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To cite this article: Youssef Ouahab , Leila Bendifallah , Pierre Rasmont & Mohamed Ait Hammou (2021): Nesting Ecology and Foraging Biology of the Mason Bee *Osmia (Helicosmia) latreillei* Spinola, 1806 (Hymenoptera: Megachilidae) in Western Algeria, *Bee World*, DOI: [10.1080/0005772X.2020.1854987](https://doi.org/10.1080/0005772X.2020.1854987)

To link to this article: <https://doi.org/10.1080/0005772X.2020.1854987>



Published online: 07 Jan 2021.



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# Nesting Ecology and Foraging Biology of the Mason Bee *Osmia (Helicosmia) latreillei* Spinola, 1806 (Hymenoptera: Megachilidae) in Western Algeria

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## Introduction

Wild bees are of immense value playing a vital ecosystem role because of the pollination services they provide to natural and agricultural ecosystems (Aleixo et al., 2014). They forage on flowers to provide their brood with pollen and/or nectar on which the latter develop. During these foraging bouts, bees transport pollen grains from one flower to another ensuring seed set and gene flow between plants (Jongjivimol & Poolprasert, 2014). Bees use nectar mainly as a source of carbohydrate while pollen is the major source of protein, although it also provides other necessary nutrients such as lipids, minerals, and vitamins (Atanassova & Lazarova, 2010).

It is estimated that 5–8% of current global agricultural production, representing an annual market value of \$235–\$577 billion worldwide, is directly attributable to animal pollination (IPBES, 2016). The contribution of wild bees to the pollination of crops is estimated at more than \$3250 dollars per hectare per year (Kleijn et al., 2015). According to Stein et al. (2017) the assessment of wild bee contribution to pollination of crops is challenging since the majority of studies are based on large-scale farms, while smallholding crop systems with fields smaller than 2 ha have received less attention in ecosystem-service research. Wild bees are highly valuable pollinators, along with managed honey bees; they ensure stable pollination

to agriculture and wild plant communities (Koh et al., 2016). In recent decades honey bee colonies have been declining for many reasons such as the use of pesticides in high quantities and epizootics (Potts et al., 2010). To get over this problem, researchers are paying more attention to the conservation and development of wild bees as alternative pollinators and research is being directed at identifying the proper way to manage wild bees for crop pollination (Seidelmann et al., 2016).

Over 20,000 species of bees have been described worldwide, belonging to seven families (Michener, 2007). With about 4000 species, the family Megachilidae is the second most diverse lineage (Engel et al., 2020; Gonzalez et al., 2019; Michener, 2007). Within this family, mason and resin bees constitute the tribe Osmiini, with 15 genera and approximately 1160 species occurring worldwide, except in South America, Australia, and Antarctica (Michener, 2007; Özbek, 2013), although the group has recently been narrowed in circumscription with the removal of the tribes Pseudoheriadini and Ochreeradii (Gonzalez et al., 2019). Species of Osmiini are highly diversified in the Mediterranean and desert climates of southern Africa, south-western North America and the Palearctic (Nadimi et al., 2013). In Algeria, studies thus far have demonstrated the presence of several species of the genus *Osmia* such as *O. latreillei* Spinola, 1806, *O. pinguis* Pérez, 1895, *O. caerulea* Linnaeus, 1758,

*O. signata* Erichson, 1835, *O. andrenoides* Spinola, 1808, *O. leaiana* Kirby, 1802, *O. niveibarbis* Pérez, 1902, *O. notata* Fabricius, 1804, *O. tunensis* Fabricius, 1787, *O. cornuta* Latreille, 1805, *O. kohlii* Ducke, 1899, *O. tricornis* Latreille, 1811, *O. versicolor* Latreille, 1811, and *O. rufa* Linnaeus, 1758 (Bendifallah & Ortiz-Sánchez, 2018; Louadi et al., 2007; 2008). Several species of Osmiini such as the Horned mason bee *O. cornifrons* Radoszkowsky, 1887, the European mason bee *O. cornuta* Latreille, 1805, the mason bee *O. latreillei* Spinola, 1806, the blue orchard mason bee *O. lignaria* Say, 1837, and the red mason bee *O. rufa*, are managed for sunflowers, almonds, apples, plums, blueberry, pears, peaches, cherry, and rape seed plantations (Bosch et al., 2002; Maccagnani et al., 2007; Pinilla-Gallego & Isaacs, 2018; Sedivy & Dorn, 2014; Shebl et al., 2018; Teper & Bilinski, 2009; van der Steen, 1991). Species of *Osmia* are solitary, although many will nest in aggregations. The nests are grouped next to each other but each bee has its own nest. Male bees emerge before females and die a few days after emergence and after copulation. After copulation, each female constructs her own nest inside pre-existing cavities in the ground, tree branches, snail shells, or wood, adding many kinds of materials including petals, leaves, mud, plant trichomes, pebbles, and soil particles to the brood cells (the kind of nesting cavities and the material used depends on the species of *Osmia*). The female collects pollen and nectar to

provision the nest, and then lays her egg on top of the provisions before sealing the brood chamber and constructing another (Mader et al., 2010; Michener, 2007). Most species of *Osmia* are generalist pollen foragers in their natural habitats, gathering pollen from between nine and 20 plant families (Sedivy & Dorn, 2014).

Studying bee nests reveals important species-specific ecological knowledge about food specialization, nesting behavior, and phylogenetic relationships of bees (Bosch et al., 2001; Engel, 2011; Michener, 2007; Vitale & Vázquez, 2017). Recently, many studies have explored the nesting bio-ecology of many diverse species of *Osmia*: nest architecture (Seidelmann et al., 2016), foraging trip duration (Williams & Tepedino, 2003), pollen load analysis (Mario & Rufus, 2018), suitability of artificial nests (Shebl et al., 2018), nesting behavior (Ladurner et al., 2008), and pollen availability in regions of different land use and landscape structures (Kratschmer et al., 2020; Williams & Kremen, 2007). Until now, however, no studies about the foraging and nesting ecology of *Osmia* have been carried out in Algeria.

The mason bee *O. (Helicosmia) latreillei* is univoltine. The species occurs only in spring and visits numerous plant species of the family Asteraceae and is considered an important pollinator of crops such as sunflower in Egypt (Shebl et al., 2018). In this study, we investigated (i) the nesting ecology of *O. latreillei* in western Algeria through a description of its nest architecture and (ii) the host-plant preferences of this species. Our results will lead to a better

understanding of the species' management needs and promote its use for ecological and economic purposes in the region.

## Material and Methods

The research was carried out from May to June 2018, during the period of activity of *O. latreillei* at the National Center for Biological Resources Development in El Bayadh, western Algeria (elevation: 1400 m, Latitude: 33°37'39"N, Longitude: 1° 8'43"E) (Figure 1). The center has an area of approximately 16 ha and is characterized by a semi-arid to arid climate with an annual rainfall of 200–250 mm per year (GEOSYSTEM Consult, 2015). The vegetation is composed of a pine forest, an almond orchard, and other typical herbaceous plants such as *Stipa tenacissima* and *Lygeum spartum*. Species of the families Asteraceae, Malvaceae, Caryophyllaceae, Fabaceae and Poaceae are the characteristic native plants in this area. A comprehensive inventory was conducted to list the native plants in the study area during the period of activity for *O. latreillei*. Plant identification was done using the guide of Quezel and Santa (1963).

To study the nesting ecology, trap-nests were made from pieces of reed of different dimensions (length 180–194 mm, diameter 7–11 mm). These were bundled together into trap nests and located horizontally on the walls of buildings as shown in Figure 2. The nests were visited daily to check on bee activity and nesting behavior inside tubes with larger diameters. At the end of *O. latreillei*'s period of

activity in mid-June, a total of 15 complete nests were selected at random (we have picked five nests from the upper part of the trap-nest, five from the middle and five from the lower part) and were taken to the laboratory. Pollen was collected from the dissected nests (dissection was performed by using a thin knife so as to not damage the cells), and then the contents of each cell were placed in an Eppendorf tube. To image our samples, the grease and nectar from each cell were eliminated through washing with absolute ethanol, by shaking the Eppendorf tube between the fingers for 30 seconds, and then the pollen is allowed to separate. After concentration, the liquid was removed with a syringe and the residue was washed again with fresh ethanol and the operation was repeated several times until the liquid became transparent (original methodology). Using a Pasteur pipette, a drop of pollen was then transferred to a slide and pulverized with the blunt end of a spatula, followed by a thorough mixing and distribution on the slide with an insect mounting pin following the methodology described by MacIvor et al. (2014). To avoid contamination among samples, the spatula and the mounting pin were cleaned with distilled water between each slide preparation. For better visibility of pollen grain microstructure, a drop of fuchsin (10% dilution with pure ethanol) was added. Pollen was then air-dried for five minutes. After drying, a drop of glycerin (10% dilution with pure ethanol) was added. Five pollen slides were made for each nest to produce a total of 75 slides. The slides were examined using light microscopy with an integrated camera. We used 40× magnification for identification and counting. The entire slide has been investigated. Some pollen samples were identified to the species level and others only to the level of genus due to the limits of pollen identification with a light microscope, and based on the list of native plants identified during the flight period (Table 1) (Aghababaeyan et al., 2014; Cordier, 2018; Dauti et al., 2014; Erkara et al., 2012; Halbritter et al., 2018; Kaya et al., 2013; Özler et al., 2009; Pinar et al., 2016; Qureshi et al., 2002; Shabestari et al., 2013; Svitlana et al., 2018; Wortley et al., 2012). After identification, pollen was quantified by consecutively counting 300 pollen grains per slide. Pollen grains were counted in groups of 100, following parallel lines equidistantly and uniformly distributed from one edge of the slide to the opposite edge, until 300 grains have been counted. Total numbers of pollen grains counted were 1500 grains per nest and 22,500 grains over all following the



Figure 1. The study area located at the National Center for Biological Resources Development in El Bayadh, western Algeria. (Photograph by Y. Ouahab).



Figure 2. Trapnests made from pieces of reed of different dimensions, located horizontally on the walls of buildings in the study area. (Photograph by Y. Ouahab).

Table 1. Classification of pollen types in nests of *Osmia latreillei*. Pollen types are classified as dominant (>45% of total grains on the slides), accessory (15%–45%), important isolates (3%–14%), and occasional isolates (<3%) (Louveaux et al., 1978).

Pollen type	Life form	Percent occurrence on slides	Classification of pollen types
<i>Taraxacum officinale</i> L.	Herb	49.42	Dominant
<i>Sonchus</i> sp.	Herb	25.12	Accessory
<i>Onopordon acanthium</i> L.	Herb	8.98	Important isolates
<i>Onopordon</i> sp.	Herb	7.70	Important isolates
<i>Scorzonera hispanica</i> L.	Herb	7.19	Important isolates
<i>Centaurea pubescens</i> Willd.	Herb	1.59	Occasional isolates

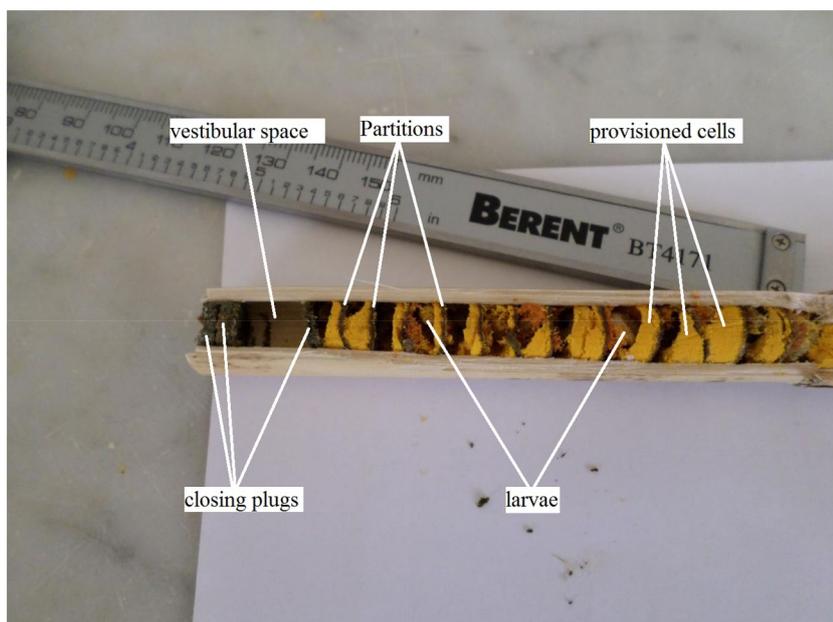


Figure 3. Dissected nest showing the internal nest architecture of *Osmia latreillei*. (Photograph by Y. Ouahab).

methodology of Gonçalves et al. (2012). We then determined the percentage occurrence of each plant taxon found in the provisions according to the methods of Louveaux, Maurizio, and Vorwohl (1978). Pollen types were classified as dominant (> 45% of total grains on the slides), accessory (15%–45%), important isolates (3%–14%), and occasional isolates (< 3%). Species represented by one pollen grain in any of the slides were considered to be contaminants.

To study the nest architecture using the same nests, cell arrangement, cell lengths, thickness of partitions, and closing plugs were described and measured using a caliper (Tasei & Picart, 1972).

## Results and Discussion

### Nest Architecture and Nesting Behaviour

A typical nest of *O. latreillei* (Figures 3 and 4) consists of a series of provisioned cells arranged linearly, similar to other species of *Osmia* such as *O. georgica* and *O. bicornis* (Bosch et al., 2001; Seidelmann et al., 2016). The cells are separated from one another by thin partitions made from a pulp of finely masticated leaf tissue. According to Hartman et al. (1944), *O. georgica* scrapes this material from the surface of leaves and rolls it into a ball for transport back to the nest. Arriving at the nest, *O. georgica* chews and soaks the material with saliva, then builds the partition, which dries and appears in dark green color. The partitions are of uniform size, slightly concave inwardly and quite thin (less than 1 mm) but their thickness increases towards the edges attached to the sides of the tube, presumably for improved structural integrity. The nest is capped by a closing plug thicker than the partitions but made from the same material. Nesting females leave an empty space between the nest cap and the last provisioned cell. The empty space consists of 1–3 empty vestibular spaces. Seidelmann (1999), in his work on the function of the vestibulum in nests of *O. rufa*, suggests that the bee constructs a vestibulum to avoid offspring mortality due to the high risk of parasitism and to protect the brood against unstable weather conditions. The brood cells are provisioned with a mixture of nectar and pollen. To fill a cell, the bee makes several trips back and forth to the nest in order to visit as many plants as necessary. After a foraging trip and returning to the nest, the bee returns head-on to deposit the collected nectar on the pollen deposited during the previous trip, it mixes

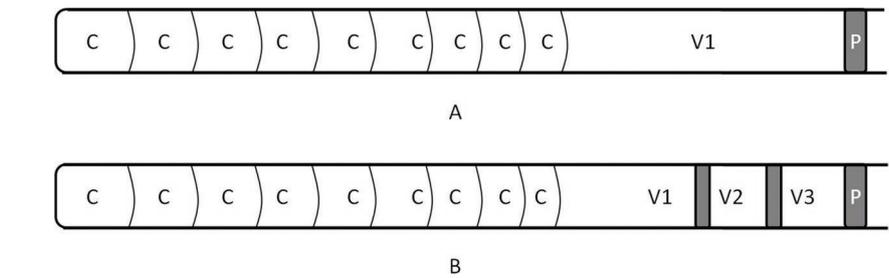
everything with its mandibles and then turns around to deposit the new pollen (which will be mixed with the nectar of the next trip) by rubbing its metasomal venter with its hind legs and the same operation is repeated multiple times for each cell. The pollen mass is placed against the partition which separates the current cell from the preceding one. The anterior end of the mass is slightly concave, and an elongate and white egg is attached by one end near the center of the concavity.

Cell length ranges from 3.0 to 9.5 mm with 81.15% of all cells falling between 4.0 and 7.0 mm. The mean length of all the examined cells was  $5.52 \pm 1.58$  mm. The brood cells of female offspring are usually larger in size and located in the back of the nest, while cells of male offspring are comparably smaller and located in the anterior part of the nest. This arrangement is similar for many solitary bee species. Raw (2009) reported the same observation in nests of *O. bicornis* and explained this phenomenon as a reason for the sexual dimorphism in phenology of the species which allows males to leave the nest sooner than females.

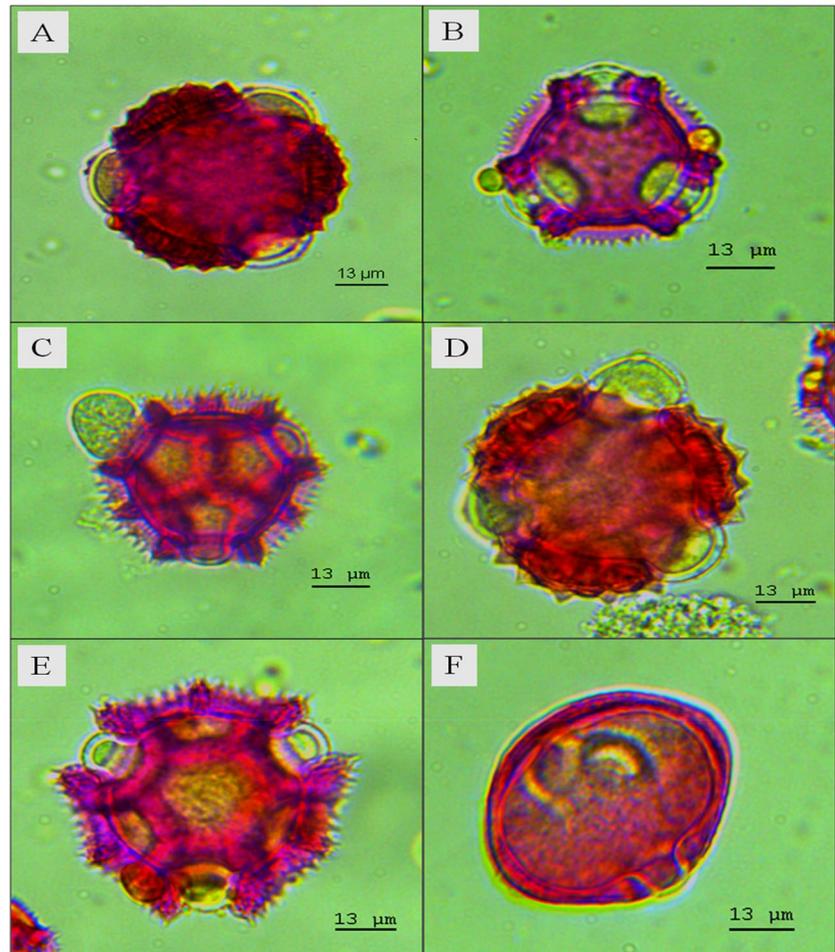
#### Pollen Analysis

Our results showed the presence of a total of 52 plant species in the study area during the activity period of *O. latreillei*. Overall, 10 pollen types were collected by this bee, four of which (*Centaurea acaulis*, *Malva sylvestris*, Undetermined-1, and Undetermined-2) were classified as accidental contaminants because they were represented by only one grain of pollen in all of the examined slides. The other six species – *Taraxacum officinale*, *Sonchus* sp., *Onopordon acanthium*, *Onopordon* sp., *Scorzonera hispanica*, and *Centaurea pubescens* – are the main sources of food for *O. latreillei* in the study area (Figure 5).

Our findings support the results of Müller (2014), Shebl et al. (2018), and Baldock et al. (2018), stating that all the plants visited by *O. latreillei* for collection of floral resources belong to the Asteraceae. In our study area females of *O. latreillei* feed their larvae exclusively with pollen of Asteraceae. This ubiquitous and highly diversified family of plants plays an important role for many specialized bees because of the considerable amount of pollen and nectar provided by its compound inflorescences over an extended time period (Müller & Bansac, 2004). Spear et al. (2016) suggest that specialization on Asteraceae pollen, which is known to be a poor quality



**Figure 4.** Diagrammatic representation of two nests of *Osmia latreillei* showing provisioned cells (C), vestibular spaces (V), and closing plugs (P). A, nest with single vestibular space; B, nest with multiple vestibular spaces.



**Figure 5.** Photographs of the pollen grains found in nests of *Osmia latreillei*. A, *Onopordon acanthium*; B, *Taraxacum officinale*; C, *Sonchus* sp.; D, *Onopordon* sp.; E, *Scorzonera hispanica*; F, *Centaurea pubescens*. (Photographs by Y. Ouahab).

food (lacking several essential amino acids) (Praz et al., 2008), can protect mason bees from brood parasitism by sapygid wasps. The same study demonstrates that species of *Osmia* that specialize on pollen of Asteraceae were parasitized significantly less frequently compared to specialists on Fabaceae or generalists. Oligolectic bees show morphological, physiological, and behavioral specializations that enable them to collect pollen more efficiently compared to generalist species (Leppik, 1966; Rasmussen et al., 2020). In some specialist species of *Osmia* such as *O. latreillei*, the

ventral metasomal scopa used as a pollen collecting structure is a morphological trait that probably enables these bees to collect pollen from flowers of Asteraceae quite efficiently. In our study, among Asteraceae, pollen of *T. officinale* and *Sonchus* sp., both very common at the National Center, was collected predominantly, implying that *O. latreillei* primarily visited these plants. *T. officinale* was the primary pollen source (49.42%), with *Sonchus* sp. representing the second-most frequently visited plant (25.12% of the total number of pollen grains counted which is 22,500).

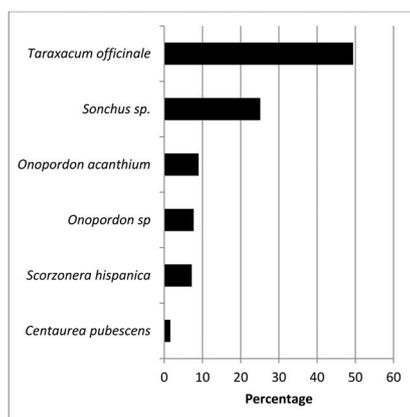


Figure 6. Percent occurrence on slides of different pollen taxa in nests of *Osmia latreillei*.

Following these species were *O. acanthium*, *Onopordum* sp., and *S. hispanica*, all of which were much less abundant in the study area (representing each ~8% of the grains), and *C. pubescens*, a rare species in the study area, whose pollen plays only a marginal role in the diet of *O. latreillei* (it was recorded as only 1.59% of the grains) (Figure 6) (Table 1). The frequencies of occurrence of pollen types in the 15 samples analyzed showed that *T. officinale* was the most consistent occurring on 78.66% of the 75 slides, followed by *Sonchus* sp. (49.33%), *S. hispanica* (38.66%), *O. acanthium* (33.33%), *Onopordum* sp. (29.33%), and *C. pubescens* (14.66%). These results can be explained by the fact that the flowering period of the two genera *Taraxacum* and *Sonchus* corresponded to the period of highest nesting activity of *O. latreillei*, and there seems to be a synchrony between these two plants and *O. latreillei* in our study area. Mayer and Kuhlmann (2004) point out that despite the fact that pollination systems can be generalized (flowers with generalized pollination systems are those that attract multiple types of pollinators), one could expect a good synchronization between pollinating insects and their preferred host plants. This holds especially true for arid areas where environmental factors such as rainfall, temperature, relative humidity, and sunlight intensity limit the flowering season to a short period of the year, as is the case in our study area. According to an ultrastructural study of pollen grains consumed by larvae of *O. tricornis*, *O. cornuta*, *O. latreillei*, and *O. rufa*, the cytoplasm of *Sonchus* pollen (which has thin intines) was almost entirely lacking in the pollen grains recovered from faeces of *O. latreillei*, which indicates efficient digestion of *Sonchus* pollen grains by this composite specialist (Suárez-Cervera et al., 1994). Unlike our study, Levin and Haydak (1957), in their work on the value of pollen

of different plant taxa to the nutrition of *O. lignaria*, found dandelion allowed considerably more growth, but none of the larvae feeding on it reached the final instar, suggesting that *Taraxacum* pollen may be toxic or lack sufficient nutrients alone.

With these results we were able to conclude that *O. latreillei* is a specialized species visiting only plants from the Asteraceae and with a higher preference for the genera *Sonchus* and *Taraxacum* in our study area. We also concluded that there is local synchrony between the phenology of this bee species and these two genera. For a better management of this species in Algeria, more investigations of bee pollen loads are necessary to complete the list of plant taxa utilized by *O. latreillei* as a pollen source in this region as well as in other areas of the country where these bees occur.

## Acknowledgement

We are grateful to Prof. Andreas Müller, Institute of Agricultural Sciences, Biocommunication and Entomology, for the identification of the bee species.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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