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Definition of mosquitoes (Thaumaleidae) and flies (Vermileonidae) (Nematocera and Brachycera) (Insecta: Diptera).

Carlos Henrique Marchiori[1]

1 Instituto Federal Goiano

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Co-authors: Marco Vinícios de Oliveira Santana[2] and Klebert de Paula Malheiros[3].

[2-3]Instituto Marco Santana, Goiânia, Goiás, Brazil.

Diptera are traditionally classified into two suborders, Nematocera and Brachycera, the first having long antennae (mosquitoes) and the second short antennae (flies). Remember that, in the English language, only mosquitoes are usually called "mosquitoes" (in English there are other terms such as "midges" and "gnats"). Although Brachycera is monophyletic, today it is known that Nematocera is paraphyletic, for this reason, many authors question their grouping. In this first part of the article, some other families of Nematocera will be approached, called by some "Conservative Diptera", with 13 families with aquatic and semi-aquatic representatives registered in Brazil. Brachycera will be discussed in the second article [1-3].

Culicomorpha is a clade widely accepted as monophyletic and is divided into two superfamilies: Culicoidea, which includes the families Culicidae, Dixidae, Corethrellidae, and Chaoboridae; and Chironomoidea, including the families Thaumaleidae, Simuliidae, Ceratopogonidae and Chironomidae. There are not many discordant hypotheses about the phylogenetic positioning of Culicomorpha within Diptera, with most studies converging on the hypothesis of monophyly of the Culicomorpha + Ptychopteromorpha clade. However, other hypotheses are suggested, such as Culicomorpha + Bibionomorpha s.l.); Culicomorpha + (Anisopodomorpha + Bibionomorpha) + Brachycera) (Krzeminski, 1992); Culicomorpha + (Psychodomorpha + Brachycera) or the family Thaumaleidae + Culicomorpha [1-3].

Family Thaumaleidae

Thaumaleidae is a small family of Nematocera with only 190 known species, closely related to Ceratopogonidae, Chironomidae, and Simuliidae. It is an essentially Holarctic family, with very few species found in the southern hemisphere. They are called in English "solitary midges", "seepage midges" or "madiculous midges". Its larvae resemble some Ceratopogonidae, mainly *Forcipomyia.* Thaumaleids or solitary mosquitoes are small, yellowish-brown to blackish dipterans, with a wingspan of 3 to 7.5 mm. The eyes are holistic in both sexes, the antennae are short and ridge-like, and the wings broad with all veins unbranched, with the second main vein slightly curved to strongly arched. (Figure 1) [1-4].

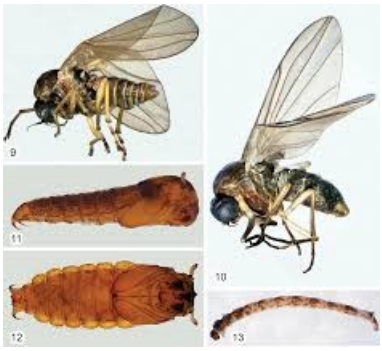

Figure 1. figs. 9–13. Vistas do habitus de adultos, pupas e larvas de Thaumaleidae. 9, Atlantic Neothaumalea Pivar & Pinho,2018, masculino; 10,Andrrosopa gillespieae Arnaud & Boussy, masculino; 11, N. atlantica 12, N. atlantica, pupa, vista ventral; 13, Andrrosopa sp., larva, vista lateral. Source: file:///C:/Users/USUARIO/Downloads/79929-Article%20Text-290776-318560-10-20221228%20(1).pdf.

Adults are recognized by the seven veins reaching the margin, the costa running around the entire margin, the absence of ocelli, and particularly by the short antennae no longer than the head [4-5].

They are tiny yellowish-colored mosquitoes whose larvae are quite specialized in living inhygropetric environments, inhabiting thin vertical liquid sheets along the walls of waterfalls, preferring cold climates. Wing venation of Thaumaleidae. However, unpaired prolegs, a ventrally directed truncate head, and prothoracic spiracles on a short respiratory tube differentiate them. They feed by grazing on diatoms. Little or no life history information is available (Figure 2) [5-7].

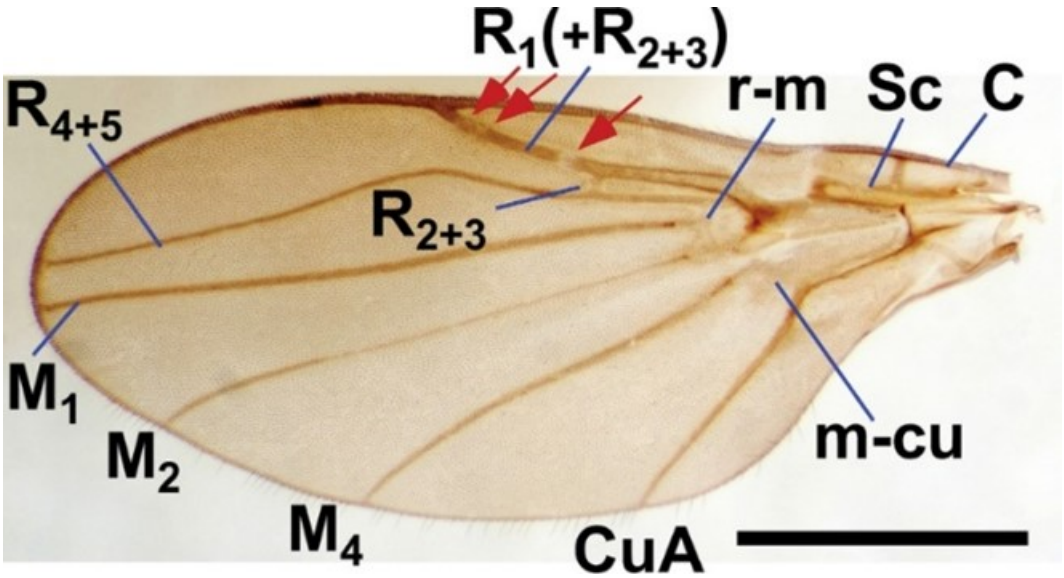

Figure 2. The left wing of *Niphta nudipennis* (Edwards, 1930) with arrows indicating three depigmented gaps. Abbreviations: C, costa; CuA, anterior branch of cubital vein; M, medial veins; m-cu, medial-cubital crossvein; R, radial veins; r-m, radial-medial crossvein; Sc, subcosta. Source: https://zookeys.pensoft.net/article/71180/.

Thaumaleidae are easily recognized by their ability to zigzag swiftly across the water's surface. They are distinguished by

their heads with downward-directed mouthparts (hypognathous) and the mottled greenish-brown pigmentation of the integument of the thorax and abdomen [7-10].

Larvae feed by scraping detritus and diatoms from the surface of stones but it is not known whether adults feed. They do not form mating groups in flight like other mosquitoes. Although the habitats exist, no Thaumaleids from Costa Rica have yet been reported. The closest known species is from Sonora, Mexico. Over 150 species in 8 genera are known from temperate regions on all continents except Antarctica. They are only known in South America from southern Chile and Argentina and a possible record from Ecuador (Figure 3) [10-12].

Figure 3. Thaumaleidae larvae showing segmentation. Sources: Image: Stephen Moore and https://www.landcareresearch.co.nz/assets/Tools-And-Resources/Identification/freshwater-invertebrates/thaulmaleidae_ew_08-115_30xmontage_b_650__ScaleWidthWzEwMjRd.jpg.

The larvae could be located in wet rocks and in the vertical area of the rocks where there is a sufficient film of water to submerge them. They can be collected by removing the rocks and throwing water on them so that they fall into a white container placed below. Adults can be collected from larval sites by blowing lightly on moist rock surfaces. The movement of the air causes the wings to rise, revealing their presence and they can be directly inhaled. They can also be collected by passing the net overhanging vegetation where they rest on branches and leaves [12-14].

Mature larvae and pupae can be reared on thin layers of filamentous algae obtained from wet rocks and placed in Petri dishes. A few drops of water should be applied to the algae to keep it under a thin layer of water. They must be placed in a warm place and periodically checked to keep the algae moist and in search of new pupae or adults (Figure 4) [15-17].

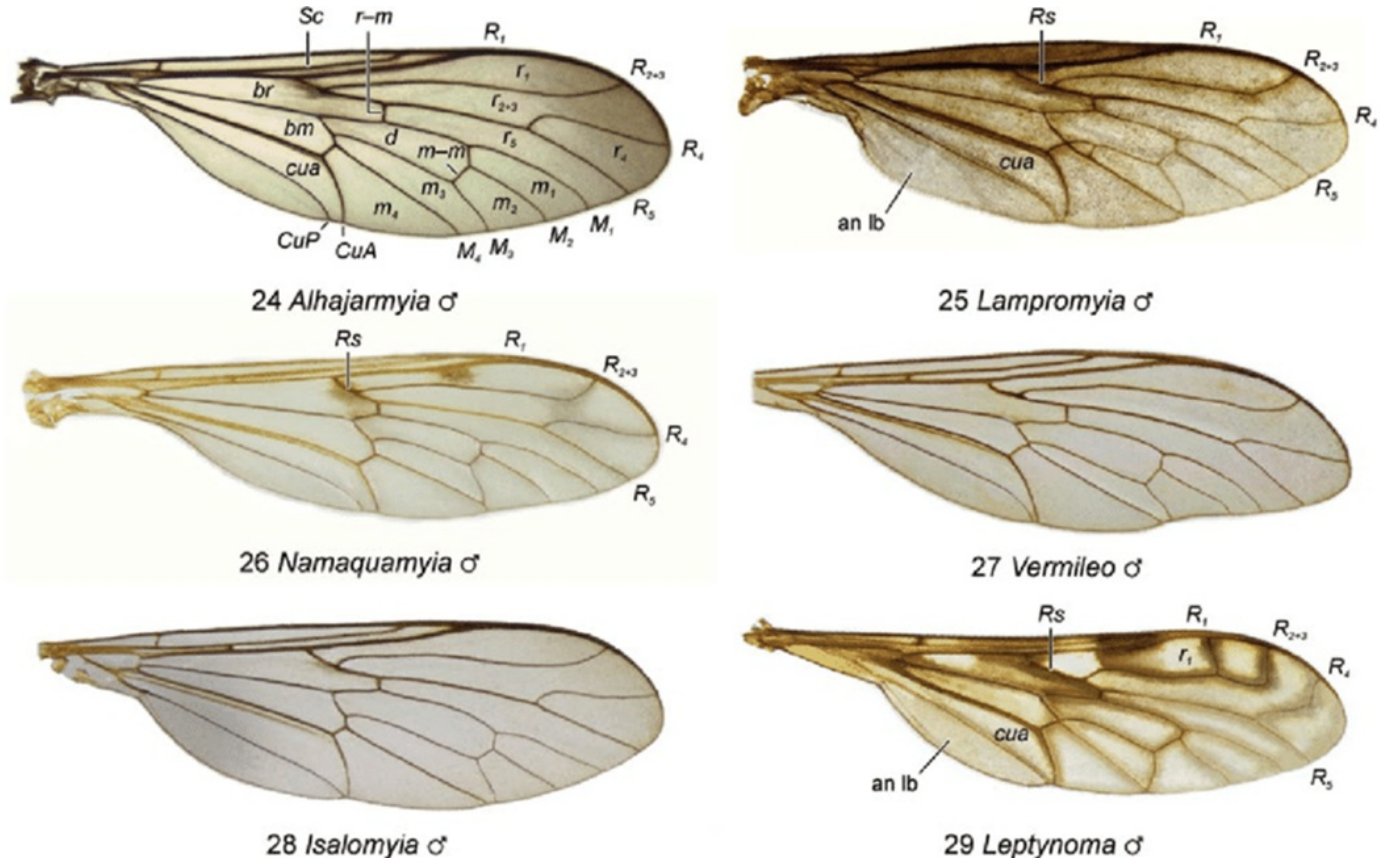

Figure 4. Habitus views of Thaumaleidae adults, pupae and larvae. (9),*Neothaumalea atlantica* Pivar & Pinho, 2018, male; (10), *Androprosopa gillespieae* Arnaud & Boussy, 1994, male; (11), *N. atlantica* pupa, lateral view; (12), *N. atlantica* Pivar & Pinho, pupa, ventral view; (13), *Androprosopa* sp., larva, lateral view. Source: https://www.researchgate.net/figure/figureS-9-13-Habitus-views-of-Thaumaleidae-adults-pupae-and-larva-9-Neothaumalea_fig2_366643958.

Thaumaleidae larvae are easily recognized by their ability to glide swiftly across the water's surface in a zigzag pattern. They are distinguished by their heads with downward-directed mouthparts (hypognathous) and the mottled greenish-brown pigmentation of the integument of the thorax and abdomen [18-19].

The larvae are amphipneustic with a pair of short respiratory tubes in the prothoracic segment and a transverse respiratory opening between a pair of finger-like processes in the eighth abdominal segment. The record of this family in Brazil is quite recent, with only one species found in 2018, *Neothaumalea atlantica* Pivar & Pinho, 2018, in waterfalls in Aparados da Serra Geral, SC, the place with the coldest climate in Brazil. There is a collection of a pupal exuvia probably of this genus also in MG [18-19].

Genus: *Afrothaumalea* Stuckenberg, 1960, *Androprosopa* gn. nov., *Austrothaumalea* Tonnoir, 1927, Niphta Theischinger, 1986, *Oterere* McLellan, 1988, *Thaumalea* gen. nov. and *Trichothaumalea* Edwards (1929) [18-19].

Distribution: Bulgaria, Czech Republic, France, Germany, Italy, Poland, Slovakia, Switzerland and Yugoslavia. Therefore, this species is now reported for the first time from Spain (and the Iberian Peninsula).

Thaumalea Ruthe, 1831.

It has data for 6 attributes including Body symmetry; Bilaterally symmetric: cellularity/; Multicellular: development mode; Holometabolous: Eating.

Eunotia Ehrenberg 1837.

feeding structure: sucking mouthparts.

Thaumalea pyrenaica Vaillant, 1968.

Thaumalea verralli Edwards, 1929 [20-23].

Family Vermileonidae

The infraorder Vermileonomorpha is often included within the Tabanomorpha, although more recent classifications place them as their sister taxon. Some classifications place Nemestrinoidea within Tabanomorpha, although this is not widely accepted. There are two currently recognized superfamily-level lineages in Tabanomorpha; the Tabanoidea and the Rhagionoidea (the latter comprising Austroleptidae, Bolbomyiidae, and Rhagionidae) [24-26].

Asyloidae flies are generally large, showy flower visitors as adults and almost exclusively predators that live in the substrate as larvae. Two of the largest families are significant exceptions to this rule: the larvae of Bombyliidae, or bee flies, are insect parasitoids, and Asilidae, also known as robber flies, attack insects as adults. Asyloid flies are distributed throughout the world, with their greatest diversity occurring in arid and sandy areas [Asyloid flies are generally large, showy flower visitors as adults and almost exclusively predators that live in the substrate as larvae. Two of the largest families are significant exceptions to this rule: the larvae of Bombyliidae, or bee flies, are insect parasitoids, and Asilidae, also known as robber flies, attack insects as adults. Asyloid flies are distributed throughout the world, with their greatest diversity occurring in arid and sandy areas [26-28].

The family Vermileonidae is a small family of uncertain affinities and unusual biology. It includes less than 80 described species, most of them rare and with restricted distribution, in 10 genera. The Vermileonidae family belongs to the Brachycera suborder. It is the only member of the infraorder Vermileonomorpha. It is a small family with no well-established taxonomy. It was considered a subfamily of Rhagionidae (Vermileoninae) (Figure 5) [27-29].

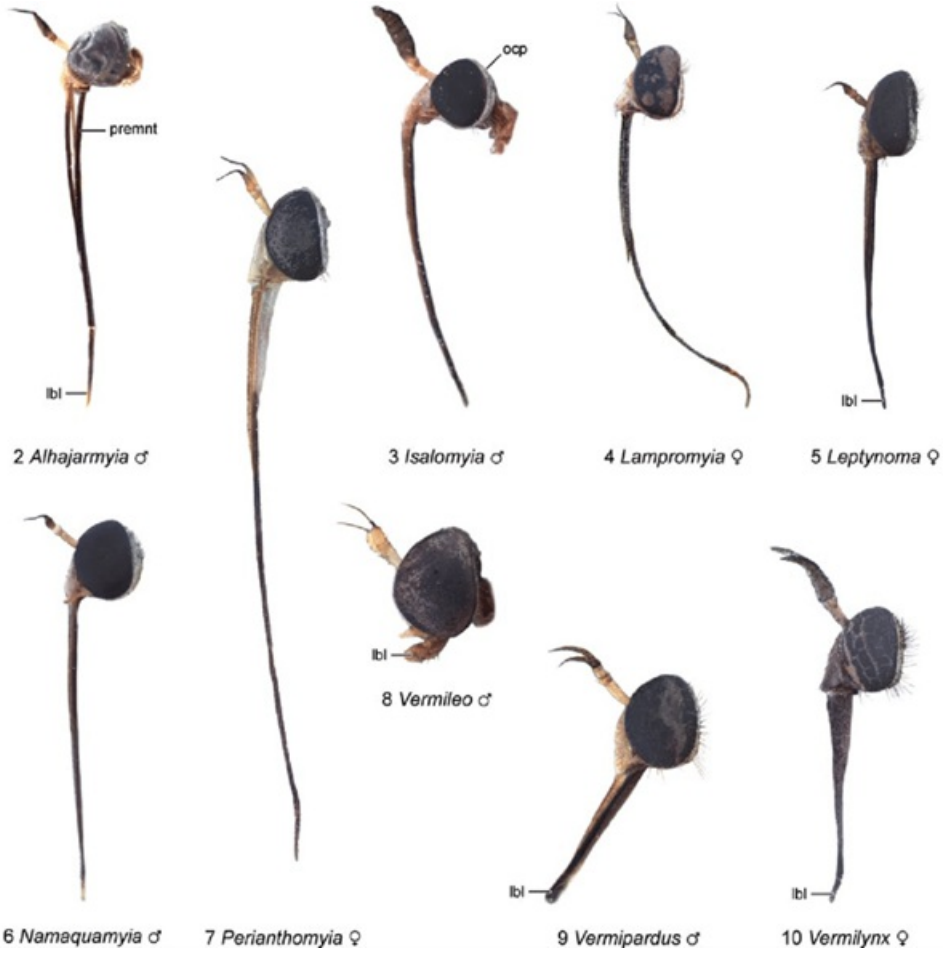

Figure 5. *Vermileo vermileo* (Linnaeus, 1758) and *Leptynoma* sp. (Vermilionidae) on *Lapeirousia Lapeirousia corymbosa* (L.) Ker Gawl. (Iridaceae). Sources: Photo Hamish Robertson © and Photo 1962095, (c) Jorge Almeida, some rights reserved (CC BY-NC-ND) and https://www.biodiversity4all.org/photos/1962095.

Its biology and morphology are so different from Rhagionidae sensu stricto that today it is accepted to place it in another family. It is sometimes placed within the infraorder Tabanomorpha, although the most recent classifications recent ones consider it a sister taxon. Most species are found in the arid regions of western Africa and southern Europe [30-31].

Vermileonidae larvae are voracious predators. To obtain their food they use the same method as that of some species of Neuroptera of the Myrmeleontidae family, the so-called ant lions. They dig a funnel-shaped hole in sandy soil, bury themselves at the bottom, and wait for an insect to fall into the trap. The tenth and eleventh segments of the larva have transverse rows of hooks that they use to anchor themselves in loose sand. The fifth segment has a ventral pseudopod that is used to catch prey (Figure 6) [32-34].

Figure 6. figs. 24-29. Wings of Vermileonidae (dorsal views): (24)*Alhajarmyia stuckenbergi* Swart, Kirk-Spriggs & Copeland sp. nov. ♂; (25) *Lampromyia flavida* Engel & Cuthbertson, 1937 ♂; (26) *Namaquamyia manselli* (Stuckenberg, 2000) ♂; (27) *Vermileo vermileo* (L., 1758) ♂ (non-Afrotropical); (28) *Isalomyia irwini* Stuckenberg, 2002 ♂; (29) *Leptynoma amanuensis* (Stuckenberg sp. nov.) ♂. Abbreviations: an lb -anal lobe; bm -basal medial cell; br -basal radial cell; CuA -anterior branch of cubital vein; cua -anterior cubital cell; CuP -posterior branch of cubital vein; d -discal cell; M 1 -first branch of media; m 1 -first medial cell; M 2 -second branch of media; m 2 -second medial cell; M 3 -third branch of media; m 3 -third medial cell; M 4 -fourth branch of media; m 4 -fourth medial cell; m-m -medial crossvein; R 1 -anterior branch of radius; r 1 -first radial cell; r 2+3 -second + third radial cell; R 2+3 -second branch of radius; r 4 -fourth radial cell; R 4 -upper branch of third branch of radius; r 5 -fifth radial cell; R 5 -lower branch of third branch of radius; r-m -radial-medial crossvein; Sc -subcostal vein; Rs -radial sector. Source: https://www.researchgate.net/figure/29-Wings-of-Vermileonidae-dorsal-views-24-Alhajarmyia-stuckenbergi-Swart_fig3_357975553

Members of this family Vermileonidae are notable for the way their larvae feed. Like ant lion larvae (Myrmeleontidae), vermileonid larvae build conical traps in the ground and wait for prey (an ant) to fall into them and then devour them. This is the only family of flies in which this phenomenon occurs. For their part, adults feed on nectar (Figure 7) [35-37].

Figure 7. Heads of Vermileonidae (lateral views): (2) *Alhajarmyia stuckenbergi* Swart, Kirk-Spriggs & Copeland sp. nov. ♂; (3) *Isalomyia irwini* Stuckenberg, 2002 ♂; (4) *Lampromyia rebecca* Stuckenberg, 1996 ♀; (5) *Leptynoma namaquaensis* (Stuckenberg, 1960) ♀; (6) *Namaquamyia manselli* (Stuckenberg, 2000) ♂; (7) *Perianthomyia monticola* (Stuckenberg, 2000) ♀; (8 *Vermileo vermileo* (L., 1758) ♂ (non-Afrotropical); (9) *Vermipardus intermedius* (Stuckenberg,

1955) ♂; (10) *Vermilynx vansoni* (Stuckenberg, 1955) ♀. Figs 2-10. Sources: Photographs B.S. Muller and https://www.researchgate.net/figure/10-Heads-of-Vermileonidae-lateral-views-2-Alhajarmyia-stuckenbergi-Swart_fig2_357975553.

The target taxonomic group is the infraorder Tabanomorpha, which traditionally includes the families Rhagionidae, Athericidae, Tabanidae, Vermileonidae, and Oreoleptidae. The positioning of Pelecorhynchus Macquart and Austroleptis Hardy among the Tabanomorpha is controversial, as is the status of the Vermileonidae and the Xylophagomorpha. Here, some of the main biogeographic methods that use phylogenies in a study of the biogeographic evolution of Tabanomorpha are critically analyzed. This implies carrying out a phylogenetic analysis of the Tabanomorpha and using this database in a biogeographic analysis [38-39].

Genus: *Alhajarmyia* Stuckenberg, 2003, *Isalomyia* Stuckenberg, 2002, *Lampromyia* Macquart, 1835, *Leptynoma* Westwood, 1876, *Namaquamyia* Stuckenberg, 2002, *Vermileo* Macquart, 1834, *Vermilynx* Stuckenberg, 1995, *Vermiophis* Yang, 1979, *Vermipardus* Stuckenberg, 1960 and Vermitigris Wheeler, 1830 [40-41].

The vermileonids are a family of medium-sized Diptera (5-20 mm) with a thin body and long legs. The larvae are very easy to find and recognize since they look healthy and make funnel-shaped traps in sandy soils dry and dry, just like the antlions (Planipennia).

In the Iberian Peninsula (Spain), four species are known belonging to two genera:*Lampromyia* Macquart, 1835 and *Vermileo* Macquart, 1834. Two species have been captured belonging to both genders, which represent the first appointment of this family for Portugal.

Lampromyia funebris Dufour, 1850.

Vermileo nigriventris (Strobl, 1906) [42].

Taxa covered

Vermileo vermileo (Linnaeus, 1758) (worm lion)

Characteristics

Slender, medium-sized flies, 9-12 mm long, resembling beaked flies (family Rhagionidae). Wings without alula, legs long, abdomen slender and claviform.

Prevent

About forty species worldwide, mainly Mediterranean in Europe. Not in the Netherlands and Belgium.

Way of life

The larva lives terrestrially in a sandy, shaded place protected from direct rainfall and builds a pitfall trap at night. The captured insects are paralyzed with a poisonous bite and sucked dry. Like the antlion, the larva can prevent its prey from

escaping the trap by throwing sand at it. The larva does not dispose of its feces properly at the time of molting [43].

The Brachycera can be divided into three groups: the “lower” Brachycera represented by the infra orders Tabanomorpha, and Asilomorpha, which would correspond to the group of orthorraphic Brachycera (included in the present phase of the project and Muscomorpha-Aschiza (still pending inclusion in the Biotic base), as well as the Muscomorpha-Schizophora-Acalyptratae (still pending inclusion in the Biotic base) and the Muscomorpha-Schizophora-Calyptratae (still pending include in the Biotic base). However, this classification scheme can vary according to the authors in the same way that it has also changed throughout the classification history of the Diptera.

The infraorders, superfamilies, and families, according to the classification scheme of McAlpine et al., have been included in the Biotic database during the present stage of the project (Table 1) [44-45].

Table 1. List of taxa considered as Brachycera inferior, objective of part 2 of the taxonomic authority catalog project of the Order Diptera (Insecta) in Mexico.

Infraorder	Superfamily	Family	Presence in Mexico	No. Species in Mexico
		Therevidae	S!	52
		Scenopinidae	S!	16
		Vermileonidae	S!	02
		Asiloidea Mydidae	S!	48
Tabanomorpha	Asiloidea	Apioceridae	S!	22
		Asilidae	S!	471
		Therevidae	S!	52
		Scenopinidae	S!	16
		Vermileonidae	S!	02
Total				681

Source:http://www.conabio.gob.mx/institucion/proyectos/resultados/infES011.pdf

This paper presents the geographical distribution of Tabanomorpha, excluding the greatly diversified family Tabanidae.

1- *Alhajarmyia* Stuckenberg gen. nov. 1 species from the Afrotropical region (Oman, Western Hajar).

2- *Isalomyia* Stuckenberg gen. nov. 1 species from the Afrotropical region (Madagascar).

3- *Lampromyia*: 13 species – 9 species from Palearctic region: 3 from Canary Island, 2 from Spain, 1 from France, Spain, Algeria and Canary Island, 2 from Morocco, and 1 from northwest Africa (Morocco and Algeria); 4 species from Afrotropical region, 2 from South Africa 2 from Zimbabwe.

4- *Leptynoma* Westwood, 1876: 7 species – 1 species from the Palearctic region, from Namibia, Brandberg; 6 species from Afrotropical region, 4 from South Africa (Cape), and 2 from Namibian (Uguchab River and Luderitz District).

5- *Namaquamyia* Stuckenberg, 2002: 1 species from the Afrotropical region, from Sudan.

6- *Protovermileo* Hennig, 1967: 1 fossil species from the Palearctic region, from Baltic Amber (Eocene/Oligocene).

7- *Vermileo*: 10 species – 3 species from Palearctic region: 1 from Greece (Crete), 1 from southern France, and 1 from Spain and Portugal (Cercadilla & Los Molinos); 1 species from Afrotropical region, from Sudan; 3 species from Neotropic\al region: 1 from Mexico (Guerrero), 1 from Jamaica, and 1 from Cuba (Trinidad Mountains); 3 species from Nearctic region: 1 from California (Alta Meadow), 1 from California to New Mexico and Colorado, and 1 from Mexico.

8- *Vermilynx* Stuckenberg, 1995: 2 species from the Afrotropical region: 1 from South Africa (Namaqualand) and 1 from South Africa and Namibia.

9- *Vermiophis* Yang, 1979: 7 species from the Palearctic region, from China (Shaanix, Gansu, Beijing, Shandong, Hubei, and Tibet).

10- *Vermipardus* Stuckenberg, 1960: 13 species from the Afrotropical region, 12 from South Africa (Transvaal, Cape, and Natal), and 1 from Lesotho (Basutoland).

11- *Vermitigris* Wheeler, 1930: 4 species from the Oriental region: 2 from Indonesia (Sumatra and Borneo), 1 from India (Malayan Peninsula), and 1 from China (Guangxi) (Table 2) [45].

Table 2. The distribution of the Vermileonidae genera.

Genus	Palearctic	Nearctic	Oriental	Afrotropical	Australian	Neotropical
Alhajarmyia				1		
Isalomyia				1		
Lampromyia	9			4		
Leptynoma	1			6		
Namaquamyia				1		
Vermileo	2	3		1		4
Vermilynx				2		
Vermiophis	7			2		
Vermipardus				13		
Vermitigris				4		
Total	19	3	0	35		4

Source: file:///C:/Users/Lenovo/Downloads/25-274-2-PB.pdf

Small funnel-shaped holes form, protected from rain, in rocky cavities or near the walls of buildings. These holes are located in protected, dry places with fine sand. On a farm in Banyoles, Girona, the floor of the agricultural machinery warehouse was full of holes. Many elongated, whitish larvae were seen at the bottom of each funnel. When he touched them with the end of a straw, they twitched.

According to the 'Catalogue of Diptera of Spain, Portugal and Andorra (Insecta), the Iberian Peninsula has 4 species belonging to two genera, *Lampromya* and *Vermileo*. Vermileonids are patient hunters that build funnels of fine sand and steep walls where they sit at the bottom under a thin layer of sand waiting for what comes. The vibrations cause the Vermileonidae to attack the prey and bend its body trying to grab it, forming a pincer. The prey is tethered thanks to pseudopods at the end of the abdomen and in the buccal jaws. Once tied up, you already have your food.

The larvae buried themselves first and gradually built a funnel. The larvae were found in a rock wall cavity and several Vermileonidae funnels. The Vermileonidae is a family about which there is not much information available on the internet. Species in this family were previously found in the family Rhagionidae, but the biology of vermileonids has little to do with them. Females do not lay eggs just anywhere, as the larvae need very fine sand.

Human constructions offer many opportunities for vermileonids. A shed, a house wall that has a wide overhang, or a dry stone wall that borders a property or field are good for them. It is also possible to see images of a hole in a rocky wall. The geological formation of these mountains allowed the action of water to excavate long and abundant cavities. A large number of vermileonids find shelter in them (Figures 8-9) [46].

Figure 8. Pupae and adults of Vermileonidae. Sources: Pradera C and https://desinsectador.com/2019/08/21/apuntes-sobre-vermileonidos-diptera-vermileonidae/.

Figure 9. Vermileonidae larva tractor shed with floor full of vermileonid funnels. Sources: Pradera C and https://desinsectador.com/2019/08/21/apuntes-sobre-vermileonidos-diptera-vermileonidae/.

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