Bulletin of Insectology **71** *(1): 143-149, 2018*
ISSN 1721-8861

First record of the Asiatic bee *Megachile disjunctiformis* in Europe

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Abstract

Megachile disjunctiformis Cockerell 1911 (Hymenoptera Megachilidae) is recorded for the first time in Europe. After previous observations in 2011 and 2016 near Bologna, Italy, three specimens (one female and two males) were captured in three different locations of the Bologna area in 2017 and identified. The species is known from China, Japan, Taiwan, Hong Kong and Korea. In this paper a description of the specimens and comparison with other similar species are provided. Furthermore visited plants are indicated. The finding localities are relatively close to two important Bologna trading areas, suggesting that these may be the original sites of introduction in Italy. Little is known about this species and its biology in Italy will be subject of future investigations.

Key words: *Megachile disjunctiformis*, *Callomegachile*, alien species, non-native insect species, resin bees, Italy, Bologna.

Introduction

In the last decades the number of unintentionally introduced non-native insect species increased enormously, due to the augmenting international trade (Drake *et al.*, 1989; Bacon *et al.*, 2012). In many cases the introduction of alien insect species represents a severe damage for local flora or fauna, especially when they act as pests, parasites or predators (Kenis *et al.*, 2009). In the case of bees (Hymenoptera Apoidea), the potential impact of non-native species is difficult to quantify, since they are usually considered beneficial insects for their role in pollination of wild and cultivated plants. On the other hand, they can play a negative impact through the transmission of pathogens and parasites to native bee species, the competition for nesting sites or floral resources, spread of alien weeds (exotic bees exhibit marked preferences for flowers of exotic plants) and the alteration of plant-pollinator networks (Goulson, 2003; Russo, 2016).

Among non-native introduced bees, the family Megachilidae and in particular the genus *Megachile* Latreille 1802 is the most represented group in terms of number of species. The reason is that they nest in stems, twigs and wood cavities and thus can be easily transported within these vegetative parts (Russo, 2016).

Megachile disjunctiformis Cockerell 1911 is an Asiatic megachilid of the subgenus *Callomegachile* Michener 1962. Its countries of origin are China, Japan, Taiwan, Hong Kong and Korea (although the records from Korea have not been confirmed) and it has not been recorded in Europe before (Hirashima, 1974; Lee and Ryu, 2013) (figure 1). The only previous evidence of *M. disjunctiformis* as alien species comes from an Australian report of 1967, where an adult specimen was found in instrument filters of an aircraft coming from Vietnam; nevertheless the taxonomic identification remains uncertain (Chadwick and Nikitin, 1979).

A description of the species can be found in Cockerell (1911). Male and female have black body with white hairs at the base of the abdomen and adjacent part of the thorax. Males are smaller (about 10 mm length) than females (maximum 18 mm length). In the female, the abdominal scopa is creamy white until the fourth segment and black beyond and the clypeus bears a pair of apical tubercles. Male clypeus is bare and shining, except for a dense white beard, and with strong punctures; anterior tarsi and tibiae are simple, anterior coxae with small spines, reddish at the end (Cockerell, 1911).

The biology of this species is poorly known and few references are present. *M. disjunctiformis* belongs to the so called "resin bees" or "dauber bees", a group of species that line nest cavities with mud and resin collected from trees (Michener, 2007; Praz, 2017). It is reported to nest in bamboo reeds and to plug the cells with a mixture of mud and resin (Osaka Museum collection, 2017). A Japanese blog reports of a gregarious nesting in wood cavities, with holes plugged with pine resin (https://ameblo.jp/bembix888/entry-11594407989.html). The flying season in Japan is from June to August (Osaka Museum collection, 2017) and some Japanese specimens were collected in August and September (Kyoto Museum collection, 2017), but the number of generations is not known. In the areas of origin the known visited plants are *Vitex cannabifolia* Siebold et Zucc. (Verbenaceae), *Clerodendrum trichotomum* Thunb. (Verbenaceae) and *Maackia tashiroi* (Yatabe) Makino (Fabaceae) (Kyoto Museum collection, 2017; MANGAL Ecological Interactions database, 2017).

Among Indian and South East Asiatic *Callomegachile*, three species look very similar to *M. disjunctiformis*: *Megachile disjuncta* F. 1781, *Megachile conjuncta*

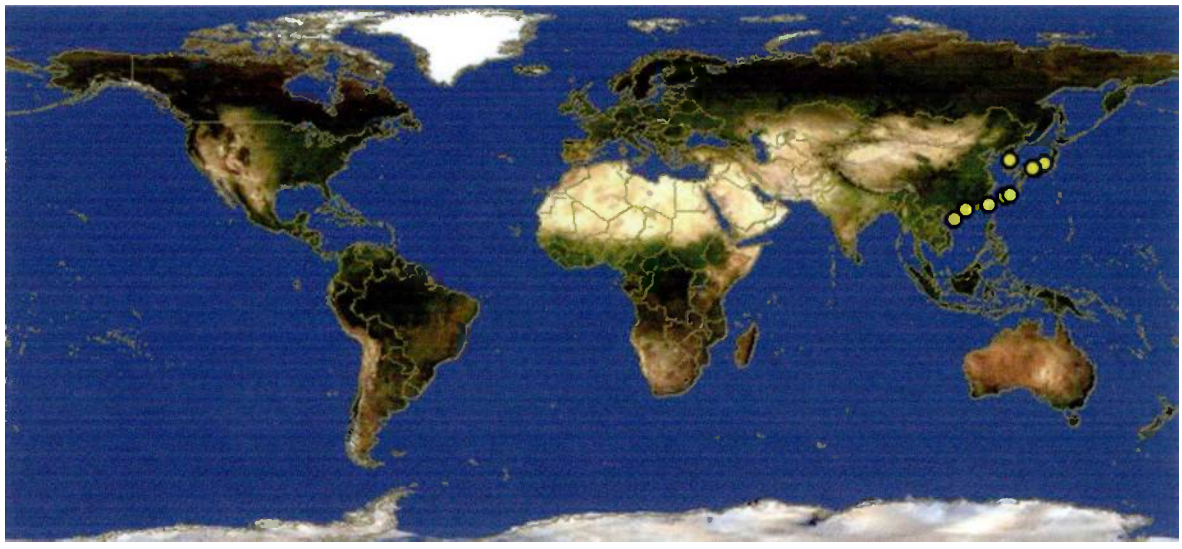

Figure 1. Records of *M. disjunctiformis* in its countries of origin (Ascher and Pickering, 2018).

Smith 1853 and an undetermined species of *Megachile* belonging to the *biroi* group (Ascher *et al.*, 2016). In all these species females are black with whitish hairs on the posterior thorax (propodeum) and anterior metasoma, and their wings are largely infuscated. Although they appear very similar in dorsal view, they differ in the colour of their scopal hairs, which are black, orange-red, and pale-yellow respectively. Males of *M. disjuncta* and *Megachile* sp. *biroi* group are very similar to each other and to conspecific females, while in *M. conjuncta* a clear sexual dimorphism exists, with males having a fulvous pubescence on head and thorax and fringes of fulvous hairs in the distal part of the tergites. The males of *Megachile* sp. *biroi* group can be distinguished from those of *M. disjuncta* by the black hairs on the pleuron below the wing bases and by the smaller and much denser tergal punctuation. Other diagnostic features can be found in male genitalia (Ascher *et al.*, 2016).

M. disjuncta and *M. conjuncta* have been recorded in southern China, India, Indonesia, Malaysia, Singapore, Sri Lanka and Thailand. In addition, *M. disjuncta* has been found also in northern China, Vietnam, Madagascar, Mauritius and Seychelles. *Megachile* sp. *biroi* group is reported only in Singapore (Ascher *et al.*, 2016). The biology and ecology of these species are very similar to that of *M. disjunctiformis*. They nest in pre-existing cavities, including human infrastructures. They collect pollen mainly from plant species of the families Fabaceae (*Crotalaria pallida* Aiton, *Peltophorum pterocarpum* (DC.) K.Heyne, *Memecylon caeruleum* Jack, *Tamarindus indica* L.) but also Lamiaceae (*Vitex trifolia* L.), Acanthaceae (*Asystasia gangetica* (L.) T.Anderson) and others (Karunaratne *et al.*, 2005; Soh and Ngiam, 2013).

Recently another non-native megachilid species belonging to the subgenus *Callomegachile* has been introduced from Asia to Europe: *Megachile sculpturalis* Smith 1853. The species was already present in the US and it rapidly spread across the country (Mangum and Brooks, 1997; Batra, 1998) and to Canada (Paiero and Buck, 2003). Its dispersal in North America is well documented because of its large size and recognisable aspect (Parys *et al.*, 2015).

In Europe *M. sculpturalis* was observed for the first time in France in 2008, near the port of Marseilles (Vereecken and Barbier, 2009), then in Italy in 2009 (Quaranta *et al.*, 2014), in southern Switzerland in 2010 (Amiet, 2012) and in 2015 in Germany (Westrich *et al.*, 2015) and Hungary (Kovács, 2015). In Italy until now it has been recorded in the northern and alpine regions, in the Po valley (Emilia Romagna) and in Tuscany (Quaranta *et al.*, 2014; Bortolotti, personal observation). Two species of the same subgenus have been observed in North and Central America: *Megachile umbripennis* Smith 1853 in southern Florida and New Jersey and *Megachile rufipennis* F. 1793, originally from Africa and recently established in the Greater Antilles (Parys *et al.*, 2015).

Only few other species of *Callomegachile* naturally occur in the western Palaearctic, including *Megachile simonyi* Friese 1903 and *Megachile cephalotes* Smith 1853 on the Arabian Peninsula, and *Megachile paucipunctulata* Kirby 1900 from the Socotra Archipelago, Yemen (Straka *et al.*, 2017).

Materials and methods

Specimen collection

Adult males of *M. disjunctiformis* were found in September 2017 during a study of the bee fauna in urban gardens of Bologna (Italy). An image search on Internet was run and revealed that similar female specimens had been found in 2011 and 2016 in the metropolitan area of Bologna. The author of the pictures, who had sent them to an Italian entomological forum for taxonomic identification, was contacted and joined the team, adding a female specimen collected in June 2017. The three specimens (two males and one female) are conserved in the entomological collection of CREA-AA of Bologna. Before taxonomic identification, the specimens were pinned and the genitalia of one of the males were extracted and mounted on a transparent plastic.

Specimen identification

For the taxonomic identification, the specimens were compared with the original description of *M. disjunctiformis* by Cockerell (1911) and with diagnostic keys of the genus *Megachile* of Asia (Cockerell, 1927; Lee and Ryu, 2013). Furthermore, the pictures of alive and pinned specimens were sent to a specialist for a taxonomic confirmation. Images found on internet, in specialized websites (Kyoto Museum collection, 2017; Osaka Museum collection, 2017; Ascher and Pickering, 2018) and in a book (Tadauchi and Murao, 2014) were also used as complementary sources of comparison. Diagnostic keys of *Callomegachile* species from other Asiatic countries were used, in order to exclude a possible confusion with similar species (Ascher *et al.*, 2016).

Results

Specimen records

The first record of *M. disjunctiformis* in Italy dates back to June 2011: a female specimen entered in an apartment situated in Castel Maggiore, a locality in the metropolitan area of Bologna, probably in search of a nesting site. The specimen was photographed and the record was sent to an Italian entomological forum (Forum Entomologi Italiani, 2011) where the bee was identified as a probable *M. disjunctiformis* (figure 2a).

In August 2016 another female was recorded and photographed on the terrace of the same apartment, visiting flowers of *Delosperma cooperi* (Hook.f.) L.Bolus, a perennial plant of the family Aizoaceae, and lavender (*Lavandula angustifolia* Mill., Lamiaceae) and the pictures were sent again to the entomological forum (Forum Entomologi Italiani, 2016) (figure 2b). In June 2017 a third female specimen was observed in the same locality of the two previous records (figure 2c) and, as the pictures of the previous two findings left a doubt about the identity of the species, it was captured and conserved for identification (figure 2d-f).

In the same year, at the beginning of September, a male specimen was collected in a vegetable garden in the city of Bologna, visiting a plant of savoury (*Satureja* L., Lamiaceae) (figure 3a-b) and two weeks later a second male was found in the botanical garden of Bologna, visiting flowers of basil (*Ocimum basilicum* L., Lamiaceae). They were both captured and prepared for taxonomic identification (figure 3c-f).

In figure 4 the geographical locations of the three sightings are indicated (records 1-3, female: 44.5767, 11.36249; record 4, male: 44.48929, 11.32323; record 5, male: 44.50062, 11.35347).

Specimen description and identification

The female specimen has a total length of 15.0 mm, the head width of 4.9 mm and a wing span of 23.9 mm. The two male specimens have a mean total length of 11.1 mm (10.4 and 11.9 mm, respectively), a mean head width of 3.9 mm (3.8 and 4.0 mm, respectively) and a mean wing span of 20.8 mm (20.5 and 21.1 mm, respectively).

Both sexes show a similar colour pattern: black head and body, with whitish hairs on the posterior part of the thorax (propodeum) and the first abdominal tergite. Both wing pairs are transparent at the base and apically infuscated (figures 2 and 3). The female scopa is pale yellow in the first four proximal sternites and dark in the distal ones (figure 2e). The male shows white hair on the front and the distal part of clypeus (figure 3d) and presents two small reddish spines on the anterior coxae (figure 3e).

Given the colour of the female scopa, the specimen could be easily confused with *Megachile* sp. *biroi* group. However, it can be distinguished by the clypeal margin, which bears several tubercles (figure 2f) while it is simple in *Megachile* sp. *biroi* group (Ascher *et al.*, 2016), and by the metasoma, which is dull and densely

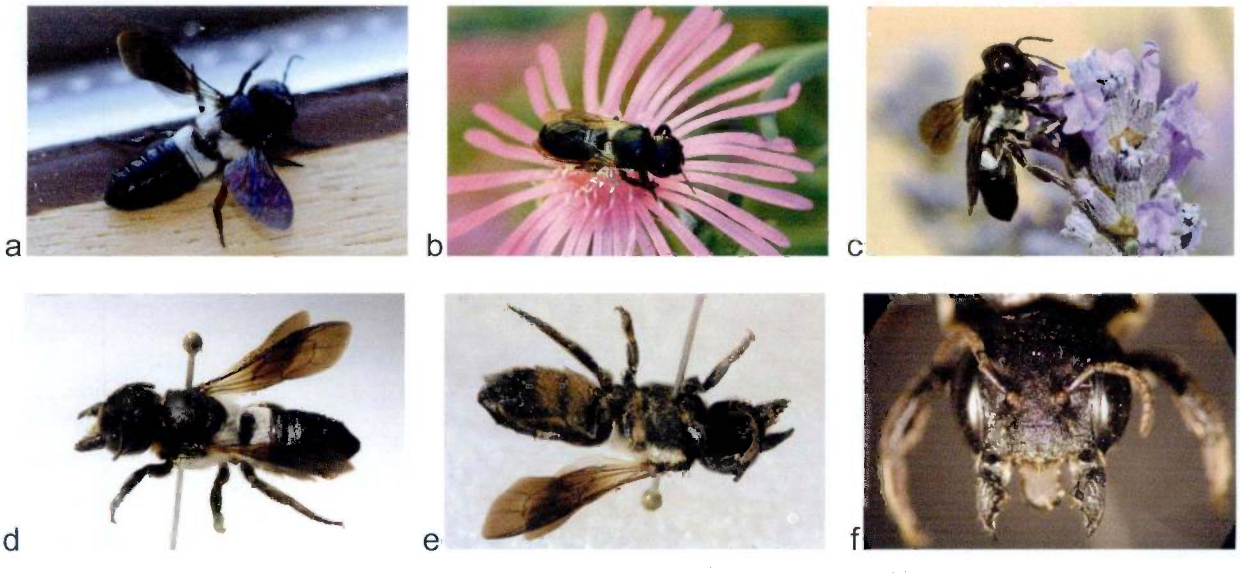

Figure 2. *M. disjunctiformis* females. (a) first specimen observation 2011; (b) second specimen observation 2016; (c) third observation and (d, e) collected specimen 2017, (f) detail of clypeus and mandibles. Photo (a-e) F. Luthi; (f) L. Bortolotti.

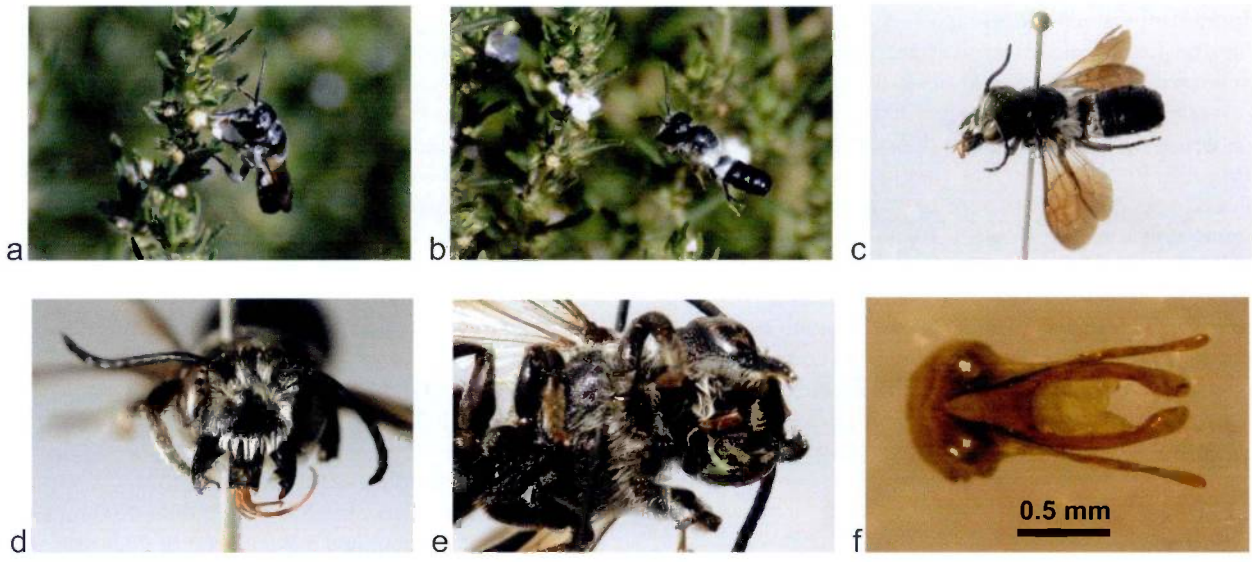

Figure 3. *M. disjunctiformis* males. (a, b) first specimen observation 2017; (c) second specimen pinned 2017; (d) frontal view of the second male head with details of the clypeus and mandibles; (e) first male in ventral view with detail of the reddish spines on the anterior coxae; (f) male genitalia extracted from the first male specimen. Photo (a, b, f) L. Bortolotti; (c, d, e) F. Luthi.

Figure 4. Maps of records of *M. disjunctiformis*. Records 1-3: 3 female specimens in 2011, 2016 and 2017; record 4: male specimen beginning September 2017; record 5: male specimen mid September 2017. The green dot represents the Bologna trade hub (Interporto), while the yellow one represents the wholesale commercial district.

punctured in *Megachile* sp. *biroi* group (Ascher *et al.*, 2016) while it is shining with coarse punctures in *M. disjuntiformis*.

Males of *M. disjunctiformis* could be confused with those of *M. disjuncta* and *Megachile* sp. *biroi* group for the general appearance, from which they however differ in the white hairs on the pleuron below the wing bases, black in *Megachile* sp. *biroi* group (figure 3a; Ascher *et al.*, 2016) and in the different characteristics of the male genitalia in our specimens (figure 3f; Ascher *et al.*, 2016). Furthermore the reddish spines on the anterior coxae are cited in Cockerell's first description of *M. disjunctiformis* (figure 3e; Cockerell, 1911).

Discussion

Although several alien *Megachile* species were transferred from country to country with commercial movements, this is the first time *M. disjunctiformis* is found out of its area of origin, apart from the Australian uncertain record.

The specimens have been observed three times along seven years, but during different periods. In 2011 and 2017 the females were observed in June, while in 2016 in August. This flying period seems to be consistent with that reported for Japanese populations (Osaka Museum collection, 2017). In 2017 the two males were observed in September, which rouses some doubts about the number of generations. Since in most bee species (Stephen *et al.*, 1969) males emerge before females, these observations seem not to be compatible with a monovoltine cycle, unless males of this species would have a very long life span. However, in this case the captured males would have shown clear signs of aging (lack of hair, ruined wings), which is not the case, especially for the second male specimen collected that seemed newly emerged. Instead, the presence of newly emerged males at the beginning of September could suggest a second generation or a partial second generation, (e.g. some individuals in the same population are monovoltine whereas others are bivoltine) as reported in *Megachile rotundata* (F. 1787) in USA (Pitts-Singer and Cane, 2011). This latter species is monovoltine in Eurasia, where it is native, and partially bivoltine in USA, where it was introduced in the late 1940s (Pitts-Singer, 2008). As to *M. disjunctiformis*, no females were found in the same places as the male specimens during the subsequent weeks. Moreover, the female specimen recorded in 2017 was observed in a different place at a distance of about 8.5 and 10 km from the findings of the males. It is possible that the specimens have experienced different climatic conditions during their development according to where the parental nests were located. Since *M. disjunctiformis* is an aboveground nesting species, temperature may strongly affect the phenology of different populations, as shown in *Osmia* spp. (Sgolastra *et al.*, 2012). Thus, the different flying period of the three specimens might also be the result of differentiated populations.

The other Asian *Callomegachile* imported to Europe, *M. sculpturalis*, shows in Northern Italy a monovoltine cycle and a flying period from July to late August, with males emerging in July or early August and females flying until late August or beginning of September, depending on the year (Quaranta *et al.*, 2014). These periods are consistent with those observed for North American and Japanese populations (Iwata, 1933; Batra, 1998) and this would suggest that Japanese bee species at similar latitude can maintain the original life cycle.

M. sculpturalis was most probably transported by transcontinental shipping inside the host plant where it nested, since this is the most common way of arrival of accidentally introduced non-native bees (77% of the total), the majority of which nest in stems, twigs, cavities and holes in wood (Russo, 2016). The location of *M. disjunctiformis* female findings in 2011, 2016 and 2017 is not far from the main trading hub (Interporto) of Bologna and near to a large wholesale commercial district (Centergross), which could represent the sites of arrival and spreading of the invader bee.

Given our observations spread over several years, it is not possible to ascertain whether the five specimens belong to a single introduction or to different ones. In both cases, the low number of observed individuals from 2011 to date seems to suggest a low reproduction rate of this species, compared to other non-native megachilid species like *M. sculpturalis*.

Among the potential negative impacts of introduced bees, competition for nesting sites seems to be the most relevant for non-native *Megachile* (Barthell and Frankie, 1998; Laport and Minckley, 2012; Roulston and Malfi, 2012), while a minor concern exists for a disruption in pollination networks or a decreasing in pollination of native plants, which is mainly limited to island locations (Rasmussen *et al.*, 2012; Groom *et al.*, 2014). On the other hand, the positive impact of introduced megachilids on crop and wild plant pollination is a general assumption, but it was confirmed only for species deliberately introduced for pollination purposes, such as *M. rotundata* on *Medicago sativa* L. (Pitts-Singer and Cane, 2011).

Since the visited plants and nesting habits of *M. disjunctiformis* are poorly known even in the habitat of origin, it is almost impossible to predict the potential impact of this species on the local flora and fauna of the invaded areas. New findings of specimens in the same place during the next years, and the possible successful attempt to attract females in artificial nesting shelters, could bring us useful information on the biology and ecology of the species and on its potential impact on the local environment.

Acknowledgements

We would like to express our gratefulness to the participants of Forum Entomologi Italiani for the first indications on the specimen observed in 2011, and to John S. Ascher for confirming the identification from photographs of the pinned male and female specimens. Our thanks go also to Maurizio Pavesi, Natural History Museum of Milan, for his advice and suggestions. Finally we would like to thank the three anonymous reviewers for their valuable comments and suggestions.

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Received December 15, 2017. Accepted March 26, 2018.