

## Preferences of sheep, when supplemented, for forages in a Mediterranean rangeland management system

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**Abstract.** Most rangelands in Jordan are degraded and contain almost no perennial vegetation. A study was conducted near Tal alRumman, Jordan to evaluate grazing behaviour of sheep under typical sheep management conditions where supplemental barley provides the majority of the intake by sheep. The objectives were to determine if sheep preferred herbaceous or woody vegetation and to evaluate a management system that utilises limited areas of ungrazed perennial vegetation in expanses of heavily-grazed and severely-degraded rangeland. Twenty-five Awassi ewes were placed in three 0.1-ha paddocks of ungrazed native rangeland for 2.5 h each day for 3 consecutive days and observed. The three paddocks were grazed for 9 days during each of four seasons: winter, spring, summer and autumn. Sheep were herded to and from the experimental paddocks in the morning and were fed 0.5 kg of barley in the evening. Virtually all grazing occurred in the experimental paddocks because rangeland areas where sheep were housed were severely degraded and contained very little herbage ( $<40$  kg DM ha<sup>-1</sup>). Herbage mass of herbaceous perennial vegetation in the study area averaged 165 kg DM ha<sup>-1</sup> and potentially edible portions (leaves and twigs) of shrubs averaged 82 kg DM ha<sup>-1</sup>. Sheep spent more time ( $P < 0.05$ ) grazing than browsing, chewing, standing or ruminating during all seasons. Sheep spent most of their time grazing during the first hour of grazing, and then the time spent grazing declined ( $P < 0.05$ ) and time standing and ruminating tended to increase near the end of the 2.5-h grazing period. Under typical management in Jordan where sheep are supplemented with barley, sheep clearly preferred herbaceous vegetation over shrubs. To meet sheep preferences, rangeland restoration efforts in Jordan should focus on establishment of mixes of grasses, forbs and shrubs rather than planting only shrubs. This study suggests that allowing sheep access to perennial vegetation for 2–3 h per day can potentially extend the grazing period of limited areas of restored rangeland while providing sheep sufficient time to complete a grazing bout.

**Additional keywords:** activity patterns, Awassi ewes, barley, restoration, supplementation.

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### Introduction

Livestock grazing is the dominant agriculture enterprise, and an important part of the culture, of the Hashemite Kingdom of Jordan. About 90% of the country is arid or semiarid rangeland and is known as the Badia. The Badia extends into Iraq, Saudi Arabia and Syria. Cover is minimal in most areas of Badia, and rangeland health is a critical concern. Herbage production in the Badia is estimated to be less than 10% of potential levels (Al-Tabini *et al.* 2012). Heavy stocking rates, continuous grazing near permanent water sources, dryland cultivation and drought have been attributed to cause much of the downward trend in rangeland condition in Badia (Al-Tabini 2001). To increase herbage production, increase the cover of perennial vegetation and reduce erosion, it has been suggested that seeding or transplanting perennial shrubs on deteriorated rangelands, such as those found in Badia, should be carried out (e.g. Al-Tabini

*et al.* 2008; Ben Salem *et al.* 2010). In areas of Jordan with over 100 mm of annual precipitation, there also may be opportunities to establish drought-tolerant perennial grasses (Bailey *et al.* 2010).

Rangeland restoration efforts in the Badia and other areas in the Middle East have been limited in size because of seed cost, lack of equipment and labour requirements (Le Houérou 2000). In many cases, rangeland restoration has been conducted in demonstration plots that vary in size from 1 to 20 ha. Often restoration plots are surrounded by extensive areas of extremely deteriorated rangeland with almost no perennial vegetation. Yet rangelands in Jordan contain large populations of sheep and goats of ~1 523 900 (DOS 2012). These livestock herds are sustained by purchased grain rather than ingesting rangeland vegetation. Currently, 80–90% of sheep diets contain grain, typically barley (Al-Eisa 1998; Al-Tabini *et al.* 2012). Average

herd size in the Badia has decreased over time and is currently 109 sheep (Al-Tabini et al. 2012). If sheep were to rely entirely on the herbage from the restored areas, a typical Bedouin herd could only graze for a few days to a few weeks because restoration areas are usually small. Ruminants require at least some roughage in the diet (Weston 1974; Van Soest 1994). The value of small-scale rangeland restoration efforts would be enhanced if the period of grazing could be extended.

Rangeland restoration should consider the needs and preferences of important herbivores. In Jordan, the dominant herbivore is sheep (Titi et al. 2000; Al-Tabini 2001). Sheep are typically categorised as intermediate feeders and can graze and browse on grasses, forbs and shrubs (Holechek 1984). Although numerous studies have examined grazing preferences by sheep (e.g. Migongo-Bake and Hansen 1987), rangeland livestock husbandry practices in Jordan and many other areas in the Middle East differ from other regions of the world. Sheep are fed grain daily and allowed to graze sparsely vegetated rangeland (Al-Eisa 1998; Al-Tabini et al. 2012). Grazing preferences by Bedouin sheep may vary from previously reported studies because almost all of the nutrients sheep consume are from barley grain. Preferences are not constant and can be affected by experience and availability of other feeds (Provenza 1996; Villalba et al. 2004). For example, sheep fed barley grain showed a greater preference for high protein foods compared with controls (Villalba and Provenza 1999). Our overall goal was to develop management to sustainably graze plots of restored rangeland under typical sheep husbandry practices in the Badia. One of the specific objectives of this study was to determine if access to a plot containing perennial vegetation for 2.5 h was sufficient for sheep to complete a grazing bout. We hypothesised that sheep could complete a grazing bout in 2 h and become satiated as indicated by a switch from foraging to resting. Anecdotal observations of Bedouin herders suggested that access to ungrazed or lightly grazed perennial vegetation for more than a few hours was not efficient because sheep under typical management would stop foraging. The other specific objective of this study was to determine preferences of sheep for shrubs and herbaceous vegetation under the typical management systems for sheep in Jordan where sheep consume 0.5 kg of barley each day and are allowed to graze rangeland. We hypothesised that sheep would prefer shrubs, because nutrient profiles of grain are often more similar to herbaceous vegetation than shrubs. Understanding forage preferences under typical Bedouin husbandry will allow managers to develop more appropriate restoration plans and associated seed mixes to meet land-use objectives, including livestock grazing.

## Methods

The study was conducted at the Royal Botanical Garden (RBG) and adjacent rangeland located ~30 km north-west of Amman, Jordan near Tal alRumman (32°10'57"N, 35°49'38"E). The experimental paddocks in the RBG were located in the Zarqa River watershed on a south-eastern exposure with Rendzina soils and slopes varying from 10 to 25%. Elevation averaged 400 m. Common plant species grazed are *Poa bulbosa* L., *Hordium* spp., *Avena sterilis* L., *Erodium gruinum* (L.) L'Hér. ex

Aiton, *Salsola vermiculata* L., and *Ephedra aphylla* Forssk. The rangeland adjacent to the RBG was severely degraded with almost no perennial vegetation. The area is hilly with excessive bare soil (>90% cover). The only vegetation is a few shrubs, such as *Euphorbia hirosolymiatana* Boiss. and *Sarcopoterium spinosum* (L.) Spach., and some occasional herbaceous perennials such as *Urginea maritima* (L.) Baker, *Ferula communis* L., and *Phlomis viscosa* Poir.

Climate at the study site is Mediterranean with precipitation occurring from October to April. Observations of sheep behaviour were recorded during four seasons in 2009: winter (January), spring (April), summer (June) and autumn (September). Precipitation from October 2008 to April 2009 at the site totalled 260 mm with no other precipitation occurring during the period of the study. Eighty per cent of the precipitation occurred in February and March 2009. Only 1 mm of precipitation occurred during April 2009.

Herbage mass of herbaceous and shrub vegetation at the study site was estimated at the RBG in April 2009 by clipping 1-m<sup>2</sup> quadrats at 27 randomly selected locations where the paddocks were established. Vegetation was separated into herbaceous and shrub categories, dried at 50°C for 48 h, and weighed. These herbage mass estimates were the peak with no changes during the remainder of the study except for deterioration from weathering. Virtually no vegetative growth would be expected after April because of the absence of precipitation and increasing ambient temperatures during the spring and summer.

Three 0.1-ha paddocks were established during each season. Locations of these paddocks were randomly selected within the study site. A small flock of 25 Awassi ewes that were 3–5 years of age and weighed on average 60 kg were used in the study. Six of the 25 ewes in the study had lambs. Lambs were born in the winter between October and February. The flock grazed a paddock for 2.5 h in the morning for 3 consecutive days before switching to the next paddock. In total, sheep were observed for 9 days (three paddocks) during each season. Paddocks were not grazed before observations began. The flock was herded to the paddock within the RBG and herded out of the paddock and the RBG after the 2.5-h session. After sheep left the RBG, they were placed with other sheep for the remainder of the day. Although rams were not taken to the RBG, they were in the main herd and the ewes in study were exposed to rams daily. Virtually no grazing occurred outside the experimental paddocks in the RBG. The area where sheep were kept outside of the RBG contained very little vegetation (herbage mass of <40 kg DM ha<sup>-1</sup>). In the evening, all sheep were fed 0.5 kg DM of barley. Prior to the beginning of the study, ewes used in the study were allowed to graze in the study area for 3–5 h on 3 different days to allow them to become familiar with the vegetation and the terrain.

A focal animal approach was used to measure activity by the sheep (Lehner 1996). Individual sheep were marked on the left and right shoulder to allow observers to identify the 25 ewes in the study and to distinguish among sheep. The focal sheep was followed and continuously observed during the 2.5-h session. Southcott et al. (1962) reported that one marked sheep and focal animal observation approach was a reliable indicator of group activity. A different randomly-selected ewe was used for each

paddock. The distance between the observer and the focal (marked) sheep was kept to a minimum to ensure the behaviour of the sheep could be discerned, but sufficient distance was maintained to avoid frightening the sheep and affecting their behaviour. Every minute, observers classified the activity of the focal sheep into one of six categories: (1) grazing, (2) browsing, (3) chewing, (4) ruminating, (5) standing, and (6) resting. Grazing consisted of prehension of grasses and forbs, while browsing was the prehension of shrubs or tree leaves and stems. Chewing was defined of mouth movements that occurred between prehension events, and were separated from mouth movements that occurred in rumination. Less than 0.5% of sheep activity was classified as resting, and the category was removed from the analyses. The session of 2.5 h of observations was separated and summarised into five 30-min periods: 0.0–0.5 h, 0.5–1.0 h, 1.0–1.5 h, 1.5–2.0 h and 2.0–2.5 h.

Grazing behaviour data were analysed using non-parametric statistical techniques. Even after square-root and arc-sine transformations, data were not normally distributed, which prevented use of parametric approaches such as repeated-measures ANOVA. Chi-square was used to determine if the frequency of observations of sheep activity differed among categories during a season. Data from each season was analysed separately. Each 30-min observation period was considered as a single observation so that the total number of experimental units for this Chi-square analysis was 45 (five periods per day, 3 days per paddock, and three paddocks per season).

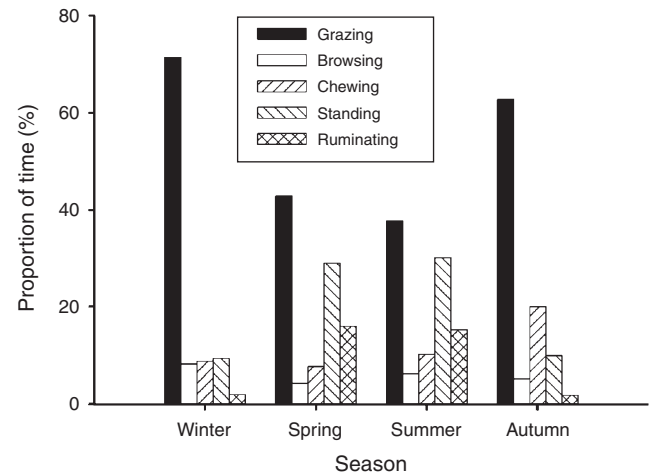
Friedman non-parametric two-way analysis on ranks (Lehner 1996) was used to determine if activity varied from the first to the last 30-min period. Each season was analysed separately. The 3 days of observation in a paddock were averaged together, and paddock was considered a blocking factor. Correspondingly, there were 15 experimental units (five periods per paddock, three paddocks per season) for this analysis.

To determine if activity varied among the 3 days that sheep were in a paddock, separate Friedman analyses were conducted for each behaviour. Paddocks within season were used as blocking factors, and the five observation periods within a day were averaged together. Seasons were analysed separately, and there were nine experimental units (3 days per paddock and three paddocks per season).

## Results and discussion

Herbage mass averaged 165 kg DM ha<sup>-1</sup>. Approximately 60% of the herbage mass was grasses, and the remainder was forbs. Average shrub mass (leaves and twigs, but not stems) was 82 kg DM ha<sup>-1</sup>.

Consistently in each of the four seasons, the proportion of time that sheep spent grazing grasses, browsing shrubs, chewing, standing and ruminating was not equal ( $P < 0.01$ ). Sheep spent much more time grazing than other behaviours during the winter, spring, summer and autumn seasons (Fig. 1). Even though shrubs made up ~0.33 of the grazeable vegetation in the study site, sheep spent only a small proportion of their time browsing (Fig. 1). In contrast, Migongo-Bake and Hansen (1987) found that 40–50% of the diet of sheep was shrubs or trees. Land managers in the Badia typically use shrubs for rangeland restoration in Jordan because of their ability to establish in dry



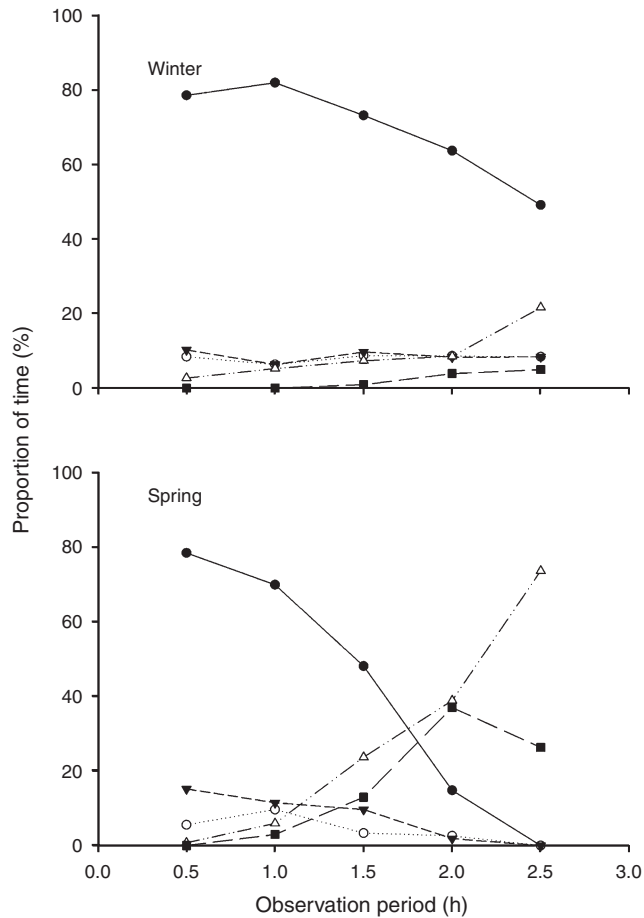
**Fig. 1.** Activity patterns of sheep (grazing, browsing, chewing, standing and ruminating) during the winter, spring, summer and autumn seasons. Values reflect averages of 2.5 h observation periods collected over 3 days in each of 3 paddocks during each season.

conditions and because managers believe that shrubs would complement diets of sheep fed barley grain. In this study, sheep fed barley (the typical management practice) preferred herbage over shrubs.

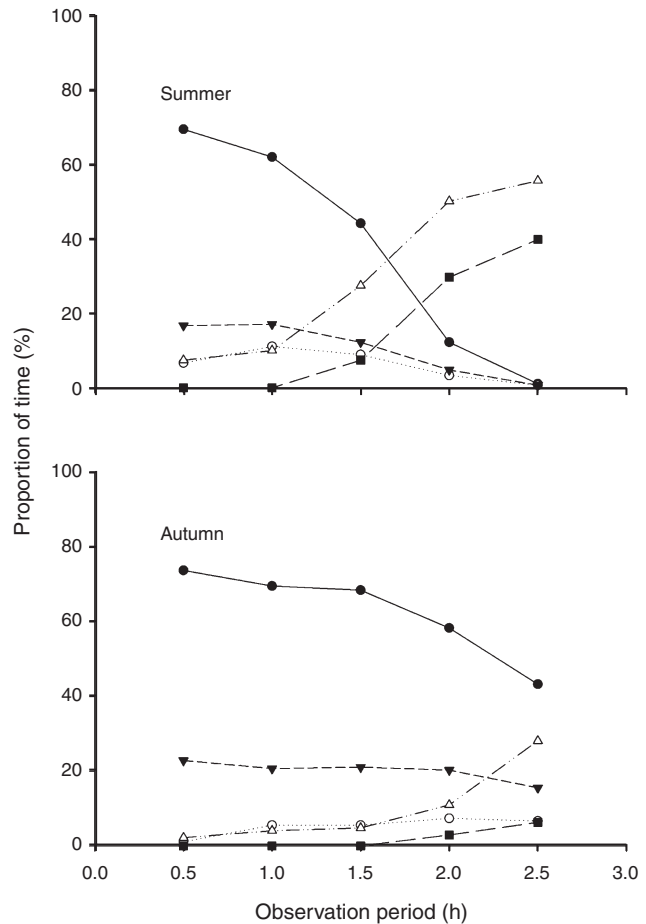
Behaviour patterns were consistent during the 3 days that sheep grazed each paddock. No differences ( $P > 0.05$ ) in any of the behaviours were detected among Days 1, 2 and 3 in a paddock during the winter, spring, summer and autumn seasons (data not shown). Although forage utilisation within the paddock was not measured, the extent of defoliation during the 3 days of observation apparently was not sufficient to alter behavioural patterns. Sheep were able to become satiated and end grazing before the end of the observation session.

Sheep reduced ( $P < 0.05$ ) the time spent grazing during the 2.5-h observation session in all seasons (Figs 2 and 3). Initially, sheep spent most of their time grazing herbaceous species. Towards the end of the 2.5-h observation session, sheep shifted from grazing and began to stand or ruminate. Baumont *et al.* (2000) suggested that sheep shift from foraging to resting as they become satiated. One explanation for the shift from foraging to standing or ruminating is that sheep were able to fill their rumens during the 2.5-h grazing session. Feeding 0.5 kg of barley in the evening also likely affected grazing behaviour. De Rosa *et al.* (1996) found that supplemented goats did not graze as long as goats that were not supplemented.

Results from this study support the concept of limiting grazing time on small plots of restored rangeland to extend the time that the plot can benefit Bedouin herders. Sheep in Badia obtain most of their nutrients from purchased barley grain, and increasing the amount of rangeland herbage in the diet of sheep will reduce feed costs and likely improve sheep health. In the spring and summer, sheep in this study almost completely stopped grazing and browsing after 2 h. In the autumn and winter, time spent foraging dropped by ~40% after 2 h. Forage quality in spring and summer were likely much higher than during autumn or winter because most of the precipitation fell during



**Fig. 2.** Activity patterns of sheep (grazing, ●; browsing, ○; chewing, ▼; standing, Δ; and ruminating, ■) during 30-min periods of the 2.5-h session that sheep were in the experimental paddock each day. Values reflect the average of observations collected over 3 consecutive days in each of three paddocks for (a) the winter and (b) the spring seasons.



**Fig. 3.** Activity patterns of sheep (grazing, ●; browsing, ○; chewing, ▼; standing, Δ; and ruminating, ■) during 30-min periods in the 2.5-h session that sheep were in the experimental paddock each day. Values reflect the average of observations collected over 3 consecutive days in each of three paddocks during the summer and autumn seasons.

or shortly after most of the precipitation occurred (February and March). In addition, ewes with lambs would have had higher nutrient requirements in the winter session because they had recently lambed (Kearl 1982). Limiting grazing time in revegetated plots will reduce time actively spent by herders with the sheep. Rather than herding sheep for hours in an attempt to find forage in severely degraded rangeland, herders could spend 2–3 h in a revegetated plot and then return to their camp site. Limiting the grazing time to a few hours each day and continuing feeding barley would also increase the time that a small revegetated plot could be used before appropriate utilisation levels were reached.

In the Badia, large areas would need to be revegetated to support an average herd (109 sheep) in Jordan (Al-Tabini *et al.* 2012). Based on the herbage mass measured in this study, 300–400 ha of restored rangeland would be needed support one herd year-long without supplement. Few, if any, restoration plots approach the size required to support typical herds in the Badia. To encourage large-scale restoration efforts, limiting daily grazing time (2–3 h per day) and ending all grazing before

defoliation becomes excessive may be a reasonable approach to sustainably graze small-scale restoration projects in the Badia. More research is needed to determine the long-term impacts of limited grazing on restored rangeland on typical sheep management in the Badia.

### Management implications

The clear preference of sheep for herbage in this study suggests that rangeland reclamation efforts in Jordan should not focus entirely on planting and establishment of shrubs. The use of perennial grasses and forbs should be considered in restoration efforts. In areas with greater than 100 mm of annual precipitation, drought-tolerant perennial grasses may be an option for seeding (Bailey *et al.* 2010). Mixes of grasses, forbs and shrubs would likely match preferences of sheep more closely than shrub plantings. After perennial vegetation becomes established, grazing could be controlled and the grazing period extended by limiting sheep access to small restoration plots to 2–3 h per day.



## References

- Al-Eisa, A. (1998). Changes and factors affecting Bedouin movement for grazing. In: 'Drylands: Sustainable Use of Drylands into the Twenty-First Century'. International Fund for Agricultural Development (IFAD) Series, Technical Reports. (Eds Squire, Sidahmed) pp. 369–374. (IFAD: Rome, Italy)
- Al-Tabini, R. J. (2001). An evaluation of the potential of *Atriplex nummularia* for sheep production in arid Jordanian rangelands; the effects of defoliation management. PhD Thesis, Newcastle upon Tyne, United Kingdom.
- Al-Tabini, R. J., Libbin, J. D., Saoub, H., Bailey, D. W., Abuamoud, I., and Hawkes, J. (2008). Tal Rimah range rehabilitation – recreating a valuable resource. Jordan Component of the Sustainable Development of Drylands Project Report #4. New Mexico State University, Las Cruces, NM, USA. Available at: [http://ag.arizona.edu/OALS/susdev/Reports/Jordan\\_Component/Jordan\\_Agribusiness/NMSUTalRimahRangeRehab.pdf](http://ag.arizona.edu/OALS/susdev/Reports/Jordan_Component/Jordan_Agribusiness/NMSUTalRimahRangeRehab.pdf) (accessed 20 October 2011).
- Al-Tabini, R., Al-Khalidi, K., and Al-Shudiefat, M. (2012). Livestock, medicinal plants and rangeland viability in Jordan's Badia: through the lens of traditional and local knowledge. *Pastoralism: Research Policy & Practice* 2, 4.
- Bailey, D. W., Al Tabini, R., Waldron, B. L., Libbin, J. D., Al-Khalidi, K., Alqadi, A., Al Oun, M., and Jensen, K. B. (2010). Potential of *Kochia prostrata* and perennial grasses for rangeland rehabilitation in Jordan. *Rangeland Ecology and Management* 63, 707–711. doi:10.2111/REM-D-09-00195.1
- Baumont, R., Rache, S., Meuret, M., and Morand-Fehr, P. (2000). How forage characteristics influence behaviour and intake in small ruminants: a review. *Livestock Production Science* 64, 15–28. doi:10.1016/S0301-6226(00)00172-X
- Ben Salem, H., Norman, H. C., Nefzaoui, A., Mayberry, D. E., Pearce, K. L., and Revell, D. K. (2010). Potential use of oldman saltbush (*Atriplex nummularia* Lindl.) in sheep and goat feeding. *Small Ruminant Research* 91, 13–28. doi:10.1016/j.smallrumres.2009.10.017
- De Rosa, G., Napolitano, F., Bordin, A., Vesce, G., and Rubino, R. (1996). Influence of feeding supplementation on goats' grazing behaviour. *Options Méditerranéennes* 25, 57–68. Available at: <http://ressources.ciheam.org/om/pdf/c05/95605259.pdf> (accessed 19 October 2011).
- DOS (2012). 'Agriculture Data for Year 2011, Report.' (Department of Statistics, Government of Jordan: Amman.)
- Holechek, J. L. (1984). Comparative contribution of grasses, forbs, and shrubs to the nutrition of range ungulates. *Rangelands* 6, 261–263.
- Kearl, L. C. (1982). 'Nutrient Requirements of Ruminants in Developing Countries.' (International Feedstuffs Institute: Logan, UT.)
- Le Houérou, H. N. (2000). Restoration and rehabilitation of arid and semiarid Mediterranean ecosystems in North Africa and West Asia: a review. *Arid Soil Research and Rehabilitation* 14, 3–14. doi:10.1080/089030600263139
- Lehner, P. N. (1996). 'Handbook of Ethological Methods.' 2nd edn. (Cambridge University Press: Cambridge, UK.)
- Migongo-Bake, W., and Hansen, R. M. (1987). Seasonal diets of camels, cattle, sheep and goats in a common range in eastern Africa. *Journal of Range Management* 40, 76–79. doi:10.2307/3899366
- Provenza, F. D. (1996). Acquired aversions as the basis for varied diets of ruminants foraging on rangelands. *Journal of Animal Science* 74, 2010–2020.
- Southcott, W. H., Roe, R., and Turner, H. N. (1962). The effect of size of flock on pasture and sheep production with special reference to internal parasites and grazing behavior. *Australian Journal of Agricultural Research* 13, 880–893. doi:10.1071/AR9620880
- Titi, H. H., Tabbaa, M. J., Amasheh, M. G., Barakeh, F., and Daqamseh, B. (2000). Comparative performance of Awassi lambs and Black goat kids on different crude protein levels in Jordan. *Small Ruminant Research* 37, 131–135. doi:10.1016/S0921-4488(99)00136-4
- Van Soest, P. J. (1994). 'Nutritional Ecology of the Ruminant.' (Cornell University Press: Ithaca, NY.)
- Villalba, J. J., and Provenza, F. D. (1999). Nutrient-specific preferences by lambs conditioned with intraruminal infusions of starch, casein, and water. *Journal of Animal Science* 77, 378–387.
- Villalba, J. J., Provenza, F. D., and Han, G. (2004). Experience influences diet mixing by herbivores: implications for plant biochemical diversity. *Oikos* 107, 100–109. doi:10.1111/j.0030-1299.2004.12983.x
- Weston, R. H. (1974). Factors limiting the intake of feed by sheep. VIII. The roughage requirement of the ruminant lamb fed on concentrate diets based on wheat. *Australian Journal of Agricultural Research* 25, 349–362. doi:10.1071/AR9740349