

REVIEW

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The melittology research in Northern Africa and the Middle East: past and present situations

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Abstract

Background: More than 20,000 species in the superfamily Apoidea have been identified worldwide. This superfamily includes the most important group of insect pollinators that contribute to the integrity of ecosystems.

Main body: We have gathered in this paper data from many previous works in Northern Africa and Middle East regions. Some of these data are date from many years ago and others are recent. We present here a non-exhaustive list of some common Apoid species. In addition, certain previous studies that were published and other current research opportunities were suggested.

Conclusion: Although there are many bee experts in the Arab world, i.e., in apiculture, however, a few researchers are interested in melittology even though it seems that this region represents a large bee diversity.

Keywords: Checklist, Apoidea, Mellitology, Pollination, Solitary bees

Background

The sexual reproduction of over 90% of approximately 250,000 species of Angiosperms is depending on animal-pollination (Kearns & Oliveras, 2009). This plant-animal interaction maintains the world's biodiversity and contributes to the integrity of ecosystems. Crops often depend on honeybee colonies for their productivity, partially on wild bee pollinators also (Klein et al., 2006; Potts et al., 2016). Actually, among 107 global crops, 90 are visited by bees, being the most important group of pollinators (Klein et al., 2006). However, the economic, ecological, and biodiversity importances of pollinators are acknowledged for few systems (Delaplane & Mayer, 2000) and there is a considerable extent for studying the characteristics of pollinators in Northern Africa and the Middle

East (MENA) which moderates the value of pollinator communities. Although over 20,000 bee species have been globally reported (Ascher & Pickering, 2020), in most of Northern African and Arab countries, the total number of bee species is unclear and there are no published keys for species identification or even there is no updated checklist of bees for each country or the whole region (Grace, 2010; Shebl, Kamel, & Mahfouz, 2013). According to Rasmont (1995), the Maghreb and North Africa probably represent a bee diversity comparable or even larger than that of California where 1200 species were counted (Moldenke & Neff, 1974). Some studies show that the Maghreb and the Nile delta are remarkably rich in bee species and Morocco constitutes a hotspot for bee species richness. In contrast, in the area between western Egypt and southeastern Tunisia, the species richness is considered in a very low level (Michez & Patiny, 2007; Patiny, Michez, Kuhlmann, Pauly, & Barbier, 2009).

Dours (1872); Benoist (1941, 1949, 1950); Guiglia (1942); Priesner (1957); and Schulthess (1924) were

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among the first entomologists who were interested in the study of bee fauna in The Mediterranean and Northern Africa regions. More recent works include those of Daly (1983); Ebmer (1985); Ebmer and Grünwaldt (1976); Gusenleitner and Schwarz (2002); (Zanden, 1991, 1994, 1996).

Melittology research was done extensively in Algeria, Egypt, Morocco, and Saudi Arabia, in the last four decades probably with the beginning of the 70s. On the other hand, some works were carried out in Tunisia and Libya and probably in other countries (Bendifallah et al., 2010a).

Among the most genera studied, we found the genus *Andrena* which was studied extensively (Scheuchl, 2010; Warncke, 1974, 1980, 1983). During the 80s, a total of 196 species of *Andrena* were recorded in Northern Africa and the Middle East (Moustafa, 1986). Later, Gusenleitner and Schwarz (2002) in their work, reported about 300 species of *Andrena* in Northern Africa and more than 200 species in Algeria. Very few studies were conducted for nesting biology of bees in the whole region (Aguib, Benachour, Maghni, & Louadi, 2017; Alqarni, Hannan, Gonzalez, & Engel, 2014; Shebl, Alqarni, & Engel, 2016) but several studies were carried on the pollination of plants and crops (Aouar-sadli, Louadi, Doum, & Ji, 2008; Benachour, 2017; Benachour, Louadi, & Terzo, 2007; Benachour & Bounira, 2017; Benachour & Louadi, 2011; Benachour & Louadi, 2013; Bendifallah, Louadi, & Doumandji, 2013).

Main text

In Egypt, the first study was carried out in the late 1950s by Priesner (1957) who was interested in species of the genus *Anthophora* in the region. Suez Canal University is the hub center of melittology research in Egypt now. Several research projects of bee diversity and conservation have been started in the last two decades (Osman & Shebl, 2020; Shebl et al., 2013). Grace (2010) recorded around 370 bee species in Egypt. In 2020, 466 bee species were recorded by Ascher and Pickering (2020) representing 15 subfamilies and seven families of Apoidea. The first research with solitary bees started in the seventies at the Agriculture Research Center, Ministry of Agriculture. Some papers were published in local and international journals (Ibrahim, Nassib, & El-Sherbeeney, 1978; Moustafa, El-Hefny, Abd El-Salam, & Salem, 1979; Moustafa & El Berry, 1976; Rashad, 1978; Rashad, 1985). Extensive field expeditions were done in the Canal region, 62 species were listed in addition to some newly recorded species (Shebl et al., 2013; Shebl & Farag, 2015) (Table 1). At the beginning of this century, Suez Canal University was collaborated with Idaho University (USA) and received grants for initiating leafcutting-bee cell management for alfalfa pollination (Shebl, Kamel,

Abu Hashesh, & Osman, 2009). Some species were successfully nested in artificial nests (Kamel et al., 2019; Shebl, Hassan, Kamel, Osman, & Engel, 2018). Since there is no accurate number of native bee species in the country and still more species to be found and discovered (Abu Zeid, Shebl, & Metwali, 2019), more research is needed to be conducted.

In Algeria, the first studies established in the region started by Eaton, Morice, and Saunders (1908), Fountaine (1911), and Saunders (1906). The most recent works came later from Benachour et al. (2007), and Bendifallah et al. (2010a); Bendifallah, Doumandji, Louadi, and Iserbyt, (2012); Louadi and Doumandji (1998a, b); Louadi (1999); Louadi et al. (2007); Louadi, Berchi, and Benachour, (2007). A survey by Louadi et al. (2008) was conducted in the northeast regions of Algeria (Tell Atlas: Annaba, Skikda, El Kala, El Taref, Constantine, Khenchla, and Tebessa), and in the northeast of the Sahara (Biskra) have established a list of the solitary bees counting 382 species. These species were belonging to 55 genera and divided in six families: Apidae (17 genera, 111 species), Megachilidae (20 genera, 100 species), Colletidae (2 genera, 25 species), Melittidae (3 genera, 9 species), Halictidae (8 genera, 60 species), and Andrenidae (5 genera, 77 species). Aouar-sadli et al. (2008) noted several new records for bee fauna of Algeria in TiziOuzou region such as *Hylaeus (Prosopis) meridionalis* Förster, 1871; *Andrena (Chrysandrena) fulvago* Christ, 1791; *Nomioides facilis* Smith, 1853; and *Anthophora (Anthophora) subterranea* Germar, 1826. Also, Bendifallah et al. (2010a, b); Bendifallah, Louadi, Doumandji, and Michez (2011); Bendifallah et al. (2012); Bendifallah et al. (2015); and Bendifallah and Ortiz-Sánchez (2018) noted a diverse bee fauna in mid-northern Algeria and in the Northeastern Sahara (Mitidjaplain, Blida, Bouira, Boumerdes, Chlef, Biskra) with more than 190 taxa. *Anthophora (Lophanthophora) plumose* Pérez, *Eucera* (Heterocera) *squamosa* Lepeletier, 1841; *Eucera* (none or uncertain) *nitidiventris* Mocsary, 1978; *Xylocopa (Koptortosoma) pubescens* Spinola, 1838; *Ammobates (Ammobates) punctatus* Fabricius, 1804, were some new species and subspecies of Apoidea found in Algeria. It should be noted that studies on the systematics of some groups, also conducted basically in the northeastern part of the country, and allowed to identify new species for Algeria. For example, Aguib, Louadi, and Schwarz (2010) reported new taxa from Algeria including *Anthidium florentinum* Fabricius 1775, *Pseudoanthidium enslini* (Alfken 1928), and *Stelis similima* (Morawitz 1876). The family Andrenidae has been studied by Benarfa, Louadi, and Scheuchl (2013); Cherair, Scheuchl, Doumandji, and Louadi, (2013); Djouama, Louadi, and Scheuchl (2016), and Scheuchl, Benarfa, and Louadi (2011). About 70 species have been listed including ten

Table 1 List of some common species in North Africa and Middle East (Louadi et al., 2008; Dathe et al., 2009; Grace, 2010; Bendifallah et al., 2010a; Bendifallah et al., 2012; Kuhlmann et al., 2012; Bendifallah et al., 2013; Shebl et al., 2013; Shebl & Farag, 2015; Bendifallah & Ortiz-Sánchez, 2018; Ascher & Pickering, 2020)

Family	Species	Distribution	
Colletidae	<i>Colletes arabicus</i> Kuhlmann, 2002	Saudi Arabia and UAE	
	<i>Colletes cariniger</i> Pérez, 1903	Libya and Egypt	
	<i>Colletes coriandri</i> Pérez, 1895	Algeria, Tunisia, Libya, and Egypt	
	<i>Colletes elegans</i> Noskiewicz, 1936	Morocco, Tunisia, and Egypt	
	<i>Colletes intricans</i> Spinola, 1838	Morocco, Tunisia, and Egypt	
	<i>Colletes jejunos</i> Noskiewicz, 1936	Algeria, Egypt, and Jordan	
	<i>Colletes lacunatus</i> Dours, 1872	Morocco, Tunisia, Libya, Egypt, and UAE	
	<i>Colletes maroccanus</i> Warncke, 1978	Morocco, Libya, UAE, and Oman	
	<i>Colletes nanus</i> Friese, 1898	Morocco, Algeria, Tunisia, Libya, Egypt, Sudan, Syria, Jordan, UAE, and Oman	
	<i>Colletes perezi</i> Morice, 1904	Egypt Jordan, Yemen, and Tunisia	
	<i>Colletes pseudojejunos</i> Noskiewicz, 1959	Algeria and Egypt	
	<i>Colletes pumilus</i> Morice, 1904	Morocco, Algeria, Tunisia, Egypt, Jordan, and Saudi Arabia	
	<i>Hylaeus albonotatus</i> Walker, 1871	Morocco, Algeria Tunisia, Egypt, Jordan, Sudan, Yemen, Oman, and UAE	
	<i>Hylaeus biarmicus</i> Warncke, 1992	Morocco and Egypt	
	<i>Hylaeus dinkleri</i> Friese, 1898	Morocco and Egypt	
	<i>Hylaeus elatus</i> Warncke, 1981	Egypt, Yemen, Oman, and UAE	
	<i>Hylaeus hameri</i> Dathe, 1995	UAE and Oman	
	<i>Hylaeus moricei</i> Friese, 1898	Egypt, Syria, and Jordan	
	<i>Hylaeus angustatus</i> Schenck, 1859	Morocco, Lebanon, and Jordan	
	<i>Hylaeus sulphuripes</i> Gribodo, 1894	Morocco, Algeria, Tunisia, Libya, and Egypt	
	Andrenidae	<i>Andrena aegyptiaca</i> Friese, 1899	Morocco, Algeria, and Egypt
		<i>Andrena aegypticola</i> Friese, 1899	Libya, Egypt, Saudi Arabia, and Jordan
		<i>Andrena albifacies</i> Alfken, 1927	Morocco, Algeria, Tunisia, Libya, Egypt, and Iraq
<i>Andrena argyreofasciata</i> Schmiedeknecht, 1900		Algeria, Tunisia, Libya, and Egypt	
<i>Andrena bimaculata</i> Kirby, 1802		Morocco, Algeria, Tunisia, and Iraq	
<i>Andrena biskrensis</i> Pérez, 1895		Morocco, Algeria, Tunisia, and Egypt	
<i>Andrena caroli</i> Pérez, 1895		Morocco, Algeria, Tunisia, and Egypt	
<i>Andrena doursana</i> Dufour, 1853		Morocco, Algeria, Tunisia, Libya, and Egypt	
<i>Andrena fuscata</i> Erichson, 1835		North Africa and UAE	
<i>Andrena impunctata</i> Pérez, 1895		Morocco, Algeria, Tunisia, and Egypt	
<i>Borgatomelissa brevipennis</i> Walker, 1871		Yemen, Saudi Arabia, and UAE	
<i>Ceylalictus desertorum</i> Blüthgen, 1925		Morocco, Algeria, Tunisia, and Egypt	
<i>Ceylalictus punjabensis</i> Cameron, 1907		North Africa, UAE, and Jordan	
<i>Ceylalictus variegatus</i> Olivier, 1789		North Africa, Saudi Arabia, Yemen, Oman, Bahrain, and UAE	
<i>Dufourea nodicornis</i> Warncke, 1979		Egypt, Syria, and Jordan	
<i>Dufourea phoenix</i> Ebmer, 2008		Tunisia, UAE	
<i>Halictus brunnescens</i> Eversmann, 1852		North Africa, Egypt, and Syria	
<i>Halictus cupidus</i> Vachal, 1902		Morocco, Tunisia, and Egypt	
<i>Halictus lucidipennis</i> Smith, 1853		North Africa, Yemen, Saudi Arabia, Iraq, and UAE	
<i>Halictus pici falx</i> Ebmer, 2008		North Africa, Egypt, and Oman.	

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Family	Species	Distribution
	<i>Halictus aegypticola</i> Strand, 1909	Egypt, Jordan, and Lebanon
	<i>Halictus senilis</i> Eversmann, 1852	North Africa, Egypt, Iraq, Jordan
	<i>Halictus tibialis</i> Walker, 1871	Egypt, Jordan, Oman, Yemen, and UAE
	<i>Lipotriches parca</i> Kohl, 1906	Yemen, Bahrain, Libya, Egypt, Sudan, and UAE
	<i>Lasioglossum aegyptiellum</i> Strand, 1909	Libya, Egypt, Syria, and Iraq
	<i>Lasioglossum articulare</i> Pérez, 1895	North Africa, Egypt, Jordan, Oman, and UAE.
	<i>Lasioglossum decolor</i> Pérez, 1895	Algeria, Tunisia, Libya, and Egypt
	<i>Lasioglossum transitorium</i> Schenck, 1870	North Africa, Syria, Jordan, and Egypt
	<i>Nomia forbesii</i> Kirby, 1900	Sudan, Yemen, and UAE
	<i>Nomia lutea</i> Warncke, 1976	Algeria, Egypt, and Sudan
	<i>Nomia zonaria</i> Walker, 1871	Egypt, Sudan, Saudi Arabia, and UAE
	<i>Nomioides deceptor</i> Saunders, 1908	North Africa, Egypt, Saudi Arabia, and UAE
	<i>Nomioides klausi</i> Pesenko, 1983	Algeria, Tunisia, Saudi Arabia, UAE, and Oman
	<i>Pseudapis nilotica</i> Smith, 1875	North Africa; Saudi Arabia, Qatar, Oman, UAE, and Jordan
	<i>Panurgus nigriscopa</i> Pérez, 1895	Oman, Egypt, Morocco, Algeria, and UAE
	<i>Panurgus dentatus</i> Friese, 1901	Morocco, Algeria, Tunisia, Libya, Egypt, Jordan, and Saudi Arabia
	<i>Rophites algirus</i> Pérez, 1895	Morocco, Algeria, Tunisia, and Lebanon
	<i>Systropha diacantha</i> Baker, 1996	Oman and UAE
	<i>Systropha androstenes</i> Baker, 1996	UAE and Saudi Arabia
	<i>Sphecodes olivieri</i> Lepeletier, 1825	Morocco, Algeria, Egypt, Oman, Qatar, and UAE
	<i>Sphecodes longuloides</i> Blüthgen, 1923	Morocco, Tunisia, and Algeria
Melittidae	<i>Dasypoda albipila</i> Spinola, 1838	Egypt, Saudi Arabia, UAE, and Oman
	<i>Dasypoda hirtipes</i> Fabricius, 1793	North Africa, Egypt, Syria, and Iraq
	<i>Dasypoda sinuata</i> Pérez, 1895	North Africa and Egypt
	<i>Melitta aegyptiaca</i> Radoszkowski, 1891	Morocco, Tunisia, and Egypt
	<i>Melitta schmiedeknechti</i> Friese, 1896	North Africa and Egypt
	<i>Promelitta alboclypeata</i> Friese, 1900	Morocco
Megachilidae	<i>Anthidium anguliventre</i> Morawitz, 1888	Egypt, Jordan, Syria, and Oman
	<i>Anthidium manicatum</i> Linnaeus, 1758	North Africa, Egypt, Syria, and Lebanon
	<i>Chelostoma rapunculi</i> Lepeletier, 1841	North Africa, Iraq, Jordan, and Syria
	<i>Coelioxys decipiens</i> Spinola, 1838	Morocco, Tunisia, Egypt, Yemen, Oman, and Iraq
	<i>Coelioxys haemorrhhoa</i> Foerster, 1853	North Africa and Egypt
	<i>Eoanthidium bakerorum</i> Engel, 2004	North Africa, Egypt, and UAE
	<i>Icterantheidium ferrugineum</i> Fabricius, 1787	Morocco, Algeria, Tunisia, Egypt, Oman, Lebanon, Syria, UAE, and Saudi Arabia
	<i>Icterantheidium grohmanni</i> Spinola, 1838	Morocco, Algeria, Tunisia, Egypt, Syria, and Lebanon
	<i>Megachile amabilis</i> Cockerell, 1933	Sudan, Egypt, and Oman
	<i>Megachile apicalis</i> Spinola, 1808	Morocco, Algeria, Tunisia, Egypt, and Iraq
	<i>Megachile submucida</i> Alfken, 1926	Egypt and Saudi Arabia
	<i>Megachile walkeri</i> Dalla Torre, 1896	Egypt, Oman, Saudi Arabia, and UAE
	<i>Osmia alfkenii</i> Ducke, 1899	Morocco, Algeria, Tunisia, and Egypt
	<i>Osmia caerulea</i> Linnaeus, 1758	North Africa, Egypt, Jordan, and Syria

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Family	Species	Distribution
	<i>Osmia ferruginea</i> Latreille, 1811	North Africa, Egypt, Jordan, and Syria
	<i>Osmia latreillei</i> Spinola, 1806	North Africa, Egypt, Syria, Jordan, and Saudi Arabia
	<i>Osmia lhotelleriei</i> Pérez, 1887	North Africa, Egypt, Syria, and Jordan
	<i>Osmia fasciata</i> Latreille, 1811	Egypt, Jordan, UAE, and Iraq
	<i>Osmia gemmea</i> Pérez, 1895	North Africa, Egypt, and Syria
	<i>Osmia notata</i> Fabricius 1804	North Africa and Egypt
	<i>Stelis aegyptiaca</i> Radoszkowsky, 1876	North Africa, Egypt, and UAE
	<i>Stelis phaeoptera</i> Kirby, 1802	Algeria, Tunisia, Egypt, and Iraq
Apidae	<i>Amegilla albigena</i> Lepeletier, 1841	North Africa, Egypt, Jordan, Syria, and Lebanon
	<i>Amegilla quadrifasciata</i> de Villers, 1789	North Africa, Egypt, Syria, Iraq, and Lebanon
	<i>Ammobates oraniensis</i> Lepeletier, 1841	North Africa, Egypt, and Jordan
	<i>Bombus moscaryi</i> Kriechbaumer, 1877	Morocco, Algeria, Tunisia, Libya, Egypt, Syria, and Lebanon
	<i>Bombus lapidarius</i> Benoist, 1928	Morocco and Saudi Arabia
	<i>Bombus niveatus</i> Kriechbaumer, 1870	Lebanon and Syria
	<i>Ceratina citriphila</i> ockerell, 1935	Morocco, Algeria, Egypt, and Yemen
	<i>Ceratina parvula</i> Smith, 1854	North Africa, Egypt, Syria, and Jordan
	<i>Ceratina tarsata</i> Morawitz, 1872	Morocco, Egypt, Sudan, and Yemen
	<i>Eucera notata</i> Lepeletier, 1841	North Africa and Egypt
	<i>Eucera cuniculina</i> Klug, 1845	North Africa, Egypt, and Jordan
	<i>Nomada fenestrata</i> Lepeletier, 1841	Northern Africa Egypt, Lebanon, Jordan, and Iraq
	<i>Xylocopa pubescens</i> Spinola, 1838	North Africa, Egypt, Lebanon, Yemen, Jordan, Syria, and Saudi Arabia
	<i>Xycolopa aestuans</i> Linnaeus, 1758	Egypt and Sudan
	<i>Xylocopa sulcatipes</i> Maa, 1970	Egypt, Saudi Arabia, Yemen, and UAE

new species for the country, e.g., *A. (Orandrena) monilia* Warncke 1967, *A. (Suandrena) cyanomicans* Pérez 1895, *A. haemorrhoea* (Fabricius, 1775), and one new record, i.e., *Andrena tebessana* Scheuchl et al. (2011). Between 2009 and 2012, 35 species belonging to the family Halictidae were identified in different localities in Batna (eastern Algeria); *Lasioglossum musculum* was reported for the first time in Algeria (Chichoune, Benachour, Louadi, & Ortiz-Sánchez, 2018). In the region of the Aures (northeast of Algeria), 33 species have been identified belonging to the tribe Anthophorini and of which six were new to the country such as *Anthophora (Anthophora) punctilabris* (Pérez, 1879), *A. (Lophanthophora) mucida* (Gribodo, 1873), and *A. (Petalosternon) extricata* Priesner, 1957 (Maghni, Louadi, Ortiz-Sánchez, & Rasmont, 2017). A total of 15 species of cleptoparasitic bees of *Nomada* Scopoli, 1770 (Hymenoptera Apidae) were found between 2011 and 2014 in five locations of north eastern Algeria and two species, i.e., *Nomada rubiginosa* Pérez, 1884, and *Nomada glaucopsis* Pérez, 1890, were

new to the fauna of the country (Bakiri, Louadi, & Schwarz, 2016). The presence of *Sphecodes puncticeps* Thomson, 1870, a cleptoparasitic species in Algeria was also confirmed by Chichoune et al. (2018). At least, *Andrena taraxaci* and three species of Megachilidae (*Megachile albisecta*, *M. marginata*, and *M. minutissima*) were added to the faunistic list of wild bees in Algeria (Bouti, Berkani, Doumandji, & Quaranta, 2020). According to Ascher and Pickering (2020), the number of species in Algeria was about 826 species, 204 of them were belonging to Megachilinae (Table 1).

According to Penati and Mariotti (2015), the first research established about the hymenopterological fauna of Tunisia was done by Giacomo Doria in 1880 who described 57 taxa in unpublished paper deposited at Museo civico di Storia naturale (Genoa, Italy). Like other countries, the most research about the Apoidea were done by foreigner entomologists, e.g., Daly (1983), Gusenleitner and Schwarz (2002), Penati and Mariotti (2015), Scheuchl (2009), Schulthess (1924), Warncke

(1980). We have noted the work of Sonet and Jacob-Remacle (1987) on pollination of the forage legume *Hedysarum coronarium* L. Those authors mentioned the presence of four families (Apidae, Halictidae, Andrenidae, and Megachilidae). Also, the work of Zanden (1991, 1994) on the Megachilidae where the author reported the presence of the genus *Anthocopa* in the region of Gafsa in 1991, and described in 1994 new subspecies, i.e., *Hoplosmia anceyibiarnica* from Tunisia which was also recorded in Algeria and Morocco and *Protosmia querquedula*.

Although the absence of national research centers and specialized researchers, as the main causes, it seems that Tunisia is a very rich country with a total of 651 species (Ascher & Pickering, 2020) (Table 1). The first study established in 2009 gave a first approach to the composition of bee fauna in four regions of Tunisia, showed the presence of six families: Megachilidae (5 genera), Apidae (10 genera), Halictidae (5 genera), Andrenidae (3 genera), Colletidae (2 genera), and Melittidae (1 genus). The most represented genus, with 20% of all recorded species, was *Eucera* (Chouchaine, 2015). The second study (Imene Rjiba, 2014, unpublished data) was conducted in the region of Bizerte (north of Tunisia) and in an orchard in the region of Chott-Meriem, Sousse (east of Tunisia). The study was addressing the diversity of wild bees more than their abundance. A total of six families were listed: Crabronidae, Apidae, Halictidae, Megalichidae, Andrenidae, and Sphecidae. A study of Crabronid fauna in Tunisia revealed the presence of 22 species belonging to 12 genera and three subfamilies (Astatinae, Crabroninae, and Pemphredoninae) (Khedher, Yildirim, & Braham, 2020). Recently, a *Hoplitis mucida* was discovered in Tunisia (El Kef in northern Tunisia) (Müller, Mauss, & Prosi, 2017), revealed striking differences than the two subspecies used to be known, *H. mucida mucida* (Dours, 1873) and *H. mucida stecki* (Frey-Gessner, 1908).

In 2020, a preliminary study conducted in a semi-arid environment in Tunisia concerned the distribution of insect visitors, in addition to honey bees hives, revealed the presence of three superfamilies: the Apoidea (represented mainly by the Apidae and Megachilidae families), the Ichneumonoidea, and the Vespoidea (Ben Abdelkader, Ounisi, Barbouche, & Ammar, 2020).

Although research on the conservation of wild bees is common in the Mediterranean area, little is known about their status in the Libyan ecosystem. Libya as all other countries of the Mediterranean Basin contains many non-*Apis* species that spread all over the country. Among the works carried out in the Maghreb region during the first half of the twentieth century, we found the work of Guiglia (1942) who studied the Hymenoptera of Libya. Recently, about 151 bee species were

recorded by Grace (2010) and 276 species were reported by Ascher and Pickering (2020) in Libya (Table 1).

The melittology research in Libya based on a team-work at Faculty of Science, Omar Al-Mukhtar University. Currently, there are some ongoing studies focused on wild bee's diversity of the Al-Jabal Al-Akhder that is a dense in east Libya, covered with agricultural and wild plants. Also, some basic ecological studies such as species distribution and their interaction with wild plant flowers are in progress. Surely, the results of these studies will encourage other researchers to get involved and explore the country's native bee diversity and its great impact on the ecosystem.

In Morocco, the bee fauna was studied by Benoist (1941, 1949, 1950). Ebmer and Grünwaldt (1976) and Ebmer (1985) were particularly interested in the fauna of the Halictidae by describing the species of the genera *Lasioglossum* and *Halictus* of this country. More recently, Pierre Rasmont and Yvan Barbier of the research team of Mons and Gembloux, carried out most wild bee research. A total of 925 species belonging to Andrenidae (193), Apidae (233), Colletidae (75), Halictidae (143), Megachilidae (267), and Melittidae (14) were reported in Morocco (Ascher & Pickering, 2020) (Table 1). Currently, there is a great funded project by ICARDA to evaluate the role of solitary bees in crop pollination. This project extended to other countries, e.g., Algeria represented in the National Institute of Agronomic Research (Algiers and Touggourt) whose work began in 2020.

Patiny et al. (2009) evaluated the distribution of some bee species within a region including the Sahara and Arabian deserts and their adjacent areas. They found that the *Hoplitis mucida* (Dours, 1873) was presented in Maghreb region (Morocco, Algeria, and Tunisia). The *Melitturga albescens* was the only palaeartic species found in Atlas Mountains and Tafilalt in Morocco. *Panurgus dentatus* was reported in Morocco along the southern slopes of the Atlas Mountains and in Egypt (Nile Valley) (Shebl, Patiny, & Michez, 2015), the mountains south of Tripoli and westwards into Tunisia. *Dasy-poda oraniensis* was restricted to Morocco and western Algeria and was not existed in the eastern part of North Africa.

Taxonomic works including material from Saudi Arabia started after 1970 (Alqarni, Hannan, & Engel, 2012; Alqarni, Hannan, Gonzalez, & Engel, 2014; Alqarni et al., 2014a, b, c; Daly, 1983; Ebmer, 1984, 1985; Engel, 2004; Engel, 2008; Engel, Hannan, & Alqarni, 2012; Engel, Alqarni, & Shebl, 2017; Engel, Alqarni, Shebl, Iqbal, & Hinojosa-Díaz, 2017; Michez & Patiny, 2007). In a survey conducted in 2013, 22 genera were documented in the literature for Saudi Arabia (Engel, Alqarni, & Hannan, 2013). Later, in 2017, at least 45 genera were found in the country with some expected new genera

and species (Engel, Alqarni, & Shebl, 2017). Probably the total species number across the country is around 200 to 250 species including some cleptoparasitic taxa. The large carpenter bees (Xylocopinae, *Xylocopa* Latreille) occurring in central Saudi Arabia were reviewed, and two species were listed, i.e., *Xylocopa aestuans* and *X. sulcatipes* Maa (Hannan et al., 2012) in addition to a new species described from Sarawat Mountains (Engel, Alqarni, Shebl, Iqbal, & Hinojosa-Díaz, 2017). *Melitta* Kirby, 1802 (Melittidae: Melittinae) was recorded for the first time in Saudi Arabia (Table 1). *Melitta schmiedeknechti* Friese, 1898 females were captured also in Saudi Arabia, representing the first discovery of this species, previously found across northern Africa and the southern Levant (Shebl et al., 2016). The nest architecture, foraging behavior, and host plants of the leafcutting bee, *Megachile minutissima* (Hymenoptera: Megachilidae), was also studied in Saudi Arabia (Alqarni, Hannan, Gonzalez, & Engel, 2014).

Baker (2004) collected and documented many data of several British hymenopterists between 1979 and 1993 in Qatar, UAE, and Oman. He reported the main two studies; Roche (1981) and Hamer (1986) and he published a list of bees and wasps found in these countries. Two new species, *Andrena Arabica* and *A. madaqi* (Hymenoptera, Apidae), were described from UAE (Scheuchl & Gusenleitner, 2007). A survey in 2009 revealed the presence of 140 species, 46 genera in six of seven families found in UAE (Dathe et al., 2009) (Table 1). This was a low number compared to that known in the Mediterranean region which has a rich flora (Jongbloed, Feulner, Böer, & Western, 2003).

The first information concerning the bees of Syria dates from 1890. Thirty-four species were recorded from Damascus. Later in 1908, 20 new species of bees, mostly from Damascus and Homs, were recorded. In 1956, the list of the bees described and recorded was about 55 species (Mavromoustakis, 1956b). In 2010, Grace (2010) cited 266 species from Syria, while (Ascher & Pickering, 2020) reported the presence of 440 species (Table 1).

In Lebanon, bee fauna is not well documented. The first works were from Mavromoustakis (1955, 1956a, 1962) who collected extensively bees of Anthidiini and Osminii. About 163 species were cited by Grace (2010), but 260 species were listed by Ascher and Pickering (2020). Boustani et al. (2020) listed four species of bumblebees with different foraging ranges.

Like Syria and Lebanon, the investigation about bee fauna in Jordan is very poor. In 2006, 53 species were identified, recorded, and classified into five families: Apidae, Megachilidae (widely diversified), Halictidae (highly abundant), Andrenidae, and Colletidae (Al-Ghazawi, Zaitoun, Mazary, Schindler, & Wittmann, 2006). About 50 *Andrena* species were found in Jordan (Erwin Scheuchl

and Gideon Pisanty) unpublished data in Pisanty, Scheuchl, and Dorchin (2018).

In Iraq, studies in this concern were very few also. Augul (2018) investigated the fauna of bees (Hymenoptera, Apoidea) from different regions of Iraq. A total of 16 species from 13 genera belonging to four families was found. The same author revised all the species that were recorded in previous investigations and reported the presence of 110 species, 32 genera belonging to five families: Apidae, Andrenidae, Colletidae, Halictidae, and Megachilidae. In 2019, a revision about the Sphecidae was done, 41 species belonging to 12 genera, and four subfamilies of the family Sphecidae were found in Iraq (Augul, 2019).

Unfortunately, we were unable to find any literature about the bee fauna of Yemen and Oman except those cited by Baker (2004). Some genera were recorded by Alqarni et al. (2014c) and Engel (2011). According to Ascher and Pickering (2020), 67 species recorded in Yemen representing five families and 83 species were recorded in Oman, considered very low number compared to those of other regions (Table 1).

This work describes the situation of mellitology research in North Africa and the Middle East. It also cites the most common species present in the region. According to the literature, the bee fauna is very rich in MENA region with the presence of the six families in all the countries. The diversity of species is variable according to the countries geography, topography, and floral diversity. There are many common bee species, for each family, exist in MENA region, Apidae with almost 549 species, followed by the Megachilidae with 555 species. The Andrenidae and the Halictidae families came third place with almost 326 and 330 species respectively. Finally, the Colletidae and the Mellittidae presented 148 and 25 species respectively. This review forms the basis for further studies involving the identification and bee-plant interactions in MENA regions. The continuous surveys will add more information about the bees in the region. Those efforts will be made to seek out further material in the field, obtain observations on their floral visitation behaviors, nesting biology, and locate immature stages.

Conclusions

Bees have great economic and ecological value. Recently, their continuous global loss requires the urgent development of specific conservation strategies. However, the difficulty of estimating the loss of bees and/or their preservation is due to lack of information (e.g., databases, not updating previous findings, etc.) concerning their worldwide diversity. Nevertheless, very little work has so far aimed to study the diversity of bees in the Arab world and Northern Africa although studies on bee

diversity are abundant in many countries. One of the major problems facing scientists especially in Northern Africa is the lack of funding and collaboration for conducting several research expeditions across the countries. Moreover, upcoming researches in these countries need to focus on taxonomy, diversity, ecology, and biology of native bees. Our utmost goal of such initiative and consortium is to show the great impact of native bees on the pollination services of wild and cultivated plants that are requesting continuous protection and conservation.

Abbreviations

UAE: United Arab Emirates; MENA: Middle East and North Africa

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Authors' contributions

MS, MO, and SK collected data from Egypt. FBA collected data from Tunisia and Morocco. LB and KB collected data from Algeria. AB and EB collected data from Libya. FBA and MS collected data from the Middle East. All authors read and approved the final manuscript.

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