*Pakistan J. Zool., vol. 51(2), pp 521-526, 2019.* **DOI**: http://dx.doi.org/10.17582/journal.pjz/2019.51.2.521.526

# Saint Croix Sheep Stocked on Taiwan Grass (*Pennisetum purpureum*) Displayed High Grazing Behavior at Noon Throughout the Year Under Subtropical Conditions in Mexico at 18° N

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**Article Information**
**Received 04 May 2017**
**Revised 12 July 2017**
**Accepted 07 August 2017**
**Available online 06 February 2019**

**Authors' Contributions**
**Jair MO designed the study. Jersson MO and Jair MO acquired and analyzed the data. Jair MO wrote the article while Jersson MO helped in writing the article. LMTU helped in preparation of manuscript.**

**Key words**
**Grazing behavior, Ruminating, Lying down, Hair sheep, *Pennisetum purpureum*.**

## ABSTRACT

In the tropics, environmental conditions might induce different grazing patterns from those reported in temperate sheep breeds. However, scarce information has been generated on this topic, thus the present study was conducted to analyze the grazing behavior of Saint Croix sheep at 18º N in Mexico. The present study was carried out using ten adult ewes, 32.8±5.1 kg, stocked on a Taiwan grass (*Pennisetum purpurem*) pasture maintained at a sward surface height of 30 cm. Observations were conducted during daylight hours (06:00-18:00) from May to April of the next year for three consecutive days every month of the following year. The highest ($P$<0.05) grazing activity was observed during September (38.9±11.4 min/h), while in May (27.1±14.3 min/h) was the month with least activity ($P$<0.05). Within days, the highest ($P$<0.05) grazing activity was observed at 06:00, 12:00 and 18:00 h (34.9±12.0, 31.8±12.9 and 34.5±10.6 min/h, respectively), while 09:00 and 15:00 h (28.6±13.4 and 28.0±15.7 min/h) were the periods with least activity ($P$<0.05). A correlation of -0.74 ($P$<0.05) was obtained between environment temperature and grazing activity. It was concluded that Saint Croix sheep, showed monthly pattern throughout the year and displayed high grazing activity at noon along the year, denoting great heat tolerance.

## INTRODUCTION

In the tropics, environmental conditions might induce different grazing patterns from those reported in temperate sheep breeds. Grazing animals try to adapt to poor forage conditions by increasing their grazing time (Osoro *et al*., 1999; Karadas *et al*., 2017). In addition, grazing time has been found to decline with increases in photoperiod and environmental temperature (Dunn *et al*., 1988). Thus, in different types of pasture and climatic regions, the animals adopt an appropriate strategy by changing their grazing behavior, modifying activities such as the time spent grazing, ruminating and lying down (Ashutosh *et al*., 2002). According to Rutter (2006), these changes occurred during day time, as sheep usually avoid grazing during the darkness hours. However, other studies have found that a significant amount of eating also occurs during the night (Champion *et al*., 1994). The shortening of the days (Arnold *et al*., 1981) and breed differences (Dudzinski and Arnold, 1979) might be involved in these conflicting results. Furthermore, in the tropics, the heat of the day, particularly during summer months could be a main factor affecting grazing behavior patterns, and perhaps inducing more nocturnal activity. Nevertheless, hair sheep breeds like Saint Croix are adapted to tropical conditions (Silva *et al*., 2004) and could be relatively tolerant of high temperatures, therefore the time spent grazing might not be so restricted by thermal stress. The scarce information available from tropical countries and the lack of information particularly in Saint Croix sheep keeps this an unanswered question. Therefore, the aim of the present study was to determine if Saint Croix ewes

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increase grazing behavior at noon during the tropical environment throughout one year cycle.

## MATERIALS AND METHODS

*Location*

The study was carried out at the Agricultural and Livestock Development and Research Experimental Center (CEDIA) from the Faculty of Agricultural and Livestock Sciences, Autonomous University of the State of Morelos, Mexico (FCA-UAEM); located at 18°37' N and 99°19' W, situated 1873 m above sea level and with an average annual rainfall and temperature of 800 mm and 23 °C, with a sub warm and sub humid climate (García, 1978).

*Ethics*

All procedures and methods used in the present study were following guidelines recommended and approved by the Ethical Committee for Experimentation in Animals of the Faculty of Agricultural and Livestock Sciences, Autonomous University of the State of Morelos and according with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

*Experimental paddock and management*

The experimental area consisted in a 525-m2 *P. purpureum* grassland without any grazing animals during one year before starting the experiment. Experimental paddock was fertilized using 50-100-50 (N-P-K) formula, ammonium sulfate $(NH_4)_2SO_4$ (20.5% N), calcium phosphate $Ca_3(H_2PO_4)_2$ (46% $P_2O_5$) and potassium chloride (KCl) (60% $K_2O$). The soil type is andosol with sandy loam (sandy 10%, silt 30% and clay 60%) and has a high capacity to retaining water (Millán, 2014). Drip irrigation system consisted in place four drippers belts separated to 50 cm from each other and to 25 cm from banks paddock. The drippers were located to 15 cm on the belts. Twice a week, paddock irrigation was carried out during 10 h and to maintain grass capacity in the first 10 cm soil depth one litter of water in each 45 min was supplied only in dry months (November to April) (Millán, 2014).

*Dry matter determination to consume*

Every month, five grass samples (500 g in each) were randomly selected and cut to 5 cm height of the ground with scissors using a 0.25 $m^2$ wire-cuadrant. Each grass sample was keeping into brown paper bags to obtain the fresh matter weigh. After that, each sample was weight individually on a digital bascule and 100 g were putting into a stove during 48 h at 60° C to determine the total of dry matter production (1,536,204 kg DM/ha). Finally, dehydrate samples were weigh once again to obtain data about dry matter estimation and offered according to nutritional requirements for the animals (1.4 kg DM/day/animal). Total dry matter production in the used paddock (525 $m^2$) was 80.7 kg at beginning of the study. Grass production and dry matter determination were carried out using the pasture grasses technique from Anslow and Green (1967).

*Subjects*

The experimental animals were non-pregnant Saint Croix ewes (n=10), six months old at the beginning of the study, with an average weight of 32.8±5.1 kg, which remained together as a group since weaning (3-months-old). All ewes were left in the field in order to allow grazing behavior, freely on 525 $m^2$ of Taiwan grass (*Pennisetum purpureum*) pasture, maintained at a height of 30 cm.

*Sampling periods and grazing behavior test*

Before recording of the observations started, there was an adaptive period (15 d), to let the animals accustom to management. To facilitate the animals identification, large numbers were painted on their flanks (Millán, 2014). Two trained observers monitored behavior simultaneously without interference by direct observation (El Aich *et al*., 2007) at a distance no greater than 2 m between observers and animals, every three hours for 20 min using focal sampling (2 min/animal), during three consecutive days in each month (Martin and Bateson, 1993). Observations were carried out from May-April of the next year, at periods 06:00, 09:00, 12:00, 15:00, 18:00. Data were registered for the first three days during the first week of each month, in the following year.

The registers of foraging behavior were taken with a stopwatch, which included the time spent in grazing, lying down and ruminating (Goestch *et al*., 2010). Grazing was considered as the time that a ewe was observed consuming standing vegetation (Hurnik *et al*., 1995); this behavior was composed of pretending, chewing and preparing the bolus to be swallowed (Lynch *et al*., 1992); while lying animals were considered as those observed in an inactive state, which could be sitting on the sternum or in a recumbent posture (Fraser and Broom, 1998). Rumination behavior covered: regurgitation, mastication, and re-swallowing of boluses of feed (Hurnik *et al*., 1995).

*Statistical analysis*

To compare foraging activities displayed by the ewes between the day observation periods and across months, we used ANOVA two-factor with replication on

the proportion of time ewes were grazing, ruminating or resting. Differences between means in each variable were detected using a "t"-Student test. The Pearson correlation coefficient was calculated between each of the grazing behavior variables, using the 3-h period means for grazing behaviors pooled from the three days, and the corresponding environment temperature (Towned, 2002). Statistical comparisons at 5% significance level were considered and experimental data are presented as mean ±SEM. All statistical procedures were carried out using the mixed procedure of Statistical Analyses System 9.1 (SAS Institute, Cary, NC, USA).

## RESULTS

The highest ($P$<0.05) grazing activity was observed during September (38.9±11.4 min/h), while May (27.1±14.3 min/h) was the month with the least ($P$<0.05) activity. In addition, highest ($P$<0.05) ruminating activity was observed at May, August, October and December (8.1±11.4, 8.5±12.0, 7.9±9.0 and 7.7±11.7 min/h), September, February and April being the months when lowest ($P$<0.05) rumination was observed (1.0±3.4, 1.8±4.8 and 1.3±4.2 min/h, respectively). Lastly, ewes spent more ($P$<0.05) time resting during May and December (14.3±17.1 and 14.1±13.7 min/h), while no ewes were observed lying down during September, at least in time observation (Fig. 1).

The daily pattern of foraging behaviors after observations from all days observed were pooled. Within days, the highest ($P$<0.05) grazing activity was observed at 06:00, 12:00 and 18:00 h (34.9±12.0, 31.8±12.9 and 34.5±10.6 min/h, respectively), while 09:00 and 15:00 h (28.6±13.4 and 28.0±15.7 min/h) were the periods with least ($P$<0.05) activity. In addition, the highest ($P$<0.05) ruminating activity was observed at 09:00 h (9.2±10.5 min/h), while the lowest ($P$<0.05) values corresponded to 18:00 h (0.6±2.6 min/h). Lastly, ewes spent more ($P$<0.05) time lying at 06:00, 09:00, 12:00 and 15:00 h (5.4±12.8, 7.9±12.5, 5.7±11.0 and 6.4±11.2 min/h, respectively) while least ($P$<0.05) lying was observed at 18:00 h (0.5 ± 3.0 min/h) (Fig. 2). A correlation of -0.74 ($P$<0.05) was obtained between environment temperature and grazing activity.

## DISCUSSION

In the present study, the highest grazing activity were showed during September, and the least activity were on May, so these findings are not in agreement with Ashutosh *et al.* (2002), the author found that grazing time in sheep declines with increases in environmental temperature and photoperiod. This lack of accordance it is also be due to the adaptation of Saint Croix breed to high heat temperatures in contrast with the crossbred Rambouillet sheep used

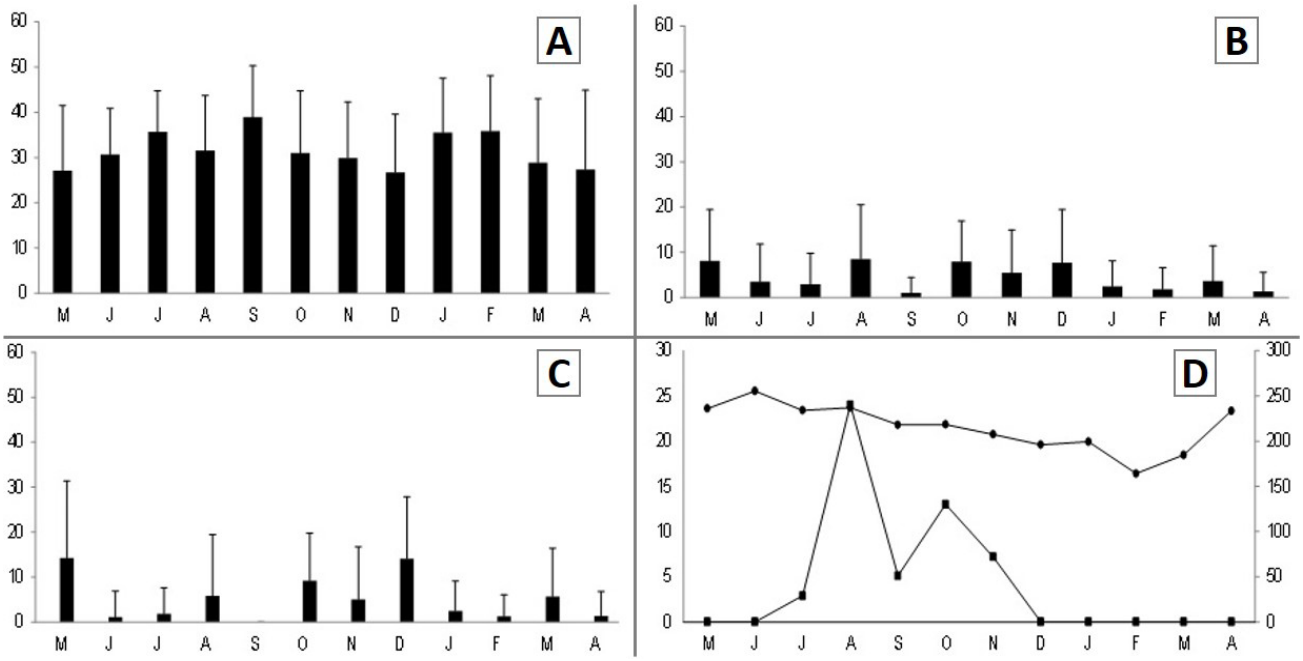


Fig. 1. Monthly pattern (average ± SE, min/h) of grazing time (A), ruminating (B) and laying down (C) in Saint Crox sheep on Taiwan (*Pennisetum purpureum*) pasture, and relation with environmental temperature (D) expressed in °C and evaporation (mm).

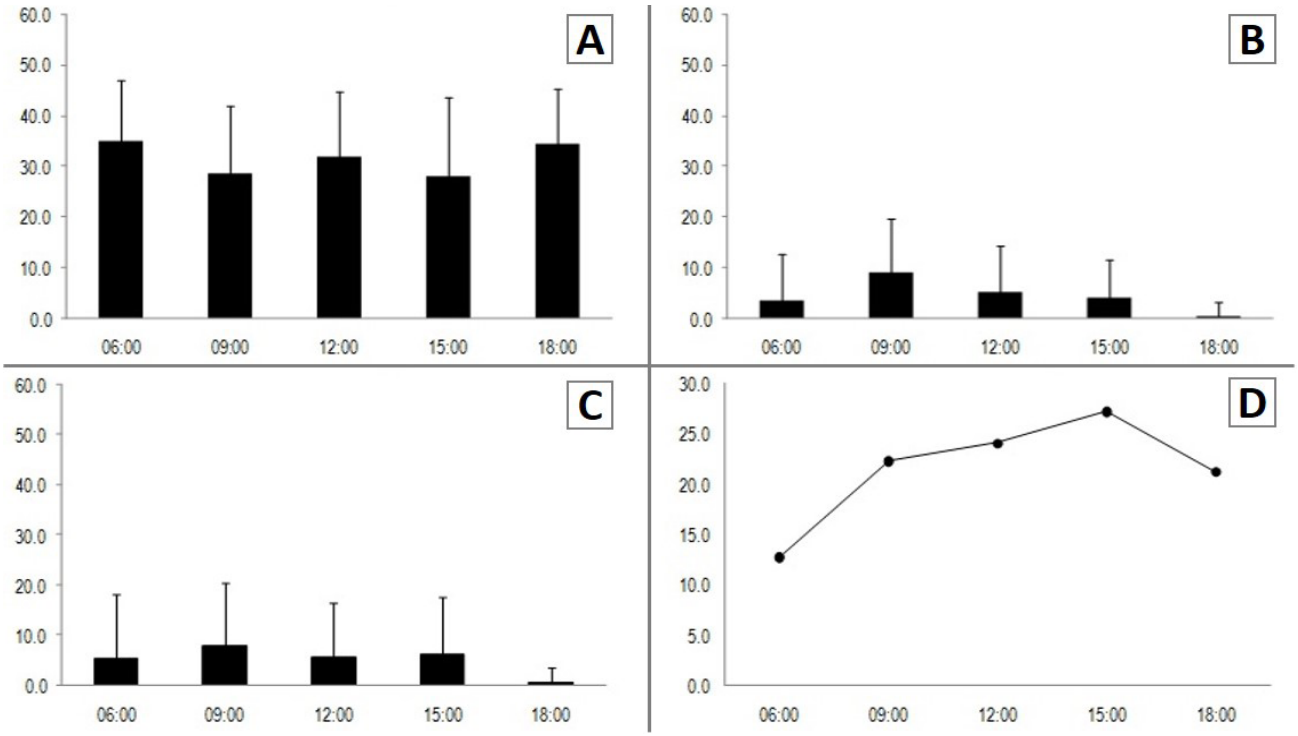


Fig. 2. Diurnal pattern (average ± SE, min/h) of grazing time (A), ruminating (B) and laying down (C) in Saint Crox sheep on Taiwan (*Pennisetum purpureum*) pasture, and relation with environmental temperature (D) expressed in °C and evaporation (mm).

(Ashutosh *et al*., 2002). A naturally short daily feeding time and an independence of activity from the environmental heat load on the animals are advantageous characteristics for animals in hot environments (Lewis, 1977). In addition, as mentioned before, seasons (rainy months) can have secondary effects on grazing, as they alter the quality and type of pasture available and so influence grazing behavior (Provenza *et al*., 1998), as confirmed by the shortest rumination periods that coincided with the short grazing periods, relating to high quality and abundant forages, and largest periods of inactivity observed during the present study. However, no clear tendency was observed in relation with a monthly pattern. Particularly, at this latitude (18° N), the raining season coincides with the summer, generating new sprouts and more green matter at this time, in comparison with the lower quality forage that is characteristic of the winter. Penning *et al*. (1991) referred that 70-99% of grazing occurred during daylight hours and several researches reported that most of the grazing activity occurs around sunrise and sunset (Parsons *et al*., 1994; Harvey *et al*., 2000; Rutter, 2006), for about three (Low *et al*., 1981a, b) or four hours (Penning *et al*., 1991; Dumont *et al*., 1995), with 25-48% of grazing included in these periods. Our results are in line with those findings. Nevertheless, a third peak of grazing activity was observed at noon, reinforcing the idea of high heat tolerance of Saint Croix sheep. These three periods of high grazing activity lead to a 6 h interval, which differs from Champion *et al*. (1994) who found peaks in eating activity every eight hours. Furthermore, these peaks were surrounded by periods of least grazing activity and highest time lying, suggesting rest episodes between activities. The sunrise and sunset grazing peaks correspond primarily to an intense motivation in response to the hunger after fasting during the night. This period was followed by the highest ruminating activity, perhaps as a consequence of the ingestion. For the sunset peak, Rutter (2006) purposed that an effective strategy for the animal is to intake a bulky feed rich in fiber with a low rate of passage (*i.e.,* grass) in the evening, helping to maintain rumen fill and reducing the need to eat at night.

In another hand, it has been reported that sheep seek a diet with a higher concentration of fiber in the evening, is supported by the findings of Dumont *et al*. (1995), which were that sheep showed an evening increase in preference for the reproductive sward, which has higher crude fiber content than the vegetative swards. Conversely, and to support the idea that sheep no need to eat at night, there are some results that showed avoiding grazing behavior at night and this is due to low light levels as well as no

sufficient visual capacity to see and to select their diets in comparison with cattle (Ayantunde *et al*., 2002) and as a strategy to predator-avoidance (Gluesing and Balph, 1980; Lima and Dill, 1990), as domestic ruminants still exhibit some strategies like to wild animals (Dwyer, 2004; Boissy *et al*., 2005).

Besides, it has been related the grazing behavior with forage quality and it was observed that ewes spent more grazing time during some particular season (summer) and with day length due to diurnal changes in chemical composition, as forage quality increasing dry matter herbage percentage from 15% to 24% during 11:30 to 19:30 both grass and clover everyday (Orr *et al*., 1997). However, for the noon peak observed, the only possible explanation is the high heat tolerance of Saint Croix sheep, which allow these animals to engage in a high grazing activity whilst avoiding heat stress in the tropics. In relation with the difference in heat tolerance between hair and wool breeds or tropical and temperate originated breeds has a significant importance and there is no doubt that this can have an effect on grazing activity. Even among temperate originated breeds some differences have been reported: Dorset Horns and Romneys are less sensitive to temperature changes than Suffolks, Southdowns and Border Leicesters. Cheviots and Suffolks begin grazing earlier in both the morning and afternoon than do Romneys, Dorset Horns, Southdowns and Border Leicesters. The Suffolks graze for longer, in all grazing periods, than sheep of all other breeds (Dudzinski and Arnold, 1979).

## CONCLUSIONS

Based on these findings, we demonstrated that Saint Croix sheep have a monthly pattern of grazing behavior throughout the year and indicate a significant high grazing behavior at noon. Besides, embrace interesting outcomes from a comparative grazing behavior perspective at 18° N, showing Saint Croix race as an excellent alternative to heat tolerance, in tropical environments.

## ACKNOWLEDGEMENTS

Jair Millán-Orozco received financial support from CONACyT-MEXICO (241234) during his PhD. studies. Authors are grateful to PhD. José Alberto Delgadillo (Centro de Investigación en Reproducción Caprina, CIRCA-UAAAN-UL), for his carefully review and valuable comments to the present manuscript. Authors are extremely grateful to all the reviewers who have involved in revisiting this manuscript submitted.

*Statement of conflict of interests*

The authors declare that they have no conflict of interests.

## REFERENCES

Anslow, R.C. and Green, J.O., 1967. The seasonal growth of pasture grasses. *J. agric. Sci*., **68**: 109-122. https://doi.org/10.1017/S0021859600017925

Arnold, G.W., 1981. In: *World animal science* (ed. F.H.W. Morley). B.I. Grazing Animals, Elsevier, Amsterdam, pp. 79-101.

Ashutosh, O., Dhanda, P. and Singh, G., 2002. Changes in grazing behaviour of native crossbred sheep in different seasons under semi-arid conditions. *Trop. Anim. Hlth. Prod*., **34**: 399-404. https://doi.org/10.1023/A:1020044226250

Ayatunde, A.A., Fernandez-Riover, S., Hiernaux, P.H., vanKeulen, H. and Udo, H. M. J. 2002. Day and night grazing by cattle in the Sahel. *J. Range Manage*., **55**: 144-149. https://doi.org/10.2307/4003350

Boissy, A., Fisher, A.D., Bouix, J., Hinch, G.N. and Le Neindre, P., 2005. Genetics of fear in ruminant livestock. *Livest. Prod. Sci*., **93**: 23-32. https://doi.org/10.1016/j.livprodsci.2004.11.003

Champion, R.A., Rutter, S.M., Penning, P.D. and Rook, A.J., 1994. Temporal variation in grazing behavior of sheep and the reliability of sampling periods. *Appl. Anim. Behav. Sci*., **42**: 99-108. https://doi.org/10.1016/0168-1591(94)90150-3

Dudzinski, M.L. and Arnold, G.W., 1979. Factors influencing the grazing behavior of sheep in a Mediterranean climate. *Appl. Anim. Ethol*., **5**: 125-144. https://doi.org/10.1016/0304-3762(79)90084-1

Dunn, R.R., Haystad, K.M. and Ayers, E.L., 1988. Grazing behavior responses of rangeland beef cows to winter ambient temperatures and age. *Appl. Anim. Behav. Sci*., **21**: 201-207. https://doi.org/10.1016/0168-1591(88)90109-8

Dumont, B., D´hour, P. and Petit, M., 1995. The usefulness of grazing tests for studying the ability of sheep and cattle to exploit reproductive patches of pastures. *Appl. Anim. Behav. Sci*., **45**: 79-88. https://doi.org/10.1016/0168-1591(95)00598-M

Dwyer, C.M., 2004. How has the risk of predation shaped the behavioural responses of sheep to fear and distress? *Anim. Welf*., **13**: 269-281.

El Aich, A., El Assouli, N., Fathi, A., Morand-Fehr, P. and Bourbouze, A., 2007. Ingestive behavior of goats grazing in the southwestern Argan (Argania spinosa) forest of Morocco. *Small Rum. Res*., 70:248-256. https://doi.org/10.1016/j.smallrumres.2006.03.011

Fraser, A.F. and Broom, D.M., 1998. *Farm animal behaviour and welfare*, 3rd ed. CAB International,

UK.

García, E., 1978. *Modificaciones al sistema de clasificación climática de Copen*. Instituto de Geografía, UNAM, México, pp. 246.

Gluesing, E.A. and Balph, D.F., 1980. Behavioural patterns of domestic sheep and their relationship to coyote predation. *Appl. Anim. Ethol*., **6**: 315-330. https://doi.org/10.1016/0304-3762(80)90132-7

Goetsch, A.L., Gipson, T.A., Askar, A.R. and Puchala, R., 2010. Invited review: Feeding behavior of goats. *J. Anim. Sci.,* **88**: 361-373. https://doi.org/10.2527/jas.2009-2332

Harvey, A., Parsons, A.J., Rook, A.J., Penning, P.D. and Orr, R.J., 2000. Dietary preference of sheep for perennial ryegrass and white clover at contrasting sward surface heights. *Grass Forage Sci*., **52**: 42-252.

Hurnik, J.F., Webster, A.B. and Siegel, P.B., 1995. *Dictionary of farm animal behavior*, 2nd ed. Iowa State University Press, Ames, USA.

Karadas, K., Tariq, M., Masood Tari, M. and Eyduran, E., 2017. Measuring predictive performance of data mining and artificial neural network algorithms for predicting lactation milk yield in indigenous Akkaraman sheep. *Pakistan J. Zool.*, **49**:1-8.

Lewis, J.G., 1977. Game domestication for animal production in Kenya: activity patterns of eland, oryx, buffalo and cattle. *J. agric. Sci*., **89**: 551-563. https://doi.org/10.1017/S0021859600061323

Lima, S.L. and Dill, L.M., 1990. Behaviour decisions made under the risk of predation: a review and prospectus. *Canadian J. Zool*., **68**: 619-640. https://doi.org/10.1139/z90-092

Low, W.A., Tweedie, R.L., Edwards, C.B.H., Hodder, R.M., Malafant, K.W.J. and Cunningham, R.B., 1981a. The influence of environment on daily maintenance behavior of free-ranging Shorthorn cows in central Australia. III. Detailed analysis of sequential behavior patterns and integrated discussion. *Appl. Anim. Ethol*., **7**: 39-56. https://doi.org/10.1016/0304-3762(81)90048-1

Low, W.A., Tweedie, R.L., Edwards, C.B.H., Hodder, R.M., Malafant, K.W.J. and Cunningham, R.B., 1981b. The influence of environment on daily maintenance behavior of free-ranging Shorthorn cows in central Australia. II. Multivariate analysis of duration and incidence of activities. *Appl. Anim. Ethol*., **7**: 27-38. https://doi.org/10.1016/0304-3762(81)90048-1

Lynch, J.J., Hinch, G. and Adams, D.B., 1992. *Behavioral of sheep: Biological principles and implications for production*. CSIRO Australia, CAB International, Oxon, England.

Martin, P. and Bateson, P., 1993. *Measuring behaviour: An introductory guide*. Cambridge University Press, Cambridge, pp. 48-50. https://doi.org/10.1017/CBO9781139168342

Millán, O.J., 2014. *Migración vertical de larvas infectantes de Haemonchus contortus y conducta ingestiva de ovinos Santa Cruz en pasto Taiwán* (Pennisetum purpureum). PhD thesis, Facultad de Ciencias Agropecuarias, Universidad Autónoma del Estado de Morelos.Cuernavaca, Morelos, México.

Orr, R.J., Penning, P.D., Harvey, A. and Champion, R.A., 1997. Diurnal patterns of intake rate by sheep grazing monocultures of ryegrass or white clover. *Appl. Anim. Behav. Sci*., **52**: 65-77. https://doi.org/10.1016/S0168-1591(96)01120-3

Osoro, K., Oliván, M., Celaya, R. and Martínez, A., 1999. Effects of genotype on the performance and intake characteristics of sheep grazing contrasting hill vegetation communities. *Anim. Sci.,* **69**: 419-426. https://doi.org/10.1017/S1357729800050992

Parsons, A.J., Newman. J.A., Penning, P.D., Harvey, A. and Orr, R.J., 1994. Diet preference of sheep: effects of recent diet, physiological state and species abundance. *J. Anim. Ecol*., **63**: 465-478. https://doi.org/10.2307/5563

Penning, P.D., Rook, A.J. and Orr, R.J., 1991. Patterns of ingestive bahaviour of sheep continuously stocked on monocultures of ryegrass or white clover. *Appl. Anim. Behav. Sci*., **31**: 237-250. https://doi.org/10.1016/0168-1591(91)90008-L

Provenza, F.D., Villalba, J.J., Cheney, C.D. and Werner, S.J., 1998. Self-organization of foraging behaviour: from simplicity to complex without goals. *Nutr. Res. Rev*., **2**: 199-222. https://doi.org/10.1079/NRR19980015

Rutter, S.M., 2006. Diet preference for grass and legumes in free-ranging domestic sheep and cattle: Current theory and future application. *Appl. Anim. Behav. Sci*., **97**: 17-35. https://doi.org/ 10.1016/j.applanim.2005.11.016

Silva, A.M.A., Silva-Sobrinho, A.G., Trindade, I.A.C.M., Resende, K.T. and Bakke, O.A., 2004. Food intake and digestive efficiency in temperate wool and tropic semi-arid hair lambs fed different concentrate: forage ratio diets. *Small Rum. Res*., **55**: 107-115. https://doi.org/10.1016/j.smallrumres.2004.01.001

Townend, J., 2002. *Practical statistical for environmental and biological scientists*. John Wiley & Sons, England, pp. 93-127.