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(REVIEW ARTICLE)

Review of the biology, ecology, and taxonomy of the bees of the families Ctenoplectridae, Fideliidae, Oxaeidae, and Stenotritidae (Insecta: Hymenoptera)

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Abstract

The Ctenoplectridae are characterized by short tongues, modified scope, and large comb-like tibial spurs adapted to collect and carry a mixture of floral oils and pollen collect floral oil, pollen, and nectar from a few genera of the family Cucurbitaceae. However, three species are thought to be kleptoparasites. A family Fideliinae of bees that is diverse throughout the world. The bees belonging to this group have diversified nesting behavior, being able to build their babies in pre-existing cavities such as woods, rocks, and alone. Large, very rare, fast-flying, ground-nesting solitary bees. The Oxaeidae are restricted to the New World and there are several species in the Tropics. Apparently, all of its species are solitary. Bees have tegumentary exocrine glands in the abdomen, the tergal glands, distributed dorsally and the sternal glands ventrally. The Stenotritidae are large, densely hairy bees, that fly at high speed and make simple nests on the ground. They place masses of ovoid stores in the cells. These are arranged in rows and are covered with a waterproof secretion. The larvae do not spin cocoons. This work studies the biology, ecology, and taxonomy of the parasitoids of the families of bee Ctenoplectridae, Fideliidae, Oxaeidae, and Stenotritidae. 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, the University of São Paulo, Latin American Literature, and the University of Brasilia.

Keywords: Bioecology; Classification; Nomenclature; Search; Taxonomy

1. Introduction

Bees (suborder Apocrita, superfamily Apoidea) are considered the most diverse group among the Hymenoptera, and the number of species would be 20,000. Nonetheless, it is believed that this number can reach higher values several surveys of bees and their floral resources used were carried out in several regions of Brazil (Figure 1) [1,2,3].

Source: https://pt.wikipedia.org/wiki/Apoidea

Figure 1 Superfamily Apoidea

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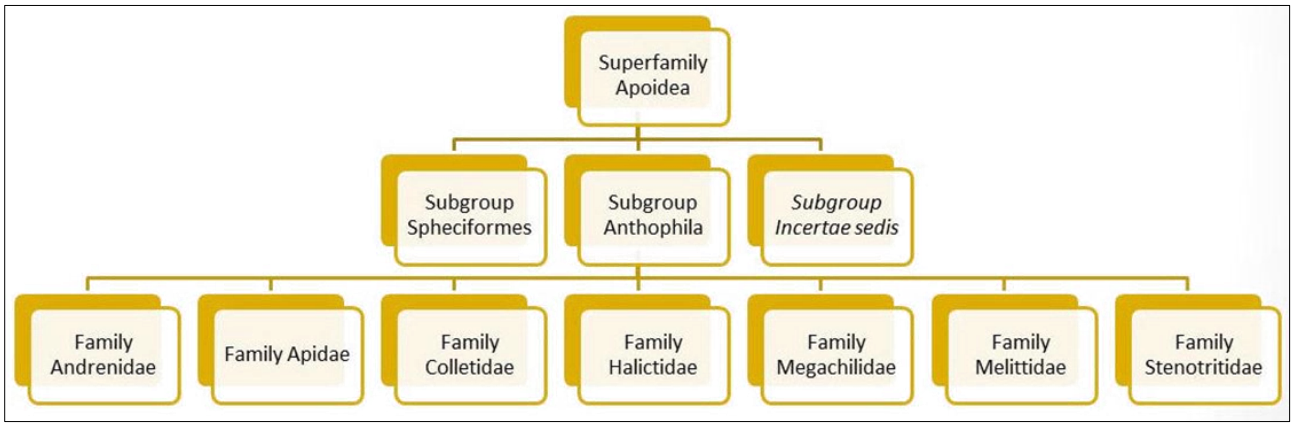
Bees are considered the main pollinators in different temperate and tropical ecosystems, being fundamental elements in plant-pollinator communities in the Cerrado. In the cerrado in the states of São Paulo, Mato Grosso, and Minas Gerais, about 75% of the plant species are pollinated exclusively, primarily, or secondarily by bees [4,5,6].

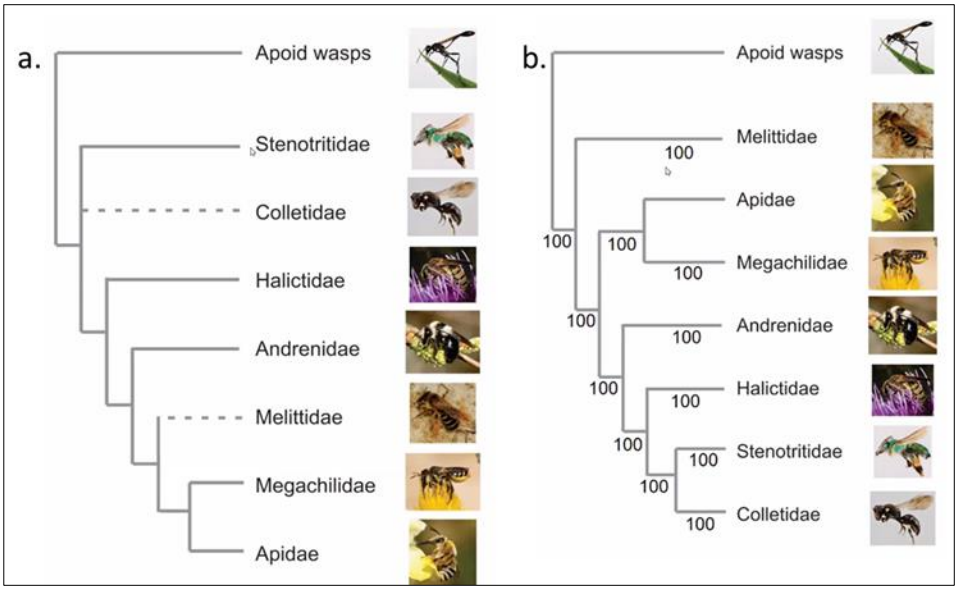
The causes of the decrease and/or extinction of Brazilian bee species are evident. The continuous and growing process of urbanization with the occupation of areas of vegetation natural for agriculture or livestock is accompanied by the destruction and devastation of nesting sites and sources of food (Figure 2) [7,8,9].



Source: https://beeswitheeb.com/2017/10/29/endless-bees-most-beautiful-and-most-wonderful/

Figure 2 Families of the superfamily Apoidea

This way, the monitoring of the species allows us to quantify the seasonal fluctuations in the frequencies of individuals, identify the key species, determine the preferences for habitats and/or floral resources, as well as, the way of organization of the communities (Figure 3) [10,11].



Source: https://entomology.umd.edu/news/seminar-blog-meet-the-bee-relatives-what-can-phylogenies-teach-us-about-bee-evolution-and-ecology

Figure 3 Phylogenetic relationships between seven families of bees based on (a) morphology (Alexander & Michener, 1995) and (b) molecular data (Branstetter et al., 2017)

Objective

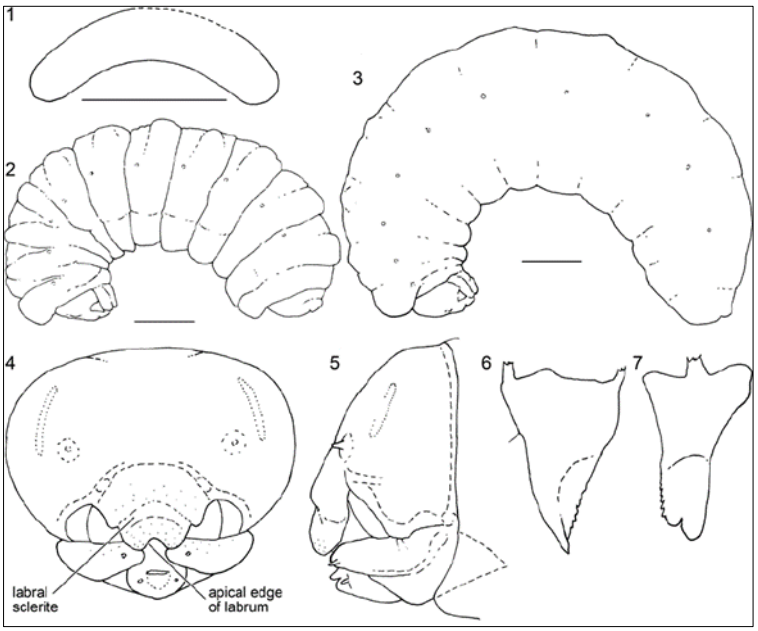
This work studies the biology, ecology and taxonomy of the parasitoids of the families of bee Ctenoplectridae, Fideliidae, Oxaeidae, and Stenotritidae.

2. 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, the University of São Paulo, Latin American Literature and the University of Brasilia. However, in principle, within these articles, there could not necessarily be a discussion focused on biology, ecology, and taxonomy**.**

2.1. Family Ctenoplectridae

The bee Ctenoplectridae with the two genera, *Ctenoplectra* Kirby, 1826 and *Ctenoplectrina* Cockerell, 1930, comprises 9 species in tropical Africa, 10 in Asia, and 1 in Australia (Figure 4) [12,13].



Source: https://www.researchgate.net/figure/Camera-lucida-diagram-of-egg-of-Ctenoplectra-cornuta-lateral-view-with-partial_fig1_232664161

Figure 4 Camera lucida diagram of the egg of *Ctenoplectra cornuta* sp. nov., lateral view, with partial reconstruction of midbody indicated by an interrupted line, anterior end to left. Figures 2–7. Last larval instars of *C. cornuta*. 2. Post-defecating larva, lateral view. 3. Predefecating larva, lateral view. 4, 5. Head of latter, frontal, and lateral views, respectively. 6, 7. Right mandible, dorsal, and inner views, respectively

The Ctenoplectridae are characterized by short tongues, modified scopae, and large comb-like tibial spurs adapted to collect and carry a mixture of floral oils, nectar, and pollen from a few genera of the family Cucurbitaceae. The unusual morphology has made it difficult to infer their closest relatives, in turn preventing an understanding of these bees' geographic and temporal origin and had led early authors to place them in their own family Ctenoplectridae. Recent molecular phylogenetic analyses find Ctenoplectrini to be monophyletic and closest to the long-horned bees, Eucerini [14,15,16].

However, three species are thought to be kleptoparasites. The presumably kleptoparasitic species form a clade *Ctenoplectrina* that is sister to the remaining genus *Ctenoplectra*, confirming the independent evolution of kleptoparasitism in this tribe [17].

Nests are known from few species only, which use existing small holes in wood and stone or old nests of other bees, which they provision with a mixture of pollen and floral oil, exclusively gathered from plants of a few genera of the family Cucurbitaceae [18,19].

2.2. Family Fideliidae

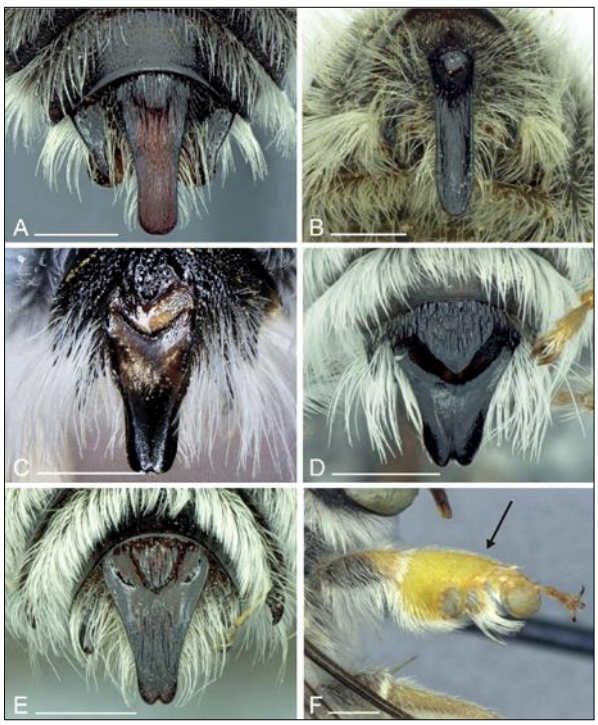
Family Fideliidae occurs in general in semi-arid regions of Asia, Africa, and South America. It is constituted by the general *Fidelia* Friese, 1899, *Parafidelia* Brauns (1926), *Neofidelia* Moure and Michene, 1955 and *Pararhophiris* Friese, 1898 (Figure 5) [20,21].

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

Figure 5 Subfamily Fideliinae

A subfamily Fideliinae of bees that is diverse throughout the world. The bees belonging to this group have diversified nesting behavior, being able to build their babies in pre-existing cavities such as woods, rocks, and alone. These bees can also use various materials in the construction of their children, such as petals, leaves, resin, soil particles, shells, and plant trichomes [20,21,22].

Members of *Fidelia* are robust bees, ranging in size from approximately 7.5 to 20.0 mm. Their pilosity may be white through yellow to orange, while the integument is mostly brown to black females have a metasomal scopa, as well as a brush of long dense hairs on their hind basitarsi. The female hind basitarsus itself is flattened and paddle-like and is used in nest excavation (Figure 6) [21,22,23].



Source: https://www.researchgate.net/figure/FideliaA-B-Fidelia-kobrowi-Brauns-1905-A-T7-B-Forebasitarsus-C-D-F-villosa_fig5_294109852

Figure 6 *Fidelia* A–B. *Fidelia kobrowi* Brauns, 1905. A. T7. B. Forebasitarsus. C–D. *Fidelia villosa* Brauns, 1902 authorship? C. T7. D. Forebasitarsus. E–F. *Fidelia paradoxa* Friese, 1899. E. T7. F. Forebasitarsus

Genus: *Fidelia*

Distribution: Botswana, Namibia and South Africa.

Some Species: *Fidelia fasciata* Whitehead & Eardley, 2003 (Namibia, South Africa), *Fidelia friesei* (Brauns, 1926) (Botswana, Namibia, South Africa), *Fidelia hessei* Whitehead & Eardley, 2003 (Namibia, South Africa), *Fidelia kobrowi* Brauns, 1905 (Namibia, South Africa) and *Fidelia major* Friese, 1911 (Namibia, South Africa).

Distribution: Botswana, Namibia and South Africa.

Biology: Nest in soil, often in aggregations. Burrows may be as long as 2 meters, usually constructed at an angle into the ground and are lined with plant material. These bees collect pollen from a variety of flowers commonly those in the families Asteraceae and Mesembryanthemaceae (Aizoaceae) [22,23,24].

2.3. Family Oxaeidae

Large, very rare, fast-flying, ground-nesting solitary bees. They are restricted to the New World and there are several species in the Tropics. Apparently, all of its species are solitary. It was considered for some time as a separate family but is undoubtedly just a highly modified lineage of Andrenidae. In their review of Oxaeinae (treated by them as Oxaeidae). A feature not shared by any other large bees. Their nests are deep burrows in the ground, and provisions are a soupy mixture of pollen and nectar in cells with a waxlike waterproof lining (Figure 7) [25,26,27].

Source: https://www.semanticscholar.org/paper/A-review-of-the-genera-and-subgenera-of-Oxaeinae-Engel/af467a1afaae636312e876fe11555f396e889c8c/figure/3

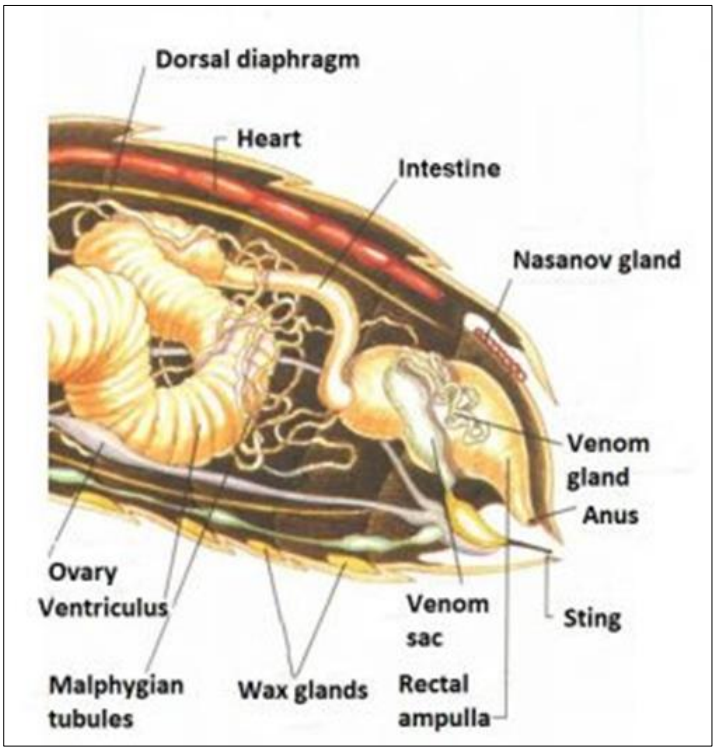
Figure 7 Photographs of *Protoxaea gloriosa (*Fox, 1893). 1. Dorsal habitus of females. 2. Lateral habitus of females. 3. Dorsal habitus of males. 4. Lateral habitus of males. 5. Facial view of male. 6. Facial view of female

The family can be distinguished from other Apoidea by a few characteristics: The structure of the antenna (short, elbowed, flagellum shorter than eye length), the position of the ocellus of males close to the antennal fossae, the strongly differentiated phase on the posterior ocellus, the venation of the wings, the compact, orange hairs, located basally on the ventral surface of the median femur, the apical modification of the posterior femur of the female and the structure of the genitalia of the male [27,28,29].

Endemic family of the western hemisphere, made up of bees moderately large, robust, and good fliers. The family, first ranked by Cockerell in 1933 and recognized by Rozen in 1965, includes 4 genera and about twenty species: *Oxaea* Klug 1807, tropical, with approximately 8 species, not reviewed; it is the only genus found in Colombia. *Notoxaea* Hurd & Linsley, 1976, located mainly in southern South America, with one species; *Protoxaea* CockereH and Porter, 1899, from the Nearctic, with 3 species; and *Mesoxaea* Hurd & Linsley 1976, from North and Central America, 5 species and the

males form groups to sleep. The only genus present in Colombia (*Oxaea*) is characterized by not having maxillary palps and a poorly differentiated gonostyle. They recognized 4 genera in the group, two of which are represented in Brazil: *Oxaea* and *Notoxaea* [28,29,30].

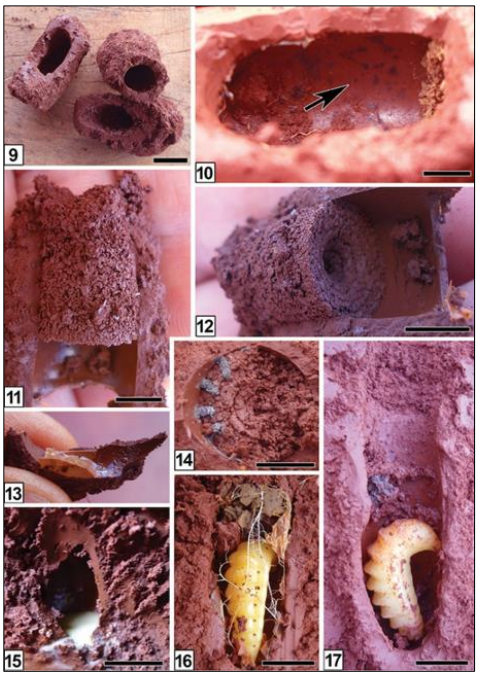
Bees have tegumentary exocrine glands in the abdomen, the tergal glands, distributed dorsally and the sternal glands ventrally. Most of these glands are made up of class III cells, probably producing pheromones that are important in processes such as communication, mating, defense and delimitation of territories of the species (Figure 8) [29,30,31].



Source: https://abejas.org/en/bees-internal-anatomy/

Figure 8 Internal anatomy of a bee: In the anterior part of the sternites of segments four to seven are located the wax glands —four pairs, one for each segment. In each sternite, there are two light-colored areas called "wax mirrors" that carry pores where the greasy secretion of the wax glands, located in the inner part of each sternite, comes out. The scales or plates of wax are carried by bees to their mouth with the second pair of legs. Then they use their jaws to knead and shape them to later build the combs

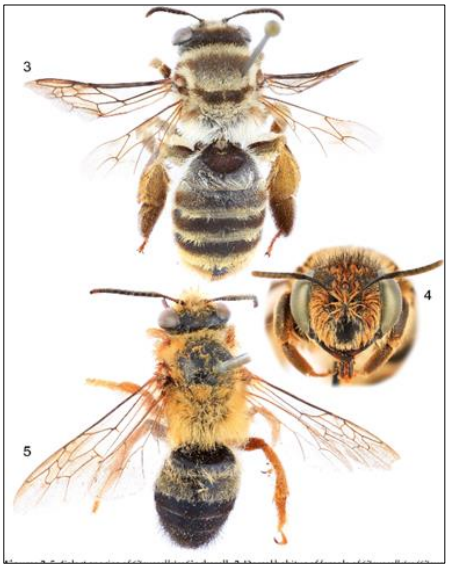
Oxaea flavescens (Klug, 1807) has highly developed glands of this type, located in sternites III, IV and V. In most species, class III glands do not have a reservoir and, in *O. flavescens*, the intersegmental membranes form branched invaginations, where the secretion is accumulated. These glands are particular because their secretion reacts positively to periodic acid-Schiff treatment and stains with bromophenol blue, which indicates a glycoprotein nature. The morphology and ultrastructure of these glands are reported. Their nests are deep tunnels excavated in the ground; their food, pollen and nectar are mixed and collected in cells covered with a waxy covering (Figure 9) [31,32].



Source: https://binary.pensoft.net/fig/32156/big

Figure 9 (9) Three individual *Oxaea austera* Gerstaecker, 1867, cells removed from the soil, 10 Black manganese mottles on the inner surface of the chamber (arrow), 11 Closed cells showing the antechamber filled with unconsolidated soil, 12 Internal views of a closed cell showing the spiral closure, 13 Cellophane-like lining, 14 Radial arrangement of fecal pellets in contact with the spiral closure, 15 Longitudinal section of a cell showing the semiliquid provisions, 16 Cell with a post-defecating larva, the mass of fecal pellets in the upper part and a mesh of rootlets originally developed between the lining and the soil wall, 17 Post-defecating larva inside another cell showing remains of the antechamber, spiral closure and fecal pellets

2.4. Family Stenotritidae



Source: https://www.semanticscholar.org/paper/Notes-on-the-classification-of-Ctenocolletes-Engel/ff837f436d0ebff517a6fb658ef3a0eeaf5aa937/figure/2

Figure 10 Select species of *Ctenocolletes* Cockerell, 1929. 3. Dorsal habitus of female of *Ctenocolletes (Ctenocolletes) rufescens* Houston, 1983. 4. Facial view of female *Ctenocolletes (Ctenocolletes) nicholsoni* (Cockerell, 1929). 5. Dorsal habitus of male of *Ctenocolletes (Ctenocolletes) ordensis* Michener, 1965

Stenotritidae (mining bees, very fast and very hairy) is, among all recognized bee families, the smallest existing, with only 21 species (species in 2 genera), so all of them are concentrated only in Australia in Brazil (2010). Previously, the Stenotritidae was just a subdivision belonging to the Colletidae family. However, now it already deserves the title of family, being considered only a "sister" family of the Colletidae family. It is important to consider that the bees of this family are large and that their larvae do not weave cocoons (Figure 10) [33,34,35].

Of primary importance is that they have unmodified mouthparts, while coletids differ from all other bees in having a bilobed tongue. They can be completely black, with yellow or metallic green bands. The ocelli are located very low on the face [35,36,37].

The Stenotritidae are large, densely hairy bees, that fly at high speed and make simple nests on the ground. They place masses of ovoid stores in the cells. These are arranged in rows and are covered with a waterproof secretion. The larvae do not spin cocoons. *Stenotritus pubescens* (Smith, 1868), feeds only on *Eucalyptus* L'Hér., (Myrtaceae) pollen, showing that they are specific in their choice of flowers. Fossil brood cells from the Pleistocene have been found on the Eyre Peninsula in South Australia [36,37,38].

3. Conclusion

The Superfamily Apoidea was revised in order to provide nomenclatural changes. Some subfamilies have been raised to the family level. The resulting classification forms the following families: Ctenoplectridae (a subfamily of Apidae), Fideliidae (a subfamily of Megacilidae), Oxaeidae (a subfamily of Andrenidae), and Stenotritidae (a subfamily of Colletidae).

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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