Israel Journal of Plant Sciences Vol. 53 2005 pp. 247–252

The sandy areas of Caesarea, a rare situation of alpha and beta diversity linked by plant succession

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(Received 27 July 2005 and in revised form 26 November 2005)

ABSTRACT

Sand blown from the Mediterranean beach inland, in the past and at present, becomes stabilized due to vegetation activity. Within the mesic Mediterranean territory of Israel, being a rather extreme and dry type of environment, every small change in the substratum induced by vegetation activity becomes prominent. Dozens of associations have been described elsewhere. The present paper deals with the gradual changes in the vegetation composition along the psammosere in the Caesarea area. This unique situation in the Mediterranean area calls for immediate protection and conservation, mainly from urban sprawl.

Keywords: Sand vegetation, coastal Israel, plant succession, conservation

INTRODUCTION

The vegetation of the sandy soils of the coastal plain was one of the first ecosystems of Israel studied by Eig (1939), the founder of botanical research in this country. Eig's opinion was supported by M. Zohary, who edited Eig's (1946) synopsis of the country's vegetation. Eig's vegetation class name (Retametea raetam) was published in the official contemporary way by Danin and Solomeshch (1999). Additional local ecological studies were carried out in the sandy soils of Caesarea by Kutiel et al. (1978/9), Danin and Yaalon (1982), Kutiel and Danin (1987), and Barbour et al. (1982). Notes on alien species in the coastal area were included in publications by Dafni and Heller (1980, 1982, 1990), and Danin (2000, 2004). The nomenclature used in this article follows the recently published taxonomical review of the flora (Danin, 2004).

The main part of the present paper is dedicated to the syntaxa (associations, alliances, and orders) present in this habitat (Danin and Solomeshch, 1999). The aim of the present chapter is to highlight the vegetation near Caesarea and to focus on the inter-relationships of the associations in successional series (psammosere). The official syntaxonomical order, as presented in Danin and Solomeshch (1999), does not follow the successional order. Therefore, in order to emphasize the phases of plant succession, I will emphasize dominant plants having high cover.

THE SAND VEGETATION OF THE CAESAREA AREA

The vegetation of the sands of Israel was included by Eig (1939) in the class Retametea raetam. This is an azonal class, divided into orders that correlate with climatic conditions. The order Retametalia raetam is

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that of Mediterranean coastal sands. The Caesarea area (Fig. 1) is constructed of sands from several ages and their derivatives, which passed plant succession and pedogenetic processes. The main process of sand transportation took place when the most weathering-resistant component of magmatic rocks in Africa and Sinai (quarzitic sand) was carried into the Mediterranean Sea by rivers. South-to-north currents transported the sand onto Israel's shores, and winds carried them inland. The sand sheets cover older landscape, as illustrated by Kutiel et al. (1979/80). The sand became populated by plants adapted to the mobile substrate, bringing about environmental changes that enable the growth of additional plant species. The Caesarea area is blessed with a wealth of associations that participate in the psammosere—plant succession on sand. Constant flux of sands through history created sands of various ages occurring together in that area.

STAGES OF THE PSAMMOSERE SEEN IN CAESAREA

Dunes of fresh sand used to be seen in the area between the Orot Rabin power station and Kibbutz Sdot Yam until some 10–15 years ago, when illegal quarrying activity led to the disappearance of this habitat from the area. Small remnant patches of sand, which become populated with the pioneer grass *Ammophila arenaria* (L.) Link, may be seen near the coastline. This plant is known from coastal areas of the Mediterranean Sea and the Atlantic Ocean, where it constitutes associations that withstand salt spray of the sea water. These areas are also famous for their sandy substratum. In Israel there were large sandy areas populated by *A. arenaria*, which were not influenced by sea spray. Most of the area where *A. arenaria* could be seen in northern Israel was in the Caesarea area, but quarries and industrial development took away this special habitat from the citizens of Israel.

A. arenaria is not only resistant to sand burial, it requires it for maximum growth. It germinates on mobile sand during events of several consecutive rainy days. Sand coverage, even almost total, is not lethal. Shoot-borne roots develop from nodes along buried stems, and the new leaves grow above the sand. As *A. arenaria* grow older, it branches and becomes a local obstacle for the sand-carrying wind. Biogenic mounds, also known as "nebkas" (Danin 1996), accumulate around *A. arenaria* plants. In time, this grass changes dune microtopography (Danin and Nokrian, 1991; Danin 1996; Danin et al., 1998), and filamentous cyanobacteria start to be seen on the relatively stable sand within *A. arenaria* nebkas. This stage is now hardly seen in Caesarea

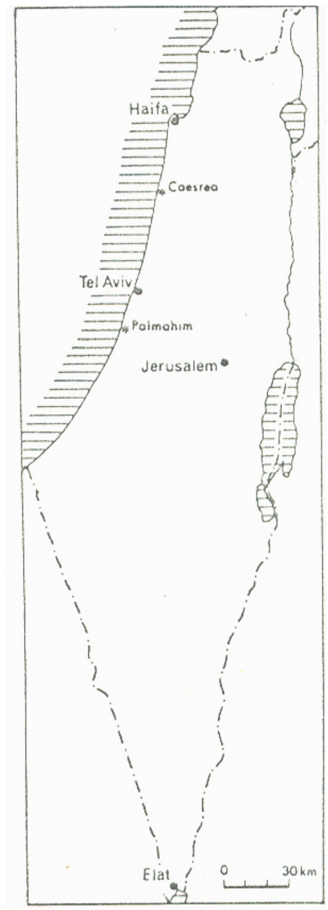

Fig. 1. Location map.

due to the fragmentation of the habitat. Annual plants resisting sand mobility, e.g., *Senecio joppensis*, begin to penetrate the nebkas and the areas between them.

As nebkas begin to trap fine-grained sand and silt plus clay, a cyanobacterial crust at or a bit below the sand surface appears (Danin et al., 1989). *Microcoleus vaginatus* is the most important filamentous cyanobacterium that constitutes this crust. Its polysaccharide sheaths become attached to sand grains, decreasing their mobility (Dor and Danin, 2001).

The second stage of succession takes place when *Artemisia monosperma* Delile germinates. Its seeds need light for germination (Koller et al., 1964), but when fully exposed to solar radiation the diaspores become dry and fail to germinate. Hence, ideal sites for its germination are where sand accretion is at a low rate and sand removal is negligible. After establishment, the growing shrubs constitute nebkas with a canopy that is more rigid than that of *A. arenaria*. *A. monosperma* builds up taller and wider nebkas than those of *A. arenaria*. Its denser crown creates shade, and buried or falling stems start to decompose into humus. Soil color darkens and waterholding capacity increases. Consequently an increasing number of annuals grow in the area. *A. monosperma* resists sand accretion via production of shoot-borne roots (Danin, 1997), and sand deflation via roots that resist desiccation after being exposed. Important companion shrubs, well adapted to sand accretion and deflation, are those of *Polygonum palaestinum* Zohary. Sites vulnerable to constant sand deflation become enriched with *Scrophularia hypericifolia* Wydler, *Echiochilon fruticosum* Desf., and *Moltkiopsis ciliata* (Forssk.) I.M.Johnst.. An association of *Artemisia monosperma* and *P. palaestinum* prevails on the only tongue of mobile sand in the Caesarea area (Fig. 2). As a result of a sudden devastating destruction, the stable sand becomes mobile again. Blowouts are sites of intensive deflation, from a few dozens to a few hundreds of square meters. Blowouts are rather common in coastal sandy areas (Watt, 1937; Barrere, 1992; Jungerius et al., 1992). The direct initiator of blowouts can be a local whirlwind traveling at a relatively high speed and having considerable lifting and carrying capacity, similar to a miniature tornado or cyclone (Watt, 1937).

Retama raetam (Forssk.) Webb establishes itself in old sites within the Artemisietum monospermae areas. These areas harbor small shrubs of *Helianthemum stipulatum* (Forssk.) C.Chr. The trend of increasing amounts of trapped silt and clay in the soil continues here and through all the next stages of the psammosere (Danin and Yaalon, 1982). Associations dominated by *Retama raetam* and *Helianthemum stipulatum* have soil richer in silt, clay, and humus, especially in the shade of *Retama* shrubs. The entire area supports an increasing number and diversity of annual plants. There are interesting developments in the *Retama*-shade microhabitat. *R. raetam* belongs to the Papilionaceae and possibly has nitrogen-rich litter. Aging sites of this community, recognized by dominance of *Trifolium palaestinum* Boiss. and *Aegilops sharonensis* Eig, have a circle of mosses growing on the *Retama* humus along with a local flora that differs from that of areas among the shrubs. Several *Sedum* species, normally confined to shallow soil pockets on hard calcareous rocks of the Mediterranean territories of Israel, are found here, as well as the chasmophytic lithophytes *Cyclamen persicum* Mill. and *Umbilicus intermedius* Boiss.

Mosses are well known for trapping airborne silt and clay (Danin and Ganor, 1991). This microhabitat is also the "gateway" for the penetration of the next stages of the psammosere. Diaspores of vines and shrubs of the Mediterranean maquis, eaten by birds, are not digested but dropped into the moss-ring from birds roosting on the *Retama* shrubs, which are the tallest perches in the area. Later on, vines such as *Ephedra aphylla* Forssk. and *Asparagus horridus* L., and shrubs of *Rhamnus*

Fig. 2. Polygono palaestini–Artemisietum monospermae on fresh, mobile sand covering Helianthemetum stipulati on stable sand.

alaternus L. and *Pistacia lentiscus* L. also arrived via endozoochory, and replace the *Retama* shrubs.

Aging dunes of this type display an increasing number of young shrubs of *P. lentiscus* and *Rhamnus* species, and a decreasing number of *Retama, Helianthemum stipulatum*, and *Calicotome villosa* (Poir.) Link shrubs. Open space among the shrubs is populated with annuals that differ from those of earlier stages. Eventually the area becomes totally covered by *P. lentiscus* and *C. villosa* (Danin and Yaalon, 1982; Danin and Solomeshch, 1999), with very few annuals and remnants of the desert components *R. retama* and *H. stipulatum*. *Ephedra* and *Asparagus* vines become replaced by other species in the same genera—*Ephedra foeminea* Forssk. and *Asparagus aphyllus* L.—as well as *Lonicera etrusca* G.Santi, *Prasium majus* L., and *Rubia tenuifolia* D'Urv.

As the *Pistacietum* becomes older, its humus layer becomes thicker, dark components are leached to deeper soil layers, and the vegetation becomes difficult to pass through. We do not find seedlings of *Ceratonia siliqua* L. in this community. However, such seedlings were seen during the last 30 years in shadow rich in humus under carob trees, allowing one to assume that such establishment may take place in the shade of *P. lentiscus* shrubs as well.

Pistacio lentisci–Ceratonietum silique is considered the climax vegetation of this area. It is seen in the small area near Caesarea and Or Aqiva on the coastal plain. The sandy areas south of Caesarea are small, have decreasing amounts of rainfall in a north-to-south gradient, and display only parts of the sere. North of Caesarea, there is a sandy area only in the Acco Plain, but it seems to be much younger and less accessible to the public than that of Caeasarea. Hence the only area in Israel where the whole psammosere is seen is the Caesarea area.

THE MOST RARE AND IMPORTANT HOT SPOT FOR VEGETATION STUDY

I have been studying the vegetation of Israel, Sinai, and Jordan and made brief botanical excursions where I could make observations on the vegetation of Turkey, mainland Greece, Crete, Cyprus, Italy, France, and Spain. There is hardly any country where such plant succession processes can be seen and studied. In 1980, Dr. M. Costa, when speaking of the coastal vegetation of Valencia, Spain (OPTIMA meeting in Madrid; Costa, 1982), displayed three stages of plant succession on dunes, known in the recent past but replaced now by houses. Urbanization has similarly decreased natural coastal vegetation in Israel.

I hope that nobody will be allowed to take this most precious piece of land from the public of Israel and the world. We owe it to future generations. It should be turned into an open-air museum, as the vegetation and the processes that occur there are of a museum quality and rarity.

ACKNOWLEDGMENT

I thank Dr. M.G. Barbour for the critical reading of the manuscript.

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APPENDIX 1
SYNOPSIS OF SAND VEGETATION

Associations that occur in Caesarea area are marked by an asterisk (*)

Retametea raetam
Retametalia raetam
Ammophilo – Artemisienalia monospermae
Artemision monospermae
*Cypero macrorrhizi – Ammophiletum arenariae
*Cutando memphiticae – Ammophiletum arenariae
Scrophulario hypericifoliae – Ammophiletum arenariae
Centropodio forsskali – Ammophiletum arenariae
Senecioni joppensis – Artemision monospermae
*Polygono palaestini – Artemisietum monospermae
Centropodio forsskali – Artemisietum monospermae
*Stipagrostio lanatae – Artemisietum monospermae
Seneceioni joppensis – Ononidetum natricis subsp. stenophyllae
Echinopo philistaei – Artemisietum monospermae
Launaeo fragilis – Artemisietum monospermae
Echio angustifoliae – Artemisietum monospermae
Convolvulo lanati – Artemisietum monospermae
Scrophularion hypericifolii
*Moltkiopsio ciliatae – Scrophularietum hypericifoliae
*Echiochilo fruticosi – Artemisietum monospermae
Geranio robertiani – Artemisienalia monospermae
Phagnalo rupestris – Retamion raetam
*Senecioni joppensis – Retametum raetam
Centropodo forsskali – Retametum raetam
Corynephoro articulati – Retametum raetam
Dittricho viscosi – Retametum raetam
Prasio maji – Retametum raetam
Bilacunario boissieri – Retametum raetam
Solano sinaici – Retametum raetam
Trifolio palaestini – Helianthemion stipulati
Ephedro aphyllae – Helianthemetum stipulati
Retamo raetam – Echiochiletum fruticosi
* Plantago sarcophyllae – Helianthemetum stipulati
*Trifolio palaestini – Helianthemetum stipulati
* Pistacio lentisci – Helianthemetum stipulati
**Pistacio lentisci – Calicotometum villosae

APPENDIX 2

SYNOPSIS OF THE STRAND VEGETATION

Associations that occur in Caesarea area are marked by an asterisk (*)

Ammophiletea arenariae

Lotion cretici

Lotio cretici – Ammophiletum arenariae
*Elymo farcti – Cakiletum maritimae
*Othantetum maritimis
Helianthemo stipulati – Lotetum cretici
Sporobolo pungentis – Lotetum cretici
Salsolo kali – Ipomoetum imperati
Atractylido cardui – Crucianelletum maritimae
Limono oleifoli – Crithmetum maritimi