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ARAŞTIRMA MAKALESI / RESEARCH ARTICLE

SOLITARY BEES (HYMENOPTERA: APOIDEA) DIVERSITY AND PALYNOLOGICAL ANALYSIS OF THEIR ASSOCIATED FLORAL RESOURCES IN WESTERN EGYPT

Batı Mısır'daki Bireysel Arıların (Hymenoptera: apoidea) Çeşitliliği ve Bunlarla İlişkili Çiçek Kaynaklarının Palinolojik Analizi

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ABSTRACT

Egypt is one of the important countries in terms of bee diversity in Northern Africa. The Eastern part of the country has been the subject of several studies over the last decade, especially in comparison to the Western part. In this work, we explore the diversity of solitary bees in the Alexandria Governorate, specifically in the Al Hawaria region (30°57'13" N, 29°40'27" E), based on two years of research conducted in 2021 and 2022. A total of 51 species were identified in the region: 25 species of Apidae, 16 of Megachilidae, 5 of Andrenidae, 4 of Halictidae, and one species of Colletidae. Pollen grain identification from plants and some solitary bee species revealed the creation of reference slides for pollen grains from 32 flowering plant species (both crops and wildflowers) across 19 plant families. The plant family preferences were varied among different bee genera. The most commonly visited plant families were Asteraceae, Brassicaceae, and Fabaceae, which accounted for 58% of the total bee-attracting flora. The pollen spectrum from the *Xylocopa aestuans* (L. 1758) nest consisted of two pollen types, while the nest of *Osmia* sp. contained a single pollen type.

Keywords: Apoidea, Bees, Pollination, Pollen grains, Palynology

ÖZ

Mısır, Kuzey Afrika'nın arı çeşitliliği açısından önemli ülkelerinden biridir. Ülkenin doğu kısmı son on yılda batı kısmına kıyasla birçok eserde incelenmiştir. Burada 2021 ve 2022 yıllarında iki yıllık çalışmalar sırasında İskenderiye Valiliği'nin Al Hawaria bölgesindeki 30 57'13" N 29 40'27" E'deki yalnız arıların çeşitliliğini ele alıyoruz. Bölgede bulunan toplam tür sayısı 51 tür (25) idi. Apidae'den 16'sı, Megachilidae'den 5'i, Andrenidae'den 5'i, Halictidae'den 4'ü ve Colletidae'den 1 tür). Bitkilerden toplanan bazı polen tanelerinin ve bazı yalnız arı türlerinin tanımlanması, bu çalışmada 19 bitki familyasına ait 32 çiçekli bitki türünden (mahsuller ve kır çiçekleri) polen tanelerinin referans slaytlarının yapıldığını ortaya çıkardı. Bitki familyalarının tercihi farklı arı cinsleri arasında farklılık gösteriyordu. Arıların ziyaret ettiği en çok temsil edilen familyalar Asteraceae, Brassicaceae ve Fabaceae idi ve bunlar toplam arı florasının %58'ini oluşturdular. *Xylocopa aestuans*'ın çalışma yuvasındaki polen spektrumu toplam iki polen türünden oluşurken, Osmia sp'nin yuvası bir polen türünden oluşmuştur.

Anahtar kelimeler: Apoidae, Arılar, Polinasyon, Polen taneleri, Palinoloji

GENİŞLETİLMİŞ ÖZET

Çalışmanın amacı: Al Hawaria bölgesindeki *Apis* dışı arıların tür kompozisyonunu ve alanın çiçek kaynakları ile etkileşimlerini ve toplanan bireysel arıların (yaklaşık 9 türün vücutlarında polen görülmüştür) vücut setaları üzerinde bulunan farklı polen tanelerini (polen taksonları) tanımlamaktır.

Gereç ve Yöntem: Çalışma alanı, Mısır'ın İskenderiye kentinin batısındaki Burj Al Arab şehrinde bulunan Al-Hawaria bölgesidir (30°57'13" N, 29°40'27" E). Bu alan şehirleşme ve diğer antropojenik değişikliklerden uzaktır. Yalnız arı türlerinin araştırılması 2021 ve 2022 yıllarında bazı ekilmemiş ve ekili bitkiler üzerinde gerçekleştirilmiştir.

Bireysel arılar iki yıl boyunca, hava durumuna göre belirlenen aralıklarla, aylık veya haftalık olarak bir süpürme ağı kullanılarak toplanmıştır. Arılar siyanür kavanozları kullanılarak öldürüldü ve İskenderiye Üniversitesi Ziraat Fakültesi Entomoloji ve Zooloji Bölümü'ndeki laboratuvara nakledilmeden önce kağıt mendil içinde korunarak iğnelenip etiketlendikten sonra ahşap kutularda saklanmıştır. Etiketler saat, tarih, yer ve toplayıcının adı gibi toplama bilgilerini içermekte oup veriler çeşitli türlere ait bireysel arılar için kaydedilmiştir.

Arıların tanımlanması: Ain Shams Üniversitesi Fen Fakültesi Entomoloji Bölümü ve Süveyş Kanalı Üniversitesi Ziraat Fakültesi Bitki Koruma Bölümü referans koleksiyonları kullanılarak gerçekleştirilmiştir. Bazı türler, özellikle Osminii ve Anthidini kabilelerinden olmak üzere Avrupalı taksonomistlere gönderilmiştir. Bazı türlerin kimliğini doğrulamak için çevrimiçi veri tabanları ve Hymenoptera Atlası da kullanılmıştır. Arıların farklı taksonomik özelliklerini incelemek için stereoskopik mikroskop kullanılmıştır.

Arılar ve bitkiler arasındaki etkileşim, çeşitli bitkilerden, arılardan ve arı yuvalarından toplanan polen tanelerinin tanımlanmasıyla incelenmiştir. Polen analizi, İskenderiye Üniversitesi Ziraat Fakültesi Uygulamalı Entomoloji ve Zooloji Bölümü'nde Westrich & Schmidt (1986), Westrich (1990), Sawyer (1981), Tellería (2000) ve Esmaeil (2016) yöntemleri izlenerek gerçekleştirilmiştir.

Bulgular: 2021 ve 2022 yıllarında Al Hawaria bölgesinde 13 bitki türünün çiçeklenme dönemlerinde toplam 820 bireysel arı örneği toplanmıştır. Arılar beş familya (Apidae, Megachilidae, Halictidae, Colletidae ve Andrenidae) tarafından temsil edilip Melittidae familyası bu çalışmada yer almamıştır. Toplanan arılar 24 cinsi temsil etmekte olup (Apidae'den 9, Megachilidae'den 7, Halictidae'den 5, Colletidae'den 2 ve Andrenidae'den bir) bölgede bulunan toplam tür sayısı 51 tür olarak belirlenmiştir (25 Apidae, 16 Megachilidae, 5 Andrenidae, 4 Halictidae ve bir Colletidae türü). **Aile: Apidae:** Bölgede Anthophora, Amegilla ve Eucera'nın çeşitli arı türleri yaşamakta olup bu üç cinsin ortaya çıkışı, keptoparazitik arı türlerinin (*Thyreus* sp, *Nomada* sp, *Melecta* sp ve *Epeoles* sp) ortaya çıkışıyla aynı zamana denk gelmiştir. 25 Apidae türü Asteraceae, Solanaceae, Brassicaceae, Aizoaceae, Labiatae, Tamaricaceae, Malvaceae, Oxalidaceae, Pedaliaceae ve Fabaceae familyalarından çeşitli bitkileri ziyaret etmiştir. **Aile: Megachilidae:** Megachilidae familyasından 16 tür Asteraceae, Brassicaceae, Aizoaceae, Lamiaceae, Tamaricaceae, Malvaceae, Papaveraceae ve Fabaceae familyalarının florasından toplanmış olup Megachile, Osmia ve Hoplitis cinslerine ait bazı türler tür düzeyinde teşhis edilirken, diğerleri tespit edilememiştir. **Aile: Andrenidae:** Andrenidae, Şubat-Haziran ayları arasında aktif olan ve Asteraceae, Aizoaceae, Fabaceae ve Brassicaceae florasından kaydedilen Andrena cinsinden beş tür ile temsil edilmiştir. **Aile: Halictidae:** Halictidae familyasından *Halictus, Lasioglossum, Pseudapis, Ceylalictus* ve bir cleptoparasitic cins olan *Sphecodes* dahil olmak üzere çeşitli cinsler toplanmıştır. Dört tür tespit edilmiştir: *Ceylalictus variegatus* Olivier, 1789, *Pseudapis nilotica* Smith, 1857, *Lasioglossum vagans* Smith, 1857 ve *Halictus quadricinctus* Fabricius, 1776. Tüm türler Asteraceae, Solanaceae, Brassicaceae, Aizoaceae, Lamiaceae, Tamaricaceae, Pedaliaceae ve Fabaceae'den çeşitli floraları ziyaret etmiştir. **Aile: Colletida:** Colletidae, *Colletes lacunatus* Dours, 1872 baskın tür olmak üzere iki cins (*Colletes* ve *Hylaeus*) ile temsil edilmiştir. Örnekler Brassicaceae ve Aizoaceae familyalarının florasından toplanmıştır. Colletidae, tür zenginliği ve bolluğu açısından diğer familyalara kıyasla en az kaydedilen familyadır.

Palinolojik Analiz: Bu çalışmada 19 bitki familyasına ait 32 çiçekli bitki türünden (ekinler ve kır çiçekleri) polen tanelerinin referans slaytları hazırlanmış ve İskenderiye Üniversitesi, Ziraat Fakültesi, Uygulamalı Entomoloji ve Zooloji Bölümü'nde depolanmıştır. Çalışılan polen tanelerinin mikrofotoğrafları ve ölçümleri bu çalışmaya dahil edilmiştir.

Sonuç: Bu örneklerle, araştırma bölgesinde bal arıları ve diğer yabani arı türleri tarafından ziyaret edilen yem bitkilerinin bir listesini derlenmesi sağlanırken çeşitli botanik familyalardan polen taksonlarının varlığı, toplanan bitkilerin referans slaytları ile karşılaştırılarak tespit edilmiştir. Arıların vücut kıllarının (vücut, abdominal ve tibial setalar) mikroskobik analizi, 10 bitki familyasına ait 17 bitki cinsinin (tarla ve yem bitkileri, yabani otlar, süs bitkileri ve sebze bitkileri) arı poleni yem kaynağı olarak kaydedildiği ortaya konulmuştur. En çok temsil edilen familyalar, toplam arı florasının %58,8'ine katkıda bulunan Asteraceae (4 cins), Brassicaceae (3 cins) ve Fabaceae (3 cins) olmuş, Cucurbitaceae, Apiaceae, Aizoaceae, Tamaricaceae, Solanaceae, Boraginaceae ve Oleaceae gibi familyalar birer cinse sahip olduğu belirlenmiştir.

Apidae familyası diğer dört familyaya kıyasla en yüksek tür bolluğuna sahip olup bitki familyalarının tercihi farklı arı cinsleri arasında değişiklik gösterdiği belirlenmiştir. Arılar tarafından en çok ziyaret edilen bitki familyaları Aizoaceae, Lamiaceae, Asteraceae, Brassicaceae ve Tamaricaceae olarak tespğit edilmiştir. Diğer familyalar dört veya daha az cins tarafından ziyaret edilmiş, Lamiaceae, Asteraceae ve Brassicaceae familyalarının zaten bitkilerin bireysel arılar için en çok tercih edilen polen kaynakları arasında olduğu teyid edilmiştir.

INTRODUCTION

Bees are one of the most diverse and important groups of insects. They are rich in species diversity, sociality and nesting biology (Michener, 2007). Very few bee species produce honey, but the majority provide a valuable pollination service to ecosystems (Osman & Shebl, 2020). There are 20,000 known bee species worldwide (Michener, 2007), but very little information is known for Egypt in terms of diversity, nesting biology and sociality (Shebl et al., 2013). Most of the previous studies were conducted during the last century in several areas of the country (Shebl et al., 2013; Shebl et al., 2021). Several genera have been extensively studied such as *Anthophora* (Priesner, 1957), *Halictus* (Blüthgen, 1933 and 1934), *Andrena* (Moustafa et al., 1979), *Osmia* (Moustafa & El Berry, 1976), *Sphecodes* (El Akkad & Kamel, 2002) and *Nomia* (Shoukry et al., 2004) and there is an urgent need to update the checklist and clarify the status of diversity with the current climatic and environmental changes (Okely et al., 2024; El-Naggar et al., 2022). Two species have recently been recorded from the Al-Hawaria region (western part of Egypt) of genus *Hoplitis* (Shebl et al., 2023).

The development of beekeeping may be hindered by a lack of knowledge about the forage plants that are good for domesticated honeybees and wild bee pollinators, including the names of the plants, when they flower and their potential benefits for bees. To date, wild and honey bee plants have not been well studied throughout Egypt (Abou-Shaara, 2015). The purpose of this research was to list the solitary bees present in the Al-Hawaria region (western part of Egypt). In addition, to identify different types of pollen grains (pollen taxa) present on the body setae of solitary bees. Using these samples, we would be able to compile a list of the forage plants visited by honey bees and other wild bee species in the study area.

MATERIAL AND METHODS

Study Area and Specimen Collection

This survey was conducted in the Al-Hawaria region of Alexandria (30°57’13” N, 29°40’27” E). Several plant species were sampled in the field during the winter, spring, summer, and autumn seasons of 2021 and 2022. The following plants were studied: *Lycium shawi*, *Enarthrocarpus lyratus*, *Diplotaxis harra*, *Papaver rhoeas*, *Malva parviflora*, *Centaurea alexandrina*, *Centaurea glomerata*, *Oxalis pes-caprae* L., *Mesembryanthemum crystallinum*, *Tamarix aphylla*, *Sesamum indicum*, *Trifolium alexandrinum*, and *Ocimum basilicum*.

Solitary bees were collected using a sweep net at intervals over two years, in either monthly or weekly sessions depending on weather conditions. Bees were killed in cyanide jars and placed in tissues before being transferred to the Entomology and Zoology Laboratory at the Faculty of Agriculture, Alexandria University, for pinning, labeling, and storage in wooden boxes. The labels included the collection time, date, location, and collector’s name. Data were recorded for solitary bees of different species.

Identification

Bees were identified using reference collections from the Department of Entomology, Ain Shams University, and the Department of Plant Protection, Suez Canal University. Additionally, some species

were sent to European taxonomists, particularly from the tribes Osmiini and Anthidini. Online databases and the *Atlas of Hymenoptera* were also used to confirm species identities. A stereoscopic microscope was employed to examine the taxonomic features of the bees.

Identification of Pollen Grains from Plants and Bees

Pollen analysis from wild bees was conducted in the Applied Entomology and Zoology Laboratory at the Faculty of Agriculture, Alexandria University, using the methods outlined by Westrich & Schmidt (1986) and Westrich (1990).

Reference Slide Preparation

Accurate identification of pollen collected by wild bees often requires a reference collection. Therefore, reference slides of pollen grains from available flowering plant species (crops and wildflowers) within the study area were prepared. All potential pollen sources were collected and identified, noting their frequency, distribution, flower density, and flowering period. If possible, a flower or single stamen was kept in water indoors for a few days to ensure a supply of ripe pollen. The pollens were shaken onto a microscope slide, or an anther was removed with forceps and placed on the slide. A drop of ether was added to disperse the pollen, and any visible particles larger than the pollen were removed. Pollens were also obtained from pressed field specimens.

Degreasing (Fat Removal)

Drops of ether were carefully applied to the pollen using a rod or glass tube, dissolving fats or oils, which were then absorbed with tissue paper.

Staining and Mounting

A drop of warmed, stained jelly (or two small drops of different densities of stain) was applied to the pollen with a glass rod. A cover slip was positioned carefully, with one edge lowered first to avoid air bubbles. The slide was placed on a warm plate for about 10 minutes. The jelly should be just sufficient to fill the space under the cover slip. Once set, any surplus was cleaned off with cold water. The cover slip edges were sealed with clear nail varnish to preserve the sample for years (Sawyer, 1981).

Preparation of Pollen from Scopa Setae

Pollen was removed under a stereoscopic microscope using an appropriately sized insect pin. All equipment (needles, forceps, microslides) was kept clean. To minimize pollen loss, the cleaned microslide and cover slip were placed on a piece of paper (~12 x 12 cm). If pollen grains fell off the slide, they were returned using an insect pin. It was crucial to avoid contamination between slide preparations. Degreasing was only necessary for oily pollens (e.g., from Asteraceae and Fabaceae). Each pollen sample was placed on a slide and degreased with ether. A drop of stained glycerin jelly, melted in a water bath, was applied to the cover slip, which was then placed over the pollen layer. The preparation was sealed with diluted Canada balsam (mixed with xylene) and examined under a stereomicroscope (SM) using a micrometer eyepiece and slide at 400x or 1000x magnification. Pollen identification was based on literature (Esmaeil, 2016) and the reference collection of local flora.

Preparation of Pollen Provision from Brood Cells contents (nests).

Pollen provision analysis offers a more complete description of solitary bee diets than direct observation. A total of two pollen mass samples were collected from nests of two genera (*Xylocopa* and *Osmia*). The pollen masses were stored in open vials to avoid fungal development and refrigerated until processed. Each mass was dissolved in 100 ml of distilled water at 80–90°C, stirred for 15–20 minutes with a glass rod and then a magnetic stirrer. Five milliliters of the solution were centrifuged, and the residue analyzed (Tellería, 2000**).** Microscopic samples were mounted with glycerin jelly as previously described.

Pollen Grain Identification

Pollen grain identification was done by comparing samples to a reference pollen collection from local flora and consulting appropriate literature. Identification was generally made to the plant genus level, and sometimes to the species level.

RESULTS

A total of 820 solitary bees were collected during the flowering season of 13 plant species in the Al Hawaria region during the two years 2021 and 2022. The bees were represented by five families (Apidae, Megachilidae, Halictidae, Colletidae and Andrenidae). The family Melittidae was absent in this study and in the two previous studies. The collected bees represented 24 genera (9 of Apidae, 7 of

Megachilidae, 5 of Halictidae, 2 of Colletidae and one of Andrenidae). The total number of species found in the region was 51 (25 of Apidae, 16 of Megachilidae, 5 of Andrenidae, 4 of Halictidae and one of Colletidae) (Tables 1-3).

Family: Apidae: The area was inhabited by various bee species of *Anthophora*, *Amegilla* and *Eucera*. The appearance of these three genera was coincided with the appearance of their cleptoparasitic bees (*Thyreus* sp, *Nomada* spp, *Melecta* sp and *Epeoles* sp). 25 species of Apidae were visited several plants of the families Asteraceae, Solanaceae, Brassicaceae, Aizoaceae, Labiatae, Tamaricaceae, Malvaceae, Oxalidaceae, Pedaliaceae and Fabaceae (Table 1).

Family: Megachilidae: Sixteen species of Megachilidae were recorded from several flora of the families Asteraceae, Brassicaceae, Aizoaceae, Labiatae, Tamaricaceae, Malvaceae, Papaveraceae and Fabaceae. Some species of the genera *Megachile*, *Osmia* and *Hoplitis* were identified to species level, but some others could not be determined **(Table 2).**

Family: Andrenidae: Andrenidae, represented by five species of the genus *Andrena*, were active from February to June, were recorded from the flora of several families, Asteraceae, Aizoaceae, Fabaceae and Brassicaceae (Table 3).

Family: Halictidae: Several genera of *Halictus*, *Lasioglossum*, *Pseudapis*, *Ceylalictus* and a genus of celptoparasitic bee of *Sphecodes* were collected. Four species were identified: *Ceylalictus variegatus* Olivier, 1789, *Pseudapis nilotica* Smith, 1857, *Lasioglossum vagans* Smith, 1857 and *Halictus quadricinctus* Fabricius, 1776. All species were visited a diverse group of flora from Asteraceae, Solanaceae, Brassicaceae, Aizoaceae, Labiatae, Tamaricaceae, Pedaliaceae and Fabaceae.

Family: Colletidae: Colletidae, was represented by two genera (*Colletes* and *Hylaeus*), with *Colletes lacunatus* Dours, 1872) as the dominant species. The specimens were collected from the flora of the Brassicaceae and Aizoaceae families. Colletidae was the least represented family in terms of species richness and abundance compared to the other families.

Palynological analysis: A reference slide of pollen grains from 32 flowering plant species (cultivated and wild), belonging to 19 plant families, was made in this work at the laboratory of the Department of Applied Entomology and Zoology, Faculty of Agriculture, Alexandria University (Table, 4). Microphotographs and measurements of the studied pollen grains were included in this study.

The presence of pollen taxa from different botanical families was found and identified by comparison with the reference slides of the collected plants. The results of microscopic analysis of body hairs of solitary bees (body, abdominal and tibial setae) are summarised in (Table, 5, Figs. 1 and 2). The data showed that 17 genera (field and forage crops, weeds, ornamentals and vegetables) belonging to 10 plant families were recorded as sources of bee pollen forage plants. The most represented families were Asteraceae (4 genera), Brassicaceae (3 genera) and Fabaceae (3 genera), they contributed with **58.8%** of the total bee flora, while the families of Cucurbitaceae, Apiaceae, Aizoaceae, Tamaricaceae, Solanaceae, Boraginaceae and Oleaceae had one genus each.

Table 1. List of activity period, and floral resources of the collected species of the family: Apidae.

Species	Activity period	Floral resources
Anthophora aegyptiaca Dalla Torre & Friese.	January	*Lycium shawi*
Anthophora albosignata (Friese,1886).	March	*Enarthrocarpus lyratus*
Anthophora angolensis Dalla Torre,1896.	April	*Centaurea glomerata,*
Anthophora (*Heliophila*) *concinna* (Klug, 1845)	April – May	*Centaurea glomerata, Enarthrocarpus lyratus, Mesembryanthemum crystallinum*
Anthophora dispar Lepeletier, 1841.	January-February	*Centaurea glomerata, Lycium shawi.*
Anthophora fascialoides Brooks, 1988.	January-February	*Lycium shawi, Enarthrocarpus lyratus*
Anthophora hispanica (Fabricius, 1787)	February	*Lycium shawi.*
Anthophora moricei Friese,1899.	January-July	*Centaurea glomerata, Centaurea alexandrina, Lycium shawi, Enarthrocarpus lyratus, Mesembryanthemum crystallinum, Ocimum basilicum*
Anthophora senescens Lepeletier,1841.	January- June	*Lycium shawi, Enarthrocarpus lyratus, Ocimum basilicum*
Anthophora (*Heliophila*) *tenella* Klug,1845.	April -June	*Mesembryanthemum crystallinum, Ocimum basilicum*
Anthophora wegelini Friese,1914.	March -June	*Enarthrocarpus lyratus, Ocimum basilicum*
Amegilla albigena (Lepeletier,1841).	April – December	*Centaurea glomerata, Mesembryanthemum crystallinum, Ocimum basilicum*
Amegilla andresi (Friese, 1914).	June- December	*Lycium shawi, Mesembryanthemum crystallinum, Ocimum basilicum, Trifolium alexandrinum*
Amegilla byssina (Klug, 1845).	June-December	*Lycium shawi, Mesembryanthemum crystallinum, Sesamum indicum*
Amegilla quadrifaciata (de Villers,1789)	February-October	*Enarthrocarpus lyratus, Mesembryanthemum crystallinum, Ocimum basilicum, Trifolium alexandrinum*
Eucera biskrensis (Alfken,1933)	February	*Centaurea glomerata, Enarthrocarpus lyratus*
Eucera cuniculina Klug,1845.	January-April	*Centaurea glomerata, Centaurea alexandrina, Enarthrocarpus lyratus, Mesembryanthemum crystallinum, Malva parviflora*
Eucera dimidiate Brulle,1832	January-February	*Lycium shawi, Enarthrocarpus lyratus*
Eucera eucnemidae Dours, 1873.	February	*Enarthrocarpus lyratus, Malva parviflora*
Eucera thoracica Smith,1854.	January	*Oxalis pes- caprael*
Xylocopa aestuans (L. 1758)	April- July	*Centaurea glomerata, Enarthrocarpus lyratus, Mesembryanthemum crystallinum, Ocimum basilicum, Tamarix aphylla, sesamum indicum, Trifolium alexandrinum*
Ceratina tarsata Morawitz,1870.	May- June	*Ocimum basilicum*
Thyreus hyalintus (Vachal,1903).	April- May	*Centaurea glomerata, Mesembryanthemum crystallinum, Ocimum basilicum*
Nomada mauritanica Lepeletier, 1841.	February- March	*Enarthrocarpus lyratus*
Nomada rhenana Morawitz, 1872.	February	*Enarthrocarpus lyratus*
Epeoles sp.	April	*Centaurea glomerata*
Melecta sp.	February	*Enarthrocarpus lyratus*

Table 2. List of activity period, and floral resources of the collected species of the family: Megachilidae.

Species	Activity period	Floral resources
Megachile flavipes Spinola,1838.	April – June	*Mesembryanthemum crystallinum., Trifolium alexandrina., Ocimum basilicum.*
Megachile minutissima Radoszkowski,1876	April - August	*Mesembryanthemum crystallinum., Ocimum basilicum., Papaver rhoeas., Tamarix aphylla*
Megachile nigripes Spinola,1838.	April -June	*Mesembryanthemum crystallinum., Ocimum basilicum., Trifolium alexandrinum*
Megachile patellimana Spinola,1838.	May -October	*Mesembryanthemum crystallinum., Ocimum basilicum., Tamarix aphylla.*
Megachile submucida Alfken 1926.	June - October	*Tamarix aphylla., Trifolium alexandrinum*
Osmia (*Hoplosmia*) *bidentata* Morawitz, 1876	May	*Ocimum basilicum.,*
Osmia ferruginea Latreille,1811	February- April	*Centaurea glomerata., Centaurea alexandrina., Enarthrocarpus lyratus.*
Osmia submicans Morawitz,1870	February - May	*Enarthrocarpus lyratus., Ocimum basilicum., Malva parviflora.*
Osmia (*Helicosmia*) *latreillei* Spinola,1806	April	*Enarthrocarpus lyratus., Mesembryanthemum crystallinum.,*
Hoplitis (*Hoplitis*) *zonalis* (Perez,1895).	April	*Enarthrocarpus lyratus.*
Hoplitis (*Pentadentosmia*) *moricei* (Friese,1899)	June	*Ocimum basilicum.*
Chalicodoma siculum (Rossi, 1792)	March	*Enarthrocarpus lyratus.*
Pseudoanthidium stigmaticorne Dours,1873.	June	*Centaurea alexandrina., Mesembryanthemum crystallinum.*
Stelis murina Perez,1883	April	*Centaurea glomerata.*
Coelioxys coturnix Perez,1884.	May- July	*Ocimum basilicum., Tamarix aphylla.*
Coelioxys decipiens Spinola,1838.	May	*Ocimum basilicum.*

Table 3. List of activity period, and floral resources of the collected species of the family: Andrenidae

Species	Activity period	Floral resources
Andrena fuscosa Erichson, 1835.	February- April	*Centaurea glomerata.* *Diplotaxis harra.* *Enarthrocarpus lyratus*
Andrena flavipes Panzer 1799	April- June	*Centaurea glomerat* *Centaurea alexandrina* *Mesembryanthemum crystallinum* *Trifolium alexandrinum*
Andrena ovatula (Kirby, 1802).	June	*Trifolium alexandrinum.*
Andrena mariana Warncke,1968	March- June	*Enarthrocarpus lyratus* *Trifolium alexandrinum*
Andrena vetula Lepeletier, 1841	February – March	*Enarthrocarpus lyratus*

Table 4. List of various flowering plants (crops & weeds) within study area in Alexandria at Al-Hawaria region showing its habitats, vegetation type, flowering period and pollen size.

Family	Scientific name	Plant habitats & Vegetation Type	Flowering Period	* Pollen size
Asteraceae	*Centaurea alexandrina*	Perennial herb	April- June	M
	Centaurea glomerata	Annual herb	February -April	M
	Chrysanthemum spp.	Perennial herb	March - September	M
	Sonchus oleraceus	Annual herb	May - September	M
	Senecio vulgaris	Annual herb	June - October	M
	Artemisia Judaica	Annual / biennial herb	June - September	M
Brassicaceae	*Enarthrocarpus lyratus*	Annual herb	January - April	S
	Eruca vesicaria ssp. sativa	Annual herb	May -August	S
	Diplotaxis harra	Annual herb	January- April	S
	Brassica nigra	Annual herb	June – August	S
	Sisymbrium irio	Annual herb	December - April	S
Fabaceae	*Vicia faba*	Annual herb	January - March	M
	Melilotus officinalis	Annual / Biennial herb	June – September	M
	Trifolium alexandrinum	Annual herb	April- May	S
Aizoaceae	*Mesembryanthemum crestallinum*	Perennial herb	April -July	S
	Mesembryanthemum nodiflorum	Perennial herb	April -July	S
Polygonaceae	*Rumex vesicarius*	Annual herb	March - May	S
	Rumex spinosus	Annual herb	March - June	S
Malvaceae	*Malva parviflora*	Annual herb	February - March	L
Apiaceae	*Ammi majus*	Annual / Biennial herb	June - December	S
Papaveraceae	*Papaver rhoeas*	Annual herb	February- April	M
Pedaliaceae	*Sesamum indicum*	Annual herb	July- August	M
Cucurbitaceae	*Cucurbita pepo*	Annual creeping	April- May	VL
Rosaceae	*Malus domestica*	Perennial tree	March- April	M
Boraginaceae	*Echium horridum*	Annual herb	March- May	S
Commelinaceae	*Commelina erecta*	Perennial herb	April - July	M
Convolvulaceae	*Convolvulus arvensis*	Perennial herb	June - September	L
Labiatae	*Ocimum basilicum*	Annual / Perennial herb	All year	L
Solanaceae	*Lycium shawii*	Shrub	December-March	S
Oxalidaceae	*Oxalis pes-caprae*	Perennial herb	January- April	M
Chenopodiaceae	*Chenopodium murale*	Annual herb	March- May	S
Tamaricaceae	*Tamarix aphylla*	Perennial tree	July- October	S

* Pollen size: S: Small (10-25 µm); M: Medium (26-50 µm); L: Large (51-100 µm); VL: Very Large (>100 µm) (Vossler, 2015)

Table 5. Various floral source of pollen grains found on abdominal and tibial scopal hairs of some collected solitary bee samples

Bee Family	Bee species	* Samples Type	Pollen Type (Floral Host)	Plant family
Apidae	*Xylocopa aestuans*	*TS*	*Cucurbita pepo*	Cucurbitaceae
	Eucera caniculina pumila	*TS-BS*	*Centaurea* sp.	Asteraceae
	Anthophora hispanica	*TS-BS*	*Vicia faba*	Fabaceae
			Sisymbrium irio	Brassicaceae
	Anthophora angolensis.	*TS-BS*	*Echium horridum*	Boraginaceae
			Ammi majus	Apiaceae
Megachilidae	*Megachile* sp.	*AS*	*Mesembryanthemum crestallinum*	Aizoaceae
			Chrysanthemum sp.	Asteraceae
			Melilotus officinalis	Fabaceae
			Tamarix aphylla	Tamaricaceae
	Hoplitis sp.	*AS*	*Lycium shawii*	Solanaceae
			Olea europaea	Oleaceae
			Centaurea sp. *Sonchus* sp.	Asteraceae
Andrenidae	*Andrena fuscosa*	*TS-BS*	*Enarthrocarpus lyratus*	Brassicaceae
	Andrena ovatula	*TS*	*Trifolium alexandrinum*	Fabaceae
			Diplotaxis harra	Brassicaceae
Colletidae	*Colletes lacunatus*	*TS*	*Enarthrocarpus lyratus*	Brassicaceae
			Artemisia Judaica	Asteraceae

Samples type: TS: tabial scopal setae; AS: Abdominal scopal setae; BS: body setae

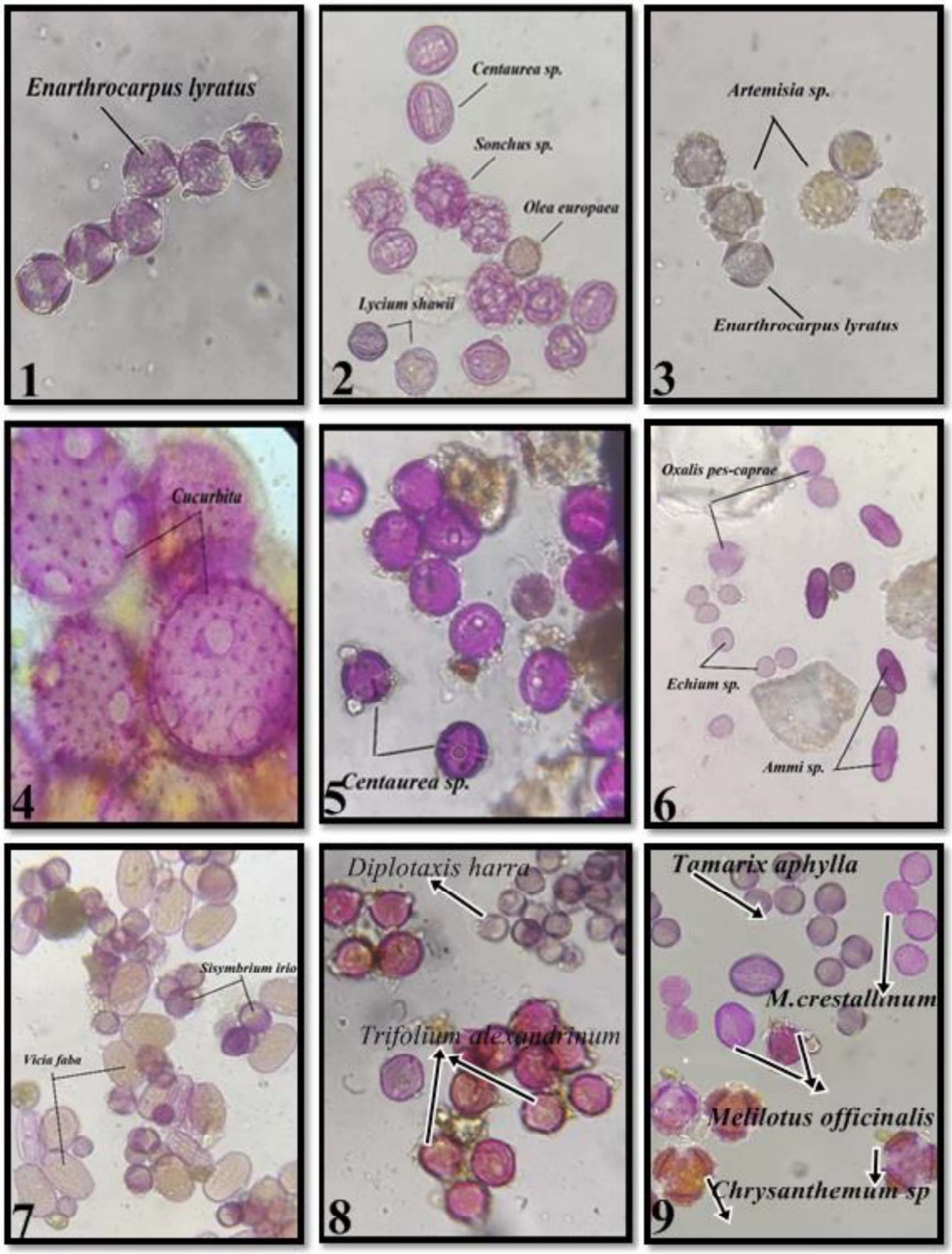

Figure 1. Stereo microscope photographs of some pollen grains found on specialized hairs located in the hind legs or ventral metasoma of solitary bee samples.1: *Andrena fuscosa*, **2**: *Hoplitis* sp., **3**: *Colletes lacunatus*, **4**: *Xylocopa aestuans*,**5**: *Eucera caniculia pumila*, **6**: *Anthophora angolensis*., **7**: *Anthophora hispanica*, **8**: *Andrena ovatula*, **9**: *Megachile* sp.

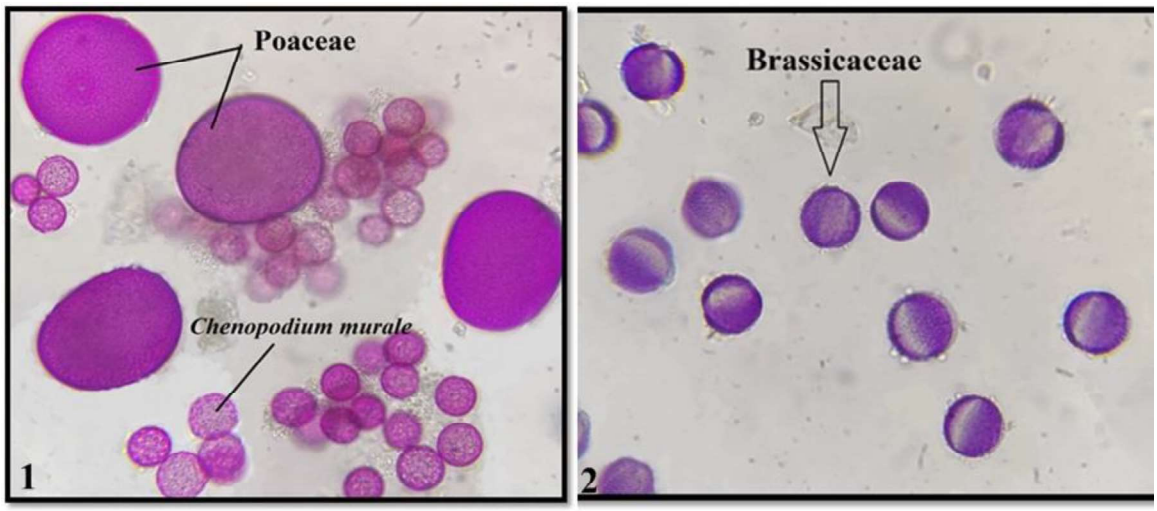

Figure 2. Pollen provision types present in nests of solitary bees 1: *Xylocopa aestuans* (L. 1758) nest and 2: *Osmia* sp. nest

DISCUSSION

Several field expeditions are essential to investigate species composition across Egypt. Some areas have been ignored or poorly addressed in previous works for several reasons (Norfolk and Dathe, 2019). Some areas of North Africa have recently been extensively studied in Lebanon (Boustani, et al., 2021) and Morocco (Lhomme, et al., 2020). In this context, more efforts are need to be made in Egypt and some other countries in Northern Africa to prioritise pollinator research if we hope to quantify and address the ongoing pollinator decline in the region (Shebl, et al., 2021). The current research was conducted to fill the gap in the western part of Egypt, but on a small scale in a small locality with low beekeeping activities. All the collected species were found in other regions such as the canal region in the eastern part of Egypt with some differences in the collected species due to the climatic, vegetation and topographic variations of the area (Shebl et al., 2013; El Aaser, 2013 & Shebl et al.,2015; Shebl et al.,2016). All previous genera were mentioned in (Shebl et al., 2013; Salem & El-Azab, 2017) except *Hoplitis* and *Pseudoanthidium* were not recorded. Two species of the genus *Hoplitis* were recorded for the first time recently: *H. zonalis* (Perez, 1895) appeared in April 2021 on *Enarthrocarpus lyratus* (Brassicaceae) and *H. moricei* (Friese, 1899) was recorded in June 2021 on *Osimum basilicum* (Labiatae) as mentioned in (Shebl et al., 2023). The area hosted a huge diversity of long tongued bees with 16 species of Megachilidae and 25 species of Apidae in addition to some other undetermined species. In contrast, short tongued bees were less diverse with no records of Melittidae. Some species were present in high numbers, such as *Andrena flavipes* Panzer 1799 and *Andrena ovatula* (Kirby, 1802). This high diversity of species composition suggests that there is still much to be done on the bee fauna across Egypt in other areas such as the southern plateau of the country, which occurs in two different biogeographic zones.

Bee communities are influenced by the plant community, plant diversity, canopy cover, land use and nesting suitability (Grundel et al., 2010). Therefore, a complete list of the area's flora was compiled with available pollen resources and palynological analysis of pollen grains in bee scopal hairs and a few nests. The most attractive plant families for bees were Asteraceae, Brassicaceae and Fabaceae, as found in other studies in the Mediterranean area (Zoratti et al. 1995). The most abundant families were Asteraceae, Rosaceae, Labiatae, Fabaceae, Brassicaceae and Poaceae. Plants of Asteraceae taxa were the predominant forage flora for bees, followed by Poaceae, Labiatae and Fabaceae and 11 minor sources (Garg 1996). In the case of oligolectic bees, which were recorded in several specimens in this study, Asteraceae and Fabaceae, followed by Brassicaceae and Lamiaceae, were the most important hosts (Zurbuchen and Müller 2012). The most represented

botanical families visited by honeybee workers in Egypt were Fabaceae, Asteraceae, Brassicaceae, Malvaceae, Cucurbitaceae and Convolvulaceae (Esmaeil 2016; Abou-Shaara, 2015). Similar findings were also observed in European bees, where 73% of foraging visits by solitary bees were to Asteraceae (Centaurea sp.) and Apiaceae, which were occurred naturally on farmland (Wood et al. 2015). Most monolectic and oligolectic species were also attracted to the plant family Asteraceae, followed by Fabaceae, Brassicaceae and Campanulaceae (Bogusch et al. 2020.). Many Asteraceae taxa were highly attractive hosts (66.7% of visits) for oligolectic wild bees, followed by Brassicaceae, Lamiaceae, Fabaceae and *Echium vulgare* (Boraginaceae) (Kuppler et al. 2022).

The pollen spectrum present in the nests of two solitary bee genera (*Xylocopa aestuans* (L. 1758) and *Osmia* sp.) was determined by studying the pollen load residues found on the larval cells of the nests. From the data obtained, it was found that the pollen spectrum in the studied nest of *X. aestuans* L. was composed of a total of two pollen types, of which *Chenopodium murale* (Chenopodiaceae) showed the highest frequency of occurrence, followed by pollen grains of *Phragmites* sp. (Poaceae). On the other hand, the second nest was composed of one type of pollen grain (Brassicaceae), present in the nest of *Osmia* sp. The same results were found that two species of *Xylocopa* (*X. latipes* Drury and *X. pubescens* Spinol) were collecting nectar and pollen from several plant species belonging to different families, which were considered as polylectic bees (Raju and Rao, 2006). *Osmia submicans* Morawitz, 1870, which was also collected from the area, is known to be a polylectic bee (Amiet et al., 2004). In this context, the use of field strips and the maintenance of wild flowers around cultivated crops could increase bee species richness and abundance (Mohamed et al., 2024; Owayss, et al., 2020). In this perspective, the conservation of pollinators is mandatory and through this approach their ecological services in the ecosystem could be enhanced and secured for better pollination services.

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