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Seasonal effect on physiological and haematological profiles, scrotal circumference and testicular parameters in indigenous goat bucks under tropical humid island ecosystem

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ABSTRACT

Andaman local goat (ALG) is a meat animal in Andaman and Nicobar islands (ANI) of India. Present study was conducted to measure the seasonal effect on physiological and haematological profiles, scrotal circumference (SC) and testicular weight during rainy and dry summer seasons in ALG. A total of 10 adult intact ALG bucks (body condition score: 3.0-3.5 and classified as good; 3-4 years) were selected from the goat breeding farm, ICAR-CIARI, Port Blair. Results revealed that these experimental profiles differed significantly between the seasons. Significantly higher haematological profiles, SC and testicular weight were observed during rainy season than dry summer season whereas physiological profiles such as rectal, skin and scrotal temperature were higher during dry summer than wet rainy season. The study concluded that rainy season has significantly greater beneficial effects than dry summer season on reproduction and artificial breeding programmes in semi-intensive management of goat in the present location.

Keywords: Andaman and Nicobar Islands, Goat, Scrotal circumference, Season

The productivity and reproduction rate are severely affected during extreme weather conditions in ANI goats. Goat population is decreased in ANI due to which it suffers from intensive inbreeding, lack of suitable breeding bucks and breeding management. Photoperiod, temperature humidity index (THI) and rainfall control the sexual activity and are the main environmental factors that cause seasonality in reproduction in goats. Although seasonality is less marked in the buck than the doe, males exhibit a pronounced seasonal reduction in sexual behaviour and spermatogenesis (Delgadillo and Chemineau 1992).

Haematological values can provide strong valuable baseline information on physiological and nutritional status of animals and also help to diagnose the health status (Radostits *et al.* 2006). Estimation of testicular and scrotal parameters is the key component in evaluation of breeding soundness, growth and development of scrotum and testis and its related semen quality parameters, endocrinological profiles and libido of the breeding males in various livestock species (Pant *et al.* 2003, Elmaz *et al.* 2008). Season significantly influences the libido, testicular size and hormone secretion either through photoperiod (Barth and Waldner 2002) and/or through changes in ambient temperature, relative humidity and rainfall in male animals (Sekoni and Gustafsson 1987). Testicular temperature should be at least 3-4°C less than body temperature in goat to perform the optimum function, i.e. testicular temperature of 34.8-35.2°C in caprine species is suitable or optimum for higher spermatogenesis and androgen synthesis (Patni *et al.* 2016). Another testicular parameter, SC also varies with seasons (Strumpt *et al.* 1993). Higher testicular temperature which in turn limits blood flow into the testis results in hypoxia and testicular degeneration, characterized by disturbance or disruption of spermatogenesis, causes atrophy of the seminal epithelium, leading to a reduction of fertility in breeding male (Rasooli *et al.* 2010).

Haematological, scrotal and testicular profiles of different goat breeds have been investigated by several authors (Delgadillo *et al.* 2002, Barkawi *et al.* 2006); lacking similar information for indigenous goat breeds of ANI. Knowledge on reproductive variations in different seasons helps to improve the goat husbandry and breeding practices. Therefore, objective of the present study was to ascertain the seasonal variation in scrotal temperature and haematological profiles and its association with SC and testicular attributes in Andaman local goat under humid tropical island ecosystem of ANI.

MATERIALS AND METHODS

Experimental station and animals: Present study was conducted at Goat Breeding Farm, ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands, India. The seasons were classified into

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rainy (May to November) and dry summer (December to April) as per the monsoon availability for five whole calendar years in ANI. Average sun light hours per day was differed significantly between rainy (4.28 ± 0.89) and dry summer (9.20 ± 0.74) seasons. Average rainfall (mm) differed significantly between rainy (444.92 ± 13.62) and dry summer (89.04 ± 8.84) seasons. Average THI differed between rainy (84.92 ± 1.59) and dry summer (85.59 ± 1.15) seasons.

Ten apparently healthy (body condition score: 3.0-3.5 out of 5, classified as good) bucks of 3-4 years of age were selected for the present study. Andaman local goat were maintained in the semi-intensive system where they were allowed for grazing from 0700 to 1200 h. Experimental animals were maintained under uniform feeding, lighting, housing and other standard management practices as per the farm schedule. This experiment was conducted in peak of the respective seasons. Throughout this study, the nutrition of bucks remained uniform and constant.

Blood collection and analysis: The blood samples were collected from jugular vein into collection tubes (20 IU of heparin/mL of blood) at early morning between 0700 and 0900 h during dry and rainy seasons. Haematological profiles such as total red blood cells (TRBC), haemoglobin (HB), erythrocyte sedimentation rate (ESR), packed cell Volume (PCV), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), total white blood cell (TWBC) and differential cell counts were estimated with automatic blood analyser.

Physiological profiles: Physiological responses such as rectal temperature (RT), skin temperature (ST) and scrotal temperature were recorded twice daily at 0800 and 1400 h. RT was recorded using digital thermometer by inserting it into the rectum of the animal and touching the rectal mucous membrane for one minute. Skin and scrotal temperature were measured using an infrared thermometer. The rectal, skin and scrotal temperatures were measured and expressed in °C.

Scrotal circumference and testicular parameters: Testicular parameters and SC were measured by using a Vernier calliper (Mitutoya Digimatic Caliper, Japan) and a measuring tape following proper restraining of the buck in a control table as recommended by the Society of Theriogenology (Chenoweth *et al.* 2010). Testicular length was measured by placing the fixed arm of the calliper at the proximal end and the sliding arm at the distal end of the testes. Care was taken to exclude the epididymis. Thickness or depth was measured by placing the fixed arm of the calliper at the anterior aspect and the sliding arm at the posterior aspect of each testis, at the point of maximum depth. Width of each testis was measured by sliding the other testes up in the scrotum and placing one arm of the calliper at the medial aspect and the other at the lateral aspect, at the point of maximum width. For measurement of SC, the testes was pushed firmly into the bottom of the scrotum by placing the thumb and fingers laterally on the side of the neck of the scrotum and pushed ventrally. A flexible cloth tape was formed into a loop and slipped over the scrotum and SC was measured in centimetres by pulling the tape snugly around its greatest diameter. Testicular volume was estimated by using the following formula for volume of an ellipsoid as described by Love *et al.* (1991) ($4/3\pi abc$, a = thickness/2; b = width/2 and c = length/2). Weight of the testes was calculated by multiplying 1.038 with volume as 1.038 is the approximate density of testicular tissue (Amann 1990). Testis index was calculated from testis volume and body weight of the bulls as testis index (cm^3/kg): testis volume (cm^3)/body weight (kg). SC and testicular parameters were measured four times by the same operator at monsoon and dry summer seasons.

Statistical analysis: In the present study, in order to determine any possible differences in the observed experimental parameters with respect to between seasons, student t-test was applied using SAS Software (SAS, Version 9.3.1; SAS Institute, Inc., Cary, NC, 2011). The data used in the study were tested for normality before analysis using Shapiro Wilk statistics. Figures represent the non-transformed data. The mean values are expressed as mean±SEM. Differences were considered significant if $p<0.05$. Associations between different experimental parameters in different seasons were analysed for statistical significance using Pearson's correlation coefficient using SAS Software. If the r value is greater than 0.50, the correlation is considered as large, 0.50-0.30 is considered as moderate, 0.30-0.10 is considered as small.

RESULTS AND DISCUSSION

Haematological profiles differed significantly ($p<0.05$) between rainy and dry seasons. TRBC (10.07%), Hb (6.29%), ESR (13.12%), PCV (3.34%) and MCHC (6.09%) were significantly higher in rainy than in dry season whereas MCV (4.93%), MCH (6.52%) and TWBC (7.98%) were significantly higher during dry than rainy season (Fig. 1). Similarly, differential cell count percentage such as neutrophils, lymphocyte, monocyte and eosinophil were significantly higher during dry than rainy season (Fig. 2).

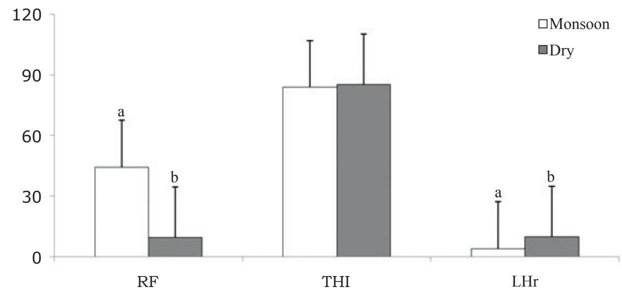

Fig. 1. Average season-wise climatological data during the experimental period in Andaman and Nicobar Islands. THI, Temperature Humidity Index; RF, Rainfall (×10[1]; mm); LHr, Light Hours. Monsoon, April to November and Dry, December to March. Vertical bar on each point represents standard error of mean. Vertical bar with small letters (a, b) indicates significant ($p<0.05$) difference between monsoon and dry seasons.

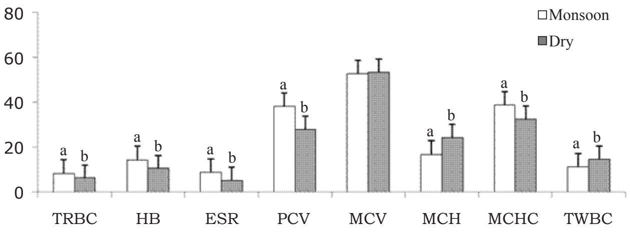

Fig. 2. Haematological profiles of Indigenous Goat of Andaman and Nicobar Islands in monsoon and dry seasons. Vertical bar on each point represents standard error of mean. TRBC, Total Red Blood Cell ($\times 10^6$/ mm^3); Hb, Heamoglobin (g/dl); ESR, Erythrocyte Sedimentation Rate (mm/hr); PCV, Packed Cell Volume (%); MCV, Mean Corpuscular Volume (μ^3); MCH, Mean corpuscular haemoglobin (µg); MCHC, Mean corpuscular haemoglobin concentration (%) and TWBC, Total White Blood Cell ($\times 10^3/mm^3$). Vertical bar with small letters (a, b) indicates significant ($p<0.05$) difference between the different seasons. Monsoon, April to November and dry season, December to March.

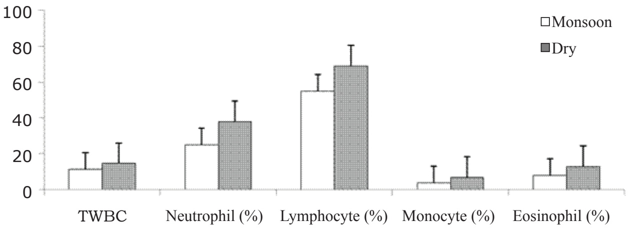

Fig. 3. Differential Cell count of Indigenous Goat of Andaman and Nicobar Islands in monsoon and dry seasons. Vertical bar on each point represents standard error of mean. TWBC, Total White Blood Cell ($\times 10^3/mm^3$). Vertical bar with small letters (a, b) indicates significant ($p<0.05$) difference between the different seasons. Monsoon, April to November and dry season, December to March.

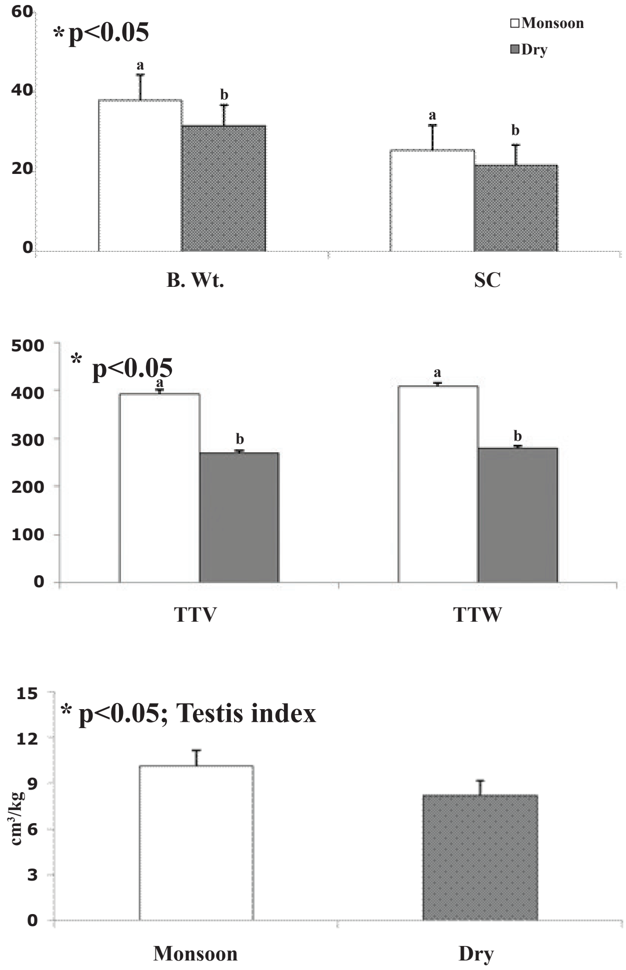

Fig. 4. Effect of season on scrotal and testicular biometrics of indigenous goat (buck) of Andaman and Nicobar Islands. B. Wt., Body weight (kg); SC, Scrotal Circumference (cm); TTV, Total testicular volume (cm^3) and TTW, Total testicular weight (gm). Monsoon, April to November; Dry, December to March. Vertical bar on each point represents standard error of mean. Vertical bar with small letters (a, b) indicates significant ($p<0.05$) difference between monsoon and dry seasons. N= 10 bucks.

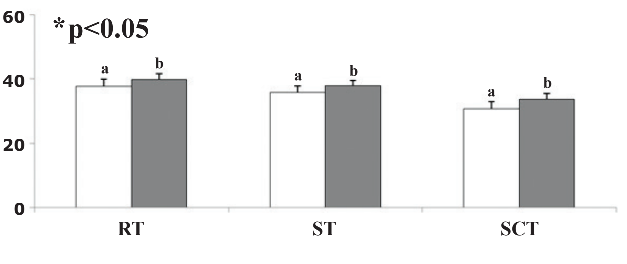

Fig. 5. Effect of season on rectal, skin and scrotal temperature of indigenous goat (buck) of Andaman and Nicobar Islands. RT, Rectal temperature (°C); ST, Skin temperature (°C) and SCT, Scrotal temperature (°C). Monsoon, April to November; Dry, December to March. Vertical bar on each point represents standard error of mean. Vertical bar with small letters (a, b) indicates significant ($p<0.05$) difference between monsoon and dry seasons. N= 10 bucks.

Scrotal and testicular biometrics revealed that SC (8.15%), testicular weight (18.72%) and body weight (9.12%) were significantly ($p<0.05$) higher during rainy than dry summer season (Fig. 3). Temperatures of rectum (2.57%), skin (2.88%) and scrotum (4.58%) were significantly ($p<0.05$) higher during dry summer than rainy season (Fig. 4). Correlation coefficient results revealed that body weight, SC and testicular weight were correlated positively and significantly ($p<0.05$) with each other and these parameters were negatively and significantly ($p<0.05$) correlated with rectal, skin and scrotal temperatures in rainy and dry summer seasons.

Season has significant effect on physiological and haematological profiles and SC and testicular weight in ALG buck which in turn induce deleterious effects on the production and reproduction performances (Fig. 5). Goats in ANI are perennial breeder; however available literature speculates some sort of seasonality is prevailed as similar to other tropical goat breeds (Perumal *et al.* 2019). Here in Andaman and Nicobar Islands, stress means combination of all the stressors including high ambient temperature, relative humidity, temperature humidity index (THI; 85.59), longer photoperiod (9.20 h), reduced rainfall (89.04 mm), higher solar direct irradiance (6.24 ± 0.56 (kWh/m^2/day) and sea surface temperature (29.94 ± 1.30°C). With the short width of Andaman group of Islands (average: 24 km and maximum: 52 km), the effects of these stress factors were severe on livestock health and well beings in Andaman and Nicobar Islands. Heat stress induces higher sweating, high respiration rate, vasodilation with increased blood flow to skin surface, high rectal temperature, reduced metabolic rate, decreased dry matter intake, efficiency of feed utilization and altered water metabolism, which negatively affects the production and reproduction performances in livestock species (West *et al.* 1999). Effect of season on the reproductive characteristics of several buck breeds has been reported (Al-Ghalban *et al.* 2004, Talebi *et al.* 2009). Thus it establishes a fact that effect of seasons on measurement of these parameters in ALG will help to the goat rearers to adopt suitable protecting mechanism with or without nutritional intervention to avoid wastage of energy in the adverse summer seasons. Moreover, the goats are reared in semi-intensive system and it exposes them to different photoperiod and temperature in summer and rainy seasons. There was paucity of information on effect of season on the physiological and haematological profiles and testicular and scrotal biometrics in the ALG and to the best of our knowledge this is the first study on effect of season on these parameters. But many authors reported that hot summer season has severe adverse effects on the production and reproduction performances in different animal species (Sejian *et al.* 2010).

RT is a suggestive marker of stress in domestic livestock species (Sejian *et al.* 2010). In caprine and bovine species, similar report that RT was increased as the animal was going to exercise (Coulon and Pradel 1997). Based on the previous literature in other animal species, it was suggested that the goats undergone walking were suffered severe stress as the evidence from the physiological parameters. ST was significantly higher in the summer stressed than rainy group, but is lower than the RT because the sweating leads to reduce the ST. Sweating has also been used to evaluate the response to heat stress in some mammalian species such as cattle, sheep and horses (Kumar *et al.* 2011). This indicates that apart from relieving the heat through respiratory evaporative cooling, animal also needs cutaneous evaporation to eliminate heat from the body indicated the severity of stresses on these animals in physiological parameters. Further, it is also fact that RT acts as an indicator of heat summer stress in goat as in the sheep (Sejian *et al.* 2011).

Haematological profiles are important in the determination of physiological changes occurring in animals (Kumar and Pachaura 2000). Haematological parameters such as PCV, RBC, MCV, MCHC and MCH are used to evaluate adaptability of animals to adverse environmental conditions (Koubkova *et al.* 2002). Hb and TWBC are also indicators of adaptation to adverse environmental conditions (Kumar and Pachauri 2000). Moreover, Hb values are used to assess the degree of stress and wellbeing of animals. The blood parameters were significantly affected in summer stress induced goat as indicated that these animals were suffered with severe haemoconcentration. The higher value in summer stress affected animal was due to adaptive mechanism exhibited by the goat. Haematological profiles were significantly reduced in dry summer than in wet rainy season and this was due to the following reasons: (1) as the environmental temperature increased, body temperature also increased which led to rise in water intake and reduced feed intake (Quartermain and Broadbent 1997) leading to deficiency of essential minerals and protein which are important for haemoglobin synthesis, will not be present in the body of the animals in adequate level leading to reduced erythropoiesis, (2) increased body temperature in turn causes the rostral cooling centre of the hypothalamus stimulating the medial satiety centre, which inhibits the appetite centre, resulting in reduced feed intake (Albright and Allison 1972), (3) at high ambient temperature, peripheral vasodilatation and redistribution of cardiac output are associated with expansion of blood volume and haemodilution (Olson *et al.* 1995) and (4) destruction of more number of RBC (Shafferi *et al.* 1981). In general, the oxygen consumption rate is increased when the animal is walking or running in summer season. Moreover, the goat is moving long distance in the forest to search the feed especially in summer seasons. This leads to increase in the oxygen demand to meet the muscular activity. That may lead to increase in the RBC production and haemoglobin concentration in goat. Further, in the experiment, the animals were allowed to drink water or feed the fodder that leads to haemodilution in summer season which decreases the blood parameters particularly RBC, HB, PCV and ESR (Sejian *et al.* 2012). Generally during thermal stress, severe dehydration has been reported in livestock which ultimately leads to increased level of Hb and PCV (McManus *et al.* 2009). Further, severe water deprivation in these goats during exposure to summer season could have aggravated the condition. It also revealed that walking in summer season was a highly energy spending activity for goat and also more sweating during the walking leads to high haemoconcentration. In addition, PCV and Hb are considered to be the indices of the organic response to summer heat stress in goat (Sejian *et al.* 2010). Similarly, PCV value was decreased in dry season heat stressed animals due to excessive RBC destruction and/or haemodilution (Shebaita and Kamal 1975). Therefore, significantly reduced erythrocytic indices were observed in dry summer season in the present study. Our study revealed higher TWBC and neutrophils in dry than in rainy season. This could be due to release of corticosteroids due to summer stress which in turn increased leukocyte count and accelerated mobilization of mature neutrophils from bone marrow storage pool (Jain 1986). It also revealed that during hot period, lymphocyte count could also be increased (Narayan *et al.* 2007). Goat might be affected by sub-clinical parasitic infection in summer which in turn increased leucocyte profiles (Rutkowiak 2001). Monocyte count was also increased during summer could be associated with increased cortisol secretion (Jain 1993). Therefore, TWBC was increased during dry hot summer season. Similar reports were available in literature that higher TWBC in bovine species (Saror and Coles 1973) was during summer season. Negative energy balance and increased blood cortisol concentration during dry summer season leads to immune-suppression which in turn increased susceptibility towards infectious diseases (Kehrli *et al.* 1989). Therefore, TWBC production was increased in dry summer season in goats of Andaman and Nicobar Islands.

Reproductive failure in meat animals is more attributed to male whereas in milk (dairy) animals, it is more attributed to female (Flowers 2013). ALG is meat animals and hence it is needed to give more importance on selection of the breeding buck to reduce the reproductive failure in goat husbandry in Andaman and Nicobar Islands. Information about seasonal regulation of reproduction in the male would be beneficial for both conservation of germplasm and commercial production aspect. Reproduction in mammals is finally regulated by complex interactions among the physical factors, viz. of food, rainfall, sunshine hours, relative humidity and maximum and minimum temperatures (Bronson and Heideman 1994). Photoperiod/ day length is well known to activate this seasonal cycle by working on the neuro-reproductive-endocrine system. Bronson (1985) reported that the environments, in where, the females are capable to reproduce successfully during nutritionally challenging seasons of the year; males could experience no or very little seasonal variation and depression in reproductive potential. And this statement could explain the apparent ability of bucks in this study to produce adequate quantities of semen throughout the year and show only moderate seasonal or monthly variation in semen production and its quality parameters (Perumal *et al.* 2015). Seasonal variation in semen quality was associated with variation in SC and testicular size which was influenced by environmental factors such as changes in photoperiod and temperature (Hammoudi *et al.* 2010). In our study, SC and testicular weight were significantly higher in rainy than dry summer season and this might be due to high THI and longer light period in dry summer season that resulted thermal degeneration of scrotum and testes (Gianlorenço *et al.* 2003). Reduction of SC and testicular weight might be due to tunica albuginea adhesions in dry summer season, leading to severe testicular degeneration, reduce SC in the absence of any clinical symptoms (Pant *et al.* 2003). Further, he stated that the testes are extremely sensitive to high ambient temperature, causing degenerative changes, characterised by a reduction in testicular consistency and its size (McEntee 1990). Seminiferous tubules are made up of 77% of testicular volume (Amann 1990) and higher temperature severely affects these tubules resulting into smaller testes and therefore smaller SC and testicular weight in summer than rainy season (Aguiar *et al.* 1992). Increased testicular volume prior to and during the breeding season is due to higher area occupied by seminiferous tubules (Barkawi *et al.* 2006) which is caused by FSH and LH and secretion of these hormones is associated with the reduction in the photoperiod (Santiago-Moreno *et al.* 2013). High significant correlation existed between SC and testicular weight and semen quality parameters in goat as reported in other domestic animal species (Al-Ghalban *et al.* 2004). Further, high environmental temperature and relative humidity adversely affects the hypothalamic-pituitary gonadal axis, decreased GnRH production and reduced the volume of seminiferous tubule, which in turn reduced the testicular volume and SC (Fields *et al.* 1979). Further, in rainy season, the availability of green fodder, rich in minerals and vitamin A, improves the plasma oestradiol and plays an important role in the activation of hypothalamic-pituitary-gonadal axis, ultimately increasing the plasma testosterone levels, causing higher activation and increment of spermatogenesis, causing to an increase in size of testis (Amann 1990). SC has significant ($p<0.05$) and positive correlation with testicular volume and weight, sperm production and sperm reserves in epididymis in bovine species (Palasz *et al.* 1994) and testosterone concentration in seminal plasma and higher semen quality parameters in bubaline bulls was observed (Javed *et al.* 2000). Similar observation was reported in the present study. Similarly, negative energy balance due to summer season depresses the activity of the GnRH pulse generator (Bronson *et al.* 1994) and production of gonadotrophins and ultimately adverse effect on SC and semen production parameters. Daily temperature and day length had significant positive correlation with testicular firmness and were negatively correlated with LH and SC (Pierce *et al.* 1987) as same results were obtained in our study that dry summer heat stress and longer day length had reduced the SC in goat. During short photo period, melatonin concentration is increased which in turn protects the testicular tissue and sperm from free radicals as an antioxidant. Significant seasonal variation in melatonin secretion in goat that may partly explain the variation in SC observed between the seasons in caprine species in our study. Thus season has significant effects on biometry of the reproductive tract in the present study (Strumpt *et al.* 1993).

Testes are highly sensitive to increasing ambient temperature, consequently degenerative changes are observed as in the form of reduction in testicular weight, size and change in its consistency (McEntee 1990), which finally affects the semen production and fertility. Heat stress affects the scrotum and testicular structures which in turn decreases the secretion of gonadal hormones, particularly androgen and spermatogenesis. Testicular temperature should be at least 3-4°C less than body temperature in goat to perform the optimum function, i.e. testicular temperature of 34.8-35.2°C in caprine species is suitable or optimum for higher spermatogenesis and androgen synthesis (Patni *et al.* 2016). In our study, rectal, skin and scrotal temperature were significantly higher in dry summer than rainy season in Andaman local goat breeds. Scrotal temperature was less than the rectal and skin temperature in summer and rainy seasons in goat. Similar results were reported in the earlier studies (Patni *et al.* 2016). However these temperatures are slightly more than the temperature of thermal comfort range, recommended for small ruminants (20-30ºC); still these goats reproduce normally which indicates that these goat breeds have the testicles with high thermoregulatory capacity (Santos *et al.* 2005) and have adapted to the existing environmental conditions and are close to thermo neutral conditions. Heat stress reduces testis blood flow and testosterone blood levels (Hedia *et al.* 2019), thus affect the function of scrotum. Longer scrotal length and larger distance between the testicles and the abdominal cavity provide maximum heat loss, which may be higher thermoregulatory effort in goats of under this island ecosystem (Johnson 1980). Similar finding was observed in goat breeds of ANI. Therefore these goat breeds reproduce successfully under the island ecosystem.

Haematological profiles, scrotal circumference and testicular parameters of goat were significantly greater in rainy season with lowest being recorded in dry summer season. The physiological parameters were significantly greater in summer than in rainy season. Based on the result, the study suggested rainy season has greater beneficial effects than dry summer season on reproduction and artificial breeding programmes in the semi-intensive management of goat in the present location.

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