

**THE IMPACT OF GEOMORPHOLOGIC AND CLIMATIC  
CONDITIONS ON THE VEGETATION OF SALT MARSHES  
ALONG THE MEDITERRANEAN COAST OF ISRAEL AND  
SINAI**

by

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INTRODUCTION

Three kinds of salines have been distinguished in the Middle East (ZOHARY, 1973): (1) Mediterranean coastal salines (including northern Sinai and the salines near Akko in Israel); (2) Turanian inland salines (including Central Anatolia and Central Iran); (3) Hot desert salines (including those of the Red Sea coastal salines and of the Dead Sea area). A general description of the vegetation of these salt marshes is presented by ZOHARY (1973), DANIN (1980) and a detailed study of specific areas is given by ZOHARY & ORSHAN (1949), ORSHAN & ZOHARY (1955) and BURVIN (1963).

Several hydrogeological studies of the Mediterranean coastal area of Israel and Sinai have taken place in the last 20 years. The results of these studies may throw additional light on our understanding of the environmental conditions affecting the distribution of vegetation.

The aims of the present paper are to correlate the distribution of the Mediterranean coastal salt-marshes of Israel and Sinai with hydrogeological and geomorphological conditions. The impact of soil texture and climatic gradients on the composition of vegetation will be discussed as well. These East Mediterranean salines will be compared with those of southern France.

ENVIRONMENTAL CONDITIONS

The most important factors that influenced the formation of salt marshes along the Mediterranean coast of Israel and Sinai were the geomorphologic-tectonic ones. Geologic faults, that are still active, formed three principal kinds of coastal areas. (Fig. 1.)

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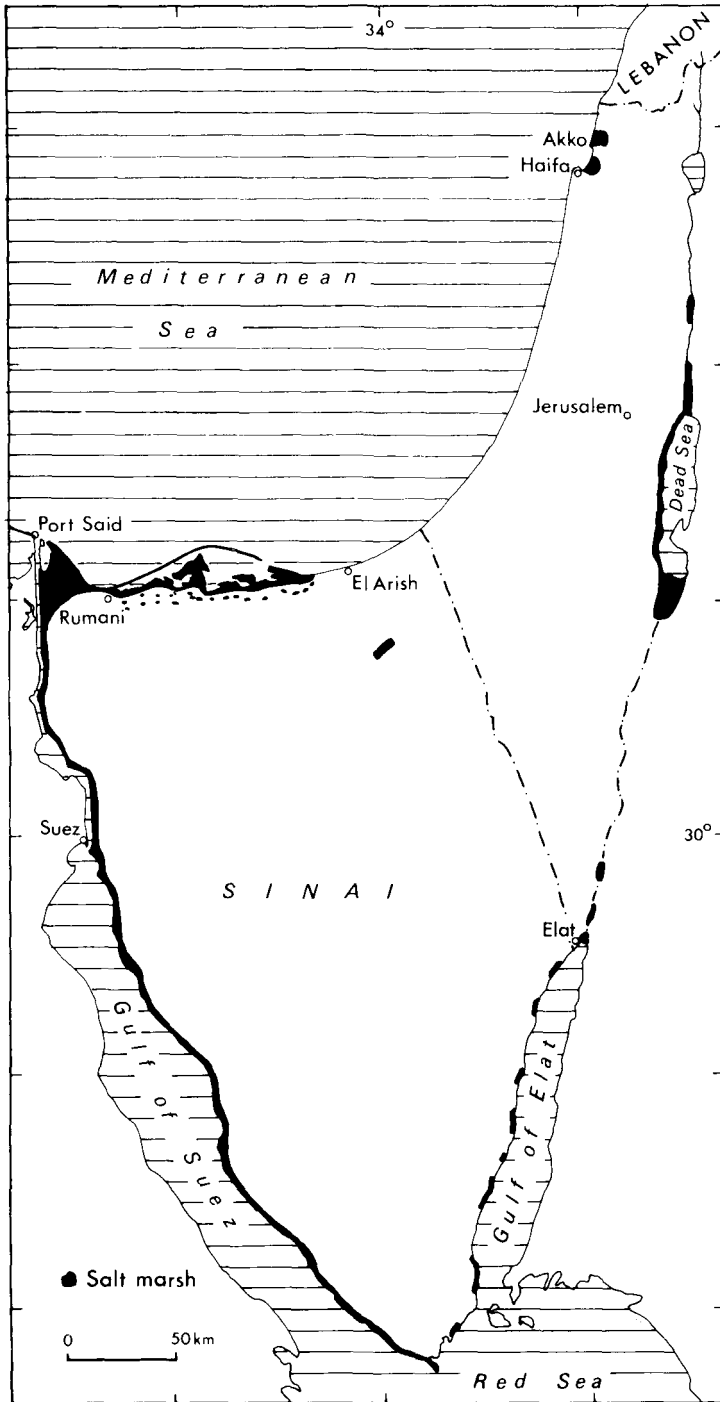


Fig. 1.—Salt marsh vegetation of Israel & Sinai. Partly based on studies of G. Orshan, N. H. Tadmor, A. Danin, G. Halevy and A. Shmida - Dept. of Botany. The Hebrew University, Jerusalem.

1. The Zevulun Plain, between Haifa and Akko, is a rift valley (graben) that forms a low coast (KAFRI & ECKER, 1964 and Fig. 2). The western parts of the aquifer (the water-bearing layer) are mixed with seawater and at the outlet of the Na'aman and Qishon rivers salt marshes occur near the sea. This area receives ca 600 mm of mean annual rainfall.

Sand dunes, accumulated above the soil with high water-table of saline to brackish water, do not display any salinization because of the additional fresh rain water that is held in the deeper sand layers and do not mix with the brackish or saline water (ARAD, KAFRI & FLEISHER, 1975). The pattern of subterranean patches of high salinity in the area is assumed to be affected by the faults that are the main conduit for active contamination of the aquifers by seawater (ARAD & *al.*, 1975).

2. The principal coastal area between Akko and the border with Lebanon, and between Haifa and El-Arish, is elevated from a few meters to several dozens of meters above the sea. The principal aquifer is opened to the sea below sea level and it does not influence the top soil (ISSAR, 1961 and ISSAR & KAFRI, 1972). Even if there are swamps in small valleys parallel to the sea there is no contact with sea water, and the rate of evapotranspiration does not support development of salt marshes. This area receives from 100 mm of mean annual rainfall in the south to 600 mm in the north.

Rivers, such as the Alexander river (between Haifa and Tel-Aviv), having an outlet to the Mediterranean Sea which resembles much that of the Na'aman river do not support any salt marshes. This is because the zone of interface of saline and fresh water is much deeper than the root zone. It seems that tidal supply of seawater salinity inland, so common in deltas and other coastal salines, does not function in most of the coastal areas of Israel because of the lack of proper geomorphologic structure.

3. The coast of the northern Sinai west of El-Arish is not uplifted geologically and a large area is at sea level or a few meters above it. The aquifer is close to the surface and is influenced by mixing with sea water and direct evaporation (NEEV, 1980). Mean annual rainfall here is only 100 mm or less. This additional quantity of water infiltrates through the sands and streams underground northwards to the Mediterranean, leaching the soil at the southern part of the depressions where the water-table is high and salt marshes occur. This may be seen by the groves of date palms often planted there.

## VEGETATION

The vegetation of the salt marshes of the Zevulun Plain has been described by ORSHAN & ZOHARY (1955). Near the banks of the Na'aman and Qishon rivers, in the tributaries near the coast, drainage channels and local depression, the *Tamaricetum meyeri mediterraneum* is develo-

ped. *Tamarix tetragyna* Ehrenb. var. *meyeri* (Boiss.) Boiss. is accompanied here by *Arthrocnemum macrostachyum* (Moric.) Moris & Delponte, *A. fruticosum* (L.) Moq., *Halimione portulacoides* (L.) Aellen and a few other perennial halophytes.

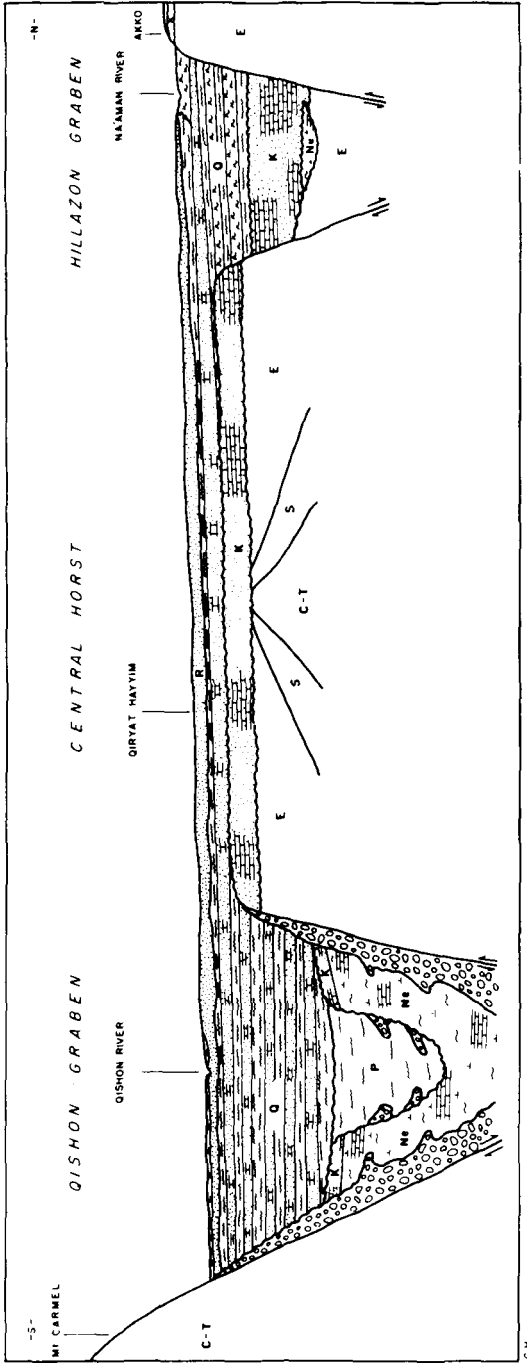
*Arthrocnemum macrostachyum* - *Sphenopus divaricatus* association develops on slightly elevated sites which enjoy better soil leaching than the first belt and is rich in annual companions. The sands blown inland from the beach cover the clayey halomorphic soil or mix with it. Hence, the sandy texture of the soil creates a mosaic of microhabitats. A similar mosaic was described by MOLINIER & al. (1964) in the Camargue, l.c. Southern France. The vegetation there and here can be divided to a layer of lignified hydrohalophytes such as *Arthrocnemum macrostachyum* (= *A. glaucum*) and *Juncus acutus* L. which use the 50 to 100 cm deep salty or brackish water and a layer of annuals or perennials which use the available moisture in the leached sandy soil. Near Akko some of the psammophytes growing among the hydrohalophytes are *Centaurea procurrans* Sieb. & Spreng., *Polycarpon succulentum* (Del.) J. Gay and *Trifolium tomentosum* L. Other associations which were described by ORSHAN & ZOHARY (1955) are hard to detect at present because much of the area has been drained since then.

Local small depressions among sand dunes close to the coast between Haifa and El-Arish are populated with plants of fresh-water swamps, the most characteristic of which are: *Typha latifolia* L., *Typha australis* Scham. & Thonn., *Phragmites australis* (Cav.) Trin., *Juncus acutus*, *Inula viscosa* (L.) Ait. and *Holoschoenus vulgaris* (L.) Fritsch. Many other hydrophytes occur in these depressions. Near the outlet of fresh water rivers to the sea a few halophytic components establish themselves. Such are *Limonium meyeri* (Boiss.) O. Ktze., *Halimione portulacoides* and *Hordeum marinum* Huds. These species may dominate in belts or patches of salt marshes in the Zevulun Plain. Occasional specimens of halophytes which prevail in the salines of northern Sinai such as *Zygophyllum album* L. f. and *Halocnemum strobilaceum* (Pall.) M. B. occur along the southern coastal area of Israel.

The dominant plant in the vast areas of salt marshes of northern Sinai is *Halocnemum strobilaceum* (ZOHARY, 1973; DANIN, 1980). A typical depression among the sand dunes shows a saline center where sodium chloride is collected by the Bedouin during the summer. The salt center is surrounded by a belt dominated by or populated only by *H. strobilaceum*. There are patches with dominance of *Suaeda vermiculata* Forssk. & J. F. Gmel., *Arthrocnemum macrostachyum*, *Limoniastrum monopetalum* (L.) Boiss. and *Juncus arabicus* (Asch. & Buch) Adams. Sand dunes surrounding the salt marshes which are influenced by saline ground water are dominated by *Zygophyllum album*; other sands not influenced by salinity are dominated by *Artemisia monosperma* Del., *Stipagrostis scoparia* (Trin. & Rupr.) De Winter or *Cornulaca monacantha* Del. Annual species are rather rare here because of the low quantity of rainfall and the coarse texture of the sand which do not supply the plants with sufficient moisture. South of the El

SCHEMATIC GEOLOGICAL CROSS-SECTION (N-S)  
ZEVULUN PLAIN

Not to scale



LEGEND

- |                     |     |                     |  |
|---------------------|-----|---------------------|--|
| PLEISTOCENE         | Q   | SAND & CALC. SST    |  |
| KURDANE Fm          | K   | SILTY SAND (MARINE) |  |
| EOCENE              | E   | CLAY (MARINE)       |  |
| CENOMANIAN-TURONIAN | C-T | CLAY (CONTINENTAL)  |  |
| COAST LINE          |     | CLIFF               |  |
| RIVER               |     |                     |  |

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OF THE ZEVULUN PLAIN  
U. KAFRI & A. ECKER, 1964

Arish-Rumani road, date palms are planted along the southern edge of the saline depressions. The coastal areas of Sabkhat el Bardawil as well as small islands there are dominated by nearly pure stands of *Halocnemum strobilaceum*. Sand hills in this area are populated by *Zygophyllum album* with very few companions.

#### DISCUSSION

The sharp climatic differences between the Zevulun Plain and N. Sinai enable us to extrapolate from some microenvironmental differences reported elsewhere to macroenvironmental differences in these two areas. The studies of MOLINIER & *al.* (1964) and CORRE (1975) in the Camargue of southern France revealed that *Arthrocnemum macrostachyum* is more drought and salt resistant than *A. fruticosum* (= *Salicornia fruticosa* (L.) L.) and the latter is more resistant than *A. perenne* (Mill.) Moss (= *Salicornia radicans* Sn.) and *Salicornia europea* L. is the least resistant of all. Thus, all the four are found in the Zevulun Plain. Only the first two are found in northern Sinai, with *A. macrostachyum* more common. The salt marshes of the Red Sea coast are even drier and the only species of these four present there is *A. macrostachyum*.

The relatively high air humidity, rainfall and other sources of fresh water in the Camargue and in the Zevulun Plain enable development of a rich flora and many plant communities when compared with that of northern Sinai. The associations of the former sites have two layers, i.e., lignified hydrohalophytes and herbaceous glycophytes (non-halophytes). However, there are only one layered associations of lignified hydrohalophytes in northern Sinai. In the salt marshes of northern Sinai the wet saline soil supports the nearly monospecific communities of hydrohalophytes and there is not enough leaching of the soil for glycophytes and to supply them with sufficient moisture. In other words wherever there is sufficient moisture it is too salty to support herbaceous flora and wherever it is leached it is too dry. This resembles the situation in the Judean Desert, Israel (DANIN, 1978) where semishrub xerohalophytes use water of salty layers and form a monospecific layer. They are accompanied by glycophytic annuals wherever soil occurs above the chalk and are devoid of companions on chalk outcrops.

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### Abstract

Salt marshes developed close to the Mediterranean coast of Israel near Akko where a Pleistocene local rift valley led to sedimentation of sand and clay. The water table is high and its fresh water becomes mixed with seawater. Sand covering the halomorphic clayey soil supports nonhalophytic psammophytes. A layer of hydrohalophytic semishrubs poor in species is accompanied by a rich herbaceous flora of halophytes and glycophytes enjoying the diverse soils, diverse microtopography and ca. 600 mm of mean annual rainfall. Most of the Israeli coast does not support salt marshes because the upper aquifer opens into the sea below sea level and thus rainwater does not mix with seawater. The northern Sinai coast has clayey-sandy ground in a flat terrain. Seawater mixes here with water of the high aquifer and leads to development of extensive saline areas. The dry environment (100 mm of mean annual rainfall) sieves out the layer of herbaceous halophytes and glycophytes and leaves the hydrohalophytic semishrubs. These occur in associations that are poorer in components than those of the halophytes near Akko or in southern France.

### Resumen

La zona de marismas se forma en las proximidades de la costa mediterránea, cerca de Akko, donde existe un valle arcilloso-arenoso sedimentario Pleistocénico. El nivel freático es alto y su contenido hídrico se mezcla con el agua del mar. Se puede observar la presencia de una vegetación compuesta de pequeños arbustos hidrohaliófitos acompañados de una rica flora herbácea, compuesta por halófitos y glicófitos, aparentemente bien establecida en estos suelos de microtopografía variada y unos 600 mm de precipitación anual. Las costas del norte de Sinai compuestas también de arena y arcilla son completamente planas y en sus suelos se mezcla el agua marina con la de las capas freáticas altas, dando lugar a extensas áreas salinas. La precipitación es pobre (100 mm por año) y como consecuencia la vegetación queda prácticamente reducida al estrato herbáceo.