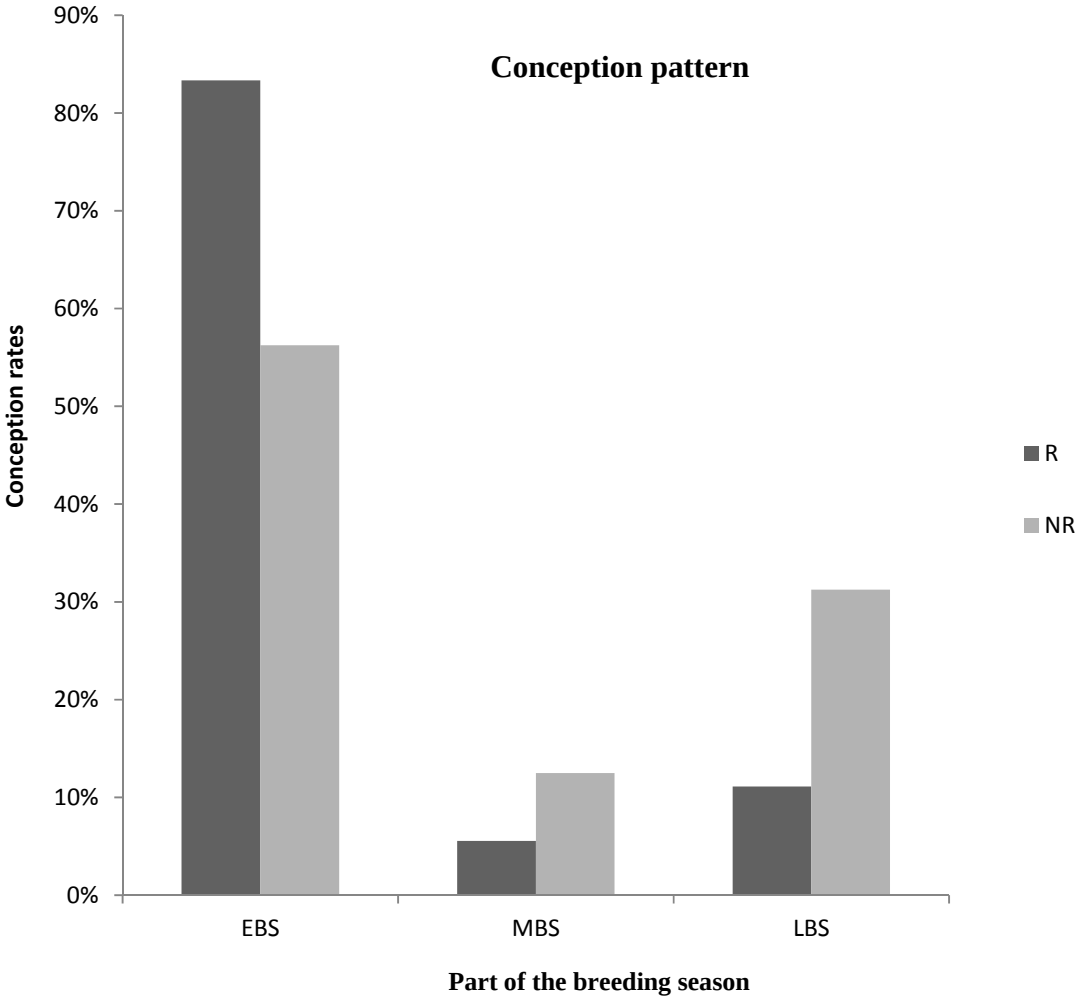
Calves of two cows incorporated in the experiment died before the onset of the breeding season and were thus excluded from the data set. Body weight and BCS of cows were similar ($p>0.05$) between and within the groups throughout the experimental period-namely at the onset of the breeding season, mid-breeding season and around pregnancy diagnosis, as illustrated in the Table 5.1.

Table 5.1 BW and BCS of cows at the onset (OBS), mid breeding season (MBS) and around pregnancy diagnosis (PD) for the RG and NRG

	Group	
Trait	RG	NRG
BW OBS (kg)	409 ± 38[a]	421 ± 48[a]
BW MBS (kg)	408 ± 41[a]	420 ± 44[a]
BW PD (kg)	415 ± 42[a]	431 ± 49[a]
BCS OBS	2.8 ± 0.5[a]	2.8 ± 0.4[a]
BCS MBS	2.4 ± 0.3[a]	2.4 ± 0.3[a]
BCS PD	2.8 ± 0.4[a]	2.8 ± 0.3[a]

[a,a] Means with same superscripts in the same row do not differ ($p>0.05$)

The conception rates were 76% for the RG and 55% for the NRG. Although a numerical difference was evident, conception rates did not differ ($p>0.05$) between treatment groups. However, when conception rates were allocated into early, mid and late parts of the breeding season, differences ($p<0.05$) between RG and NRG were observed. Conception rates differed between the RG and NRG during the early and late part of the breeding season but not in mid-breeding season. The conception pattern is presented in Figure 5.1.



(↔) indicates significant differences ($p<0.05$)

Figure 5.1 Conception rates in early (EBS), mid (MBS) and late part of the breeding season (LBS) for RG and NRG

Survival analysis indicated that product-limit survival curves Vs CCI differed significantly ($p<0.05$) between the removal and non-removal groups (Figure 5.2). In addition, survival analysis showed that CBI and BCS at the beginning of the breeding season were significant ($p<0.001$) predictors of conception.

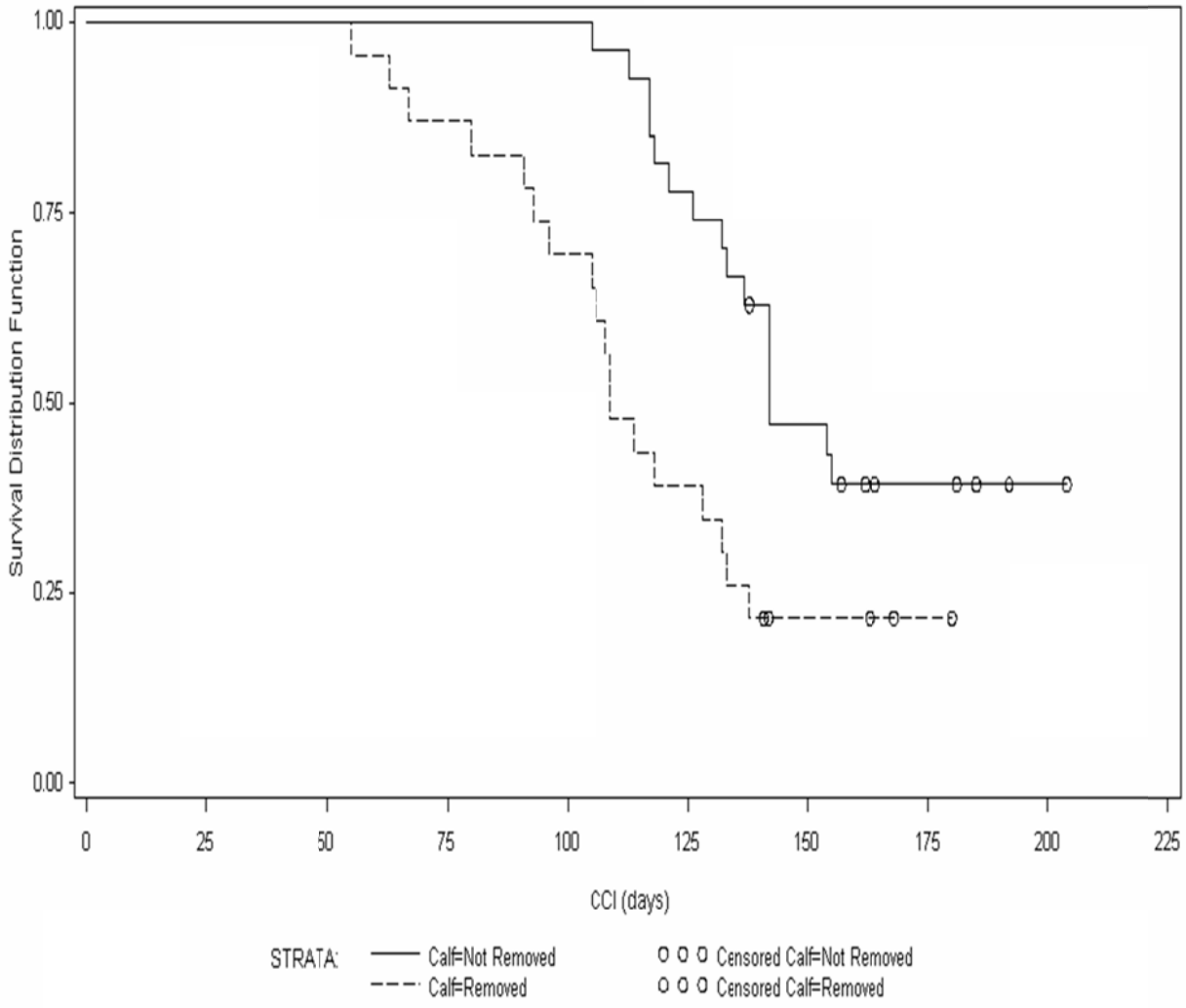


Figure 5.2 Product-Limit survival curves Vs calving to conception intervals of cows with calves removed 48 hours compared to cows without calves removed

Survival analysis estimates that 50% of cows in the RG will conceive an average within the first 19 days of the breeding season while for NRG in the first 38 days of the breeding season. The approximate speed of conception for cows in the RG and NRG is presented in Table 5.2.

Table 5.2 Speed of conception for Removal and Non removal groups

	Day of Conception			
	Removal Group		Non Removal Group	
% of Cows Conceiving	CCI[1]	BCI[2]	CCI[1]	BCI[2]
25%	93 [55 - 108]	3	126 [113- 142]	22
50%	109 [96 - 132]	19	142 [≥ 132]	38
75%	138 [≥ 114]	38	[≥ 154]	

[1]Calving to conception interval: Average (95% confidence interval)

[2] Breeding to conception interval

The weights of calves were similar at birth ($p>0.05$) and again at weaning (C_{ww} was 135.2 ± 22 kg for R group and 135.5 ± 19 kg for NR group) but gender differences ($p<0.05$) in terms of weaning weights of calves were observed as bull calves were 9% heavier than heifer calves.

The effect of 48-hr calf withdrawal on ovarian steroids, metabolites and their variation with sampling time is presented in Table 5.3.

Table 5.3 Effect of 48-hr calf withdrawal on circulating estradiol, progesterone, cortisol, urea and creatinine concentrations in beef cows under extensive conditions (Mean ± SD)

		Group	
Characterists	SP[1]	R group	NR group
Estradiol (pmol/l)	24 hr	118.8 ± 100.1[a]	84.7 ± 58.3[a]
	36 hr	151.9 ± 110.1[b]	141.3±86.3[b]
Progesterone (nmol/l)	24 hr	11.7 ± 26.2	4.2 ± 4.6
	36 hr	7.4 ± 6	4.7 ± 3.2
Cortisol (nmol/l)	24 hr	26.2 ± 18.7	19.1 ± 18.4
	36 hr	19.4±14	17.6±17
Urea (mmol/l)	24 hr	3.3 ± 2[c]	2.9 ± 1.4[d]
	36 hr	3.9 ± 1.5[c]	2.5 ± 0.9[d]
Creatinine (µmol/l)	24 hr	92.1 ± 17.9[a]	89.5 ± 17[a]
	36 hr	82.6 ± 17.9[b]	75.4 ± 14.6[b]

SP[1] = sampling time

[a,b] Means with different superscripts in the same column differ significantly ($p < 0.05$)

[cd] Means with different superscripts in the same row differ significantly ($p < 0.05$)

Cows with longer calving to breeding interval showed an increased ($r=0.393$ and $p=0.001$) estradiol concentration compared to cows with shorter CBI. There was an association between the concentration of plasma cortisol and urea ($r=0.344$ and $p=0.01$), as well as concentration of cortisol and creatinine ($r=0.278$ and $p=0.05$).

Table 5.4 Correlation between variables – Effects of 48-hr calf removal on rebreeding performance of *Bos indicus* cows and calf-weaning weights in extensive production systems

Control Variables			EBS	MBS	LBS	BwDec	BCSDec	PD	Estrad.	Prog	Urea	Creat	Cort	Dayspp	Cww
Group and Samp_time	EBS	Correlation	1.000												
		Significance (2-tailed)	.												
		Df	0												
	MBS	Correlation	-.508	1.000											
		Significance (2-tailed)	.000	.											
		Df	54	0											
	LBS	Correlation	-.680	-.285	1.000										
		Significance (2-tailed)	.000	.033	.										
		Df	54	54	0										
	BwDec	Correlation	-.145	-.045	.200	1.000									
		Significance (2-tailed)	.285	.742	.139	.									
		Df	54	54	54	0									
	BCSDec	Correlation	-.089	.132	-.013	.551	1.000								
		Significance (2-tailed)	.515	.333	.922	.000	.								
		Df	54	54	54	54	0								
	PD	Correlation	-.032	.022	.017	.082	.340	1.000							
		Significance (2-tailed)	.815	.874	.901	.546	.010	.							
		Df	54	54	54	54	54	0							

Control Variables			EBS	MBS	LBS	BwDec	BCSDec	PD	Estrad.	Prog	Urea	Creat	Cort	Dayspp	Cww
	Estradiolpmoll	Correlation	.092	-.030	-.076	-.054	.100	.112	1.000						
		Significance (2-tailed)	.502	.827	.575	.690	.463	.409	.						
		Df	54	54	54	54	54	54	0						
	Progst_nmoll	Correlation	.022	.000	-.024	-.123	-.274	-.628	.017	1.000					
		Significance (2-tailed)	.874	.999	.859	.365	.041	.000	.900	.					
		Df	54	54	54	54	54	54	54	0					
	Urea_mmoll	Correlation	.165	-.097	-.101	.145	.088	.025	-.066	.019	1.000				
		Significance (2-tailed)	.225	.479	.459	.287	.521	.855	.628	.892	.				
		Df	54	54	54	54	54	54	54	54	0				
	Creat_umoll	Correlation	.066	.089	-.148	-.015	.303	.074	.169	.001	-.034	1.000			
		Significance (2-tailed)	.631	.516	.275	.915	.023	.589	.212	.992	.802	.			
		Df	54	54	54	54	54	54	54	54	54	0			
	Cortisol_nmoll	Correlation	-.072	.130	-.030	-.023	.084	-.285	-.173	.146	.344	.278	1.000		
		Significance (2-tailed)	.597	.341	.826	.864	.537	.033	.203	.282	.009	.038	.		
		Df	54	54	54	54	54	54	54	54	54	54	0		
	Dayspp	Correlation	.471	-.057	-.475	-.428	-.089	-.210	.393	.179	.018	.160	.158	1.000	
		Significance (2-tailed)	.000	.676	.000	.001	.516	.120	.003	.188	.895	.240	.243	.	
		Df	54	54	54	54	54	54	54	54	54	54	54	0	
	Cww	Correlation	-.082	-.183	.248	.159	.094	.160	-.085	-.074	-.104	-.176	-.362	-.471	1.000
		Significance (2-tailed)	.546	.177	.066	.242	.490	.240	.535	.588	.447	.195	.006	.000	.
		Df	54	54	54	54	54	54	54	54	54	54	54	54	0

5. 5 Discussion

Results of the present study indicate that BW and BCS were similar between RG and NRG over the experimental period, which was likely to occur because cows were randomly allocated to the two experimental groups and were in the same extensive management system. In addition, the observed results were congruent with those of other studies on 48-hr or 96-hr calf removal (Quintans *et al.*, 2004).

As cows in both groups had a good body condition score at the onset of the breeding season (BCS ≥ 2.7) and since this variable has been reported to be strongly correlated with conception rates (Osoro and Wright, 1992; DeRouen *et al*., 1994; Morrison *et al*., 1999; Renquist *et al*., 2006), similar conception rates between the groups tested in this study were expected. However, conception rates were numerically greater for the RG (76%) than for the NRG (55%), which finding agrees with the results of several others studies (Walters *et al*., 1982; Fanning *et al.*, 1995; Geary *et al*., 2001; Roche *et al.*, 2009).

Despite the shorter CBI in RG and similar BCS and BW between the groups at the onset of the breeding season, the higher conception rates observed in RG highlights the positive effect of 48-hr calf removal on conception rates of *Bos indicus* cows in an extensive production system in sub-tropical conditions. Furthermore, the beneficial effect of 48-hr calf removal on herd productivity was evident through increasing the number of cows that conceived early in the breeding season (Figure 5.1 and Figure 5.2). Similar results have been previously reported (Walters *et al*., 1982; McCartney *et al.,* 1990; Belloso *et al.* 2002).

Cows in the NRG had lower conception rates and conceived later in the breeding season. These cows weaned lighter calves (calves were younger at weaning and weighed less) and according to Marshall *et al.* (1990) they had an increased likelihood of conceiving later in the subsequent breeding season or even not conceiving. Non-pregnant cows are

often culled due to reproductive inefficiency and represent an economic loss to the farmer (Grossi *et al*, 2008).

It was found in the present study that weaning weights of calves were not affected by 48-hr calf removal and these findings agree with those from other studies (Odde *et al.*, 1986; Fanning *et al.*, 1995; Bell *et al.,* 1998).

In the RG estradiol concentrations increased and progesterone concentration decreased with sampling time, which is in concurrence with previous studies (Walters *et al*., 1982; Whisnant *et al*., 1985). The observed trend for the concentration of estradiol and progesterone in the RG and the fact that the majority of cows in the same group conceived in the early part of the breeding season illustrates that the withdrawal of suckling may have provoked estrus in RG by removing the negative effect of suckling.

It was expected that cortisol concentration would decrease with sampling time due to the adaptation of cows to the stress of blood sampling (Koolhaas *et al.,* 1999). Despite the lack of any statistical difference between the groups, cortisol concentrations were numerically higher in the RG than in NRG, probably due to the combined stress of blood sampling and calf removal. Previous data on 48-hr calf removal in *Bos taurus* cows in an intensive production system (Whisnant *et al.,* 1985) indicated a temporary increase in cortisol concentrations, 9 to 12 hr after calf removal. Our findings in *Bos indicus* cows in an extensive production system in sub-tropical conditions show a similar increase in cortisol concentrations, although these were higher at 24 and 36 hr after calf removal compared to the NRG.

High plasma urea and creatinine concentrations have been reported to be associated with catabolism of protein due to negative energy balance or stress (Wikhund *et al*., 1996; Butter, 2000). In the current study the concentrations of urea and createnine were within the reference ranges (Ndlovu *et al.,* 2007) but urea differed significantly between the groups, suggesting that the catabolism of protein was higher in the RG than in NRG. In

addition, urea concentration in the NRG and creatinine in both groups followed the cortisol trends with sampling time and these variables were correlated with cortisol. Therefore, stress may explain part of the variations observed in the concentration of creatinine and urea and cortisol was more pronounced in the RG than in the NRG. However, the results suggest that stress due to calf removal did not interfere with reproduction hormones or conception rates which agree with the finding from other studies (Wikhund *et al*., 1996; Butter *et al.*, 2000).

5.6 Conclusions

Forty-eight-hour calf removal prior to the breeding season seems to block the negative effect of suckling and enhance conception rates, so that the majority of cows conceive in the early part of the breeding season. Calf removal marginally increased plasma concentrations of cortisol, creatinine and urea without adversely affecting reproduction or calf-weaning weights of *Bos indicus* beef cattle in extensive production systems.

6. General Discussion and Conclusions

The major factors that influence post-partum re-conception rates in *Bos indicus* cows under extensive management conditions were reviewed (Chapter 2). There is a need for a better understanding of the reproductive hormones and metabolite profile during the post-partum period in extensively managed *Bos indicus* cows. These aspects have only been studied in detail in *Bos taurus* cows under intensive management conditions (Alverez-Rodiguez *et al.*, 2010; Forde *et al.*, 2011). The primary focus of the present study was thus on the effects of post-partum BCS, BW, age and parity number on ovarian steroids, metabolites and the related conception rates in *Bos indicus* cows under extensive management conditions.

The difficulties of obtaining the hormonal profile of *Bos indicus* cows in true extensive management conditions over the entire oestrous cycle was taken into consideration and this is probably the reason for the limited number of reports in this field. In order to overcome these problems the present study was performed based on: (1) synchronisation of oestrus to avoid low oestrus detection in *Bos indicus* cows; (2) analysis of concentrations and changes in concentrations of plasma hormones and metabolites from 24 hours before oestrus to 24 hours after oestrus; and (3) maintenance of experimental animals under extensive management conditions throughout the study period (Chapter 3).

The results of the present study on post-partum plasma concentrations of estradiol and progesterone (Figure 3.17) around oestrus in *Bos indicus* cows under extensive conditions were similar to that reported in *Bos taurus* cows in intensive management systems (Forde *et al.*, 2011). In addition, the present experiments enclose an extended analysis by including the metabolic status (energy balance) of the cows to the start of the breeding season. The concomitant analysis of metabolic status of the cows (BCS and energy balance) observed in the present study provide a better interpretation of the effects and interactions of BCS on plasma concentrations of steroids, metabolites and subsequent

conception rates. The results obtained on the correlation between BCS at the start of the breeding season with estradiol, indicate with confidence the necessity of maintaining at least a BCS of 2.5 at the beginning of breeding season in order to maximise the post-partum re-conception rates. These new findings differ from those of previous reports (Shwalback *et al*.1996; Renquist *et al.,* 2006) in which a BCS of at least 2 is recommended in extensive and semi-extensive *Bos indicus* beef cows and their crosses.

Despite the fact that the effects of BCS at the start of the breeding season or at calving were related to the subsequent conception rates (Ezanno *et al.,* 2005; Renquist *et al.,* 2006; AlIbrahim *et al.,* 2010) the present study provides more data to stress the importance of BCS in post-partum reproduction, based on the positive correlation complex between BCS-estradiol-conception rates. The practical implications of the present findings are more important for the management of *Bos indicus* cattle in extensive conditions, with emphasis on Mozambican farmers where the study took place and where the conception rates are generally rather low (< 60%).

Results of the metabolites that indicate the catabolism of protein (urea and criatenine) show that at a BCS 2, 2.5 and 3, in cows experiencing a positive energy balance the requirements for energy seems to be satisfied as the breakdown of protein did not exceed the upper level concentrations of creatinine and urea in the circulating blood.

The hypothesis that stress could impair the post-partum re-conception rates in beef cows under extensive conditions was the topic of a number of studies but the data were inconclusive (Dieleman *et al.,* 1986; Dobson and Smith, 2000; Walker *et al.,* 2008). In the present study, similar results were obtained for plasma cortisol concentrations, compared to previous studies on *Bos taurus* beef cows and dairy cows but with a transient elevation at the beginning of the blood sampling and decreasing thereafter. Since cortisol did not correlate with estradiol or progesterone, the observed results support the thesis that stress probably did not interfere with post-partum re-conception rates of extensive beef cows.

The average conception rate (90.5%) obtained for cows in the experimental group in the present study (Chapter 3) was high. This data represents a tremendous increase in cattle productivity in Mozambique compared to the conception rates that are generally below 60%. Furthermore, the fact that for 60% of the cows, conceptions occurred in the first 21 days after the start of the breeding season indicates that the reproductive management based on BSC of at least 2.5 to the breeding season contributed positively to the weaning weight of the calves and, therefore, to the herd productivity.

The mechanisms involved in the effect of suckling on post-partum re-conception rates and on calf-weaning weights were considered in the present study by testing two hypotheses: (1) If restricting suckling at night from 45 days post-partum increases conceptions rates in the subsequent breeding season; and (2) If 48-hr calf removal prior to the breeding season improves the conceptions rates of *Bos indicus* cows under extensive conditions. For productive characteristics calf-weaning weights were compared between treatment and control groups.

Results from both hypotheses demonstrate a considerable increase in post-partum re-conception rates: 80% for 12 hr calf removal and 76% for 48-hr calf removal compared to their control groups 59% and 55%, respectively. Although a numerical difference was evident, the conception rates did not differ significantly between treatment and control groups. Similar results were observed in terms of period of occurrence of conception during the breeding season in both suckling-management strategies in which conceptions were concentrated in the first 21 days after the start of the breeding season.

The analysis of conception data by means of Chi-square analysis showed no statistical difference between treatment and control groups. But when the evaluation of conception data was performed by means of survival analysis (conception over time of the breeding season) it was found that the product-limit survival curves Versus CCI differed significantly ($p < 0.05$).

This new way of analysing conception data (by means of survival curves) provides a better understanding of the factors that influence reproduction in post-partum *Bos indicus* beef cows under extensive conditions by simultaneous inclusion of time and binary variables and predict the conception rates over the breeding season (Table 5.2). Results from the present study indicate that the use of Chi-square analysis to compare conception rates of extensive beef cows under natural breeding over a defined period of breeding season do not take into account the events over time. For this reason, the analysis might not express the reality. In addition, conception rates are true rates (Transfield *et al.,* 1996) and these rates measures the speed at which a cow conceives over a defined period of time. It follows that survival analysis provides a more accurate method for comparing conception rates between groups of animals.

The 12-hr-calf-removal strategy used in the present study is similar to that used in subsistence production systems but the purpose of this practice in subsistence systems is to increase milk yield for the following morning. The later practice does not result in an increase in subsequent conception rates or reduce inter-calving periods because the milk is used for household purposes followed by excessive suckling by the calf after milking.

In terms of conception rates and calf weaning weights the reproductive management strategy based on 12-hr calf removal from 45 days post-partum to the start of the breeding season is more advantageous under extensive conditions since it improves conceptions rates and increases the calf-weaning weights compared to 48 hr-calf removal.

Results from the experiments performed in the present study emphasise the benefits of calf removal on post-partum re-conception rates of *Bos indicus* cows under extensive management. In addition, the findings stress the correlation complex of BCS-estradiol-conception rates. Furthermore, maximum post-partum re-conception rates can be achieved if the BCS at the beginning of the breeding season is at least 2.5, regardless of the calf-removal strategy.