Original Article

Importance of hormonal changes during the periparturition period in black Bengal goats

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Abstract

Background and Aim: The maintenance of pregnancy in livestock requires specific metabolic and functional changes between conception and the end of gestation, mediated through the interplay of hormones. The objectives of this study were to delineate the changes in plasma progesterone, estradiol, triiodothyronine (T_3), thyroxine (T_4), insulin, and cortisol concentrations during periparturient period in black Bengal goats and to elucidate the interrelationship between T_4 and cortisol in building up of the estradiol prior to parturition.

Methods: The blood samples were collected on days −25, −20, −15, −10, and −5 with respect to the date of expected kidding, on the day of kidding (day 0) and also on days 5, 10, 15, 20, and 25 postpartum. Plasma was separated and stored at −20°C until assay of hormones by radioimmunoassay.

Results: Plasma progesterone concentration declined from day − 25 abruptly to the day of kidding and remained at basal level up to day 25 postpartum; whereas, plasma estradiol concentration declined abruptly from the day of kidding to a lower level than that of prepartum. Plasma insulin concentration declined ($P < 0.05$) abruptly from day − 15 to the day of kidding followed by increase by day 10 postpartum. Circulating cortisol concentrations decreased from day 25 prepartum to the day of kidding, but increased by day 15th postpartum. Plasma T_3 and T_4 concentrations decreased from day 25 prepartum to the day of kidding which increased by day 25 postpartum.

Conclusion: Plasma estradiol was positively correlated with cortisol and T_4 indicating that changes in cortisol and T_4 levels contribute to increase in estradiol prior to delivery and therefore may directly influence the process of parturition.

Key words: Cortisol, estradiol, goat, insulin, progesterone

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INTRODUCTION

Black Bengal goats are known to be famous for their fertility, prolificacy, meat, and skin quality as well as adaptability to hot-humid conditions. Problems of slower growth rate, low production of milk, and higher kid mortality[1,2] hamper full exploitation of productive potential of black Bengal goats. Exploration of the fundamental endocrine involvement during late pregnancy is essential for development of management strategies for induction of parturition. The interplay of hormones regulates the metabolic and functional changes between mother and conceptus and thus associated with the maintenance of pregnancy in domestic ruminants. During early pregnancy, the growing fetus solely depends on uterine microenvironment for survival and growth as the uterine environment undergoes continual modifications to cope with the needs of the embryo. To meet these needs, the body attempts to reset its endocrine functions including thyroid secretion. There is also a change in body metabolic rate and some of the related biochemical components which are mainly controlled by thyroid hormones and insulin. Changes in nutrients during pregnancy and lactation are governed by thyroid hormones viz., triiodothyronine (T_3) and thyroxine (T_4),

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and insulin. The decreased levels of progesterone prior to the time of parturition and the increased levels of estradiol and prostaglandins on the day of kidding play a crucial role in spontaneous parturition.

The endocrine changes during late pregnancy and parturition have been reported in various species.[3,4] Serum progesterone concentration declined immediately before parturition in cow,[5,6] ewe,[7,8] pig,[9,10] and goat.[11] A rise in glucocorticoid concentrations preceeding parturition has been reported in cow,[12,13] ewe,[14] and pig.[15,16] Serum estradiol concentrations have been found to increase in several species before parturition,[17] including cow,[18] ewe,[17] and pig.[19] Soliman *et al*.,[20] reported that thyroid hormones increased during late pregnancy in cow. Although a plethora of studies are available on concentrations of various hormones during late pregnancy in other species, information on black Bengal goat is inadequate. The objectives of the study are (i) To characterize the changes in plasma progesterone, estradiol, cortisol, T_3, T_4 and insulin concentrations during late pregnancy and parturition and (ii) to assess the interrelationship between T_4 and cortisol in building up the estradiol peak prior to delivery in black Bengal goat.

MATERIALS AND METHODS

Animals

Five cycling black Bengal goats (aged between 3 and 5 years) were used in the present study. All the animals were maintained using standard farm practices at the goat herd of Physiology and Climatology Division, Indian Veterinary Research Institute at Izatnagar–located at 170 m above the mean sea level in the Indo-Gangetic Plain on [28°22′N latitude and 79°24′E]. The agro-climatic situation is dry and tropical with the highest temperatures occurring from May to July, with a mean monthly temperature of 40°C. The minimum and maximum ambient temperatures ranged from 5 to 35°C and from 25 to 45°C, respectively; while the mean relative humidity varied between 20 and 90%. The rainfall was erratic and mainly concentrated during July-August with a precipitation of 250-600 mm per annum. The animals selected for the study were free from any anatomical, physiological, or infectious disorders and were mated. The pregnant goats were housed in goat pen with a brick floor and fed on a diet of green fodder and concentrate mixture.

Blood sampling

Blood samples were collected once daily from all the goats in heparinized tubes through jugular venipuncture prior to feeding. The blood samples were collected on days −25, −20, −15, −10, and −5 with respect to the date of expected kidding, on the day of kidding (day 0) and also on days 5, 10, 15, 20, and 25 postpartum. Plasma was separated by centrifugation at 3,000 rpm for 30 min at 4°C and stored frozen at −20°C until assay of hormones.

Assay of hormones

The concentrations of insulin, cortisol, T_3, T_4, progesterone, and estradiol were quantified by the radioimmunoassay kits procured from Immunetech, France. The sensitivity of the T_3 assay was 0.1 nmol/L and the inter- and intra-assay coefficients of variation were 8.6 and 3.3%, respectively. The sensitivity of the T_4 assay was 9.5 nmol/L and the inter- and intra-assay coefficients of variation were 8.6 and 6.2%, respectively. The sensitivity of the insulin assay was 0.5 μIU/ml and the inter- and intra-assay coefficients of variation were 3.4 and 4.3%, respectively. The sensitivity of the progesterone assay was 0.08 ng/ml and the inter- and intra-assay coefficients of variation were 9.0 and 5.8%, respectively. The sensitivity of the estradiol assay was 4.5 pg/ml and the inter- and intra-assay coefficients of variation were 11.2 and 12.1%, respectively. The sensitivity of the cortisol assay was 10 nmol/L and the inter- and intra-assay coefficients of variation were 9.2 and 5.8%, respectively.

Statistical analysis

The data were expressed as the mean ± standard error of the mean (SEM). Data was analyzed for descriptive statistics and significance has been obtained by using analysis of variance (SPSS 16.0, Chicago, IL, USA). Relationship between plasma estradiol and T_4 as well as between estradiol and cortisol was assessed by Pearson's correlation analysis.[21] The values of different hormones during different days of pre- and postpartum period were compared with that of day 25 prepartum by using paired *t*-test.

RESULTS

The gestation length in the goat varied from 140 to 148 days with a mean of 142.7 ± 2.9 days. The concentrations of insulin, cortisol, T_3, T_4, progesterone, and estradiol are presented in [Figures 1-6].

Plasma insulin and cortisol profiles

In the present study, peripheral plasma insulin concentration was 35.97 ± 7.99 μIU/ml on day −25 and rose to 51.49 ± 6.94 μIU/ml on day −15. The insulin levels then decreased ($P < 0.05$) abruptly to 17.791 ± 1.22 μIU/ml on the day of kidding which increased to 36.92 ± 3.75 μIU/ml on day 10 postpartum [Figure 1]. Plasma cortisol concentration was 59.37 ± 12.91 nmol/L on day 25 before expected kidding. The concentration then decreased ($P < 0.01$) to 29.87 ± 11.14 nmol/L on day 5 prepartum which further increased to 48.04 ± 6.65 nmol/L on the day of kidding. The cortisol concentrations then decreased to 19.87 ± 1.89 nmol/L on day 5th postpartum which increased ($P < 0.05$) to 35.77 ± 8.01 on day 15th postpartum [Figure 2].

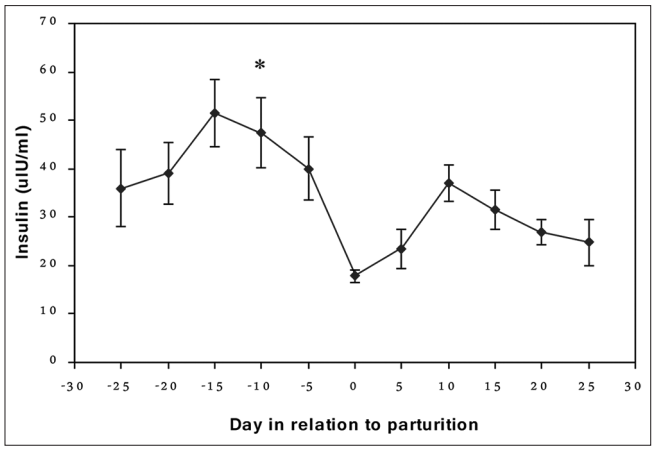

Figure 1: The changes in plasma insulin concentrations during periparturient period in goats. Data are expressed as mean ± standard deviation (SD). Statistical analysis was done by paired *t*-test. The level of significance depicted for day 10 prepartum are in relation to the concentration of hormone on –25th day (basal value).*$P < 0.05$

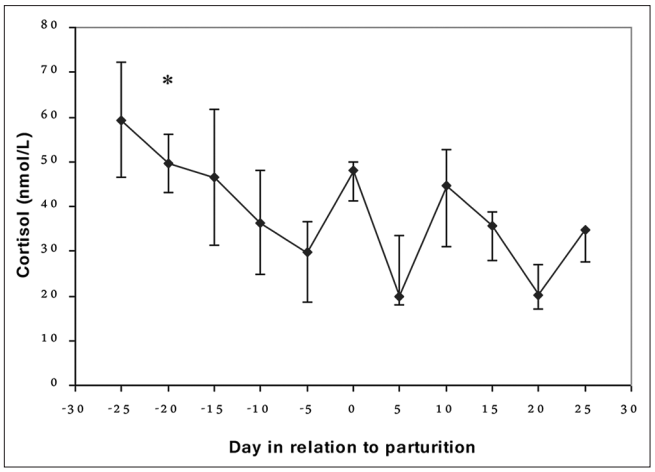

Figure 2: The changes in plasma cortisol concentrations during periparturient period in goats. Data are expressed as mean ± SD. Statistical analysis was done by paired *t*-test. The level of significance depicted for day 20 prepartum are in relation to the concentration of hormone on –25th day (basal value).*$P < 0.05$

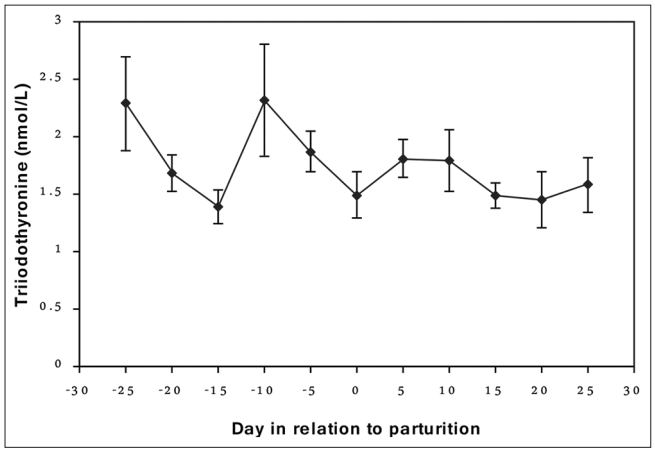

Figure 3: The changes in plasma triiodothyronine (T3) concentrations during periparturient period in goats. Data are expressed as mean ± standard deviation

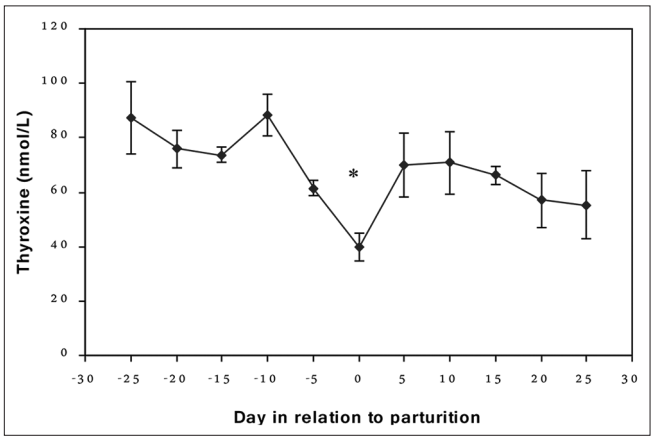

Figure 4: The changes in plasma thyroxin (T4) concentrations during periparturient period in goats. Data are expressed as mean ± SD. Statistical analysis was done by paired *t*-test. The level of significance depicted for day of parturition are in relation to the concentration of hormone on –25th day (basal value).*$P < 0.05$

Plasma T_3 and T_4 profiles

The concentrations of T_3 was 2.29 ± 0.41 nmol/L on day 25 prepartum with respect to the day of expected parturition (day 0), declined to 1.39 ± 0.15 on day 15 prepartum and reached to 1.49 ± 0.20 nmol/L on the day of kidding. After kidding the concentrations increased to 1.79 ± 0.27 nmol/L on day 10 postpartum after which concentrations decreased to 1.58 ± 0.24 nmol/L on day 25 postpartum [Figure 3]. Plasma T_4 concentrations decreased from 87.51 ± 13.3 nmol/L on day 25 prepartum through 73.73 ± 2.72 nmol/L on day 15 prepartum to 39.68 ± 5.20 nmol/L on the day of kidding. The concentration rose abruptly after kidding to 70.76 ± 11.47 nmol/L on day 10 postpartum and declined thereafter to 55.36 ± 12.48 nmol/L on day 25 postpartum [Figure 4].

Plasma steroid hormone profiles

Plasma progesterone concentration was 4.95 ± 0.98 ng/ml on day − 25 which then declined to 3.41 ± 0.14 ng/ml on day 5 prior to parturition, decreasing abruptly to 0.09 ± 0.02 ng/ml on the day of kidding and remained at basal level up to day 25 postpartum [Figure 5]. Peripheral plasma estradiol concentrations decreased from 40.82 ± 5.93 pg/ml on day −25 to 27.56 ± 4.38 pg/ml on day 10 prepartum and then rose ($P < 0.05$) to 50.03 ± 10.13 pg/ml on the day of kidding. The concentrations decreased abruptly after kidding from 24.26 ± 3.32 pg/ml on day 5th postpartum to 16.68 ± 2.43 pg/ml on day 15th postpartum [Figure 6].

Relationship between circulating estradiol and cortisol as well as between estradiol and T_4 levels

The interrelationship between estradiol and cortisol as well as between estradiol and T_4 is presented in Table 1.

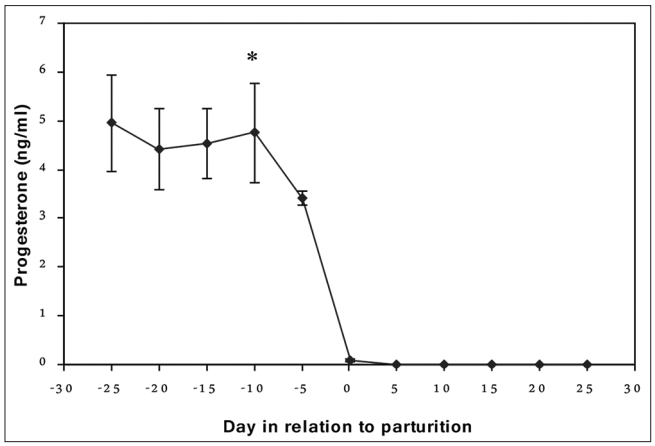

Figure 5: The changes in plasma progesterone concentrations during periparturient period in goats. Data are expressed as mean ± SD. Statistical analysis was done by paired *t*-test. The level of significance depicted for day 10 prepartum are in relation to the concentration of hormone on –25th day (basal value).*$P < 0.05$

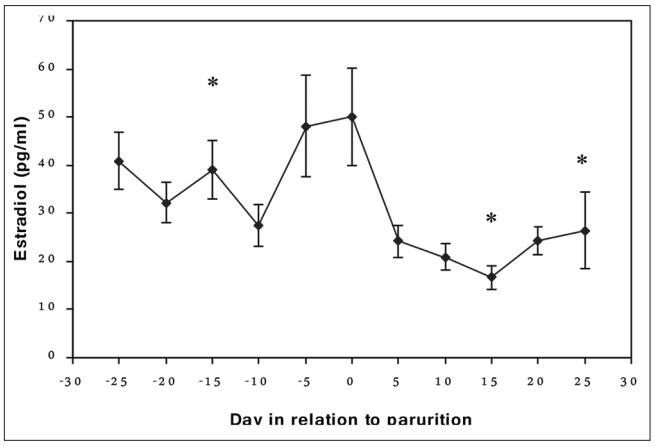

Figure 6: The changes in plasma estradiol concentrations during periparturient period in goats. Data are expressed as mean ± SD. Statistical analysis was done by paired *t*-test. The level of significance depicted for day 15 prepartum, day 15 and 25 postpartum are in relation to the concentration of hormone on –25th day (basal value).*$P < 0.05$

Table 1: Correlation of level of estradiol with the level of T_4 and cortisol on different pre- and postpartum days

Days	T_4		Cortisol	
	r	*P*	*r*	*P*
−25	−0.89	<0.05	0.11	<0.05
−20	−0.78	<0.05	0.54	<0.05
−15	0.40	>0.05	0.78	<0.05
−10	0.19	>0.05	−0.79	>0.05
−5	−0.89	<0.05	−0.27	>0.05
0	0.89	>0.05	0.59	<0.05
5	0.51	>0.05	0.20	<0.05
10	−0.20	<0.05	0.39	<0.05
15	0.58	<0.05	0.93	<0.05
20	0.59	<0.05	0.32	<0.05
25	0.58	<0.05	0.37	<0.05

Data are expressed as mean±standard deviation. Statistical analysis was done by Pearson's correlation. The level of significance depicted for different days are in relation to the level of estradiol

Estradiol and cortisol levels were positively correlated during most of the days of experimentation except on day 10 and day 5 prepartum. Similarly positive correlation was observed between estradiol and T4 levels except on day 25, 20, 5 prepartum and day 10 postpartum.

DISCUSSION

To the best of our knowledge, this report represents the first study on the peripheral endocrine profiles during late pregnancy and parturition in black Bengal goat, an indigenous breed of goat. As reported earlier by Khan and Ludri[22] and Mondal *et al*.,[23] and also observed in the present study, the decline in plasma insulin concentration around parturition could facilitate the mobilization of nutrients from fat depot for milk synthesis. In an earlier report,[24] plasma insulin levels have been found to increase from day 84 onwards in pregnant goats suggesting the crucial role on insulin in partitioning of nutrients to the fetus. The decrease in insulin levels during late pregnancy may be attributed to sharp increase in nonesterified fatty acid (NEFA) concentrations and decrease in glucose concentrations. In contrast, plasma cortisol level increased immediately before parturition in black Bengal goat which is in agreement with earlier studies in cow,[12,13] ewe,[8,14] and pig.[15,16] The secretion of adrenocorticotropic hormone (ACTH) from fetus increased during last stage of parturition, caused increase in the concentrations of cortisol by stimulating the rapid growth of fetal adrenals. Like cow,[6,25] ewe,[7,8] goat,[23,26] and pig;[9,10] plasma progesterone concentrations decline before kidding in black Bengal goat. The sudden decrease in progesterone level might be contributing to initiation of parturition by causing a significant change in estrogen-progesterone ratio. However, further studies should be done to substantiate this mechanism. Plasma estradiol levels increased before kidding which are in agreement with earlier reports in cow,[18,27] ewe,[14,17] goat,[12,28,29] and pig.[9,19,30] Patel *et al*.,[31] reported that prepartum increase in plasma estradiol is required for uterine contraction that also triggers the release of prostaglandin for contraction of myometrium.

In the present study, plasma T_3 and T_4 concentrations declined during late pregnancy, which is similar to earlier reports in goat[32] and sheep.[33,34] Plasma T_3 and T_4 concentrations decrease during late pregnancy due to inhibitory effect of glucocorticoid which rise before parturition; whereas, their increase during postpartum period indicates the enhancement of utilization of nutrients due to stress of parturition. The decline in plasma T_3 and T_4 levels around parturition may be due to transfer of these hormones from placenta to the fetus. Riis and Madsen[35] reported that decrease in plasma T_3 and T_4 concentrations

reduced the rate of oxidation and the rate of continuous breakdown and formation of protein and fat in mammary tissue. This will also tend to reduce the adverse effects of nutrient deficiency at the onset of lactation. The decrease in the concentration of plasma T_3 on the day of kidding and its subsequent elevation indicates enhanced utilization as a result of increased metabolism due to stress of parturition during which the concentration of cortisol increases rather than being utilized by mammary tissue alone. Decrease in the concentration of plasma T_3 and T_4 on the day of kidding is in agreement with Riis and Madsen[35] who showed a sudden drop in T_4 at the onset of lactation and reported that low plasma T_4 and high plasma growth hormone concentration favor the mammary gland in the partitioning of nutrients between mammary and non-mammary tissue. In the present study, estradiol was positively correlated with cortisol and T_4 levels during most part of the experimental period. The alteration in thyroid hormone and cortisol levels possibly contribute to increase in estradiol prior to delivery; and therefore, T_4 and cortisol may directly influence the process of parturition.

Limitations of the study

Due to the small sample size of the study animals in the present study, multiple regression analysis could not be done to link the independent contribution of hormonal changes to the parturition mechanism and also we could not establish a direct link between the change of hormones and the process of parturition, by studying the parturition scoring system etc., Therefore, future studies with a large sample size are warranted to substantiate the independent contribution of the hormonal changes to the process of parturition.

CONCLUSION

In conclusion, positive correlation between cortisol and estradiol as well as between estradiol and T_4 during prepartum period suggests that alterations in cortisol and T_4 levels may contribute to the increase in estradiol prior to delivery, which may directly influence the process of parturition.

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