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Primary habitats of a few synanthropic plants in Israel

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Abstract

Most weeds and synanthropic plant species in many parts of Israel are derived from the local flora. Several species in undisturbed habitats are adapted to live in relations with harvester ants. These old primary adaptations enabled them to develop on human-induced fertile soils (i.e. cattle enclosures, encampments, garbage heaps, ruins, and roadsides). *Silybum marianum*, a common ruderal plant in the Mediterranean region, has pappous achenes that assist wind dispersal. An oily food body (elaiosome) at the achene's top functions as an ant-attractant. The harvester ant *Messor semirufus* efficiently collect achenes and transfer them into their nests. Later, they place intact achenes in the nest's refuse zone together with soil particles, parts of plant diaspores, dead ants, and other organic remains. When wet, the material in the refuse zone disintegrates as a result of microbial activity. Soil near the nests had 2.4 times more nitrates, 4.5 times more phosphorous, and 1.2 times more potassium as compared with the area between the nests. The weight of *S. marianum* plants near the nests was 9 times higher than in the control grassland. The former produced 3-4 times more heads per plant near the nest than in the grassland.

Other ruderal species of the genera *Carduus, Notobasis, Beta, Chrysanthemum, Malva, Calendula*, and *Emex* were also found as important components near nests of the harvester ants.

Introduction

The synanthropic flora of Israel is customarily divided into segetal and ruderal plants (ZOHARY 1973). The intensive human interference with the vegetation and environment of the Mediterranean area during the last millennia is regarded as one of the most important factors that influenced the floristic richness of the area (ZOHARY 1962, 1973; PIGNATTI 1978, 1983). There is no doubt that human interference opened new habitats for plants that are adapted to live in synanthropic habitats. However, the stigma of being an obligatory synanthropic plant has to be tested by studying the primary habitats of species by species. The last comprehensive review of the ruderal flora of the East Mediterranean was that of ZOHARY (1973). He listed the important plants of the ruderal habitats; in his account on the distribution and origin of segetals and ruderals (l.c., pp. 646-650) he did not mention any theory concerning the origin of the ruderals. Nearly non primary habitat is attributed to the ruderal plants in Flora Palaestina (ZOHARY 1966, 1972; FEINBRUN-DOTHAN 1978, 1986).

Nests of harvester ants were found to be a habitat rich in nutrients (COLE 1932, GOLLEY and GENTRY 1964, WIGHT and NICHOLS 1966, KOYUMDJISKY et al. 1967, KING 1977, OFFER 1980, BUCKLEY 1982, BEATTIE 1985, RISSING 1986, DANIN and YOM-TOV 1990, DANIN 1989). In various grasslands in the Mediterranean territories of Israel (DANIN and PLITMANN 1987) we observed circles of tall plants 1-3 m in diameter. These were nests of the harvester ants *Messor semirufus* (E. ANDRE) Santschi subsp. *semirufus* and *Messor semirufus* (E. ANDRE) Santschi subsp. *ebeninus* Eorel (AVIDOV 1968). Most of the plants that were dominants in these circles were regarded as ruderals (ZOHARY 1966, 1972; FEINBRUN-DOTHAN 1978).

The aim of the present paper is to review the supporting facts for the hypothesis that several of the common ruderal plants were preadapted to the new synanthropic habitats through association with harvester ants.

Methods and materials

Ant nests were detected by the appearance of much taller vegetation in the grassland where they developed. After detecting actual activity of harvester ants, the vegetation of the nests was recorded. The plot area was 50 x 50 cm; 10 such plots were recorded for each dominant species on the

nest's refuse zone and 10 control plots in the grassland, at least 5 m away from the nest's margin. In the study of two sites (1 and 3 in Tab. 1; DANIN and YOM-TOV 1990, DANIN 1989) all the above-ground phytomass was harvested, and dry weighed. In the rest of the sites (2 and 4-6 in Tab. 1), height of most plants was measured, total vegetation cover and relative contribution of each species was estimated (DANIN and NOY-MEIR, unpublished data). Soil fertility (nitrates, phosphorous and potassium contet) was analyzed in plots of the two species (DANIN and YOM-TOV 1990, DANIN 1989). Plant names and authors are after Flora Palaestina (ZOHARY 1966, 1972; FEINBRUN 1978, 1986).

Environment and vegetation

In all the study sites annual plants cover the entire area. The dominant plants, locations, mean annual rainfall, and soil type for the study sites are summarized in Tab. 1. The dominant species, mean number of species per plot ± SE, height or standing phytomass (expressed as dry weight of the plot) are listed in Tab. 2. The plants near the nest are 2-6 times taller than the plants among the nests. Species composition always differ from the control. The number of species per plot near the nest differs in most cases from the control. In the slightly saline soil of site 3 the number of species near the nest is higher than that of the control. In the sites where *Silybum marianum* was the dominant the number of species in the control area was significantly higher than by the ant nests. *S. marianum* seems to overtop the other species efficiently and decrease the number of its companions. A similar effect takes place in the plots dominated by *Malva parviflora* in the Judean Desert and *Beta vulgaris* in the Jordan Valley. The number of species near the nests dominated by *Chrysanthemum coronarium* and *Echium judaeum* did not differ much. However, the lists of species differ remarkably (DANIN and NOY-MEIR, unpublished data).

Association of several species with harvester ants

The physiognomic appearance of nests of harvester ants is similar for all the species that dominate on the nests (Tab. 2). All the species that dominate near the nests have much more robust individuals there than their individuals away from the nest. They are capable of responding to the rich nutrient situation and aerated soil better than any other species in the local flora. They can be regarded as eutrophic when compared with the oligotrophic (*sensu* DAUBENMIRE 1964) grassland species. Experimental work is needed to ascertain if these species respond to the high nitrate, phosphorous, or potassium content, or to their combinations. The aeration may be of great significance (GLINSKI and STEPNIEWSKI 1985).

Despite of the physiognomic similarity of the sites dominated by various species each of them has its own syndrome of adaptations to arrive and establish in the vicinity of the nest. The most advanced syndrome is that of the myrmecochorous species. Their diaspore is provided with an oily food body (elaiosome) that functions as an ant-attractant (SERNANDER 1906; BERG 1975;

Tab. 1 - Locations and habitats where ant nests and their vegetation were analyzed. Soil types are after Dan et al. (1975); rainfall data are after Dorfman (1981)

Site	Dominant species	Location	Mean annual rainfall (mm)	Soil type
1	Silybum marianum	Lower Galilee	370	Basaltic Protogrumusol
2	Malva parviflora	Judean Desert	300	Brown Lithosol
3	Malva parviflora	Jordan Valley	150	Alluvial Light Brown Soil
4	Beta vulgaris	Jordan Valley	200	Alluvial Brown Soil
5	Chrysanthemum coronarium	Jordan Valley	200	Brown Stony Soil
6	Echium judaeum	Jordan Valley	200	Brown Stony Soil

Tab. 2 - Mean number of species/plot, mean height of most plants in the plot or mean standing phytomass on the vegetation near the nest and on the control grassland

Site	Dominant	Number of species	SE	Height (cm)	SE	Standing phytomass	SE (g)
1 ants	Silybum marianum	7.3	2.0			447.3	64.0
1 control	Avena sterilis + Hordeum spontaneum	24.3	2.9			142.4	19.6
2 ants	Malva parviflora	7.7	2.2	63.3	2.9		
2 control	Erucaria rostrata	13.0	2.1	17.5	1.7		
3 ants	Malva parviflora	12.1	1.1	37.7	3.9		
3 control	Aizoon hispanicum	9.5	1.4	6.8	0.6		
4 ants	Beta vulgaris	13.5	2.0			226.6	8.8
4 control	Aizoon hispanicum	15.5	2.2			48.6	5.1
5 ants	Chrysanthemum coronarium	8.2	1.2	84.5	2.6		
5 control	Stipa capensis	8.3	1.6	49.0	3.6		
6 ants	Echium judaeum	10.2	1.6	82.5	3.7		
6 control	Stipa capensis	9.0	1.6	35.3	3.2		

BUCKLEY 1982; BEATTIE 1983, 1985). This mechanism is not reported much in literature for harvester ants in grasslands but was found to be the syndrome of *Silybum marianum* (DANIN and YOM-TOV 1990). A more generalist syndrome that functions here successfully is synzoochory (RIDLEY 1931; PIJL 1972) of species with hard coated diaspores. The ants collect the diaspores into the nest; unable to obtain all the seeds they deposit diaspores with viable seeds into their refuse zone.

The following is a list of the most common species found near ant nests in Israel with notes on their syndrome of dispersal.

Silybum marianum

The pappous wind-dispersed achenes of this species possess an oily food body that is attractive to ants (DANIN and YOM-TOV 1990). The ants perform secondary movement to the achenes that arrive by wind and collect them into the nest. They efficiently remove the food body, partly scratch the achene coat with their mandibles and do not consume the seed. Soil near the nests had 2.4 times more nitrates, 4.5 times more phosphorous, and 1.2 times more potassium as compared with the area between the nests. The weight of *S. marianum* plants near the nests was more than 9 times higher than in the control grassland. The former produced 3-4 times more heads per plant near the nest than in the grassland.

Carduus argentatus

This species resembles much *S. marianum* in its modes of dispersal. It has achenes with readily caducous pappus and oily food body (cf. FEINBRUN-DOTHAN 1978, Figs. 633, 634). Both *C. argentatus* var. *argentatus* and var. *esdrael esdraelonicus*, *C. australis*, and *C. getulus* Pomel (l.c., Figs. 631, 632) possess this body. From the illustrations of *C. australis* and *C. getulus* Pomel (FEINBRUN-DOTHAN, Figs. 631, 632) it seems that they have a food body as well. *C. argentatus* is occasionally found as a dominant near ant nests.

Notobasis syriaca

This species resembles *Silybum marianum* in its habitus and is often found together with it near ant nests. The pappus of *N. syriaca* is caducous but not as readily as that of *S. marianum*. Experiments should be made to test if there is mimicry of *N. syriaca* and *S. marianum*.

Beta vulgaris

Diaspores of *B. vulgaris* subsp. *maritima* are synaptospermic containing 1-7 seeds. Harvester ants collect such diaspores into the nest and fail to obtain most of the seeds from among the hardened sepals. They dispose the diaspores into the refuse zone (DANIN 1989). They efficiently use the seeds of other synaptosprmic diaspores such as those of *Pteranthus dichotomus*. Soil near the nests had 48.1 times more nitrates, 5.6 times more phosphorous, and 3.3 times more potassium as compared with the area between the nests.

Malva parviflora

The diaspore of this species is a 1-seeded mericarp with a very hard coat. Un-bitten whole diaspores were found in the refuse zone of nests with *M. parviflora* as a dominant or as a companion.

Echium judaeum

The diaspore of this species is a hard coated nutlet. Most nutlets, found in refuse zone of nests in sites 2-6 (Tab. 1), contained seeds and were hardly bitten.

Emex spinosa

The aerial diaspores are trigonous, spiny, 1-seedes fruits with a hard coat. Intact diaspores were found in the refuse zone of many nests in sites 2-6 (Tab. 1). *E. spinosa* was not found as a dominant near nests but was a common companion of nest vegetation where other species dominated.

Chrysanthemum coronarium

There are two types of achenes in this heterocarpous species. There are many that develop from the disc florets; they are obpyramidal with a narrow wing. There is one peripheral circle of achenes that develop from the ray florets; they are triquetrous and 3-winged. Plant debris from the refuse zone of nests from sites 4, 5, and from the coastal plain near Tel Aviv were studied. In most cases intact peripheral achenes of *C. coronarium* were found, whereas from those of the central florets mostly the empty achene coats could be detected.

Calendula arvensis

This is a polymorphic and heterocarpic species (HEYN, DAGAN and NACHMAN 1974). There are nests in sites 2-6 where *C. arvensis* is an important companion. In many of the debris-samples from the refuse zone of sites 2-6, intact diaspores of this species were found. Nearly non achenes of the «rostrate» type were found there, but plenty of the «cymbiform» and «annulate» forms (cf. HEYN et al., 1974, Fig. 5).

Conclusions

All the species that grow as dominants near nests of harvester ants are eutrophic as compared with the oligotrophic species of the grassland in the area between the nests. They have bi-modal or pluri-modal seed dispersal (PLITMANN 1986). Some of them have obvious myrmecochory as indicated by their oily food body; others have hard coated diaspores, or as in heterocarpous species, some hard coated diaspores. These modes of dispersal may be regarded as adaptations to ant dispersal. The worker ants that collect seeds and bring them into the nest do not select diaspores. It is the worker ants inside the nest that obtain seeds wherever they can and dispose the intact hard coated diaspores, together with plant debris, in the refuse zone of the nest.

The adaptations to live with harvester ants may be regarded as preadaptations to many ruderal habitats.

Apart from *Echium judaeum*, the species listed above are of the most important dominants of ruderal habitats in Israel.

Summary

The most common ruderal plants of Israel grow in association with nests of the harvester ant *Messor semirufus*. Responding to the high nutrient situation of the nest's, soil by efficient growth, the plants adapted to live near the nests outcompete most other annuals in the nest area. The true myrmecochorous species among these plants are *Silybum marianum* and the few species of *Carduus* of Israel, all of which have ant-attractant oil body (elaiosome) that has no role in seed germination. At least part of the diaspores produced by the following species are hard for ants to open: *Beta vulgaris, Malva parviflora, Chrysanthemum coronarium, Calendula arvensis*, and *Emex spinosa*. The diaspores of these plants are brought by the worker ants into the nests. When disposing the seeds that are hard to open near the nest, those listed above grow successfully and overtop most other species. Having the ability to grow successfully in nutrient rich soils these plants were preadapted to prosper in the ruderal habitats created by human activity.

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