Fodder trees and shrubs in range and farming systems in North Africa

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INTRODUCTION

The shrublands of North Africa cover about 940,000 km^2, of which 65,000, 350,000 and 525,000 km^2 are located in semiarid, arid and desert regions, respectively (Le Houérou, 1989a). They provide both a valuable grazing resource, because of their nutritive value and palatability, and prevent soil erosion by increasing soil stability. According to Le Houérou (1989a), grazing represents 60 to 80% of the economic output of North African shrublands. Used as fodder, trees and shrubs supply a greater amount of protein to livestock on a year round basis. In addition, browse plants are comparatively high in phosphorus but relatively low in energy-supplying constituents.

CONTRIBUTION OF FODDER TREES AND SHRUBS TO LIVESTOCK DIETS

The contribution of browse to the livestock diet varies with the nature of the ecosystem. In less favorable environments, where the grazing season for vegetation is short, the contribution of native fodder shrubs to the animals' diet is very high and may exceed 70% (high mountain, steppe and desert ecosystems). In more favorable areas, shrubs are generally used on a seasonal basis.

SHRUBLANDS OF THE SEMI-ARID TO HUMID ECOSYSTEMS

In the semi-arid to humid ecoclimatic zones of the N. African countries, the major natural shrubland ecosystems are dominated by *Quercus* spp. (3.47 million hectares), *Cedrus atlantica* (0.15 million hectares), *Pinus halepensis* (1.27 million hectares), *Tetraclinis articulata* (0.94 million hectares), *Olea europea*, *Ceratonia siliqua*, *Pistacia lentiscus* (0.72 million hectares), *Juniperus phoenicea* (2.3 million hectares), and 0.7 million hectare parkland of *Argania spinosa* (Le Houérou, 1989a).

The High Atlas study case

In the High Atlas, farming systems integrate both agricultural and pastoral components in which fodder trees play an important role. Crops are cultivated on farms with an average size of 0.5 ha. Small ruminant feeding systems are based on pastoral resources which provide 94% of small ruminant energy requirements (Bourbouze, 1982). Pasture grazing, especially for small ruminants, comes primarily from watersheds which are public lands.

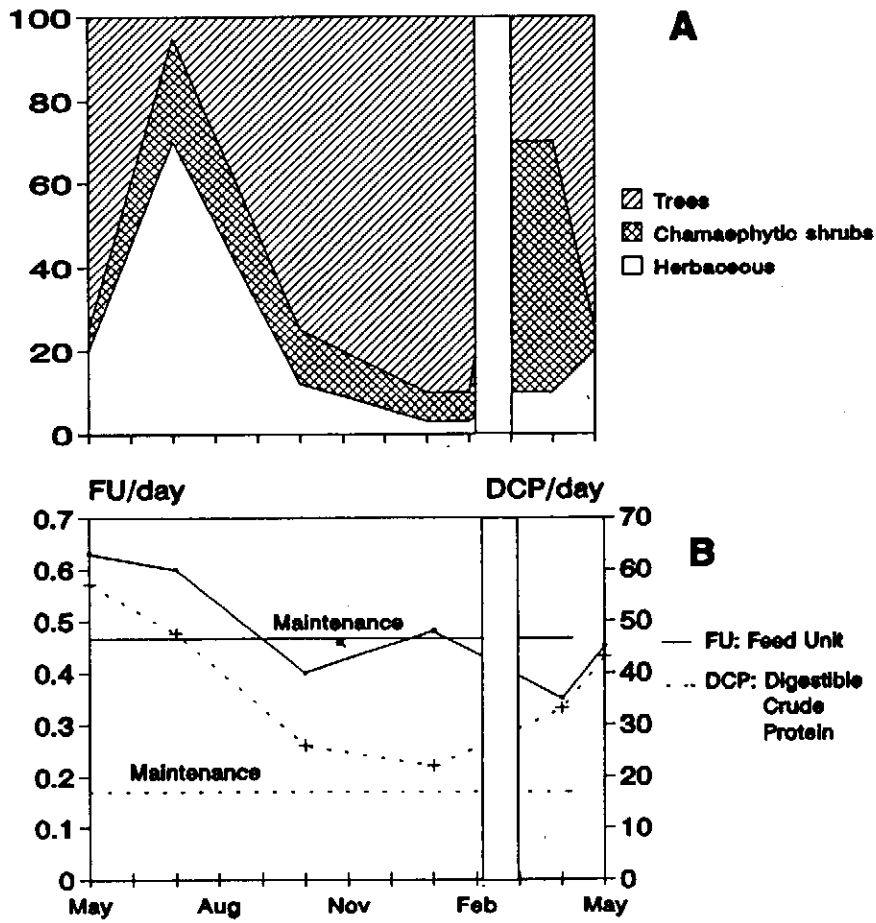
The main fodder trees in the watersheds are *Fraxinus xanthophyloides*, *Quercus rotundifolia* and *Juniperus oxycedrus*. The shrubs used as fodder are *Cytisus* spp., *Globularia mainii*, *Ormenis scariosa*, *Genista* spp. and *Thymus* spp.

The nutritional quality of these fodder trees varies among species. *Fraxinus xanthophyloides* has a good nutritional quality (0.8 feed units (FU)/kg DM, and 15% crude protein in DM) and is an important source of both energy and protein. The nutritive values of *Quercus rotundifolia* and *Juniperus oxycedrus* are low in comparison to *Fraxinus xanthophyloides*. *Quercus rotundifolia* and *Juniperus oxycedrus* average 8 and 5% crude protein and ash in DM, respectively. *Quercus* spp. is rich in phenolic compounds such as tannins which result in a decrease in digestive utilization. El Honsali (1982) compared the use of oak leaves, highly rich in tannins, by sheep and goats. He concluded that infusion of tannins slightly improved dry matter intake for goats whereas it had an adverse effect on sheep.

In the High Atlas, Bourbouze (1982) shows that the contribution of fodder trees and shrubs to goat diets remains high, except in July (Figure 1). Among fodder trees, *Quercus rotundifolia*, despite its low nutritive value, contributes the most, from both leaves and acorns, i.e, 86% in January. Indeed, during periods when food is short (winter), shoots or branches of *Quercus ilex* are cut by herders and provided to goats. The use of more *Juniperus oxycedrus* in goat diet is compromised by the presence of spines.

Trees and shrubs used as fodder provide a sufficient amount of protein to meet goat maintenance requirements year-round (Figure 1).

FIGURE 1. **Diet botanical composition of goats (A) and contribution of range feed resources to cover goat maintenance requirements (B) in the High Atlas of Morocco (Bourbouze, 1982).**



STEPPE ECOSYSTEMS

Halophytic steppe and desert regions

Feeding systems in these regions, characterized by a pre-Saharan climate where the precipitation averages 70 mm/year at most, are based exclusively on open range feed resources since supplementary feeds are rare. The open ranges are used by herds of dromedaries in grazing patterns based on seasonal and yearly movements. Seasonal movements among regional grazing areas ensure forage balance and water availability. Yearly decisions concern environmental conditions (climatic crisis, droughts) and the political boundaries of the different countries.

The three major shrublands are: 1) crassulescent halophytic steppes, 2) nanophanerophytic steppes and 3) wormwood sub-desertic steppes. The crassulescent halophytic steppes with *Salsola* spp., *Suaeda* spp., *Arthrocnemum indicum* and *Salicornia* spp. cover 4 million hectares. The nanophanerophytic steppes with *Ziziphus*, *Atriplex*, *Calligonum* and *Tamarix* and wormwood sub-desertic steppes, dominated by *Haloxylon*, *Anabasis* and *Traganum*, occupy areas of 2 and 3 million hectares, respectively (Le Houérou, 1989a).

Trees and shrubs of these halophytic steppes survive a higher water stress and tolerate various amounts of salt in the soil. They supply the majority of protein to livestock, especially dromedaries and goats. The crude protein contents of these halophytic plants are high and remain stable throughout the seasons. The crude protein content in DM of *Acacia raddiana*, legume tree, and *Traganum nudatum* varies from 11% to 19% during the early and late season, respectively. *Calligonum comosum* and *Salsola* spp. have lower protein levels. Ash content in DM of the halophytic species is extremely high. It varies in autumn from 19% for *Haloxylon scoparium* to 45% for *Traganum nudatum*. Moreover, *in vitro* dry matter digestibility coefficients are adequate (45 to 55% of DM on average). These levels should, however, be considered with caution because of the high ash content which might lead to a reduction in the metabolizable energy of these forages. These trees and shrubs are chiefly grazed by dromedaries.

TABLE 1. Diet botanical composition, and nutritive value, and total consumption of the dromadery diet in the southern steppe of Morocco (Moumen 1991).

	January	April	June	October
	Botanical composition (in %)			
Species				
Nanophanerophytes				
Acacia raddiana		9.83	4.26	17.98
Calligonum comosun	4.47		8.51	
Salsola spp	43.72	11.15	5.58	9.45
Ziziphus lotus		0.98		
Haloxylon scoparium		7.17		17.02
Tamarix spp.				10.23
Traganum nudatum	36.52		13.97	16.08
TOTAL	84.71	29.12	32.31	70.77
Chamaephytes				
Gaillonia reboudiana		12.75		
Peganum harmala		6.17		
Launea arborescens				25.77
TOTAL		18.92		25.77
Herbaceous				
Diplotaxis harra	15.29		67.69	
Pennisetum dichotomum				3.46
Others		51.96		
TOTAL	15.29	51.96	67.69	3.46
	Chemical composition			
Crude protein (% DM)	12.60	13.59	19.63	10.94
NDF (% DM)	33.11	38.24	42.34	33.82
ADF (% DM)	25.39	30.57	31.22	26.25
ADL (% DM)	11.82	10.88	7.30	8.19
	In vitro dry matter digestibility (% DM)			
IVDMD	51.78	39.11	38.92	43.16
	Intake (kg/An/Day)			
Intake (kg/An/Day)	10.58	13.56	12.10	10.90

A study carried out in the southern steppe of Morocco indicates that the diet of dromedaries is from fodder trees, fodder shrubs and herbaceous plants (Moumen, 1991). Contributions of the different species vary depending on the grazing season (Table 1). Early in the season, *Salsola* spp. and *Traganum nudatum* average 43.7 and 36.5%, respectively. In spring, dromedaries include more herbaceous plants in their diet whereas, in summer, they ingest mainly *Diplotaxis harra* (67.7%) and *Traganum nudatum* (14%). Late in the grazing season, fodder trees and shrubs become the only dietary component and average 71 and 25%, respectively.

The botanical composition of the diet is dominated by fodder trees and shrubs resulting in a high crude protein content year-round (Table 1). The values for *in vitro* dry matter digestibility are adequate early in the season and become low thereafter. Digestibility coefficients, expressed on an organic matter basis, are much lower because of the high ash content of the available halophytic species.

Total dry matter consumption averages 10.6, 13.8, 12.00 and 10.9 kg/animal/day in January, April, June and October, respectively (Moumen, 1991). Total consumption is lower both early and late in the season because of the low availability of herbaceous plants. Dromedary production averages 198 kg of live meat and 580 kg of milk per animal unit per year.

Chamaephytic steppes

The climate in the chamaephytic steppes is arid with an average precipitation of 200 mm. It is characterized by a pulse of precipitation and a large number of years with precipitation below average. The major North African shrublands are *Artemisia herba alba* steppe (7 million hectares) on silty soils and *Artemisia campestris* (4 million hectares) on sandy soils (Le Houérou, 1989a).

In these steppes, sporadic cultivation makes the farming systems more and more agropastoral. Three different types of resources contribute to feed small ruminants, i.e., range forages, agricultural by-products (straw and stubble) and supplementary feed. El Aich (1987) found that 40%

and 15% of the animal needs were provided by *Stipa tenacissima* and *Artemisia herba alba* in normal and dry years, respectively. *Artemisia herba alba* communities are used as spring pastures by sheep producers.

Aerial phytomass production of the *Artemisia* plant community averages 200 to 250 kg DM/ha (Merzak, 1990). *Artemisia herba alba* averages crude protein contents of 12 and 9% early and late in the season, respectively. Ash levels remain high (> 19%) regardless of the period of the year (Merzak, 1990). Despite their mean digestibility coefficients (49%), *Artemisia* spp. have high content of essential oils which interferes with the energy assimilation. Cook *et al.*(1952) reported that the metabolizable energy in *Artemisia tridentata* is lower because of the essential oils; its metabolizability is of the magnitude of 0.30 as compared to alfalfa hay, 0.82.

A study conducted on the oriental steppe of Morocco indicates that sheep ingest a large proportion of *Artemisia herba alba* and the other shrubs, especially during periods of drought (Table 2). *Artemisia herba alba* contribution is 76.5 % on average.

However, sheep respond quickly to changes in range botanical composition resulting from concentrated rain. In the *Artemisia* spp. community, sheep ingest a diet rich in cell wall content, with an adequate level of protein (Table 2). The average ratio ADL/ADF of 45.6% indicates a depressed digestion of the fibre fraction. *In vitro* organic matter digestion coefficients of sheep diets are low whereas dry matter intake levels are acceptable (Table 2) and allow an average gain of 100 g/day during spring for yearling rams (Merzak, 1990).

Unregulated and selective grazing by livestock has shifted many *Artemisia* spp. communities to a situation where unpalatable forbs or aggressive shrubs of low palatability dominate. In addition, sporadic cultivation and uprooting make the extent of desertification serious. As results of shrubland depletion, feeding calendars for small ruminants experience a shortage of feed in summer and autumn, especially in dry years.

TABLE 2. Botanical composition of diet, nutritive value and intake of sheep in *Artemisia* plant community at Oriental Steppe of Morocco (Merzak, 1990).

	Early spring	Mid-spring	Early summer
Botanical composition (in %)			
Artemisia herba alba	78.05	68.55	82.95
Other shrubs	10.30	15.80	10.40
Herbaceous plants	5.63	12.31	3.15
Chemical composition			
Ash (% DM)	11.32	15.09	9.47
Crude protein (% DM)	7.55	7.90	7.98
NDF (% DM)	47.61	48.10	52.28
ADF (% DM)	36.41	34.79	36.25
ADL (% DM)	14.79	16.61	17.59
In vitro organic matter digestibility (% DM)			
IVDMD	48.78	47.43	31.42
Intake			
g DM/an/day	861	802	745
g DM/$LW^{0.75}$/day	76.77	76.29	72.16

SHRUBLAND IMPROVEMENTS

Grazing management

Strategies for improving shrubland productivity and use depend on the nature of the ecosystem. In more resilient ecosystems, i.e., semi arid to humid shrublands, there is a need to keep shrubs and find a way to increase the proportion of high quality preferred food available, relative to animal requirements. Indeed, small changes in forage composition of high quality protein plants are disproportionately important in improving animal status. For instance, a vegetation rest results in an increase in the abundance of preferred species and the standing crop of biomass.

Phosphorus fertilizers are expected to increase phytomass, improve botanical composition and enhance the establishment of legumes.

In a less favorable environment, stands containing high numbers of less-preferred individuals must be managed to allow the establishment and persistence of preferred genotypes. Proper grazing pressure is the key factor in shrub management. Under higher stocking rates, the density of senescent *Artemisia herba helba* plants increased and the survival of seedlings decreased.

Plantations of introduced species

Seedling and planting provide an opportunity to include shrub species that will contribute to stability and diversity as well as useful productivity of the ecosystem. Many shrub species were introduced in the region, such as *Acacia* spp., *Atriplex* spp., *Prosopis* spp. and *Opuntia* spp. They have been planted over more than half million hectares in Morocco, Algeria, Tunisia, Libya and Egypt. Among these fodder shrubs, *Atriplex* spp. are the most recommended and frequently planted species.

The ecological value of *Atriplex* spp.

Atriplex spp. can grow normally with only 150 to 200 mm rainfall and are not affected by heavy textured and high salinity soils and water. Their frost resistance is high. The choice of species is the determinant for establishment of a plantation. Baumann (1990) compared legume shrubs (*Acacia* spp.) to non-legume shrubs (*Atriplex* spp.) on the oriental steppe of Morocco. He concluded that the rates of establishment of legume shrubs were very low because *Acacia* spp. need a mean precipitation of more than 150 mm and deep sandy soils. The rates of establishment of *Atriplex* varied among species in the range 70-75%. In the same study, *Artemisia herba helba* used as a control, had the highest survival rates.

The phytomass yield varies with the density of the seedlings. Palatable biomass of *Atriplex nummularia* (yearling twigs and leaves) averaged 462 kg DM/ha (Tazi *et al.*, 1991). Protection of *Atriplex* spp. during establishment increases the amount of herbaceous grown beneath and

between bushes. There are regeneration problems with *Atriplex* spp. after 6 to 7 years of utilisation, especially on shallow soils. The average duration for *Atriplex nummularia* plantation is 8 to 10 years.

Atriplex spp. provide a good palatable fodder year-round, because they keep their foliage. However, animals avoid shrubs in spring when herbaceous plants are available. Palatability studies indicate that introduced shrubs (*Atriplex nummularia*, *Acacia cyanophylla* and *Medicago arborea*) are very low dietary components during the growing season when herbaceous plants are available but, as the season advances, animals ingest more shrubs (Saadani, 1987).

Atriplex nummularia is relatively high in protein and ash. The crude protein and ash contents of *Atriplex nummularia* average 18.2 ± 0.45 and 22.7 ± 1.31 *per cent.* respectively. Crude protein content (ash) of *Acacia cyanophylla* averages 13.5 (10.0), 10.4 (9.2), and 11.07 (11.9) for spring, summer and autumn, respectively. The mean ratios of ADL/ADF (>50%) indicate a depressed digestion of the fibre fraction. The digestibility of *Atriplex* spp. averages 59% in spring and 49% in summer, whereas *Acacia cyanophylla* has lower digestibility, i.e., 26 and 20% in spring and summer, respectively (Saadani, 1987). The intake of *Atriplex* spp. varies in the interval of 50 to 55 g DM/kg$LW^{0.73}$. Increased consumption of *Atriplex* spp. is accompanied by higher water intakes because of the increased water required for urinary excretion of sodium. Sheep grazing *Atriplex vesicaria* consume 7 to 7.5 kg/day of water in comparison to 3.2 kg/day on grasslands (Wilson *et al.*, 1969). As supplementary fodder, *Atriplex* spp. should not make more than 25 to 30% of the sheep's diet.

The economical feasibility of *Atriplex* spp.

The question of the economical feasibility is of central interest. The establishment costs for a plantation (nursery, soil preparation, transport, planting, watering and maintenance) averaged $350 US/ha (Tafrata Perimeter, Morocco) with *Atriplex nummularia* in 1987. A 30 to 35% supplementary cost should be accounted for as cost of protection. With an average production of 500 kg DM/ha (140 FU), and assuming that the

duration of use of the plantations is 8 years, the cost per FU is about $0.45 US. Le Houérou (1989b) suggested that *Atriplex* plantations can be produced at a moderate cost as soon as yields are over 1000 FU/ha.

The economic viability of *Atriplex* spp. plantations appear uncertain under North African conditions. However, the value of browse plantations is undeniable if their multitude functions are taken into consideration. The comparison with other range improvements are aspects that answer both the technical validity and the economic feasibility of fodder shrub development.

The social feasibility of *Atriplex* spp.

Social acceptability must be assessed prior to any range rehabilitation programme. Questions such as: 1) why people prefer certain shrubs and 2) how people assess the value of a shrub, determine the success of the programme.

Feedbacks from shrub plantations are diverse. Shrub plantations are considered as government actions and are subject to lack of confidence from livestock producers. In the east of Morocco, sheep producers prefer rehabilitation with native shrub (*Artemisia herba alba*). For a technician, *Atriplex* spp. are planted to serve many purposes. But the message the livestock producer receives does not imply the same reasons. A survey on attitude regarding *Atriplex* in the Dhamar Montane Plains (DHV, 1989) showed nearly all villagers recognized "salt tree" (shajar al milh) could be grazed by sheep; but they did not mention that *Atriplex nummularia* can be used for firewood, as a windbreak or for erosion control.

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