Influence of the bipartite scrotum on the testicular and scrotal temperatures in goats

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The influence of the scrotal bipartition and of the year period on the scrotal-testicular thermal regulation was evaluated in male goats raised in Piauí State, Brazil. Eighteen male goats at mating age were accomplished in this study and arranged into three Groups (6 animals each) obeying the classification as goats presenting no scrotal bipartition (Group I), goats showing scrotal bipartition at 50% of the testicular length (Group II), and goats with more than 50% of scrotal bipartition (Group III). The scrotal, testicular and spermatic funiculi temperatures were evaluated invasively with the aid of a digital thermometer and non-invasive with a pyrometer in the proximal, medial and distal portion. The data were acquired during the dry (October-November) and rainy (February-March) period of the year, measured in two shifts: morning (6h00-7h00) and afternoon (14h00-15h00). The results were submitted to variance analysis (ANOVA) following the SNK test for average comparison (p<0.05). The year period interfered on the scrotal-testicular thermal regulation, due to increased temperatures of the scrotal, testicular and spermatic funiculi during the dry period in comparison with the rainy period. The bipartition level was also a factor which contributed to the influence of scrotal-testicular temperature regulation, due to lower average scrotal-testicular temperature rates observed during both periods in the goats with higher levels of scrotal bipartition (>50%). It is possible to conclude that with the experimental conditions applied on this study, the level of scrotal bipartition and the climatic conditions interfere with the scrotal-testicular thermal regulation in goats.

INDEX TERMS: Small ruminant, scrotal division, scrotal-testicular thermal regulation.
The localization of the testicles in the scrotum is a regulatory escroto-testicular. The testicles are kept away from the body to avoid overheating, which can affect fertility. The scrotal skin is well vascularized, allowing for the dissipation of heat, and contains sweat glands that help with temperature regulation. The scrotum is a termoacoplável, and not invasive, with a digital pyrometer (MT4 - laser-road, Santa Cruz, CA 95060). The scrotum temperature was obtained in a non-invasive form by digital pyrometer (MT4 - laser-road, Santa Cruz, CA 95060). The scrotum, testicle, and spermatic funiculi temperatures were obtained using an invasive method with the application of a clinical thermometer (BD-Brasil, Rua Alexandre Dumas 1976, São Paulo,SP).

Scrotal, testicles, and spermatic funiculi temperatures. The scrotal, testicle, and spermatic funiculi temperatures were measured during the dry (October-November) and rainy (February-March) periods into shifts, morning (6h00-7h00 a.m.) and afternoon (2h00-3h00 p.m.), in order to observe the influence of the daily ambient temperature variance on the organ. Before the testicle temperature estimation, in each Group, a draw of the antimere (left or right) was evaluated at the morning, and the afternoon shift. This procedure was taken in order to avoid repetitive inflammatory lesion.

The testicle and spermatic funiculi temperatures were obtained using an invasive method with the application of a thermopar digital thermometer (Thermopar Type K-HD9218 with a penetration pole and temperature sensor TP 741, with precision of 0.1°C, Delta OHM SRL, Via G. Marcon 5, 35030 Caselle Di Selvazzano (PD), Italy), while the scrotum temperature was obtained using an invasive method with the application of a clinical thermometer (BD-Brasil, Rua Alexandre Dumas 1976, São Paulo,SP).

Environmental parameters and rectal temperatures. During the experiment, data in relation to ambient temperature and relative humidity were estimated with the aid of a digital thermal-hygrometer (Model DT8829, Delit Sistema e Instrumentos Ltda, Rua Corrientes 135, Pq. Novo Oratório, Santo André, SP). The rectal temperature was estimated using a digital clinical thermometer (BD-Brasil, Rua Alexandre Dumas 1976, São Paulo,SP).

The study was performed at an experimental goat livestock of 18 cross breed reproductive males, located at the Agriarum Centre in the Piauí Federal University, Teresina city, Piauí State, Brazil. The animals were arranged into three Groups with six animals each according to the descriptions of Almeida (2003) and obeying the classification as goat presenting no scrotal bipartition (Group I), goat showing scrotal bipartition at 50% of the testicular length (Group II), and goat with more than 50% of scrotal bipartition (Group III) (Fig.1).

SCROTAL, TESTICLES, AND SPERMATIC FUNICULI TEMPERATURES. The scrotal, testicles, and spermatic funiculi temperatures were measured during the dry (October-November) and rainy (February-March) periods into shifts, morning (6h00-7h00 a.m.) and afternoon (2h00-3h00 p.m.), in order to observe the influence of the daily ambient temperature variance on the organ. Before the testicle temperature estimation, in each Group, a draw of the antimere (left or right) was evaluated at the morning, and the afternoon shift. This procedure was taken in order to avoid repetitive inflammatory lesion.

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The scrotal temperature was measured at the scrotal surface at proximal, medial and distal portions, positioning the pyrometer at approximately 1.0cm away from the scrotal skin. The testicle temperature were evaluated on the medial surface at proximal, medial and distal portions, introducing the thermometer under the scrotal skin by non-perforating the testicle in order to avoid producing damage on the testicle parenchyma, while the spermatic funiculi temperature was measured on the proximal and distal portions, introducing the thermometer on the scrotal skin. Before all invasive temperature measurements taken the skin was cleaned using iodide alcohol in order to avoid infective processes. Inflammations secondary to the needle thermometer introduction were not observed during and after the experimentation.

**Statistical analysis.** The data were submitted to the variance analysis (ANOVA) following the Student-Newman-Keuls (SNK) test for average comparison at 5% probability level.

**RESULTS**

The results demonstrated that the scrotal, the testicle and the spermatic funiculi temperatures decreased from the proximal to the distal portions independent to the scrotal morphology (Fig.2-4).

The comparison of the data referring to the environment temperature and the relative humidity in dry (35.07±2.43°C/56.09±2.3%) and rainy (30.29±2.26°C/76.23±3.4%) periods was considered significant (p<0.05).

The intrafunicular temperature in the proximal portion varied only in relation to the year period and the difference among the Groups was considered not significant (Fig.2). However, in the distal portion the variation of the spermatic funiculi temperature was significant among the Groups, being more expressed in the dry period in comparison to the rainy period. Significant ratios of the funiculi temperature were observed in the proximal and the distal portion between the dry and the rainy period, otherwise being independent of the scrotal bipartition (Fig.2).

In the rainy period, a significant ratio (p<0.05) was observed in the results obtained during the morning in comparison to the afternoon data, being the lower result observed in the goats of the Group III (Fig.2). In the dry period, significant differences were observed among the Groups either during dry or rainy periods, in both periods of the day; once more, the animals of the GIII demonstrated the lowest temperature average among the Groups being 36.10±0.09 and 37.88±0.11°C for dry and rainy periods, respectively.

The temperature distribution along the testicles presented a classic and standard distribution, being higher temperature in relation to the caput region and decreasing to lower temperature in direction to the caudate extremity, where as the differences of temperature during the year periods were considered significant (Fig.3).
During rainy and dry periods, the comparison of the data concerning the testicle temperature among the Groups revealed a significant difference in the animals of the Group III, presenting the lowest temperature rates during the morning (35.07±0.10/36.01±0.07 oC) and the afternoon (36.54±0.08/37.56±0.10 oC) as shown in Figure 3. On the other hand, the goats of the Group II in the morning during the dry period presented an unexpected behavior on the testicle temperature at the proximal region, revealing high average levels in contrast to the data acquired in the afternoon when the temperature was higher than the animals of the Group III (Fig.3).

Similar behavior was observed in relation to the medial and distal testicle temperature (TM/TD), presenting low temperature rates in the rainy period in comparison to the dry period when the lowest results were measured during the morning. The goats of the Group III presented the lowest temperature results for TM and TD. The animals of the Group II showed an irregular behavior due to the similarity of the results either being close to goats of Group I or III (Fig.3).

The scrotal temperature (Fig.4) was inferior in relation to the testicle and funicular temperatures which were elevated in the evening during the dry period when compared to the rainy period, demonstrating similar behavior as the testicular temperature.

**DISCUSSION**

The dry and rainy periods studied in the current investigation demonstrated a significant alteration on the environmental temperature and the relative humidity of air from 35.07±2.43 oC and 56.09±2.3% to 30.29±2.26 oC and 76.23±3.4%. Although in our study, this significant alteration, did not show any influence from the environment temperature to the rectal temperature of the goat, but we observed a higher rectal temperature which was higher than the testicular and scrotal temperatures, a fact to be in agreement to the descriptions made for goat (Lima Júnior et al. 1995) and bovine (Godinho & Cardoso 1980, Kastelic et al. 1997, Strapa et al. 2004).

A decrease on the scrotal, testicle and spermatic funiculi temperatures were observed when comparing the year periods and also in the day-time period (morning/afternoon). In agreement to Lima Júnior et al. (1995), the highest temperatures were observed in the afternoon. Based on this, there is a notable the influence of the year period on the scrotal, testicular, and spermatic funiculi temperatures. The funiculi temperatures during the dry period of proximal and distal portions were almost equal for GI 38.06±0.13/37.25±0.11°C, for GII 37.95±0.11/37.12±0.12°C, and for GIII 37.82±0.14/36.99±0.10°C. But, in the rainy period, it was possible to observe a decrease like for GI 37.29±0.29/37.01±0.21°C, for GII 37.11±0.19/36.91±0.32°C, and for GIII 36.91±0.12/36.83±0.15°C (Fig.2). In this context, in bulls kept in a 15°C and 25°C environment temperature (Kastelic et al. 1997), a variation was demonstrated on the arterial blood temperature at the proximal portion of the funiculi (34.3-36.5°C) and in the testicle caput region (31.7-34.8°C). In our study, the results observed during the dry and rainy periods were lesser than the results described above. Hence, we believe that this difference could be explained by the different method of temperature investigation applied: while Kastelic et al. (1997) daily and directly measured, the temperature on the testicular artery, we chose for temperature measurement the perivascular space of spermatic funiculi.

It has been proved that differences on the morphology of spermatic funiculi and scrotum could influence the mechanism of testicle thermal regulation. Actually, length and diameter alterations on the testicle artery, decrease of the arterial wall thickness, and distance between the artery and vein are directly related to the regulation of temperature (Cook et al. 1994). Many studies had
described that goats presenting scrotal bipartition demonstrate higher diameter and length of the spermatic funiculi and higher length of arteries than animals not presenting this anatomical specializations, resulting in better and larger heat losses of in these animals overview by Nunes (2005). Therefore, our results could be explained by the presence of this characteristic due to the lesser values of temperature encountered in the group of animals with large scrotal bipartition level during the shifts and year periods (Fig.3-4).

A variation between the testicle and scrotal temperatures was observed during the dry and rainy periods as concerning the morning and afternoon shifts of environmental temperatures. In agreement with Lima Júnior et al. (1995), in goat the temperatures of the proximal and distal scrotal bipartition in animals showing scrotal bipartition (SB) and no scrotal bipartition (NB), were 34.89±0.12, 31.36±0.43°C for SB versus 34.77±0.20, 32.02±0.41°C for (NB), where as, during the afternoon, theses animals demonstrated an increase on the temperature being 35.10±0.27 and 31.82±0.21°C for SB versus 35.27±0.23 and 32.61±0.61°C for NB. In the same study, in the morning shift, the testicle temperature was 34.85±0.11 and during the afternoon shift it was 31.70±0.34°C for SB 21.0±0.33, 32.30±0.25°C versus 35.31±0.14 and 32.72±0.23°C for NB, respectively. Based on our results, there is a suggestion of interaction between the variation on the environmental temperature and the scrotal testicular temperature. This could be by an insulating effect in the organ resulting the scrotal tem-perature in the bovine to significantly alterate on the testicle after 24 and 48 hours as observed by Kastelic et al. (1996). Making an analogy with our results, it is possible that the dry period refers to the insulation bag and the rainy period does not, hence, there is an interference to the data obtained, demonstrating that the scrotal and testicle temperature during the dry period were higher in comparison to the rainy period.

In our study the goats of experimental Groups I, II and III presented a decrease on the scrotal and testicular temperature from the proximal to the distal region, a fact which was specifically distinct in the Group with high levels of scrotal bipartition and lowest results for temperature. It has been reported that the scrotal temperature in proximo-distal way decreases from 30.4°C to 28.8°C (Kastelic et al. 1995) and as concerning for the testicle temperature from 34.3°C to 34.5°C (Kastelic et al. 1997).

Our results revealed that the lowest rate of scrotal testicular temperatures were observed during the rainy periods at the lowest environmental temperature (30.29°C), similar to the descriptions for bovine (Kastelic et al. 1997) which showed low scrotal and testicle temperatures at 15°C.

**CONCLUSION**

Based on the methods applied and on the results, it is possible to conclude that the scrotal bipartition level inter-feres significantly with the scrotum-testicular thermal regulatory process in the goat. This responds to a physiological variation of the scrotum-testicular temperature by variation of the environmental temperature along the year, due to wideness of the skin surface area promoted by the scrotal bipartition, contributing to and facilitating the heat changes between the scrotal wall and the ambient. Summarizing, it can be affirmed that animals with scrotal bipartition are capable for better scrotum-testicular temperature regulation towards environmental temperature variation.

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