INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
09–104/MSA/2009/11–6–681–689
http://www.fspublishers.org

Full Length Article

Effect of Small Ruminant Grazing on the Plant Community Characteristics of Semiarid Mediterranean Ecosystems

MOUNIR LOUHAICHI[1], AMIN K. SALKINI AND STEVEN L. PETERSEN†
International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria
†Plant and Animal Sciences Department, Brigham Young University, Provo, UT 84602, USA
[1]Corresponding author's e-mail: M.Louhaichi@cgiar.org

ABSTRACT

Rangeland degradation has been widespread and severe throughout the Syrian steppe as a result of both unfavorable environmental conditions and human induced impacts. To explore the effectiveness of management-based strategies on establishing sustainable rangeland development, we compared the response of temporarily removing grazing from rangelands ecosystems to those under a continuous heavy grazing regime. Results indicated that ungrazed sites had both higher biomass production and plant species composition than grazed sites. Ungrazed plots produced more than fourfold herbaceous biomass production than continuously grazed plots ($p < 0.001$). Extent of plant cover was 20% greater in ungrazed plots than grazed plots (33.5 & 13.5%, respectively). Furthermore areas protected from heavy grazing had over 200% greater species composition. Thus, protection from grazing can increase forage production and species composition, but may not necessarily improve plant species available for livestock utilization. A more balanced grazing management approach is recommended to achieve an optimal condition of biomass production (quantity), vegetation cover, quality and available forage species that contribute to proving livestock grazing conditions.

Key Words: Vegetation sampling; Overgrazing; Species diversity; Semiarid; Steppe

INTRODUCTION

Domestic livestock have grazed Mediterranean rangelands for thousands of years, in particular regions that are found in West Asia and North Africa (WANA) (Noy-Meir & Seligman, 1979; Perevolotsky & Seligman, 1998). Sheep and goat production was historically an important occupation for rural populations located within WANA countries (Fitzhugh, 1987; Steinbach, 1987; Nygaard & Amir, 1988). Over time, impacts associated with livestock grazing have been heightened due to poor management practices and the arid or semiarid climate regime characteristic of this area (Chaichi *et al.*, 2005). Average annual precipitation and temperature patterns are highly variable with low average annual rainfall that is erratic and poorly distributed both temporally and spatially. Droughts are common within the region, resulting in lower forage and crop productivity and limited water availability for plants, livestock and wildlife. Additionally, annual to seasonal air temperatures can range widely with highs reaching over 45°C during the summer months. The effects of high temperatures are aggravated by dry winds, or sirocco, which may occur during the growing season, making the steppe an exceedingly hostile environment.

Traditionally, WANA rangelands have contributed food and shelter to the poorest sector of the region's population. These rangelands provide the major source of feed for Bedouin livestock production systems, a valuable resource for sustaining rural communities (Zacaria, 1947; Nordblom & Shomo, 1995). WANA Rangelands also provide a diversity of vital ecological attributes, processes, products and services such as the maintenance of nutrient cycling and hydrologic dynamics, the filtering of environmental pollutants, medicinal herbs used by local peoples and the preservation of biodiversity for millions of resource-poor agro-pastoral farmers. Currently WANA rangelands support high human population densities that apply significant pressure on these resources through elevated livestock grazing practices. These impacts have lead to increased rates of desertification, a problem that continues to worsen until proper management measures are developed and implemented that reduce these grazing impacts.

Overgrazing in the WANA region has been attributed in part to the grazing activities of small ruminant animals in particular domestic sheep and goats. These animals are currently being raised under limited livestock production systems that require high energy inputs but result in low overall productivity. Therefore farmers often depend on government subsidies and agricultural by-products to sustain small-scale farming practices (Thomson *et al.*, 2003). The expanding demand for meat and milk within the WANA region has resulted in higher national flock sizes

To cite this paper: Louhaichi, M., A.K. Salkini and S.L. Petersen, 2009. Effect of small ruminant grazing on the plant community characteristics of semiarid Mediterranean ecosystems. *Int. J. Agric. Biol.,* 11: 681–689

within the most productive rangelands in the area (Aw-Hassen *et al.,* 2008) and crop development occurring primarily on marginal lands within low rainfall zones (Gintzburger *et al*., 1997). These practices have resulted in lower grain production for human consumption, animal feed deficits, accelerated soil erosion, the reduction of desirable and palatable species, increased numbers and distribution of un-palatable or toxic plants, reduced water quality, elevated soil salinity, loss of genetic integrity within forage plants and decreased biodiversity (Manzano *et al*., 2000; Ares *et al.,* 2003; Salkini *et al*., 2008). These trends have also led to significant rangeland degradation, threatening long term sustainability under current use and management programs. Together these factors negatively affect livestock productivity, food security and the livelihood of the people living in these rural communities. For example, Le Houérou and Boulos (1992) reported that as much as 1 to 2% of all rangeland areas in the WANA region are lost from desertification each year. Reports from the mid-fifties indicate that between 60 to 80% of the small ruminant's diet in the WANA emanate from rangelands, whereas the current rate has plunged to less than 10%, where rangelands are in poor condition (Nordblom *et al*., 1995).

Grazing by domestic livestock is commonly associated with changes in species composition in native grasslands (Noy-Meir *et al*., 1989; Westoby *et al.,* 1989; Milchunas & Lauenroth, 1993; Milton *et al*., 1994; Ruiz-Fernandez, 2007). Under long-term-intensive grazing the shift in species composition frequently involves the replacement of palatable with unpalatable plant species, in particular woody perennials that provide low to no forage value. Grazing systems, which are management tools for controlling the frequency and duration of grazing and rest periods, optimize livestock and plant performance and minimize undesirable woody species invasion (Heitschmidt & Taylor, 1991).

Rangeland resources within Syria are widely degraded with an urgent need for rehabilitation. However, before engaging in rangeland rehabilitation and management, research is needed to assess rangeland condition at the local level and to identify the most effective methods for reversing desertification. Rangeland condition can be assessed in part from the productivity and availability of important forage plant species (Uniyal *et al*., 2005). In this study we investigated plant community structure and productivity relative to different grazing strategies within a Syrian rangeland covering approximately 10.5 million hectares, translating to more than half of the country's landmass (Serra *et al*., 2003; Dutilly-Diane *et al*., 2006). Specific objective of this study was to quantify and compare rangeland productivity under a continuously grazed system with a system that was temporarily ungrazed for 2 years before sampling.

MATERIALS AND METHODS

Site description. The study was conducted in the Khanasser valley, located in northwestern Syria approximately 70 km southeast of Aleppo city. This area represents an ecotone between Mediterranean and Irano-Turanian phytogeographical regions. The soils are predominantly derived from calcareous parent material with relatively high pH (8.3), low organic matter (0.6%) and multi-nutrient deficiencies. The climate is described as Mediterranean semiarid, where winter rains are highly variable between years and concentrated from December through March. Average annual precipitation is approximately 210 mm, ranging between 53 to 367 mm (calculated from a 75 year time period). Mean monthly temperatures ranged from 2.4°C in January to 36°C in August with an average annual temperature of 17.6°C (average over 32 years). Subzero temperatures occur at night during the months of December and January but rarely during or after February. All climatic data reported here was obtained from the ICARDA's meteorological station located at the study area.

Vegetation physiognomy consists of low grasses (*Hordeum murinum, Carex stenophylla*) with scattered high grasses (*Stipa lessingiana, Hordeum bulbosum*), shrubs (*Noaea mucronata, Teucrium polium*) and woody plants (*Crataegus aronia, Pistacia atlantica*). The most abundant herbaceous species is *H. murinum,* which frequently occurs with *N. mucronata* in late seral dominated ecosystems (Al-Oudat *et al*., 2005). Overgrazing of these rangelands promotes replacement of palatable mid grasses *(Stipa barbata & Dactylis glomerata)* by low grasses *(Hordeum murinum & Koeleria phleoides).* Low grasses are eventually replaced by unpalatable grasses, in paritucular those at the mature stage of development.

To quantify the differences between grazed and protected plant communities, two adjacent sites were selected. The first site was located in the hillslopes of Al-Hoss near the village of Mgherat (35° 48' 19" N, 37° 30' 58" E, altitude 320 m) and the second site was situated near the village Om Myal in the hillslopes of Shbeath (35°46' 08" N, 37° 34' 47" E, altitude 325 m). The experimental layout at each hill slope included two different gazing regimes; one open to grazing and the other protected from grazing for 2 years. Vegetation sampling occurred in the spring of 2002, during the peak season of primary production.

Sampling Procedure

Herbaceous biomass. A randomly selected plot having 50 x 50 m plot (0.25 ha), was used to sample each grazing regime. In this plot, peak standing crop by species group was assessed during spring 2002. Twelve 1 m × 1 m quadrats were randomly distributed inside each plot to estimate biomass production. Above-ground biomass was harvested by manually clipping 2.5 cm above soil surface within each quadrat. This height represents a typical standing crop height after the plants have been bitten by animals like sheep during grazing. Once plants were clipped and bagged, all vegetation material was oven dried (48 h at 70°C) and weighed. The percent of total standing biomass for above-ground plant parts was determined for all species present.

Herbaceous cover. Two methods were used to estimate percent herbaceous cover. First, a 1 m^{-2} quadrat was used to visually estimate percent cover of stones/rocks, bareground, total plant canopy cover and herbaceous plant cover. Second the line intercept method was used to determine herbaceous cover (Ripley *et al.,* 1963; Owensby, 1973; Barabesi & Fattorini, 1998; Thompson, 1992), which has similar accuracy to quadrat method, but requires less sample time (Canfield, 1944). For this method, a random starting point was established based on its orientation to the sampling area. From this point, three 50 m transect lines were established at 120° from each other. Percent cover was calculated as the proportion of the transect line covered by each species. The chance of a particular species being encountered along the transect line was proportional to its width (perpendicular to the transect line). Density can be calculated by multiplying the total reciprocal of maximum plant width by the unit area/total transect length (Cox, 1990).

Cover = sum of intercept lengths for a species/total length of transect × 100.

Eco-characterization of plant taxa and plant nomenclature was based primarily on the work of Zohary and Feinbrum (1966–1986), Mutard (1966) and Zohary (1962).

Species composition and life form. Species composition presents an efficient expression for revealing the spatial distribution of a species and the numerical strength of a particular species present across a landscape. Furthermore, it reflects a combination of environmental and historical events at a site. We used the dry-weight-rank method to estimate species composition (Jones & Hargreaves, 1979). In both sites species composition was recorded using 50 randomly assigned quadrats (50 × 20 cm) per treatment.

Life form and similarity index. Plant species were split into eight groups based on morphology (life form) and life span. The groups included: chamaephyte (semi-shrub), phanerophyte (shrub), geophyte (perennial herb with bulb or tuber), therophyte (annual grasses), perennial grasses, biennial forb, perennial forb and therophyte (annual forb). Motyka's similarity index (Mueller-Dombois & Ellenberg, 1974) was used to make comparisons between species composition and life form group at each site:

Similarity index (%) = 2c/(a+b) x 100%.

Where c is the number of species common to the both samples a and b are the number of all species in sample A and all species in sample B, respectively.

Palatability class. Using the data from the line intercept method, all recorded species were placed into 4 classes. Class I, II, III and IV represent high palatability, moderate palatability, low to unpalatable and poisonous species, respectively.

Statistical analyses. Analysis of variance (ANOVA) was used to test for vegetation differences between grazed and protected steppe plant communities (Sokal & Rohlf, 1995). Duncan's test was used to identify differences between sample means. All analyses were conducted using SAS 9.1 software (SAS, 2004). Differences between means were considered significant if P values were ≤ 0.05. Means and standard error values are reported in each figure.

RESULTS

During the sampling year, rainfall was below long-term seasonal average in fall (30.5 vs. 22 mm) and winter (117 vs. 104 mm). In contrast, rainfall was similar to long-term seasonal average in spring (55.5 vs. 57 mm). The plant species from both sites are listed in Table I and II. A total of 145 plant species belonging to 34 families were recorded of these species 20.4, 12.2, 13.6 and 7.8% belonging to the families *Asteraceae*, *Poaceae*, *Fabaceae* and *Apiaceae*, respectively (Table III). Results of this analysis indicated that differences occur among measured variables including herbaceous and shrub biomass, percent cover and species composition.

Herbaceous and shrub biomass. As expected, there was more biomass production in the ungrazed areas than in the grazed ones ($P < 0.001$) (Fig. 1). Biomass of native shrubs was lower in grazed plots compared to protected plots (Fig. 2). Results indicated difference in biomass at the Al-Hoss site ($P = 0.0322$) but none at the Shbeath site ($P = 0.1170$).

Percent bare-ground and plant cover. Percent bareground was greater on grazed sites ($P = 0.005$), whereas percent plant canopy cover was higher in the ungrazed sites ($P = 0.008$). However no significant differences were found in stone and rock cover ($P = 0.3849$) (Fig. 3). Overall, among both treatments and sites, percent bareground was the predominant cover component, constituting more than 50% of the total surface cover. This was followed by plant canopy cover (26%) and stone and rock cover (22%).

The ungrazed area at the Al-Hoss site provided over 40% of total plant cover with *H. murinum* (38%) exhibiting the highest percent cover by species. *T. polium* had 12.5% cover and *Bromus danthoniae* had 5.2% cover. The grazed area had 16% total plant cover with *H. murinum at* 47%, *Eurca sativa at* (8.3) and *Medicago minima* at (4%) plant cover by species (Table IV). The ungrazed area at the Shbeath site provided 33.5% total plant cover. Of this, *N. mucronata* representing 35%, followed *by H. murinum* (34.2%) and *Carex stenophylla* (9.2%). In the grazed area, total plant cover was 13.5%, with *Carex stenophylla* representing 42% of that area followed by *H. murinum* (22.3%) and *N. mucronata* (7.5%) (Table V).

Table I. List of species in Al-Hoss site (Syria) in the protected and grazed area

Species	P	G	Species	P	G	Species	P	G
Achillea aleppica	√	0	*Erodium cicutarium*	√	√	*Onobrychis ptolimaica*	√	0
Achillea membranacea	√	0	*Eryngium creticum*	√	√	*Ononis sicula*	√	√
Adonis annua	√	0	*Eryngium glomeratum*	√	√	*Onopordum heteracanthum*	√	√
Aegilops ovate	√	0	*Euphorbia densa*	√	√	*Ornithogalum narbonense*	√	0
Aegilops sp.	√	0	*Euphorbia macroclada*	√	√	*Papaver rhoeas*	√	0
Alkanna strigosa	√	0	*Fagonia indica*	√	√	*Peganum harmala*	√	√
Allium truncatum	√	0	*Filago contracta*	√	√	*Phlomis* sp.	√	√
Anagallis arvensis	√	0	*Filago pyramidata*	√	√	*Picris damascena*	√	0
Anemone coronaria	√	0	*Fumaria parviflora*	√	0	*Pimpinella corymbosa*	√	√
Anethum graveolens	√	0	*Gagea chlorantha*	√	0	*Plantago coronopus*	√	√
Anthemis cotula	√	0	*Galium chaetopodum*	√	√	*Plantago cylindrica*	√	0
Arnebia decumbens	√	0	*Garhadiolus angulosus*	√	√	*Plantago psyllium*	√	0
Arum sp.	√	0	*Gymnarrhena micrantha*	√	0	*Poa bulbosa*	√	√
Asphodelus microcarpus	√	0	*Hedypnois rhagadioloides*	√	0	*Poa* sp.	√	0
Astracantha echinus	√	0	*Helianthemum salicifolium*	√	√	*Pterocephalus involucratus*	√	√
Astragalus asterias	√	0	*Herniaria hemistemon*	√	√	*Ranunculus asiaticus*	√	0
Astragalus hamosus	√	0	*Hippocrepis unisiliquosa*	√	0	*Ranunculus* sp.	√	0
Astragalus sp.	√	0	*Holosteum* sp.	√	√	*Raphanus raphanistrum*	√	0
Astragalus spinosus	√	0	*Hordeum bulbosum*	√	0	*Reseda lutea*	√	0
Astragalus tribuloides	√	0	*Hordeum murinum*	√	√	*Rhaponticum pusillum*	√	0
Atractylis cancellata	√	√	*Hypericum triquetrifolium*	√	√	*Roemeria hybrida*	√	0
Avena sp.	√	0	*Iris pseudacorus*	√	0	*Salsola vermiculata*	√	√
Bromus danthoniae	√	0	*Ixiolirion tataricum*	√	0	*Salvia palaestina*	√	0
Bromus tectorum	√	0	*Koeleria phleoides*	√	√	*Satureja* sp.	√	0
Bupleurum gerardii	0	√	*Koelpinia linearis*	√	√	*Scabiosa prophyroneura*	√	0
Bupleurum lancifolium	√	√	*Lactuca orientalis*	√	√	*Scorzonera papposa*	√	√
Carduncellus eriocephalus	√	√	*Lagoecia cuminoides*	√	0	*Senecio glaucus*	√	0
Carduus pycnocephalus	√	√	*Linum strictum*	√	0	*Silene coniflora*	√	0
Carex stenophylla	√	√	*Lolium rigidum*	√	√	*Sinapis arvensis*	√	√
Carrichterra annua	√	0	*Lophochloa phleoides*	√	0	*Stipa barbata*	√	0
Centaurea pallescens	√	√	*Malva aegyptia*	√	√	*Stipa lessingiana*	√	0
Ceratocephala falcata	√	√	*Matthiola longipetala*	√	0	*Teucrium polium*	√	√
Cichorium pumilum	√	√	*Medicago minima*	√	√	*Teucrium pruinosum*	√	0
Coriandrum sativum	√	0	*Medicago rigidula*	√	√	*Thymus syriacus*	√	0
Cousinia postiana	√	0	*Muscari racemosum*	√	0	*Torilis leptophylla*	√	0
Dactylis glomerata	√	0	*Nardurus maritimus*	√	√	*Trigonella astroites*	√	0
Dianthus strictus	√	√	*Nigella arvensis*	√	0	*Trigonella monantha*	√	0
Echinops gaillardotii	√	√	*Noaea mucronata*	√	√	*Trigonella monspeliaca*	√	√
Echium sp.	√	√	*Notobasis syriaca*	√	0	*Verbascum* sp.	√	√
Eremopyrum bonaepartis	√	0	*Onobrychis crista-galli*	√	√	*Vicia sativa supsp.amphicarpa*	√	0
						Ziziphora tenuior	√	0

P = Protected, G = Grazed, √ = Present, 0 = Absent

Species composition and frequency. The ungrazed plots had more species (120 & 118 for the Al-Hoss & Shbeath sites, respectively) than the grazed plots (51 & 56, respectively for Al-Hoss & Shbeath sites) (Table I & II). Table VI and VII represent the 10 most frequent species composition encountered in the grazed and protected plots for both sites.

Life form and similarity index. The life form of the analyzed taxa exhibited a wide range of variation. Life form, which was divided into eight classes, took into account the growth of higher plants resulting from tissue initiation at the apices. It included chamaephyte, a perennial plant that sets its dormant vegetative buds just at or above the surface of the ground; geophyte a perennial plant that propagates by underground bulbs or tubers or corms; phanerophyte the surviving buds or shoot apices are borne on shoots, which projected into the air. Therophyte plants completed their life cycle from seed to seed and died. Results of species, sampling and their respective life forms are shown in Table VIII and IX. Therophytes were the most predominant life form and represented over 50% of the total flora of total species recorded. Perennial forbs and chamaephytes constitute 16.3% and 11.3% of all life forms in the sampled vegetation, respectively. The computation of the similarity index in species composition between the grazed and ungrazed sites revealed similar results (59%) for both sites.

Species palatability. At the Al-Hoss site, there were 20 more highly palatable species and 7 more moderately palatable species in the ungrazed plots than in the grazed plots. In contrast there were 36 more low to unpalatable species and 13 more poisonous species in grazed plots than ungrazed plots (Fig. 4). At the Shbeath site, there were 22 more highly palatable species and eight more moderately palatable species in the ungrazed plots than in the grazed plots. In contrast there were 19 more low to unpalatable species and 9 more poisonous species in grazed plots than ungrazed plots (Fig. 4).

Table II. List of species in Shbeath site (Syria) in the protected and grazed area

Species	P	G	Species	P	G	Species	P	G
Achillea aleppica	√	0	*Fagonia indica*	√	√	*Papaver rhoeas*	√	0
Adonis annua	√	0	*Filago contracta*	√	√	*Papaver* sp.	√	0
Aegilops sp.	√	0	*Filago pyramidata*	√	0	*Peganum harmala*	√	√
Alkanna strigosa	√	0	*Galium chaetopodum*	√	√	*Phlomis* sp.	√	√
Allium stamineum	√	0	*Garhadiolus angulosus*	√	0	*Picris damascena*	√	0
Alyssum damascenum	√	0	*Gymnarrhena micrantha*	√	√	*Pimpinella corymbosa*	√	√
Anagallis arvensis	√	√	*Hedypnois rhagadioloides*	√	√	*Plantago coronopus*	√	0
Andrachne telephioides	√	√	*Helianthemum salicifolium*	√	0	*Plantago cylindrica*	√	0
Androsace maxima	√	0	*Herniaria hemistemon*	√	√	*Plantago psyllium*	√	0
Anthemis cotula	√	0	*Hippocrepis unisiliquosa*	√	0	*Poa bulbosa*	√	√
Arnebia decumbens	√	0	*Holosteum* sp.	√	√	*Poa* sp.	√	0
Astracantha echinus	√	√	*Hordeum bulbosum*	√	0	*Pterocephalus involucratus*	√	√
Astragalus asterias	√	√	*Hordeum murinum*	√	√	*Raphanus raphanistrum*	√	0
Astragalus hamosus	√	0	*Hypecoum procumbens*	√	0	*Reseda lutea*	√	0
Astragalus sp.	√	0	*Hypericum triquetrifolium*	√	0	*Rhaponticum pusillum*	√	0
Astragalus spinosus	√	√	*Iris pseudacorus*	√	0	*Roemeria hybrida*	√	0
Astragalus tribuloides	√	0	*Ixiolirion tataricum*	√	0	*Salvia palaestina*	√	0
Atractylis cancellata	√	√	*Koeleria phleoides*	√	0	*Scabiosa prophyroneura*	√	√
Avena sp.	√	0	*Koelpinia linearis*	√	√	*Schismus barbatus*	√	0
Bromus danthoniae	√	√	*Lactuca orientalis*	√	√	*Scorpiurus muricatus*	√	0
Bromus tectorum	√	0	*Lagoecia cuminoides*	√	0	*Scorzonera papposa*	0	√
Bupleurum gerardii	√	0	*Lathyrus* sp.	√	0	*Senecio glaucus*	√	0
Bupleurum lancifolium	√	√	*Leopoldia eburenea*	√	0	*Silene coniflora*	√	√
Capparis ovata	√	√	*Linum strictum*	√	√	*Sinapis arvensis*	√	0
Carduncellus eriocephalus	√	√	*Lolium rigidum*	√	0	*Stipa barbata*	√	0
Carduus pycnocephalus	√	√	*Lophochloa phleoides*	√	0	*Stipa lessingiana*	√	0
Carex stenophylla	√	√	*Malva aegyptia*	√	√	*Teucrium creticum*	√	0
Carrichterra annua	√	0	*Matricaria chamomilla*	√	0	*Teucrium polium*	√	√
Centaurea pallescens	√	√	*Matthiola longipetala*	√	√	*Teucrium pruinosum*	√	0
Ceratocephala falcata	√	0	*Medicago minima*	0	√	*Texiera glastifolia*	√	0
Coriandrum sativum	√	0	*Medicago radiata*	√	0	*Thymus syriacus*	√	√
Crepis sp.	0	√	*Medicago rigidula*	√	√	*Torilis leptophylla*	√	√
Cynodon dactylon	0	√	*Melilotus indicus*	√	0	*Torularia torulosa*	√	√
Dactylis glomerata	√	0	*Nardurus maritimus*	√	√	*Trachynia distachya*	√	√
Dianthus strictus	√	√	*Nigella arvensis*	√	0	*Trifolium tomentosum*	√	0
Echium sp.	√	√	*Noaea mucronata*	√	√	*Trigonella monspeliaca*	√	√
Erodium cicutarium	√	√	*Notobasis syriaca*	√	0	*Trigonella* sp.	√	0
Eryngium creticum	0	√	*Onobrychis aurantiaca*	√	0	*Verbascum* sp.	√	0
Eryngium glomeratum	√	√	*Onobrychis crista-galli*	√	√	*Vicia sativa supsp.amphicarpa*	√	0
Euphorbia densa	√	√	*Ononis sicula*	√	0	*Vicia* sp.	√	0
Euphorbia macroclada	√	√	*Onopordum heteracanthum*	√	√	*Ziziphora tenuior*	√	√

P = Protected, G = Grazed, √ = Present, 0 = Absent

DISCUSSION

Many studies worldwide have shown that chronic and intensive grazing of rangelands can be detrimental to plant and plant communities, because it removes leaf area that is necessary to absorb photosynthetically active radiation and convert it to chemical energy (Caldwell *et al.*, 1981; Briske & Richards, 1995; Ahmed *et al.*, 2006; Mosallam, 2007). Rangelands in the Syrian steppe have experienced similar plant removal from herbivory that has resulted in the dominance of unpalatable shrub species such as *N. mucronata* (Al-Oudat *et al.*, 2005).

Regarding biomass production, this study substantiates results reported in comparable studies from similar biophysical regions, where grazing has had a negative effect on rangeland productivity and sustainability (Gallacher & Hill, 2006; Ouled Belgacem, 2008). Differences in overall herbaceous biomass production between grazed and ungrazed plots were highly significant ($P < 0.001$). Continuous grazing has been shown to be particularly devastating toward total herbaceous biomass production (Crawley, 1983; Call & Roundy, 1991). However while differences in shrub biomass were significant at the Al-Hoss site ($P = 0.0333$), they were not significant at the Shbeath site ($P = 0.1170$). This suggests that variation in shrub encroachment may occur when sampling within plots from different sites, likely due to variability in soil properties, water availability, or nutrient levels.

An increase in exposed soil coinciding with a reduction in vegetation cover can be perceived as an indicator of ecosystem dysfunction (Tongway & Ludwig, 1997). Lower vegetation cover reduces the efficiency with which resources can be captured and utilized such as water, organic material and nutrients (Blackburn, 1986; Humberto *et al.*, 1996; Simons & Allsopp, 2007). While both treatments had similar stone/rock cover ($p = 0.3849$), protection from grazing resulted in an increase in total plant cover compared to grazed sites.

Table III. Main family names for Al-Hoss and Shbeath sites (Syria) in the protected and grazed areas (%)

	Al Hoss		Shbeath	
Family name	**Protected**	**Grazed**	**Protected**	**Grazed**
Asteraceae	19	25	16.1	21.4
Poaceae	14	9.6	14.4	10.7
Fabaceae	13.2	11.5	16.9	12.5
Apiaceae	6.6	9.6	5.9	8.9
Lamiaceae	5.8	3.8	5.9	7.1
Brassicaceae	3.3	1.9	5.9	3.6
Caryophyllaceae	2.5	3.8	2.5	5.4
Euphorbiaceae	1.7	3.8	2.5	5.4
Ranunculaceae	5	1.9	2.5	0
Boraginaceae	2.5	1.9	2.5	1.8

Table IV. The 10 highest species cover in Al-Hoss site (%)

Protected		Grazed	
Species	**Species cover**	**Species**	**Species Cover**
Hordeum murinum	38	*Hordeum murinum*	46.8
Teucrium polium	12.5	*Eruca sativa*	8.3
Bromus danthoniae	5	*Medicago minima*	4
Aegilops sp.	5	*Centaurea pallescens*	3.5
Eryngium creticum	4	*Teucrium polium*	3.5
Carex stenophylla	3	*Filago contracta*	3.4
Helianthemum salicifolium	3	*Euphorbia macroclada*	3.2
Onopordum heteracanthum	2	*Eryngium creticum*	2.5
Dianthus strictus	2	*Eryngium glomeratum*	2.5
Carrichterra annua	2	*Carex stenophylla*	2.5

Table V. The 10 highest species cover in Shbeath site (%)

Protected		Grazed	
Species	**Species Cover**	**Species**	**Species Cover**
Noaea mucronata	35	*Carex stenophylla*	42
Hordeum murinum	34	*Hordeum murinum*	22
Carex stenophylla	9	*Noaea mucronata*	7.3
Teucrium polium	4	*Koeleria phleoides*	4.5
Dianthus strictus	3.5	*Eryngium creticum*	4.3
Linum strictum	2	*Bupleurum lancifolium*	2.3
Astragalus spinosus	2	*Teucrium polium*	2.1
Lophochloa phleoides	1	*Peganum harmala*	1.9
Koeleria phleoides	1	*Pterocephalus involucratus*	1.8
Onopordum heteracanthum	1	*Astracantha echinus*	1.4

Table VI. The 10 highest species composition in Al-Hoss site (%)

Ungrazed Area		Grazed Areae	
Species	**Species composition**	**Species**	**Species composition**
Hordeum murinum	52	*Hordeum murinum*	73
Teucrium polium	8	*Centaurea pallescens*	9.5
Noaea mucronata	6.5	*Teucrium polium*	4
Onopordum heteracanthum	5.5	*Herniaria hemistemon*	2.5
Carrichterra annua	4	*Koeleria phleoides*	2.5
Stipa lessingiana	3.5	*Onopordum heteracanthum*	2
Lactuca orientalis	2.5	*Phlomis* sp.	1.5
Eruca sativa	2.5	*Echinops gaillardotii*	1.5
Medicago minima	2	*Eruca sativa*	1.3
Aegilops sp.	2	*Lactuca orientalis*	1

Table VII. The 10 highest species composition in Shbeath site (%)

Protected Area		Grazed Area	
Species	**Species composition**	**Species**	**Species composition**
Hordeum murinum	42	*Hordeum murinum*	79
Noaea mucronata	27	*Pterocephalus involucratus*	3.5
Eruca sativa	11	*Lactuca orientalis*	3
Teucrium polium	6	*Noaea mucronata*	2.5
Linum strictum	5	*Carduncellus eriocephalus*	2.5
Koeleria phleoides	4	*Astragalus spinosus*	2.5
Torularia torulosa	2	*Koeleria phleoides*	1.5
Lactuca orientalis	1	*Centaurea pallescens*	1.4
Helianthemum salicifolium	1	*Dianthus strictus*	1.2
Ziziphora tenuior	0.2	*Andrachne telephioides*	0.5

Table VIII. Life-form distribution of surveyed species of Al-Hoss site

Life form	**Protected plot**		**Grazed plot**	
	No. of species	**%**	**No. of species**	**%**
Chamaephyte (semi-shrub)	12	10	5	9.8
Phanerophyte (shrub)	1	0.8	1	2
Geophyte (perennial herb with bulb or tuber)	8	6.7	1	2
Biennial forb	3	2.5	2	3.9
Perennial grass	6	5	2	3.9
Perennial forb	19	15.8	10	19.6
Therophyte (annual forb)	59	49.2	26	51
Therophyte (annual grass)	12	10	4	7.8
Total species	120	100	51	100

The negative impact of continuous grazing on species composition will continue to increase as long as no change in management has taken place. We observed substantially higher herbaceous species diversity in protected plots compared to grazed plots. In agreement with these results Milchunas and Lauenroth (1993) and Osem (2002) reported that grazing by domestic livestock is commonly associated with changes in species composition in rangelands throughout the world.

As for life forms, the flora of both the ungrazed and grazed sites consisted primarily of therophytes (annuals), which made up approximately 60% of the plant species occurring at the site (Table VI & VII). The high percentage of therophytes indicated that recovery time was limited for other plants to establish in the community, in particular phanerophytes and chamaephytes, which required more time to re-establish in newly rested sites. Both phanerophytes and chamaephytes place their buds higher off the ground and subsequently are more sensitive to grazing compared to plants that maintain their buds at ground-level or below the soil surface (Liddle, 1975). The number of therophytes in ungrazed sites was more than double than that of the grazed plots. These findings correspond with several studies, which report changes in plant species composition result from livestock grazing (Smith & Schmutz, 1975; Noy-Meir *et al*., 1989).

Table IX. Life-form distribution of surveyed species of Shbeath site

Life form	Protected plot		Grazed plot	
	No. of species	%	No. of species	%
Chamaephyte (semi-shrub)	10	8.5	9	16.1
Phanerophyte (shrub)	0	0	0	0
Geophyte (perennial herb with bulb or tuber)	3	2.5	1	1.8
Biennial forb	3	2.5	1	1.8
Perennial grass	6	5.1	3	5.4
Perennial forb	15	12.7	9	16.1
Therophyte (annual forb)	69	58.5	29	51.8
Therophyte (annual grass)	12	10.2	4	7.1
Total species	118	100	56	100

Fig. 1. Differences in herbaceous biomass between grazed and ungrazed areas at the Al-Hoss and Shbeath study sites (g.m^{-2})

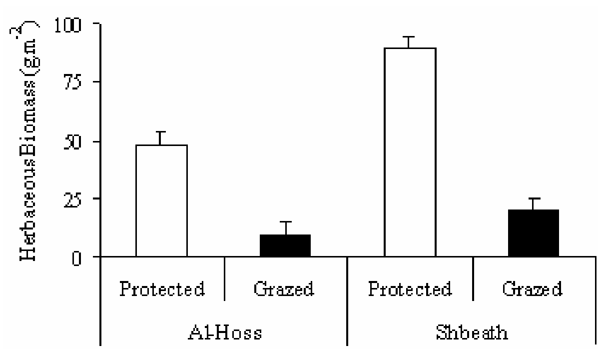
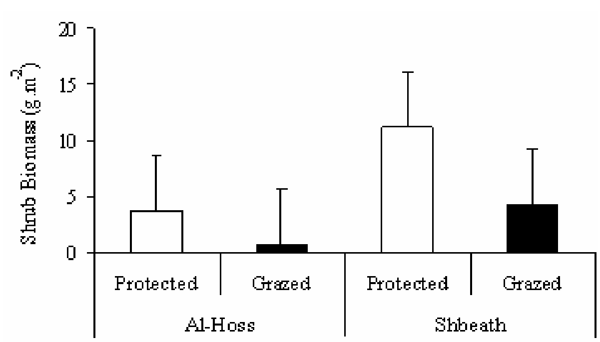


Fig. 2. Differences in shrub biomass between grazed and ungrazed areas at the Al-Hoss and Shbeath study sites (g.m^{-2})



At the Al-Hoss site, *H. murinum* had the highest plant cover for both grazed and ungrazed plots. This annual grass species is one of the most competitive invaders of Syrian rangelands. It takes advantage of existing soil moisture when available and is not preferred by livestock. At the Shbeath site, *N. mucronata* and *H. murinum* occurred in ungrazed plots. *N. mucronata* can tolerate xeric conditions and is unpalatable to livestock. In the grazed plot, *C. stenophylla* had the highest percentage. This species is able to tolerate heavy grazing, because its buds are situated near the soil surface and it can reproduce vegetatively via rhizomes.

Fig. 3. Percent cover in grazed and protected plots for Al-Hoss and Shbeath sites. PC = plant cover; SRC = stone cover; BGC = bare soil cover

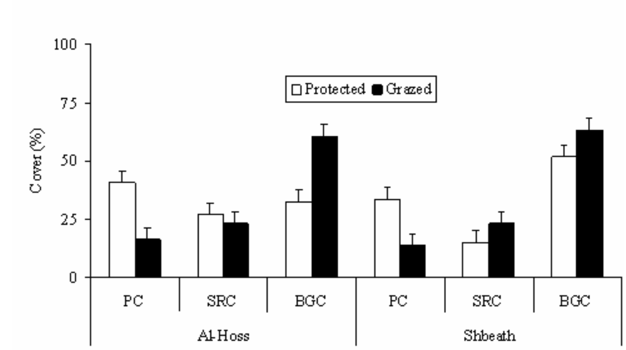
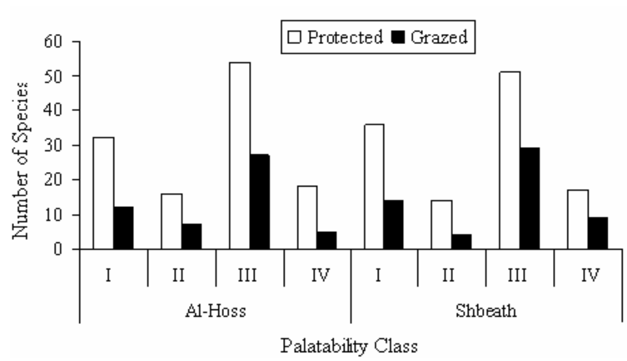


Fig. 4. Palatability class: I = high palatable; II = medium palatable; III = low-unpalatable; IV = poisonous plants



Four palatability classes have increased under protection from continuous grazing. In fact exclusion of grazing has improved the overall productivity in terms of biomass. However it did not enhance the forage quality. Thus, a prescribed grazing management should be undertaken to help the most palatable species get established and slowly disfavor non-palatable and poisonous species. These results are in conformity with several studies suggesting that once unpalatable species attain dominance it can be difficult to reverse the change by relaxing or even removing grazing (Westoby *et al.*, 1989).

CONCLUSION

Studies have shown that chronic and intensive grazing of semiarid rangelands can impair plant community structure and increase bare-ground exposure. This degradation often results in undesirable plant species composition, weed invasion, sharp declines in plant biomass production and a loss of species diversity. In a Syrian semiarid rangeland that has been exposed to long-term grazing, we found that selective grazing of more palatable species during year-long grazing shifted plant community composition toward less desirable forage species (i.e., *N. mucronata* & *Euphorbia macroclada*) over preferred species (i.e., *M. minima* & *S. lessingiana*). A reduction in floristic structure and composition subsequently reduced the carrying capacity of these lands, a condition that strains the economic and social fabric of this region. We were also able to describe the palatability of the species found in these communities. From these data, we are able to propose a management strategy to reduce the impacts of overgrazing on plant community condition. Improved grazing management can be a legitimate tool for sustainable management of rangeland ecosystems and consequently improve small ruminant production of semiarid Mediterranean ecosystems. Proper management can in turn reduce rangeland degradation and slow the rate of desertification in more vulnerable arid to semiarid regions.

Acknowledgment. This research was supported by the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. We also would like to thank you Dr. Al-Audat Mohamed for his contribution during data collection and Ms. Sawsan Hassen and Ms. Rima El-Khatib for their support with data analysis and reporting.

REFERENCES

Ahmed, M., F.A. Raza, J. Masud and I. Ali, 2006. Ecological assessment of production potential for rangeland vegetation in Southern Attock, Pakistan. *Int. J. Agric. Biol.*, 8: 212–215

Al-Oudat, M., A.K. Salkini and J.A. Tiedemann, 2005. *Major Plant Species in Khanasser and Shbeath Mountains*. ICARDA and AECS, Aleppo, Syria

Ares, J., H. Del Valle and A. Bisigato, 2003. Detection of process-related changes in plant patterns at extended spatial scales during early dryland desertification. *Global Change Biol.,* 9: 1643–1659

Aw-Hassen, A., F. Shomo and L. Iniguez, 2008. *Small Ruminant Production: Challenges and Opportunities for Poverty Alleviation in West Asia and North Africa*. ICARDA, Aleppo, Syria

Barabesi, L. and L. Fattorini, 1998. The use of replicated plot, line and point sampling for estimating species abundance and ecological diversity. *Environ. Ecol. Stat.*, 5: 353–370

Blackburn, W.H., T.L. Thurow and C.A. Jr. Taylor, 1986. "Soil erosion on rangeland". *In*: *Use of Cover, Soils and Weather Data in Rangeland Monitoring Symposium Proceedings*, pp: 31–39. Society for Range Management, Denver, Colorado

Briske, D.D. and J.H. Richards, 1995. Plant responses to defoliation: a morphological, physiological and demographic evaluation. *In*: Bedunah, D.J. and R.E. Sosebee (eds.), *Wildland Plants: Physiological Ecology and Developmental Morphology*, pp: 635–710. Society for Range Management, Denver, Colorado

Caldwell, M.M., J.H. Richards, D.A. Johnson, R.S. Nowak and R.S. Dzurec, 1981. Coping with herbivory: photosynthetic capacity and resource allocation in two semiarid Agropyron bunchgrasses. *Oecologia*, 50: 14–24

Call, C.A. and B.A. Roundy, 1991. Perspectives and processes in revegetation of arid and semiarid rangelands. *J. Range Manag*., 44: 543–549

Canfield, R.H., 1944. Measurement of grazing use by the line intercept Method. *J. For.,* 42: 192–194

Chaichi, M.R., M.M. Saravi and A. Malekian, 2005. Effects of livestock trampling on soil physical properties and vegetation cover (case study: Lar Rangeland, Iran). *Int. J. Agric. Biol.*, 7: 904–908

Cox, G.W., 1990. *Laboratory Manual of General Ecology*, 6th edition, William C. Brown Publishers, Dubuque, IA

Crawley, M.J., 1983. *Herbivory: The Dynamics of Plant-animal Interactions*, p: 437. Oxford, United Kingdom: Blackwell Scientific Publications, UK

Dutilly-Diane, C., F. Ghassali, N. Batikha, G. Arab, E. Khoudary, C. Saint-Macary, J.A. Tiedeman and M. Louhaichi, 2006. *Al Badia Community Survey in Syria: Descriptive Statistics*, ICARDA Syria

Fitzhugh, H.A., 1987. *Systems Approach to Small Ruminant Research and Development*, Vol. 54, pp: 1–12. Small Ruminants in the Near East, FAO Animal Production and Health Paper, FAO, Rome, Italy

Gallacher, D.J. and J.P. Hill, 2006. Effects of camel grazing on the ecology of small perennial plants in the Dubai (UAE) inland desert. *J. Arid Environ.*, 66: 738–750

Gintzburger, G., T.L. Nordblom and A.E. Osman, 1997. Agro-pastoral systems feed calendars and feed resources in Arab countries of the Mediterranean region. *In*: Haddad, Tutwiler and Thomson (eds.), *Improvements of Crop-livestock Integration Systems in Dry Areas of West Asia and North Africa*, pp: 24–38. ICARDA, Aleppo, Syria

Heitschmidt, R.K. and C.A. Jr. Taylor, 1991. Livestock Production. *In*: Heitschmidt, R.K. and J.W. Stuth (eds.), *Grazing Management: An Ecological Perspective*, pp: 161–177. Portland, OR: Timber Press

Humberto, S., G.P. Nabhan and D.T. Patten, 1996. The importance of Olneya tesota as a nurse plant in the Sonoran desert. *J. Veg. Sci.*, 7: 635–644

Jones, R.M. and J.N.G. Hargreaves, 1979. Improvements to the dry-weight-rank method for increasing botanical composition. *Grass Forage Sci.*, 34: 181–189

Le Houérou, H.N. and L. Boulos, 1992. Bioclimatic and Phytogeographic characteristics of arid rangelands in Northern Africa and the Near East. *In*: *Proc. IVth International Rangeland Congress*, Vol. 1, pp: 536–543. CIRAD Montpellier, France

Liddle, M.J., 1975. A selective review of the ecological effects of human trampling on natural ecosystems. *Biol. Conserv.*, 7: 17–36

Manzano, M.G., J. Navar, M. Pando-Moreno and A. Martinez, 2000. Overgrazing and desertification in northern Mexico: highlights on northeastern region. *Annl. Arid Zone*, 39: 285–304

Milchunas, D.G. and W.K. Lauenroth, 1993. Quantitative effects of grazing on vegetation and soils over a global range of environments. *Ecol. Monogr.*, 63: 327–366

Milton, S.J., W.R.J. Dean, M.A. Du Plessis and W.R. Siegfried, 1994. A conceptual model of arid rangeland degradation. *Biol. Sci.*, 44: 70–76

Mosallam, H.A.M., 2007. Comparative study on protected and non-protected areas. *Int. J. Agric. Biol.,* 9: 202–214

Mueller-Dombois, D. and H. Ellenberg, 1974. *Aims and Methods of Vegetation Ecology*. Wiley, New York

Mutard, P., 1966. *Nouvelle Flora Du Liban Et De La Syria*. Editions de l'Imprimerie Catholoques, Beyrout, Liban, Syria

Nordblom, T., G. Arab, G. Gintzburger and A. Osman, 1995. *Survey of Bedouin Groups with Contracts to Graze the Government Rangeland Plantation at Maragha, Aleppo Province, Syria*. Regional symposium on integrated crop-livestock systems in the dry areas of West Asia and North Africa, Aleppo, Syria: ICARDA, Syria

Nordblom, T. and F. Shomo, 1995. *Food and Feed Prospects to 2020 in the West Asia/North Africa Region*. ICARDA, Social Science Papers No. 2, Aleppo, Syria: ICARDA, Syria

Noy-Meir, I. and N.G. Seligman, 1979. Management of semi-arid ecosystems in Israel. *In*: Walker, B.H. (ed.), *Management of Semi-arid Ecosystems*, pp: 113–160. Elsevier, Amsterdam

Noy-Meir, I.M. Gutman and Y. Kaplan, 1989. Responses of Mediterranean grassland plants to grazing and protection. *J. Ecol.*, 77: 290–310

Nygaard, D.F. and P. Amir, 1988. Research Strategies for Development: Improving Sheep and Goat Production in Developing Countries. *In:* E.F. Thomson (ed.), *Increasing Small Ruminant Productivity in Semi-arid Areas: Proc. A Workshop Held at the International Center for Agricultural Research in the Dry Areas, Aleppo, Syria, 30.11-03.12*. Dordrecht The Netherlands: Klumer Academic Publishers

Osem, Y., A. Perevolotsky and J. Kigel, 2002. Grazing effect on diversity of annual plant communities in a semi-arid rangeland. Interactions with small-scale spatial and temporal variation in primary productivity. *J. Ecol.,* 90: 936–946

Ouled Belgacem, A., H. Ben Salem, A. Bouaicha and M. El-Mourid, 2008. Communal rangeland rest in arid area, a tool for facing animal feed costs and drought mitigation: the case of Chnini community, Southern Tunisia. ***J. Biol. Sci.***, 8: 822–825

Owensby, C.E., 1973. Modified step-point system for botanical composition and basal cover estimates. ***J. Range Manag.***, 26: 302–303

Perevolotsky, A. and N.G. Seligman, 1998. Role of grazing in Mediterranean rangeland ecosystems. ***Bio. Sci.***, 48: 1007–1017

Ripley, T.H., F.M. Johnson and W.H. Moore, 1963. A modification of the line intercept method for sampling understory vegetation. ***J. Range Manag.,*** 16: 9–11

Ruiz-Fernández, E.J., R.D. Valdez-Cepeda, L. Perez-Romero, D. Rodriguez-Tenerio and R. Magallanes-Quitanar, 2007. Strategies for re-vegetation of degraded arid rangelands in Zacatecas, México. ***Int. J. Agric. Biol.,*** 9: 857–862

Salkini, K.A., M. Audat and M. Louhaichi, 2008. Rehabilitation of degraded rangelands: Case study of Khanasser Valley. *In*: *The 48th Annual Science Week Conference on the Animal Wealth in Syria: Current Status and Prospects for Future Development*". Aleppo University Campus 17 – 20 November 2008, Aleppo, Syria

SAS, 2004. *SAS/STAT User's Guide, Version 9.1*. SAS Institute, Cary, North Carolina

Serra, G., D. Williamson and C. Batello, 2003. *From Indifference to Awareness: Encountering Biodiversity in the Semi-arid Rangelands of the Syrian Arab Republic*. FAO Inter-departmental Working Group on Biological Diversity for Food and Agriculture, FAO, Rome

Smith, A.D. and E.M. Schmutz, 1975. Vegetative changes on protected versus grazed desert grassland ranges in Arizona. ***J. Range Manag.,*** 28: 453–458

Sokal, R.R. and F.J. Rohlf, 1995. *Biometry: The Principles and Practice of Statistics in Biological Research.* W.H. Freeman and Co. New York

Simons, L. and N. Allsopp, 2007. Rehabilitation of rangelands in Paulshoek, Namaqualand: Understanding vegetation change using biophysical manipulations. ***J. Arid Environ.***, 70: 755–766

Steinbach, J., 1987. The Possibilities and Development Requirements for Improving Small Ruminant Production in the Near East. Small Ruminants in the Near East. *In*: Qureshi, A.W. and H.A. Fitzhugh (eds.), *Small Ruminants in the Near East*, Vol. I, pp: 13–20. FAO

Thompson, S.K., 1992. ***Sampling.*** John Wiley and Sons, New York

Thomson, E., M.A. Martini and N.R. Tutwiler, 2003. *Sheep Management Practices in Iraq, Jordan and Syria: The Case of Reproduction and Fertility*, p: 48. Integrated Natural Resource Management Research report Series No. 2

Tongway, D. and J. Ludwig, 1997. The nature of landscape dysfunction in rangelands. *In*: Ludwig, J., D. Tongway, D. Freudenberger, J. Noble and K. Hodgkinson, (eds.), ***Landscape Ecology.*** Function and Management, Principles from Australia's Rangeland, CSIRO Publishing, Australia

Uniyal, S.K., A. Awasthi and G.S. Rawat, 2005. Biomass availability and forage quality of Eurotia ceratoides Mey in the rangelands of Changthang, eastern Ladakh. ***Curr. Sci.,*** 89: 201–205

Westoby, M., B. Walker and I. Noy-Meir, 1989. Opportunistic management for rangelands not at equilibrium. ***J. Range Manag.***, 42: 206–74

Zacaria, A.M., 1947. *Tribes of Al Sham*. Damascus: Dar-El Fikr

Zohary, M., 1962. *Plant Life of Palestine*. Roland Press Co., New York

Zohary, M. and N. Feinbrum, 1966–1986. *Flora Palaestina*, Vol. 4. The Israel academy of sciences and humanities, the Jerusalem Academic Press, Israel

(Received 03 April 2009; Accepted 21 April 2009)