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Accessible Forage Biomass of Browse Species in Matruh Area, a Mediterranean Coastal Region, Egypt

S. Z. Heneidy
Botany Department, Faculty of Science, University of Alexandria, Alexandria, Egypt

Abstract: Thirty-two sites with five different habitats were selected to represent study area to highlight the above ground as well as the actual available biomass for the grazing animals. The vegetation of the area was composed of both perennial and annual species, where the woody species (browse species) was the most common life-form. The highest total above-ground phytomass was 1897± 843 kg ha^{-1}. Eighty six percent of perennials biomass was produced in the rocky ridge habitat during the wet season. While, the rest was produced in the saline depression habitat (675 ± 22.9 kg ha^{-1}). The primary productivity of the pasture in these habitats was 169 ± 5.3 and 1083±674 kg ha^{-1} y^{-1} respectively. The highest biomass of accessible parts was produced in the non-saline depression habitat The annual average of the primary production in present study was 590± 117 kg ha^{-1} y^{-1}, while that for the accessible production was 410 ± 39 kg ha^{-1} y^{-1}. In addition the average Rain Use Efficiency (RUE) in the study area was 5.1 kg ha^{-1} y^{-1} mm^{-1} for accessible production and was 8.7 kg ha^{-1} y^{-1} mm^{-1} for primary production. Moreover, the Carrying Capacity (CC) in the study area ranged from 0.5 to 4.4 ha head^{-1} (mean = 1.7 ± 0.17 ha head^{-1}). Calculating the Coefficient of Variation (CV), revealed that when the CV value was 1.2 for the primary production it reflected a great variation between sites, compared with a value of only 0.54 for accessible production. The average Production to Rain Variability Ratio (PRVR) was 2.4 for primary production and 1.1 for accessible dry matter production. The relationships between accessible production and each of carrying capacity (CC) and RUE were also studied. It was inversely related to the first (r = - 0.83**) while was directly related to the second measure (r = 0.45*).

Key words: Accessible, browse, productivity, Rain-Use Efficiency, carrying capacity

Introduction

Forage trees and shrubs play an essential and multiple role in the balance of the arid and semi-arid grazing systems exploited by man and his animals. This role becomes more important as the dry season grows longer (Le Houérou, 1980 and Heneidy, 2002). The world=s rangelands constitute an important global resources. Range has been defined by the society for range management as land which supports vegetation useful for grazing on which routine management of that vegetation is through manipulation of grazing rather than cultural practices (Tueller, 1988)

According to Hodgkinson and Harrington (1985) about two-third of the herbivores feed on artificial pastures developed from clearing native vegetation and sowing exotic forage plants. Water and nutrients are often added to boost the pasture production. The remaining one-third of herbivores feed on natural pastures where the pre-pastoral flora and fauna remain largely intact. They call these pastures as rangelands. It is worth mentioning that most of these Natural pastures are prevailing in arid and semi-arid zones.

The arid natural ecosystem within rainfall < 400 mm like that characterizing all the western Mediterranean regions under grazing is dominated by chamaephytes dwarf shrubs (Abdel-Razik *et al*., 1988a). In this region browse species are the main source of food for grazing animal (Heneidy, 1992). Also degradation of its rangeland is evident in many parts as a result of long history of overgrazing, over cutting, many social economic and cultural activities (Ayyad *et al*., 1983; Abdel-Razik *et al*., 1988a,b; Heneidy, 1992; Heneidy and El-Darrier, 1995).

In Egypt, the Mediterranean desert (west area of Alexandria city) vegetationally and floristically is considered one of its richest parts (Ayyad, 1978). This area especially the area around Matruh has an important role in the development and rehabitation programs. Also, this area is relatively rich in livestock number and grazing activity. Therefore, measurements of the biomass or standing crop has been of the interest to range workers for sometimes because herbivores depend directly upon plant phytomass for their food (Milner and Hughes, 1970). Native vegetation, especially browse species (shrubs and sub-shrubs), in the Mediterranean arid zone are very important in the grazing system. The main economic value of browse species is grazing. Some of them have very high grazing value in terms of forage yield, season of production and forage quality. Productivity in rain-fed conditions may conveniently be assessed via the Rain-Use Efficiency factor (RUE) which is the quotient of the overall aerial phytomass production in kg DM ha^{-1} y^{-1} divided by the annual rainfall in mm (Le Houérou, 1984). The present study is endeavour to evaluate the biomass and primary production of the rangeland species especially shrubby ones; besides the evaluation of the accessible parts of the rangeland species in different sites; in addition to estimation and highlighting the Rain Use Efficiency and carrying capacity of the pasture.

Materials and Methods

Study area: The study area is located in the west of Matruh. It lies between meridians 31° 20' N and 26° 35' E. The area is a system of 3 main wadis :wadi Naghamish, wadi El-Garawla and wadi El-Zarek, which extend about 30 km southwards into the inland plateau with a width of about 10 km. This area has large variation in its topography and habitat types. The bioclimatic map of UNESCO (1977) designates its climate as arid with mild winters and warm summers. However, the amount of rainfall exceeds 250 mm in some areas, while it hardly exceeds 50 mm in others, with a mean annual of about 150 mm. The monthly average temperature ranges between 13.2°C in January and 26°C in August (Ayyad, 1978).

Standing crop phytomass and accessible parts: Thirty two sites were selected to cover the variation in physiognomy and phsiography of the study area. One hundred and twenty-eight randomized stands (each 100 m^2) were distributed in all sites. Homogeneity of a stand was judged according to edaphic and physiographic features. The direct harvest method was used for phytomass determination according to Moore and Chapman (1986). All above-ground parts of different life-forms of the most common palatable species were excavated in each stand and directly weighed in the field. Representative individuals of each species were collected in each stand during two seasons, spring and summer (representing the wet and dry season), for standing crop phytomass determination and also to determine the vegetative and accessible parts (available parts) depending upon the morphology and configuration of the plant species (Heneidy, 1992). Carrying capacity was calculated according to Heneidy (1992). Nomenclature and identification were carried out according to Täckholm (1974) and the Latin names of species were updated following Boulos (1995).

Statistical analysis: Simple Linear correlation coefficient was applied (Snedecor and Cochran, 1968) to assess the relationships between primary and accessible production and Rain Use Efficiency (RUE) and carrying capacity (CC) besides Primary Production (P) to Rain Variability Ratio (P/RVR). Then Coefficient of Variation (CV) was also applied to predict variations in production at different sites (Le Houérou, 1988).

Results

The common life-forms in the study area (Table 1) indicated that the woody species (browse species) were the most common (total 81 species). The total above-ground biomass (TAG), vegetative and accessible parts of different life-forms at 32 sites during the two seasons are represented in Table 2. The maximum above- ground biomass of shrubby species was attained at site 32 during spring (3607 kg ha^{-1}), while the minimum was at site 13 (65.5 kg ha^{-1}.). On the other hand, the sub-shrubs have two peaks of maximum biomass, the first one (mainly for *Gymnocarpos decandrum* and *Salsola tetrandra*) was attained at site 32 during spring (1113 kg ha^{-1}), while the second (mainly *Salsola tetrandra*) was at site 10 (1090 kg ha^{-1}). The minimum above- ground phytomass of sub-shrubs was attained for site 1 (3.4 kg ha^{-1}) during summer. Herbs were recorded at all sites during spring except site 19. The maximum above-ground biomass of herbs was recorded at site 3 (908 kg ha^{-1}), while the minimum was recorded for site 12 during the two seasons. The maximum biomass of annuals was recorded at site 12 (238 kg ha^{-1}), while the minimum was recorded for site 20 (36 kg ha^{-1}) during their growing season. The accessible biomass depends upon the life-forms and mostly on the configuration or architecture of the plant species. The percentages of accessible biomass of shrubby species for grazing during spring ranges from 20 to 49% at site 32 and site 26 respectively, while during summer it ranges from 19% at site 11 to 51% at site 7. Accessible percentage of biomass of sub-shrubs ranges from 89% (site 7) to 32% (site 21) during spring, while it ranges from 8.7% (site 9) to 15.3% (site 15) during summer. On the other hand, for herbs the percentage of accessible biomass mostly reached 100% from the above-ground biomass. For annuals the whole individuals may be accessible for grazing.

The total above-ground biomass (kg dry wt. ha^{-1}) and the net primary production (kg dry wt. ha^{-1} yr^{B1}) of the rangeland species are shown in Table 3. The highest total above-ground biomass of the perennials was attained at site 32 (4739 kg ha^{-1} during the wet season and 1411 kg ha^{-1} during the dry season), where, the contribution of shrubs and sub-shrubs was 75 and 23% respectively. On the other hand, the lowest total above-

Table 1: List of the common plant species in the Matruh area during their growing season

Species	Family	Species	Family
Herbs		*Anchusa aegyptiaca* (L.) DC.	Boraginaceae
Asphodelus ramosus L.	Liliaceae	*Anthemis microsperma* Boiss. and Kotschy.	Compositae
Carthamus lanatus L.	Compositae	*Beta vulgais* L.	Chenopodiaceae
Centaurea alexandrina Del.	Compositae	*Brassica tournefortii* Gouan.	Cruciferae
Echinops spinosissimus Turra	Compositae	*Bromus rubens* L.	Gramineae
Launaea nudicaulis (L.) Hook.	Compositae	*Bupleurum semicompositum* L.	Umbelliferae
Lygeum spartum Loefl. ex L.	Gramineae	*Calendula arvensis* L.	Compositae
Plantago albicans L.	Plantaginaceae	*Carrichtera annua* (L.) DC.	Cruciferae
Polygonum equisetiforme Sibth. and Sm.	Polygonaceae	*Centaurea glomerata* Vahl.	Compositae
Scorzonera undulata Vahl.	Compositae	*Chenopodium murale* L.	Chenopodiaceae
Stipa parviflora Desf.	Gramineae	*Chrysanthemum coronarium* L.	Compositae
Teucrium polium L.	Labiatae	*Cutandia dichotoma* Frossk.	Gramineae
Verbascum letourneuxii Asch.and Schweinf	Scrophulariaceae	*Didesmus aegyptius* (L.) Desv.	Cruciferae
Shrubs		*Filago desertorum* Pomel.	Compositae
Anabasis articulata (Forssk) Moq.	Chenopodiaceae	*Herniaria hirsuta* L.	Caryophyllaceae
Anabasis oropediorum Maire	Chenopodiaceae	*Hippocrepis areolata* Desv.	Leguminosae
Astragalus sieberi DC	Leguminosae	*Hordeum leporinum* (Link.) Arcany.	Gramineae
Astragalus spinosus (Forssk.) Muschl	Leguminosae	*Ifloga spicata* (Forssk.) Sch.	Compositae
Atriplex halimus L.	Chenopodiaceae	*Lobularia arabica* (Boiss.) Musch.	Cruciferae
Haloxylon scoparia Pomrl and Nouv.	Chenopodiaceae	*Malva parviflora* L.	Malvaceae
Lycium shawii Roem. and Schult.	Solanaceae	*Matthiola livida* (Delile) Maire.	Cruciferae
Periploca angustifolia Labill.	Asclepiadaceae	*Medicago laciniata* (L.) Mill.	Leguminosae
Thymelaea hirsuta (L.) Endle.	Thymelaeaceae	*Medicago trurncatula* Gaertm.	Leguminosae
Zilla spinosa (Turra.) Prantl	Cruciferae	*Onobrychis crista-galli* (L.) Lam.	Leguminosae
Sub-shrubs		*Ononis serrata* Forssk.	Leguminosae
Argyrolobium uniflorum (Decne.) JaubandSpach	Leguminosae	*Paronchyia arabica* (L.) DC	Caryophyllaceae
Artemisia herba-alba Asso	Compositae	*Phalaris minor* Retz.	Gramineae
Deverra tortuosa (Desf.) DC.	Caryophyllaceae	*Picris radicata* (Forssk.) Less.	Compositae
Echiochilon fruticosum Desf.	Boraginaceae	*Plantago crypsoides* Boiss.	Plantaginaceae
Gymnocarpus decandrum Forssk.	Caryophyllaceae	*Plantago ovata* Forssk.	Plantaginaceae
Helianthemum kahiricum Del.	Cistaceae	*Pseudorlaya pumila* (L.) Grande.	Umbelliferae
Helianthemum lippii L.	Cistaceae	*Reichardia tingitana* (L.) Roth.	Compositae
Kickxia aegyptiaca Dumort.	Scrophulariaceae	*Scabiosa rhizantha* Viv.	Dipsacaceae
Noaea mucrnata Forssk.	Chenopodiaceae	*Schismus barbatus* (L.) Thell.	Gramineae
Salsola tetrandra Forssk.	Chenopodiaceae	*Silene villosa* Forssk.	Caryophyllaceae
Salsola tetragona Del.	Chenopodiaceae	*Spergularia marina* (L.) Griseb.Spicil fl. Rumd	Caryophyllaceae
Salsola vermiculata Poir.	Chenopodiaceae	*Trifolium resupinatum* L.	Leguminosae
Salvia lanigera L.	Labiatae	*Trigonella stellata* Forssk.	Leguminosae
Salvia aegyptiaca L.	Labiatae	*Valantia hispida* L.	Rubiaceae
Suaeda pruinosa Lange.	Chenopodiaceae		
Suaeda vermiculata Forssk.	Chenopodiaceae		
Suaeda volkensii CB Clark.	Chenopodiaceae		
Annuals			
Adonis dentata Delile	Ranunculaceae		
Aegilops bicornis (Forssk) Jaub. and Spach.	Gramineae		
Aizoon canariense L.	Aizoaceae		
Anacyclus alexandrinus Willd	Compositae		

ground biomass was attained at site 16 (455 and 337 kg ha^{-1} during the wet and dry season respectively). Perennial herbs play an essential role, especially during the wet season. Their contribution reaches up to 63% of the total above-ground biomass at site 3. The highest contribution of the annual species appears at site 13 (281 kg dry wt. ha^{-1} yr^{-1}). The maximum of the net primary production for perennials was attained at site 32 (3328 kg dry wt. ha^{-1} yr^{-1}), while the minimum was at site 5 (90 kg dry wt. ha^{-1} yr^{-1}).

The accessible biomass (kg ha^{-1}) and accessible production (kg ha^{-1} yr^{-1}) of perennial and annual species for different sites are represented in Table 4. The highest accessible biomass for perennials was attained at site 32 (1273 kg ha^{-1}) during the wet season, while the lowest is in site 27 (190 kg ha^{-1}). On the other hand, during the dry season the highest accessible biomass was attained at site 3 and the lowest at site 1 (613 and 110 kg ha^{-1} respectively). Annuals attained their maximum at site 13 and the minimum at site 20 (281, 36 kg ha^{-1} respectively) during the growing season. The maximum accessible production for perennial species was attained at site 32 and the minimum was found at site 27 (938 and 10 kg ha^{-1} yr^{-1} respectively). On the other hand, the maximum of total accessible production for the pasture is attained in site 32 (999 kg ha^{-1} yr^{-1}). The amount of rainfall ranged between 59.9±13 mm in the flat plateau habitat to 107.3±9.2 mm in the saline depression habitat (Table 6).

The highest total above-ground phytomass of the vegetation was produced in the rocky ridge during the

Table 2: Total above-ground (TAG.), vegetative (Veg.) and accessible, (Acc.), biomass (kg ha^{-1}) for different life-forms during spring and summer seasons at 32 sites of Matruh area

	Shrub			Sub-shrub			Herbs			Annuals		
	T.A.G.	Veg.	Acc.	T.A.G.	Veg.	Acc.	T.A.G.	Veg.	Acc.	T.A.G.	Veg.	Acc.
Spring	381.6	267.0	160.0	5.7	4.6	3.7	127.8	125.0	122.7	118.0	118.0	118.0
Summer	224.0	157.0	110.0	3.4	2.1	1.9	--	--	--	--	--	--
Spring	149.6	84.0	50.8	350.0	229.0	169.0	387.0	357.0	322.0	139.0	139.0	139.0
Summer	218.0	145.0	103.0	419.0	171.0	103.0	192.0	141.0	109.0	--	--	--
Spring	301.0	219.0	132.0	213.0	170.0	136.0	908.0	624.0	539.0	95.3	95.3	95.3
Summer	612.0	428.0	300.0	141.0	92.0	52.0	508.0	317.0	262.0	--	--	--
Spring	1164.0	718.0	436.0	191.0	110.0	80.0	157.0	143.0	139.0	71.4	71.4	71.4
Summer	907.0	576.0	412.0	72.0	37.0	25.0	--	--	--	--	--	--
Spring	335.0	198.0	116.0	54.0	39.0	34.0	172.0	172.0	172.0	81.7	81..7	81.7
Summer	517.0	197.0	129.0	2.4	1.2	0.7	33.4	31.9	31.4	--	--	--
Spring	458.0	271.0	145.0	309.0	202.0	141.0	167.0	146.6	146.6	108.0	108.0	108.0
Summer	465.0	213.0	146.0	156.0	96.0	64.6	132.0	59.3	55.6	--	--	--
Spring	2345.0	1065.0	712.0	24.0	21.0	21.0	302.0	300.0	291.0	101.0	101.0	101.0
Summer	589.0	446.0	298.0	14.0	6.9	4.8	--	--	--	--	--	--
Spring	242.0	132.0	96.5	598.0	367.0	261.0	16.8	16.8	16.8	91.4	91.4	91.4
Summer	366.0	155.0	110.0	409.0	169.0	121.0	--	--	--	--	--	--
Spring	316.0	126.0	101.0	169.0	118.0	93.0	120.0	117.5	118.0	62.0	62.0	62.0
Summer	268.0	151.0	104.5	412.0	54.4	36.0	8.2	7.4	7.4	--	--	--
Spring	453.0	265.0	194.4	1090.0	672.0	443.0	101.0	82.2	78.3	38.8	38.8	38.8
Summer	94.0	35.0	18.0	309.0	127.9	71.0	24.4	24.4	24.4	--	--	--
Spring	304.0	212.0	143.8	802.0	567.0	401.0	109.0	90.0	78.9	64.6	64.6	64.6
Summer	215.0	80.0	39.8	495.0	168.6	87.9	11.8	8.2	7.1	--	--	--
Spring	695.0	270.0	192.0	963.0	676.0	424.0	6.4	6.4	6.4	238.0	238.0	238.0
Summer	801.0	534.0	243.0	225.0	77.0	47.4	4.8	4.8	4.8	--	--	--
Spring	65.5	43.0	27.9	597.0	381.0	267.0	228.0	228.0	227.5	281.0	281.0	281.0
Summer	141.0	63.6	47.8	329.0	181.0	123.0	39.3	39.3	39.3	--	--	--
Spring	227.0	123.0	87.3	432.0	226.0	186.0	267.0	245.0	230.0	91.0	91.0	91.0
Summer	155.0	72.0	47.5	449.0	157.0	102.0	76.4	65.0	61.8	--	--	--
Spring	302.0	283.0	134.5	139.0	87.0	53.0	113.0	113.0	113.0	88.5	88.5	88.5
Summer	321.0	224.0	140.6	116.0	80.0	59.0	44.7	44.7	44.7	--	--	--
Spring	71.5	44.0	30.6	116.0	83.0	57.5	268.0	217.0	217.0	74.9	74.9	74.9
Summer	109.0	64.8	45.7	117.0	70.0	32.3	111.0	90.0	73.8	--	--	--
Spring	514.0	312.0	190.0	102.0	53.5	39.3	52.8	52.8	52.8	39.4	39.4	39.4
Summer	281.0	95.4	66.2	233.0	137.0	100.0	17.7	7.0	5.0	--	--	--
Spring	467.0	295.0	194.0	355.0	288.0	163.0	441.0	417.0	410.0	75.0	75.0	75.0
Summer	522.0	275.0	187.0	205.0	77.5	56.5	13.4	13.4	13.4	--	--	--
Spring	156.0	69.0	60.4	1006.0	713.0	494.0	--	--	--	51.0	50.0	51.0
Summer	453.0	248.0	168.0	699.0	230.0	149.0	--	--	--	--	20.0	
Spring	474.0	295.0	205.0	60.0	39.0	31.3	8.2	5.8	5.2	36.0	36.0	36
Summer	222.0	133.0	80.0	91.0	32.0	29.9	--	--	--	--	--	--
Spring	295.0	160.0	123.0	986.0	440.0	320.0	113.4	102.0	97.9	45.6	45.6	45.6
Summer	406.0	203.0	128.0	809.0	278.0	176.0	--	--	--	--	--	--
Spring	800.0	268.0	266.0	103.0	84.4	73.0	510.0	510.0	510.0	114.0	114.0	114
Summer	905.0	547.0	383.0	22.0	13.6	9.5	71.0	71.0	71.0	--	--	--
Spring	1201.0	603.0	353.0	140.0	79.0	50.0	19.5	19.5	19.5	45.4	45.4	45.4
Summer	452.0	195.0	118.0	247.0	94.0	56.0	14.5	14.5	14.5	--	--	--
Spring	645.0	334.0	213.0	432.0	202.0	151.0	32.5	23.7	19.0	116.0	116.0	116.0
Summer	509.0	224.0	150.0	24.0	12.9	9.0	11.8	7.1	5.0	--	--	--
Spring	727.0	355.0	246.0	684.0	489.0	352.0	--	--	--	117.0	117.0	117.0
Summer	243.0	93.0	55.5	305.0	138.0	100.0	--	--	--	--	--	--
Spring	713.0	496.0	348.0	797.0	569.0	423.0	49.0	49.0	49.0	188.0	188.0	188.0
Summer	241.0	98.0	59.0	403.0	118.0	74.0	--	--	--	--	--	--
Spring	167.0	53.0	40.5	304.0	191.0	143.0	6.6	6.6	6.6	104.4	104.4	104.4
Summer	212.0	148.0	87.0	218.0	146.0	88.0	17.7	7.1	4.3	--	--	--
Spring	832.0	512.0	334.0	477.0	328.0	251.0	15.0	15.0	15.0	136.0	136.0	136.0
Summer	222.0	89.0	51.0	653.0	262.0	150.0	--	--	--	--	--	--
Spring	129.0	63.0	40.4	643.0	457.0	357.0	179.0	179.0	179.0	180.0	180.0	180.0
Summer	366.0	155.0	118.0	428.0	181.0	127.0	59.2	49.7	44.0	--	--	--
Spring	286.0	169.0	134.0	766.0	613.0	263.0	41.4	38.5	33.4	62.0	62.0	62.0
Summer	542.0	273.0	177.0	416.0	178.0	96.4	--	--	--	--	--	--
Spring	293.0	211.0	141.0	309.0	246.0	190.0	473.0	469.0	469.0	95.8	95.8	95.8
Summer	148.0	103.0	72.0	189.0	105.0	71.5	89.0	79.0	79.0	--	--	--
Spring	3607.0	1145.0	713.0	1113.0	696.0	540.0	18.9	18.9	18.9	61.3	61.3	61.3
Summer	795.0	341.0	208.0	616.0	180.0	128.0	--	--	--	--	--	--

Table 3: The total above-ground biomass (kg d.wt ha^{-1}), the net primary production (kg d.wt ha^{-1} y^{-1}) and Rain Use Efficiency (RUE) of different sites for perennial and annual species in Matruh area

Biomass (kg dry wt. ha^{-1})				
Wet season				
Perennials	Annuals	Dry season	Net production (Kg dry wt. ha^{-1}y^{-1})	RUEc (kg ha^{-1} y^{-1} mm^{-1})
515	119	224	410	4.6
887	138	830	196	6.3
1420	95	1261	254	3.8
1511	71	979	603	5.5
561	82	553	90	9.2
935	108	879	164	8.0
2661	101	603	2159	34.7
857	92	775	174	2.3
604	62	561	106	1.3
1644	39	427	1256	14.5
1215	65	722	558	7.0
1664	238	1012	890	10.2
890	281	509	662	6.3
926	91	680	337	2.4
560	89	502	147	1.2
455	75	337	193	1.1
669	39	631	176	1.9
1262	75	741	596	6.2
1162	51	1083	130	0.8
542	36	313	265	3.1
1396	46	1214	228	3.4
1413	114	997	530	6.3
1359	45	713	691	23.1
1099	116	532	683	12.6
1412	117	603	926	7.9
1559	188	632	1115	17.5
477	104	446	135	2.7
1324	136	875	585	8.8
950	180	853	277	9.6
1094	62	958	198	6.5
1074	96	416	754	44.9
4739	61	1411	3389	46.9

perennials was 86% while the lowest was in the saline depression (675 ± 22.9 kg ha^{-1}) where the contribution of perennials was 91% (Table 5). However, the highest accessible parts were produced in the non-saline depression 864 ± 35 and 400 ± 64.3 kg ha^{-1} during wet and dry seasons respectively.

The primary productivity of the pasture in different habitats ranged from 169 ± 5.3 to 1083 ± 674 kg ha^{-1} y^{-1} in habitats of the saline depression and rocky ridges respectively (Table 6). The accessible production level reached its maximum in the habitats of rocky ridge (499±165 kg ha^{-1} y^{-1}) while the minimum is attained in the saline depression (149.5±1.8 kg ha^{-1} y^{-1}).

Discussion

For biologists and rangers, it is very important to have knowledge about the production of rangeland species for range management. Measurement of plant biomass or productivity has been of interest to range workers and ecologists for some times because herbivores depend directly upon plant biomass for their food (Milner and Hughes, 1970). On the other hand, any ecological argument in land use planning in arid rangelands should be based on a thorough knowledge of the harvestable primary productivity. Study of the vegetation of study area (Heneidy, 2002) indicated that it consists of 39 perennial species and 43 annuals. The grazeable (mostly new-growth) phytomass is either accessible or non-accessible to the grazing animals due to morphological configuration of the plant. A portion of the accessible phytomass is actually grazed by grazing animals and another portion is left over (Heneidy, 1992).

The present study revealed that the study area was vegetatively rich and the woody species were the most abundant life-forms. The woody species were considered the skeletal part of the grazing system in arid ecosystem (Abdel BRazik *et al*., 1988a). The grazing system represented 60 to 80% of the utilization land of North Africa in terms of economic output (Le Houèrou, 1993). In the study area most of the land is used as grazing land.

Most perennial species exhibited their greatest vegetative activity during winter and spring and they were less active or dormant during summer. This observation agrees with that noticed by Abdel-Razik *et al*. (1988a) at Omayed

Table 4: Accessible biomass (kg ha^{-1}) net primary production (kg ha^{-1} y^{-1}), Rain use efficiency (RUE) and Carrying capacity (CC) of different sites for perennial and annual species in Matruh area

Accessible (kgd.wt.ha^{-1})						
Wet season						
Perennials	Annuals	Dry season	Production level (perennials)	Primary production level (perennials + annuals)	RUE	CC (ha/head)
286	119	110	176	295	3.3	1.7
542	138	316	226	365	11.8	1.4
807	95	613	194	289	4.3	1.7
664	71	437	227	298	2.7	1.7
321	82	161	160	242	24.7	2.1
452	108	266	186	294	14.4	1.7
1023	101	303	720	821	13.2	0.6
320	91	231	89	180	2.4	2.8
311	62	148	163	225	2.8	2.2
716	39	114	602	641	7.4	0.8
615	65	136	479	544	6.9	0.9
622	238	287	335	573	6.6	0.9
522	281	210	312	593	5.7	0.8
503	91	212	291	382	3.8	1.3
303	89	245	58	147	1.2	3.4
305	74	152	153	227	1.3	2.2
282	39	169	113	152	1.6	3.3
767	75	257	510	585	6.1	0.9
554	51	314	240	291	1.8	1.7
242	36	111	131	167	2.0	3.0
541	46	304	238	284	4.3	1.8
853	114	463	389	503	6.0	1.0
422	45	189	234	279	9.3	1.8
383	116	163	220	337	6.2	1.5
597	111	156	441	552	4.8	0.9
820	188	145	675	863	13.6	0.6
190	104	180	10	114	2.3	4.4
590	136	213	377	513	7.7	1.0
582	180	589	293	473	16.4	1.1
431	62	273	158	220	7.2	2.3
809	96	223	587	682	40.6	1.3
1273	61	336	938	999	13.8	0.5

Table 5: Total above-ground (TAG) biomass and accessible biomass (mean ± standard error (SE) kg ha^{-1}) in different habitats during the two seasons

Habitat		Rocky plateau	Flat plateau	Rocky ridge	Non-saline depression	Saline depression
T.A.G	Spring	1053 ± 110	1347 ±176	1897 ± 843	1427 ± 68	675 ± 22.9
	Summer	637 ± 92.8	733 ± 66	796 ± 186	881 ±126	557 ± 53
Accessible biomass	Spring	510 ± 41	708 ± 69	744 ± 188	864 ± 35	356 ± 23.6
	Summer	199 ± 22.6	218 ± 22	231 ± 34	400 ± 64.3	208 ± 26.2

Table 6: The net primary production (NPP), accessible production (mean ± SE as kg ha^{-1} y^{-1} mm^{-1}) and rain use efficiency (RUE) of different habitats

Habitat	Rocky plateau	Flat plateau	Rocky ridge	Non-saline depression	Saline depression
NPP (kg ha^{-1}y^{-1})	412.7 ± 78.5	668.9 ± 185.2	1083.0 ± 674	547.4 ± 73.4	169.0 ± 5.30
Rainfall (mm)	77.8 ± 13.7	59.9 ± 13	75.2 ± 11	74.7 ± 14.5	107.3 ± 9.2
Accessible (kg ha^{-1}y^{-1})	309.8 ± 32.2	488.0 ± 68.2	499.0 ± 165	471.0 ± 69.7	149.5 ± 1.8
RUE to primary production	5.3	11.2	14.4	7.3	1.6
RUE to accessible	3.9	7.5	6.6	6.3	1.4

in the northwestern region. However, some shrubs and sub-shrubs were active throughout the whole year. These species were more conservative in the use of their own resources, especially soil moisture and developed a root system that was capable of exploiting soil moisture and minerals from a large volume of soil and at depth that was permanently wet, which in-turn enabled them to extend their activities even under conditions of moisture stress Ayyad *et al.* (1983). This behaviur of plant species occurred in some species in the study area. This type of species played an important role in sustainable production of the natural forage of the pasture.

The study area can be divided into 5 habitats (Heneidy, 2002) according to soil type and soil characters: the rocky plateau, the flat plateau, the rocky ridge, the non-saline depression and the saline depression. (Noy-Meir, 1973) suggested that the bulk of primary standing biomass of the community in semi-arid regions was made up of woody life-forms. This means that accessible parts do not depend upon the primary above-ground phytomass, but depend upon the configuration and morphological shape of the species and their life-forms (Heneidy, 1992). Grevstad and Klepetka (1992) recorded that the production level of herbivores may depend more upon plant architecture than on the particular species of natural enemies present.

The annual average of the primary production in present study was 590 ± 117 kg ha^{-1} y^{-1}, while the accessible production was 410 ± 39 kg ha^{-1} y^{-1}, compared with that of the woody steeps in arid zones which ranged from 300 to 600 kg ha^{-1} y^{-1} (Le Houérou, 1972). On the other hand, the value obtained in the present study was less than that obtained by Abdel-Razik *et al*. (1988a) and Heneidy (1992) at Omayed in the coastal region (668 and 720 kg ha^{-1} respectively). However, the average of annual forage yield in the saline depression habitat in coastal region was 1560 kg ha^{-1} (Heneidy and Bidak 1996) which is three times higher than that value recorded in the present study.

The RUE factor is the quotient of annual primary production by annual rainfall. RUE decreased when aridity increased together with the rate of useful rains and as potential evapotranspiration increased. But it also strongly depends on soil condition and, more than anything, on vegetation condition particularly the dynamic status. It thus greatly relies on human and animal impact on the ecosystems. The RUE is a good indicator of ecosystem productivity (Le Houérou, 1984).

The average of accessible dry matter production per mm rainfall ranged from 1.4 to 7.5 $kgha^{-1}$ y^{-1} in the habitats of flat plateau and the saline depression respectively. The average RUE was 5.1 kg ha^{-1} y^{-1} mm^{-1} for accessible production while for primary production was 10 kg ha^{-1} y^{-1} mm^{-1}. In comparison, the average of the grazeable dry matter production per mm rainfall at Omayed area was 4.8 kg ha^{-1} y^{-1} (Abdel-Razik *et al*., 1988a) while that average of RUE was 10.4 kg ha^{-1} y^{-1} mm^{-1} at salt marshes in the coastal region (Heneidy and Bidak 1996). Actual RUE figures throughout the arid zones of the world may vary from less than 0.5 in depleted sub-deseric ecosystems to over 10 in highly productive and well managed stepped (Le Houérou, 1984).

Generally, the great variations in the productivity levels in different sites are due to the variations in soil, climate, vegetative types and grazing pressure. Consequently coefficient of variation (CV) was taken as 107.3 ± 9.2 mm in the saline depression habitat. Calculated CV of the primary production (1.2) indicated that there was a great variation between sites. This variation did not depend on rainfall and only may hide other factors as mentioned above (e.g. life-forms, soil condition, topography and human impact etc). This result agrees with those obtained by Le Houérou (1988) who assessed that variability in primary production does not depend only on rainfall, but also on ecosystem dynamics, soil surface condition and texture. For accessible production, CV is lower (e.g. slight variation between different sites and also in the relative variation in the amount of rainfall at different sites. The average of the primary, production and accessible production ± SE on one hand and RUE, carrying capacity (CC), Coefficient of Variation (CV), Production to Rain Variability Ratio (P/RVR) on the other hand, has been summarized below.

Item	Average value	Rain use efficiency (RUE)	P/RVR	CV	Carrying capacity ha/head Range	Mean± S.E
1	590 ± 117	8.7	2.4	1.2		
2	388 ±35	5.1	1.1	0.54	0.5±4.4	1.7 ± 0.17
3	75.4 ± 6.7	--	--	0.5		

1 = Primary production (kgd.wt.ha^{-1} y^{-1}) ± S.E
2 = Accessible production (kgd.wt.ha^{-1} y^{-1}) ± S.E
3 = Rainfall (mm) ± S.E

The average of primary dry matter production was 590 ± 117. This figure does not include the amount eaten during the grazing season, which could increase the primary annual production. This would imply a maximum safe carrying capacity. Rain Use Efficiency for primary production and accessible part was 8.7 and 5.1 kg ha^{-1} y^{-1} mm^{-1} respectively. Carrying capacity ranged from 0.5 to 4.4 ha $head^{-1}$ and the mean ± SE was 1.7 ± 0.17 ha $head^{-1}$. The variability of annual production was 1.2 times that of the variability of annual precipitation. Production to Rain Variability Ratio (P/RVR) averages 2.4 world-wide in primary production than in accessible. Conversely, P/RVR increases when rainfall decreases and with ecosystem degradation. Finally natural vegetation is affected by rainfall variability in its composition, structures, morphology, ecophysiological adaptation and physiological processes. RUE decreases with rainfall and with the depletion status of the ecosystem (biomass, permanent ground cover, organic matter, microbial activity), (Le Houérou, 1988).

Linear correlation coefficient showed that there was highly inversely significant correlation (at 0.01 probability level) between accessible production and CC ($r = -0.83^{**}$) and significant correlation (at 0.05 probability level) between accessible production and RUE ($r = 0.45^{*}$).

The relatively high annual production of the range land under study as compared with the average production of North Africa (which varies between 200 ton ha^{-1} y^{-1}) (Le Houérou, 1975 and Sarson and Salmon, 1977) may be attributed to the fact that its vegetation is composed mainly of perennials that can exploit moisture substantial at deep layers of the soil. It is represents a good production level if compared with the production level at Omayed area 80 km west of Alexandria (Heneidy, 1992). However, this area needs more studies and a good plan for improvement as rangeland within the carrying capacity of the ecosystem, for a sustainable development.

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