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Structure and standing crop of Egyptian *Thymelaea hirsuta* populations

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Abstract

The population structure and standing crop of the desert shrub *Thymelaea hirsuta* (L.) Endl. were evaluated in six different habitats in the western Mediterranean desert of Egypt. Under favourable conditions, populations of *T. hirsuta* are denser and the size structure has a strong bias towards small, juvenile individuals, whereas the reverse tendency is found under adverse conditions with size structure biased towards big individuals. These results are discussed in the light of hypothesis of intraspecific competition. The standing crop is strongly affected by soil salinity and nature of soil surface (amount of exposed rocks).

Introduction

Many shrubs and trees are of structural and economic importance in the arid regions (Crisp & Lange 1976). They play an important role in soil protection and stabilization against movement by wind or water, provide a source of forage for animals and fuel for local inhabitants, and have medicinal and potential industrial values (Thalen 1979).

Thymelaea hirsuta, a circum-Mediterranean evergreen shrub (Rikli 1943), is one of the most common species along the western Mediterranean coast of Egypt, dominating an alliance Thymeleion hirsutae (Tadros & Atta 1958) which extends about 70 km southwards (El-Ghonemy & Tadros 1970; El-Ghonemy *et al.* 1977). It provides a source of fuel for the bedwins and contributes to the diet of the domestic animals (mainly sheep and goats), but only a small fraction of its current growth is grazed along with a larger portion of its dead material (El-Kady 1987).

Previous studies have assessed the relationship between the phytosociological behaviour and some aspects of the population dynamics of *T. hirsuta* on one hand, and the prevailing environmental factors on the other (El-Ghonemy *et al.* 1977; Shaltout 1987). In the present paper other aspects like the population structure and standing crop will be dealt with.

The structure of a population of plants can be described in terms of the ages, sizes, and forms of the individuals that compose it (Harper & White 1974). Since the fecundity and survival of plants is often much more closely related to size than to age (Harper 1977; Watkinson & White 1985; Caswell 1986; Weiner 1986), some authors (e.g. Werner & Caswell 1977; Kirkpatrick 1984; Caswell, 1986) have argued that it is better to classify the life history of plants by size rather than age which is the most widely used classification for unitary organisms. Size differences may be caused directly or through differences in growth rates due to age difference, genetic variation, heterogeneity of resources, herbivory, and competition (Weiner 1985).

The present study aims at assessing the effect of the prevailing environmental gradient on the size structure and standing crop of populations of *T. hirsuta* from six different habitats in the western Mediterranean desert of Egypt.

Study area

The study area is situated in the western coastal region of Egypt. Its landscape can be distinguished into a northern coastal plain and a southern plateau. The coastal plain supports four major habitats: a coastal ridge, saline depressions, non-saline depressions, and inland ridges. The southern plateau supports two habitats: an inland plateau with skeletal soil, and inland siliceous deposits. In general, the coastal plain is less arid and more calcareous than the southern plateau (Ayyad & Le Floc'h 1983).

Climatologically, the study area belongs to the category of 'warm coastal deserts' of Meigs (1973). The climatic gradient over a 40 km NS-transect in the study area shows an annual mean (over 15 years) of maximum air temperature of 24.1 °C in the north, and 28.4°C in the south. The rainfall varies in the same direction from 168.9 to 90.4 mm/year, and the aridity index of Emberger (1955) from 26.9 to 10.7 (Shaltout 1987). This indicates an increase in environmental aridity from the north of the study area to the south.

Methods

Forty-four stands were selected along two transects of 40 km length oriented in NS-direction, one at Burg El-Arab (29°33′E, 30°54′N) and the other at Omayed (29°12′E, 30°46′N) so as to represent the environmental variations of the six major habitats that associated with the distribution of *T. hirsuta*. The stands were selected as far from the human settlements as possible in order to ensure a minimum and equal degree of disturbance. The mean characteristics of the sampled stands in each of the six major habitats are summarized in Table 1 (after Shaltout 1983).

In each stand, the population of *T. hirsuta* was sampled using 50 2m^2 quadrats distributed randomly. The height and mean crown diameter of each individual was measured (based on 2–4 diameter measurements/ind.) and its volume was calculated as a cylinder. The volume estimates were then used to classify the population in each habitat into 14 size classes. The first and second classes were chosen to represent the seedling and juvenile stages respectively (Fig. 1). The absolute and relative frequency of individuals and mean volume per individual in each size class were then determined. To calculate the correlation between size and age of the individuals of *T. hirsuta*, 20 individuals (representing a series of volumes) were selected and their volumes were estimated. Section of the main stems (trunks) of these individuals were smoothed and the number of annual rings in each one of them was counted under the microscope. Then, the simple linear correlation coefficient was calculated between the volume and number of annual rings.

Standing crop was estimated using the stratified harvest technique as applied in forests (e.g. Rochow 1974) with some adaptation necessary under desert conditions. In applying this technique, 100 individuals of *T. hirsuta* were collected so as to represent the different size classes (class 1 was excluded as it has a negligible contribution to the standing crop). Each individual was separated into shoot and root, carefully cleaned, dried at 105 °C for three days and weighed. The average weight of shoot- and root sys-

Table 1. Mean characteristics over the number of stands (*N*) sampled in each of the six major habitats (H) that are recognized in the study area. The figures between brackets are the standard errors of the means (after Shaltout 1983). C: coastal ridge, D: saline depressions, R: inland ridges, N: non-saline depressions, P: inland plateau, S: inland siliceous deposits.

H	*N*	EC (mmhos/cm)	Distance from the coast (km)	Exposed rocks (%)	Ca CO3 (%)	Organic matter (%)
C	7	0.19	0.4	20.0	91.1	1.39
		(0.01)	(0.02)	(2.32)	(0.85)	(0.10)
D	5	1.76	2.7	0.0	47.3	1.26
		(0.99)	(0.19)		(1.50)	(0.17)
R	8	0.66	7.1	48.4	38.8	1.77
		(0.20)	(0.96)	(1.69)	(2.88)	(0.23)
N	11	0.66	15.3	0.0	30.1	1.42
		(0.21)	(1.65)		(1.66)	(0.20)
P	6	0.22	30.0	52.5	18.5	1.05
		(0.02)	(2.40)	(4.95)	(1.11)	(0.12)
S	7	0.15	37.0	5.0	12.2	0.61
		(0.02)	(1.92)	(1.89)	(1.54)	(0.12)

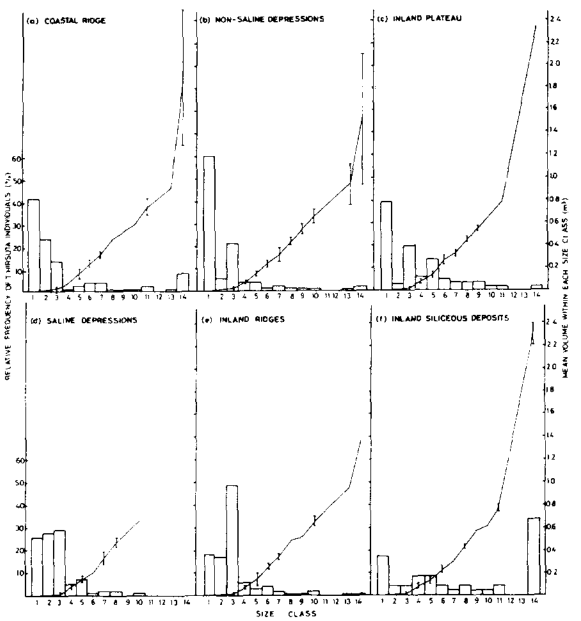

Fig. 1. Size-class frequency distribution for populations of *T. hirsuta* from six habitats. CD: coastal ridge, SD: saline depressions, ND: non-saline depressions, IR: inland ridges, IP: inland plateau, IS: inland siliceous deposits. The mean volume of shrubs (m^3) and 95% confidence limits (vertical bars) within each size class are also indicated. The ranges of the 14 size classes (cm^3) are; 1: <1, 2: 1–1000, 3: 10^3–5.10^4, 4: 5.10^4–10^5, 5: 10^5–2.10^5, 6: 2.10^5–3.10^5; 7–12, 7: increasing with 10^5, 13: 9.10^5–10^6, 14: >10^6.

tems of the individuals belonging to a certain class were then multiplied by the nr. of individuals/ha of that class in each habitat. The estimated shoot- and root weights of the size classes belonging to a certain habitat were then summed to provide an estimate for their standing crop in that habitat (kg dry matter/ha).

Results

The volume of *T. hirsuta* has a high simple linear correlation with the number of annual rings ($r = 0.99$; $p < 0.001$) suggesting a close relationship between size and age of *T. hirsuta* individuals.

As shown in Fig. 1, three types of size class frequency distributions could be distinguished: a more or less inverse J-shape (Fig. 1a, b, c) for the populations from coastal ridge, non-saline depressions, and inland plateau; an asymmetric positively skewed shape (Fig. 1d, e) for the populations from saline depressions and inland ridges; and a J-shape (Fig. 1f) for the population from the inland siliceous deposits.

With regard to the density of individuals the population from non-saline depressions has the highest density (687 ind./ha), and that from inland siliceous deposits the lowest (598 ind./ha). Generally, the densities of the populations from the coastal plain (e.g. coastal ridge, saline depressions, non-saline depressions, and inland ridges) are much higher than those from the southern plateau (e.g. inland plateau, and inland siliceous deposits) (Table 2). The estimates of standing crop indicate that the population from non-saline depressions attains the highest phytomass (553 and 117 kg dry matter/ha for shoot and root respectively), and that from saline depressions the lowest (187 and 38 kg dry matter/ha) (Fig. 2). On the other hand, the population from inland siliceous deposits, which has the lowest density, has a remarkably high phytomass (447 and 85 kg dry matter/ha). Generally, the populations of *T. hirsuta* from the saline depressions, inland ridges and inland plateau have a standing crop much lower than the other populations. With regard to the mean weight/ind., the population from inland

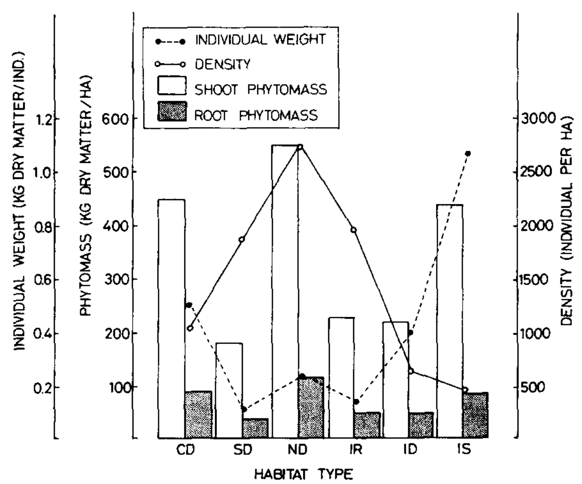

Fig. 2. Variation in shoot and root standing crop (kg dry matter/ha), density (ind./ha), and mean individual weight (kg dry matter/ind.) of populations of *T. hirsuta* from six habitats. Size class 1 was excluded from these estimates.

Table 2. Density (ind./ha) in the different size classes of populations of *T. hirsuta* from six habitats. CV: is the coefficient of variation between habitats.

Size class	CD	SD	NS	IR	IP	IS	Mean (CV)
1	767	662	4145	446	434	109	1094(1.26)
2	344	704	361	404	33	27	312(0.74)
3	251	747	1463	1184	217	27	648(0.82)
4	16	128	244	139	67	54	108(0.69)
5	47	171	223	42	150	54	114(0.61)
6	78	21	74	84	50	27	56(0.44)
7	78	43	127	28	33	14	54(0.71)
8	16	43	53	14	33	27	31(0.45)
9	16	0	43	14	33	14	20(0.71)
10	16	21	43	28	17	14	23(0.43)
11	45	0	0	0	17	27	15(1.14)
12	0	0	0	0	0	0	0
13	16	0	21	14	0	0	8(1.03)
14	141	0	74	14	17	204	75(1.00)
Total	1831	2540	6871	2411	1101	598	2558(0.80)

siliceous deposits has the highest value and those from saline depressions, inland ridges, and non-saline depressions have the lowest values (Fig. 2).

Although for most populations studied many size classes contribute to the phytomass, it is clear that the largest class usually has the major contribution to the standing crop, up to 73% in the population from inland siliceous deposits (Table 3).

Table 3. Relative contribution (%) of all size classes (class 1 is excluded) to the total standing crop of populations of *T. hirsuta* from six habitats.

Size class	CD	SD	ND	IR	IP	IS
2	<1	< 1	< 1	< 1	<1	<1
3	2	15	10	19	4	<1
4	1	12	8	10	5	2
5	3	29	13	6	21	4
6	8	5	6	16	10	3
7	11	15	15	8	9	2
8	2	12	5	3	8	3
9	4	0	8	7	16	3
10	4	12	8	12	8	3
11	10	0	0	0	7	6
12	0	0	0	0	0	0
13	6	0	7	10	0	0
14	49	0	21	9	12	73

Discussion

The measurement of the density of a population without an indication of its size distribution has little meaning in the demography of plants as compared to organisms with a more restricted variation in morphological features, such as higher animals (White 1980). The size and age of some plant life forms (notably trees) may be correlated in a general way, but unless there is an evidence on this point, the interpretation of size as age may lead to simplistic or even inaccurate conclusions (White 1980; Caswell 1986).

In the present study, a close correlation was found between the size and age of *T. hirsuta* individuals. Similar close relationships were reported for many other arid and semi-arid shrubs and trees (e.g. Barbour 1969; Crisp & Lange 1976; Goldsmith & Smart 1982; Goldberg & Turner 1986). However, it is necessary to be cautious in predicting the age from size because size becomes a poorer predictor of age as the plants reach larger sizes at which reproduction is most likely to occur (Kirkpatrick 1984; Caswell 1986).

Many populations of *T. hirsuta* in the present study have an inverse J-shape or positively skewed size frequency distribution. These may represent rapidly-growing populations with high reproductive capacity. Such distributions may indicate a high juvenile mortality as well (Harper 1977) but they nevertheless seem to represent long-term stability, since in most stable populations one would expect an excess of juvenile over mature individuals (Leak 1965; Crisp & Lange 1976; Moore & Bahadresa 1978; El-Ghonemy *et al.* 1980; Goldberg & Turner 1986). On the other hand, the population of *T. hirsuta* from inland siliceous deposits, which has the lowest density in the present study, has more mature than juvenile individuals. This may indicate that recruitment of *T. hirsuta* individuals is rare in this habitat, which may be related to its hyperaridity and low fertility, as it is the one furthest away from the coast and with the lowest organic matter content. The adverse effect of aridity on establishment of desert shrubs is reported by many authors (e.g. Barbour 1969; Goldsmith & Smart 1982).

Although the high amount of exposed rocks that characterises the inland ridges and inland plateau may create hyperarid conditions comparable to that of inland siliceous deposits, the heterogeneity of both habitats allows favourable microsites for the establishment of new *T. hirsuta* individuals (see Ayyad & Ammar 1974).

Competition is one of the factors affecting size variability in plant populations. If it is important, we would expect the spatial pattern of plants to have an effect on size distributions (Weiner 1985). Plants with neighbors closeby will grow less than plants with few or distant neighbors (Weiner 1984). This may be related to the decrease of the area available for each individual with increasing density (Mithen *et al.* 1984). The inverse relationship between density and individual size (weight) of *T. hirsuta* as shown in the present study for the population from non-saline depressions (high density-small individual size) and that from inland siliceous deposits (low density-great individual size) may be partially related to the effect of intra-specific competition (Jacquard, pers. comm.). Shaltout (1987) presents some support to this hypothesis as he noticed for the populations of *T. hirsuta* from non-saline depressions a clumped distribution pattern and that from inland siliceous deposits a random one. He mentioned that this change may be related to the effect of intra-specific competition. Comparable observations and conclusions were made by Moore & Bahadresa (1978) in their study on *Zygophyllum eurypetrum*, a semi-desert shrub, and by Schlesinger & Gill (1978) regarding *Ceanothus megacarups*, a chaparral shrub. However, assessing the effect of intra-specific competition on the population dynamics of *T. hirsuta* needs further field and experimental studies.

The flourishing of *T. hirsuta* in an area is taken by Arab natives as an indication of the suitability of that area for crop and fruit cultivation, which refers to good status of soil moisture and fertility (Migahid *et al.* 1955). In the present study, the *T. hirsuta* population from non-saline depressions attains the highest standing crop associated with the highest density/ha. This may be due to favourable moisture and nuatritional conditions, as it is a catchment area that receives an additional amount of water and nutrients due to run-off from adjacent elevated areas (Shaltout & El-Ghareeb 1985). On the other hand, the low estimates of standing crop of *T. hirsuta* populations from saline depressions, inland ridges, and inland plateau may be due to salinity with respect to the first habitat, and the high amount of exposed rocks in the latter ones. The sensitivity of *T. hirsuta* to both factors is also reported by Ayyad & Ammar (1974) and Ayyad & El-Ghareeb (1982) in the area of the present study.

Floret *et al.* (1983) have estimated a maximum value of 749.0 kg dry matter/ha for the above ground standing crop of *T. hirsuta* in the presaharan desert of Tunisia, as compared with a maximum value of 553.0 kg dry matter/ha in the present study. On the other hand, the present estimate is considerably higher than that done by Shaltout & El-Ghareeb (1985) in the same habitat. This may be due to the fact that the present estimate is restricted to an area solely occupied by *T. hirsuta* plants, and not to the whole area as done in the former study.

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References

Ayyad, M. A. & Ammar, M. Y. 1974. Vegetation and environment of the western Mediterranean coastal land of Egypt. II. The habitat of inland ridges. J. Ecol. 62: 439–456.

Ayyad, M. A. & El-Ghareeb, R. E. 1982. Salt marsh vegetation of the western Mediterranean desert of Egypt. Vegetatio 49: 3–19.

Ayyad, M. A. & Le Floc'h, E. 1983. An ecological assessment of renewable resources for rural agricultural development in the western Mediterranean coastal region of Egypt. Case study: El Omyed test area. REMDENE Project (Alexandria), Centre L. Emberger (Montpellier), ORSTOM (Paris).

Barbour, M. G. 1969. Age and space distribution of the desert shrub *Larrea divaricata*. Ecology 50: 679–685.

Caswell, H. 1986. Life cycle models for plants. Lectures on Mathematics in the Life Sciences 18: 171–233.

Crisp, M. D. & Lange, R. T. 1976. Age structure, distribution and survival under grazing of the arid-zone shrub *Acacia burkitti*. Oikos 27: 86–92.

El-Ghonemy, A. A., Shaltout, K., Valentine, W. & Wallace A. 1977. Distributional pattern of *Thymelaea hirsuta* (L.) Endl. and associated species along the Mediterranean coast of Egypt. Bot. Gaz. 138: 479–489.

El-Ghonemy, A. A. & Tadros, T. M. 1970. Sociological studies of the natural plant communities along a transect 200 km long between Alexandria and Cairo. Bull. Fac. Sci. Alexandria University 10.

El-Ghonemy, A. A., Wallace, A. & Romney, E. M. 1980. Frequency distribution of numbers of perennial shrubs in the northern Mojave desert. Great Basin Nat. Mem. 40: 34–38.

El-Kady, H. F. 1987. A study of range ecosystems of the western Mediterranean coastal desert of Egypt. Thesis Technical University, Berlin.

Emberger, L. 1955. Une classification biogéographique des climats. Recueil des Travaux du Laboratoire de Botanique, Géologie et Zoologie de la Faculté des Sciences de l'Université de Montpellier 7: 3–43.

Floret, C., Le Floc'h, E., & Pontanier, R. 1983. Phytomasse et production vegetale en Tunisie Presaharienne. Acta Ecologica Ecol. Plant. 4: 133–152.

Goldberg, D. E. & Turner, R. M. 1986. Vegetation change and plant demography in permanent plots in the Sonoran desert. Ecology 67: 695–712.

Goldsmith, F. B. & Smart, N. 1982. Age, spacing and growth rate of *Tamarix* as an indication of lake boundary fluctuations at Sebkhet Kelbia, Tunisia. J. Arid Environm. 5: 43–51.

Harper, J. L. 1977. Population biology of plants. Academic Press, London.

Harper J. L. & White, J. 1974. The demography of plants. Ann. Rev. Ecol. Syst. 5: 419–463.

Kirkpatrick, M. 1984. Demographic models based on size, not age, for organisms with indeterminate growth. Ecology 65: 1874–1884.

Leak, W. B. 1965. The J-shaped probability distribution. Forest Science 11: 405–409.

Meigs, P. 1973. World distribution of coastal desert. In: H. K. David & A. Z. Wiloon (eds), Coastal deserts. Their natural and human environment. Univ. of Arizona Press, Tuscon.

Migahid, A. M., Abd El-Rahman, A. A., El-Shafei, A. M. & Hammouda, M. A. 1955. Types of habitats and vegetation of Ras El-Hikma. Bull. Inst. Desert Egypte 5: 107–190.

Mithen, R., Harper, J. L. & Weiner, J. 1984. Growth and mortality of individual plants as a function of 'available area'. Oecologia 62: 57–60.

Moore, P. D. & Bhadresa, R. 1978. Population structure, biomass and pattern in a semi-desert shrub *Zygophyllum eurypterum*, in the Turan biosphere reserve of north-eastern Iran. J. Appl. Ecol. 15: 837–845.

Rikli, M. 1943. Das Pflanzenkleid der Mittelmeerländer. Verlag Huber, Bern.

Rochow, J. J. 1974. Estimates of above-ground biomass and primary productivity in a Missouri forest. J. Ecol. 62: 567–577.

Schlesinger, W. H. & Gill, D. S. 1978. Demographic studies of the chaparral shrub, *Ceanothus megacarpus*, in the Santa Ynez mountains, California. Ecology 59: 1256–1263.

Shaltout, K. H. 1983. An ecological study of *Thymelaea hirsuta* (L.) Endl. in Egypt. Ph. D. Thesis, Tanta University.

Shaltout, K. H. 1987. Pattern, phenology and sex ratio of Egyptian *Thymelaea hirsuta* populations. Vegetatio 72: 67–73.

Shaltout, K. H. & El-Ghareeb, R. 1985. Effect of protection on the phytomass and primary production of ecosystems of the western Mediterranean desert of Egypt. I. Ecosystems of non-saline depressions. Bull. Fac. Sci. Alexandria University 25: 109–131.

Tadros, T. M. & Atta, B. A. M. 1958. The plant communities of barly fields and uncultivated desert areas of Mareotis (Egypt) Vegetatio 8: 161–175.

Thalen, D. C. P. 1979. Ecology and utilization of desert shrub rangelands in Iraq. Junk Publishers, The Hague.

Watkinson, A. R. & White, J. 1985. Some life history consequences of modular construction in plants. Phil. Trans. R. Soc. London B 313: 31–51.

Weiner, J. 1984. Neighbourhood interference amongst *Pinus rigida* individuals. J. Ecol. 72: 183–195.

Weiner, J. 1985. Size hierarchies in experimental populations of annual plants. Ecology 66: 743–752.

Weiner, J. 1986. How competition for light and nutrients affects size variability in *Ipomoea tricolor* populations. Ecology 67: 1425–1427.

Werner, P. A. & Caswell, H. 1977. Population growth rates and age vs. stage distribution models for teasel (*Dipsacus sylvestris* Huds.). Ecology 58: 1103–1111.

White, J. 1980. Demographic factors in populations of plants. Botanical Monographs 15: 21–47.