

Seasonal Variation in Above-ground Annual and Perennial Phytomass of an Arid Rangeland in Libya

G. GINTZBURGER

Abstract

An *Aristida pungens*-*Retama retam* rangeland in the arid Jeffara plain in Libya produced 2,000 and 950 kg (dry matter) ha⁻¹ of net above-ground phytomass with 200 mm and 171 mm of rainfall during the 1977/78 and 78/79 growing seasons, respectively. Annual plants contributed 460 and 300 kg (dry matter ha⁻¹) in the 2 seasons, respectively. Perennial shrubs lost their 1978 winter-spring aerial production during the long 1978 summer and dry winter when grazable forage was most needed. In contrast, spring production of annual plants remained available and grazable until late summer. Settlement of shepherds' families on site is not advised as the dead standing phytomass (270 kg dry wood ha⁻¹) may be rapidly exhausted for fuel consumption, leading to wind erosion problems on presently fixed sand dunes.

Libya has embarked on a large rangeland development programme involving 2 million ha (Gintzburger and Bayoumi 1977) of its estimated 12.5 M ha of nonagricultural lands located above the 50 mm isohyet (Le Houerou 1965). Most rangeland development projects are located between the 100 and 200 mm year⁻¹ isohyets on what is considered as marginal, yet sometimes valuable, cropping land by local farmers. In the northwestern zones of Libya, approximately 500,000 ha were surveyed to provide Libyan authorities with vegetation maps as well as estimates of rangeland carrying capacities (GEFLI 1974) based upon research work in a similar environment in Tunisia (Le Houerou 1969, Floret et al. 1983).

To provide their rural population with modern facilities, including schooling, medical care, and technical assistance in agriculture, the Libyan authorities have planned to allocate one set piece of rangeland to each shepherd's family. It was anticipated that each shepherd should derive an adequate minimum and sustained income from proper management of his land and flock of sheep and goats.

Conflicting estimates of long-term carrying capacity (1.5 to 3 ha sheep⁻¹) reported by different advisory teams rendered rangeland management and planning difficult. Problems were compounded by desertification hazards in this region. Suggested long-term carrying capacities resulted largely from guesses or one-time measurement, usually at the supposed peak standing phytomass in a similar environment. The relationship between average annual rainfall and net consumable rangeland production proposed by Le Houerou and Hoste (1977) for the Mediterranean Basin, though useful, appeared to be optimistic and needing refinement. None of these estimates took into account the yearly distribution of the rangeland production or considered the contribution and availability of ephemerals (annuals and ephemeroïds).

This situation prompted the author to measure the seasonal variation of above-ground phytomass of a rangeland type representative of some 100,000–200,000 ha of the Libyan Jeffara Plain. The information gathered was aimed at providing range managers with an improved knowledge of above-ground phytomass dynamics and forage availability throughout seasons, hence to assist in plan-

ning rational long-term utilization of Libyan rangelands by livestock.

Site Description

The site, known as the "the BGII workshop", was located 60 km southwest of Tripoli in the Jeffara Plain, midway between the towns of Azizia and Bir-El-Ghanem, and in the centre of one of the major Libyan rangeland development schemes. The area consists of undulating sandy plains with fixed dunes generally orientated in a northeast/southwest direction. Dune height varies from 1 to 15 m above the interdunal flats.

Climatic conditions are inferred from those recorded at Azizia and Bir-El-Ghanem as no major mountains or escarpments occur between the 2 towns. Both towns fall within the Mediterranean Lower Arid Bioclimate with mild winters (Le Houerou 1969). The average annual rainfall ranges between 100 and 200 mm year⁻¹ and the average minimum temperature of the coldest month fluctuates between 5 and 7°C. Frost is rare. The average maximum temperature of the coldest month (January) reaches 17–18°C, thus allowing for growth of most plants.

Rain falls exclusively during the winter months with high intra- and inter-annual variability. The rainy season can start by early October but is highly unreliable. Rainfall is often randomly distributed on patches or strips of land described as "thunderstorm cells of 3–8 km diameter (Noy-Meir 1973).

Strong winds inducing sand blasting of the vegetation are common on the Jeffara Plain (Gintzburger and Huxley 1979). Especially devastating is the hot desert wind known as "Gibbli" occurring in spring, raising air temperature to 40–45°C in a few hours, drying off annual plants in a day as was the case in early April 1978, and often burning cereal crops just after flowering.

The soil is a deep (more than 150 cm) uniform eolian sand, with little textural or structural differentiation down the profile. Colour is brownish-red and reaction is alkaline (pH = 7.5–7.7). Soil surface is stable and there are no signs of wind or water erosion on site. Water infiltration is total when rain falls. Soil organic matter is negligible (1% and less). Phosphorus and nitrogen content are extremely low and limit plant growth in wet years (Floret et al. 1982).

As surface wells are rare in the BGII zone, the area was a traditional winter-spring grazing zone complementary to the summer grazing on perennial vegetation in the Jebel Neffusa area, in a similar pattern to the one described by Telahigue (1981) in southern Tunisia. Nowadays, drilling of private deep wells has boosted uncontrolled irrigation practices on small farms producing vegetables. These compete with the grazing project for available land and water resources.

Vegetation consists of a treeless scrub physiognomically dominated by a perennial grass (*Aristida pungens*) and a tall Leguminosae shrub (*Retama retam*) which covers most of the fixed sand dune country of the Jeffara Plain (Fig. 1).

Nomenclature of common vascular plants found in the region refers to Quezel and Santa (1962) and Keith (1965).

Phyto-sociologically, the vegetation type may belong to the soil Under-Association with *Retama retam* of the *Rhantherium suaveolens* Desf.-*Artemisia campestris* L. Plant Association (Le Houerou 1969), with a *Retama retam* density of 209 (SE=12, n=55) shrubs ha⁻¹. However, the site is in a drier and warmer climatic variant of Le Houerou's Association and also a slightly different

At the time of the research, the author was working as an FAO range ecologist with the Agricultural Research Centre (Tripoli, Libya). The research was financed through a Libyan funded FAO project (TF/LIB06). Present address of the author: Institut National de la Recherche Agronomique (LECSA), Place Viala, 34060 Montpellier, France.

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Fig. 1. View of one plot on the BGII experimental site (Jeffara Plain, Libya).

Under-Association due to deep sandy soils. This is confirmed by the noticeable occurrence of a tall Leguminosae shrub, *Genista saharae* Coss. et Dur. (83 (SE=9, n=55) shrubs ha⁻¹), and sometimes of a small Cyperaceae, *Cyperus conglomeratus* (Rottb.). Both species disappear when sand depth decreases.

Material and Methods

While primary productivity is the rate at which organic material is photosynthesized in a plant community, the net primary productivity is that part of primary production stored in above- and below-ground plant organs in excess of the organic compounds used by the plants for their own metabolic needs. Above-ground net primary productivity or Crop Growth Rate (CGR) is expressed in dry matter weight produced per unit of land area and per unit of time (kg ha⁻¹ time⁻¹). The net Above-Ground Primary Productivity is estimated by the measurement of the seasonal variation of the above-ground phytomass (AGP) due to both annuals (AAGP) and perennials (PAGP) or to the whole rangeland vegetation (RAGP) of an enclosure, considering losses due to consumer organisms as negligible. Other losses, mainly due to shedding of plant parts such as flowers, fruits, leaves and branches, usually occur at the end of or after the main growing season.

The measurement of Above-Ground Phytomass (AGP) and its seasonal variation is simple in principle, but is complicated in the

arid zone, as the vegetation type has a low plant density and patchy ground distribution. At the BGII experimental site, the mixture of tall shrubs (Nano-phanerophytes) such as *Retama retam* and *Genista saharae*, dwarf shrubs (Chamaephytes) such as *Artemisia campestris* and *Rhantherium suaveolens*, and annuals, combined with micro-relief of small sand dunes ("Nebkhas") make sampling of vegetation difficult.

In December 1977, 81 plots of 40 m² each were pegged out on a fenced area of 1 ha, 1 km north of the BGII workshop.

The experimental site and surrounding area were under grazing prohibition 3 years before the start of biomass measurements. However, strict enforcement of prohibition was not possible and encroaching flocks lightly grazed the area.

In February 1978, the linear intercepts of foliar cover of perennial plants including tall and dwarf shrubs, annuals including ephemeroïds, and dead standing wood were measured on nine 15-m transects using the Canfield method (Canfield 1941). Transects were laid down on a systematic design. Each transect radiates and starts 10 m away from the central point of the experimental site.

The AGP was sampled from 9 plots randomly selected from the pre-pegged area. Plot dimensions were 4 × 10 m for perennial plants and 1 × 2 m for annual plants. Each plot was harvested only once and regrowth after clipping was not measured.

Perennial plants present on the 40 m² plot were clipped at ground level, then separated per species and tied up in separate

bundles, the fresh weight of each being recorded. The bundles were then sun dried for a minimum of a week and their dry weight recorded, except for the September samplings of perennial plants which were lost after the fresh weight was recorded. In this case, the dry weight of the perennials was estimated from the September 1978 fresh weight measured at clipping time corrected by the specific percentage of dry matter recorded on species sampled at the end of May 1978. It was assumed that this percentage remained stable throughout summer. The estimated data are presented in brackets in Table 2.

Annual plants were harvested in 2 m² plots randomly located inside the 40 m² plot. Sorted plants were oven-dried at 75–80° C for 3 days, and their dry weight recorded.

The dead standing plant biomass was harvested, sun dried and weighed but the ground litter was not measured. Plant biomass or phytomass is expressed in kilogram (kg) or metric ton (t) of dry matter (DM).

Four biomass harvests were performed in the first season and 3 in the second. Between the 2 seasons, a flock of 110 sheep and 15 goats was allowed to graze the enclosure for 2 half-days, on 4 and 5 October 1978, to remove all dead standing biomass from annual plants and to incorporate seeds in the soil before opening rainfall.

Attempts to analyse the contribution of perennials and annuals,

Table 1. Percent mean intercept of major species on the BGII site as determined from nine 15 m transects on 22 Feb. 1978.

Genus and species	% Mean Intercept ± SE	Plant height (cm)	Vernacular Names
Perennials			
<i>Aristida pungens</i> Desf.	11.4 ± 3.5	20–50	"Sbot"
<i>Genista saharae</i> Coss et. Dur.	8.9 ± 4.0	100–250	"Aleg"
<i>Artemisia campestris</i> L.	5.6 ± 2.3	30–60	"Chahal"
<i>Retama retam</i> Webb.	3.7 ± 1.3	50–200	"R'tem"
<i>Helianthemum lippii</i> var. sessiliflorum (Desf.) Murb.	3.5 ± 1.9	10–30	"R'giga"
<i>Salvia verbenaca</i> (L.) Briq.	0.5 ± 0.2	10–30	"Sag Ennaga"
<i>Nolletia chrysocomoides</i> (Desf.)	0.3 ± 0.3	20–50	
<i>Rhanterium suaveolens</i> Desf.	0.2 ± 0.2	20–50	"Arfedg"
Other perennial plants(See text)			
Annual plants and ephemeroïds (*)			
<i>Erucaria uncata</i> (Boiss.) Asch. et Schw.	11.3 ± 3.3	20–50	
<i>Matthiola longipetala</i> ssp. Kralickii (Pomel) M.	2.6 ± 1.8	10–30	
<i>Anthemis pedunculata</i> Desf.	2.4 ± 0.6	5–10	"Rebbiana"
<i>Cutandia dichotoma</i> (Forsk.) Trab.	1.6 ± 0.3	5–10	"Sboul-el-far"
<i>Schismus barbatus</i> ssp. calycinus (L.) M. et. W.			
<i>Koeleria pubescens</i> ssp. Salzmannii (B. et R.) Trab.			
<i>Picris coronopifolia</i> Desf.			
<i>Plantago albicans</i> L. (*)	1.0 ± 0.2	5–10	"Inhem"
<i>Plantago psyllium</i> L. (*)			
<i>Lotus pusillus</i> Medik	0.4 ± 0.1	< 5	
<i>Hippocrepis bicontorta</i> Lois.	0.4 ± 0.1	< 5	"Nefel"
<i>Centaurea dimorpha</i> Viv. (*)	0.4 ± 0.1	5–10	"Blala"
<i>Erodium triangulare</i> (Forsk.) Musch.	0.3 ± 0.2	5–10	"Ghleghet-el-Ghoul"
<i>Senecio gallicus</i> ssp. coronopifolius (Desf.) M.	0.3 ± 0.1	5–15	
Other annual plants (see text)			

species by species, have failed to show significant differences between 2 harvests. The low frequency or the absence of some species on the sampled plots induced a high coefficient of variation of phytomass harvested. Therefore, all data were pooled and examined using an analysis of variance. Least Significant Differences (LSD) of means were determined.

Results and Discussion

Linear Interception by Vegetation and Bare Soil

Species contribution to line intercepts are presented in Table 1.

The perennials, annuals and dead standing wood contributed 34.1% (SE=3.7), 21.8% (SE=4.9), 8.9% (SE=2.0), respectively, to the line intercept. About 43% of the intercept was covered by perennials and dead standing wood which effectively protected the soil from wind erosion. Bare ground occupied about 35%.

Although not included in Table 1, several other perennial and annual plants contributed individually for less than 0.2% to line intercept. These perennials are: *Argyrobolium uniflorum* (Desc.) Jaub. et Spach., *Rumex tingitanus* L., *Ononis natrix* L., *Linaria aegyptiaca* (L.) Dum. Cors., *Echiochilon fruticosum* Desf., *Stipa lagascae* R. et S., *Malcolmia aegyptiaca* Spr., *Teucrium polium* L. Annual plants are *Filago germanica* L., *Astragalus cruciatus* Link., *Vicia* L., *Neurada procumbens* L., *Ifloga spicata* (Forsk.) Sch. Bip., *Daucus sahariensis* Murb., *Paronychia argentea* (Pourr.) Lamk., *Silene colorata* Poiret, *Scabiosa arenaria* Forsk., *Diplo-taxis harra* (Forsk.) Boiss., *Lotus creticus* L., *Medicago littoralis* Rhode, *Medicago striata* Bast., and *Reseda arabica* Boiss.

In spite of their low contribution to the vegetation cover, these species help in characterising the vegetation type and, as it is the case with the annual plants, may contribute significantly to sheep and goats' diet.

Table 2. Seasonal variation of the Rangeland Above-Ground Phytomass (RAGP) and Growth Rate (GR)

Harvest Date	Mean RAGP	SE	Difference between clipping	Rangeland Growth Rate (GR)
		(kg (DM) ha ⁻¹)		(kg(DM) ha ⁻¹ day ⁻¹)
7–15 Feb. 78	1958	145		
1–4 Apr. 78	3109	427	+1151	+21.7
28–29 May 78	2045	235	–1064	–18.7
17–18 Sep. 78	(2506)*	(380)*	(+ 461)*	
Grazing**				
28 Dec. 78 to 2 Jan. 79	1087	202	(–1419)*	
11 Apr. 79	2042	407	+ 955	+ 9.2
25–26 June 79	2294	202	+ 252	0

* (data) = estimates of Dry Matter, see text.

** Flock of sheep and goats grazing in enclosure, 4–5 Oct. 1978.

LSD ($P<0.05$) = 786

LSD ($P<0.01$) = 1050

LSD ($P<0.001$) = 1347.

On the BGII site, another 12% (SE=1.6) intercept is due to annual plants growing under perennial shrubs, mainly *Retama retam*. Annual plants find a favourable environment under these shrubs where better physical and chemical soil characteristics may have developed compared with conditions existing on flat, open range (Mott and McComb 1974).

Range condition was assessed as good. As a comparison, Shaws and Fisser (1978) measured covers of only 7–8% of all live vegetation in an *Artemisia campestris*-*Thymelaea microphylla* Coss et. Dur. range type near Assa in the Jeffara Plain, 200 km west of the BGII site. In southern Tunisia, rangeland with a total vegetation cover of 40–50% is rare and, when found, is considered to be in good condition (FAO 1979).

Dead Standing Phytomass (DSP)

Between February 1978 and April 1979, the DSP did not vary significantly, averaging 277 ($SE=24$) $kg\ ha^{-1}$, and consisted mainly of *Rhantherium suaveolens*, *Ononis natrix*, and sometimes of dead branches of *Retama retam*.

This finding has a clear bearing on future land use of the BGII site, especially if settlement plans are carried out. Assuming a minimum daily fuel consumption of $10\ kg$ of dry dead wood per family of 5–8 persons (Thalen 1979), approximately $1\ ha$ of rangeland per month (or a minimum of 10 – $12\ ha\ year^{-1}$) would be cleared of its DSP per settled family. Considering that the settlement plan allocates $150\ ha$ per family at BGII, wind erosion damage and sand dune movement can be expected within 5 to 8 years of initial settlement, especially around houses and permanent stock shelters.

Seasonal variation of Rangeland (RAGP), Perennial (PAGP) and Annual (AAGP) Above-Ground Phytomass

In early spring 1978, from February until early April, the RAGP shows an increase from 1.9 to $3.1\ t\ ha^{-1}$. This spring flush of production is due to a significant ($P<0.05$) increase of the PAGP ($+0.93\ t\ ha^{-1}$) mostly from *Retama retam* (Fig. 2) and also from a

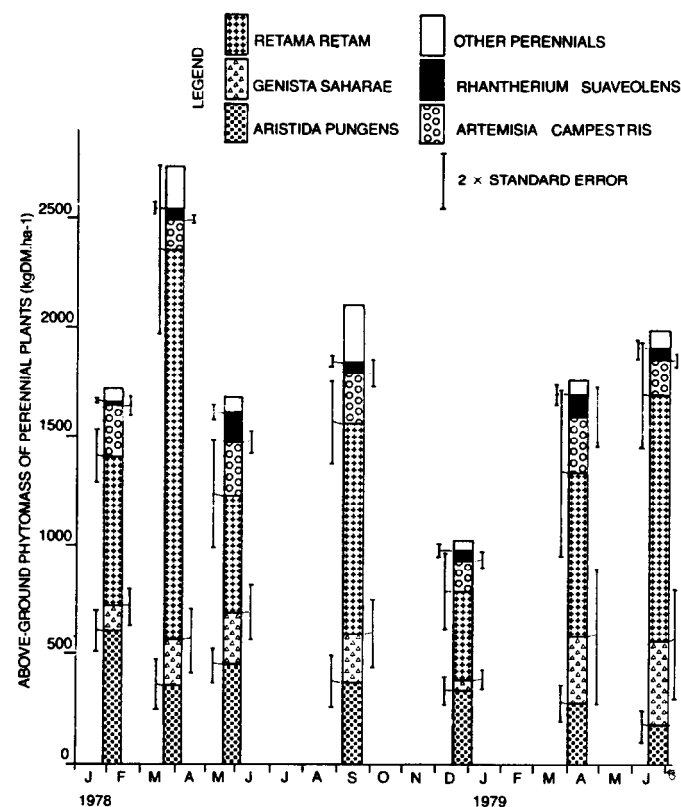


Fig. 2. Contribution of perennial plants to seasonal phytomass.

significant ($P<0.05$) increase of the AAGP ($+0.22\ t\ ha^{-1}$). During this flush period, perennial and annual plants are flowering and fruiting.

From April until the end of May 1978, there is a significant ($P<0.01$) RAGP decrease to $2\ t\ ha^{-1}$. During this period, the AAGP did not vary significantly, so that the loss of standing phytomass must be assigned to the perennial component of the vegetation. Four species, namely *Aristida pungens*, *Genista saharae*, *Retama retam* and *Artemisia campestris*, contributed up to 92% ($SE=1$) of the PAGP throughout 1978 and 1979. Only *Retama retam* shows a significant ($P<0.01$) phytomass variation between February and April ($+1.1\ t\ ha^{-1}$) and between April and end of May 1978 ($-1.2\ t\ ha^{-1}$). Thus, *Retama retam* is mostly responsible for the drop of RAGP between April and end of May 1978. This was

confirmed by field observations in 1978 showing that *Retama retam* shed a large amount of flowers and pods. In contrast to annual plants which dry up and stand as hay ("Guech") (Fig. 3), the

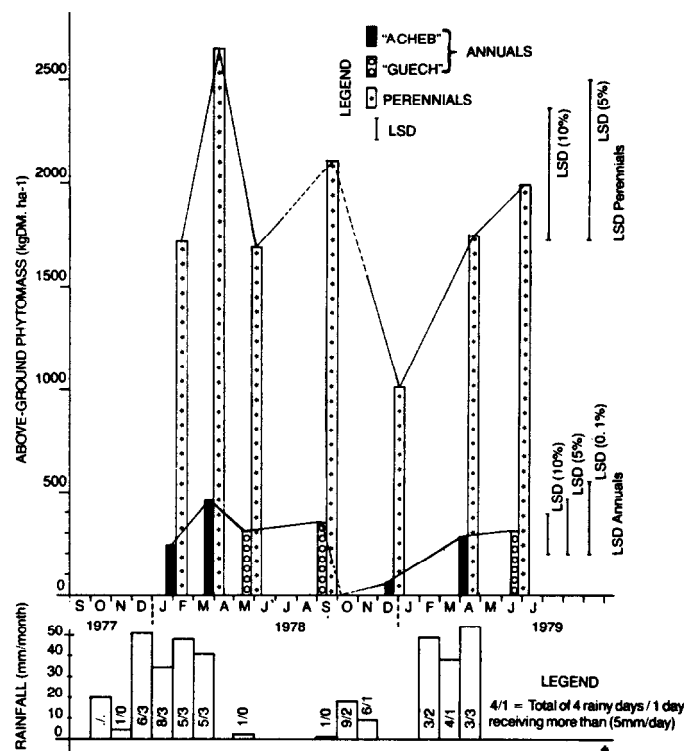


Fig. 3. Seasonal variation of annual and perennial above-ground phytomass and rainfall distribution.

perennial shrubs shed their leaves as a drought evading mechanism (Orshan and Zand 1962, Fahn 1964). The shedding of spring leaves and even small stems was rapid after the "Gibbli" period, early April 1978. This phenomenon has been overlooked by range managers of the Arid Mediterranean North African zones who assumed until recently (Floret et al. 1983) that spring and late spring production of perennial shrubs remains available, so overestimating the grazable phytomass of native shrubs at the end of summer.

No significant change affects the RAGP from end of May until mid-September, in spite of an apparent PAGP increase ($+0.46\ t\ ha^{-1}$). This PAGP increase, though not significant, could be accounted for by late regrowth of some of the perennial shrubs when winter leaves are partly replaced by summer leaves (Orshan 1954).

During the same period, the AAGP remained stable throughout the summer and available as "Guech". This was observed in the Semi-Arid region of Israel as well (Tadmor et al. 1974). At BGII, the dense and tall shrubs certainly contributed to protecting the "Guech" from being sand blasted by the "Gibbli". Early weathering of the "Guech" is more frequent in the Chamaephytic Steppe of Southern Tunisia (Floret et al. 1983) and seems related to the very poor vegetation cover of perennial shrubs.

A sharp and significant ($P<0.001$) fall in RAGP was observed between mid-September and late December 1978 (Table 2). This was associated with the temporary introduction, on 4–5 October, of a sheep and goat flock in the enclosure and to the extremely dry 1978/79 winter. The site received $28\ mm$ in 16 rainy days, from end of September until 14 November 1978, after which no rainfall was recorded until 18 February 1979 (Fig. 3).

Indeed, the heavy loss of total phytomass ($-1.4\ t\ ha^{-1}$) cannot be entirely due to flock grazing on the 1-ha experimental site. During

the grazing period, the animals fed on the dry annuals ("Guech") and on pods spread around *Retama retam* bushes but total consumption could not have exceeded 305 kg of dry matter (122 sheep equivalent at 2.5 kg of dry matter day⁻¹ sheep⁻¹). After the grazing period, no standing "Guech" was left on the site. Therefore the perennial vegetation must have continued to shed a considerable amount of leaves and stems late in the 1978/79 dry winter as described by Orshan (1972). In contrast, over the same time period, the annual vegetation produced 62 kg ha⁻¹ (SE=9) despite the opening rains which were poor in quantity and intensity (Fig. 3). This emphasizes the ability of annual plants to benefit even from small winter precipitations on sandy arid rangeland.

From the end of December 1978 to mid-April 1979, the RAGP increased ($P<0.05$) again to 2 t ha⁻¹. The regrowth of perennials started after the site received 50 mm of rain in the last week of February 1979, and vegetation growth was supported by 38 mm in March and 55 mm early in April 1979. This was the last rainfall of the season, after which the growing season ended.

From mid-April 1979 until the end of June 1979 clipping, no significant change of the RAGP occurred and it remained around 2 t ha⁻¹. In contrast to the 1978 spring, the 1979 spring was not affected by any "Gibbli". Also, although not measured, the 1979 pod production of *Retama retam* and *Genista saharae* was negligible and many of these shrubs did not flower at all. The poor performance of the perennial shrubs is certainly linked with the late opening rains as observed on *Retama retam* in the Neguev Desert by Fahn and Sarnat (1963).

Net Rangeland Above-Ground Primary Production (NRAGPP)

Because of the extended drought into the early winter 1978/79, during which perennial shrubs kept shedding their leaves and possibly their 1978 stem and phyllod production, the 1978 December RAGP is taken as reference to estimate the Net Rangeland Above-Ground Primary Production of the 1977-78 and 1978-79 seasons. Therefore, the 1977/78 NRAGPP was calculated to be 2 t ha⁻¹ while the 1978/79 NRAGPP levelled to 0.95 t ha⁻¹, the annual plants contributing respectively 0.46 (SE=0.12) and 0.30 (SE=0.03) t ha⁻¹.

The relative yearly primary production level of the BGII rangeland, 0.65 for the 1977/78 season and 0.52 for 1978/79 season respectively, compare well with the relative yearly primary production level of 0.4–0.8 in the Subtropical steppe and Subtropical deserts (Evenari et al. 1976) and slightly higher than those measured in the Presaharan Tunisia (Floret et al. 1983).

Rangeland Growth Rate

During the 1978 growing season, the total rangeland growth rate was 21.7 kg ha⁻¹ day⁻¹ (Table 2) with a contribution of 17.6 kg ha⁻¹ day⁻¹ and 4.1 kg ha⁻¹ day⁻¹ for perennial and annual plants, respectively. Considering that in spring, perennial shrubs do not contribute to sheep diet, rangeland growth rate due to the annual plants is able to sustain one Sheep Unit per 1.5 ha (with a 50% use factor of the annual plants growth rate).

This level of production was not reached during the poorer 1978/79 growing season when the growth rate of the total rangeland, the perennial and the annual plants were 9.2, 6.9, and 2.2 kg ha⁻¹ day⁻¹, respectively. The late opening rain and the overall poor 1978/79 season was certainly responsible for this drop in performance from one year to another.

These figures are comparable with those obtained from similar arid zones in Tunisia and Israel (Floret et al. 1983, Tadmor et al. 1974, Gutman 1978).

During the flush of the spring growing season, the moisture content of the annual plants is about 64% (SE=1.5). It allows sheep and goats to live without being watered throughout the "Acheb" period. At the same time, the average moisture content of the perennials is about 38% (SE=1.5). When the "Acheb" dries up into "Guech", its moisture content decreases to 7% (SE=0.8) by late May while the perennials still retain 27% (SE=1.8) moisture. Dur-

ing the "Guech" period, the animals need watering every day. Nomads of the Sirte region, and settled populations of the Jebel Akhdar and Jebel Neffusa have long known how to profit from the high growth rate and moisture content of annuals and ephemerals available in winter-spring in the inland desert. This efficient grazing pattern was disrupted in recent years, resulting in overuse of Libyan coastal rangelands.

Rangeland Relative Growth Rate

While Rangeland Growth rate quantifies the rate of phytomass growth and therefore the net primary productivity of the rangeland, the relative growth rate allows a comparison of the efficiency of various plants, crops, or vegetation types to produce dry matter per unit of phytomass per unit of time (Hunt 1978).

On the BGII site, the relative growth rate of perennials and annuals reached 0.057 and 0.085 kg kg⁻¹ week⁻¹, respectively, between February and April 1978 and 0.036 and 0.104 kg kg⁻¹ week⁻¹, respectively, between December 1978 and April 1979. In comparison, a highly fertilized native pasture of the Northern Neguev displayed a relative growth rate ranging from 0.75 kg kg⁻¹ week⁻¹ early December to 0.04 kg kg⁻¹ week⁻¹ at the end of the growing season late March when the ungrazed primary production reached 6.5 t ha⁻¹ with 259 mm rainfall well distributed throughout the winter (Benjamin et al. 1978).

When comparing the performance of the annual and perennial components of the BGII vegetation, the annual plants are more efficient producers of dry matter per kg of phytomass and per unit of time than are the perennials. During the same period of production, in 1978, the annual plants had a relative growth rate 50% higher than the perennials and 190% higher in 1979.

In Southern Tunisia, Floret and Le Floch (pers. com.) observed that the peak growth of perennials usually occurs in early summer, after the growth of annual plants. However, compared to annual plants in general, woody species (perennial) have a lower relative growth rate and are ill-adapted either for quick replacement of foliage by regrowth or for rapid seedling establishment on bare ground resulting from disturbance (Grime and Hunt 1975). In Semi-Arid and Arid Mediterranean environment where heavy grazing, severe soil disturbance and short growing seasons are normal, annual plants may have a greater survival ability than perennials. The role of perennial plant and shrubs is not questioned as they are a determinant factor of landscape stability and nutrient cycling (Mott and McComb 1974, Wilcox 1979). One wonders, however, if the present policy of rangeland management and regeneration of Semi-Arid and especially Arid Mediterranean zones based almost solely on perennial plants (use of native perennials and fodder shrub plantation), is technically sound and viable. Rangeland improvement programmes should make better use of annual plants in Mediterranean Semi-Arid and Arid zones, by selection and re-introduction of annual species with high relative growth rates and producing large seed quantity and weight (Noy-Meir 1978). The use of annual *Medicago* spp. abundantly distributed throughout North Africa and the Middle-East would be a valuable option (Gintzburger and Blesing 1979, Francis 1981, Chatterton and Chatterton 1981). Other annual legumes such as *Hippocrepis* spp., *Hedysarum* spp., *Vicia* spp., etc. warrant further investigations.

Conclusions

In the Jeffara Plain, at the BGII site, the net Above-Ground Primary Production of an *Aristida pungens*-*Retama retam* rangeland type reached 2.0 and 0.95 t ha⁻¹ with 200 mm of well-distributed rainfall during the 1977/78 growing season and 171 mm of rainfall with a poor and late start for the 1978/79 season respectively. In spite of the large contribution of the perennial shrubs to the total above-ground primary production, very little is actually grazable or available when it is needed, i.e., by the end of the summer. Most of these perennial shrubs shed leaves and/or branches. Phytomass losses of the perennials were particularly

acute after the "Gibbli" period in April 1978 and during the long dry summer and autumn which followed.

In contrast, the phytomass of annual plants remained stable (0.40 t ha⁻¹ in 1978) and available for grazing throughout summer due to the wind break effect of shrubs. Perennial shrubs should be spared as they play a major role in soil stabilization and nutrient recycling on the BGII fixed sand dunes. In this regard, settlement of families in the BGII area is not recommended as wood harvesting for fuel consumption, if not strictly controlled, will lead to wind erosion problems, and subsequent loss of production.

In terms of improvement of rangeland production, annual plants should be preferred to perennial shrubs. Native annuals are more efficient dry matter producers than perennials and displayed a 50% and 190% higher relative growth rate than perennials during the 1978 and 1979 spring growing season. Without minimizing the role played by perennial shrubs as standing fodder reserves during drought, rangeland improvement programmes dealing with the Semi-Arid and Arid Mediterranean zones should turn more of their effort towards the selection and use of native annual species (such as annual *Medicago* spp.) with high seed yielding characteristics, in carefully planned rangeland reseeding operations.

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