Dan Eisikowitch & Gad Ish-Am

The ecology of crop pollination in the Mediterranean region

Abstract

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Modern crops in Israel stem from two main sources: domestication of local wild plants, and acclimation of crops from other sources. Selection is usually directed towards higher and better yields, in accordance with climate, diseases and, more recently, market demands. Pollination of the targeted crops is still neglected, partly because some of the oldest of them are wind pollinated, some are selfers, and some parthenocarpic. Among the older, locally domesticated crops some continue to be totally dependent on bee pollination, and were probably selected without the grower's awareness of the local bees' contribution. However, replacement of the local honey-bee *Apis mellifera syriaca* by the more docile but less adapted *A. m. ligustica,* and destruction of the native solitary bees' habitats, created a real crisis in local crops such as almonds, prunes, and many others. An even more serious problem has occurred with introduced plants, which were selected in their native habitats where they had co-evolved with their local pollinators. The interrelationship between the local pollinators' ecology and the crop's characters (blooming period, flower morphology, nectar flow) is, therefore, an important variable to be considered by the crop selector and breeder.

Introduction

Modern crops in Israel go back to two main sources: domestication of the local wild plants (D. Zohary & Hopf 1988) and acclimation of crop plants introduced from other regions. Crop selection has generally been directed toward better yield, climate tolerance and/or disease resistance. Unfortunately, the role of pollination has been a neglected area and still lacks appropriate study, mainly due to the fact that some of the oldest crop plants are wind pollinated, such as dates and olives; some are selfers, such as wheat, barley, peas and cicer (D. Zohary & Hopf 1988, Free 1970); and a few are parthenocarpic, such as the cultivated sycomore fig (Galil 1968, Galil & Eisikowitch 1968). However, apart from the above-mentioned crops (which are almost or totally free of pollinator involvement), others such as almonds, water-melons, apples and pears (D. Zohary 1983) were and are ultimately dependant on pollinators, mainly bees. These crops were probably selected without any particular awareness of the pollinator's role,

since these pollinators had always been part of the ecological system and had occupied man-made habitats throughout their domestic evolution.

The aim of this paper is to evaluate the role of local pollinators in the pollination and productive yield of indigenous and introduced crop plants.

The habitat

The State of Israel is part of the region occupying the eastern end of the Mediterranean basin, bordered in the west by the Mediterranean sea, in the north and north-east by the Mediterranean portions of Lebanon and Syria, in the east by the deep and hot Jordan Valley, and in the south by the Sinai desert. (Fig. 1)

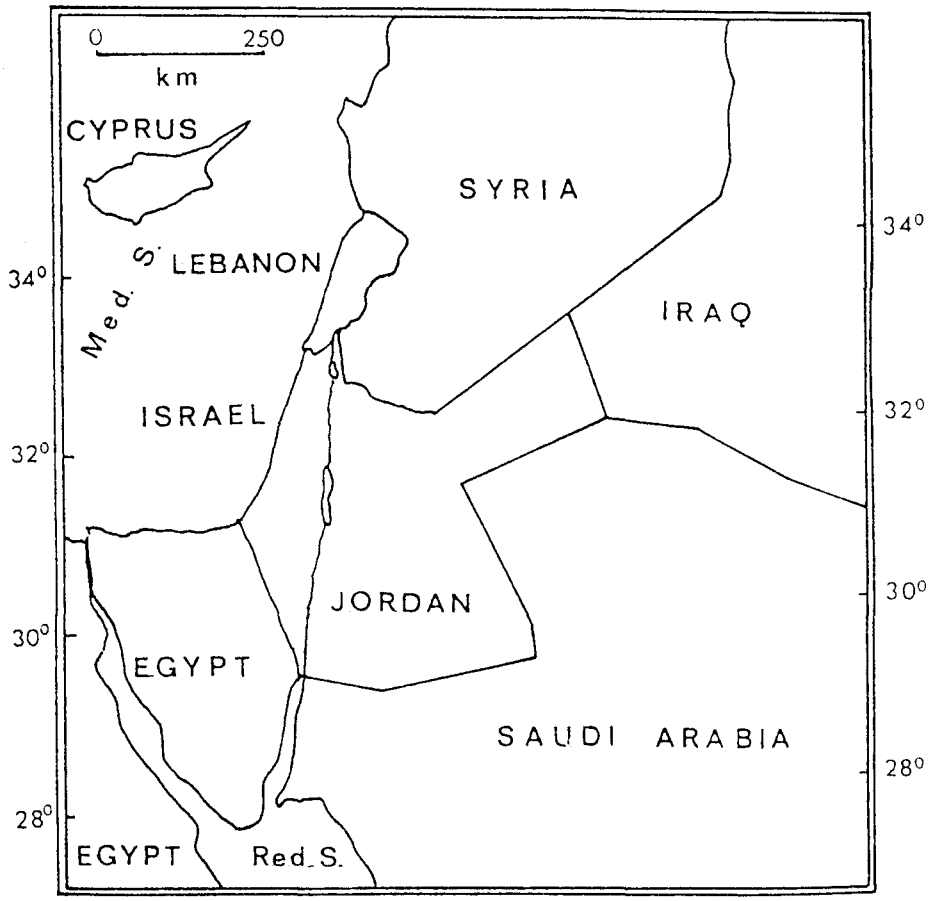

Fig. 1. Israel's location within the E Mediterranean basin.

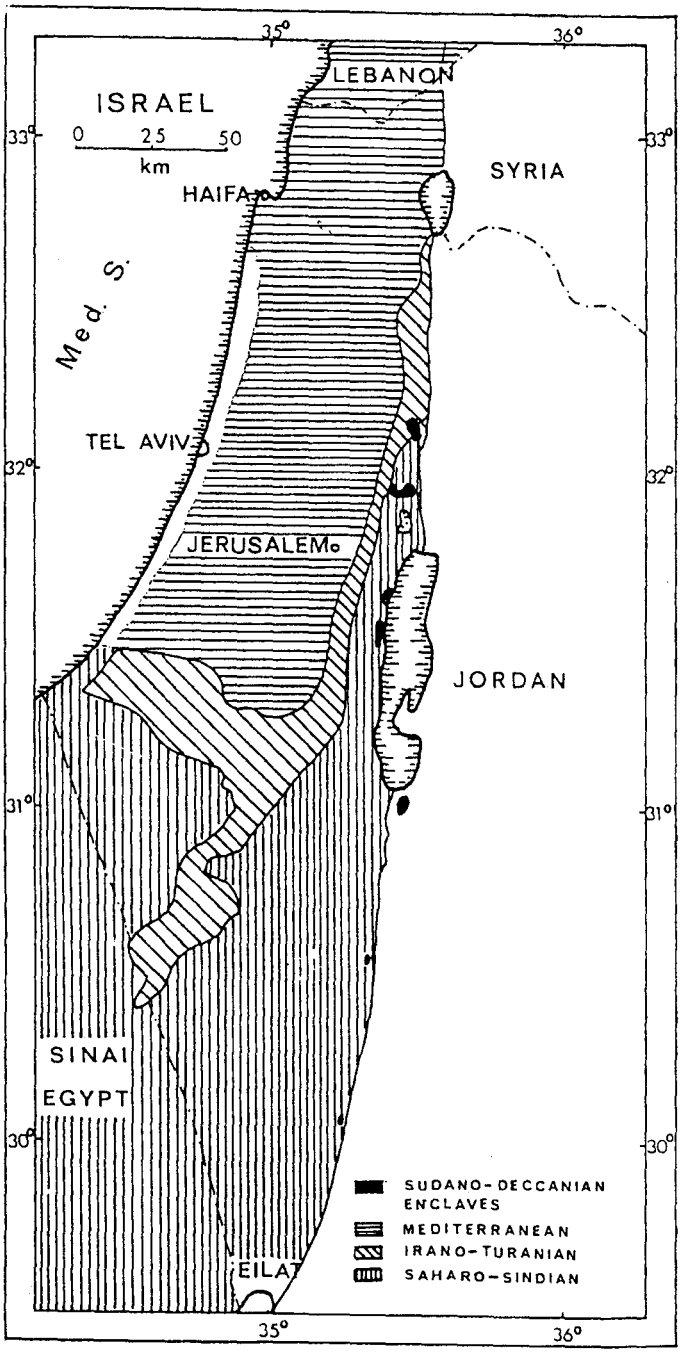

Fig. 2. Vegetation map of Israel (After M. Zohary 1962).

Due to its geographical position between the Mediterranean climatic region and the deserts, Israel's climate is highly varied, with a mean annual rainfall ranging from 1000 mm in the higher Mediterranean region to 25 mm in the extreme desert, sometimes over a distance of only 50 km. The mean annual temperature also varies, from 16°C in the north to 23°C in the southern desert (Jaffe 1988). Because of its unique climate and rich historical past, the flora of Israel displays a great variety of plant species and comprises phytogeographical elements of Mediterranean, Saharo-Arabic, Irano-Turanian, Eurosiberian and Sudanic affinity (M. Zohary 1962).

Because the distance between different climatic regions may sometimes be only a few hundred meters, in many instances plants representing two or three different phytogeographical elements can be found growing together in the same habitat. This huge habitat variety is also reflected in the richness of the bee fauna, including hundreds of species of solitary bees, a local honey-bee *(Apis mellifera syriaca),* and three species of bumblebees (Kugler 1988). Fig. 2 presents the phyto- and zoogeographical regions of Israel.

Changing the crop habitat

As mentioned, the Mediterranean basin comprises many habitats with various ecological niches. An ecological niche has been defined by Wallace & Srb (1961) as a "unique constellation of environmental factors that may be capable of supporting a given form of life". Usually the mentioned factors are temperature, edaphic conditions,

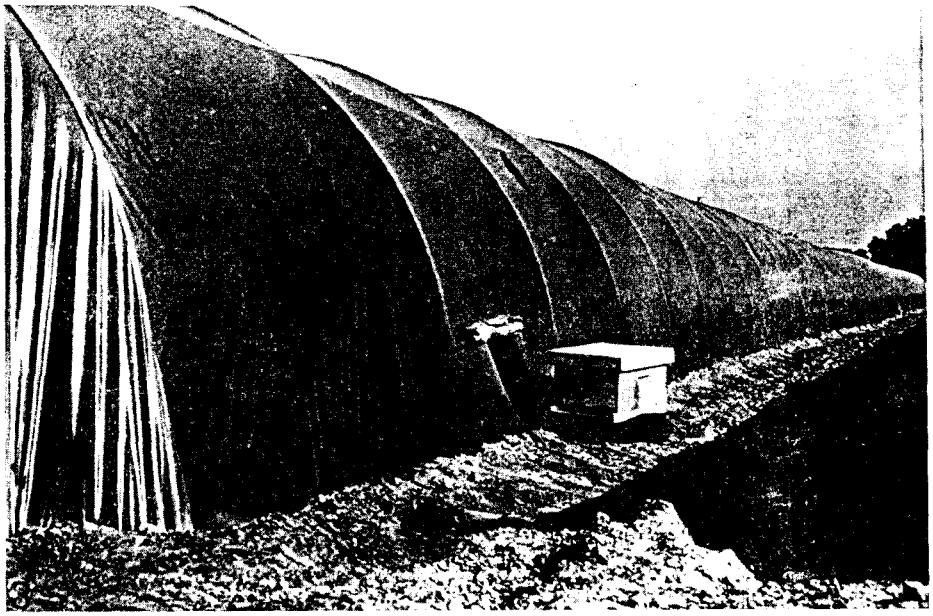

Fig. 3. Greenhouse with hive in the desert.

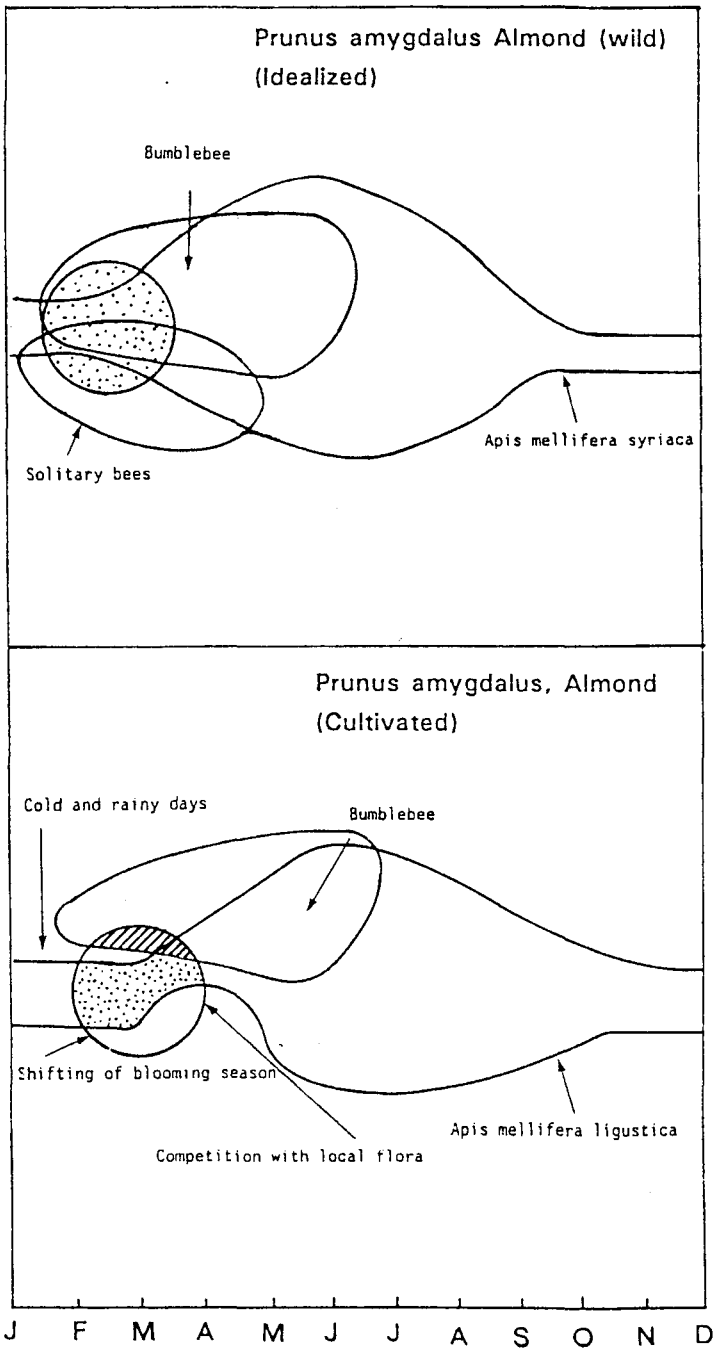

Fig. 4. Hypothetical diagram of niche space of wild (A) and cultivated (B) almonds with their pollinators. – Horizontal axis: time (Jan-Dec); vertical axis: environmental variables.

and illumination, as well as predation, competition, and parasitism (Odum 1971, Krebs 1985). The pollination requirement as an important ecological variable is generally ignored, despite of the fact that pollination may be a limiting factor for the propagation and dispersal of plants. The last 70 years of intensive development in Israel has turned many natural habitats into agricultural and urban areas, using such modern mechanical methods as deep ploughing, monoculture in orchards, and fertilization and pest management by chemicals. All of these factors have caused a dramatic habitat destruction, eliminating the bees' nesting sites with a consequent significant decline in their populations (Kugler, pers. comm.).

The local honey-bee, *Apis mellifera syriaca,* which was adapted to the local habitat (Dietz 1982, Ruttner 1988), was replaced by the more docile but less adapted Italian honey-bee *A. m. ligustica* (Ben-Neriah 1964), which further reduced the potential pollinators' numbers and efficiency. Modern agriculture also shifted toward the desert, while the use of greenhouses and plastic covers created a partition between the target crops and the local pollinators (Fig. 3). All of these resulted in a serious pollination crisis, both in the local and introduced crops.

In order to achieve pollination, a partial overlap between the plants' niches and those of its pollinators must normally occur. *Ficus carica,* for example, is absolutely dependent on its pollinator and will never produce normal-seeded fruits without its mutualistic wasp, *Blastophaga psenes.* For this reason fig formation in the U.S. failed when the common fig was first introduced to California (Condit 1963). *Ficus* is an exceptional case of specialist plant, having complete niche overlap with its pollinator. Most of the other crops are less specialized and therefore less dependent on one particular pollinator.

The cultivated almond, *Amygdalus communis* varieties, were probably selected from wild type ancestors within their habitat in the Mediterranean region. Thus this plant was exposed to a wide range of native pollinators, such as *Apis mellifera syriaca* and solitary bees like *Andrena, Lasioglossum, Osmia,* and *Antophora* species (C. O'Toole, personal communication), as well as the social bee *Bombus terrestris* (personal observations). The generalistic flower character of almond and its flexibility within the frame of a wide range of pollinators enabled a broad distribution of cultivated almond through Israel and other Mediterranean countries. However, mass plantation of cultivated almonds demanded a huge pollinator population, while local pollinator populations dwindled and became less apt to face the almonds' demands. Furthermore, the blooming period of the cultivated almonds became postponed for 2-3 weeks so that they became exposed to higher competition by local wildflowers (personal observations). As a result, the overlap between almonds and their available pollinators was reduced and pollination became a serious limiting factor for fruit set (Fig. 4).

The fate of introduced crop plants, under modern agricultural condition, shows many similarities with that of local plants growing in urbanized areas. Avocado *(Persea americana),* for instance, was introduced to Israel about 60 years ago (Oppenheimer 1980). It had come from Central America, where its flower morphology and floral reward had co-evolved with the local wasps *(Vespidae),* stingless bees *(Meliponinae),* and certain beetles (Papademetriou 1976; Free & Williams 1976; Davenport 1986;

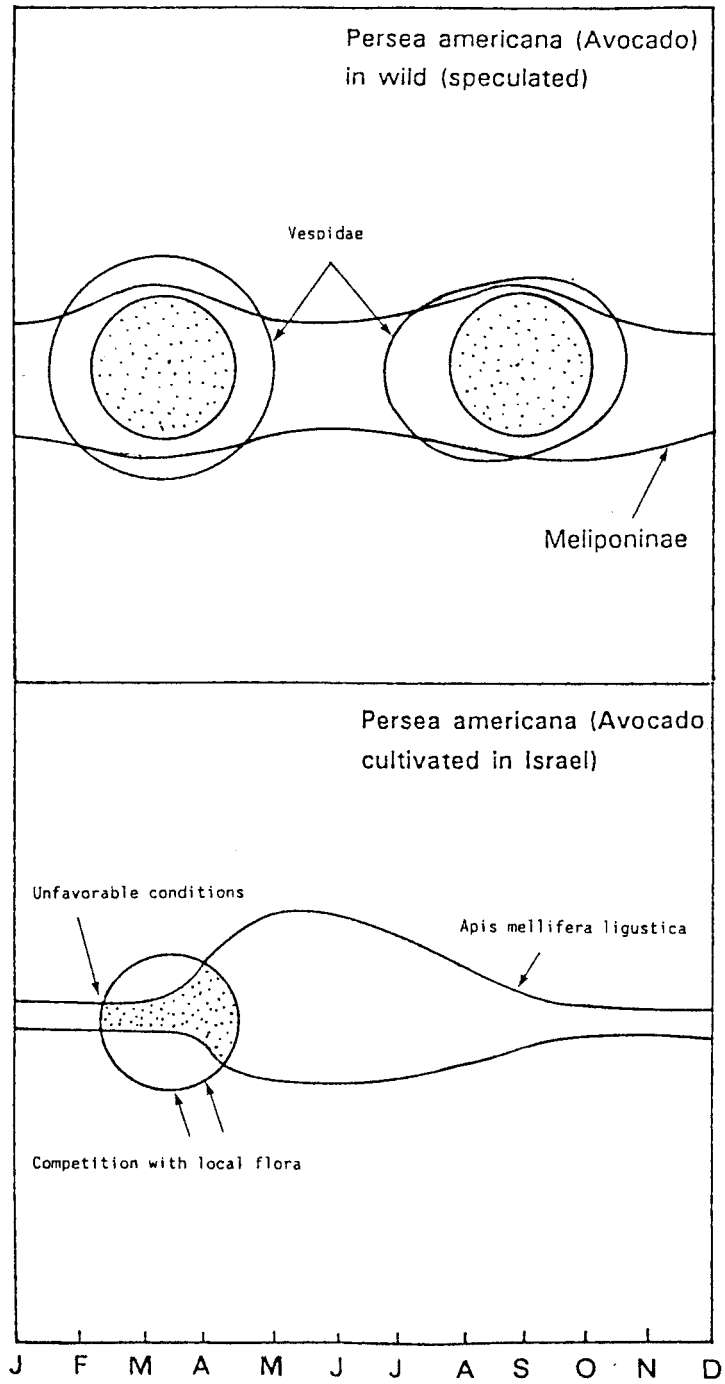

Fig. 5. Hypothetical diagram of niche space of wild (A) and cultivated (B) avocado with their pollinators. – Horizontal axis: time (Jan-Dec); vertical axis: environmental variables.

Gazit, personal communication). When avocado was transferred into the Mediterranean conditions of Israel, honey-bees were found to be its only possible pollinators, and therefore hives were regularly placed in avocado orchards in Israel. However, during most of the avocado blooming period the honey-bees leave the orchards, attracted by citrus flowers as well as wildflowers of the *Cruciferae, Papilionaceae,* etc. This competition for pollination has led to a dramatic reduction in fruit set of avocado in these orchards (Fig. 5) (Ish-Am & Eisikowitch 1992).

Conclusions

The Mediterranean basin, being the cradle of many nations and cultures, has also served as a melting pot for a variety of locally developed crops, and for many imported species. The great number of local bees and other insects constituted a source of pollinators, the local crops and their pollinators having coadapted throughout the long evolution of the Mediterranean region of Israel.

However, due to lack of political foresight to accompany the introduction of modern agriculture and urbanization during the last decades, the rich fountain of potential pollinators in Israel has dwindled significantly, and in certain cases, such as the local honey-bee, has almost vanished.

Currently, most of the cultivated crops in Israel that require pollination must rely on the commercial honey-bee. Learning from past mistakes, when new varieties of crops are created by means of selection, breeding, or genetic engineering, or are imported, the role of pollination must be borne in mind. The less a plant is dependent on pollination, the easier it will become adapted (provided that it also can face all other demands). If a pollinator is required, however, a careful investigation should be carried out in order to find a match, among the available pollinators, for the plant's flowering features.

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Address of the authors:
Dan Eisikowitch & Gad Ish-Am, Department of Botany, Tel Aviv University, Tel Aviv 69978, Israel.