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Edaphic factors and the distribution of plant associations in a sector in the coastal Mediterranean zone in Egypt

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1. Introduction

A variety of distinct habitats could be clearly recognized in the western coastal Mediterranean zone in Egypt. These habitats differ regards their exposure, microclimate, water supply, elevation above mean sea level, soil depth and other soil characteristics. Each habitat supports a special type of vegetation. In such an area with low irregular rainfall (150 mm/annum), the water relations of air and soil may be considered the factors of prime importance in the distribution of the different species as well as the plant

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communities. The physiography is an important factor in the distribution of plant communities through its effect on the soil depth and other soil properties controlling the water supply to plants (BATANOUNY 1973).

The present study aims at evaluating the effect of different factors on the distribution of plant communities in a sector in the coastal Mediterranean zone in Egypt.

2. Location of the sites studied

The present study was undertaken in an area 25 km to the east of Sidi Barrani extending about 11 km landward from north to south and about 4 km from east to west. It is bordered northwardly by the Mediterranean sea. Sidi Barrani is a settlement located nearly midway between Sallum on the Lybian borders and Matruh at a distance of 130 km from the latter. Matruh is located some 300 km west of Alexandria.

3. Vegetation of the area surveyed

In a previous study by MIGAHID & al. 1971, the plant associations in the area surveyed were investigated according to BRAUN-BLANQUET 1964. These associations are:

1. *Ammophila arenaria*-association inhabiting the coastal sand dunes.
2. *Salsola tetrandra*-association in the salt marshes adjacent to the coastal sand dune belt.
3. *Anabasis articulata-Haloxylon articulatum*-association on shallow pebbly soils.
4. *Artemisia herba-alba*-association in sandy loam relatively deep soil.
5. *Plantago albicans-Echiochilon fruticosum*-association on the inland sand dunes with deep soil.
6. *Gymnocarpus decandrum*-association on rocky slopes. This association was not found in a pure state in this studied sector, but in mixtures with other associations.

The 5 latter associations have been found to belong to the alliance Thymelaeion hirsutae. Transitional zones between these associations are occupied by mixtures of 2 or 3 associations.

4. Methods

Soil samples were collected from the successive depths in the different stands representing the studied associations. Samples from 3 stands repreenting each association were investigated for their physical and chemical propertis. Soil analysis was conducted according to methods adopted by PIPER 1949. The average data for properties of distinctive value are illustrated in Fig. 1.

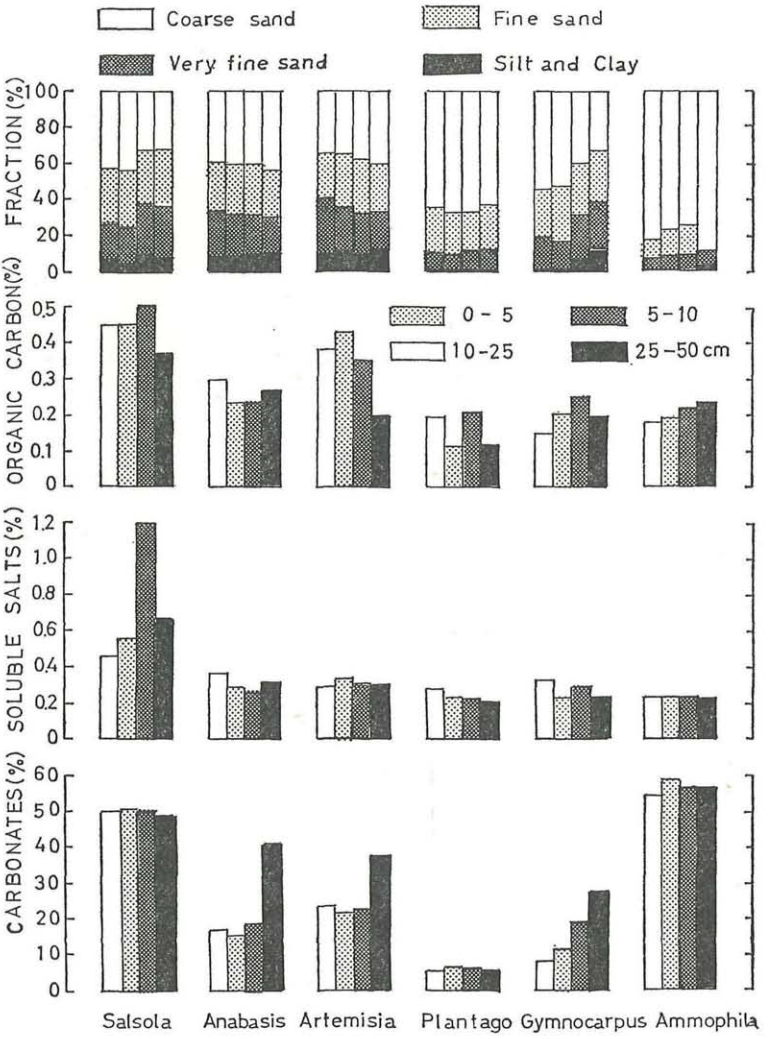

Fig. 1. Soil analysis of samples collected at successive dephts in the studied associations. Histograms showing the granulometric analysis are at the same dephts as those below showing the other properties.

Penetrability was measured by means of a stratometre devised by ZAGHLOUL 1928. The stratometre sonsists of a steal rod 1.5 m long and a heavy perforated weight of iron which is applied to the rod to make uniform strokes. This weight rests and strikes on an anvil stop clamped firmly to the rod. The strokes were manifested by allowing the heavy weight (5 kg) to fall down freely on the top of the rod from a height of half a metre. The

strokes cause the rod to penetrate through the soil for variable distances depending on the soil resistance. The distance which the rod penetrates through the soil after each strike was therefore taken as a measure of its penetrability at the depth of the lower end of the rod.

The results are expressed as histograms of successive horizontal lines, the distances between which are proportional to the penetrability at the depth indicated. The more loose the soil, the wider will be the distance between the successive lines. The number of strokes needed to push the rod a given distance within the soil has a direct relation to its resistance to penetration.

5. Results

Fig. 1 shows the average data of soil analysis at successive depths in the different associations. Histograms of the mechanical analysis show the percentages of different fractions, namely coarse sand, fine sand, very fine sand and silt and clay. Examination of these histograms reveals the following:

1. In the sand dunes, the soil is very coarse as the coarse sand fraction is the dominant one at all depths ranging from 75 to 91%.

2. The coarse sand fraction is higher in soils supporting the *Plantago*-association than in other soils except that inhabited by the Ammophiletum.

3. Excluding the sand dune communities and the *Plantago*-association, the fine and very fine sand fractions collectively are more than 50% of the total weight of the soil at all depths in soils supporting the other associations.

4. The silt and clay fractions represent the lowest category. This fraction has considerable values in soils supporting the *Salsola*-, *Artemisia*- and *Anabasis*-associations.

The soils of the studied sector are poor in organic carbon. The organic carbon content is relatively high in soils supporting the *Salsola*-association. Low organic carbon is a common feature of the desert soil.

As regards the soluble salts, the highest values are obtained in soils inhabited by the Salsoletum tetrandrae. Soils supporting other associations have low salinity.

The carbonate content, calculated as calcium carbonate, has the highest value in the coastal sand dunes followed by soils supporting the *Salsoa*-association. Very low carbonate content is observed in soils occupied by the *Plantago*-association. A remarkable feature of the carbonate content in soils supporting the *Anabasis*-, *Artemisia*- and *Gymnocarpus*-associations is its rise at low depths. This phenomenon affects the soil penetrability at these depths.

Soil Depth and Penetrability. The soil penetrability was studied in 96 stands in the area occupied by the associations of the alliance Thymelaeion hirsutae and 6 stands in the sand dunes. The results of penetrability measurements in representative stands are illustrated in Fig. 2. A

glance to this figure shows that the deepest soils in the whole sector are those inhabited by the associations of *Ammophila* and *Plantago*. The depth reaches 130 cm in both associations with an average of 111 cm in *Ammophila*- and 87 cm in *Plantago*-associations. The superficial layer in the two associations is so loose that the rod of the stratometre travels about 10 cm in the soil by its own weight before any strike.

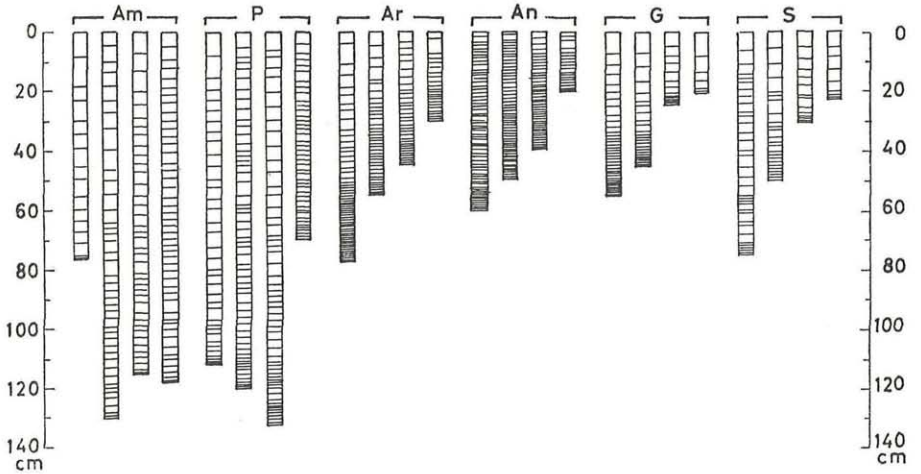

Fig. 2. Soil penetrability in representative stands from the associations in the studied area (Am = *Ammophila*-, P = *Plantago*-, Ar = *Artemisia*-, An = *Anabasis*-, G = mixture of *Plantago*- and *Gymnocarpus*- and S = *Salsola*-associations).

Soils supporting the Anabasidetum are shallow and hardly penetrable. The average depth is 38 cm ranging from 20 to 60 cm. The soil of this association is covered with a hard crust. This is indicated by the very short distance, not exceeding 1 cm, to which the stratometre travels by its own weight.

Soils inhabited by the *Artemisia*- and *Salsola*-associations are intermediate in their depths and penetrability. The presence of hard layers at variable depths is of common occurence in both associations. This is evident in soils supporting the *Anabasis*-association. The average soil depth in *Salsola*-association is 45 cm ranging from 22 to 75 cm, while it is 54 cm in the *Artemisia*-association ranging from 30 to 77.5 cm.

In a stand with a shallow hard layer in the *Plantago*-association, *Teucrium polium*, a characteristic of the *Gymnocarpus*-association, grows with the *Plantago*-association.

The number of strokes needed to push the rod of the stratometre a given distance within the soil bears a direct relation to its resistance to penetration. Fig. 3 shows the average number of strokes necessary to push the rod to a

certain depth. This number is variable in the different stands of various associations and even in the same association. The penetrability of the soil decreases in the different associations in the following order: *Ammophila-*, *Plantago-*, *Salsola-*, *Artemisia-*, *Anabasis-* and *Gymnocarpus*-associations.

Excluding the salt marsh communities from the associations belonging to the alliance Thymelaeion hirsutae, one finds a close relation between the average soil depth and the mean total plant cover. This is clear from the data in Table 1.

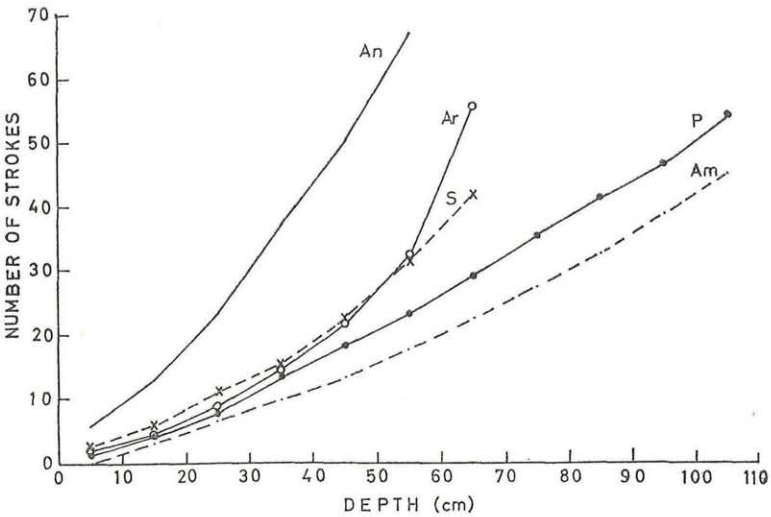

Fig. 3. Relation between number of strokes and soil depth in soils supporting area (Am = *Ammophila-*, P = *Plantago-*, Ar = *Artemisia-*, An = *Anabasis-*, and S = *Salsola*-associations).

The data in Table 1 show how far the soil depth affects the plant cover in arid zones. It is evident that deeper soil supports denser vegetation.

Table 1

Average soil depth (cm) and mean plant cover (%) in winter in the different associations belonging to the alliance Thymelaeion hirsutae with the exception of halophytic communities

Association of	Average soil depth	Mean plant cover
Plantago	89	70
Artemisia	54	62
Anabasis	38	54
Gymnocarpus	35	52

6. Discussion

The distribution of plant communities depends on numerous factors, the effects of which are direct and/or indirect. It is not correct to correlate the distribution of plants with a single factor. However, under desert conditions, the water relations of air and soil are the major controlling factors and other factors are merely contributary. The amount, availability and continuity of the water supply are controlled by many factors. In the same area with equal rainfall, the physiography and the physical properties of the soil are the major factors affecting the water supply. BATANOUNY & SHEIKH 1972 and BATANOUNY & HILLI 1973 state that „the physiography and the physical soil properties, especially depth and texture, are the major factors affecting the distribution of plant communities". The effect of relief on the distribution of plant communities is direct and indirect. Elevated parts are more exposed to weathering factors than depressions. Soil is removed from elevated parts by wind and/or water actions, thus rendering the habitat unfavourable for the growth of many plants except those having the ability to extend their roots in the rock crevices. Moreover, such habitats receive less water than lowlands which receive runoff water in addition to the local rain. The depressions receive not only water, but also the soil washed by runoff water. These habitats have deep soils favourable for plant growth. Deep soils allow the storage of some water in the subsoil providing a continuous supply of moisture for the deeply seated roots of perennials. In contrast, shallow soils will be moistened during the rainy season but will be dried in a short time. Water loss from deep layers is restricted to root absorption and transpiration, while evaporation from the soil ceases due to the presence of the upper protective dry layers (ABD EL RAHMAN & BATANOUNY 1965). The water retained in deep layers represents the water supply for perennials in the dry season. In the present study and previous works (ABD EL RAHMAN & BATANOUNY 1965; BATANOUNY & SHEIKH 1972 and BATANOUNY 1973), it has been established that vegetation is denser in deep soils than in shallow ones, even if both receive the same amount of rainfall. KASSAS & IMAN 1954 state that the gradual modification in the plant cover proceeds in coincidence with the gradual accumulation of alluvial material and the gradual thickening of the soil. MIGAHID & al. 1971 suggested a relationship between the associations in the area under survey depending on the retrogressive changes due to erosion and building up of soil. BATANOUNY & HILLI 1973 suggested a scheme for the relations among the plant communities in a semi-desert area as regards the depth and texture of soils supporting the different communities. They found that even in soils having nearly the same depth, the soil texture affects the plant cover.

Not only the soil depth is effective on plant distribution but also the soil penetrability. Soil may be deep but not easily penetrable offering great resistance to root penetration. Soil penetrability plays an important role in the distribution of different associations. In the *Plantago*-association, the soil

is easily penetrable and deep. The presence of a shallow hard layer in a stand of the *Plantago*-association is reflected on the kind of species growing with the characteristics of the Plantaginetum. This gives the evidence how far the penetrability and depth of the soil affects the kind of a species growing in an area.

In all associations, the penetrability decreases with depth, such a decrease is sharp in associations of *Artemisia* and *Anabasis*. This may be referred to the high content of fine particles and carbonates. This result is justified by the data of granulometric analysis and carbonate estimations. It is further confirmed by the fact that soils of *Plantago*-association contain very low amount of carbonates, hence no sharp decrease in penetrability is observed at low depths. In the Ammophiletum, the percentage of fine particles is low at all depths, with the result that no sharp decrease in penetrability occurs with depth.

Though certain species have a wide ecological amplitude, they show some prosperous growth and higher vitality in one habitat than in the other. The characteristic species of the alliance, growing in habitats supporting different associations, may represent such species. It has been found by BATANOUNY & ZAKI 1969 that the root systems of some characteristic species of the alliance in the different associations show different number of laterals, lateral extension and depth of penetration. The authors ascribed this to differences in soil penetrability, water content of the different layers and in salinity. It has been found also that ploughing, through its effect on the physical soil properties, modifies the depth and the lateral extension of the root system and accelerates the growth of the shoot system.

The Salsoletum tetrandrae occupies areas with high salt content. To the south of the coastal dune belt, the ground is low ranging between 2.5 and 10 m above mean sea level. This renders the water table and the underground level of sea water very close to the surface, with the result that high salinity prevails in the belt between contours 2.5 and 10 m. Soils supporting the Salsoletum have high carbonate content. This may be referred to the transportation of fine calcareous particles from the coastal dunes to the lowland. Runoff water coming from the highland in the south carries fine waterborne material which is deposited in the salt marsh area. The major part of these fine deposits is carried down to the sea through the downstreams of wadis and waterways across the dune belt.

The coastal dunes are formed of comminuted, water-worn shells, carbonate of lime. The carbonate content rises to high levels. These dunes are characterised by being very permeable to water, loose, homogeneous and coarse-grained, which characters are responsible for the rapid drying of the surface soil and rapid increase in water content of the lower layers. The *Ammophila arenaria*-association inhabits these mobile dunes. It is remarkable that plants growing in this habitat are usually sand binders tolerating the burial of their shoots and the exposure of their roots. These plants, mainly

geophytes, are capable of producing adventitious roots from the buried vegetative parts which fix the mobile sand and preserve it from weathering. Some plants in this habitat produce long fibrous roots running parallel to the soil surface at very shallow depths not exceeding 10 cm. These superficial roots may benefit from the condensed dew in the uppermost layer.

In conclusion, with the exception of salt marshes, it has been evident that variations in penetrability and soil depth affect the distribution of plant communities as well as the growth of plants and their root penetration and habit. The importance of the physical properties of soil, especially depth and penetrability, in the distribution of different species and plant communities in the desert region has been emphasized by numerous authors (Kassas & Imam 1954; Abd el Rahman & Batanouny 1965; Batanouny 1973; Batanouny & Khalifa 1970, Batanouny & Sheikh 1972 and Batanouny & Hilli 1973).

It is advisable, in a preparation for any programme of land use in semi-arid regions, that a survey be made of soil depth and penetrability in the areas to be utilized. On the basis of such a survey, among other factors, one is enabled to chose the type of economic plants to be grown in every part of the area.

7. Summary

Different habitats are recognizable in the western coastal Mediterranean zone in Egypt. Each habitat supports a definite type of vegetation. Soils of these habitats vary widely as regards their physical and chemical properties. Physiography, through its effect on these properties, has a paramount effect on the distribution of plant associations. The present study shows that, with the exception of salt marshes, variations in the soil physical properties, particularly the penetrability, depth or texture, affect the distribution of the plant communities in such a semi-arid zone. The importance of these factors is referred to their influence on the water relations of plant and soil.

8. Zusammenfassung

In der westlichen Mittelmeer-Küstenregion Ägyptens sind verschiedene Standorte erkennbar, die jeweils einen bestimmten Vegetationstyp tragen. Die Böden dieser Standorte sind nach ihren physikalischen und chemischen Eigenschaften sehr unterschiedlich. Eine genaue Naturbeschreibung oder Physiographie ist durch das Aufklären dieser Eigenschaften von ausschlaggebendem Einfluß auf die Verteilung der Pflanzengesellschaften. Wenn von Salzbodengesellschaften abgesehen wird, konnte in der vorliegenden Arbeit gezeigt werden, daß ein Verändern der physikalischen Bodeneigenschaften, besonders der Durchlässigkeit, der Tiefe oder des Gefüges die Verteilung der Pflanzengesellschaften in einem solchen semi-ariden Gebiet beeinflußt. Die Wichtigkeit dieser Faktoren ist auf ihren Zusammenhang mit dem Wasserhaushalt zwischen Pflanze und Boden zurückzuführen.

9. References

ABD EL RAHMAN A. A. & BATANOUNY K. H. 1965. Vegetation and root development in the different microhabitats in wadi Hof. — Bull. Inst. Désert d'Egypte 15: 55—66.

BATANOUNY K. H. 1973. Soil properties as affected by topography in desert wadis. — Acta Bot. Acad. Sci. Hung. 19: 13—21.

— & HILLI M. R. 1973. Phytosociological study of Ghurfa desert, Central Iraq. — Phytocoenologia 1: 223—249.

— & KHALIFA T. 1970. Contribution to the autecology of *Urginea maritima* in Egypt. — Phyton (Austria) 14: 41—53.

— & SHEIKH M. Y. 1972. Ecological observations along Baghdad-Huseiba road, Western desert, Iraq. — Feddes Repertorium 83: 245—263.

— & ZAKI M. A. F. 1969. Root development of two common species in different habitats in the Mediterranean region in Egypt. — Acta Bot. Acad. Sci. Hung. 15: 217—226.

BRAUN-BLANQUET J. 1964. Pflanzensoziologie, 3. Aufl. — Wien.

KASSAS M. & IMAM M. 1954. Habitat and plant communities in the Egyptian desert. III-The wadi bed ecosystem. — J. Ecol. 42: 424—441.

MIGAHID A. M., BATANOUNY K. H. & ZAKI M. A. F. 1971. Phytosociological and ecological study of a sector in the Mediterranean coastal region in Egypt. — Vegetatio 23: 113—134.

PIPER C. S. 1949. Soil and plant analysis. — Adelaide.

ZAGHLOUL M. 1928. *The soil stratometre. A method for the examination of deep* lying soil. — Nature, April. 7: 337.