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Major Pollen Plant Species in Relation to Honeybees' Activity in the Jordanian Desert Area

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ABSTRACT

This study was conducted in Badia region, North East part of Jordan, during 2000 and 2001 to determine different plant species visited by workers of honeybees, *Apis mellifera* L. for pollen collection and the relationship of these plants with the honeybee activities under local conditions in the arid region. Palynological analysis of pollen loads showed that bee foragers visited 44 desert plant species in 16 plant families. The bees were efficiently pollen foragers in the springtime, carried their highest loads and stored more pollen at this time of the year. Bee workers tended to fly in the morning and reduced their activity in mid and late hours of the day. Jordan Badia, in spite of being an arid land with low rainfall each year, is a potential area, not only as rangeland, but also has good potential for beekeeping.

Key Words: *Apis mellifera*; Jordan; Badia; Pollen grains; Honeybees

INTRODUCTION

The arid land, or Badia region, encompasses a wide and significant part of Jordan. It extends from North to South in the eastern part of the country, covering an area of approximately 72,600 km², which constitutes 81% of the total area of Jordan. The total population of the Badia represents about 5% of the whole population of the country. Only 5% of the Badia population is still nomadic; the rest are now settled. In this region, climate is continental with large diurnal and seasonal temperature fluctuations. Air temperature fluctuates from a daily mean minimum of 10ºC to a mean maximum of 24.5ºC, with a mean daily temperature of 17.5ºC. Occasionally absolute minimum and maximum temperature might reach -5 and 46ºC, respectively. Rainfall is subject to drastic fluctuations by place and season. The mean annual rainfall varies from less than 50 mm in the south up to 250 mm in the northwest on the highland (Meteorological Department, 1998). In Badia, barley is the main field crop in dry farming, while forage, vegetables, fruit orchard and wheat are grown under irrigation. Recent study in plant taxonomic resulted in an increase in the total list of recorded plant species from 150 to 223 (Cope & El-Eisawi, 1998).

Beekeeping is an integral part of mixed farming system in many parts of Jordan and is also practiced as a cottage industry, especially in rural areas. Previous preliminary investigations revealed that North Badia in Jordan is an adequate area for apiculture (Haloua, 1989; Al-ghzawi *et al*., 2001). It is also obvious that the success of developing modern beekeeping in the country depends not only on using better strains of bees but also on the abundance and richness of nectar and pollen around an apiary (Mattu *et al*., 1989). Sugden and Furgala (1982) found a positive correlation between honey production and foraging activity of the honeybee. Moreover, pollen collection correlated significantly with honey production (Cale, 1967). Pollen is the sole source of protein and lipids in the diet of honeybees, and is crucial for their survival and development (Stanley & Linskens, 1974; Schmidt & Buchmann, 1999).

The present work was undertaken to assess the beekeeping potentialities in the Badia region by identifying the different plant species visited by workers of honeybees, *Apis mellifera* L. for pollen collection and their relationships with honeybee activity under local conditions in the arid region, of northeast Jordan.

MATERIALS AND METHODS

To study the local vegetation and utility of the component species as sources of bee forage during 2000 to 2002, twelve colonies of *Apis mellifera* L. were used. Each colony was established in a standard one-storey, 10- frame Langstroth hive in an apiary of Badia Research and Development Program, Safawi, Jordan. At the beginning of the experiment, all colonies were equalized to have similar amount of worker bees, brood combs, and stored food. The colonies were transported to the experimental sites and kept there over the period of experiment. In the study area, the colonies were supplied continuously with water and protected from sunlight by shading. All management practices including feeding, supering, swarm prevention and *Varroa*-control was carried out to the colonies as necessary.

To study the foraging activity of the bees under desert condition, the number of foragers returning to the hive entrance was recorded for one minute duration on an hourly basis between 06.00 to 16.00 h for one day every two weeks

(Nye & Mackensen, 1970). Foraging efficiency of a colony was measured in terms of number of bees with pollen load entering the hives. The amount of pollen stored inside the hives was measured using the same procedure used for bees and brood counting according to the procedure described by Gerig (1983).

Pollen samples were collected at regular two weeks intervals for a period of two years by means of pollen traps fitted to the entrances of the hives and left for a period of 24 h. Ten pollen loads were chosen at random from each pollen trap in each sampling date. Pollen samples were cleaned, dried at room temperature and weighed. Qualitative pollen analysis of the honey samples was carried out following the usual methods as described by Louveaux *et al.* (1978). Also pollen collected in the pollen traps was identified with the help of the reference pollen slide collection made from another specimen of the desert flora at the honeybees' laboratory. The identification of individual pollen types was made up to family, genus or even up to species level wherever possible.

RESULTS

The analysis of pollen loads showed that the bees visited 44 flowering plant species belonging to 16 plant families (Table I). The highest diversity of pollen plants were found in the Compositae family (14 plant species) followed by the Cruciferae family (eight plant species) and the rest families had a very limited pollen plant species growing in the arid areas. The flowering time for most of desert plants extended between February and June, with an exception in the case of *Anapasis sp.* and *Artemisia inculata* that flower between September and December each year.

Clear fluctuation in pollen collection by the honeybee workers was found in the different months of the year as shown in Fig. 1. Low pollen collectors percentage was recorded in the winter months (December- January). As the number of flowers increased during March to June, double peaks of pollen foraging bees appeared during this period. The first peak was in March, in which 72 and 81% of the returned bees were loaded with pollen, the second peak was in May with 75 and 79% for the years 2000 and 2001, respectively. In June, the high flowering rate and favorable environmental conditions especially in the morning prevailed, but the numbers of pollen foragers were down to 39 and 44% for the years of 2000 and 2001, respectively. With the increased summer temperature and drying of most plants, the pollen foraging came down sharply to its lowest level in both years of the study.

The monthly fluctuations in pollen collection over the two years of the study period resulted in great differences in the stored pollen in side the hives as shown in Fig. 2. In the first few months of the year little pollen was stored inside the hives. With the increased pollen collection in early spring months, a peak of storage pollen cells was reached in March in both years of the study. However, a reduction of pollen collection was noticed in April while in May the bees collected high amounts (Fig. 1). This was synchronous with less stored pollen (Fig. 2). In the late summer and autumn a very limited volume of stored pollen was found inside the hives.

Great daily differences in pollen foraging were recorded during different times of the day as shown in Fig. 3. Only 18% of the returned workers at 06.00 were loaded with pollen. Two hours later at 08.00 the air temperature became more favorable, the workers engaged in pollen collection in which (31%) of the returning workers were loaded with pollen. As the temperature fluctuated up, the workers reduced their pollen collection accordingly and very rapidly. Similar trend was noticed in the second year 2001.

Pollen loads were not the same throughout the year. There were great monthly fluctuations in the average weight of the pollen loads carried by the workers as shown in Fig. 4). The workers tended to carry more pollen during March of the years 2000 and 2001 with an average of 10 loads to the value of 0.168 and 0.186 g, and 0.156 and 0.147 g in May during the same years respectively. In the other months of the year, the loads carried by the workers varied from month to month.

DISCUSSION

As a result of the rainy season in December and January, the commencement of bee forage started in February with the initiation of flowering of some of the major source of pollen plant species (Table I), such as *Aizoon hispanicum, Aaronsohnia factorovskyi, Calendula tripterocarpa, Diplotaxis harra, Eruca sativa, Malcolmia crenulata, Erodium deserti, Vicia perigrina, Malva sp*. and other plant species. This is the period of the first pollen collection. The flowering start of *Heliotropium ramosissimum, Capparis leucophylla, Achillea fragrantissima, Anvillea garcinii, Notobasis syriaca, Onopordon heteracanthum, Tragopogon collinus, Cardaria draba, Citrullus colocynthis, Prosopis farcta* and *Reseda alba* from April to June enhanced the pollen foraging behavior of the bees, causing a second period of pollen collection. The only plant species that flowered in the late summer time and were visited by the bees were *Anabasis setifera* and *Anabasis syriaca* of the family Chenopodiaceae and *Artemisia inculata* of the Compositae family. All these plants were desert plants grown as a native plants in the Badia region (El-Eisawi, 1998; Cope & El-Eisawi, 1998).

The success of beekeeping in different areas depends mainly on the availability of the food source from suitable flowering plants (Crane, 1990). In spite of the hot dry summer and cold winter in the Jordan desert areas, flying activities of the workers outside the hives were performed all over the year as presented in Fig. 1. This gave an

Table I. Pollen plants visited by bees in the Jordanian Badia areas

Family	Common name	Scientific name	Flowering period
Aizoaceae	Aizoon	*Aizoon hispanicum*	February - April
Boraginaceae	Yellow Heliotrope	*Heliotropium ramosissimum*	April - June
	Millers Alkanet	*Anchusa mileri*	March - April
Capparaceae	Caper	*Capparis leucophylla*	March - June
Chenopodiaceae	Anabasis	*Anabasis setifera*	September - October
	Anabasis	*Anabasis syriaca*	September - October
Cistaceae	Sun rose	*Helianthemum lippii*	March - May
Compositae	Aaronsohnia	*Aaronsohnia factorovskyi*	February - April
	Lavender cotton	*Achillea fragrantissima*	May - July
	Desert Chamomile	*Anthemis melampodina*	March - May
	Arabian Oxeye	*Anvillea garcinii*	April – June
	Herba-alba	*Artemisia inculata*	September- December
	Marigold	*Calendula tripterocarpa*	February- May
	Sand Centaury	*Centaurea ammocyanus*	March – May
	Iberian Centaury	*Centaurea iberica*	March – May
	Pale Centaury	*Centaurea pallescens*	March – May
	Sinai Centaury	*Centaurea sinaica*	March – May
	Syrian Thistle	*Notobasis syriaca*	April – June
	Cotton Thistle	*Onopordon heteracanthum*	May – July
	Viper's Grass	*Scorzonera judiaca*	March – May
	Goat's Beard	*Tragopogon collinus*	March- July
Cruciferae	Hoary Pepperwort	*Cardaria draba*	April – June
	Diplotaxis	*Diplotaxis harra*	February - May
	Garden Rocket	*Eruca sativa*	February - May
	Common Malcolmia	*Malcolmia crenulata*	February - May
	White Mustard	*Sinapis alba*	March – May
	Rocket	*Sisymbrium orientale*	March – April
	Globe Mustard	*Texiera glastifolia*	March – May
	Zilla	*Zill spinosa*	March – May
Cucurbitaceae	Coloycynth	*Citrullus colocynthis*	April – August
Geraniaceae	Stork	*Erodium cicutarium*	March - May
	Stork	*Erodium deserti*	February – May
Leguminosae	Mesquite	*Prosopis farcta*	May - June
	Medick	*Medicago laciniata*	March - May
	Melilot	*Melilotus indica*	March – May
	Vetch	*Vicia perigrina.*	February - April
Malvaceae	Yellow Hollyhock	*Alcea chrysantha*	March – May
	Mallow	*Malva sp.*	February – May
Primulaceae	Pimpernel	*Anagallis arvensis*	March – May
Resedaceae	Mignonette	*Reseda alba*	March – June
Scrophulariacae	Transjordan Mullein	*Verbascum transjordanicum*	March – April
	Mullein	*Verbascum fruticulosum*	March – May
Tamaricaceae	Tamaisk	*Tamarix nilotica*	March – May
Zygophyllaceae	Peganum	*Peganum harmala*	March – May

indication that the colonies did not have a real winter cluster. Flying activities in the flowering period is governed by nectar and/or Pollen collections, also flying in dry seasons is governed by water collection or cleaning flight.

The number of plant species whose pollen was represented in the trap content each month showed a double cycle in the year. The first one was observed during February and March when herbaceous plants came into flower after the rains and the second came during May and June during the early part of summer season each year. In such areas as dry lands, the availability of moisture is the major factor that determines the spatial distribution and the abundance of plant species (Anderson, 1971). Minimum number of plants blooming was found in the summer months as a result of the very hot dry conditions of this time of the year.

Data obtained in this study indicated that there were seasonal fluctuations of pollen collection by honeybees with two well-separated peaks over the two years of the study period. Low pollen collection percentage was recorded in the winter months (December- February), which is characterized by low plant flowering density (Cope & El-Eisawi, 1998) and unfavorable environmental conditions with cold nights and low daytime temperatures. The increased number of flowers during March to June enhanced the bees to collect more pollen resulting in double peaks of pollen foraging during this period. The first peak was in March, where 72 and 81% of the returned bees were loaded with pollen. The second peak was in May with 75 and 79% for the years 2000 and 2001, respectively. Cold snaps and sandstorm conditions that prevailed in April of both years resulted in observed reduction of flying activities, which led to great reduction of pollen foraging during this period. The role of weather condition as a limiting factor in pollen

Fig. 1. Seasonal variations in the percentage of pollen foragers throughout the year

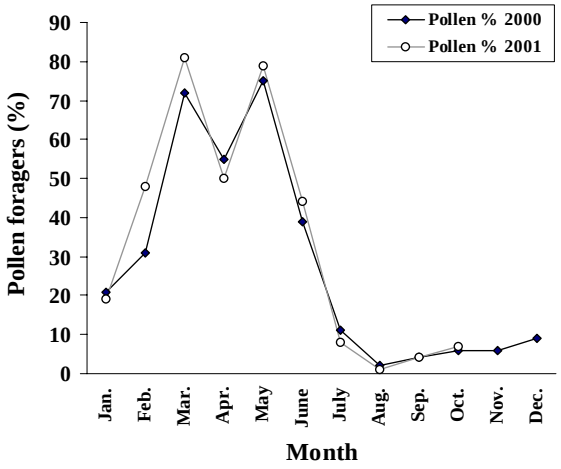


Fig. 2. Seasonal variation of pollen storing cells over two years of study

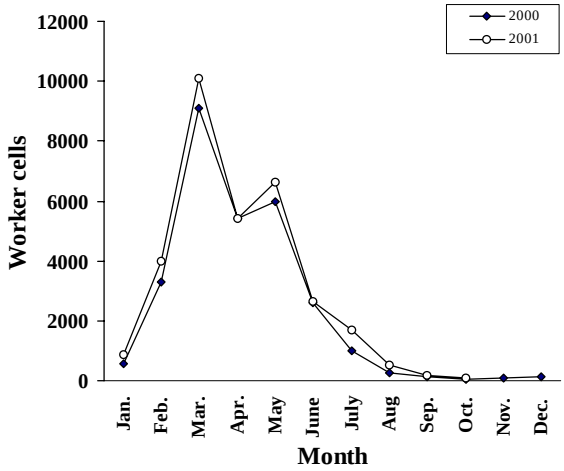


Fig. 3. Diurnal pollen foraging activity at two hours interval

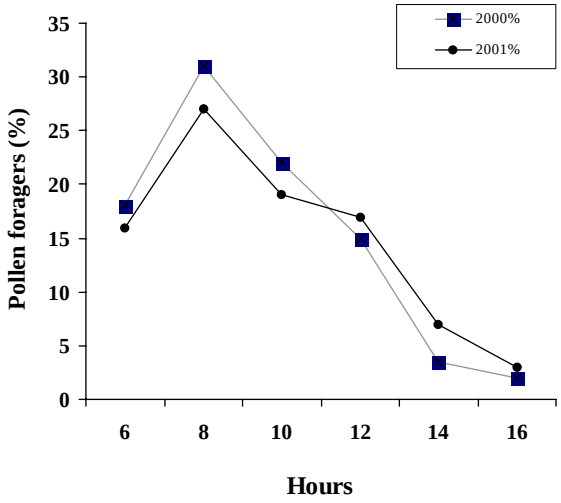
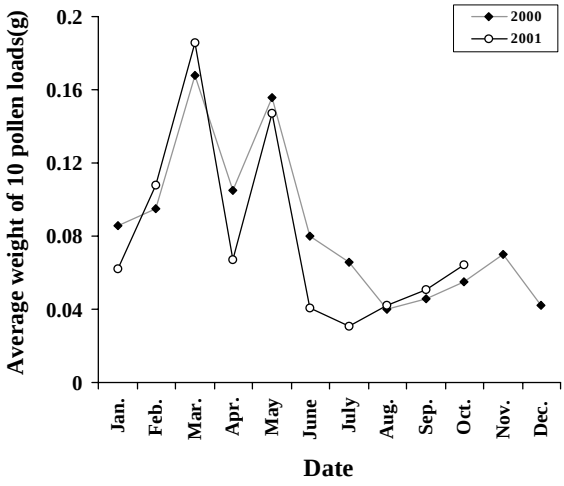


Fig. 4. Seasonal changes in the average weight of 10 pollen loads in grams



collection was studied by Lundie (1925) and Butler (1945), they demonstrated that the environmental factors outside the hive affect the tendency and efficiency of nectar and pollen collection by honeybees. There are several other factors that affect pollen collection such as the design of the trap, the size of the worker bees, the pollen load they carry in relation to the mesh of the grids in the trap (Levin & Loper, 1984) and the bees' agility and learning ability in maneuvering their loads through the grids (Louveaux, 1954).

In June, the high flowering rate and favorable environmental conditions especially in the morning prevailed, but the number of pollen foragers was reduced to 39 and 44% for the both years, respectively, possibly because the bees were more selective in gathering nectar rather than pollen. Rinderer *et al.* (1985) observed that; when nectar was abundant; European bees collected more and larger nectar loads. With the increase in summer temperature during July and August and drying of most plants, the pollen foraging reduced sharply to its lowest level in both years of the study.

The monthly fluctuations in pollen collection over the two years of study period resulted in great differences in the stored pollen inside the hives as shown in Fig. 2. In the first few months of the year little pollen was stored inside the hives. With the increased pollen collection in early spring months, a peak of storage pollen cells was reached in March in both years of the study. However, the reduction of pollen collection in April was noticed as a result of the reduced flying activities as mentioned earlier. Even though high amount of pollen was collected in May (Fig. 1) less amounts of pollen was stored (Fig. 2) as a result of high consumption rate for larval food and the increased honey collection,

which restricted space available for pollen storage. El-Sarrag *et al.* (1989) and Mclellan (1978) reported similar storing patterns. In the late summer and autumn, very limited value of stored pollen was found inside the hives.

Great daily differences in pollen foraging were recorded during different times of the day as shown in Fig. 3. Only 18% of the returned workers at (06.00) were loaded with pollen. Two hours later at (08.00) the air temperature became more favorable, the workers engaged in pollen collection in which (31%) of the workers returning to their hives were loaded with pollen. Later the temperature fluctuated up, so the workers reduced their pollen collection accordingly and very rapidly. Similar trend was noticed in the second year 2001. These results are in agreement with the findings of Mbaya (1984) who reported similar foraging patterns, in which the bees were more active in the early hours of the morning.

Pollen loads were not the same throughout the year. There were great monthly fluctuations in the average weight of the pollen loads carried by the workers (Fig. 4). The workers tended to carry more pollen during March of the years 2000 and 2001 with an average of 10 loads to the value of 0.168 and 0.186 g, and 0.156 and 0.147 g in May during the years 2000 and 2001, respectively. The other months of the year the loads carried by the workers varied from month to month as affected by different factors such as the temperature (Rashad *et al.*, 1980), relative humidity (Percival, 1965) and the attractiveness of pollen grains to honeybees (Bicchi *et al.*, 1982).

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