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Investigation of the Families Hactilidae and Metiliidae (Insecta: Hymenoptera: Vespoidea)

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Abstract

Most Halictinae are solitary and build their nest on the ground. The group is classically seen as a generalist, with bees specializing in pollen only in the Rophitini. Variations in life fears are common and encompass much of the variation we see in bees as a whole. Kleptoparasitism arose in four tribes, with Sphecodini being exclusively parasitic. Social behavior appears in Augochlorini and especially in Halictini. The crops that were cited as being pollinated by bees belonging to this family are bell pepper, tomato, cotton, plant, strawberry, camu-camu and acapu. The ecological status of Hactilidae populations is poorly understood. They can also fall prey to parasitoids or predators; for example, their nymphs may be eaten by firecracker larvae. The Metiliidae family are solitary and dig their nests in the ground, with the other characteristics that we previously presented for solitary bees. It is a small family, with few species, and they only inhabit the northern hemisphere of the planet and Africa. They are only daytime. Ectoparasitoids of larvae or pupa of other insects. Among the more than 16 thousand species of bees described and known in the world, there are about 330 species that collect oil in flowers and use this resource to feed the larvae and coat the brood cells. The objective of this paper is to know the characteristics of the families Hactilidae and Metiliidae. In terms of the type of research source, we worked with scientific articles published in national and international journals. This modality of production, in addition to being commonly the most valued in the set of bibliographic production, is the most easily accessed. Access to articles was through virtual libraries such as SciELO, ResearchGate, Hall, USP, UNB, CAPES and LILACS.

Keywords: Bee; Kleptoparasitism; Ectoparasitoid; Predator; Solitary

1. Introduction

Most Halictinae are solitary and build their nest on the ground. The group is classically seen as a generalist, with bees specializing in pollen only in the Rophitini. Variations in life fears are common and encompass much of the variation we see in bees as a whole. Kleptoparasitism arose in four tribes, with Sphecodini being exclusively parasitic. Social behavior appears in Augochlorini and especially in Halictini. The crops that were cited as being pollinated by bees belonging to this family are bell pepper, tomato, cotton, plant, strawberry, camu-camu and acapu [1].

The ecological status of Hactilidae populations is poorly understood. They can also fall prey to parasitoids or predators; for example, their nymphs may be eaten by firecracker larvae. The Metiliidae family are solitary and dig their nests in the ground, with the other characteristics that we previously presented for solitary bees. It is a small family, with few species, and they only inhabit the northern hemisphere of the planet and Africa. They are only daytime. Ectoparasitoids of larvae or pupa of other insects. Among the more than 16 thousand species of bees described and known in the world, there are about 330 species that collect oil in flowers and use this resource to feed the larvae and coat the brood cells [2].

Objective

The objective of this paper is to know the characteristics of the Families Hactilidae and Metiliidae.

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2. Material and methods

In terms of the type of research source, we worked with scientific articles published in national and international journals. This modality of production, in addition to being commonly the most valued in the set of bibliographic production, is the most easily accessed. Access to articles was through virtual libraries such as SciELO, ResearchGate, Hall, USP, UNB, CAPES and LILACS.

3. Family Halictidae

3.1. Introduction

Family Halictidae is called sweat bees because they are attracted by human sweat in the expectation of finding nutrients necessary for reproduction. They can be called green bees for their metallic green color. They are bees that occupy open vegetation to facilitate their flight. Due to this characteristic, it is a bee found in large urban regions, provided there are flowers for its food and the conditions for reproduction. Its flight season is very short and lasts for about 5 months, but it can be longer in regions where summer is longer (Figures 1-3) [1].

Source: https://www.cirrusimage.com/bees_halictid/

Figure 1 *Agapostemon virescens* (Fabricius, 1775)

Source: https://www.flickr.com/photos/hickatee/9507641854

Figure 2 *Megalopta* sp.

Source: https://www.biodiversity4all.org/observations/55996189

Figure 3 *Halictus ligatus* Say, 1837

Family Halictidae, is a family that features many species of bees. This family, however, is still little studied, and therefore, the identification of the species is very difficult. More than half of the time this family was mentioned in the works consulted, the identification was not complete, making the analysis very difficult. The crops that were cited as being pollinated by bees belonging to this family are bell pepper, tomato, cotton, jurubeba, egg, plant, strawberry, camu-camu and acapu (Figures 4-5) [3,4].

Source: https://www.cirrusimage.com/bees_halictid/

Figure 4 Halictidae bees are important pollinators of flowering plants *Augochlora pura* (Say 1837)

Source: https://www.cirrusimage.com/bees_halictid/

Figure 5 *Lasioglossum* species with a heavy pollen load

3.2. Description

They are small to medium in size, from 4 to 14 mm and are generally dark in color, although some are bright green in color and others are red. Several species have yellow markings, but a few have yellow facial markings, particularly males. The name comes from the Greek word hymen (membrane) in reference to the membranous wings without scales and with very sparse and little visible hair (Figures 6-8) [5,6].

Source: https://zookeys.pensoft.net/article/58441/zoom/fig/18/

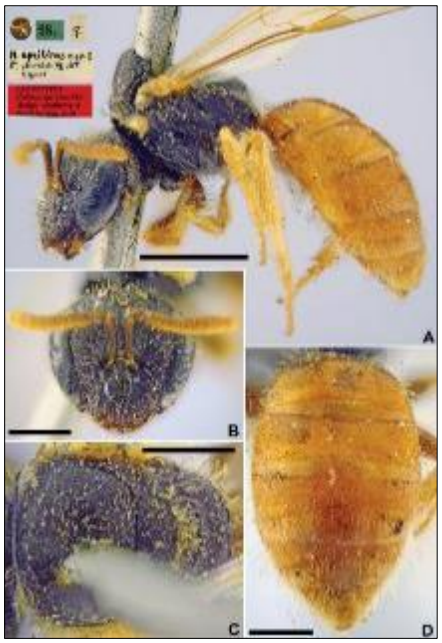
Figure 6 *Halictus determinatus* Morawitz, 1876, lectotype, female (A) habitus, lateral view (B) metasoma, dorsal view (C) mesosoma, dorsal view (D) head, frontal view (E) labels

Source: https://zookeys.pensoft.net/article/58441/element/2/133/

Figure 7 *Halictus albitarsis* Morawitz, 1876, lectotype, female (A) habitus, lateral view and labels (B) head, frontal view (C) mesosoma, dorsal view (D) metasoma, dorsal view

Source: https://zookeys.pensoft.net/article/58441/element/2/133/

Figure 8 *Halictus annulipes* Morawitz, 1876, lectotype, female (A) habitus, lateral view (B) head, frontal view (C) mesosoma, dorsal view (D) metasoma, dorsal view (E) labels



Source: https://zookeys.pensoft.net/article/58441/element/2/133/

Figure 9 *Halictus aprilinus* Morawitz, 1876, lectotype, female (A) habitus, lateral view and labels (B) head, frontal view (C) mesosoma, dorsal view (D) metasoma, dorsal view

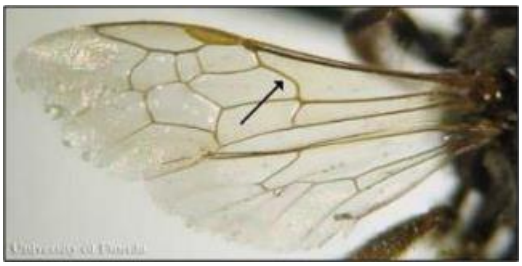
The back wings are smaller than the front wings and the two wings are interlaced. Hymenopterans have mouthparts adapted to bite and chew, bite and lick or bite and suck. Halictinae is a group of short-tongued bees, with labial palpomeres similar to each other and not elongated (A), and a hemicryptic coxa (B); upper third hidden in the mesosoma). The simple glossa, a subantenal sutural, absence of foveas (C) and angled M vein (D) separate the group from the other short-tongued bees. Its often metallic luster aids in identification, although there are several dull species and several groups of other subfamilies with luster (Figures 9-14) [7,8].

Source: https://zookeys.pensoft.net/article/58441/element/7/0/Halictus/

Figure 10 *Halictus cariniventris* Morawitz, 1876, lectotype, male (A) habitus, lateral view (B) metasoma, dorsal view (C) head, frontal view (D) mesosoma, dorsal view (E) labels

Source: https://zookeys.pensoft.net/article/58441/element/7/0/Halictus/

Figure 11 *Halictus cingulatus* Morawitz, 1876, lectotype, female (A) habitus, lateral view and labels (B) head, frontal view (C) mesosoma, dorsal view (D) metasoma, dorsal view



Sources: Photograph by Katie Buckley, University of Florid and https://entnemdept.ufl.edu/creatures/misc/bees/halictid_bees.htm

Figure 12 Example of Halictidae wing venation. The arrow points to a strongly curved basal vein that separates sweat bees from other families of bees

Source: Photograph by Katie Buckley, University of Florida

Figure 13 Example of Halictidae (sweat bee) wing venation in *Lasioglossum*, showing weak or reduced wing veins

Source: https://www.independent.co.uk/news/science/how-do-animals-see-in-the-dark-a7627966.html

Figure 14 *Megalopta genalis* Meade-Waldo, 1916 is a species of the family Halictidae, otherwise known as the sweat bees. The bee is native to Central and South America (United States Geological Survey)

3.3. Lifestyle

The reproductive behavior of this bee is curious and can vary according to the climate. And it happens like this: A fertile female (queen) finds the place where she will make the nest. With the nest organized, she begins laying one or two worker eggs (females without the ability to reproduce), to start the colony. These workers help the Queen in building the nest and feeding the offspring. In another nest, another Queen produces an egg or two of fertile males and keeps them until they fly away. So the queens alternate the offspring, sometimes only males and sometimes females (Figures 15-16B) [9,10].

Sources: Photograph by Beatriz Moisset and https://entnemdept.ufl.edu/creatures/misc/bees/halictid_bees.htm

Figure 15 *Augochlora pura* (Say 1837), adult standing next to a broken larval cell. The yellow pollen balls lining the cell are created by the female before she deposits the eggs. These provisions then sustain the developing larva until pupation and emergence as an adult

Sources: Photograph by Beatriz Moisset, pollinators.blogspot.com and https://entnemdept.ufl.edu/creatures/MISC/BEES/Augochlora_pura.html

Figure 16A Partially excavated nest of *Augochlora pura* (Say, 1837) showing an adult (top left) and a larva within a wax-coated cell (bottom right)

Source: https://bugguide.net/node/view/129032

Figure 16B Larvae of *Augochlora pura* (Say 1837)

This characteristic of the sweat bee prevents crossing between relative bees (siblings) but also divides its population between social bees (they form colonies) and solitary bees (which take care of their children alone). Most Halictinae are solitary and build their nest on the ground. The group is classically seen as a generalist, with bees specializing in pollen only in the Rophitini. Variations in life fears are common and encompass much of the variation we see in bees as a whole. Kleptoparasitism arose in four tribes, with Sphecodini being exclusively parasitic. Social behavior appears in Augochlorini and especially in Halictini. The crops that were cited as being pollinated by bees belonging to this family are bell pepper, tomato, cotton, jurubeba, egg, plant, strawberry, camu-camu and acapu (Figures 17-19) [11,12,13].

Sources: Photograph taken in Genova, Italy, Photograph by Ettore Balocchi and https://www.google.com/url?sa=i&url=https%3A%2F%2Fentnemdept.ufl.edu%2Fcreatures%2Fmisc%2Fbees

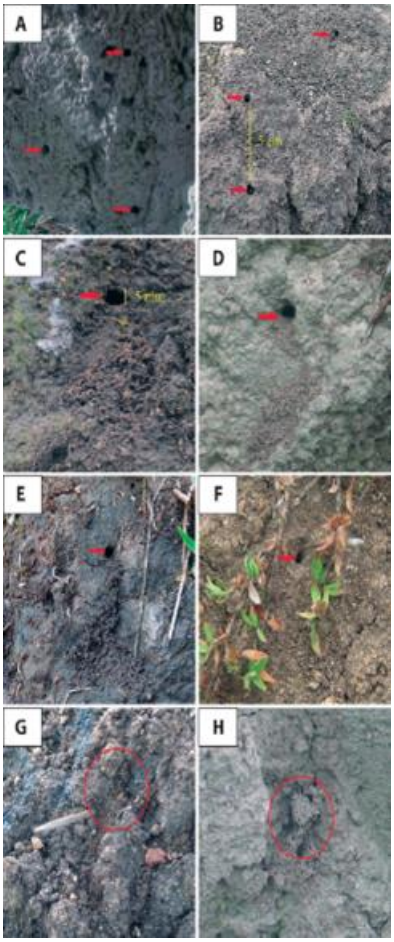
Figure 17 *Halictus scabiosae* (Rossi, 1790) a sweat bee, entering her nest (Nesting Behavior)

Source: Photograph by Katie Buckley, University of Florida

Figure 18 Typical nest entrance for Augochlorini, a tribe (group of genera in a subfamily) of sweat bees (nesting behavior)

Sources: Photograph by Tim Lethbridge, Photograph taken in Highlands County, Florida and https://edis.ifas.ufl.edu/publication/IN897

Figure 19 Adult *Sphecodes heraclei* Robertson, 1897, a parasitic sweat bee, feeding on a flower. These genera are primarily kleptoparasites of other Halictidae or bees of similar size. *Sphecodes* females typically kill the egg or larva in the cell before they lay an egg, but in most other kleptoparasitic species, eggs are laid on unfinished cell walls or through sealed cells and the larva of the cleptoparasite kills the other egg or larva before eating the host's stored food



Source: https://www.scielo.br/j/paz/a/BysJNpnFtHZvDYfJq76yJ9S/#

Figure 20 Nests *Caenohalictus alexandrei* sp. nov. in the earth banks. (A-B) aggregations of nests: (A) nesting site (C); (B) nesting site Z: (C-F) Open nest entrances with traces of soil falling down the bank: (G-H) Close nest entrances with soil. Red arrows indicate the open entrances of the nest. Red circles indicate the close entrance of the nest

Many species form dense nesting aggregations, usually on the ground, where they excavate cells in which to rear their larvae. The larvae feed on supplies of pollen and nectar. Others may choose to nest in cavities in the wood, such as holes in trees and shrubs made by borer beetles, or in artificial cavities. An unusual aspect among bees that occurs in some species of this family is that they feed at sunset and during the night (Figure 20) [14,15,16].

Some species are important in the pollination of crops. Among these are the alkali bee, *Lasioglossum vierecki* (Crawford, 1904) and *Lasioglossum leucozonium* (Schrank, 1781). While some Halictidae species are oligoleges *Rophites algirus* Pérez 1895, which only visits the flowers of hedge nettle plants most are generalists making them potentially valuable overall pollinators (Figures 21-23) [11,16].

Source: https://www.insectsofiowa.org/taxon/specimens/lasioglossum_vierecki

Figure 21 *Lasioglossum vierecki* (Crawford, 1904)

Sources: Photograph taken in Highlands County, Florida. Photograph by Tim Lethbridge

Figure 22 Adult *Lasioglossum* nymphale (Smith, 1853) Smith, a sweat bee, gathering pollen and nectar on a goldenrod

Source: https://www.oekolandbau.de/bio-im-alltag/bio-fuer-die-umwelt/vielfalt/die-vielfalt-der-wildbienen/fruehe-ziest-schluerfbiene-rophites-algirus-perez-1895/

Figure 23 *Rophites algirus* Pérez 1895

3.4. Distribution and Habitat

The subfamily is distributed throughout most of the world, and in the Neotropical region, we have six of the eight tribes present. Some species of Nomiini occur in Mexico, Cuba and the Bahamas (Figures 24A-24B) [17].

Source: Katie Buckley, University of Florida

Figures 24A Wildflowers with exposed soil for nesting, a typical habitat for sweat bees

Source: https://bugguide.net/node/view/129032

Figure 24B A few days later I found another bee and her nest

They are more common in temperate regions, although they are also found in tropical climates. They can live in many different types of habitats. The density of bees from the Halictidae Family is especially high in steppes and deserts. They are commonly found in clayey soils and along stream banks [17].

The most diverse group is Halictini, especially the genera *Halictus* and *Lasioglosum* s.l. In the Neotropical region, the Augochlorini are very diverse [18].

3.5. Classification

In the classification that admits only one family of bees, Halictinae is divided into four tribes, however, the tribe Halictini s.l. is currently divided into four distinct tribes. Thus, the tribes currently recognized for Halictinae are Rophitini, Nomiini, Nomioidini, Augochlorini, Caenohalictini, Thrinchostomini, Sphecodini and Halictini. In the multi-family classification, the groups of Halictidae would be Rophitinae, Nomiinae, Nomioidinae and Halictinae (subdivided into) Augochlorini, Caenohalictini, Thrinchostomini, Sphecodini and Halictini) [19,20,21].

Biology Subfamilies: Solitary or eusocial with most nesting in the ground and some nesting in wood. Mass-provision individual cells with pollen and nectar, which are then sealed after a single egg is laid on the provision.

3.5.1. Subfamily Halictinae

Host of: *Tamarix* sp.

Distribution: Europe, North Africa eastern Asia. This species has been recorded from Kazakhstan, Kyrgyzstan, Turkmenistan, Uzbekistan and Xinjiang Uyghur of China in Central Asia (Figure 25).

Source: https://elp.tamu.edu/ipm/bugs/bees/hymenoptera-halicitidae-subfamily-halictinae-sweat-and-furrow-bees-b/

Figure 25 Subfamily Halictinae

Some Genus: *Halictus* Latreille, 1804 ,*Lasioglossu*m Curtis, 1833 and *Nomia* Latreille, 1804.

Some Species: *Halictus albidus* Lepeletier, 1841 (Senegal, South Africa), *Halictus angustulus* Cockerell, 1937 (Democratic Republic of the Congo), *Halictus atelopterus* Cockerell, 1920 (South Africa), *Halictus basizonus* Friese, 1909 (South Africa), *Halictus beniensis* Cockerell, 1945 (Democratic Republic of the Congo) and *Halictus bidens* Cameron, 1905 (South Africa).

Biology: *Halictus* species can be solitary or weakly eusocial. This behavioral variability may be present within a species depending on the range of environmental conditions that are present across the species' geographical distribution.

3.5.2. Subfamily Nomiinae

Is a large group from the old world tropics and the Mediterranean region. Males have highly modified hind legs. Most are solitary and a few are primitively social (Figure 26).

Source: https://en.wikipedia.org/wiki/Nomiinae

Figure 26 Subfamily Nomiinae

Hosts of: *Achillea* sp., *Brassica* sp., Cruciferae sp., Lamiaceae sp., Leguminosae sp., *Melilotus officinalis* (L) (Fagaceae), *Mentha asiatica* (Boriss.) (Lamiaceae), *Solidago* sp., *Tamarix* sp. (Tamaricaceae) and *Vicia villosa* Roth (Fabaceae).

Distribution: Europe, North Africa eastern Asia. This species has been recorded from Kazakhstan, Kyrgyzstan, Turkmenistan, Uzbekistan and Xinjiang Uyghur of China in Central Asia.

Some Genus*: Lipotriches* Gerstaecker, 1858, *Nomia* Latreille, 1804 and *Pseudapis* Kirby, 1900.

Some Species: *Lipotriches ablusa* (Cockerell, 1931) (Democratic Republic of the Congo, Kenya, Malawi, Zambia), *Lipotriches acaciae* (Cockerell, 1935) (South Africa) and *Lipotriches alberti* (Cockerell, 1942) (Democratic Republic of the Congo), *Nomia amabilis* Cockerell, 1908 (Angola, Democratic Republic of the Congo, Kenya, Lesotho, Malawi, Rwanda, South Africa, Uganda, Zimbabwe), *Nomia alluaudi* (Pauly, 2000) (Kenya, Tanzania), *Nomia ampla* Walker, 1871 (Djibouti). *Pseudapis aliceae* (Cockerell, 1935) (Angola, Democratic Republic of the Congo, Kenya, Mozambique, Namibia, South Africa, Tanzania, Zimbabwe), *Pseudapis amoenula* (Gerstaecker, 1871) (Burkina Faso, Burundi, Cameroun, Central African Republic, Congo, the Democratic Republic of the Congo, Ethiopia, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Ivory Coast, Kenya, Liberia, Malawi, Mali, Mozambique, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe) and *Pseudapis anomala* Kirby, 1900 (Botswana, Mozambique, Tanzania and Yemen.

Biology: Solitary or eusocial with most nesting in the ground, and some nest in wood. Mass-provision individual cells with pollen and nectar, which are then sealed after a single egg is laid on the provision.

3.5.3. Subfamily Nomioidinae

Host of: *Peganum harmala* L. (Nitrariaceae) and *Tamarix* sp.

Distribution: Palearctic to the northern Oriental Region. This species has been recorded from Kazakhstan and Kyrgyzstan in central Asia (Figure 27).

Sources: Photographs © Connal Eardley Michael Kuhlmann and Alain Pauly first published in Eardley et al. 2010

Figure 27 Subfamily Nomioidinae

Some genus: *Cellariella* Strand, 1926, *Ceylalictus* Strand, 1913 and *Nomioides* Schenck, 1867.

Some Species: *Cellariella fulviventris* (Blüthgen, 1925) (South Africa), *Cellariella inexpectata* Pesenko & Pauly, 2005 (Kenya), *Cellariella kalaharica* (Cockerell, 1936) (Angola, Botswana, Kenya, Madagascar, Mozambique, Namibia, South Africa, Tanzania, Zambia), *Ceylalictus aldabranus* (Cockerell, 1912), *Ceylalictus capverdensis* Pesenko, Pauly and La Roche, 2002, *Ceylalictus congoensis* Pesenko & Pauly, 2005, *Nomioides bluethgeni* Pesenko, 1979 (Kenya. Also in Palaearctic region), *Nomioides griswoldi* Pesenko & Pauly, 2005 (Kenya) and *Nomioides kenyensis* Pesenko & Pauly, 2005 (Kenya, Somalia).

Biology: Solitary or eusocial with most nesting in the ground, and some nest in wood. Mass-provision individual cells with pollen and nectar, which are then sealed after a single egg is laid on the provision.

3.5.4. Subfamily Rophitinae

Host of: *Asteraceae* sp.

Distribution: This subspecies is endemic to the Pamir Mountain area in central Asia (Figure 28).

Source: https://en.wikipedia.org/wiki/Rophitinae

Figure 28 Subfamily Rophitinae

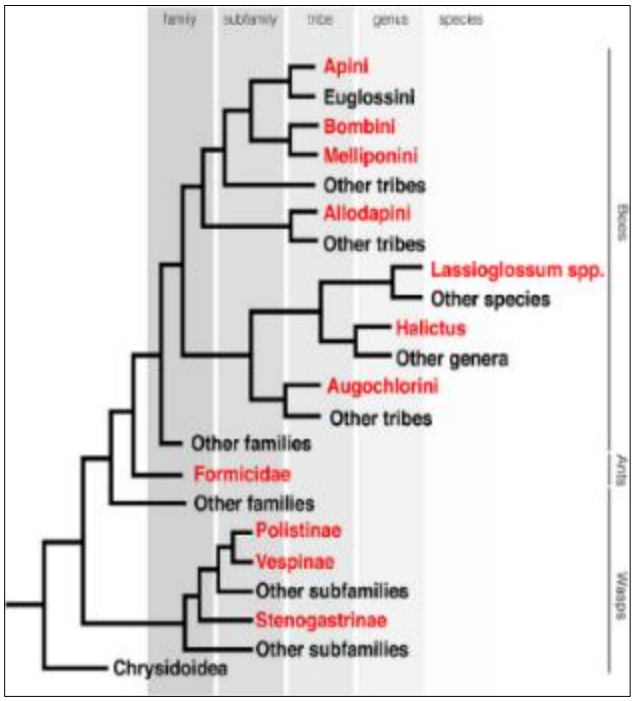
Genus: *Systropha* Illiger, 1806.

Biology: Solitary or eusocial with most nesting in the ground, and some nest in wood. Mass-provision individual cells with pollen and nectar, which are then sealed after a single egg is laid on the provision.

Source: van Noort, S. WaspWeb [Internet]. Cape Town: Hymenoptera; @ 2023 [2023 May 13]. Available from the Afrotropical region. URL: www.waspweb.org

3.6. Phylogeny

Halictinae is undoubtedly a monophyletic group and the relationships between its tribes are well-established based on molecular and morphological characteristics (Figure 29) [21,22].



Source: https://www.researchgate.net/figure/Eusociality-evolved-multiple-times-in-hymenoptera-Phylogeny-of-

Figure 29 Eusociality evolved multiple times in Hymenoptera. Phylogeny of the Aculeata. Clades containing eusocial species are highlighted in red. Phylogeny is based on Danforth et al. (2013) and Johnson et al. (2013). Each branch represents the lowest taxonomic classification level that is solely comprised of eusocial species

4. Selected manuscripts

4.1. Study 1

Halictidae is the second largest bee family with nearly 4,500 species. They are commonly called sweat bees as they are often attracted to perspiration. Halictidae species are an extremely diverse group that can vary greatly in appearance (Figures 30-36) [23].

Source: https://wildaboutants.com/2010/12/26/sweat-bee-life/?subscribe=success#subscribe-blog-blog_subscription-2

Figure 30 Sweat bees vary from solitary to social. This nest had multiple adults, which indicates they were living socially

Source: https://wildaboutants.com/2010/12/26/sweat-bee-life/?subscribe=success#subscribe-blog-blog_subscription-2

Figure 31 In this cell there is a ball of food and what looks like an egg. The food is a mixture of pollen and nectar, hence the yellow-orange color. The sweat bees line the cells with wax

Source: https://wildaboutants.com/2010/12/26/sweat-bee-life/?subscribe=success#subscribe-blog-blog_subscription-2

Figure 32 Prior to pupating, the larvae enter a resting stage called a prepupa

Source: https://wildaboutants.com/2010/12/26/sweat-bee-life/?subscribe=success#subscribe-blog-blog_subscription-2

Figure 33 You can see their eyes, mouthparts and antennae

Source: https://wildaboutants.com/2010/12/26/sweat-bee-life/?subscribe=success#subscribe-blog-blog_subscription-2

Figure 34 Everything is pretty neat and tidy

Source: https://wildaboutants.com/2010/12/26/sweat-bee-life/?subscribe=success#subscribe-blog-blog_subscription-2

Figure 35 The nest was overrun with snails (I think they ate the larval food)

Source: https://wildaboutants.com/2010/12/26/sweat-bee-life/?subscribe=success#subscribe-blog-blog_subscription-2

Figure 36 Millipedes, sowbugs

4.2. Study 2

Halictus smaragdulus Vachal, 1895 (emerald bee).

These bees share with those of their family the characteristic of being, apparently, attracted by sweat, which is why they are known as “sweat bees”. Another common feature is that they present the abdominal tergites bordered, posteriorly, by a band of clear bristles (Figure 37).

Source: https://www.researchgate.net/figure/Halictus-smaragdulus-form-vinulus-female-holotype-and-male-paratype-a-female-head-b_fig4_283354628

Figure 37 *Halictus smaragdulus* Vachal, 1895, form vinulus, female holotype and male paratype; (a), female head; (b), female propodeum; (c), male head; (d), male antenna; (e), male genitalia, ventral view; (f), labels of the female holotype

It is a small bee (6 to 8 mm long) recognizable by the metallic, golden-green reflections with which it presents itself. Sexual dimorphism is notorious: males are 5 to 6.5 mm long and have a body with golden-green metallic reflections; the femurs are black with metallic reflections, but their apices, as well as the tibias and tarsi, are yellow; on the head, the antennae are brown, the lip and apical margin of the clips are pale yellow, and the face relatively short, as well as the 4th antennal segment; in the metasoma (Figure 38).

Source: Zdeněk Hyan [Other photographs by this author]

Figure 38 *Halictus smaragdulus* Vachal, 1895, female

Females differ from males in the following characteristics: on the middle and hind tibiae they show a dark, central spot; a longitudinal, glabrous groove of the last segment of the abdomen, and the rounded bastibial plate. As a general rule, these bees build their nests on the ground. The cells are coated with a water-repellent secretion. A supply of honey and

nectar is left in each chamber as food for the larva. The females that appear in the summer hibernate, build the nest the following year, and die the following autumn. Mating takes place in summer (Figure 39) [24].

Source: https://www.researchgate.net/figure/Halictus-smaragdulus-form-vinulus-female-holotype-and-male-paratype-a-female-head-b_fig4_283354628

Figure 39 *Halictus smaragdulus* Vachal, 1895, form vinulus, female holotype and male paratype; (a), female head; (b), female propodeum; (c), male head; (d), male antenna; (e), male genitalia, ventral view; (f), labels of the female holotype

4.3. Study 3

4.3.1. Halictidae Family

Augochloropsis agapostemon sp. nov. (Figure 40).

Source: https://pbase.com/tmurray74/sweat_bees_halictidae

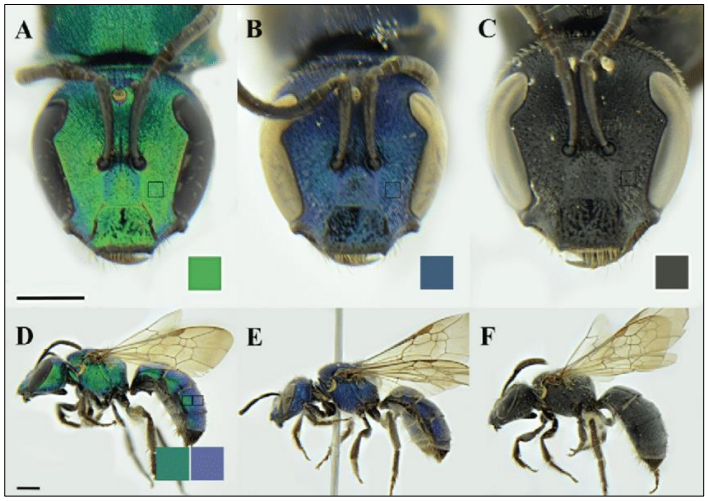
Figure 40 *Augochloropsis agapostemon* sp. nov

The Halictidae family is one of the most diversified in Brazil. Bees in this family have green, blue, reddish, or even black metallic luster. They have different levels of sociability ranging from solitary to subsocial. The Augochlorini tribe is well represented in tropical forest areas, with its greatest diversity in southern Brazil and Argentina (Figure 41).

Source: https://val.vtecostudies.org/projects/vtbees/augochlorini/

Figure 41 Augochlorini tribe

As examples of Halictidae species that are quite common and well distributed in the south and southeast regions of Brazil, we can mention: *Augochlora amphitrite* (Schrottky, 1909), *Augochlora semiramis* (Schrottky, 1910), *Augochlorella ephyra* (Schrottky, 1910), *Augochloropsis cleopatra* (Schrottky, 1902), *Augochloropsis cupreotincta* (Cockerell, 1900), *Augochloropsis sparsilis* (Vachal, 1903), *Dialictus opacus* (Moure, 1940), *Pseudaugochloropsis graminea*, Kerr 1972 and *Pseudagapostemon pruinosus* Moure & Sakagami, 1984 (Figure 42) [25].



Source: https://www.researchgate.net/figure/Color-variation-of-Augochlora-amphitrite-A-B-C-D-E-F-bars-correspond-to-1mm_fig1_328319536

Figure 42 Color variation of *Augochlora amphitrite* (Schrottky, 1909). A. B. C. D. E. F

4.4. Study 4

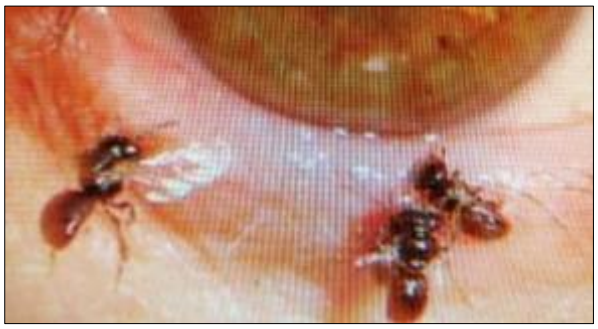
4.4.1. The woman found 4 bees inside her eye (sweat bee).

In 2019, a young Taiwanese woman sought a hospital to treat an eye annoyance and was surprised by the reason. At the Qing Minge festival According to BBC, G1 and Superinteressante magazine at the time, it all started while He was participating in the Chinese Qing Minge festival, which honors the dead annually (Figure 43).

Source: https://edition.cnn.com/2019/04/10/asia/bees-found-in-taiwanese-womans-eye-scli-intl/index.html

Figure 43 Sweat bees sometimes land on people to imbibe perspiration

On this occasion, people usually clean and decorate the graves of their loved ones. And that's what the Taiwanese girl was doing. She was weeding a grave when a strong wind came up. Instantly, He was bothered by something in one of her eyes. She even washed it with water, thinking it was just dirt, but it didn't work, as the strange feeling didn't go away. Shortly after, her organ began to swell, which made the situation even more worrying (Figure 44).



Source: https://edition.cnn.com/2019/04/10/asia/bees-found-in-taiwanese-womans-eye-scli-intl/index.html

Figure 44 The tiny sweat bees were found inside her left eye

Seeking medical help, however, waited until the next morning and, seeing that the problem continued, went to Fooyin University Hospital, located in the Daliao district of Kaohsiung. Hong Chi Ting, the attending physician. "I saw something that looked like insect legs, so I slowly took them out and put them under a microscope one by one without damaging their bodies," Ting said. According to the health professional, the bees were 4 millimeters each (Figure 45).

Source: https://edition.cnn.com/2019/04/10/asia/bees-found-in-taiwanese-womans-eye-scli-intl/index.html

Figure 45 The woman's eye was badly swollen when she went to seek medical treatment (sweat bee)

The report also reported that the young woman only did not lose her sight because she did not rub her eyes, not even when washing them with water. The bees found in he's eye belong to the Halictidae family and tend to live in mountainous regions and near graves, all over the world, according to the doctor. He explains that they are attracted to human perspiration and are generally not aggressive, except in cases where they are touched. In the case of the Taiwanese woman, the bees remained in her eye, feeding on the moisture and salt of her tears. That's how they survived [26].

4.5. Study 5

4.5.1. A contribution to the kleptoparasitic bees of Turkey: The genus Sphecodes Latreille (Hymenoptera: Halictidae)

The present study was carried out to determine the occurrence and distribution of the kleptoparasitic bee genus *Sphecodes* Latreille (Hymenoptera: Halictidae) of Turkey.

The material comprises samples collected from various parts of Turkey since the 1960s and certain private collections in Europe. The examination of the material and an overview of the published sources allowed us to reach the conclusion that the *Sphecodes* of Turkey are represented by 33 species ((Figure 46).

Source: Photo: Henning Bang Madsen, 22.IV.2011

Figure 46 Female of large blood bee *Sphecodes albilabris* (Fabricius, 1793)

Of these, *Sphecodes crassanus* Warncke, 1992 are new records for Turkey as well the Asian continent. *Sphecodes alternatus* Smith, 1853, *Sphecodes ephippius* (Linnaeus, 1767), *Sphecodes gibbus* (Linnaeus, 1758), *Sphecodes albilabris* (Fabricius, 1793), and *Sphecodes ouncticeps* Thomson, 1870 were found to be the most widespread and abundant species occurring throughout the country. On the contrary, *Sphecodes armeniacus* Warncke, 1992, *Sphecode majalis* Parez 1903, *Sphecode niger* Hagens, 1874 and *Sphecodes scabricollis* Wesmael, 1835 were considered to be the rarest species, recorded from just one locality each.

New localities for the inspected material are given to make a contribution to the knowledge about the distribution patterns of the species. As a kleptoparasitic genus, the known host records of *Sphecodes* were also included. Although species of the genus *Sphecodes* only forage for nectar on flowers and do not collect pollen, the plant species visited were also added if available [27].

4.6. Study 6

4.6.1. *Lasioglossum coeruleum* (Robertson, 1893)

Classification

- Kingdom Animalia (Animals).
- Phylum Arthropoda (Arthropods).
- Subphylum Hexapoda (Hexapods).
- Class Insecta (Insects).
- Order Hymenoptera (ants, bees, wasps and sawflies).
- No Taxon (Aculeata - ants, bees and stinging wasps).
- No Taxon (Apoidea (clade Anthophila) - bees).
- Family Halictidae (sweat, furrow, Nomiine, and short-faced bees).
- Subfamily Halictinae (sweat and furrow bees).
- Tribe Halictini
- Genus *Lasioglossum*
- No Taxon (Subgenus *Dialictus*, metallic-sweat bees).
- *Lasioglossum coeruleum* (Robertson, 1893).
- Other Common Names: Deep-blue sweat bee.
- Synonyms and other taxonomic changes: *Halictus coeruleus* Robertson, 1893; *Chloralictus caeruleus* (Robertson, 1893); *Dialictus coeruleus* (Robertson, 1893).
- Explanation of Names: *Lasioglossum (Dialictus) coeruleum* (Robertson, 1893).

- Size: Female: Length 5.25-7mm and Male: Length 6.75mm.
- Range: Minnesota to Massachusetts, south to Georgia.
- Habitat Known to nest in rotten logs.
- Season: March to October.
- Food: Visits flowers from several families (Figures 47A-47D) [28].

A B C D

Source: https://www.naturalista.mx/taxa/199104-Lasioglossum-coeruleum

Figures 47A, B, C, D Nest formation sequence

4.7. Study 7

4.7.1. Scientific name: Pseudaugochloropsis sp. (Figure 48).

Source: https://www.flickr.com/photos/rhnc/5568959625

Figure 48 *Pseudaugochloropsis* sp.

- Family: Halictidae.
- Common Name: Green bee.
- Distribution: It occurs in all regions of Brazil.
- Characteristics: It is a bright green bee about 9 mm long with yellowish or brown hairs.
- Observations: Females make their nests on the ground. They manage to vibrate the poricidal anthers of the flowers, getting pollen deposited in the ventral part of the body.
- In the Garden: Were observed visiting flowers of *Ouratea cuspidata* Engl. (Ochnaceae) and *Cuphea gracilis* Kunth (Lithraceae).

4.8. Study 8

The present study aims to contribute information on biological aspects such as behavior, nest architecture and pollen resources used as a source of food by the species *Neocorynura muiscae* Smith-Pardo & Gonzalez, 2006.

Source: https://www.researchgate.net/figure/Male-of-Neocorynura-centroamericana-a-lateral-habitus-b-dorsal-habitus-c-frontal_fig7_307625774

Figure 49 Male of *Neocorynura*: a) lateral habitus, b) dorsal habitus, c) frontal view of head, d) dorsal view of mesosoma, e) part of mesoscutellum, metanotum and base of propodeum (propodeal triangle), f) dorsal view of metasomal segment 1 (T1) and base of T2

The nests had a single entrance that connected to a chamber where there were usually three cells built with immatures or pollen. It was also observed that the depth of the nests depends on the type of soil and vegetation present. From behavioral observations, wear on the wings, wear on the females' jaws and observation of the ovaries, it was determined that the species can sometimes show quasi-social behavior (Figure 49).

Finally, most of the pollen grains found in the extracted nests belonged to the Asteraceae, Melastomataceae and Ericaceae families, which are resources often found in Andean forests and in the case of Ericaceae by the blueberry culture in the study site [29].

5. Introduction

The Melittidae family includes the melitid bees. They are small to medium bees. They are specialists in the collection of pollen, choosing only certain species, so their work is very important for their pollination. They have also been observed to collect flower oils. Here you can learn about the Plants and flowers that attract bees (Figures 50-52) [30,31,32].

Source: https://en.wikipedia.org/wiki/Melitta_eickworti

Figure 50 *Melitta eickworti* Snelling & Stage, 1995

Sources: https://doi.org/10.17161/jom.i98.14816 and https://journals.ku.edu/melittology/article/view/14816

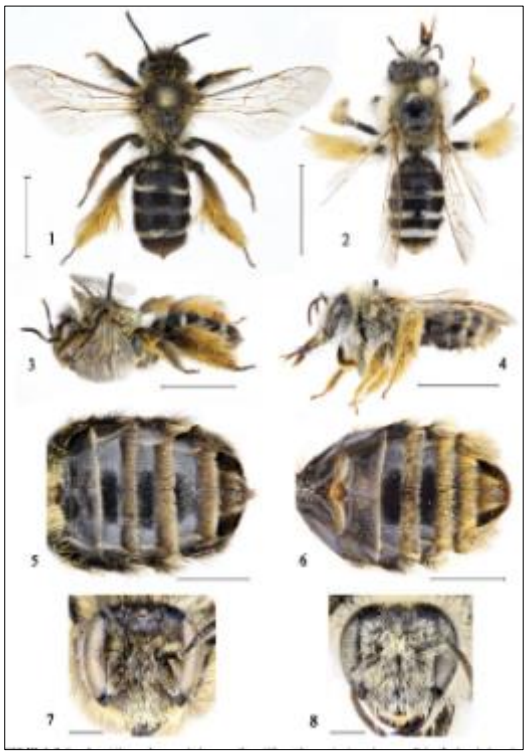
Figure 51 *Hesperapis* from the lower Midwestern United States

Source: https://www.researchgate.net/figure/Figures-1-2-Female-of-Hesperapis-Carinapis-infuscata-new-species-1-Lateral-habitus_fig1_347378916

Figure 52 Female of *Hesperapis infuscata*, new species. (1). Lateral habitus. (2). Dorsal habitus

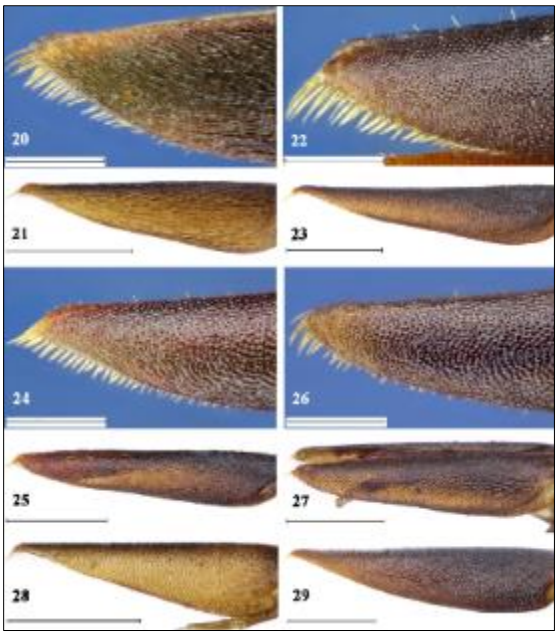
5.1. Description

They are generally small to moderate in size; they often have a thick scopa for pollen collection. The tibias of the legs are longer than the entire body and they use them as sponges to gather the oils accumulated in the dewclaws, their host plant (Figures 53-56) [33,34,35].



Sources: https://www.semanticscholar.org/paper/A-new-widespread-European-bee-species-of-the-genus-Radchenko/5c4f3d8ed2509ed91d0f706a6e15e4c7b6e7a69c/figure/0

Figure 53 Females of *Dasypoda morawitzi* sp. nov. Two different forms of color pubescence (left—the female from the Kiev region; right—from the Kherson region of Ukraine): (1, 2). Female in dorsal view; (3, 4). Female in lateral view; (5, 6). Head in frontal view; (7, 8). Metasoma in ventral view

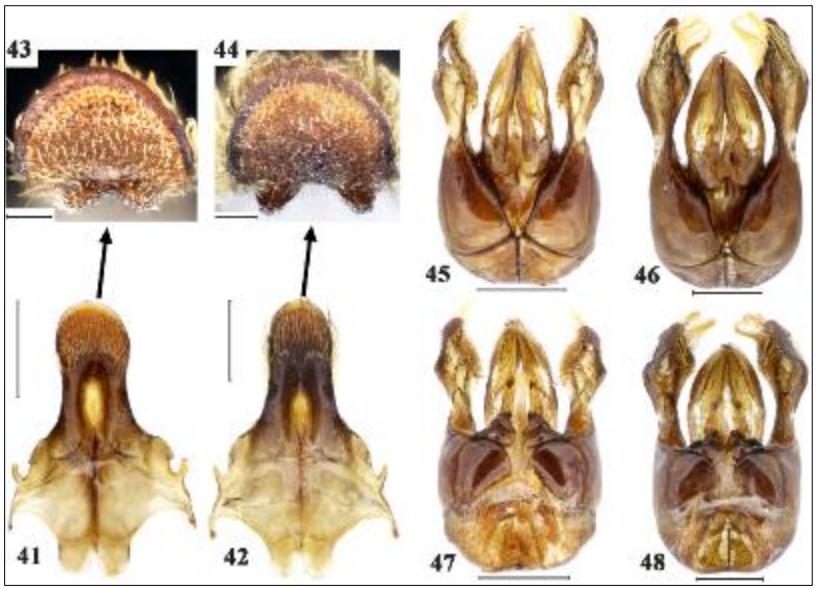


Source: https://www.semanticscholar.org/paper/A-new-widespread-European-bee-species-of-the-genus-Radchenko/5c4f3d8ed2509ed91d0f706a6e15e4c7b6e7a69c/figure/1

Figure 54 Structure of the galea (lateral view): (20–21). *Dasypoda morawitzi* sp. nov.; (22–23). *Dasypoda* hirtipes (Fabricius, 1793); (24–25). *Dasypoda sinuata* Pérez, 1895; (26–27). *Dasypoda oraniensis* Pérez, 1896; (28). *Dasypoda albipila* Spinola, 1838; (29). *Dasypoda tubera* Warncke, 1973; (20, 22, 24, 26)—females; (21, 23, 25, 27–29)— males

Source: https://www.semanticscholar.org/paper/A-new-widespread-European-bee-species-of-the-genus-Radchenko/5c4f3d8ed2509ed91d0f706a6e15e4c7b6e7a69c/figure/1

Figure 55 Structure of body. *Dasypoda morawitzi* sp. nov.: (30). Malar area; (31). Pygidial plate; (32–34). Hind tibia; (35). Sternum 6; (36). Sternum 7; (37). Sternum 8; (8–40). *Dasypoda hirtipes* (Fabricius, 1793): (38). Sternum 6; (39). Sternum 7; (40). Sternum 8; (35–40)—dorsal view; (30–31)—female; (32–40)—male)



Source: https://www.semanticscholar.org/paper/A-new-widespread-European-bee-species-of-the-genus-Radchenko/5c4f3d8ed2509ed91d0f706a6e15e4c7b6e7a69c/figure/1

Figure 56 Structure of male sterna and genitalia: (41–42). Sternum 8 (ventral view; (43–44). Apex of sternum 8 (ventral view); (45–48). Genitalia (45–46) —dorsal, (47–48) —ventral view); (41, 43, 45, 47) —*Dasypoda morawitzi* sp. nov.; (42, 44, 46, 48)— *Dasypoda hirtipes* (Fabricius, 1793)

5.2. Biology

They are solitary and dig their nests in the ground, with the other characteristics that we previously presented for solitary bees. It is a small family, with few species, and they only inhabit the northern hemisphere of the planet and Africa. They are only daytime. Ectoparasitoids of larvae or pupa of other insects (Figures 57-60) [36,37,38].

Source: https://www.buzzaboutbees.net/melittidae-bee-family.html

Figure 57 One of my favorite from the Melittidae family is the beautiful *Dasypoda hirtipes* (Fabricius, 1793) – Pantaloon bee, so called because of the long hairs on the rear legs giving the appearance of 'pantaloons'. Building nests

Source: https://www.picfair.com/pics/0280469-melittidae-in-the-nest

Figure 58 Melittidae in the nest

Source: https://en.wikipedia.org/wiki/Dasypodainae#/media/File:Dasypoda_altercator_DSCF0332.JPG

Figure 59 *Dasypoda altercator* (Harris, 1780) digging. The term oligolecty is used in pollination ecology to refer to bees that exhibit a narrow, specialized preference for pollen sources, typically to a single family or genus of flowering plants. The preference may occasionally extend broadly to multiple genera within a single plant family, or be as narrow as a single plant species

Source: https://observation.org/species/8098/observations/?

Figure 60 Pantaloon bee *Dasypoda hirtipes* (Fabricius, 1793)

Among the more than 16 thousand species of bees described and known in the world there are about 330 species that collect oil in flowers and use this resource to feed the larvae and coat the brood cells. These bees specialize in collecting

oil. In the Macropidini and Redivivini tribes only the genera *Macropis* (in Europe) and *Rediviva* (in Africa), which represent between 26-29 species, are known to collect floral oils (Figures 61-64) [39,40,41].

Source: https://www.eurekalert.org/news-releases/590104

Figure 61 The females from this species of oil-collecting bees in south africa *Rediviva* have disproportionately long legs with dense hairs on their feet. they use the front legs to collect oil from the equally long spurs of the snapdragon flower *Diascia* and Diascia *whiteheadii* K. E. Steiner (Scrophulariaceae)

Source: https://www.eurekalert.org/multimedia/867738

Figure 62 The oil-producing snapdragon flower from South Africa *Diascia whiteheadii* K. E. Steiner (Scrophulariaceae)

Source: https://en.wikipedia.org/wiki/Macropis_nuda

Figure 63 Genera *Macropis* Panzer 1809 (Hymenoptera, Apoidea, Melittidae). Family Primulaceae known as the primrose family, are a family of herbaceous and woody flowering plants including some favorite garden plants and wildflowers. Most are perennial though some species, such as scarlet pimpernel, are annuals

Figure 64 *Lysimachia ciliata* L., (Primulaceae) (Fringed Loosestrife). the loose fringe, is a species of flowering plant in the Primulaceae family. It is an erect perennial herb growing to 120 cm tall and 60 cm wide, with simple opposite leaves and smooth green stems. The star-shaped yellow flowers bloom in mid-summer. In nature, it appears in wet or soggy environments, such as swamps and stream banks, as well as in forests, shrubs and fields. *L. ciliata* attracts bees (oil-producing), songbirds and small mammals

5.3. Distribution

These bees have a very wide distribution, covering the Palearctic, Nearctic and Ethiopian biogeographic regions; On the other hand, they do not exist in South America and there is only one Australian species. The Iberian genera are distributed throughout the Western Palearctic [42,43].

5.4. Classification

It is a tiny family of bees, with more than 200 species described in three subfamilies. Bees in this family are well known for their specialized and oligolectic foraging habits. The sub-families comprise Dasypodainae, Melittinae and Meganomiinae [44,55].

Subfamily Dasypodainae: It is a small subfamily of bees with more than 100 species in eight genera, found in Africa and in the northern temperate zone, mainly in xeric habitats similar to the Brazilian Caatinga a bee from this sub-family it inhabits meadows, fields, valleys and gardens in California, USA (Figure 65).

Sources: Vladimir Bryukhov and https://insecta.pro/taxonomy/924223

Figure 65 Subfamily Dasypodainae

Subfamily Meganomiinae: A subfamily with 10 species in four genera, found only in Africa, with distribution limits in Yemen and Madagascar (Figure 66).

Source: Photographs © Simon van Noort (Iziko Museums of South Africa)

Figure 66 Subfamily Meganomiinae

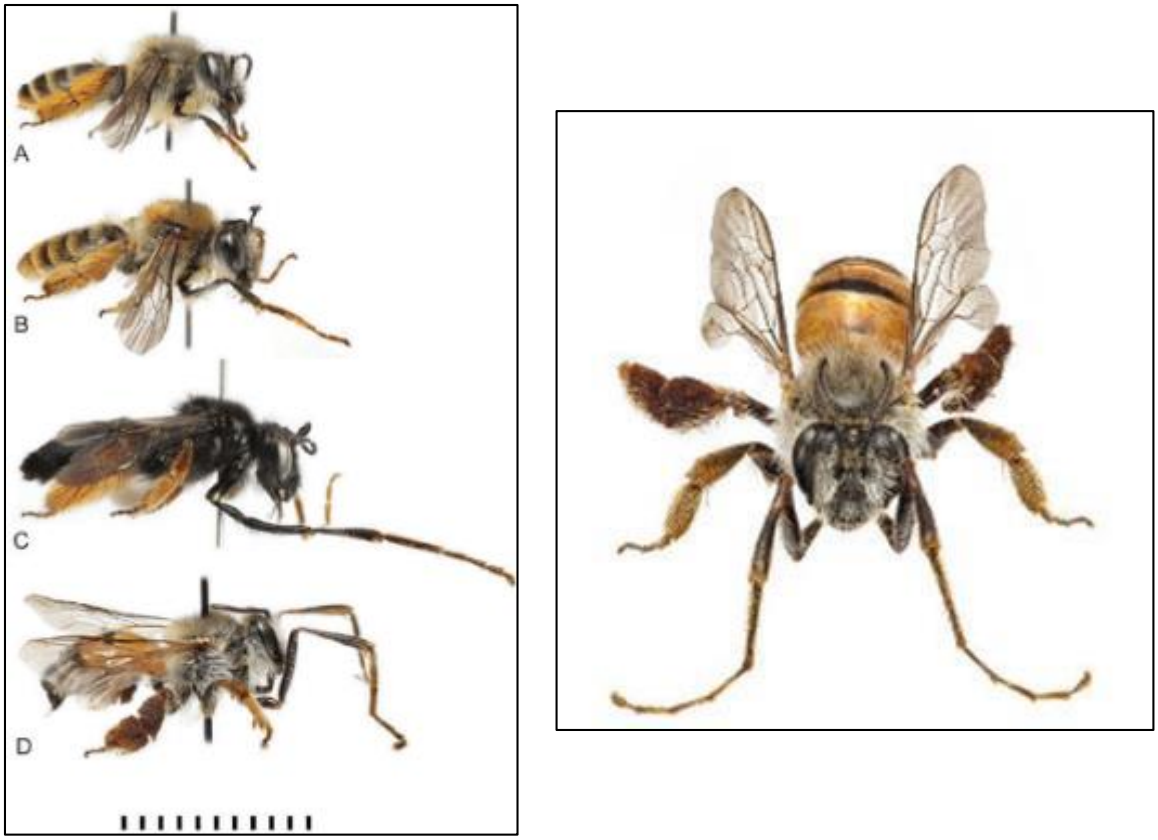
Subfamily Melittinae: It is a small subfamily with about 60 species in four genera, restricted to Africa and the northern temperate zone a bee is considered oleaginous because it prefers plants like that, such as plants. These bees can be found in parts of Canada, Montana, Idaho, Colorado, Maine, New Jersey and New York (Figure 67) [46,47,48].

Sources: Vladimir Bryukhov and https://insecta.pro/taxonomy/924223

Figure 67 Subfamily Melittinae

5.5. Fossil

Fossil Melittdae have been found occasionally in Eocene amber deposits, including those of Oise, France and the Baltic amber**.** *Rediviva* sp. these bees are currently the rarest in the world (only 200 species), but they were the first to be differentiated from wasps, just as dinosaurs ruled the earth (Figure 68) [49,50,51].



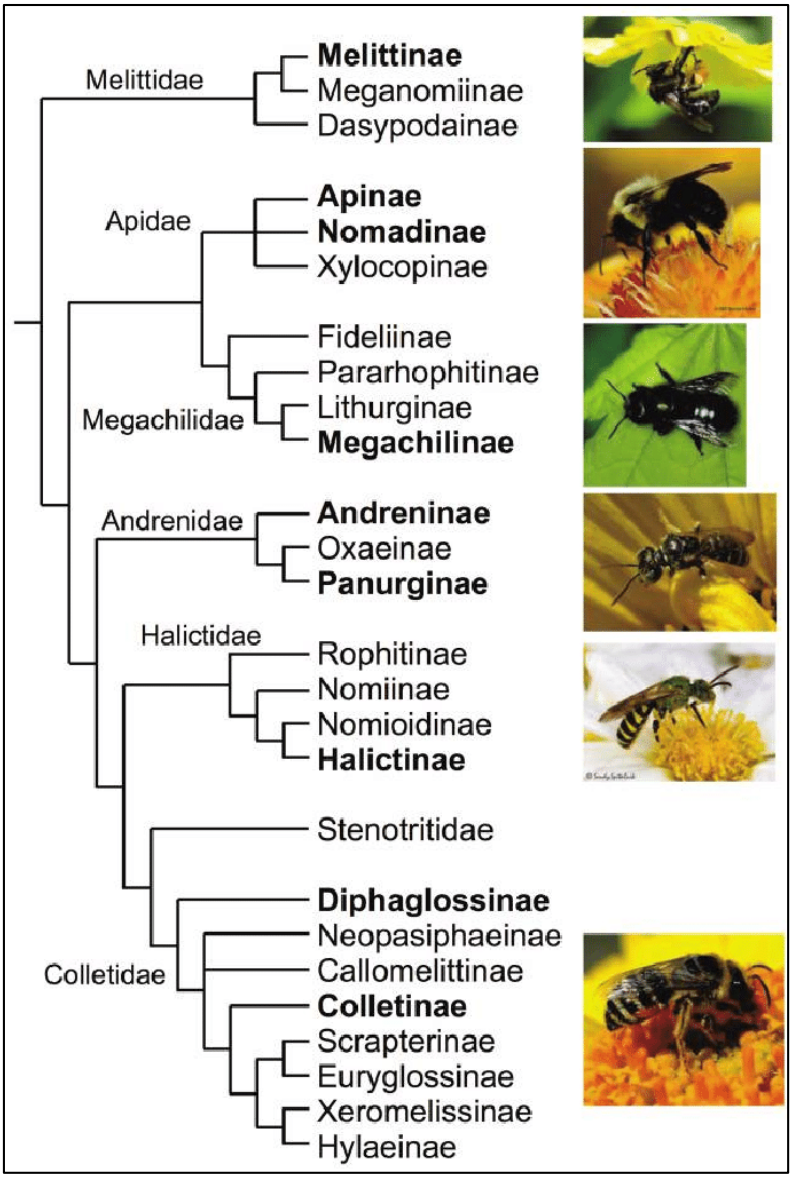
A, B, C, D E

Sources: https://www.researchgate.net/figure/Female-Rediviva-bees-in-lateral-view-showing-species-specific-variation-of-foreleg_fig3_271945914 and https://twitter.com/magdadelbosque/status/1263682355274760192

Figure 68 Female *Rediviva* bees in lateral view showing the species-specific variation of foreleg length. (A) *Rediviva alonsoae* Whitehead & Steiner 2001; (B) *Rediviva macgregori* Whitehead & Steiner, 2001; (C) *Rediviva longimanus* Michener, 1981 (D) *Rediviva emdeorum* Vogel & Michener, 1985; (E) Family Melittidae. Species: *Rediviva* sp. These bees are currently the rarest in the world (only 200 species), but they were the first to be differentiated from wasps, just as dinosaurs ruled the earth

5.6. Phylogeny

Convincing new phylogenetic hypotheses suggest that one of the smallest bee families, the Melittidae (166 species), could be the basal group of the bee clade. Family-level phylogeny of bees based on Danforth et al. (2013) and phylogeny of the subfamilies, tribes, and genera of Melittidae sensu lato according to Michez et al. (2009) (''?'') indicates that the Melittidae family is either a paraphyletic group from which all the other bees are derived, or the sister clade to all other existing bees) (Figure 69) [52,53,54,55].



Sources: Photos courtesy of J. D. Gardner (Melittidae), Donna K. Race (Apidae), Lynette Elliott (Megachilidae), Ron Hemberger (Andrenidae), Sanwdra Spitalnik (Halictidae), Hartmut Wisch (Colletidae) and Source: https://www.researchgate.net/figure/Family-and-subfamily-level-phylogeny-for-bees-based-on-Danforth-et-al-2013_fig1_332959316

Figure 69 Family and subfamily-level phylogeny for bees (based on Danforth et al. 2013). Subfamilies sampled in this study are in bold. Pictured bees (from top to bottom): *Macropis nuda* (Provancher, 1882) (Melittidae), *Bombus impatiens* (Apidae), *Osmia lignaria* (Megachilidae), *Calliopsis rhodophila* (Andrenidae), *Agapostemon virescens* (Fabricius, 1775) (Halictidae) and *Colletes* (Colletidae)

6. Selected Manuscripts

6.1. Study 1

6.1.1. Classification of Afrotropical Hymenoptera and Classification of World Hymenoptera

- **Subfamilies:** Dasylabrinae, Mutillinae, Myrmillinae, Odontomutillinae, Pseudophotopsidinae, Thopalomutillinae Sphaeropthalminae and Ticoplinae.
- **Distribution:** Cosmopolitan, but more diverse in the tropics.
- **Diversity:** Afrotropical region: 1116 species; Australasian region: 306 species; Nearctic region: 435 species; Neotropical region: 1212 species; Oriental region: 637 species; Palearctic region: 524 species; World: 4252 species in 200 genera.
- **Biology:** Ectoparasitoids of larvae or pupa of other insects [56,57].

Subfamily: Dasylabrinae:

- Tribes: Apteromutillini and Dasylabrini.
- Distribution: Afrotropical, Palaearctic and Nearctic regions.
- Biology: Provision the nest with pollen and nectar, often nest in the ground.
- Genus: *Apteromutilla* Ashmead, 1903, *Brachymutilla* André, 1901, *Liotilla Bischoff*, 1920, *Chrestomutilla* Brothers, 1971, *Dasylabris* Radoszkowski, 1885, *Dasylabroides* André, *Liotilla* Bischoff, 1920, *Stenomutilla* André, 1896 and *Tricholabiodes* Radoszkowski, 1885 (Figure 70).

Sources: Photographs © Denis Brothers (University of Kwazulu-Natal) or © Simon van Noort (Iziko Museums of South Africa)

Figure 70 *Brachymutilla* André, 1901

Some Species: *Apteromutilla aeda* (Péringuey, 1899), *Apteromutilla aethra* (Péringuey, 1899) (South Africa) *Brachymutilla melete* (Péringuey, 1898) (South Africa) and *Brachymutilla mutata* (Péringuey, 1899) (South Africa) (Figure 71).

Sources: Photographs © Denis Brothers (University of Kwazulu-Natal) or © Simon van Noort (Iziko Museums of South Africa)

Figure 71 *Brachymutilla mutata (*Péringuey, 1899)

Distribution: Afrotropical region.

Subfamily: Metillinae

- Some Tribes: Ctenotillini, Mutillini and Pristomutillini.
- Distribution: Worldwide (richest in the Old World, except for Australia, which has few species).
- Diversity: Globally 1800 species in about 40 genera.
- Biology: Ectoparasitoids of larvae or pupa of other insects. Diurnal except for a few nocturnal or crepuscular desert species. Pronounced sexual dimorphism is evident.
- Some Genus: *Arcuatotilla* Nonveiller, 1998, *Cephalotilla* Bischoff, 1920 and *Melitta*; Kirby, 1802 (Figure 72).

Sources: Photographs © Denis Brothers (University of Kwazulu-Natal) or © Simon van Noort (Iziko Museums of South Africa)

Figure 72 *Melitta*, Kirby, 1802

Species: *Arcuatotilla arcuaticeps* (André, 1905) and *Rediviva autumnalis* Whitehead & Steiner (Figure 73).

Sources: Photographs © Denis Brothers (University of Kwazulu-Natal) or © Simon van Noort (Iziko Museums of South Africa)

Figure 73 *Rediviva autumnalis* Whitehead & Steiner, 2008

- Distribution: South Africa.
- Some Genus: *Bidentotilla* Nonveiller, 1979, *Cephalotilla* Bischoff, 1920 and *Taeniotilla* Nonveiller, 1979.
- Distribution: Botswana, Cameroon, Ethiopia, Malawi, Namibia, South Africa and Zimbabwe.
- Some Species: *Cephalotilla ceratophora* Nonveiller, 1979 and *Cephalotilla chrysotaenia* Nonveiller, 1979.
- Distribution: Botswana, Cameroon, Ethiopia, Malawi, Namibia, South Africa and Zimbabwe.
- Some Species: *Cephalotilla sanguineiceps* Nonveiller, 1979 and *Cephalotilla swierstrai* Hesse, 1935 (Figure 74).

Sources: Photographs © Denis Brothers (University of Kwazulu-Natal) or © Simon van Noort (Iziko Museums of South Africa)

Figure 74 *Cephalotilla sanguineiceps* Nonveiller, 1979

- Distribution: Botswana, Cameroon, Ethiopia, Malawi, Namibia, South Africa and Zimbabwe.
- Some Genus: *Arnoldtilla* Nonveiller, 1996 and *Labidomilla* André, 1902.

- Distribution: Afrotropical, Oriental and Palaearctic regions.
- Biology: Ectoparasitoids of larvae or pupa of other insects.
- Some Species: *Arnoldtilla achterbergi* Lelej in Lelej & van Harten, 2006 (Yemen) and *Arnoldtilla bischoffi* (Arnold, 1956) (Democratic Republic of the Congo, Zambia) (Figure 75).

Sources: Photographs © Denis Brothers (University of Kwazulu-Natal) or © Simon van Noort (Iziko Museums of South Africa)

Figure 75 *Arnoldtilla bischoffi* (Arnold, 1956)

- Distribution: Afrotropical region: Democratic Republic of the Congo, South Africa, Yemen and Zambia.
- 3-Subfamily: Myrmillinae
- Some Genus: *Arnoldtilla* Nonveiller, 1996 and *Bisulcotilla* Bischoff, 1920 (Figure 76).

Sources: Photographs © Denis Brothers (University of Kwazulu-Natal) or © Simon van Noort (Iziko Museums of South Africa)

Figure 76 *Bisulcotilla* Bischoff, 1920

- Distribution: Afrotropical, Oriental and Palaearctic regions.
- Biology: Ectoparasitoids of larvae or pupa of other insects.
- Specie: *Arnoldtilla achterbergi* Lelej in Lelej & van Harten, 2006 (Yemen).
- Distribution: Afrotropical region: Democratic Republic of the Congo, South Africa, Yemen and Zambia.

Subfamily: Odontomutillinae.

- Genus *Odontomutilla* Ashmead, 1899.
- Distribution: Angola, Cameroon, Democratic Republic of Congo, Eritrea, Kenya, Sierra Leone, South Africa, Zambia and Zimbabwe.
- Some Species: *Odontomutilla rhodesiaca* Bischoff, 1920 and *Odontomutilla seminigrita* Bischoff, 1920 (Figure 77).

Sources: Photographs © Denis Brothers (University of Kwazulu-Natal) or © Simon van Noort (Iziko Museums of South Africa)

Figure 77 *Odontomutilla rhodesiaca* Bischoff, 1920

- Distribution: Angola, Cameroon, Democratic Republic of Congo, Eritrea, Kenya, Sierra Leone, South Africa, Zambia and Zimbabwe.

Subfamily: Pseudophotopsidinae

- Genus *Pseudophotopsis* André, 1896.
- Specie: *Pseudophotopsis aurea* (Klug, 1829) (Figure 78).

Sources: Photographs © Denis Brothers (University of Kwazulu-Natal) or © Simon van Noort (Iziko Museums of South Africa)

Figure 78 *Pseudophotopsis aurea* (Klug, 1829)

- Distribution: Afrotropical, Oriental and Palearctic regions.
- Diversity: Globally 30 species in a single genus.
- Biology: Unknown, most species are nocturnal [58,59].

Subfamily: Rhopalomutillinae

- Biology: Unknown, most species are nocturnal or crepuscular. Pronounced sexual dimorphism.
- Distribution: Afrotropical, Oriental and Palaearctic regions.
- Genus *Rhopalomutilla* André, 1901.
- Distribution: Afrotropical and Oriental regions.
- Diversity: Globally 50 species in 4 genera.
- Biology: Ectoparasitoids of larvae or pupa of other insects. Species exhibit pronounced sexual dimorphism with phoretic copulation.
- Specie: *Rhopalomutilla carinaticeps* Bischo, 1920 (Figure 79).

Sources: Photographs © Denis Brothers (University of Kwazulu-Natal) or © Simon van Noort (Iziko Museums of South Africa)

Figure 79 *Rhopalomutilla carinaticeps* Bischo, 1920

Subfamily: Sphaeropthalminae

- Tribe Ephutini.
- Genus: *Ephuamelia* Casal, 1968 and *Ephuchaya* Casal 1968.

Subfamily: Ticoplinae.

- Tribe Ticoplini.
- Distribution: Afrotropical, Oriental and Palearctic regions.
- Diversity: Globally 100 species in 3 genera.
- Biology: Ectoparasitoids of larvae or pupa of other insects. Sexual dimorphism ranges from extreme to slight.
- Genus *Nanomutilla* André, 1900.
- Distribution: Afrotropical and Palearctic regions.
- Biology: Ectoparasitoids of larvae or pupa of other insects.
- Specie: *Areotilla trifasciata* Mitchell & Brothers, 1998 (Figure 80).

Sources: Photographs © Denis Brothers (University of Kwazulu-Natal) or © Simon van Noort (Iziko Museums of South Africa)

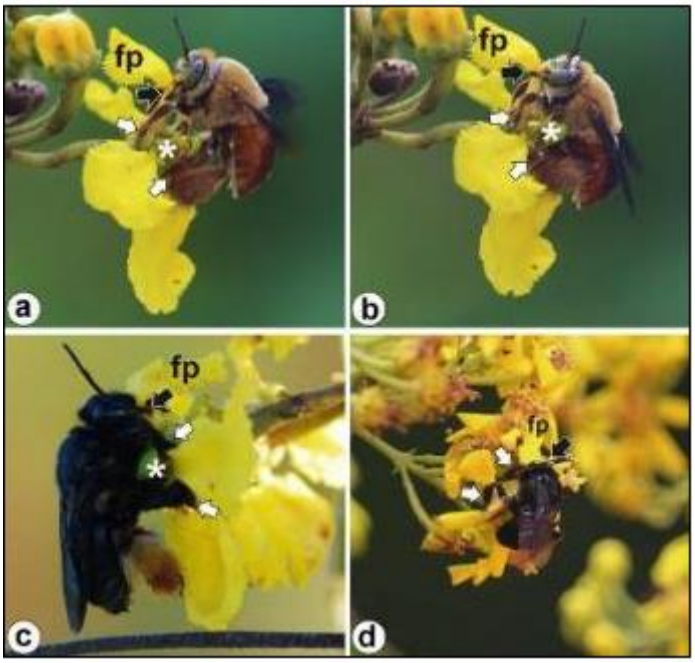
Figure 80 *Areotilla trifasciata* Mitchell & Brothers, 1998

- Distribution: Malawi, South Africa and Zimbabwe.
- Biology: Unknown, but the genus appears to be restricted to forest or dense bushveld areas with moderate to high rainfall [60,61,62].

6.2. Study 2

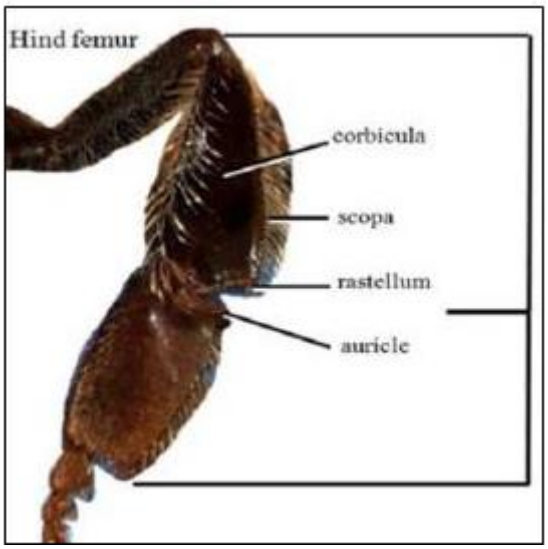
To collect, handle and transport floral lipids, bees have specialized structures in their legs or sternums. These structures are formed by changes in the shape and size of some segments of the legs and particularly for the specialization in hairiness. Basically, rows of simple or branched bristles form a kind of 'combat which are large structures in basitars.

anterior medial or anterior and medial, facing distally or proximally. Morphological changes are more pronounced in females. The oil scraped from the elaiophores (glands that secrete floral oils) is probably conducted through the 'ducts' and accumulated in the dense pilosity located just behind such bristles. Thus it is transported to the nest (Figures 81-82) [63,64,65,66].



Source: https://link.springer.com/article/10.1007/s13592-022-00945-2

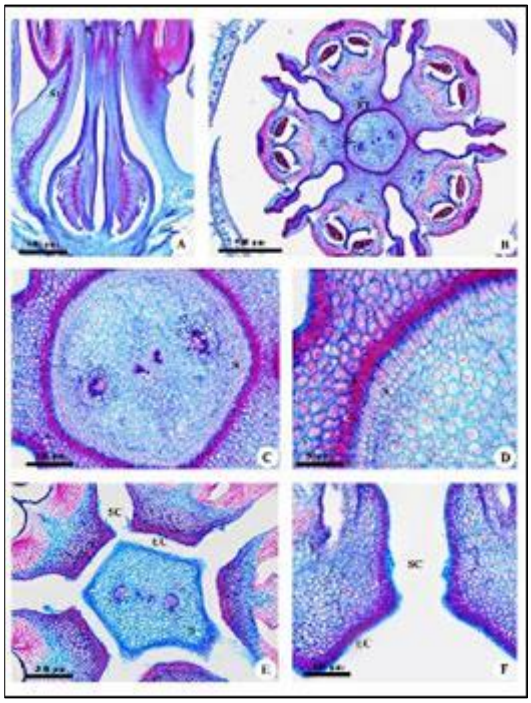
Figure 81 Plant-pollinator interactions: Malpighiaceae analyzed species was as common as the legitimate collection of this resource by oil-collecting bees, and significant differences in the proportion of illegitimate visits along the latitudinal gradient, being the robbery more common to southern sites



Source: https://www.researchgate.net/publication/320532101_Importance_of_corbiculate_bees_in_plant_protection_and_quarantine

Figure 82 Hind leg of a corbiclate bee showing the corbicula. Most of the characters that are shared among corbiculate bees are those as-sociated with the pollen-carrying and manipulating structures and with the mouth parts of their immature stages

O oil is used in larval food as a substitute for nectar, due to its higher energy value. This fact was later confirmed by several authors. The floral oil is about eight times richer in calories than the nectar. Found that the oil present in the and the oil mixed with the pollen in the larval food share most of the lipid components. In addition to being mixed with pollen, the oil is also used to coat the brood cells. suggested that the oil would be a kind of waterproofing agent for the cells, thus protecting the nests of species that nest in humid soil, a fact later verified (Figure 83) [67,68,69].



Source: https://www.scielo.br/j/abb/a/Sx8HgXCNbbxK7mXHTKLjsgM/?lang=en

Figure 83 Floral glands in asclepiads: structure, diversity and evolution. Extragynoecial compitum in flowers of *Oxypetalum banksii* subsp. *banksii* Roem. & Schult (Asclepiadaceae). (A) Longitudinal section. (B-F) Transverse sections. (A-B) Extragynoecial compitum formed by the secretion produced by the inner epidermis of the filament tube in its upper portion. (C) Secretory epidermis around the dry stigma. (D) Detail of C. (E) Continuity between the secretory epidermis of the stigmatic chamber and extragynoecial compitum at stigma level. (F) Secretory portion of the extragynoecial compitum composed exclusively of epidermis. Abbreviations: EC, extragynoecial compitum; FT, filament tube; S, stigma; SC, stigmatic chamber; St, stamen; arrow, epidermis of the extragynoecial compitum

The brood cells of oil-collecting species are generally hard and resistant due to the mixture of oil with sand or agglutinated soil, acting as a type of cement or alloy between the particles and forming an internal protective layer with a smooth and shiny appearance. This tough character is especially important, as already mentioned, for ground-nesting species [70,71].

The criteria to be included among the floral oil-producing families would be: to secrete lipids in areas located in the flowers and to be visited and pollinated by oil-gathering bees that seek this resource in the plant.

The plants that offer floral oils belong to eight botanical families (two *Monocots* and six *Eudicots*): Cucurbitaceae, Iridaceae, Krameriaceae, Malpighiaceae, Orchidaceae, Primulaceae, Scrophulariaceae and Solanaceae. After the circumscription of the Scrophulariaceae family, this number should be raised to nine, excluding Scrophulariaceae and including the families Calceolariaceae and Plantaginaceae [72,73].

6.3. Study 3

6.3.1. This list indicates all the species and subspecies of Melittidae present in Italy.

The species present in the Forum are indicated in orange and by clicking on the name you can access the relative pages. Those in black are not yet present on the Forum.

Species marked with? they are of dubious presence in Italy.

- Family Melittidae
- Subfamily Melittinae
- Genus *Macropis* Panzer, 1809.
- *Macropis (Macropis) europaea* Warncke, 1973 (Figure 84).

Source: https://en.wikipedia.org/wiki/Macropis_europaea

Figure 84 *Macropis (Macropis) europaea* Warncke, 1973

- *Macropis (Macropis) frivaldskyi* Mocsary, 1878.
- *Macropis (Macropis) fulvipes* (Fabricius, 1804).
- Genus *Melitta* Kirby, 1802.
- *Melitta (Cilissa) dimidiata Morawitz*, 1876.
- *Melitta (Cilissa) haemorrhoidalis* (Fabricius, 1775) (Figure 85).

Source: https://www.gbif.org/species/9796233

Figure 85 *Melitta (Cilissa) haemorrhoidalis* (Fabricius, 1775)

- *Melitta (Cilissa) tomentosa* Friese, 1900.
- *Melitta (Melitta) leporina* (Panzer, 1799).
- *Melitta (Melitta) nigricans* Alfken, 1905.
- *Melitta (Melitta) tricincta tricincta* Kirby, 1802.
- *Melitta (Melitta) tricincta meridionalis* Hedicke, 1933.

Subfamily Dasypodainae

- Genus *Dasypoda* Latreille, 1802.
- *Dasypoda altercator* (Harris, 1780) (Figure 86).

Source: https://ukrbin.com/show_image.php?imageid=90466

Figure 86 *Dasypoda altercator* (Harris, 1780)

- *Dasypoda argentata* Panzer, 1809.
- *Dasypoda aurata* Rudow, 1881.
- *Dasypoda braccata* Eversmann, 1852.
- *Dasypoda cingulata* Erichson, 1835 (Figure 87).

Source: Biodiversity Center (licensed under http://creativecommons.org/publicdomain/zero/1.0/) (Spain)

Figure 87 *Dasypoda cingulata* Erichson, 1835

- *Dasypoda pyriformis* Radoszkowski, 1887?
- *Dasypoda spinigera* Kohl, 1905?
- *Dasypoda visnaga* (Rossi, 1790) [74].

6.4. Study 4

6.4.1. This list indicates all the species and subspecies of Melittidae present in Romania.

The number of bee species recorded in the Romanian fauna over a period of 150 years is around 750 species. Due to Romania's position at the confluence between pannonic, continental, alpine, steppe and pontic (around the Black Sea) biogeographical regions fauna include species with various origins and distribution. Thus, the Romanian bee fauna must presumably be rich and diverse and the presence of more species cannot be excluded mostly from the south of the country.

Family Melittidae.

Genus *Melitta* Kirby, 1802 (Figure 88).

Source: https://en.wikipedia.org/wiki/Melitta_%28bee%29

Figure 88 *Melitta* Kirby, 1802

- *Melitta (Cilissa) half* Morawitz, 1876.
- *Melitta (Cilissa) hemorrhoidalis* (Fabricius, 1775) (Figure 89).

Source: https://commons.wikimedia.org/wiki/File:Melitta_haemorrhoidalis.jpg

Figure 89 *Melitta (Cilissa) hemorrhoidalis* (Fabricius, 1775)

- *Melitta (Melitta) hare* (Panzer, 1799).
- *Melitta (Cilissa) melanura* (Nylander, 1852).
- *Melitta (Melitta) nigricans* Alfken, 1905
- *Melitta (Melitta) tricincta* Kirby, 1802 (Figure 90).

Source: https://www.galerie-insecte.org/galerie/view.php?ref=237358

Figure 90 *Melitta (Melitta) nigricans* Alfken, 1905

Genus *Macropis* Panzer, 1809 (Figure 91).

Source: https://idfg.idaho.gov/species/taxa/1522647

Figure 91 Genus *Macropis* Panzer, 1809

Macropis europaea Warncke, 1973 (Figure 92).

Source: https://en.wikipedia.org/wiki/Macropis_europaea

Figure 92 *Macropis europaea* Warncke, 1973

Macropis fulvipes (Fabricius, 1805).

Macropis frivaldszkyi Mocsary, 1878.

Genus *Dasypoda* Latreille, 1802 (Figure 93).

Source: http://www.atlashymenoptera.net/page.aspx?id=195

Figure 93 *Dasypoda* Latreille, 1802

Dasypoda argentata Panzer, 1809.

Dasypoda hirtipes (Fabricius, 1793) (Figure 94).

Source: http://unmondedansmonjardin.free.fr/EN/pages_EN/dasypoda_hirtipes_EN.htm

Figure 94 *Dasypoda hirtipes* (Fabricius, 1793)

- *Dasypoda morawitzi* Radchenko 2016.
- *Dasypoda spinigera* Kohl, 1905.
- *Dasypoda suripes* (Christ, 1791) [75].

6.5. Study 5

6.5.1. Dasypoda altercator (Harris, 1780)

- Order: Hymenoptera
- Suborder: Apocrita
- Infraorder: Aculeata
- Super family: Apoidea
- Family: Melittidae
- Subfamily: Dasypodainae
- Tribe: Dasypodaini
- Genus: *Dasypoda*
- Species: *D. altercator* (Figure 95).

Source: https://war.wikipedia.org/wiki/Dasypoda_altercator

Figure 95 *Dasypoda altercator* (Harris, 1780)

Identification: *Dasypoda altercator* has 2 cubital cells, the first being larger than the second. The female has a yellow-brown hairy head and thorax with a darker area on the mesonotum. The abdomen is black and the lateral margins of the dorsal side of 2-4 tergites with dark hairiness. The tergites are finely lined posteriorly with pale hair. It is complete

or slightly interrupted on T3, and complete on T4. Tergite 5 has a black apical fringe. The nervulus is prefurcal (shifted towards the base of the wing with respect to the tip of the discal cell). The pollen brushes of the hind legs are highly developed.

The male is covered with long yellow and whitish-brown hairs, he is a little more shaggy and has longer and thinner legs.

Size: 13 to 15 mm.

Habitat: Open and sandy areas, especially continental dunes, roadsides and sand pits.

Geographical distribution: Throughout France.

Flight period: From July to September.

Habits: It nests in villages at the edge of sandy roads. The main gallery sinks 20 to 60 cm into the ground. It branches out and at the end of each branch is a spherical lodge.

Plants foraged: Exclusively Asteraceae, especially Hawkweed (*Hieracium*), Northern Hawkweed (*Picris hieracioides* L. (Asteracea) and wild chicory (*Cichorium intybus* L. (Asteraceae).

Similar species: For females

- *Dasypoda albimana* Pérez, 1905, has hairiness on outer surface of tibiae 3 at least partly brown and hairiness on tibiae 2 entirely white.
- *Dasypoda argentata* Panzer, 1809, has brown hairs on femurs 1 and 2, it forages more on Dipsacaceae. The hairy bands of its tergites are thicker.
- *Dasypoda cingulata* Erichson, 1835, has eyes tinged with blue, it forages rather Malvaceae.
- *Dasypoda maura* Pérez, 1896 and *Dasypoda dusmeti* Quilis, 1928, have either entirely black or entirely brown facial hair and the tergite 4 band is interrupted.
- *Dasypoda patinyi* Michez, 2002, with clearly bent antennal article 3.
- *Diasypoda pyrotrichia* Förster, 1855, has black facial hairiness, orange and transparent tegula, and no band of hairs on T4.
- *Dasypoda morotei* Quilis, 1928, has the hair band of T4 interrupted.
- *Dasypoda brevicornis* Pérez, 1895 and crassicornis have hairiness on the outer side of the tibiae 3 at least partly brown.
- *Dasypoda visnaga* (Rossi, 1790), has tibiae 1 with light brown to yellowish cuticle and the antennal flagellum is reddish.

The others have an inter or postural nervous or the apical white to brownish T5 fringe.

For both sexes: The genera *Melitta* Kirby ,1802, *Tetraloniell* Ashmead, 1899 and *Tetraloniella* Ashmead, 1900, have 3 cubital cells.

The genus *Eucera* Scopoli, 1770, has ulnar cell 1 smaller than ulnar cell 2 [76].

6.6. Study 6

6.6.1. We haven't seen a quarter of known bee species since the 1990s.

The 4.5-millimeter-long *Lasioglossum smeathmanellum* Kirby, 1802, bee belongs to the Halictidae family, also known as the sweat-drawn bee. Sightings of bees from the Halictidae family in the wild have declined dramatically in recent decades. Bees provide us with food. Many of the 20,000 species pollinate 85% of the world's food and fruit crops—from garlic and grapefruit to coffee and kale.

But, it seems, something is not right for these essential insects. A study recently published in the scientific journal One Earth reveals that, in recent decades, the number of bee species reported in the wild has decreased worldwide. The biggest reduction occurred between 2006 and 2015, with around 25% fewer species sighted — even as sightings by citizen scientists increased rapidly.

How Brazilian created 'killer bees' by accident and revolutionized beekeeping Sunflowers make bees defecate – a lot. Here's why it's good. Bees win Nature Photographer of the Year award Halicid Bees—also called sweat bees because they are attracted to our perspiration—pollinate important crops like alfalfa, sunflowers, and cherries. Sightings of these tiny, metallic-colored flyers have dropped by 17% since the 1990s, the study found. Bees from the rare Melittidae family, which pollinate blueberries, cranberries and orchids, declined by 41%. (All bee species in the world are divided into seven families).

Although lesser known, these wild bees complement the work of honey bees in organized hives. "Even though honeybees can be efficient pollinators of many crops, dependence on a single species is very risky," explains study lead Eduardo Zattara, a biologist at the Institute for Research on Biodiversity and the Environment in Bariloche, Argentina.

For example, during a disease outbreak in 2006, the United States lost about half of its honey bees. If there were only domesticated bees, "the loss of production would have been enormous", says Zattara. The study was based on an open-access website called the Global Biodiversity Information Facility, which contains records of bee sightings from museums, universities and ordinary citizens since the 1700s.

How Brazilian created 'killer bees' by accident and revolutionized beekeeping. Sunflowers make bees defecate – a lot. Here's why it's good. Insects contribute to atmospheric electricity, research finds Most studies on bee diversity focus on a specific area or species, which inspired this broad analysis. "There isn't a very precise and long-term sampling of bees for the whole world", clarifies Zattara. "We wanted to see if we could use these types of data to get a more global answer, and the answer was yes."

However, he cautions that the records supporting the study do not provide enough information to determine whether particular species have gone extinct. "What we can say is that wild bee populations are not exactly propagating."

The analysis shows a decline in sightings of the species on all continents except Australia, where there is a comparative paucity of data, says Zattara. There are no bees that inhabit Antarctica. During the second half of the last century, a global agricultural expansion led to habitat loss, while the widespread use of pesticides killed many plants on which bees fed. At the same time, rising temperatures have forced bee species to migrate from their native ranges or wiped them out outright.

Another cause of declines: When countries introduce non-native bees to pollinate certain crops, they can carry pathogens with them, "creating pandemics among the insects," says Zattara [77].

7. Conclusion

The analysis shows a decline in sightings of the species on all continents except Australia, where there is a comparative paucity of data. There are no bees that inhabit Antarctica. During the second half of the last century, a global agricultural expansion led to habitat loss, while the widespread use of pesticides killed many plants that bees fed on. At the same time, rising temperatures have forced bee species to migrate from their native ranges or eliminate them altogether. Regarding oils: Floral oil is about eight times richer in calories than nectar. He found that the oil present in and the oil mixed with the pollen in the larval food share most of the lipid components. In addition to being mixed with pollen, the oil is also used to coat the brood cells. suggested that the oil would be a kind of waterproofing of the cells, thus protecting the nests of species that nest in humid soil, a fact later verified

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