Scientific Paper

Effect of the presence of shade in sheep grazing areas. 2. Animal activity

Janet Solórzano-Montilla, Livia Pinto-Santini[1], Selina Camacaro-Calvete[1], Daniel Vargas-Guzmán[1] and Leyla Ríos-de Álvarez[2]*

[1]*Instituto de Producción Animal, Facultad de Agronomía, Universidad Central de Venezuela*
Ave. Universidad, vía El Limón, Maracay, Estado Aragua, Venezuela
[2]*Corporación Colombiana de Investigación Agropecuaria (CORPOICA), Centro de Investigación Tibaitatá, Colombia*
E-mail of the corresponding author: lriosdea@corpoica.org.co*

Abstract

In order to evaluate the activities done by grazing sheep, in the presence or absence of artificial shade, 24 West African ewes of 18,73 ± 2,36 kg of average live weight were used, separated into two treatments: T1: without shade (NS) and T2: with shade (WS). The shade was provided by a canopy of synthetic mesh (70 % shade) in paddocks with *Cynodon nlemfuensis*. The ambient temperature (AT in ºC), relative humidity (RH in %) and solar radiation (SR in W/m^2) were measured; and the temperature and humidity index (THI) was calculated. On three days per week (Tuesday, Wednesday and Thursday) observations of the animals were carried out, from 9:00 to 9:30 h and from 13:00 to 13:30 h, during the four weeks of the trial. The activities done by the ewes were recorded: «grazing», «walking», «standing», «ruminating», «defecating», «drinking water» and «urinating». The average AT was 29,8 ºC in the paddock with artificial shade and 29,4 ºC in NS; while RH was higher in WS (62 %) than in NS (51 %). SR was higher in NS (556,6 W/m^2) than in WS (0 W/m^2). The THI was higher in WS (79,2) than in NS (77,6). The most frequent activity was grazing, which turned out to be higher ($p \leq 0,01$) in NS than in WS (71,0 and 65,2 %, respectively). Other less relevant activities were: walking, defecating, urinating, standing, ruminating and drinking water. To conclude, the behavior was affected by climate variables, and the activities were more frequent in treatment NS than in WS.

Keywords: behavior, relative humidity, solar radiation, temperature.

Introduction

In Venezuela ambient temperatures and solar radiation are high during a large part of the year, for which few sheep breeds and other animal breeds are capable of producing more efficiently; this affects feed intake because the animals tend to change their grazing habits, especially those of temperate origin. It is necessary to make a functional analysis of climate with more accuracy, to evaluate its effects in economic terms, for example on growth, reproduction, milk or meat production; which will determine the production model (Pereira-Gotto, 1987), because it is not the same having confined animals in a roofed facility as under grazing conditions without any type of shade or with partial shade.

In hair sheep, when the ambient temperature exceeds 32 ºC, the number of respirations per minute (> 60 mov./min); at 33 ºC the respiratory rate exceeds 120 mov./min that is, the animals hyperventilate (Reyes, 2016).

Little is known about the activities performed by grazing sheep, with or without shade, such as rumination, resting, walking and drinking water, which are developed in permanent transition during the day. This information could be useful for farmers to make decisions regarding the management of the animals and the paddocks, and the requirements of natural shade or facilities, because it can have incidence on voluntary intake (Silva *et al*., 2015). Additionally, it can be of interest in the determination of animal welfare. The traits of animal behavior are early indicators of adaptation and response to environmental alterations (De *et al*., 2017). That is why the objective of the study was to determine the activities of sheep that were under grazing conditions, with or without availability of artificial shade, as well as the effect of solar radiation, ambient temperature, relative humidity and temperature and humidity index, under sunlight and under shade during the day.

Materials and Methods

Location and duration of the experiment. The trial was conducted in the laboratory-sheep section of the Animal Production Institute (IPA, for its initials in Spanish), School of Agronomy, Central University of Venezuela –located in Limón, Maracay, Aragua State–. The IPA is located at 443 m.a.s.l.; with prevailing climate of tropical dry forest (Holdridge, 1979). It shows a mean temperature of 25,3 ºC, mean relative humidity of 72,2 % and annual rainfall average of 1 038,2 mm (USICLIMA, 2013). The

trial lasted 30 days, during the rainy season, with a week of adaptation of the animals in the paddock.

Flock management. A total of 24 tropical growing ewes were used (high West African crossbreeding), apparently healthy, with average live weight (LW) of 18,7 ± 2,6 kg. The management of the animals during the experiment was the same that is habitually done in the laboratory-sheep section: the flock was under semi-confinement conditions, with grazing in star grass (*Cynodon nlemfuensis*) paddocks in the day hours (8:00 h to 15:00 h) and confinement in pens after grazing. Minerals and concentrate feed (250 g/animal/day; 16 % of crude protein), constituted by 60 % brewery waste and 40 % commercial concentrate feed, were supplied as supplement.

Treatments and design. A completely randomized design was used, and the ewes were separated in two treatments of 12 animals each:

- Treatment 1 (NS): grazing in the paddock without the presence of artificial or natural shade.
- Treatment 2 (WS): grazing in the paddock with the presence of artificial shade, provided by four canopies of tropical shade dark green mesh 70 % (poly-shade), of 3 m x 3 m each, height of 2 m, in East-West position, for a total surface of 36 m^2.

Management of the paddocks. During the four weeks of evaluation two paddocks were used (one for each treatment), whose area was calculated to estimate the biomass present during the experiment. Five samples were taken in the paddock WS and five samples in the paddock NS, and for such purpose a 70-m linear transept was used in each paddock (Gómez-García, 2008). The samples were taken to the stove at temperature of 100 ºC, until reaching constant weight, to calculate their dry matter (DM). The paddock for the treatment NS had 1 294,3 m^2, with perimeter of 154 m (offer of 1 688,2 kg DM/ha); while the paddock WS had 1 274,74 m^2, with perimeter of 152,38 m (offer of 1 476,7 kg DM/ha) (Encinozo-González *et al*., 2017).

Evaluated variables

Characteristics of the herbaceous stratum. All the characteristics of the herbaceous stratum were described by Encinozo-González (2017); and include the botanical composition, height, cover of the herbaceous stratum and biomass production.

Climate variables. The ambient variables during the day were recorded through automatic meteorological stations, model Campbell series CR 1000, with sensors for recording temperature (ºC) and relative humidity (%), solar radiation (W/m^2) and wind speed and direction, located in both paddocks.

The generated climate information was stored in a data logger and weekly downloaded using a laptop. With these data the THI (temperature-humidity index) was calculated to determine the thermal conditions of the animals. The THI was calculated through the conversion proposed by Valtorta and Gallardo (1996).

$$THI = (1{,}8AT + 32) - (0{,}55 - 0{,}55RH/100) * (1{,}8AT - 26)$$

Where:

AT: air temperature (ºC)

RH: air relative humidity (%)

Regarding the effect of some climate variables on the activities performed by the ewes during the experiment, categories or levels (low and high) were established for each one of the climate factors (table 1), which allow to study the interactions more accurately.

Behavior traits. To determine the traits of animal behavior and time utilization by the ewes, a field form was elaborated where their most common activities during grazing in NS and WS were recorded: «walking», «eating», «resting», «ruminating», «drinking water», «defecating», «standing» and «urinating».

The animals were identified by a letter of oil paint (blue for WS and green for NS), on both sides of the body and on the rear above the tail, to facilitate individual observation from a distance and to record the activities. The observations were made on

Table 1. Category of the climate variables.

Variable	Category	
	Low	High
Ambient temperature (°C)	19,7-25,9	26,0-34,9
Relative humidity (%)	30-69	70-100
Solar radiation (W/m^2)	4,5-400	401-1 200
Temperature-humidity index (units)	< 70	≥ 70

Tuesdays, Wednesdays and Thursdays, from 9:00 to 9:30 hours (close to the hour of leaving for grazing) and from 13:00 to 13:30 hours (hottest time of day and the one with the highest irradiance); and the recordings were made for each animal individually, taking into consideration the number they had on their bodies.

Live weight (LW). The ewes were weighed every week (Mondays) since the beginning of the essay until the end, with a steelyard balance (Bizerba trademark, from Spain) of 100 kg of capacity and 100 g of appreciation.

*Statistical analysis***.** In the case of the data of the most common activities performed by the ewes a binomial distribution was assumed for these variables, and the database was edited expressing the variables in proportions of occurrence of the event or activity.

To determine the effect of treatment and climate factors, the GENMOD procedure of the statistical package SAS® (Littell *et al*., 2002) was used, through a fixed-effect model, by the method of restricted maximum likelihood estimation which allows to analyze effects with unequal number of observations.

The effects included in the analysis were: treatment [NS and WS, measurement week (1, 2, 3, 4)], ambient temperature (AT: high, low), relative humidity (RH: low, high), solar radiation (SR: low, high) and THI (THI: low, high).

Results and Discussion

Climate variables. In general, the mean AT remained similar throughout the experiment (range of 24,5 ± 4,6 to 28,4 ± 4,7). The higher RH averages were shown in the paddock WS, and the highest one was 84 %. The SR was much higher in NS than in WS, as it was to be expected because the latter did not have any type of cover (64,4 ± 104,3 to 223,1 ± 347). The THIs had minimum differences among the trial weeks (73,3 ± 4,6 to 75,3 ± 4,9). The wind speed was measured only in the paddock NS (average of 0,8 ± 0,5 m/s.), but this measurement was not used to determine animal behavior.

The average values for the climate variables, during the hours of measurement of the activities performed by the ewes, are shown in table 2. The AT and RH values were similar to the ones obtained by López *et al*. (2015), and are considered normal in the study zone; in addition, the average THIs for NS and WS (72,9 ± 5 and 73,7 ± 5,4, respectively) were similar to the ones reported by Saravia (2009) and are considered as stress alert, because they exceed the threshold of 72 THI units.

In general, the values of the climate variables were higher in WS than in NS, with the exception of SR (table 2). Under high RH conditions, as the ones of the study zone in the rainy season, the lower radiant energy under the canopy limits the evaporation capacity, which causes an increase of humidity. Ambient factors such as wind speed and direction, which could favor air removal and, thus, reduce its saturation, should also be considered when establishing provisional shades in paddocks. Additionally, apart from the material used in the generation of shade, the canopy height and length (possibly larger rather than wider) could also reduce the problem. It is necessary to continue evaluating the best way to provide shade for the animals during the grazing hours, especially in the rainy season, in which the combined action of the AT, SR and RH could prevent an adequate thermal welfare of the animals. Similar results were reported by López *et al*. (2015) with the use of canvas, and by Dias *et al*. (2015) with grille roof.

Saravia and Cruz(2003) established certain indexes of heat stress to evaluate the ambient impact on dairy cows. These authors considered THI ≤ 70

Table 2. Climate variables per treatment during the observation areas.

Variable	Presence of shade (WS)		Without presence of shade (NS)	
	9:00 h	13:00 h	9:00 h	13:00 h
Ambient temperature (°C)	26,6 ± 3,1	33,0 ± 1,6	26,9 ± 1,8	31,9 ± 1,4
Relative humidity (%)	75,8 ± 15	48,5 ± 6,7	60,2 ± 7,8	42,5 ± 5,5
Solar radiation (W/m^2)	138,4 ± 57,5	292,0 ± 127,1	215,2 ± 124,5	556,6 ± 309,4
THI* (units)	76,7 ± 3,6	79,2 ± 3,7	75,8 ± 2,6	77,6 ± 2,6
Wind speed (m/s)	-	-	0,5 ± 0,2	1,3 ± 0,5

*THI: temperature-humidity index.

as normal; 70-78, alert; 78-82, danger; and ≥ 82, emergency. According to the data obtained and based on these categories, it can be said that the animals were under heat stress or stress alert (table 2). In spite of these particular climate conditions, it is possible that the canopy mitigated, somehow, the heat load from the SR in the most intense hours of day.

Rainfall during the study was 105,2 mm for July, with high rainfall on July 9 (25 mm) and July 29 (24,8 mm), which is important, not only because it ratifies the month of July as rainy, but also because rainfall can affect behavior in sheep, as it was observed that when it rained they stopped consumption to seek refuge under the canopy. Based on the cortisol concentrations during the year in goats, Meza-Herrera *et al*. (2007) reported higher levels of this hormone during the astronomic autumn in Mexico, season that coincides with that of higher rainfall in the evaluated zone, and stated that rainfall could be an important stressful agent in small ruminants. Regarding temperature, the highest value in this study was 34,9 ºC on July 18.

Several authors establish certain limits in which it could be considered that the animals are under heat stress. Eustáquio Filho *et al*. (2011), based on the physiological responses obtained in climate chambers, reported that the zone of thermal welfare in Santa Inés sheep appeared at 25 ºC of ambient temperature and 65 % of relative humidity. Similarly, Pereira *et al*. (2014) indicated that the critical temperature in sheep is 35 ºC and the zone of thermal welfare appears between 15 and 30 ºC.

According to Marai *et al*. (2007), the main changes caused by heat stress in sheep are: reduction of feed intake; changes in water, protein, energy metabolism and mineral balance; enzymatic reactions and hormonal secretions. Thus, according to López *et al*. (2015), values ≥ 72 units of THI, just as indicators of stress in many animal species, are stress indicators too for tropical hair sheep such as those of the West African breed.

Animal behavior

Frequency of the activities performed by the animals. Figure 1 shows the frequency of the different activities performed by the ewes. The prevailing activity was grazing, significantly higher ($p \leq 0,01$) in NS than in WS, with average values of 71,0 and 65,2 %, respectively. This result proved that, independently from the presence or absence of shade, the animals dedicated more than half the time to grazing or pasture consumption, if it is taken into consideration that they were subject to a restricted grazing management. The growing ewes were under semiconfinement conditions, which implied higher utilization of the grazing time to cover their dry matter ingestion needs. Similar results were reported by Oliveira *et al*. (2013), who did not find influence of the presence of artificial shade, provided with polypropylene mesh with 80 % of light retention, on the number of animals that consumed, ruminated or were idle, compared with the animals from the treatment without shade.

Silva *et al*. (2015) reported breed differences in the grazing behavior. Thus, they observed more

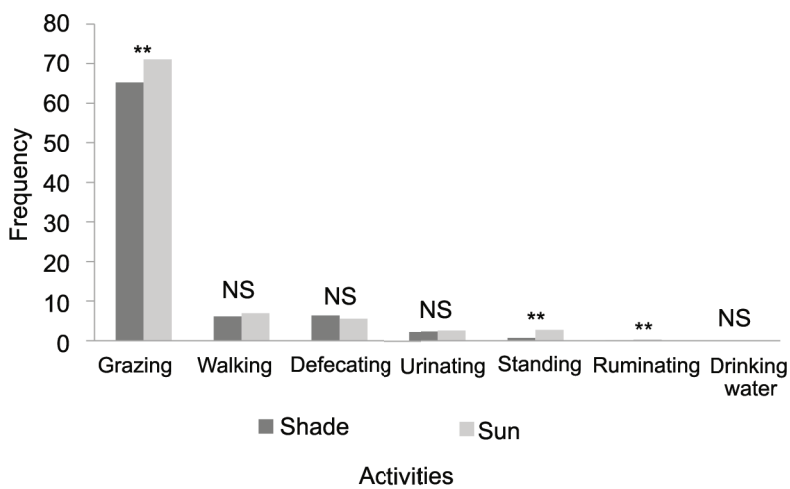

Figure 1. Frequency of the activities performed by the ewes subject to the treatments without shade (NS) and with artificial shade (WS) in the paddock (NS: p > 0,05, ** p ≤ 0,01).

time dedicated to grazing in Santa Inés sheep compared with Morada Nova sheep. In addition, these authors indicated that the highest grazing and rumination intensity occurred in the morning, and associated such behavior to the better climate conditions during that time.

Encinozo-González *et al*. (2017) stated that the availability of artificial shade influenced the selection and consumption of forage species by the experimental animals, with preference for *C. nlemfuensis* and the leaves; while in a study conducted under well-drained savanna conditions, during the rainy-dry transition time it was found that the sheep selected legumes over grasses (Morantes *et al*., 2017).

On the other hand, Zambrano *et al*. (2010) studied the behavior of grazing sheep in a traditional silvopastoral system, with predominance of scattered trees of *Samanea saman* and *Guazuma ulmifolia*, in addition to star grass, in the Portuguesa state. The proportion of time dedicated to grazing of grasses under the sun (28,8 %) was higher than in the shade (15,3 %), for which they concluded that the daily behavior of grazing sheep was mostly defined by grazing of grasses under sunlight and under shade, compared with other activities such as walking, ruminating, resting, etc. Sousa *et al*. (2015) compared the feeding behavior of hair sheep in a silvopastoral system with regards to a grass monocrop, and found that the dry matter intake (88,2 *vs*. 79,9 g DM/kg $LW^{0,75}$) and grazing time (572 *vs*. 288 min/d) was higher in the silvopastoral system. In addition, they reported higher water intake (474 *vs*. 430 mL/kg $LW^{0,75}$) and more time walking (89 *vs*. 30 min/d) in the grass monocrop with regards to the silvopastoral system, behaviors which can be associated to scarce thermal welfare. Based on these results it can be stated that the use of shade, and more specifically the presence of trees in the paddocks, provides a more favorable environment for sheep production under grazing conditions.

Other activities performed by the ewes of this trial were less relevant regarding the use of time, as in the case of walking, defecating, urinating, standing, ruminating and drinking water. Standing and ruminating were also highly significant ($p \leq 0,01$) between treatments, with higher values for NS than for WS. After grazing, the most performed activities by the animals were: walking, defecating and urinating, which did not have significant differences ($p > 0,05$) between treatments.

It is important to mention that during the experimental stage the ewes that had artificial shade in the paddock utilized it, although the frequency of this event was lower, for which the statistical program did not consider it for the analysis. An average of eight animals, from 12, used the canopy to graze, rest lying down, ruminate standing or lying down, especially in the hottest hours of day (13:00 hours), which shows the use of artificial shade to mitigate heat effects and reduce the energy expense due to thermoregulation or heat release. The above expressed facts coincide with the results obtained by Oliveira (2013) when using shade mesh for voluntary use (2,5 m^2/animal), in the semiarid region of Brazil, where the use of shade by the animals in the most critical hours of day was proven. Lima *et al*. (2014) reported that the main changes of behavior in sheep that grazed without shade availability in the Brazilian semiarid zone were a decrease in feed intake and rumination and increases in water intake.

Effect of climate variables on the activities performed by the animals. In the case of the effect of climate variables on the activities of the animals, the relative importance of grazing with regards to the other activities can be emphasized. In the case of the grazing activity (fig. 2), differences ($p \leq 0,01$) were obtained for the categories established in the case of AT and RH, with averages of 60,9 y 74,7 % y 61,0 and 74,1 %, respectively, for low and high. That is, although the AT and RH were higher, the grazing frequency was significantly higher. The average grazing values in the low and high THI were in 65,9 and 70,4 %, respectively ($p > 0,05$). Seemingly, under stress alert conditions there were not important reductions in pasture intake. Another possible explanation to these results could be that in hair sheep higher THI than the ones occurred are required, for a reduction to appear in the frequency of grazing sheep. In that sense, Reyes (2016) reported that the breaking point of THI in West African sheep is close to 80 units. When the THI exceeds this threshold, the sheep show body temperature ≥ 39,5 ºC. The SR was not significant ($p > 0,05$), with low and high averages according to the established indexes of 65,4 and 70,3 %, respectively (fig. 2).

Oliveira (2013) observed higher grazing intensity in the morning and in the late afternoon in Santa Inés sheep, times which coincide with the best atmospheric conditions. Grazing at these day hours could favor pasture intake and reduce the heat increase rate, as stated by the authors.

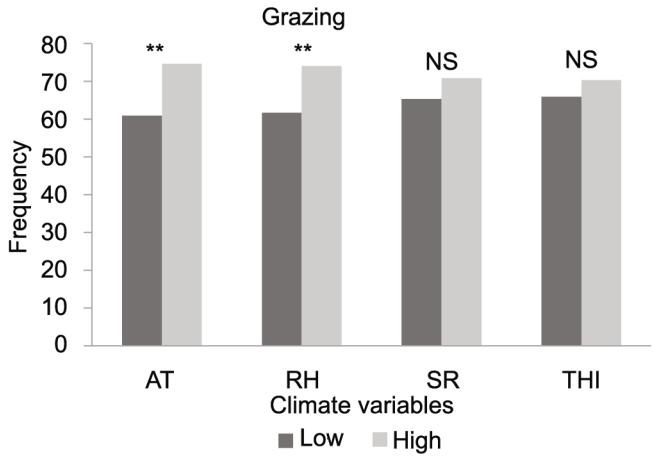

Figure 2. Effect of climate factors on the grazing activity. AT: ambient temperature, RH: relative humidity, SR: solar radiation, THI: temperature-humidity index.

In the standing activity (fig. 3) differences were observed ($p \leq 0,01$) among the frequencies for the established categories (low and high), in RH and THI, with averages of 0,8 and 2,4 % and of 0,6 and 3,1 %, respectively. It was also observed that the SR was not significant between low and high values; nevertheless, the averages were between 0,9 % (low) and 2,0 % (high), which could have influenced the fact that the animals remained standing more in NS than in WS. The standing position could show the activation of behavioral mechanisms for the reduction of the incidence of sun rays; however, such position related to the sun was not evaluated, and it is of interest to incorporate it in future studies. On the other hand, the absence of a refuge could influence the higher proportion of standing animals in the treatment NS. Kanjanapruthipong *et al.* (2015) reported that part of the behavioral mechanisms of heat loss in cattle is to remain more time in standing position, but without consuming feedstuffs, and less time in lying position when they are subject to heat stress.

One of the main benefits of shade as heat mitigation strategy is the reduction of the SR which has incidence on the animal, because it, in addition to wind speed, can significantly influence the heat load of the animal. In a study conducted by López *et al.* (2015) about the effect of grazing with or without shade on some physiological indicators in sheep during growth, the impact of radiation on the heat load of the animals was reduced by 90 % due to artificial shade.

A work conducted in climate chamber simulating the warm conditions of the semiarid region

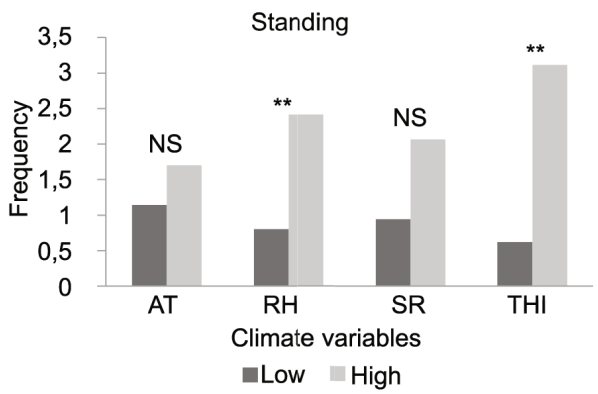

Figure 3. Effect of climate factors on the standing activity. AT: ambient temperature, RH: relative humidity, SR: solar radiation; THI: temperature-humidity index.

of India allow to show, with Garole x Malpura x Malpura sheep, a reduction in the time dedicated to consumption, rumination and lying down position in the animals under heat stress, compared with those that were under thermoneutrality conditions (De *et al*., 2017).

Rumination occupies an important place in the behavior of sheep under grazing conditions. In this study (fig. 4) was affected by RH ($p \leq 0,01$); the frequencies between the low (0,06 %) and high values (0,2 %) caused rumination to be higher in NS than in WS. The reduction of the time dedicated to rumination, the increase of the time in standing position and panting are behaviors that show decreases of thermal welfare (De *et al*., 2017). Although it was not evaluated, the resting behavior (lying down position) is extremely important and necessary for animal welfare, as reported by Leme *et al*. (2013). Thus the ambient conditions which reduce the standing time and favor rest promote animal welfare.

Although the SR was not significant ($p > 0,05$), high values were observed in this activity. In this regard, Saravia and Cruz (2003) established that the SR acts as an important charge of energy in the animal, for which it could have also affected this behavior.

Live weight (LW) of the ewes. The LW average was 20,99 ± 2,43 kg for the animals of the treatment WS and 21,24 ± 2,83 kg for those of NS ($p > 0,05$). The daily weight gain was 66,3 ± 42,8 g in WS and 66,9 ± 19,4 g in NS, and the final weight less the initial weight was 2,02 kg in both groups. The animals started with homogeneous LW and ended with equal weights; in addition, the experimental time was very short for an important variation to occur in the weights of the ewes.

These results differ from the ones reported by López *et al*. (2015), who found that the weights of growing ewes were higher in the treatment with shade than in that under sunlight, with highly significant differences between treatments.

The AT, RH and THI averages were slightly higher in WS than in NS; while SR was higher in the treatment NS. In order of importance, the activities: grazing, standing and rumination, were performed with higher frequency. The grazing, walking, urinating, standing and rumination activities were more frequent in the treatment NS than in WS, and were affected by some climate variables. The ewes started and ended the experiment with similar LW between treatments. Likewise, the made voluntary use of the canopy during the essay; the animals were observed grazing, resting, ruminating and standing under the artificial shade mainly in the afternoon hours, which reduced the effect of the high SR. To conclude, the behavior was affected by the climate variables, and the activities were more frequent in the treatment NS than in WS; however, a study with higher duration is recommended in order to corroborate these results.

Bibliographic references

De, K.; Kumar, D.; Saxena, V. K.; Thirumurugan, P. & Naqvi, S. M. K. Effect of high ambient temperature on behavior of sheep under semi-arid tropical environment. *Int. J. Biometeorol*. 61 (7):1269-1277, 2017.

Dias, L. F.; Cruz, V.; Vieira, Debora H.; Grégio, Sabrina L.; Cabral, O.; Figueiredo, Natalia de *et al.* Reações fisiológicas de cabras em diferentes ambientes e coeficiente de tolerância ao calor em cabritos. *Rev. Bras. Med. Vet*. 37 (4):286-296, 2015.

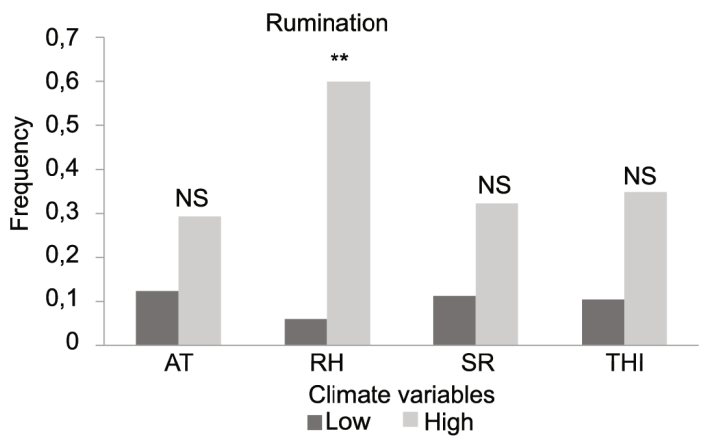

Figure 4. Effect of climate factors on the rumination activity. AT: ambient temperature, RH: relative humidity, SR: solar radiation, THI: temperature-humidity index.

Encinozo-González, O.; Camacaro-Calvete, Selina; Pinto-Santini, Livia & Ríos-de-Alvarez, Leyla. Efecto de la presencia de sombra en áreas de pastoreo de ovinos. 1. Selección de especies forrajeras. *Pastos y Forrajes*. 40 (1):45-52, 2017.

Eustáquio Filho, A.; Teodoro, Sonia M.; Chaves, M. A.; Santos, P. E. F. dos; Silva, M. W. R. da; Murta, R. M. *et al.* Zona de conforto térmico de ovinos da raça Santa Inês com base nas respostas fisiológicas. *R. Bras. Zootec*. 40 (8):1807-1814, 2011.

Gómez-García, D. Métodos para el estudio de los pastos, su caracterización ecológica y valoración. En: F. Fillat, R. García-González, D. Gómez-García y R. Reiné, eds. *Pastos del Pirineo*. España: Consejo Superior de Investigaciones Científicas, Diputación Provincial de Huesca, 2008.

Holdridge, L. R. *Ecología basada en zonas de vida*. San José, Costa Rica: IICA, 1979.

Kanjanapruthipong, J.; Junlapho, W. & Karnjanasirm, K. Feeding and lying behavior of heat-stressed early lactation cows fed low fiber diets containing roughage and nonforage fiber sources. *J. Dairy Sci*. 98 (2):1110-1118, 2015.

Leme, Thays M. da C.; Titto, E. A. L.; Titto, Cristiane G.; Pereira, A. M. F. & Netoc, M. C. Influence of stocking density on weight gain and behavior of feedlot lambs. *Small Rumin. Res*. 115 (1-3):1-6, 2013.

Lima, Carolyny B.; Costa, T. G. P.; Nascimiento, T. L.; Júnior, D. M. L.; Silva, Maria J. M. S. & Mariz, T. M. A. Comportamento ingestivo e respostas fisiológicas de ovinos em pastejo no semiárido. *JABB*. 2 (1):26-34, 2014.

Littell, R. C.; Milliken, G.; Stroup, W. W. & Freund, R. J. *SAS for linear models*. Cary, USA: SAS Institute Inc, 2002.

López, R.; Pinto-Santini, L.; Perozo, D.; Pineda, J.; Oliveros, I.; Chacón, T. *et al.* Confort térmico y crecimiento de corderas West African pastoreando con y sin acceso a sombra artificial. *Archivos de Zootecnia*. 64 (246):139-146, 2015.

Marai, I. F. M.; El-Darawany, A. A.; Fadiel, A. & Abdel-Hafez, M. A. M. Physiological traits as affected by heat stress in sheep-a review. *Small Rumin. Res*. 71 (1-3):1-12, 2007.

Meza-Herrera, C. A.; Bocanegra, J. A.; Bañuelos, R.; Aréchiga, C. F.; Rincón, R. M.; Ochoa-Cordero, M. A. *et al.* Circannual fluctuations in serum cortisol and glucose concentrations and hair coat growth in goats. *J. Appl. Anim. Res*. 31 (1):79-82, 2007.

Morantes, Martiña; Rondón-Morales, Zoraida; Colmenares, O.; Romero, Eva; Jáuregui, Damelis; Hernández-Chong, L. *et al.* Selección de herbáceas por ovinos en pastoreo continuo en sabanas bien drenadas de Venezuela. *Revista Científica, FCV-LUZ*. 27 (4):255-260, 2017.

Oliveira, F. A. de; Turco, Silvia H. N.; Aaraújo, G. G. L. de; Clemente, C. A. A.; Voltolini, T. V. & Garrido, M. S. Comportamento de ovinos da raça Santa Inês em ambientes com e sem disponibilidade de sombra. *Rev. bras. eng. agríc. ambient*. 17 (3):346-351, 2013.

Pereira-Gotto, J. N. *Fisioclimatología de los animales domésticos aplicada a la producción animal en el trópico americano.* Caracas: Editorial América, 1987.

Pereira, A. M.; Bonifácio, Ana M. R.; Santos, Camila V. dos; Silva, Irenilde A. da; Dias e Silva, T. P.; Sousa, Katiene R. S. *et al.* Thermoregulatory traits of native sheep in pregnancy and supplemented in grazing system. *J. Agric. Sci*. 6 (9):113-119, 2014.

Reyes, J. *Relación entre la temperatura superficial y la temperatura corporal en ovejas tropicales durante el pastoreo.* Tesis de grado: Facultad de Agronomía, Universidad Central de Venezuela, 2016.

Saravia, Celmira. *Efecto del estrés calórico sobre las respuestas fisiológicas y productivas de vacas Holando y Jersey.* Tesis de Maestría. Montevideo: Facultad de Agronomía, Universidad de la Republica, 2009.

Saravia, Celmira & Cruz, Gabriela. *Influencia del ambiente atmosférico en la adaptación y producción animal*. Montevideo: Facultad de Agronomía, Universidad de la Republica, 2003.

Silva, T. P. D.; Marques, C. A. T.; Torreão, J. N. C.; Bezerra, L. R.; Araújo, M. J.; Gottardi, F. P. *et al.* Ingestive behaviour of grazing ewes given two levels of concéntrate. *S. Afr. J. Anim. Sci*. 45 (2):180-187, 2015.

Sousa, L. F.; Maurício, R. M.; Paciullo, D. S. C.; Silveira, S. R.; Ribeiro, R. S.; Calsavara, L. H. *et al.* Forage intake, feeding behavior and bio-climatological indices of pasture grass, under the influence of trees, in a silvopastoral system. *Trop. grasslands*. 3 (3):129-141, 2015.

USICLIMA. *Datos climatológicos*. Caracas: Cátedra de Climatología Agrícola, Universidad Central de Venezuela, 2013.

Valtorta, S. & Gallardo, M. *El estrés por calor en producción lechera*. Argentina: Instituto Nacional de Tecnología Agropecuaria, 1996.

Zambrano, C.; Altuve, Elianny; Zambrano, L. & Parraga, C. Conducta de ovinos a pastoreo en sistema silvopastoril tradicional con predominio de samán (*Pithecellobium saman*) y guácimo (*Guazuma ulmifolia*). *Rev. Unell. Cienc. Tec*. vol. esp.:29-34, 2010.

Received: September 12, 2016
Accepted: May 7, 2017