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LIFE FORM AND LEAF SIZE SPECTRA AND PHYTOSOCIOLOGY OF SOME LIBYAN PLANT COMMUNITIES

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Abstract

Life form and leaf size spectra of four ecologically diverse plant communities were studed by Raunkiaerian and quantitative ecological methods. The Raunkiaerian spectra were similar for all the communities whereas the spectra based on quantitative basis differentiated the communities physiognomically. The characteristics revealed were *Stipa tennassima – Fruticose lichen* Community on low calcarious hills of Turhoona with clay loam soil: chamaephytic and leptophyllous; *Salicornia fruticosa – Aeluropus lagopoides* Community on saline flat of Zwara with clay loam soil: chamaephytic and nanophyllous; *Paraphalis incurva – Lotus* sp. – *Artemisia compestris* Community on the sand dunes of Bir Ghanam with sandy loam soil: therophytic and leptophyllous and *Crepis* sp. – *Paronychia arabica – Erodium laciniatum* Community on abandoned field at Zeltin with sandy clay loam soil: therophytic and microphyllous. The coverage, maturity and homogeneity of communities were low. Only one community had high maturity.

Introduction

The life form and leaf size are important physiognomic attributes which have been widely used in vegetation studies. The life form spectra are said to be the indicators of climate, microclimate (Quantin 1935, Cain 1950, Shimwell, 1971) and mesoclimate (Shimwell, 1971). Dansereau's (1951 & 1952) bioclimatic diagram is based upon life form classes. Similarly, Koppen's (1923) bioclimatic system is influenced by the life form classes (Shimwell, 1971). Habitat conditions also are indicated by them (Braun-Balnquet, 1932; Bakker, 1966). Similarly leaf size classes have been found to be very useful (Cain 1950, Cain & Castro 1959; Shimwell 1971). The leaf size knowledge may help in the understanding of the physiological processes of plants and plant communities (Oosting, 1956). In view of these applications of Raunkiaer's concepts, an attempt was made to ascertain variation of life form and leaf size spectra in four diverse types of Libyan plant communities occurring in a more or less identical climatic conditions (Koppen's Bsh type) but occupying different topo-edaphic conditions. The second objective was to compare and evaluate the Raunkiaerian spectra based on species list with the spectra based on quantitative data (importance value) of species. Many ecologists feel that Raunkiaer assigned equal weight to every species whereas ecologically all the species are not of equal importance in a vegetation. In later years, Raunkiaer (1935) himself, Oosting (1942), Cain (1945), Buell & Wilbur (1948) and Stern & Buell (1951)

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used frequency points; Tuxen & Ellenberg (1937) used Cover-abundance values and Cain (quoted by Cain & Castro, 1959) used coverage data in constructing the spectra. Since importance value (Lindsey, 1955) is an index of all the quantitative attributes, it appears to be the most suitable species quantity for this purpose.

Literature dealing with the plant ecology of Libya shows that very little work has been done on the life form and none on leaf size spectra. The only reference for Libya is that of Raunkiaer (1918a) who gave spectra for Tripoli, Cyrenaica and the Libyan desert. These spectra showed close similarity with the spectra of such nearby regions as El Golea, Ghardaia (Raunkiaer, 1918a), Oudjda desert and semi-desert (Braun-Blanquet & Marie, 1924) and Palestine (Zohary, 1962) in having high proportions of therophytes and chamaephytes. It would appear that the Raunkiaerian spectra do not differentiate different areas in a bioclimatic region and even such bioclimatic regions as the hot steppes (e.g. Tripoli) and the hot deserts (e.g. Libyan desert). The present study, therefore, approaches this problem to construct both the life form and leaf size spectra on quantitative basis.

Material and Methods

Four floristrically and ecologically different plant communities falling in hot steppe climate (Koppen's Bsh type) were studied by quadrat method. The size of sample plot used was a rectangle of 1 sq. m. area (4 x ¼ m). The quadrats were laid randomly and quantitative data were obtained. The exact location of the sites of study is as follows:

(1) Low calcarious hills: About 2 km from Turhoona on way to Tripoli.
(2) Small sand dunes: About 3 km from Bir Ghanam on way to Tripoli.
(3) Saline flat: About 16 km west of Zwara.
(4) Abandoned field: Near Zeltin.

The plant communities were characterized by dominants having highest importance value (Lindsey, 1955).

Life form and leaf size classes of Raunkiaer (1934) were followed in the classification of plants. A complete list of species (Table 1) for each locality was prepared which also included species not encountered in sampling but were present in the community as rare or uncommon species. Life form and leaf size spectra were calculated according to Raunkiaer's approach using complete list of species. Spectra were also constructed on quantitative basis using importance values of species encountered in sampling by quadrat method. The procedure was similar to these of the earlier workers (Raunkiaer, 1935; Tuxen & Ellenberg, 1937; Oosting, 1942; Cain, 1945; Buell & Wilbur, 1948; Stern & Buell, 1951) who however, used frequency, coverage etc as species quantities.

Table 1. A Locality wise list of species.

Species	Life form/Sub-class	Leaf size class
Turhoona Hills		
1. *Calycotome vinosa*	PH/Nano.	Nano.
2. *Retama retaem*	PH/Nano.	Lept.
3. *Artemisia monosperma*	CH/Suff.	Lepto.
4. *Gymnocarpos decandrum*	CH/Suff.	Lepto.
5. *Echium sericeum*	CH/Suff.	Lepto.
6. *Thymus capitatus*	CH/Suff.	Lepto.
7. *Asparagus stipularis*	CH/Suff.	Lepto.
8. *Polygonum equsetiforme*	CH/Suff.	Lepto.
9. *Salvia aegyptiaca*	CH/Suff.	Micro.
10. *Kiksia aegyptiaca*	CH/Pass. decumb.	Lepto.
11. *Atractylis* sp.	CH/Cush.	Lepto.
12. *Lichen fruticose*	CH/Thallo.	Leaf less Thallus (Lepto).
13. *Stipa tennassima*	H/N.R.	Micro.
14. *Lygeum spartum*	H/N.R.	Micro.
15. *Helianthemum lippii*	H/N.R.	Lepto.
16. *Stipa parviflora*	H/R.R.	Nano.
17. *Carduus* sp.	H./N.R.	Lepto.
18. *Allium reseum*	CR/Geo.	Micro.
19. *Scorzonera undulata*	CR/Geo.	Nano.
20. *Allium aschersonianum*	CR/Geo.	Meso.
21. *Asphodelus microcarpus*	CR/Geo.	Meso.
22. *Scilla speruviana*	CR/Geo.	Micro.
23. *Urginia maritima*	CR/Geo.	Micro.
24. *Evax lygeum*	TH	Lepto.
25. *Lobularia arabica*	TH	Nano.
26. *Launnea resedifolia*	TH	Nano.
27. *Malva sylvestris*	TH	Nano.
28. *Anacyclis alexandrianus*	TH	Lepto.
29. *Phagnolon graecum*	TH	Lepto.
30. *Ranunculus takerose*	TH	Micro.
31. *Anthyllis vulneraria*	TH	Micro.
32. *Senecio* sp.	TH	Lepto.
33. *Centaurea* sp.	TH	Micro.
34. *Picris radicata*	TH	Nano.
35. *Caklea arabica*	TH	Micro.

Table 1. (Cont'd.)

Species	Life form/Sub-class	Leaf size class
36. *Lotus* sp.	TH	Lepto.
37. *Hedysarum spinossisimum*	TH	Lepto.
38. *Didesmus bipinnatus*	TH	Nano.
Zwara Saline Flat		
1. *Tamarix nilotica*	PH/Nano.	Lepto.
2. *Nitraria retusa*	PH/Nano.	Lepto.
3. *Salvia aegyptiaca*	CH/Suff.	Micro.
4. *Arthrocnemum marosta*	CH/Suff.	Nano.
5. *Tragonum nudatum*	CH/Suff.	Lepto.
6. *Zygophyllum album*	CH/Suff.	Lepto.
7. *Limonium equsetiforme*	CH/Suff.	Lepto.
8. *Polygonum equsetiforme*	CH/Suff.	Lepto.
9. *Frankenia hispida*	CH/Suff.	Lepto.
10. *Salsola tetrandra*	CH/Suff.	Lepto.
11. *Arthrocnemum glaucum*	CH/Suff.	Nano.
12. *Iphonia* sp.	CH/Suff.	Nano.
13. *Salicornia fruticosa*	CH/Suff.	Nano.
14. *Limoniastrum monopetalum*	CH/Suff.	Nano.
15. *Artemisia compestris*	CH/Suff.	Lepto.
16. *Limonium delicatulum*	H/Ros.	Nano.
17. *Lygeum spartum*	H/N.R.	Micro.
18. *Aeluropus lagopoides*	H/N.R.	Lepto.
19. *Urginia maritima*	CR/Geo.	Meso.
20. *Plantago lagopus*	TH	Nano.
21. *Asphodelus fistulosa*	TH	Nano.
22. *Trigonella balansae*	TH	Nano.
23. *Reichardia tingituna*	TH	Micro.
24. *Hordeum glaucum*	TH	Lepto.
25. *Erodium laciniatum*	TH	Nano.
26. *Kochia numicota*	TH	Lepto.
27. *Astragalus* sp.	TH	Lepto.
28. *Picris radicata*	TH	Micro.
29. *Filago maicotica*	TH	Lepto.
30. *Senecio gallicus*	TH	Lepto.
31. *Aeluropus brevifolius*	CH/Creep.	Lepto.
32. *Suaeda* sp.	CH/Suff.	Lepto.

Table 1. (Cont'd.)

Species	Life form/Sub-class	Leaf size class
Bir Ghanam Sand Dunes		
1. *Artemisia compestris*	CH/Suff.	Lepto.
2. *Phagnolon barbeyanum*	CH/Suff.	Nano.
3. *Stipagrostis* sp.	CH/Suff.	Nano.
4. *Echiocholon fruticosum*	CH/Suff.	Lepto.
5. *Rhantherium* sp.	CH/Suff.	Lepto.
6. *Pithyranthus tortousus*	CH/Suff.	Lepto.
7. *Helianthemum lippii*	H/N.R.	Lepto.
8. *Convolvulus oleifolius*	H/S.R.	Nano.
9. *Colchicum ritchii*	CR/Geo.	Micro.
10. *Paraphalis incurva*	TH	Nano.
11. *Astragalus* sp.	TH	Lepto.
12. *Lotus* sp.	TH	Lepto.
13. *Paronychia arabica*	TH	Lepto.
14. *Mathiola humilis*	TH	Micro.
15. *Brassica tournefortii*	TH	Meso.
16. *Plantago lagopus*	TH	Nano.
17. *Diplatoxis acris*	TH	Micro.
18. *Senecio gallicus*	TH	Nano.
19. *Hussonia pinnata*	TH	Lepto.
20. *Bossia huricota*	TH	Lepto.
21. *Malva aegyptica*	TH	Nano.
22. *Malva parviflora*	TH	Nano.
Zeltin Abandoned Field		
1. *Euphorbia helioscopia*	CH/Suff.	Lepto.
2. *Anchusa aegyptiaca*	CH/Suff.	Micro.
3. *Euphorbia fruticosa*	CH/Pass. decumb.	Lepto.
4. *Salvia lanigera*	H/N.R.	Nano.
5. *Crepis* sp.	H/N.R.	Micro.
6. *Peganum harmala*	TH	Micro.
7. *Vicia* sp.	TH	Lepto.
8. *Carduus argentatus*	TH	Nano.
9. *Anacyclis alexandrianus*	TH	Lepto.
10. *Anthemis microsperma*	TH	Lepto.
11. *Launnea resedifolia*	TH	Nano.

Table 1. (Cont'd.)

Species	Life form/Sub-class	Leaf size class
12. *Carduus getulus*	TH	Micro.
13. *Hussonia pinnata*	TH	Lepto.
14. *Papaver rhoeas*	TH	Nano.
15. *Paronychia arabica*	TH	Lepto.
16. *Erodium laciniatum*	TH	Micro.
17. *Anagallis arvensis*	TH	Lepto.
18. *Astragalus* sp.	TH	Lepto.
19. *Malva parviflora*	TH	Micro.
20. *Schisinum barbatus*	TH	Lepto.
21. *Rumex spinosus*	TH	Micro.

PH/Nano. = Nanophanerophytes
Suff. = Suffrutescent
Pass. decumb. = Passively decumbent
Cush. = Cushion type
Thallo. = Thallose
N.R. = Non-rosette type
Geo. = Geophytes
Ros. = Rosette type
Creep. = Creeping
S.R. = Sub-rosette type

Leaf area of species was calculated according to Cain & Castro's (1959) procedure in which leaf area = Length x breadth of leaf x 2/3.

The community maturity index was obtained by Pichi-Sermolli's (1948) method. An idea of the homogeneity of communities was ascertained by the Raunkiaer's (1918b) law of frequency.

Soil samples were collected from each locality at a depth of 5 to 15 cm with the help of soil auger. Soil depth was also determined by the auger as far as possible. Soil texture classes were determined by a method given by the LaMotte Chemical Products Company (U.S.A.) using their soil texture determination instrument. The method is based upon Stoke's law just as the pippette and hydrometer methods are.

Results

Life Form Spectra

Raunkiaerian approach revealed remarkable similarity between the communities in having therophytes as the dominant life form. The highest percentage of therophytes were found in Zeltin abandoned field (76%), followed by Bir Ghanan sand dunes (59%), Turhoona hills (42%) and Zwara saline flat (34%). In addition to therophytes, chamaephytes were next in importance, the highest (46%) being in Zwara region. In Turhoona, cryptophytes were also higher (15%) than in Raunkiaer's "Normal Spectrum". There were no phanerophytes in Zeltin and Bir Ghanam areas and no cryptophytes in Zeltin (Table 2). The small percentage of phanerophytes found in Turhoona and Zwara belonged to nanophanerophytes sub-class. In the whole study area, chamaephytes were mostly suffrutescent type, hemicryptophytes non-rosette type and cryptophytes geophytes subclass (Table 1).

Life form spectra based on importance value of species indicated that only three life form classes are important in the study area. These are, in order of importance, chamaephytes, therophytes and hemicryptophytes (Table 2). The highest percentage of chamaephytes was in Zwara (75%), followed by Turhoona (61%) and the least in Bir Ghanan (33%). The highest percentages of therophytes was in Bir Ghanan (59) and the next in Zeltin (54%). The highest percentage of hemicryptophytes was in Turhoona (39%) followed by Zeltin (35%) and the least in Zwara (25%).

Leaf Size Spectra

Small leaf size classes were dominant in the whole study area. Large leaf sizes were entirely missing. Mesophyll class was also very poorly represented.

Raunkiaerian spectra revealed highest percentage of leptophyll in all communities. The percentage was 53 in Zwara, 50 in Bir Ghanan, 47.6 in Zeltin and 47.2 in Turhoona (Table 3).

Leaf size spectra based on importance value showed better differentiation of plant communities. The composition of leaf size classes is as under:

Table 2. Raunkiaerian and quantitative life form spectra.

		Life form classes (%)				
Locality	Spectra	PH	CH	H	CR	TH
Turhoona	(a) Raunkiaerian	5.26	25.68	13.15	15.78	42.10
	(b) Quantitative	0	60.99	39.14	0	0
Zwara	(a) Raunkiaerian	6.25	46.87	9.37	3.12	34.37
	(b) Quantitative	0	74.18	25.20	0	0
Bir Ghanam	(a) Raunkiaerian	0	27.27	9.10	4.54	59.10
	(b) Quantitative	0	33.56	7.62	0	58.87
Zeltin	(a) Raunkiaerian	0	14.28	9.52	0	76.19
	(b) Quantitative	0	8.22	35.10	0	53.80

Table 3. Leaf size spectra.

Locality	Spectra	Leaf Size Classes (%) Lepto.	Nano.	Micro.	Meso.	Macro.	Mega.
Turhoona	(a) Raunkiaerian	47.22	21.05	26.05	5.26	0	0
	(b) Quantitative	53.86	0	46.27	0	0	0
Zwara	(a) Raunkiaerian	53.12	31.25	12.5	3.12	0	0
	(b) Quantitative	32.06	67.95	0	0	0	0
Bir Ghanam	(a) Raunkiaerian	50.00	31.81	13.62	4.54	0	0
	(b) Quantitative	56.48	41.63	0	2.03	0	0
Zeltin	(a) Raunkiaerian	47.61	19.04	33.33	0	0	0
	(b) Quantitative	38.93	6.49	51.70	0	0	0

Turhoona: Leptophyll 53.86% and microphyll 46.2%.
Zwara: Nanophyll 67.95% and leptophyll 32%.
Bir Ghanam: Leptophyll 56.48% and nanophyll 41.63%.
Zeltin: Microphyll 51.7% and leptophyll 38.93%.

Phytosociology

The four plant communities were found to be ecologically and floristically distinct with only two common species between them (Table 4). The communities are as under:

Stipa tennassima-Fruticose lichen Community:

The bushy type grass, *Stipa tennassima* mainly controls the physiognomy of this community which occurred on the hills of Turhoona having clay loam soil. The community shows very high stand cover per hectare but very low community maturity index (33.3%).

Salicornia fruticosa-Aeluropus lagopoides Community:

The community is dominated by succulent halophytes as it occurs on saline flat near Zwara. The soil gets water logged during winter rains and it is clay loam type. The vegatation has low stand density per hectare and low stand cover per hectare. Community maturity index is however medium (52.5%).

Table 4. Phytosociological attributes of different communities.

Name of Species	D_2	D_3	C_2	C_3	F	F_3	Y_3
Stipa tennassima-Fruticose lichen community							
Stipa tennassima	12702.84	14.52	20066.01	68.30	42.85	21.42	34.74
Fruticose lichen	48032.61	54.84	10.03	0.03	28.57	14.28	23.28
Thymus capitatus	7057.13	8.06	2498.82	13.55	57.14	29.07	16.89
Salvia aegyptiaca	11291.43	12.90	2177.40	7.41	28.57	14.28	11.53
Gymnocarpus decandrum	5645.80	6.45	2306.71	7.85	28.57	14.28	9.52
Helianthemum lippii	2822.86	3.23	837.33	2.85	14.28	7.14	4.40
	87552.68		27896.30				
	D_9		C_9				
Salicornia fruticosa-Aeluropus lagopoides community							
Salicornia fruticosa	31616.00	53.33	3465.21	44.10	80.00	38.9	45.17
Aeluropus lagopoides	14820.00	25.00	1732.61	22.05	60.00	28.57	25.20
Arthrocnemum marosta	6916.00	11.67	2590.53	32.89	50.00	23.80	22.78
Limonium pruinosum	5928.00	10.00	83.29	1.06	20.00	9.52	6.86
	59280.00		7871.64				
	D_9		C_9				
Paraphalis incurva-Lotus sp. – *Artemisia compestris* community							
Paraphalis incurva	184426.67	37.09	783.16	8.20	100.00	15.79	20.36
Lotus sp.	148200.00	29.80	879.64	9.21	100.00	15.79	18.27
Artemisia compestris	55986.67	11.26	2560.50	26.78	100.00	15.79	18.06
Stipagrostis sp.	23053.32	4.64	3521.89	36.86	33.33	5.26	15.59
Helianthemum lippii	16466.67	3.31	1365.09	14.29	33.33	5.26	7.62
Astraglus sp.	26346.67	5.30	201.23	2.11	66.67	10.53	5.98
Plantago lagopus	23053.32	4.64	179.15	1.80	66.67	10.53	5.68
Paronychia arabica	9880.00	2.00	33.91	0.36	66.67	10.53	4.30
Bossia huricata	6586.67	1.33	14.50	0.15	33.33	5.26	2.25
Brassica tournefortii	3293.32	0.66	16.13	0.17	33.33	5.26	2.03
	447893.34		9555.22				
	D_9		C_9				

Table 4. (Cont'd.)

Name of Species	D_2	D_3	C_2	C_3	F	F_3	Y_3
Crepis sp. – *Paronychia arabica-Erodium laciniatum* community							
Crepis sp.	93860.00	26.39	5639.99	55.01	100.00	12.5	31.30
Paronychia arabica	74100.00	20.83	1032.46	10.07	100.00	12.5	14.47
Erodium laciniatum	54340.00	15.28	1700.35	16.58	50.00	6.25	12.70
Schisinum barbatus	49400.00	13.89	361.11	3.52	100.00	12.50	9.97
Rumex spinosus	49400.00	13.89	89.41	0.87	100.00	12.5	7.70
Astraglus sp.	14820.00	4.17	220.82	2.15	100.00	12.5	6.27
Euphorbia helioscopia	4940.00	1.39	788.92	7.69	50.00	6.25	5.11
Salvia lanigera	14820.00	4.17	103.25	1.00	50.00	6.25	3.80
Euphorbia fruticosa	4940.00	1.39	174.38	1.70	50.00	6.25	3.11
Launnea resedifolia	4940.00	1.39	43.47	0.42	50.00	6.25	2.69
	276640.00		10146.76				
	D_9		C_9				

D_2 = density per hectare, D_3 = relative density, C_2 = cover per hectare, C_3 = relative cover, F = frequency, F_3 = relative frequency, Y_3 = Importance value, D_9 = Stand density per hectare and C_9 = Stand cover per hectare.

Paraphalis incurva-Lotus sp. – *Artemisia compestris* Community:

The community is dominated largely by the annuals, the only perennials were *Artemisia compestris* and *Stipagrostis* sp. It occurs on small sand dunes near Bir Ghanam. The soil is sandy loam type. It shows very high stand density per hectare, low stand cover per hectare and medium community maturity index (75%).

Crepis sp. – *Paronychia arabica-Erodium laciniatum* Community:

The community is entirely dominated by herbaceous species with considerable number of annuals. It occurs on an abandoned field near Zeltin on sand clay loam soil. It has high stand density per hectare, low stand cover per hectare and high community maturity index (75%).

Poor flora is the chief characteristics of all the communities. Number of species encountered in the sampling ranged from a minimum of four in *Salicornia-Aeluropus* community to a maximum of ten in *Paraphalis-Lotus-Artemisia* and *Crepis-Paronychia-Erodium* communities. None of the communities exhibited a frequency class distribution that may be considered close fit to Raunkiaer's (1918b) law of frequency. The frequency classes of communities are as follows:

Stipa-Fruticose lichen Community:

Class A = 16.6%, Class B = 50%, Class C = 33.3%, Class D = 0% and Class E = 0%.

Salicornia-Aeluropus Community:

A	B	C	D	E
25%	0%	50%	25%	0%

Paraphalis-Lotus-Artemisia Community:

A	B	C	D	E
0%	40%	0%	30%	30%

Crepis-Paronychia-Erodium Community:

A	B	C	D	E
0%	0%	50%	0%	50%

Similarly, only one of the communities may be considered mature from Pichi-Sermolli's (1948) view point. The data are as under:

Thrhoona 33%, Zwara 52%, Bir Ghanam 63% and Zeltin 75%.

Discussion

Raunkiaerian Approach

Raunkiaerian spectra have only highlighted the influence of climate on the vegetation although the communities differed widely in their habitat conditions. Only in the spectrum of Zwara one can see some topo-edaphic influence as it contained as high as 46% chamaephytes, otherwise all spectra show strong therophytic trend. The contention that life form spectra indicate habitat conditions of communities (Braun-Blanquet, 1932) no longer seems to be justified.

When the spectra are compared with similar hot steppe regions of the world, the results however, conform remarkably with the data of previous workers (Paulsen, 1915; Raunkiaer, 1918a; Hagerup, 1930; Adamson 1939). This undoubtedly projects the validity of Raunkiaer's system indicating close relationship of his life form spectra with the climatic conditions.

A close look at the data for hot steppe and hot desert regions of the world (see Cain & Castro, 1959), however, poses certain valid questions. Firstly, why do the spectra of hot steppe and hot deserts bear close similarity? Why are chamaephytes higher than the "Normal spectrum" in these spectra? Why do Whitehill and Timbuctu differ from the rest of the hot steppe regions in having higher percentage of chamaephytes? Do they indicate regional climatic or other influence like Zwara? No previous work appears to have dealt with these questions. Chamaephytes are said to be the most important element in higher altitudes and latitudes (Raunkiaer, 1918a; Cain, 1950; Shimwell 1971). The increase of chamaephytes in other regions of the world, probably indicates harsh topo-edaphic conditions. This view is in general agreement with the habitat conditions at Zwara and possibly Bir Ghanam and Turhoona. While the survey of literature (Cain 1950, Cain *et al.*, 1971) points out precise lines of demarcation between the great majority of bioclimatic regions on the basis of life form composition, the hot steppe and hot desert regions do not differentiate. The spectra of these regions bear a very close similarity to one another. Apparently it appears to be either an inadequacy of Raunkiaer's system or Koppen's classification of bioclimates.

The Raunkiaerian leaf size spectra, like the life form spectra, showed remarkable similarity between the four communities. This again points out the limitation of Raunkiaer's system to the influence of climate alone on leaf size. Leaf size spectra for climatic regions similar to Libyan communities are not available for comparison. However, Shaukat & Qadir (1972) reported nanophylls (43%) and microphylls (33%) as the dominant classes in arid calcalcarious hills of hot desert climatic region, which differs considerably with the leaf size composition found in calcarious hills of Turhoona.

Quantitative Approach

When the life form and leaf size spectra were expressed on quantitative basis using importance value of species, each of the four communities appeared quite distinct from one another (Tables 2 & 3). It would appear that the habitat differences of communities are revealed in a better manner by these spectra than the Raunkiaerian spectra.

Only three life form classes stand out as the important elements of Libyan communities. They are chamaephytes, therophytes and hemicryptophytes. According to Raunkiaer (1918a), Cain (1950), Cain & Castro (1959) and Shimwell (1971) both chamaephytes and therophytes are dominant in the unfavourable environmental conditions, the former in the extremely cold regions like tundra, arctic and alpine zones and the latter in very dry regions of deserts, semi-deserts, etc. Following this line of interpretation, Bir Ghanam sand dunes appear to be the most rugged of all the sites as they have both therophytes and chamaephytes in high proportion. The next are Zwara having 75% chamaephytes, Turhoona having 61% chamaephytes and Zeltin having 54% therophytes.

The most significant finding, however, is the increased percentage of hemicryptophytes in the quantitative spectra as compared to those of Raunkiaerian spectra. Hemicryptophytes constitute a very important element in comparatively favourable environment like the temperate deciduous forest and grasslands (Cain, 1950, Cain & Castro 1959). The increase of favourable life form in otherwise unfavourable Libyan conditions appears to be the most significant adaptive response of the vegetation. Similarly, workers who used quantitative data in constructing life form spectra (Oosting, 1942; Cain, 1945. Buell & Wilbur, 1948; Cain quoted by Cain & Castro 1959) also noted a shift toward increased percentage of protected (favourable) life form in their quantitative spectra.

In Bir Ghanam, a slight decrease in hemicryptophytes and an increase in chamaephytes indicates clearly the most unfavourable habitat conditions. In Turpoona and Zwara areas, an increase in chamaephytes and hemicryptophytes denotes two opposing trends (unfavourable and favourable), while an increase in hemicryptophytes and decrease in therophytes and chamaephytes at Zeltin points toward most favourable conditions.

Taking into consideration the chamaephytes and therophytes as indicators of unfavourable conditions on one hand and hermicryptophytes as indication of favourable state on the other, the relative proportion of these life forms in the four spectra, reveal the following rating:

	CH + TH	H
Turhoona	60.99	39.14
Zeltin	62.02	35.10
Zwara	74.81	25.20
Bir Ghanam	92.50	7.62

The top-edaphic conditions of these areas seem to support the above conclusion (Table 5). Turhoona hills have clay loam soil of moderate depth, Zeltin has a very deep sandy clay loam soil (a good combination of sand and clay fractions), Zwara has shallow

Table 5. Physical Composition of Soils.

Locality	Soil depth (cm)	Sand %	Silt %	Clay %	Soil texture
Turhoona	43	43..4	25.4	31.2	Clay loam
Zwara	38	39.1	24.8	36.0	Clay loam
Bir Ghanam	> 120	69.0	19.7	11.2	Sandy loam
Zeltin	> 120	61.5	6.3	32.1	Sandy clay loam

clay loam soil but it is saline and gets waterlogged due to winter rains and Bir Ghanam has a deep sandy loam soil which is under the influence of wind erosion.

The leaf size spectra show greater percentage of small leaf size classes which is quite expected in a region like Libya. However, considering the relative proportions of leptophyll and nanophyll on one hand and microphyll and mesophyll on the other, the following rating is obtained:

	Leptophyll + nanophyll	Microphyll + Mesophyll
Zeltin	45.42	51.70
Turhoona	53.86	46.20
Bir Ghanam	98.11	2.03
Zwara	100.00	0.0

This rating slightly differs from the rating obtained for the life form spectra. The difference may be attributed to the difference in the stage of vegetational development of these communities. The communities of Zeltin and Bir Ghanam represent early successional stages, while the other two represent consolidating or slightly advanced stages. However, a broad generalization may be made to rate Turhoona and Zeltin to be relatively better than Zwara and Bir Ghanam.

Phytosociology

The plant communities are ecologically and floristically very distinct. Successionally, they markedly differ in their stages of development. Because of this reason perhaps coupled with the poor flora, the community maturity, homogeneity and stand coverage are at lower scales. The only community with relatively better stand cover is *Stipa tennassima-Fruticose lichen* community. This is due to the dominance of bushy type grass, *Stipa tennassima*. From the point of view of community maturity and homogeneity, however, the *Paraphalis incurva-Lotus* sp. – *Artemisia compestris* and *Crepis* sp. – *Paronychia arabica-Erodium laciniatum* communities are relatively better than the other two communities. Both of these communities show more than 60% maturity index. According to Oosting's (1956) criteria of homogeneity, these two communities approach homogenous condition to some extent as the percentage of class E is high.

Combining the quantitative ecological spectra of life form and leaf size, the communities differentitate on physiognomic grounds which is as under:

Stipa tennassima-Fruticose lichen Community:

Chamaephytic and leptophyllous

Salicornia fruticosa-Aeluropus lagopoides Community:

Chamaephytic and nanophyllous

Paraphalis incurva-Lotus sp. – *Artemisia compestris* Community:

Thereophytic and leptophyllous

Crepis sp. – *Paronychia arabica-Erodium laciniatum* Community:

Therophytic and microphyllous.

It would indicate that the quantitative ecological spectra are the best for analysing, describing and differentiating plant communities from physiognomic angle. This however, does not diminish the importance of Raunkiaer's physiognomic concepts but suggests a way of refinement in the methodology.

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