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

Mohamed A. Shebl 1, Faten Ben Abdelkader 2*, Leila Bendifallah 3, Karima Benachour 4, Ali A. Bataw 5, Emsaed M. Bufliga 16, Mohamed A. Osman 1 and Soliman M. Kamel 1

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 Apoidea 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

* Correspondence: benabdelkaderfaten@gmail.com

2Laboratory of Bio-aggressors and Integrated Pest Management in Agriculture, National Institute of Agronomy of Tunisia, Carthage University, 1082 Cité Maharjène, Tunis, Tunisia

Full list of author information is available at the end of the article

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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); Gunseliitner and Schwarz (2002); (Zanden, 1991, 1994, 1996).

Melititology 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 Adrena were recorded in Northern Africa and the Middle East (Moustafa, 1986). Later, Gunseliitner 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-Sherbeeny, 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 Iserybt, (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 Hylaenus (Prosoapis) meridonialis Förster, 1871; Andrena (Chrysandrena) fulvago Christ, 1791; Nomioioides facilis Smith, 1853; and Anthophora (Anthophora) subterranea Germar, 1826. Also, Bendifallah et al. (2010a, b); Bendifallah, Louadi, Doumandji, and Micez (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) plumosum Pérez, Eucera (Heteroeucera) squamosa Lepeletier, 1841; Eucera (none or uncertain) nitidiventris Mocsary, 1978; Xylocopa (Koptortosoma) pubescens Spinola, 1838; Anmmbobates (Anmmbobates) 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 Anthidiom 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 | Colletes arabicus Kuhlmann, 2002 | Saudi Arabia and UAE |
| | Colletes cariniger Pérez, 1903 | Libya and Egypt |
| | Colletes coriandri Pérez, 1895 | Algeria, Tunisia, Libya, and Egypt |
| | Colletes elegans Noskiewicz, 1936 | Morocco, Tunisia, and Egypt |
| | Colletes intricans Spinola, 1838 | Morocco, Tunisia, and Egypt |
| | Colletes jejunus Noskiewicz, 1936 | Algeria, Egypt, and Jordan |
| | Colletes lacunatus Dours, 1872 | Morocco, Tunisia, Libya, Egypt, and UAE |
| | Colletes maroccanus Warncke, 1978 | Morocco, Algeria, Tunisia, Libya, Egypt, Sudan, Syria, Jordan, UAE, and Oman |
| | Colletes nanus Friese, 1898 | Egypt, Jordan, Yemen, and Tunisia |
| | Colletes perezi Morice, 1904 | Algeria and Egypt |
| | Colletes pseudojejunus Noskiewicz, 1959 | Morocco, Algeria, Tunisia, Egypt, Jordan, and Saudi Arabia |
| | Colletes pumilus Morice, 1904 | Morocco, Algeria, Tunisia, Egypt, Jordan, Sudan, Yemen, Oman, and UAE |
| | Hylaeus albonotatus Walker, 1871 | Morocco and Egypt |
| | Hylaeus biarmicus Warncke, 1992 | Morocco and Egypt |
| | Hylaeus dinkleri Friese, 1898 | Egypt, Yemen, Oman, and UAE |
| | Hylaeus elatus Warncke, 1891 | UAE and Oman |
| | Hylaeus hameri Dathe, 1995 | Egypt, Syria, and Jordan |
| | Hylaeus moricei Friese, 1898 | Morocco, Lebanon, and Jordan |
| | Hylaeus angustatus Schenck, 1859 | Morocco, Algeria, Tunisia, Libya, and Egypt |
| | Hylaeus sulphuripes Gribodo, 1894 | Morocco, Algeria, Tunisia, Libya, and Egypt |
| Andrenidae | Andrena aegyptiaca Friese, 1899 | Libya, Egypt, Saudi Arabia, and Jordan |
| | Andrena aegypticola Friese, 1899 | Morocco, Algeria, Tunisia, Libya, Egypt, and Iraq |
| | Andrena albifacies Alfken, 1927 | Algria, Tunisia, Libya, and Egypt |
| | Andrena argyrofasciata Schmiedeknecht, 1900 | Morocco, Algeria, Tunisia, and Iraq |
| | Andrena bimaculata Kirby, 1802 | Morocco, Algeria, Tunisia, and Egypt |
| | Andrena biskrensis Pérez, 1895 | Morocco, Algeria, Tunisia, and Egypt |
| | Andrena caroli Pérez, 1895 | Morocco, Algeria, Tunisia, Libya, and Egypt |
| | Andrena dousana Dufour, 1853 | North Africa and UAE |
| | Andrena fuscosa Erichson, 1835 | Morocco, Algeria, Tunisia, and Egypt |
| | Andrena impunctata Pérez, 1895 | Yemen, Saudi Arabia, and UAE |
| | Borgatromelissa brevipennis Walker, 1871 | Morocco, Algeria, Tunisia, and Egypt |
| | Ceylalictus desertorum Blüthgen, 1925 | North Africa, UAE, and Jordan |
| | Ceylalictus punjabensis Cameron, 1907 | North Africa, Saudi Arabia, Yemen, Oman, Bahrain, and UAE |
| | Ceylalictus variegatus Olivier, 1789 | Egypt, Syria, and Jordan |
| | Dufourea nodicornis Warncke, 1979 | Tunisia, UAE |
| | Dufourea phoenicea Ebmer, 2008 | North Africa, Egypt, and Syria |
| | Halictus brunescens Eversmann, 1852 | Morocco, Tunisia, and Egypt |
| | Halictus cupidus Vachal, 1902 | North Africa, Yemen, Saudi Arabia, Iraq, and UAE |
| | Halictus lucidipennis Smith, 1853 | North Africa, Egypt, and Oman. |
| | Halictus pici falx Ebmer, 2008 | |
| Family       | Species                        | Distribution                                      |
|--------------|--------------------------------|---------------------------------------------------|
| Halictidae   | Halictus aegypticola Strand, 1909 | Egypt, Jordan, and Lebanon                         |
|              | Halictus senilis Eversmann, 1852 | North Africa, Egypt, Iraq, Jordan                  |
|              | Halictus tibialis Walker, 1871  | Egypt, Jordan, Oman, YemeN, and UAE                |
|              | Lipatriches parca Kohl, 1906     | Yemen, Bahrain, Libya, Egypt, Sudan, and UAE       |
|              | Lasio glossum aegyptiellum Strand, 1909 | Libya, Egypt, Syria, and Iraq                      |
|              | Lasio glossum articulare Pérez, 1895 | North Africa, Egypt, Jordan, Oman, and UAE.        |
|              | Lasio glossum decolor Pérez, 1895 | Algeria, Tunisia, Libya, and Egypt                 |
|              | Lasio glossum transitorium Schenck, 1870 | North Africa, Syria, Jordan, and Egypt             |
|              | Nomia forbesi Kirby, 1900        | Sudan, Yemen, and UAE                              |
|              | Nomia lutea Warncke, 1976        | Algeria, Egypt, and Sudan                          |
|              | Nomia zonaria Walker, 1871       | Egypt, Sudan, Saudi Arabia, and UAE                |
|              | Nomioides deceptor Saunders, 1908 | North Africa, Egypt, Saudi Arabia, and UAE         |
|              | Nomioides klasii Pesenko, 1983   | Algeria, Tunisia, Saudi Arabi, UAE, and Oman       |
|              | Pseudapis nilotica Smith, 1875   | North Africa; Saudi Arabia, Qatar, Oman, UAE, and Jordan |
|              | Panurgus nigricopa Pérez, 1895   | Oman, Egypt, Morocco, Algeria, and UAE             |
|              | Panurgus dentatus Friese, 1901   | Morocco, Algeria, Tunisia, Libya, Egypt, Jordan, and Saudi Arabia |
|              | Rophites algirus Pérez, 1895     | Morocco, Algeria, Tunisia, and Lebanon             |
|              | Systropha diacantha Baker, 1996  | Oman and UAE                                      |
|              | Systropha andrasthenes Baker, 1996 | UAE and Saudi Arabia                          |
|              | Sphecodes olivieri Lepeletier, 1825 | Morocco, Algeria, Egypt, Omaa, Qatar, and UAE   |
|              | Sphecodes longuloides Blüthgen, 1923 | Morocco, Tunisia, and Algeria                |
| Melittidae   | Dasypoda albipila Spinola, 1838  | Egypt, Saudia Arabia, UAE, and Oman               |
|              | Dasypoda hirtipes Fabricius, 1793 | North Africa, Egypt, Syria, and Iraq              |
|              | Dasypoda sinuata Pérez, 1895     | North Africa and Egypt                            |
|              | Melitta aegyptiaca Radoszkowski, 1891 | Moroco, Tunisla, and Egypt                      |
|              | Melitta schmiedeknecht Friese, 1896 | North Africa and Egypt                          |
|              | Promelitta alboclypeata Friese, 1900 | Morocco                                           |
| Megachilidae | Anthidium argutilventre Morawitz, 1888 | Egypt, Jordan, Syria, and Oman                   |
|              | Anthidium manicatum Linnaeus, 1758 | North Africa, Egypt, Syria, and Lebanon           |
|              | Chelostoma rapunculi Lepeletier, 1841 | North Africa, Iraq, Jordan, and Syria          |
|              | Coelioxys decipiens Spinola, 1838 | Moroco, Tunisia, Egypt, Yemen, Oman, and Iraq    |
|              | Coelioxys haemorrhoa Foerster, 1853 | North Africa and Egypt                           |
|              | Eoanthidium bakerorum Engel, 2004 | North Africa, Egypt, and UAE                      |
|              | Icteranthidium ferrugineum Fabricius, 1787 | Morocco, Algeria, Tunisia, Egypt, Oman, Lebanon, Syria, UAE, and Saudi Arabia |
|              | Icteranthidium grohmanni Spinola, 1838 | Morocco, Algeria, Tunisia, Egypt, and Lenanonen |
|              | Megachile amabilis Cockerell, 1933 | Sudana, Egypt, and Oman                           |
|              | Megachile apicalis Spinola, 1808 | Morocco, Algeria, Egypt, and Iran                 |
|              | Megachile submucida Alfken, 1926 | Egypt and Saudi Arabia                            |
|              | Megachile walkeri Dalla Torre, 1896 | Egypt, Oman, Saudi Arabia, and UAE               |
|              | Osmia alfkeni Ducke, 1899        | Morocco, Algeria, Tunisia, and Egypt              |
|              | Osmia caerulea Linnaeus, 1758    | North Africa, Egypt, Jordan, and Syria           |
new species for the country, e.g., *A. (Orandrena) monilia* Warncke 1967, *A. (Suandrena) cyanomica* Pérez 1895, *A. haemorrhhoa* 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 glaucopis* 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). 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).

### Table 1

| Family | Species | Distribution |
|--------|---------|--------------|
| **Osmia** Latreille, 1811          | *Osmia ferruginea* Latreille, 1811 | North Africa, Egypt, Jordan, and Syria |
|          | *Osmia latreillei* Spinola, 1806 | North Africa, Egypt, Jordan, and Saudi Arabia |
|          | *Osmia latreillii* Pérez, 1887 | North Africa, Egypt, Syria, and Jordan |
|           | *Osmia fasciata* Lateille, 1811 | Egypt, Jordan, UAE, and Iraq |
|           | *Osmia gemmata* Pérez, 1895 | North Africa, Egypt, and Syria |
|           | *Osmia notata* Fabricius 1804 | North Africa and Egypt |
|           | *Stelis aegyptiaca* Radoszkowski, 1876 | North Africa, Egypt, and UAE |
|           | *Stelis phaeoptera* Kirby, 1802 | Algeria, Tunisia, Egypt, and Iraq |
| **Apidae**          | *Amegilla albigena* Lepeletier, 1841 | North Africa, Egypt, Jordan, Syria, and Lebanon |
|          | *Amegilla quadrifasciata de Villers, 1789* | North Africa, Egypt, Syria, Iraq, and Lebanon |
|          | *Ammobates anarsiensis* Lepeletier, 1841 | North Africa, Egypt, and Jordan |
|          | *Bombus maysauty* Kriechbaumer, 1877 | North Africa, Egypt, and Jordan |
|          | *Bombus lapidarius* Benoist, 1928 | Morocco and Saudi Arabia |
|          | *Bombus niveatus* Kriechbaumer, 1870 | Lebanon and Syria |
|          | *Ceratina citriphila* ackerell, 1935 | Morocco, Algeria, Egypt, and Yemen |
|          | *Ceratina panula* Smith, 1854 | North Africa, Egypt, Syria, and Jordan |
|          | *Ceratina tarata* Morawitz, 1872 | Morocco, Egypt, Sudan, and Yemen |
|          | *Euca cerata* Lepeletier, 1841 | North Africa and Egypt |
|          | *Eucera cuniculina* Klug, 1845 | North Africa, Egypt, and Jordan |
|          | *Nomada fenestrata* Lepeletier, 1841 | Northern Africa, Egypt, Lebanon, Jordan, and Iraq |
|          | *Xylocopa pubescens* Spinola, 1838 | North Africa, Egypt, Lebanon, Yemen, Jordan, Syria, and Saudi Arabia |
|          | *Xylocopa aestuans* Linnaeus, 1758 | Egypt and Sudan |
|          | *Xylocopa sulcatipes* Maa, 1970 | Egypt, Saudi Arabia, Yemen, and UAE |
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 aneczybiarnica* from Tunisia which was also recorded in Algeria and Morocco and *Protosmia querqueda*. 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 *Eucer (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, Yildrim, & 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 Megachilidea families), the Ichneumonoidea, and the Vespoidae (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 teamwork 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-Akhdar 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 palaearctic 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. *Dasypoda oranienis* 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* Maal (Hannan et al., 2012) in addition to a new species described from Sarawat Mountains (Engel, Alqarni, Shebl, Igbal, & 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. maidaqi* (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-Ghzawi, 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, Andenridae, 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 Northen 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

Acknowledgements
The authors would like to express their gratitude to the editor and anonymous reviewers for their insightful comments, which greatly improved the quality of this manuscript.

Authors’ contributions
MS, MO, and SK collected data from Egypt. FBA collected data from Tunisia and Morocco. LS 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.

Funding
Not applicable.

Availability of data and materials
Not applicable.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Author details
1Department of Plant Protection, Faculty of Agriculture, Suez Canal University, Ismailia 41522, Egypt. 2Laboratory of Bio-aggressors and Integrated Pest Management in Agriculture, National Institute of Agronomy of Tunisia, Carthage University, 1082 Cité Mahrajène, Tunis, Tunisia. 3Department of Agronomy, Faculty of Sciences, M'Hamed Bougara University of Boumerdès, Avenue de l’Indépendance, 35000 Boumerdès, Algeria. 4Institut de la Nutrition, de l’Alimentation et des Technologies Agro-alimentaires-Laboratoire de Biosystématique et Ecologie des Arthropodes, Université Frères Mentouri Constantine 1, Route Ain El Bey, 25000 Constantine, Algeria. 5Department of Natural Resources and Arthropodes, Université Frères Mentouri Constantine 1, Route Ain El Bey, Agro-alimentaires-Laboratoire de Biosystématique et Ecologie des Arthropodes, Université Frères Mentouri Constantine 1, Route Ain El Bey, 25000 Constantine, Algeria. 6Department of Plant Protection, Faculty of Agriculture, Suez Canal University, Ismailia 41522, Egypt. 7Department of Agronomy, Faculty of Sciences, M’Hamid Bougara University of Boumerdes, Avenue de l’Indépendance, 35000 Boumerdes, Algeria. 8Department of Zoology, Faculty of Science, Omar Al Mukhtar University, Al Bayda, Libya.

Received: 7 December 2020 Accepted: 18 March 2021
Published online: 01 April 2021

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