Arxius de Miscel·lània Zoològica, 4(2006): 42–48

Diversity of bees (Hymenoptera, Apiformes) in extensive orchards in the highlands of Jordan

A. Al–Ghzawi, S. Zaitoun, S. Mazary, M. Schindler & D. Wittmann

Al–Ghzawi, A., Zaitoun, S., Mazary, S., Schindler, M. & Wittmann, D., 2006. Diversity of bees (Hymenoptera, Apiformes) in extensive orchards in the highlands of Jordan. *Arxius de Miscel·lània Zoològica*, vol. 4: 42–48, Doi: http://doi.org/10.32800/amz.2006.04.0042

Abstract

Diversity of bees (Hymenoptera, Apiformes) in extensive orchards in the highlands of Jordan.— Bees visiting the blossoms of fruit trees were surveyed for the first time in Jordan. A transect was determined in Ebbin village in Ajlun (32° 22" N, 35° 49" E) where the bees were collected from blossoms of stone fruit trees. Most of the specimens were identified up to the species level and few specimens were identified up to the genus level only. A total of 1,461 specimens were collected during the study period and 53 bee species were identified and recorded for the first time in Jordan. The collected species represented five families: Apidae, Megachilidae, Halictidae, Andrenidae and Colletidae. The results showed that Apidae and Megachilidae were the largest in terms of diversity, while Halictidae showed the highest abundance.

Key words: Pollinators, Stone fruit trees, Wild bees, Insects, Jordan

Resumen

Diversidad de abejas (Hymenoptera, Apiformes) en huertas extensivas de las zonas montañosas de Jordania.— Por primera vez se ha realizado un inventario de las abejas que visitan los árboles en flor de Jordania. Se determinó un transecto en el pueblo de Ebbin, Ajlun (32° 22" N, 35° 49" E) donde las abejas se recolectaron en las flores de árboles frutales de hueso. La mayor parte de los especímenes se identificaron hasta el nivel de especie y algunos únicamente hasta el nivel de género. Durante el periodo del estudio se recolectaron un total de 1.461 especímenes. Ha sido la primera vez que se han identificado y registrado 53 especies de abejas en Jordania. Las especies recolectadas representan a cinco familias: Apidae, Megachilidae, Halictidae, Andrenidae y Colletidae. Los resultados han revelado que las familias Apidae y Megachilidae son las mayores en términos de diversidad, mientras que la Halictidae es la menor en términos de abundancia.

Key words: Polinizadores, Árboles frutales de hueso, Abejas, Insectos, Jordania

Rebut: 25/01/2006; Acceptació definitiva: 01/12/2006

A. Al–Ghzawi[1] & S. Mazary, Dept. of Plant Production, Fac. of Agriculture, Jordan Univ. of Science and Technology, P. O. Box 3030, 22110 Irbid, Jordan; S. Zaitoun, Dept. of Biotechnology, Fac. of Agricultural Technology, Al–Balqa' Applied Univ., Al–Salt, Jordan; M. Schindler & D. Wittmann, Inst. of Agricultural Zoology and Bee Biology, Melbweg 42, 3127 Bonn, Germany.

[1]E–mail: ghzawi@just.edu.jo

Introduction

Jordan has an area of 89.3 thousand km^2 and only 0.6% of the country is water. It has a wide variety of climates and altitude ranges from 300 m below sea level to 1,600 m above sea level. These conditions permit a great diversity of insects, plants and animals. The total area presently occupied by stone fruit trees is estimated to be 883 thousand donums (1 donum = 1,000 m^2) with approximately 16,816 million trees, constituting 33.9% of the total agricultural area (Anon, 2004). Fruit trees are planted mainly in the Mediterranean and Saharo–Arabian regions that are characterized by cool winter temperatures. Vargas & Romero (1987) cited that under Mediterranean conditions, almonds usually bloom early in the season when daylight is short and the temperature is cool. Such conditions influence the activity of insect pollinators, and consequently lead to inadequate pollination.

Many kinds of insects visit flowers of crop plants, weeds and natural vegetation (Kevan & Baker, 1983). The common European honeybee is credited with nearly all the pollination in nature and agriculture (Parker et al., 1987; Batra, 1995; Kearns et al., 1998). Bees particularly pollinate one or more cultivars of over 66% of the world's crop species (Morse & Calderone, 2000) and they are directly or indirectly responsible for about 15–30% of food production (McGregor, 1976). In Jordan, imported races of *Apis mellifera*, besides the native *Apis mellifera syriaca*, are kept not only for honey and wax production but are also widely used as pollinators for the majority of cultivated species requiring insect pollination (Zaitoun, 2000; Hajeer, 2005). As pollination activity of honeybees is low in cold temperatures, current deadly infectious diseases such as *Acarapis woodi* and *Varroa destructor* (Oldroyd, 1999) and low economic significance (Bienenfeld, 1996; Williams et al., 1991) have increased the cost of *Apis mellifera* hive introduction and maintenance in agriculture zones. This highlights the need to find alternative species for use as managed crop pollinators (Sugden, 1993). Wild bees can be equal or better pollinators than *Apis mellifera* for important agricultural crops such as Solanaceae plants (O'Toole, 1993) and forage legumes (Richards, 1996). Interest has grown in finding non–*Apis* pollinators that are potentially useful in orchards.

In stone fruit trees orchards in the highlands of Jordan, farmers consider the pollination problem to be of economic importance. Low activity of honeybees in cold temperatures during the flowering period of stone fruit trees leads to inadequate pollination and decreases production. Another alternative to this problem would be to find wild bees able to pollinate in periods of low temperatures and to rear them to a suitable population level. Knowledge of native bees that might contribute to the pollination of crops such as fruit trees in the area and in the neighboring countries is lacking. Jordanian farmers presently consider it is critical to identify such insects, studying their life–cycle and rear them for use as pollinators. This study was therefore performed to survey, identify and estimate the abundance of the bee species that visit the flowers of stone fruit trees grown in the highlands of Jordan under Mediterranean conditions. Basic knowledge of native insect pollinators is required to increase their numbers by means of successful management rearing programs in order to improve fruit tree productivity in the area.

Material and methods

Study site

The study was performed in the surroundings of Ebbin village (32° 22" N, 35° 49" E), Ajlun district (1,150 m a.s.l.) in northern Jordan. The region is characterized by a Mediterranean climate with cold rainy winter and a relatively hot summer. Bees were collected on a transect through mostly rain–fed stone fruit orchards and their surroundings composed of fruit trees, evergreen oak woods and uncultivated plains with sparse herbaceous vegetation.

Collecting and mounting of insects
Species richness of flower visitors to the stone fruit trees was studied in spring at the height of flowering. Bees visiting the stone fruit trees in the transect sector were caught by sweep netting. Insect visitors were collected weekly on a sunny day between 09:00 and 14:00 throughout the entire flowering period. Only flower–visiting wild bees (not honey bees) were included in this study. The collected specimens were killed in ethyl acetate jars and stored in paper envelopes. Time and date of collection were documented for each specimen. In the lab, specimens were pinned, mounted and oven–dried for 24 hours at 40°C. Each specimen was attached to an independent label containing the collecting time and date, area of collection and scientific name of the host plant. All specimens were kept in special insect boxes supplied with foam plates for pinning and naphthalene balls to enable long storage without pest damage. Voucher specimens of bees are kept in the Laboratory of Beekeeping, Faculty of Agriculture / Jordan University of Science and Technology.

Identification of specimens
Initial identification to the genus level was conducted in the labs of the Jordan University of Science and Technology and Al–balqa Applied University. Identifications were further approved and identified to species level by M. Schwarz (Ansfelden, Austria) [Nomada, Sphecodes, Thyreus], M. Kuhlmann (Münster, Germany) [Colletes], E. Scheuchl (Velden, Germany) [Andrena], A. Müller (Zürich, Swiss), A. Ebmer (Linz, Austria) [Halictus, Lasioglossum, Pseudapis, Nomia] S. Risch (leverkusen, Germany) [Eucera].

Results

Survey of bees
Table 1 shows classification and total number of collected specimens of wild bee species visiting the flowers of stone fruit trees during the study period. A total of 1461 bee individuals were recorded visiting flowers of stone fruit trees. 1411 specimens were identified up to the species level. The remaining specimens were identified only up to the genus level. 53 species were recorded for the first time in Jordan. These species belong to 23 genera in five families, namely Apidae, Megachilidae, Halictidae, Andrenidae and Colletidae of the suborder Apocrita. Bees from the families Halictidae and Apidae were the most frequent native insect visitors to the flowers with 803 and 267 individuals respectively. Megachilidae (192 individuals) and Andrenidae (170 individuals) families were intermediately abundant. The least abundant bees represented the family Colletidae (29 individuals only).

Discussion

During the study period, a total of 53 insect species were identified visiting flowers of stone fruit trees. They belonged to five families (Apidae, Megachilidae, Halictidae, Andrenidae and Colletidae) of the order Hymenoptera. The same bee families have been recorded previously as visitors and pollinators of blossoms of stone fruit trees in other countries of the world, and also of blossoms of vegetable crops and wild plants in the natural landscape (Free, 1993).

Identification of 53 different bee species visiting blossoms of stone fruit trees in an restricted area and in a short period of the year supports the richness of bee fauna in this Mediterranean climate area. This finding supports the observation of Michener (2000) regarding bee fauna in the Mediterranean climate as in warm–temperate desertic areas with more or less regular rainfall; the differences in faunas could be due to variations in size and local

Table 1. Diversity of insect species visiting the blossoms of fruit trees and wild plants.
Tabla 1. Diversidad de especies de insectos que visitaron árboles en flor y plantas silvestres.

Family	Subfamily	Tribe	Genus	Species	Determination
Apidae	Apinae	Anthophorini	*Anthophora*	*albigena*	Lepeletier 1841
			Anthophora	*aestivalis*	Panzer 1801
			Anthophora	*plumipes*	Pallas 1772
		Bombini	*Bombus*	*terrestris*	Linne 1758
		Eucerini	*Eucera*	*nigrescens*	Perez 1879
			Tetralonia	*salicariae*	Lepeletier 1841
			Tetralonia	*dentata*	Germar 1839
	Nomadinae	Nomadini	*Nomada*	*succincta*	Panzer 1798
			Nomada	*nesiotica*	Mavromoustakis
1958					
			Nomada	*fabriciana*	Linnaeus 1767
			Nomada	*braunsiana*	Schmiedeknecht
1882					
	Xylocopinae	Xylocopini	*Xylocopa*	*violacea*	Linne 1758
		Ceratinini	*Ceratina*	*chalybea*	Chevrier 1872
			Ceratina	*cucurbitina*	Rossi 1792
Megachilidae	Megachilinae	Megachilini	*Megachile*	*melanopyga*	Hedicke 1938
			Megachile	*hungarica*	Mocsary 1877
			Megachile	*parietina*	Geoffroy 1785
			Megachile	*pilidens*	Alfken 1924
		Osmiini	*Chelostoma*	*diodon*	Schlletterer 1929
			Heriades	*syriaca*	Benoist1929
			Hoplitis	*crenulata*	Morawitz 1872
			Hoplitis	*pallicornis*	Friese 1895
			Osmia	*melanogaster*	Morawitz 1872
			Osmia	*rufa*	Linnaeus 1758
		Lithurgini	*Lithurgus*	*tibialis*	Morawitz 1875
		Anthidini	*Anthidium*	*undulatum*	Mavromoustakis
1948					
			Pseudoanthidium	*palaestanicum*	Mavromoustakis
1938					
			Stelis	*nasuta*	Latreille 1809
			Trachusa	*pubescens*	Mor.
			Trachusa	*verhoeffi*	Mavromoustakis
1955					
Halictidae	Halictinae	Halictini	*Halictus*	*sexcinctus*	Fabricius 1775
			Halictus	*quadricinctus*	Fabricius 1776
			Halictus	*pollinosus*	Sichel 1860
			Lasioglossum	*calceatum*	Scopoli 1763
			Lasioglossum	*marginatum*	Brulle 1832
			Lasioglossum	*pallens*	Brulle 1833
			Lasioglossum	*pauxillum*	
			Sphecodes	*albilabris*	Fabricius 1793
			Sphecodes	*monilicornis*	
Andrenidae	Andreninae		*Andrena*	*alfkenelloides*	Warncke 1969
			Andrena	*elmaria*	Gusenleitner 1998
			Andrena	*flavipes*	Panzer 1799
			Andrena	garrula	Warncke 1969
			Andrena	humilis	Imhoff 1832
			Andrena	*iliaca*	Warnccke 1969
			Andrena	*impasta*	Warncke 1975
			Andrena	*melittoides*	Friese 1899
			Andrena	*krausielle*	Gusenleitner 1998
			Andrena	*spectabilis*	Smith 1853
			Andrena	*thoracica*	Fabricius 1775
			Andrena	*tscheki*	Morawitz 1872
Colletidae	Colletinae		*Colletes*	*caskanus*	Strand
	Hylaeinae		*Hylaeus*	*angustatus*	

vegetational, edaphic and topographic conditions. The bee species recorded in the present study have previously been documented in various areas of the European Community and in other parts of the world (Rasmont, 1995; Kevan & Phillips, 2001). The number of species collected in this survey was lower than that recorded by Quaranta et al. (2004) in Italy (355 species) and Rasmont et al. (2006) in Belgium and France (360 species). Such differences in the number of bee species could be attributed to human activity (Osborne et al., 1991), progressive reduction of suitable habitats, the use of toxic products, unsuitable trophic resources (Radeghieri *et al*. 1998) or environmental fragmentation (Opdam et al., 1993). In addition, the present study was restricted to visitors of stone fruit trees during their flowering period; all wild and cultivated plants present in the area were excluded. We are unable to make comparisons with other countries with similar environmental conditions as faunistic data and resources are not available (Rasmont et al., 1995, 2006).

Most bee visitors collected in this study have been recorded to visit fruit trees in different parts of the world. Bosch (1994) found *Osmia cornuta* to be a potentially effective pollinator of almond trees. *O. lignaria* was used successfully in Utah as an alternative pollinator to honey bee to pollinate cherry trees; *Prunus avium* (Bosch & Kemp, 2000). *Bombus terrestris* are currently used to pollinate commercial tomato crops in green houses (Morandin et al., 2001) and also blueberry (Stubb & Drummond, 2001). From the family Megachilidae, *Megachile rotundata* has been introduced into Chile and Argentina from the United States, and used in legume breeding programs under greenhouses and cages (Bohart, 1972; Ruz, 2002). Several bee species belonging to the genera: *Apis, Andrena*, and *Megachile* have been described to be effective pollinators of cultivated cruciferous and legume crops. Two species of wild bees, the alkali bee (*Nomia melenderi*) and the alfalfa leaf cutter bee (*Megachile rotundata*), are extensively managed for alfalfa pollination while *Osmia cornifrons* (Megachilidae) has been successfully managed for apple pollination (Bohart, 1972). Besides, several *Osmia* species have been developed as fruit tree pollinators in the USA, Europe and Japan (Bosch & Kemp, 2002, Krunić et al., 2005).

There is a positive relationship between bee and floral abundance (Heithaus, 1974; Banaszak & Krzysztofiak, 1996). The richness of bee species in the present study can perhaps attributed to the high plant biodiversity in Jordan (Al–Eisawi, 1993; Abu–Irmaileh, 2000). Further studies should be conducted to monitor bee visitors of wild and cultivated plants throughout the year in different parts of Jordan and research into the pollination value of each species on target crops is urgently needed. The biology and rearing of the most effective pollinators should be investigated in order to increase their numbers in the area so as to improve fruit tree productivity.

Acknowledgments

The research was financially supported by the Deanship research / Jordan University of Science and Technology (Project no. 134/2004) and Biodiversity Project/ National Centre for Agriculture Research and Technology Transfer (NCARTT).

References

Abu–Irmaileh, B., 2000. *Weeds of Cultivated Fields*. Publication of Jordan Univ., Deanship of Research.

Al–Eisawi, D. M., 1993. *Field Guide to Wild Flowers of Jordan and Neighbouring Countries*. National Library, Amman, Jordan.

Anon, 2004. *Annual Agricultural Statistical Year Book*. Ministry of Agriculture, Amman, Jordan.

Banaszak, J. & Krzysztofiak, A., 1996. The natural wild bee resources (Apoidea, Hymenoptera) of the Wigry National Park. *Pol. Pismo. Ent*., 65: 33–51.

Batra, S. W., 1995. Bees and pollination in our changing environment. *Apidologie,* 26: 361–370.

Bienenfeld, K., 1996. Die Bedeuting der Bienenhaltung in Deutschland. *Dtsch. Bienenj*., 5: 14–18.

Bohart, G. E., 1972. Management of Wild Bees for the Pollination of Crops. *Ann Rev. Entomol*.,17: 287–312.

Bosch, J., 1994. Improvement of field management of *Osmia cornuta* (Latreille) (Hymenopetera, Magachilidae) to pollinate almond. *Apidologie*, 25: 71–83.

Bosch, J. & Kemp, W. P., 2000. Exceptional Cherry Production in an Orchard Pollinated with Blue Orchard bee. *Bee World*. 163–172.

– 2002. Developing and establishing bee species as crop pollinators: the example of *Osmia* spp. (Hymenoptera Megachilidae) and fruit trees. *Bull. Entomol. Res*., 92: 3–16.

Free J. B., 1993. *Insect pollination of crops*. 2nd edition, Academic Press, London, UK.

Hajeer, Y., 2005. The role of honey bees *Apis mellifera syriaca* in pollination of four muskmelon (*Cucumis melo* L.) cultivars grown under semiarid conditions. M. Sc. Thesis, Jordan University of Science and Technology, Irbid, Jordan.

Heithaus, E. R., 1974. The role of plant–pollinator interactions in determining community structure. *Ann. Missouri Bot. Gard*., 61: 675–691.

Kearns, C. A., Inouye, D. W. & Waser, N., 1998. Endangered mutualism: the conservation of plant– pollinator interaction. *Annu. Rev. Ecol. Syst*., 29: 83–112.

Kevan, P. G. & Baker, H. G., 1983. Insects as Flower Visitors and Pollinators. *Ann. Rev. Entomol*., 28 : 407–453.

Kevan, P. G. & Phillips T. P., 2001. The economic impact of pollinator declines: an approach to assessing the consequences. *Conservation Ecology,* 5(1): 8.
URL: http://www.consecol.org/vol5/iss1/art8 [visited: 20 April 2005]

Krunić, M., Stanisavljević, L., Pinzauti, M. & Felicioli, A., 2005. The accompanying fauna of *Osmia cornuta* and *Osmia rufa* and effective measures of protection. *Bull. Insectol*., 58(2): 141–152.

McGregor, S. E., 1976. *Insect Pollination of Cultivated Crop Plants. Agric. Handbook.* U. S. Dept. Agric. No. 496, Washington, D. C., USA.

Michener, C. D., 2000. *The Bees of The World*. John Hopkins Univ. Press, Baltimore and London.

Morandin, L. A., Laverty, L. A. & Kevan, P. G., 2001. *Bombus impatiens* (Hymenoptera; Apidae) Activity and Pollination Levels in Commercial Tomato Green Houses. *J. Econ. Entomol*. 94(2) : 462–467.

Morse, R. A. & Calderone, N. W., 2000. *The Value of Honeybees As Pollinators of U.S. Crops in 2000, Ithaca, New York*. 2000.
URL: http://bee.airoot.com/beeculture/pollination2000/pgl [visited: 20 August 2005]
URL: http://www.beeculture.com/content/PollinationReprint07.pdf [visited: 09 July 2010]

O'Toole, C., 1993. Diversity of native bees and Agroecosystems. In *Hymenoptera and Biodiversity*: 169–195 (J. LaSalle & I. D. Gauld, Eds.). Cab International, Wallingtord.

Oldroyd, B. P., 1999. Coevolution while you wait: *Varroa jacobsoni*, a new parasite of western honeybees. *Trends Ecol. Evol*., 14: 312–315.

Opdam, P., Apeldoorn, Van R., Schotman, A. & Kalkhoven, J., 1993. Population responses to landscape fragmentation. In: *Landscape ecology of a stressed environment*: 148–171 (Claire C. Vos & P. Opdam, Eds.). Chapman and Hall, London.

Osborne, J. L., Williams, I. H. & Corbet S. A., 1991. Bee pollination and habitat change in the European Community. *Bee World,* 72: 99–116.

Parker, F. D., Batra, S. W. & Tepedino, V. J., 1987. New pollinators for our crops. *Agric. Zool. Rev*., 2: 279–304.

Quaranta M., Ambroselli, S., Barro, P., Bella, S. Carini, A., Celli, G., Cogoi, P., Comba, L., Comoli, R., Felicioli, A., Floris, I., Intoppa, F., Longo, S., Maini, S., Manino, A., Mazzeo, G., Medrzycki, P., Nardi, E., Niccolini, L., Palmieri, N., Patetta, A., Piatti, C., Piazza M. G., Pinzauti, M., Porporato, M., Porrini, C., Ricciardelli D. G., Romagnoli, F., Ruiu, L., Satta, A. & Zandigiacomo, P., 2004. Wild bees in agroecosystem and semi–natural landscapes. 1997–2000 collection period in Italy. *Bull. Insectol*., 57(1): 11–61.

Rasmont, P., 1995. How to restore the Apoid diversity in Belgium and France? Wrong and right ways, or the ed of the protection paradigm. In: *Changes in Fauna of Wild Bees in Europe*: 53–64 (J. Banaszak, Ed.). Pedagogical Univ., Bydgoszcz, Poland.

Rasmont, P. A., Ebmer, J., Banaszak, J. & Zanden, G. V., 1995. Hymenoptera (Apoidea Gallica). *Bull. Soc. Entomol. France*. 100: 1–98.

Rasmont, P., Paly, A., Terzo, M., Patiny, S., Michez, D., Iserbyt, S., Barbier, Y. & Haubruge, E., 2006. *The survey of wild bees (Hymenoptera, Apoidea) in Belgium and France.* FAO, Rome.
URL: http:// www.fao.org/ag/AGP/AGPS/C–CAB/Castudies [visited: 8 October 2006]

Richards, K. W., 1996. Comparative efficacy of bee species for pollination of legume seed crops. In: *The conservation of bees*: 81–103 (A. Matheson, S. Buchmann, C. O'Toole, P. Westrich & I. H. Williams, Eds.). Academic Press, London.

Ruz, L., 2002. Bee Pollinators Introduced to Chile: a review. In: *Pollinating bees– The conservation link between agriculture and nature*: 155–167 (P. Kevan & I. V. Fonseca, Eds.). Ministry of Environment, Brasilia.

Sugden, E. A., 1993. The africanized honey bee phenomenon: potential societal interactions. *Am. Bee J*., 132: 691–692.

Stubb, C. S. & Drummond, F. A., 2001. *Bombus impatiens* (Hymenoptera; Apidae) An alternative to *Apis mellifera* for Low bush Blueberry Pollination. *J. Econ. Ent*., 94(3): 609–616.

Vargas, M. J. & Romero, M. A., 1987. Mejora del almendro en Cataluna. *Fruticult. Prof*., 11: 93–98.

Williams, I. H., Corbet, S. A. & Osborne J. L., 1991. Beekeeping, wild bees and pollination in the European Community. *Bee World,* 72: 170–180.

Zaitoun, S. T., 2000. Population dynamics of the Syrian Honeybee, *Apis mellifera syriaca*, under semi–arid Mediterranean conditions. In: *The Seventh IBRA Conference on Tropical Bees: Management and Diversity, 19–26 March 2000, Chiang Mai, Thailand*: 319–321. IBRA, Cardiff, UK.