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# Family Gasteruptiidae (Insecta: Hymenoptera) as parasitoids of arthropods (Arthropoda: Insecta)

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## Abstract

The Gasteruptiidae are also hyperparasitic species. The "Parasitica" lay their eggs in other juvenile insects (eggs, larvae, or pupae) and the larvae hatch and develop feeding on the host. Many of these parasitoid wasps are used as biological control of agricultural pests. Larvae are predators/parasitoids and/or kleptoparasites. Their hosts are bees and wasps of the Colletidae, Megachilidae, Sphecidae, Apidae, Anthophoridae, and Vespidae families. When females oviposit their eggs on or nearby host larvae with the help of an ovipositor not present in males, they hatch into *Gasteruption*, Latreille, 1796, larvae which proceed to consume the host's larvae. The aim of this article was to describe the bionomy and classification of the family Gasteruptiidae (Insecta: Hymenoptera). Indexed articles, scientific book chapters, theses databases, university dissertations, national and international scientific articles, scientific journals, documents, and academic and scientific journals are available online ResearchGate, HAL SSRN, Scielo, and Qeios were used. The present work uses the reference of bibliographical research, understood as the act of inquiring and seeking information on a certain subject, through a survey carried out in national and foreign databases, with the objective of detecting what exists of consensus or controversy.

**Keywords:** Gasteruption; Hosts; Kleptoparasites; Larvae; Parasitoids

## 1. Introduction

Currently, due to the state of knowledge of the parasitoids, it is possible to identify, in general, the family of the host; when the identification level reaches the genus of this host there will be a fine tool to carry out biodiversity assessments with these groups. It has been demonstrated in several studies that parasitoid Hymenoptera are sensitive to ecological disturbances, especially caused by pesticides, in such a way that investigators can identify fluctuations in parasitoid populations before they occur in their victim populations. This sensitivity makes these Hymenoptera ideal candidates for conservation and biodiversity studies [1,2,3].

Parasitoids represent the richest group of species in the order Hymenoptera: they are common and abundant in all terrestrial ecosystems, they develop as parasitoids of many arthropods, especially insects, constituting an important element for controlling the populations of other insects due to their ability to respond to the density of their host populations and are widely used in biological control programs [2,3].

Evanioidea comprises three extant families, Aulacidae, Gasteruptiidae, and Evaniidae, and several fossil taxa of uncertain position. Some systematists have uncovered biological and molecular morphological evidence questioning the monophyly of Evanioidea, but no major formal changes at the taxonomic level [3,4,5].

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The Gasteruptiidae is one of the most distinct families among Apocrita wasps, with surprisingly little variation in appearance for a group that contains about 500 species in two subfamilies and with 6 genera worldwide (Figure 1) [5,6].

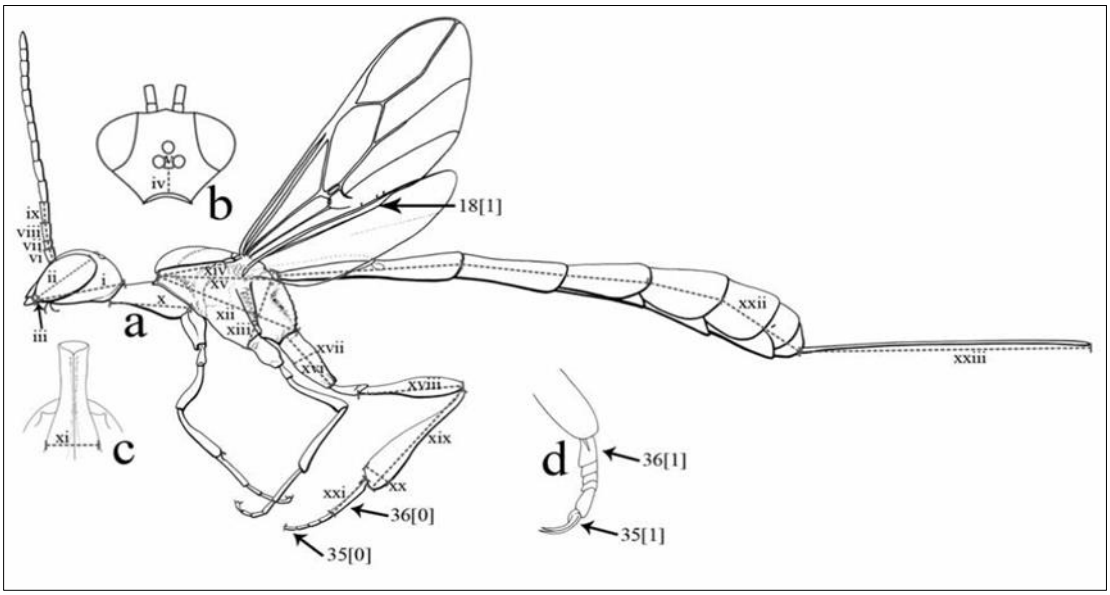

Source: https://entomologytoday.org/tag/gasteruptiidae/

**Figure 1** Specimen of Gasteruptiidae Family. The fat lower legs that dangle below flying wasps in the Gasteruptiidae family turn out to be filled with insect fat body, and they may play key roles in flight dynamics, detecting vibrations from prey, and even detoxification

### 1.1 Description

The absence of teeth on the crown of the head, and the somewhat thickened antennae, easily differentiate these wasps from those of the family Stephanidae, which also contains slender species with long necks Gasteruptiidae Ashmead, 1900 is a family with about 500 described species and occurs on all continents except Antarctica.

Its representatives are easily distinguishable from other Hymenoptera. by the metasoma dorsally inserted on the propodus, with its base almost touching the methanotum, elongated, neck-shaped propleura. These insects resemble ichneumonids but have short antennae and a costal cell on the forewings, and a thin neck. They have one or no submarginal cells and or no transverse vein (Figure 2) [4,5,6].




Source: https://www.mindat.org/paleoimg.php?id=87418

**Figure 2 a** lateral view; **b**: head in dorsal view; **c:** propleuron in ventral view; **d:** left hind tarsus: Head: i: head; ii: eye length; iii: malar space height; iv: distance between posterior ocellus and occipital margin; v: distance between posterior ocelli; vi: scape vii: pedicel; viii: first flagellomere ix: second flagellomere Mesosoma: x: propleuron; xi: propleuron width; xii: mesosoma length; xiii: mesosoma; xiv: pronotum; xv: distance between anterior margin of pronotum and metasoma insertion; xvi: hind coxa; xvii: hind coxa width; xviii: hind femur; xix: hind tibia; xx: hind tibia width; xxi: hind first tarsomere; Metasoma: xxii: metasoma length; xxiii: ovipositor sheath xxiv

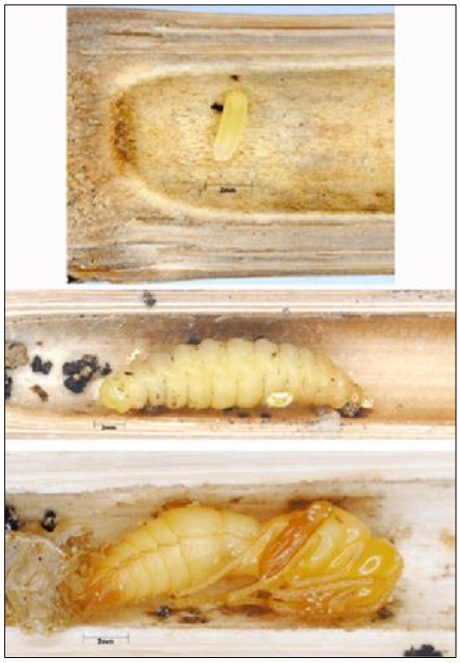
The "propleura" forms an elongated neck. The petiole is connected to the propodeum in an elevated position. The tibia of the hind legs has a mallet-shaped thickening. Females generally have a long ovipositor except in the genus *Pseudofoenus* Kieffer, 1902, with which they deposit their eggs in the nests of solitary bees and wasps, where their larvae parasitize these species.

Larvae are parasitic on wasps and solitary bees (such as bumblebees) and females are often found flying around the nest-building sites of these hosts. Gasteruptiidae is easily recognizable among other Hymenoptera:

- The presence of a long abdomen inserted very high on the propodeum.
- An elongated propleuron resembling a neck.
- The antennae with 14 segments in females and 13 segments in males, the eye relatively elongated, extending almost to the mandible, the claviform metatibia [7,8,9].

### 1.2 Biology

Family Gasteruptiidae is parasitoids of wasps and solitary bees. The female lays eggs on the larva or on the egg of the host. When this is consumed, the parasitoid starts to eat the food stored by the host's female inside the cell (Figure 3).



Source: Christophe Barthélémy C, Kung S, Kong H

**Figure 3** *Pararrhynchium* sp. Egg, mature larva and pupa

There are also hyperparasitic species. The “Parasitic” lay their eggs in other juvenile insects (eggs, larvae, and pupae) and the larvae hatch and develop feeding on the host. Many of these parasitoid wasps are used as biological control of agricultural pests [10,11,12].

### 1.3 Reproductive Behavior

Known hosts for Gasteruptiidae are solitary bees and wasps that build their nests in holes in the wood of trees or in holes in the ground. Host records include species from the Apidae families (Apinae, Colletinae, Megachilinae, Stenotritinae), Sphecidae**,** and Vespidae. Distribution and habitat: Palearctic element. Frequents the large *Ferula* L. (Apiaceae) in bloom.

Wasps in the family Gasteruptiidae are predatory inquilines that lay eggs within cells of solitary bees and wasps that nest on plant stems or in underground nests, with the resulting larvae feeding in larders and/or nest inhabitants. The oviduct in this female wasp is not used for boring into wood, as in some other wasps, but is used as a means of a remote placement device; the wasp introduces it into an existing nest or burrow **(**Figure 4A-4B) [13,14,15].


Source: https://www.flickr.com/photos/koolbee/12003905916,

**Figure 4 A** Patrolling. Figure **4B** Close-up. Figure **4C** Entering one bee nest to lay eggs. Figure **4D** Leaving another bee nest. Figure **4E** She got a surprise with this one and exited quickly when this bee objected

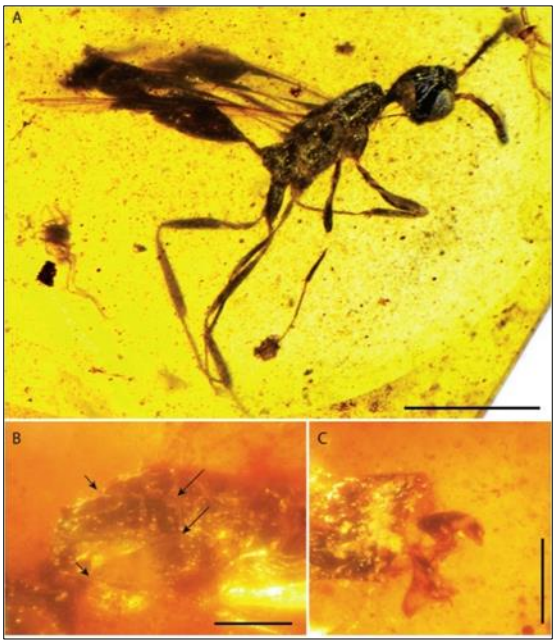
### 1.4 Biological Cycle

Females of different species lay eggs close to the egg, on the larva, on the food supply, on the cell wall, or outside the host cell. Gasteruptiidae larvae feed on the host egg or larva, then consume its food supply, and may pierce the adjacent cell and attack another larva. The 1st stage larva behaves like an endoparasitoid, sucking the contents of the host egg, while the larva in more developed stages behaves like a predator, consuming all the prey, of which only the encephalic capsule and the torn cuticle remain [15,16,17].

### 1.5 Classification

It includes three families, with approximately 1100 described species. Two of them are related to each other (Aulacidae and Gasteruptiidae), and the other (Evaniidae) is more distant. All three are represented in Europe, differing mainly in venation, gaster shape, and insect hosts. The three most important host groups are various wood-boring beetles, solitary wasps, bees, and egg packets of cockroaches.

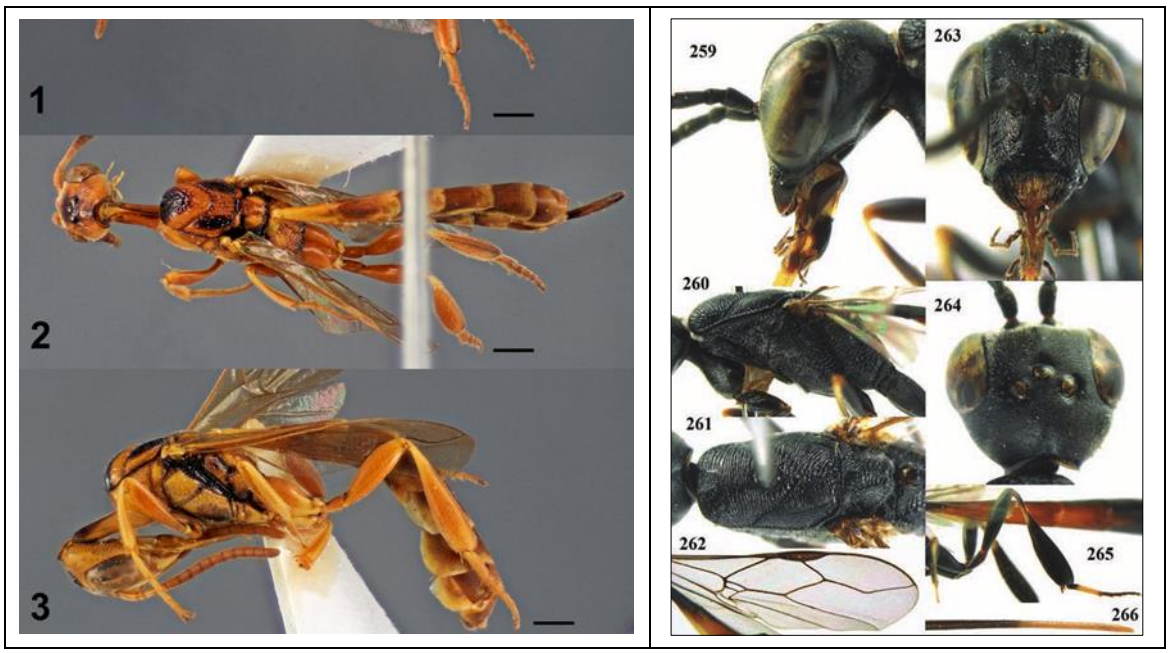
Within the “Parasitica”, Evanioidea is a small superfamily with medium-sized species, usually black, or black with a red gaster. The venation on the forewings is relatively complete, and all of them are recognizable by their dorsoventrally compressed ovipositor, and by the way, the gaster (metasome) is implanted near the top of the propodeum (mesosome) (Figure 5) [17,18,19].




Source: https://www.sciencedirect.com/science/article/abs/pii/S019566712100046X

**Figure 5** The Mid-Cretaceous amber from the Achin State of Myanmar provides some well-diversified fauna wasps. Here we describe a new genus and species, *Paleoaulacus minutus* gen. et sp. nov.

It contains about 500 species in two subfamilies Gasteruptiinae and Hyptiogastrinae, with 9 genera distributed worldwide. The smaller of the two subfamilies, Hyptiogastrinae, has a distribution restricted to Gondwana, with most species in Australia, 2 in New Zealand, 2 in South America, and 8 in the Southwest Pacific (New Britain, New Caledonia, New Guinea), Fiji and Vanuatu (Figures 6A-6B) [16,17,18].

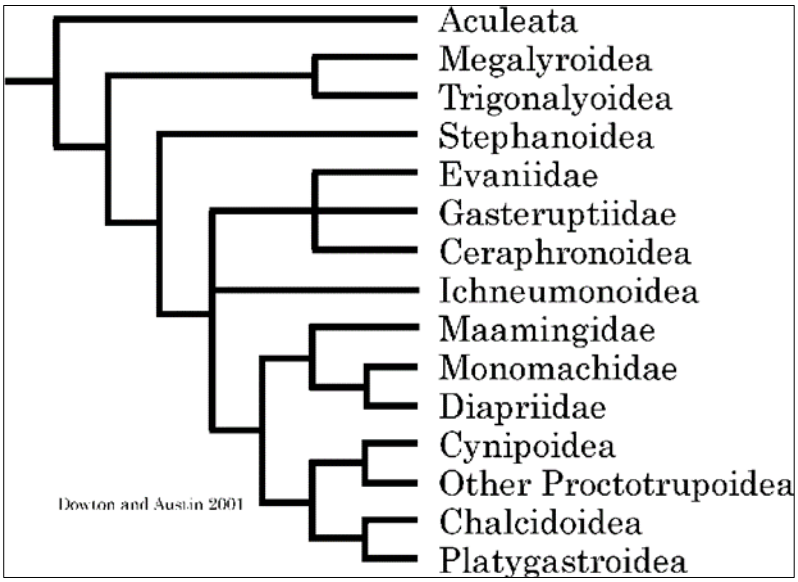



Source: https://www.sciencedirect.com/science/article/abs/pii/S019566712100046X and Source: https://www.researchgate.net/figure/Figures-259-266-Gasteruption-jaculator-Linnaeus-female-Netherlands-259-head-lateral_fig32_268870363

**Figure 6A** Subfamily Hyptiogastrinae 1, lateral habitus, holotype ♀. 2, dorsal habitus, holotype ♀. 3, lateral habitus, paratype ♂. 4, dorsal habitus, paratype ♂. **Figure 6B** Subfamily Gasteruptiinae (Linnaeus), female, Netherlands. 259 head lateral 260 mesosoma lateral 261 mesonotum dorsal 262 fore wing 263 head anterior 264 head dorsal 265 hind leg 266 apex of ovipositor sheath

### 1.6 Phylogeny

The most evident evidence suggesting that Evanioidea is not monophyletic is the difference between the hosts of the three families. Evaniidae oviposits in cockroach oothecae are buried in the substrate, lost in the litter, or even attached to female cockroaches. The Gasteruptiidae are "predator-tenants" that lay eggs inside the brood cells of solitary bees and wasps that nest in plant stems or underground nests, with the subsequent development of larvae where food is stored or in the nest inhabitants themselves. Aulacidae, considered by many experts to be the most ancestral of the three families, are endoparasites of Xyphidriidae, Cerambycidae, and Buprestidae. (Figure 7) [17,18,19].




Source:https://www.semanticscholar.org/paper/Phylogeny-and-Classification-of-Hymenoptera-Sharkey/9dca1eeac422818788b385b381e9fb17310dd478/figure/3

**Figure 7** Strict consensus tree of Apocrita taxa based on mitochondrial genes 16S rDNA and CO1, and nuclear genes 28S rDNA and 18S rDNA, simplified from Castro and Dowton (2006). Dashed lines indicate taxa that may be paraphyletic

Several experts hypothesize a rapid transition from parasitizing wood borer larvae to parasitizing nesting cells in plant stems, but not to parasitizing cockroach eggs (Gasteruptiidae and Aulacidae also share more synapomorphies with each other than with Evaniidae and have often been grouped together in a single-family (Gasteruptiidae) with evidence that species in several other distantly related lineages (Chalcidoidea, Cynipoidea, Ichneumonoidea) have developed dorsally articulated metasomas, has led people to question the monophyly of Evanioidea. Evanioidea shares two possible apomorphies (A) the dorsal articulation of the metasoma (B) the loss of all functional metasomal spiracles except the seventh segment.

*Objective*

Objective of this manuscript and report on family Gasteruptiidae insect parasitoids.

## 2. Method

The aim of this article was to describe the bionomy and classification of the family Gasteruptiidae (Insecta: Diptera). Indexed articles, scientific book chapters, theses databases, university dissertations, national and international scientific articles, scientific journals, documents and academic and scientific journals were available online ResearchGate, HAL SSRN, Scielo, and Qeios were used. The present work uses the reference of bibliographical research, understood as the act of inquiring and seeking information on a certain subject, through a survey carried out in national and foreign databases, with the objective of detecting what exists of consensus or controversy.

## 2.1 Studies conducted and selected

### *2.1.1 Study 1*

Considering that no specific studies related to these wasps have been carried out in Panama, this study seeks to contribute to their knowledge with a list of the species present in our country.

For its part, Gasteruptiidae records 4 species belonging to the genus *Gasteruption* Kieffer, 1904. These two families belonging to the Evanioidea superfamily are rarely collected in the field, so we suggest that more species could be found in Panama, considering their distributional ranges.

Distribution: Worldwide.

Biology: Parasitoids of solitary bees and wasps (Anthophoridae, Colletidae, Megachilidae, Sphecidae, and Vespidae (Masarinae).

- *Gasteruption bispinosum* Kieffer, 1904.

Distribution: Argentina, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, Guyana, Mexico, Panama, Paraguay, Peru, Suriname, Trinidad, Tobago, and Venezuela.

- *Gasteruption brasiliense* (Blanchard, 1840).

Distribution: Argentina, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, Guyana, Honduras, Mexico, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela.

- Right *Gasteruption* Macedo, 2011.

Distribution: Costa Rica and Panama.

- *Gasteruption sartor* Schletterer, 1890.

Distribution: Colombia, Costa Rica, Guatemala, Mexico, Panama, Peru, and Venezuela

*Gasteruption hastator* (Fabricius, 1804). The female lays an egg in a bee's nest tapeworms of the genus *Hylaeus,* Fabricius, 1793; the larva, when hatching, feeds on the egg/larva of the bee guest and the food reserves it had prepared [20].

### *2.1.2 Study 2*

- Hymenoptera
- Evanioidea
- Gasteruptiidae
- Gasteruptiinae

*Gasteruption*. Size/Size: ~1.2cm.

Areas with naturally adapted vegetation. Since the creation of cities, a lot of *Gasteruption* wasps migrated to the anthropic environment, where this one was found, as they need hosts to live and these have also migrated, mostly, to towns. Forest areas. Since the creation of cities, many *Gasteruption* wasps have migrated to the anthropic environment, where it was found, as they need hosts to live and these also migrated, to a large extent, to cities

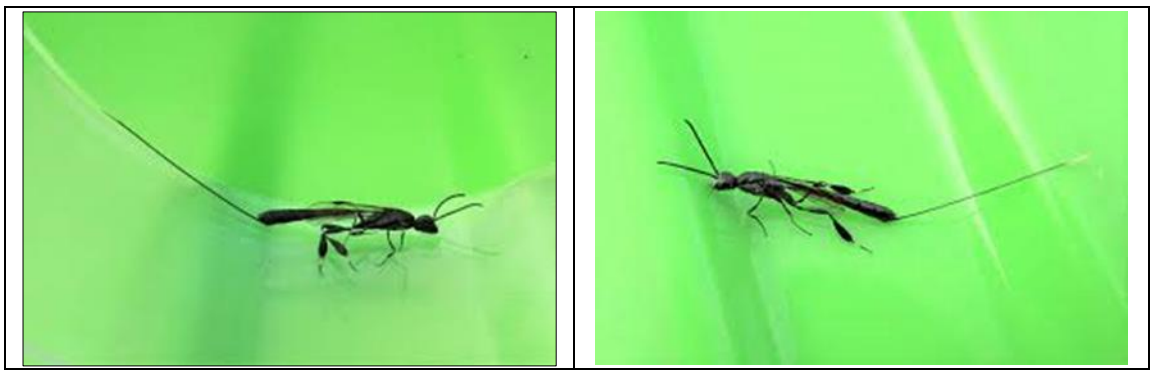
The genus *Gasteruption* has more than 500 described species and, surprisingly, most of them are very similar, making species-level identification difficult without knowledge of them or a specimen in hand. These wasps belong to the order Hymenoptera, superfamily Evanioidea, family Gasteruptiidae and subfamily Gasteruptiinae [21,22,23].

Larvae are predators/parasitoids and/or kleptoparasites. Their hosts are bees and wasps of the Colletidae, Megachilidae, Sphecidae, Apidae, Anthophoridae, and Vespidae families. When females oviposit their eggs on or nearby host larvae with the help of an ovipositor not present in males, they hatch into *Gasteruption* larvae which proceed to consume the host's larvae.

These insects resemble Ichneumonidae but have short antennae and a costal cell on the forewings, and a thin neck. They have one or no submarginal cells and or no transverse vein. They are usually dark with brown or orange markings. Adults are common and can be found on flowers.

When finished, *Gasteruption* larvae feed on the host's food store until the growth cycle is at an end, culminating in their emergence as adult wasps. This means that *Gasteruption* wasp larvae are predators/parasitoids of the above-mentioned bee and wasp families and/or kleptoparasites (meaning they feed on the host species of *Gasteruption* in the Neotropical zone so far.

Adults feed on the nectar of flowers, especially the flowers of Apiaceae. Their importance can be noted as pollinators and population controllers. In this case, the individual portrayed was found feeding on the nectar of the flower of *Euphorbia graminea* Jacq. (Euphorbiaceae) (Figure 8) [24,25,26].



Source: https://www.naturespot.org.uk/species/gasteruption-agg

**Figure 8** Genus *Gasteruption*, Latreille, 1796

*2.1.3 Study 3*

The objective of this work was to know the families of parasitoid Hymenoptera, which occur in native forests in the Environmental Protection Area of Córrego da Velha, in Luz, MG, Brazil.

The insects were collected in the Protection Area of the Córrego da Velha, located in the Municipality of Luz, MG, Brazil, during the period from August/2003 to March/2004. For the capture of insects, two traps from the Malaise type were mounted inside 2 Atlantic Forest fragments at 30 m from the edge.

The families Aulacidae 2(0.09%), Leucospidae 40(3,54%) and Gasteruptiidae 2(0.18%). considered infrequent in samplings were captured in this experiment. The Ichneumonidae and Encyrtidae were the families more frequent, while Aulacidae, Gasteruptiidae, Leucospidae, and Signiphoridae were the least abundant. With this study, the knowledge of the distribution of families of parasitoids to Brazil [27,28,29].

*2.1.4 Study 4*

This page contains pictures and information about the Gasteruptiidae wasps that we found in the Brisbane area, Queens and, Australia.

The objective of this study was to investigate families of parasitoids of the order Hymenoptera collected in nearby native forest areas, using Malaise traps and yellow basins, in Araporã, MG, and Itumbiara, GO.

Weekly collections were carried out with 10 yellow water traps, randomly distributed at ground level to sample areas of vegetation. Collection site, 3 Malaise traps were used.

A total of 16,124 specimens of parasitoids distributed in 8 superfamilies and 22 families were collected: Scolebythidae, Bethylidae, and Dryinidae (Bethyloidea), Braconidae and Ichneumonidae (Ichneumonoidea),

Evaniidae (Evanoidea), Figitidae (Cynipoidea), Diapriidae (Proctotrupoidea), Scelionidae and Platygastridae (Platygastroidea), Megaspilidae and Ceraphronidae (Ceraphranoidea), Chalcididae, Eurytomidae, Pteromalidae,

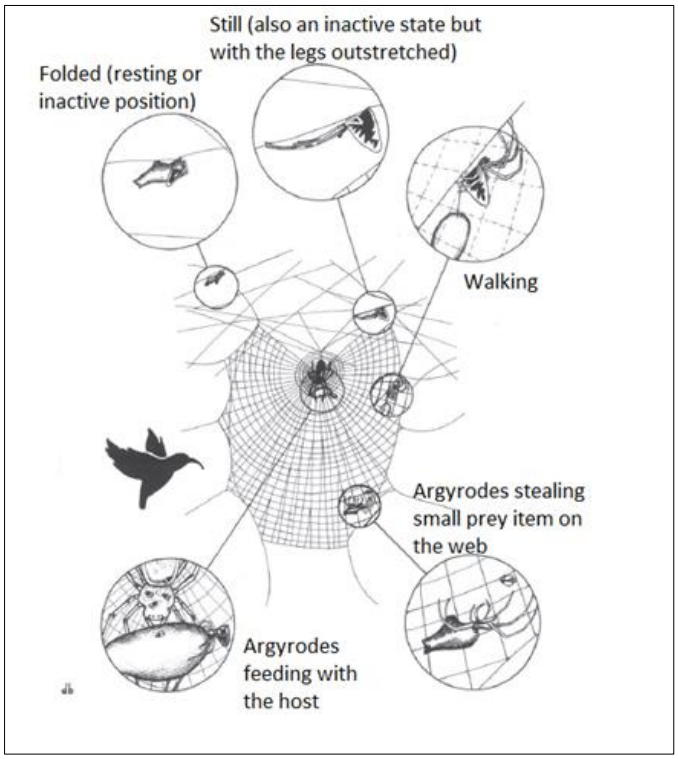
Agoanidae, Torymidae, Eucharitidae, Eupelmidae, Encyrtidae, Eulophidae and Mymaridae (Chalcidoidea), from February to October 2002, with 10,476 (65.0%) in the Malaise trap and 5,648 (35.0%) in the yellow basins.

A total of 9,747 specimens were collected in Araporã (60.5%) and 6,377 in Itumbiara (39.5%). The number of individuals obtained in Araporã was greater than in Itumbiara, although the collection methods have been the same. Factors such as quality and availability of resources, host density, size, and floristic composition of the sampled fragment can influence these results. The most abundant families were: Ichneumonidae, with 4,562 (28.3%), and Braconidae, with 2,532 (15.7%). Malaise traps and yellow bowls have been indicated for capturing insects of the orders Hymenoptera, Diptera, and Thysanoptera. Methodologies for capturing Hymenoptera are important "Parasitic" [30,31].

### *2.1.5 Study 5*

kleptoparasitism

Some interactions between different organisms can be characterized by opportunism, such as kleptoparasitism. Parasitism is defined as an interaction between a parasitic species that obtains resources through one or more host individuals, causing damage and causing harm to the host species. The term kleptoparasitism was introduced to describe the theft of food previously collected or processed by someone else.




Source: https://singapore.biodiversity.online/taxo4254/mainSpace/files/Edited%20diagram%20of%20kleptoparsitism%20in%20spiders.png

**Figure 9** The web of *Nephila claviples* L., 1767 (Araneae: Araneidae) provides food and a habitat for a large number of guests. The *Phaethornis longirostris* (Delattre, 1843) (Aves; Apodiformes; Trochilidae) visit briefly and takes small prey and silk. The *Argyodes elevatus* (Taczanowski, 1873) (Araneae: Theridiidae) is a permanent resident and highly trained and specialized that many share the host's meal or steal entire prey packets. Its congeneric *Argyodes caudatus* (Taczanowski, 1874) (Araneae: Theridiidae) is less specialized and takes mall insects from the capture area of the hosts' web. Mill child flies may use the host's cephalothorax as a platform to move on prey

This type of behavior is also called food parasitism, piracy, or stealing behavior, and is recognized as an important feeding strategy recorded in large groups such as marine invertebrates, insects and spiders (comprising the largest number of kleptoparasites ever identified), fish, reptiles, birds, and mammals, and may occur between individuals of the same species or different species.

Depending on the approach to obtaining access to food, kleptoparasitism can be considered aggressive, also called ostensive theft, where there is a use of force or threat to gain access to food. It can also be classified as a 'scramble' when

the resource obtained is exploited simultaneously by a predator and a kleptoparasite, with little or no violence between them.

- Intraspecific kleptoparasitism

Intraspecific interactions occur between individuals of the same species.

- interspecific kleptoparasitism

Interspecific interactions happen when the individuals involved in the interaction belong to different species, so in this case the parasite is of a different species than the victim. [32,33].

*2.1.6 Study 6*

- Family Gasteruptiidae Ashmead, 1900
- Subfamily Gasteruptiinae Ashmead, 1900
- Genus *Gasteruption* Latreille, 1796
- *Gasteruption jenningsi* sp. nov

**Distribution:** It is known only from its type locality, Ouinné.

*Gasteruption maquis* Jennings, Krogmann & Parslow, 2015.

**Distribution:** Species known only from New Caledonia, Grande Terre, Province Sud.

Subfamily Hyptiogastrinae Crosskey, 1953.

Genus *Pseudofoenus* Kieffer, 1902.

*Pseudofoenus caledonicus* Jennings & Austin, 2005.

**Distribution:** Species are known only from New Caledonia and Grande Terre [34,35,36].

## 3. Conclusion

Parasitoid Hymenoptera can be good bioindicators, due to the fact that they represent the diversity of their hosts, which in turn constitute a large part of the diversity of all arthropods. Therefore, when inventorying parasitoid Hymenoptera, a sample of the great diversity of arthropods is really being made. The larvae of Gasteruptiidae are predators/parasitoids and/or kleptoparasites. Their hosts are bees and wasps of the Colletidae, Megachilidae, Sphecidae, Apidae, Anthophoridae, and Vespidae families. When females oviposit their eggs on or nearby host larvae with the help of an ovipositor not present in males, they hatch into *Gasteruption* larvae which proceed to consume the host's larvae.

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