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Family Braconidae as a parasitoid of insect pests for the world fruit industry

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Abstract

The Braconidae Family are wasps mainly of parasitic habits. Members of the Mesostoinae are not parasitic but rather form galls on plants. In many species polyembryony occurs: an egg multiplies clonally producing many individuals. The larva develops on or inside the body of its host, mainly other insects with complete metamorphosis (holometabolous) and some with simple metamorphosis (hemimetabolous). The family has two major lineages: the cyclostomes and the non-cyclostomes, this condition is related to the shape of the clypeus. According to biology, two groups can be found: idiobionts and koinobionts (cenobionts). The aim of this study is to describe the phenology of the Braconidae Family (Hymenoptera: Braconidae). In its conceptual and taxonomic aspect. To this end, a bibliographic survey of Braconidae was carried out in the years 1989 to 2021. Only complete articles published in scientific journals and expanded abstracts presented at national and international scientific events. Data were also obtained from platforms such as: Academia.edu, Frontiers, Qeios, Pubmed, Biological Abstract, Publons, Dialnet, World, Wide Science, Springer, RefSeek, Microsoft Academic, Science and ERIC.

Keywords: Polydnaviruses; Mutualistic; Koinobiont; Cenobiont; Scielo

1. Introduction

The braconids (Braconidae) are a family of hymenoptera apocrites of the superfamily Ichneumonoidea. It is considered the second family of the order Hymenoptera in size. 17,000 species have been described; but it is estimated that between 30,000 and 50,000 remain to be described. Others believe that there are between 42,000 and 43,000 species. They are worldwide in distribution and are diverse in all areas. Adults of some species are known to feed on nectar, honeydew, or juice from damaged fruit; a few feed on other insects (Figures 1, 2 and 3) [1, 2].

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

Figure 1 Specimen of Braconidae

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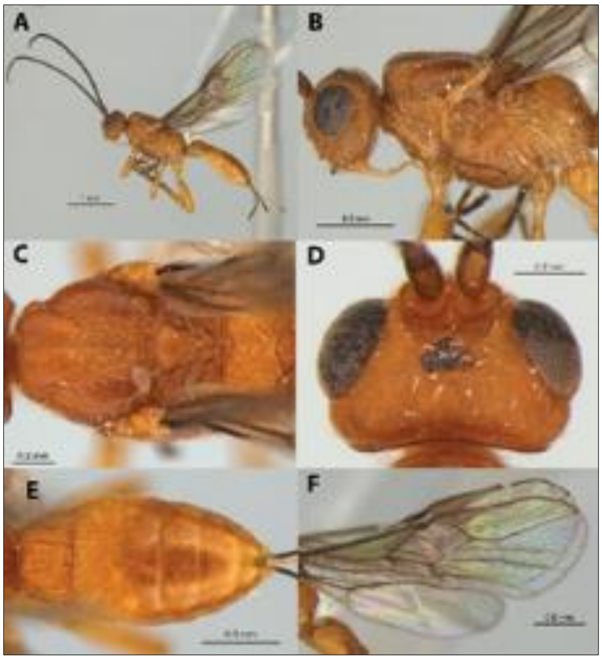
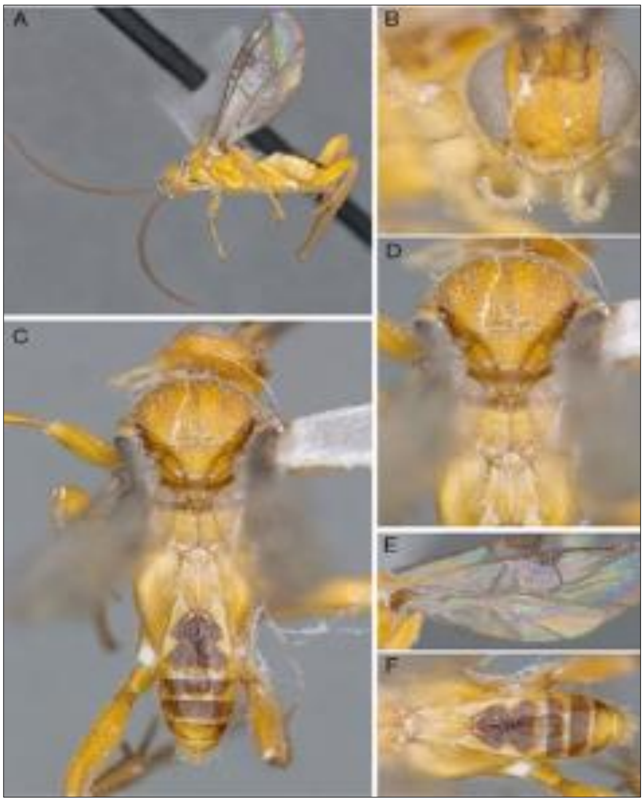


Source: https://jhr.pensoft.net/article/62345/

Figure 2 Female, holotype A habitus, lateral, view B head and mesosome, lateral view C head and metasoma, dorsal view D head, dorsal view E metasoma, dorsal view F wings

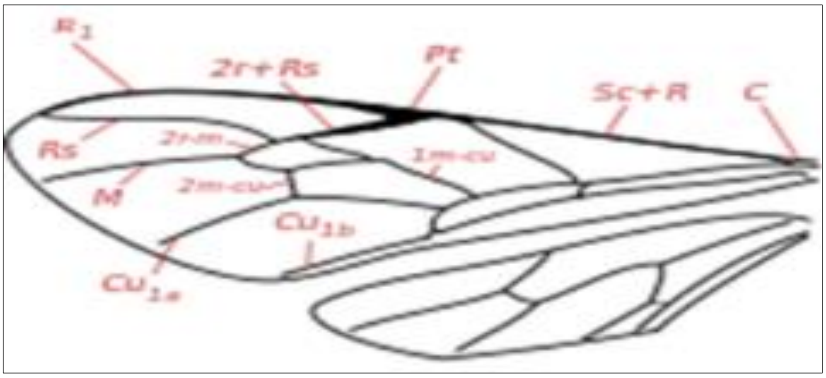


Source: https://www.researchgate.net/figure/A-Male-paratype-B-Head-frontal-view-C-Habitus-dorsal-view-D-Propodeum-and_fig7_325575724

Figure 3 Male paratype. (B) Head, frontal view. (C) Habitus, dorsal view. (D) Propodeum and metasomal tergite, dorsal view. (E) Fore wing. (F) Metasoma, dorsal view of *Diolcogaster flammeus* sp. nov. (Hymenoptera: Braconidae)

1.1. Morphology

This is a large and beneficial group of parasitic Hymenoptera. Adults are usually small and rarely measure more than 1.5 cm. They resemble ichneumonids in that they do not have a costal cell. They present marked morphological variations. Most are black-brown (sometimes with reddish markings), although some species have marked patterns and colorations as part of Müllerian mimicry complexes. The recurrent wing vein is absent or has only one, unlike members of the family Ichneumonidae, which generally have two. The antennae have 16 segments or more. The hindlimb trochanter has two segments (Figures 4, 5 and 6) [1, 2].



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

Figure 4 Braconidae wing morphology

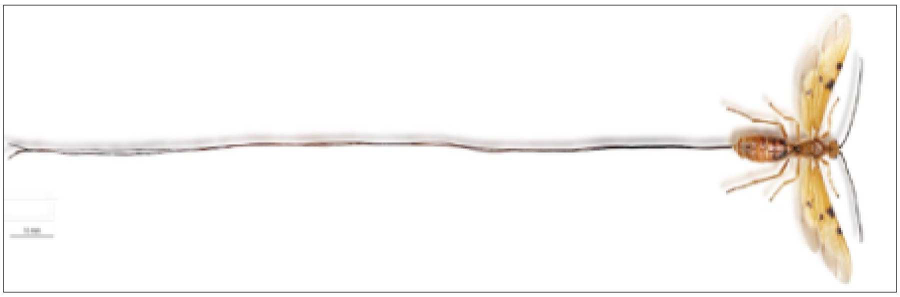
Source: https://www.researchgate.net/figure/Figures-9e12-Adults-of-Streblocera-spp-9-habitus-of-S-E-major-lateral-aspect_fig2_308495434

Figure 5 9, habitus of S. (E.) major \, lateral aspect; 10, antennae of S. (E.) major \, lateral aspect; 11, habitus of lateral aspect; 12, antennae and mesosoma \, lateral aspect

Source: http://mahn-84.blogspot.com/2016/05/braconidae-of-taiwan-extraordinary.html

Figure 6 Trochanter has two segments

Females have a long ovipositor, an organ that is usually characteristic of each species. This variation is related to the type of host. Species that parasitize certain Lepidoptera (Tortricidae, Pyralidae, Oecophoridae) have long ovipositors because the caterpillars generally hide behind thick layers of plant tissue. Other species have long ovipositors to avoid the spines or hairs of host larvae or to reach beetle larvae hidden within semi-rotten wood (Figures 7, 8 ,9A and 9B) [3].

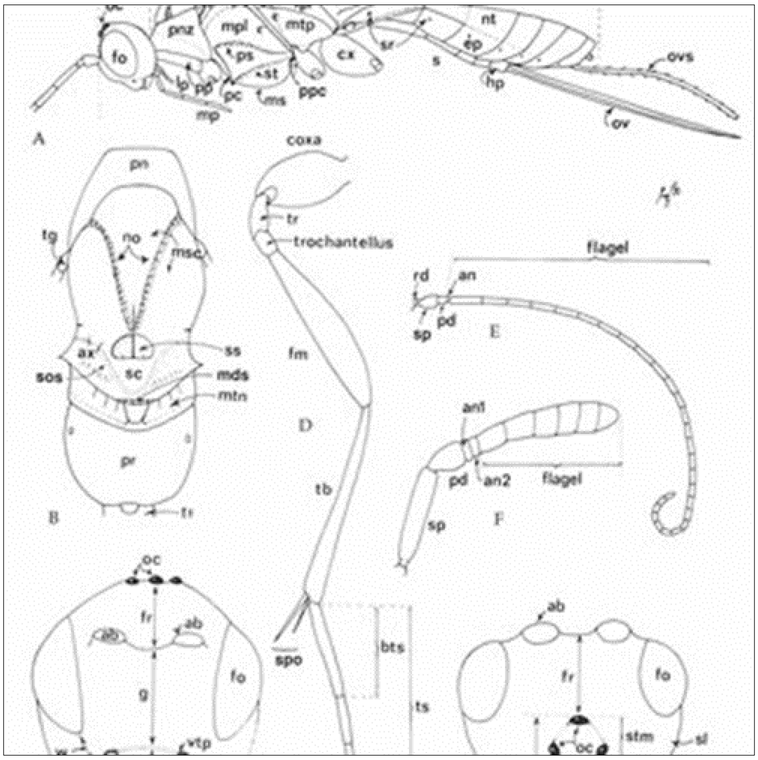


Source: http://mahn-84.blogspot.com/2016/05/braconidae-of-taiwan-extraordinary.html

Figure 7 Ovipositor of Braconidae

Source: https://commons.wikimedia.org/wiki/File:Wingless_braconid_ (Braconidae, _Heterospilus_sp.)_ (35789148151).jpg

Figure 8 Wingless braconid (Braconidae, *Heterospilus* sp.) USA, TX, Bastrop Co.: Smithville 12 K N of Smithville 30.095492°N 97.166755°W 144m Winkler sample



Source: https://www.researchgate.net/figure/Figs-A-G-morphology-of-Hymenoptera-A-body-lateral-aspect-B-mesosoma-dorsal-aspect_fig1_302989015

Figure 9A A, body, lateral aspect; B, mesosoma, dorsal aspect; C, head, frontal aspect; D, leg; E, F, antenna, Ichneumonoid and Chalcidoid type, respectively; G, head, dorsal aspect. Legenda: ab= base of antenna; an= anellus (1, 2= first and second, respectively); ar= arolium; asd= anterior subalar depression; ax= axilla; bts= basitarsus; c= clypeus; cl= tarsal claw; cx= coxa; ep= epipleuron (or latero-tergite); flagel= flagellum; fm= femur; fo=eye; fr= frons; g= face; hp= hypopygium

1.2. Parasitism

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

Figure 9B *Apanteles* cocoons under caterpillar. While the vast majority of braconids are in their larval form, particularly Coleoptera, Diptera, and Lepidoptera, but also some also called metamorphosis, is the mode of development of certain insects involving three distinct stages: egg, nymph, and adult stage) insects aphids, (Heteroptera, Embiidina). They are parasitoids

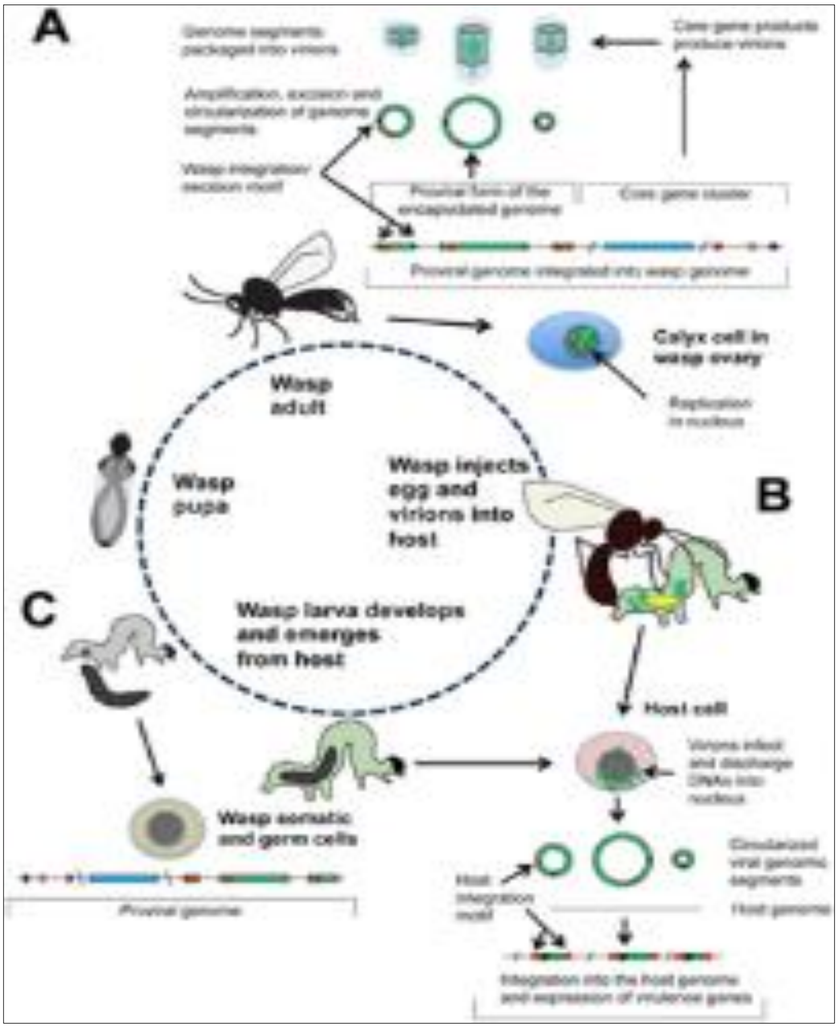
The Braconidae Family are wasps mainly of parasitic habits. Members of the Mesostoinae are not parasitic but rather form galls on plants. In many species polyembryony occurs: an egg multiplies clonally producing many individuals. The larva develops on or inside the body of its host, mainly other insects with complete metamorphosis (holometabolous) and some with simple metamorphosis (hemimetabolous). The family has two major lineages: the cyclostomes and the non-cyclostomes, this condition is related to the shape of the clypeus. According to biology, two groups can be found: idiobionts and koinobionts (cenobionts) (Figure 9C, 9D and 9E) [3, 4].

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

Figure 9C Empty cocoons of Microgastrinae

Source: https://megaarquivo.wordpress.com/tag/braconidae/

Figure 9D This wasp injects enough venom to paralyze, but not kill, a caterpillar. There, the wasp larvae are born and feed on the live caterpillar. But the parasite has a refinement of cruelty: along with the venom, it injects a species of virus that modifies the caterpillar's DNA, rendering its immune system incapable of destroying the larvae



Source: https://journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1002757

Figure 9E Virulence gene families in the encapsidated genomes of BVs. Polydnaviruses are unique mutualistic viruses associated with thousands of parasitoid wasps. They are characterized by a segmented packaged DNA genome and are necessary for parasitic success. Virus particles are produced in the wasp ovaries from a set of "viral" sequences integrated into the wasp genome. The polydnavirus/wasp associations as observed today result from the integration of a viral genomes into the wasp genome during evolution

1.3. Biology

They have a symbiotic relationship with polydnaviruses that they inject into their host, preventing the host from rejecting the parasitoid. Many species of this family have considerable use in controlling insects that represent pests. The classification of Braconidae is currently the subject of review. The gregarious forms of Macrocentrinae all appear to be polyembryonic. Cheloninae are parasites of eggs and larvae: the female lays on the host's egg and the parasite matures and emerges from the late-stage larva or pupa. Certain braconids even belong to Müllerian mimicry rings (Figure 10) [4, 5].

The Aphidiinae constitute a well-known group that is exclusively endoparasitic on nymphs and adults of aphids. Neoneurinae are endoparasites of worker ants. Blacinae attack Coleoptera larvae [4, 5].

Source: Pezzini C, Jahnke SM, Köhler A. Morphological characterization of immature stages of Habrobracon hebetor (Hymenoptera, Braconidae) ectoparasitoid of Ephestia kuehniella (Lepidoptera, Pyralidae). Journal of Hymenoptera Research. 2017; 60: 157-171

Figure 10 Immature stages of female (side view): A Prepupa B first pupal phase C second pupal phase D third pupal phase before adult emergence. Scale: 0.5 mm

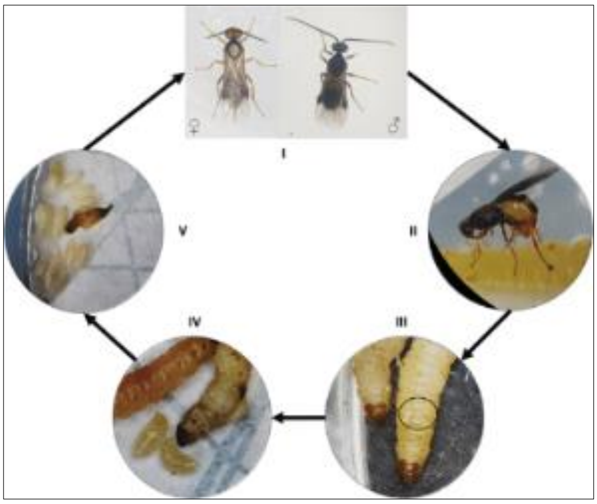
1.4. Diet

Most braconid wasps drink nectar as adults, with many showing a preference for nectar on flowers of the mustard and carrot families. As larvae, braconids consume their host organism. Certain subfamilies of braconid wasps specialize in particular groups of insect hosts. Some examples include:

- Aphidiinae – parasitoids of aphids
- Neoneurines - parasitoids of worker ants
- Microgastrins - caterpillar parasitoids
- Opiinae – parasitoids of flies
- Ichneutinae – parasitoids of sawflies and leaf-mining caterpillars [5].

1.5. Life cycle

Like all members of the order Hymenoptera, braconid wasps undergo complete metamorphosis with four life stages: egg, larva, pupa, and adult. The adult female usually oviposits in or on the host organism, and the braconid wasp larva emerges ready to feed on the host. In some braconid species, such as those that attack hornworm caterpillars, the larvae spin their cocoons in a group on the body of the insect host (Figures 11 and 12) [5, 6].



Source: https://www.sciencedirect.com/science/article/abs/pii/S1467803916000049

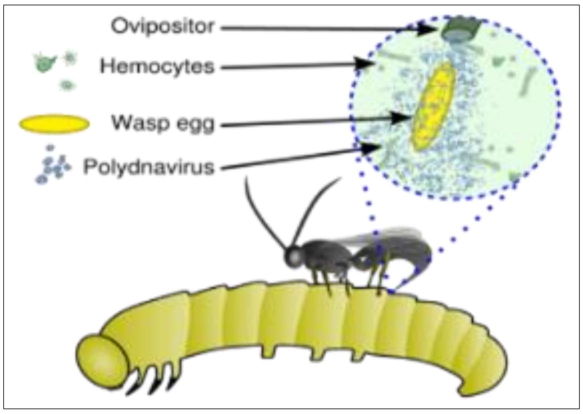
Figure 11 Life cycle of Bracon brevicornis Wesmael, 1838. and B. hebetor. Life cycle of B. brevicornis and B. hebetor. I: female and male wasps, II: female wasp injects venom, III: parasitoid eggs on host (encircled), IV: parasitoid larvae, V: pupated parasitoid larvae. Full-size

Source: https://watermark.silverchair.com/aesame

Figure 12 (AÐH) Embryonic development Braconidae (A) female laying egg. (B) Egg, 0Ð2 h. (C) Egg, 4Ð6 h; developing embryo showing cleavage nuclei and the trophamnion; arrow indicating micropyle. (D) Egg, 18Ð20 h; arrow indicating alimentary canal. (E) Egg, 24Ð26 h; arrow indicating dissociated trophamnion cell. (F) Egg, 36Ð38 h. (G) Egg, 46Ð48 h; developed embryo showing three-layered egg membrane; arrow indicating inner embryonic membrane. (H) Egg, 46Ð48 h

1.6. Special adaptations and defenses

Braconid wasps carry the polydnavirus genes within their bodies. The virus replicates within braconid wasp eggs as they develop within the mother. The virus does not harm the wasp, but when the egg is deposited in an insect host, the polydnavirus is activated. The virus prevents the blood cells of the host organism from recognizing the parasitoid egg as a foreign intruder, allowing the braconid egg to hatch (Figure 13) [5, 6].



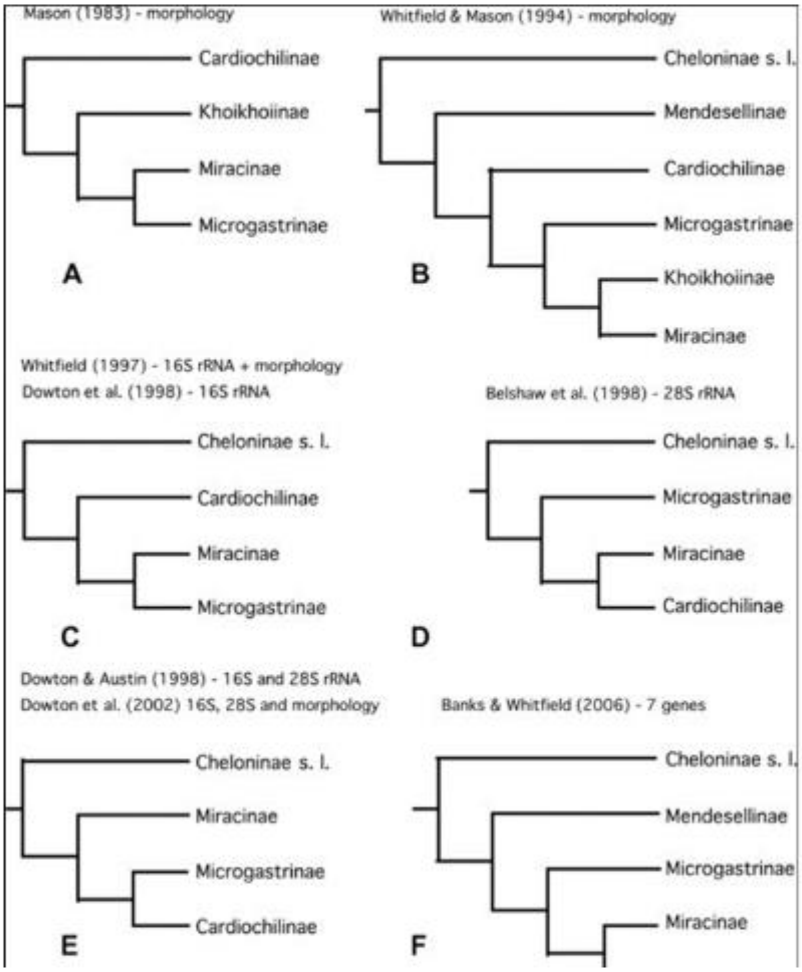
Source: https://en.wikipedia.org/wiki/Polydnavirus

Figure 13 Diagram of a POS host association

1.7. Range and Distribution

The braconid wasp family is one of the largest insect families and includes more than 40,000 species worldwide. They are widely distributed throughout the world, wherever their host organisms are present [5, 6].

1.8. Taxonomy and Phylogeny



Source: https://www.sciencedirect.com/science/article/abs/pii/S1055790308000444

Figure 14 The complex has received significant phylogenetic attention in recent years due in part to the taxons'association with mutualistic polydnaviruses, with which they compromise host immune systems

Subfamilies: Adeliinae, Agathidinae, Alysiinae, Amicrocentrinae, Aphidiinae, Apozyginae, Betylobraconinae, Brachistinae, Braconinae, Cardiochilinae, Cenocoeliinae, Cheloninae, Dirrhopinae, Doryctinae, Euphorinae, Exothecinae, Gnampodontinae, Helconinae, Hysteromerinae, Homolobinae, Hormiinae, Ichneutinae, Khoikhoiinae, Macrocentrinae, Masonine, Mendesellinae, Mesostoinae, Meteorideinae, Meteorinae, Microgastrinae, Microtypinae, Miracinae, Neoneurinae, Opine, Orgilinae, Pselaphaninae, Rhyssalinae, Rogadinae, Sigalphinae, Telengaiinae, Trachypetinae, Vaepellinae, Xiphozelinae and Ypsistocerinae (Figure 14) [5,6].

Objective

The aim of this study is to describe the Braconidae Family (Hymenoptera: Braconidae) as a parasitoid of insect pests for the world fruit industry.

2. Methods

The method used to prepare this mini review was Marchiori 2021 methodology [7].

2.1. Studies conducted and selected

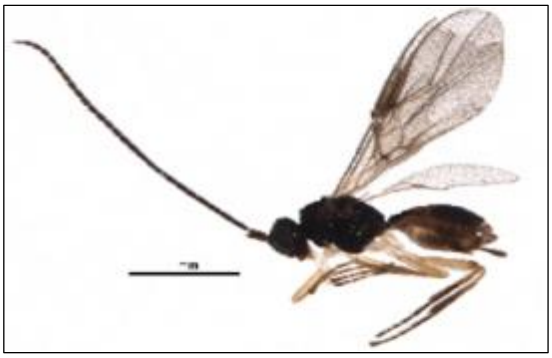
2.1.1. Study 1

Occurrence of Braconidae in the Brazilian Amazon

Six species of Braconidae were identified for the region, in addition to two species of *Doryctobracon* not yet formally described, but characterized. *Doryctobracon areolatus* (Szépligeti, 1911) and *Opius bellus* (Gahan, 1930) are widely distributed, present in eight states of the Amazon (Figures 15, 16, 17 and 18).

Source: https://entnemdept.ufl.edu/creatures/beneficial/wasps/doryctobracon_areolatus.htm

Figure 15 *Doryctobracon areolatus* (Szépligeti, 1911)



Source: https://v3.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=79768

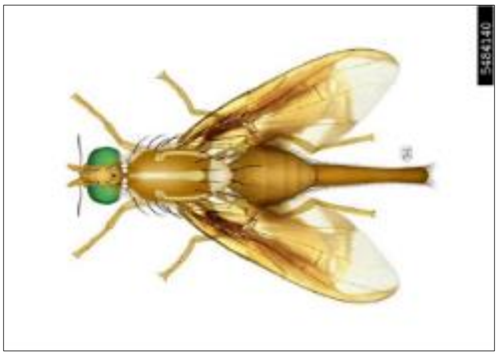
Figure 16 *Opius bellus* (Gahan, 1930)

Diachasmimorpha longicaudata (Ashmead, 1905) was introduced in Amapá, however, no specimens were recovered in the various surveys carried out in the state. It is possible to obtain copies of the alisiine *Idiasta delicata* (Papp, 1969). There is only one record (two specimens), associated with an unidentified *Anastrepha* species.

Source: https://entnemdept.ufl.edu/creatures/beneficial/d_longicaudata.htm

Figure 17 Diachasmimorpha longicaudata (Ashmead, 1905)

The association of a particular species of braconid with a species of *Anastrepha* can only be considered when only one species of parasitoid emerges from the same fruit sample and fly. The association of braconids with *Anastrepha* species can be verified in several states of the Brazilian Amazon. *Doryctobracon areolatus* and *O. bellus* are associated with the highest number of *Anastrepha* species (16 and 9, respectively). *Anastrepha atrigona* Hendel, 1914 is associated with five species of braconids.



Source: https://www.invasive.org/browse/detail.cfm?imgnum=5484140

Figure 18 *Anastrepha atrigona* Hendel, 1914

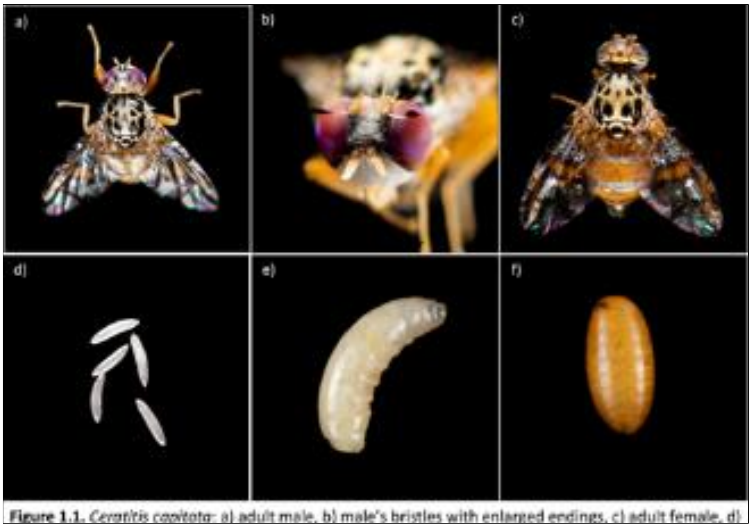
Only recently was the identity of the *Opius* specimens named *Opius* sp. or *Opius* sp. pr. *bellus*, in studies carried out in Brazil. These specimens belong to *Opius bellus* (Gahan, 1930), based on morphometric and molecular analyses. Therefore, all records of the authors of *Opius sp.* will be, in this manuscript, considered as from *O. bellus*.

The State of Amapá has the highest number of records (6), followed by Amazonas (5), Roraima (5) and Tocantins (5). Only for the State of Mato Grosso there are still no records of parasitoids of Tephritidae [8].

2.1.2. Study 2

The objective of this study was to verify the importance of conilon coffee as a host of fruit flies and which species of Tephritidae and Lonchaeidae are associated with this culture in the State of Espírito Santo.

In the three years of conducting the work on *Coffea Canephora* L. (Rubiaceae), about 38.1% of the samples showed infested fruits. In the period, 680 specimens of tephritids were obtained in fruits of this species of coffee. Of these, 613 specimens (90.15%) were from *Ceratitis capitata* Wiedemann,1824 and 67 (9.85%) belonged to the genus *Anastrepha*, showing the prevalence of the mediterranean fly in conilon coffee in the state of Espírito Santo (Figures 19, 20, 21 and 22).



https://www.semanticscholar.org/paper/Genetics-and-mechanisms-of-insecticide-resistance-Amat/49664e4b48cd904d35ed7407fbdd6b692273bb25/figure/0

Figure 19 *Ceratitis capitata* Wiedemann, 1824: a) adult male, b) male's bristles with enlarged endings, c) adult female, d) eggs, e) larvae and f) pupa

Among the species of the genus *Anastrepha* collected, the species *Anastrepha fraterculus* (Wiedemann, 1830) was the most important, followed by the species *Anastrepha sororcula* Zucchi, 1979 and *Anastrepha obliqua* (Macquart, 1835). In the period, parasitoids associated with tephritids were obtained, belonging to the families of the order Hymenoptera: Braconidae and Chalcididae.

Source: Photograph by Vanessa Dias, University of Florida

Figure 20 Female (left) and male (right) of *Anastrepha fraterculus* (Wiedemann, 1830). Both specimens are from the Brazilian-1 morphotype

The following parasitoid species were found: *Asobara anastrephae* (Muesebeck, 1958), *Opius bellus* Gahan, 1930 and *Utetes anastrephae* (Viereck, 1913) (Braconidae). Sixty specimens of Lonchaeidae were collected in *Coffea canephora* (Berthaud & Charrier, 1988) (Rubiaceae), identified as belonging to two species of the genus *Neosilba*: *Neosilba bella* Strikis & Prado, 2008 and *Neosilba pendula* (Bezzi, 1919).

The species *A. pendula* was the most frequent with 92.3% of the specimens obtained from this family. The results obtained confirm the status of conilon coffee as a poor host for fruit flies and with low natural parasitism in the producing regions of the state of Espírito Santo. Thus, the management of fruit flies in conilon coffee becomes unnecessary, since conilon coffee fruits allow very low population multiplication of these insects [9].

Source: http://www.biovirtual.unal.edu.co/Alysiinae/Asobara%20anastrephae.html

Figure 21 *Asobara anastrephae* (Muesebeck, 1958)

Source: https://www.agrolink.com.br/problemas/bicho-das-frutas_462.html

Figure 22 *Neosilba pendula* (Bezzi, 1919)

2.1.3. Study 3

This study aimed to analyze the influence of altitudinal variation on the community of the Braconidae of the Jaraguá State Park, located between the coordinates 23° 24' S and 45° 44' W, with an average altitude of 900 m (Malaise trap) and distant from the center of São Paulo about 16 km this park represents a unique area for the study of altitudinal variation as it is one of the highest regions of the Paulista Plateau (Figures 23, 24 and 25).

Source: https://malaiseprogram.com/discover/what-is-a-malaise-trap/

Figure 23 Malaise trap

Braconidae distributed in 20 subfamilies. With the exception of the total abundance by points, the subfamily Doryctinae was excluded from all results presented. Microgastrinae and Alysiinae were the two subfamilies that presented the highest richness in genera among the identified subfamilies and, together with the Doryctinae, they account for 75.1% of the full abundance.

Source: https://bugguide.net/node/view/1458260

Figure 24 Subfamily Microgastrinae

Point 5 was the one with the lowest richness and abundance compared to the other points. In it, 261 specimens were collected distributed in 26 genera from 15 subfamilies. The greatest abundance occurred at point 4, with 718 specimens. The biggest richness was found at point 2, with 41 genera distributed in 19 subfamilies. Of the total of 27 specimens sampled in the Parque, 16 were collected at point 5. The preference of these insects may be related to the altitude of the point (1,020 m), since they are of small size and with reduced wing nerves, which makes them dependent on the wind to move around. Great distances, and this direction is favored by high altitude environments superiors.

Source: https://sciencepress.mnhn.fr/en/periodiques/european-journal-taxonomy/2019/557

Figure 25 Subfamily Alysiinae

The use of the environment a parasitoid, however, is directly linked to the presence of the host insect and, indirectly, to the vegetation structure. In this case, the host insects are aphids, which feed mainly on plants of the families Myrtaceae and Lauraceae. These two families had the highest abundance in point 5 (58.3% and 40.0%) and were not very expressive in the other points. Therefore, the high percentage of occurrence of this subfamily may be more related to the vegetation structure.

At its highest point, the abundance and wealth of Braconidae fauna were the smallest, suggesting that there may be an influence of altitude in this community. Several authors consider that the elevation of altitude is accompanied by a reduction both in the richness and abundance of insects studied. This reduction could be explained by the decrease in available resources, as the vegetation structure becomes less complex, with less heterogeneity of habitats, which can lead to a lower occurrence of potential insect’s hosts for braconids [10].

2.1.4. Study 4

Pest monitoring is essential to meet the principles of sustainability and respect for the environment, being an ally in integrated pest management (IPM). it is necessary monitoring to identify this biological control, to assist in decision making in the MIP, for this, caterpillars were collected in soybean (*Glycine max* (L.) (Merr.) (Fabaceae) to identify the occurrence of parasitoids.

The collections were carried out randomly in the area with cloth beating between the lines, after collection, the caterpillars were taken to the laboratory and treated with an artificial diet, the monitoring of the caterpillars was daily until the caterpillars reached the end of the cycle.

The caterpillars *Chrysodeixis includens* (Walker, 1858) (Lepidoptera, Noctuidae, Plusiinae) were collected during the (Figures 26, 27 and 28).

Source: https://entnemdept.ufl.edu/creatures/field/soybean_looper.htm

Figure 26 *Chrysodeixis includens* (Walker, 1858) (Lepidoptera, Noctuidae, Plusiinae)

Source:https://www.agrolink.com.br/problemas/lagarta-falsa-medideira_38.html

Figure 27 *Chrysodeixis includens* (Walker, 1858) (Lepidoptera, Noctuidae, Plusiinae)

Morning in March 2017 at the IFTM campus Uberaba (Minas Gerais state, Brazil), caterpillars killed by fungi, bacteria, viruses, parasitoids or fleas were counted. 201 live caterpillars were collected, and the percentage of natural deaths or by fungi, bacteria, viruses or that did not complete the cycle was 20%, it was also found that 19.9% of the total caterpillars collected died by parasitoids of the following categories: Order Hymenoptera family Ichneumonidae with 1 species (13 insects); Order Hymenoptera family Braconidae with 2 unidentified species A and B (A-54 insects and B-55 insects); Order Hymenoptera family Encyrtidae with 1 species (2179 insects); Diptera order family Tachinidae with 3 unidentified species A, B and C (A-1 insect, B-20 insects and C-1 insect).

Source: https://agronomicabr.com.br/DetalheAgriporticus.aspx?id=932

Figure 28 Order Hymenoptera family Braconidae with 2 unidentified species A and B (A-54 insects and B-55 insects)

The total of the evaluations it was identified that 39.9% of the caterpillars were naturally controlled, showing that the biological control with monitoring was efficient [11].

2.1.5. Study 5

The aim of this study was to record the parasitoid *Gnathopleura semirufa* (Brullé, 1846) parasitizing flies of the family Sarcophagidae in Brazil (Figures 20 and 30).

Figs. 1-4. 1, Fêmea de *Gnathopleura semirufa* sobre as larvas de *Peckia (Squamatodes) trivittata* na abertura bucal da carcaça de *Sus scrofa* (seta aponta *G. semirufa*); 2, *Peckia (Squamatodes) trivittata* (macho); 3, *Gnathopleura semirufa* (fêmea). 4, *Gnathopleura semirufa* (fêmea), mostrando o padrão cromático da asa.

Figure 29 Record *of Peckia (Squamatodes) trivittata* (Curran, 1927) (Diptera, Sarcophagidae) parasitized by *Gnathopleura semirufa* (Brullé, 1846)

Source: https://biodar.unlp.edu.ar/sarcophagidae/en/info/20439.html

Figure 30 *Oxysarcodexia thornax* (Walker, 1849) (Diptera: Sarcophagidae)

Collected from 305 pupae *Oxysarcodexia thornax* (Walker, 1849) (Diptera: Sarcophagidae), 143 *Peckia chrysostoma* (Wiedemann, 1830) (Diptera: Sarcophagidae) and 182 of *Sarcodexia lambens* (Wiedemann, 180) (Diptera:

Sarcophagidae) that emerged 75, 51 and 31 parasitoid species *G. semirufa,* respectively. The total percentage parasitism observed was around 25.0%. The host showing the highest percentage parasitism was *P. chrysosotoma* in cattle liver.

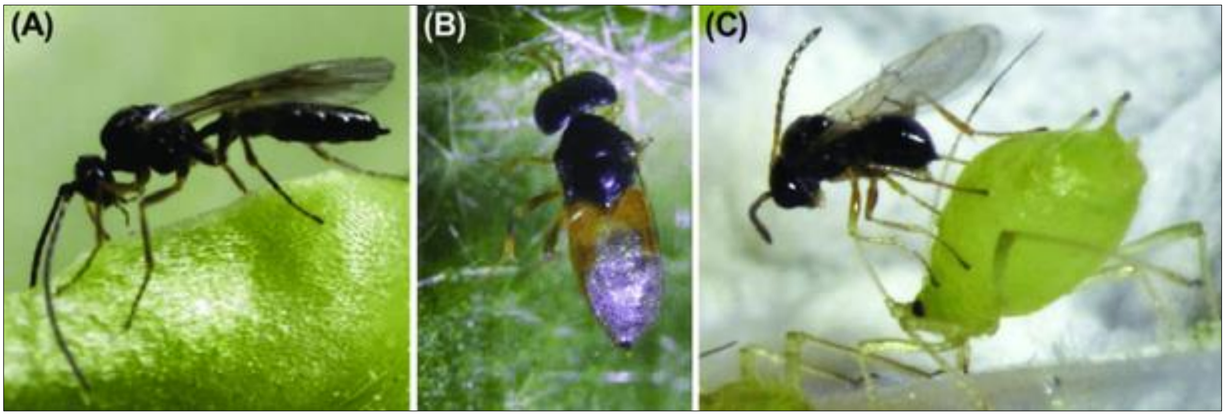
The percentage of parasitism observed in *O. thornax*, *P. chrysosotoma* and *S. lambens* was 24.6%, 35.7% and 17.0%, respectively.

These traps pitfall are used for studying parasitic Diptera and Hymenoptera. This work marks the first occurrence of *G. semirufa* parasitizing *O. thornax*, *P. chrysosotoma* and *S. lambens* in soutern of Goiás. Brazil [12].

2.1.6. Study 6

Aphids are important pests of rapeseed. Among the biological control agents of these pests, parasitoids stand out, which, in turn, are controlled by hyperparasitoids. In order to record new associations between aphids, parasitoids and hyperparasitoids, in Passo Fundo (State of Rio Grande do Sul, Brazil), mummies of aphids were collected on leaves of *Brassica napus* L. (Brassicaceae) (canola), hybrid Hyola 433, from June to September 2015. In the laboratory, the mummies were individualized in Petri dishes until the emergence of parasitoids or hyperparasitoids.

The following have been identified associations: the aphid *Myzus persicae* (Sulzer, 1776) (Hemiptera: Aphididae) with the parasitoid *Diaeretiella rapae* (M'intosh, 1855) (Hymenoptera, Aphidiidae) and the hyperparasitoids *Alloxysta fuscicornis* (Hartig, 1841) (Hymenoptera: Figitidae) and *Syrphophagus aphidivorus* (Mayr, 1876) (Hymenoptera: Encyrtidae), *Lipaphis erysimi* (Kaltenbach, 1843) (Hemiptera: Aphididae) and *Brevicorine brassicae* (Linnaeus, 1758) (Hemiptera: Aphididae) with the hyperparasitoid *A. fuscicornis* (Figure 31) [13].



Source: https://www.researchgate.net/figure/A-Braconid-parasitoid-B-aphelinid-parasitoid-and-C-hyperparasitoid-of-aphids_fig4_315610396

Figure 31 (A) Braconid parasitoid, (B) aphelinid parasitoid, and (C) hyperparasitoid of aphids

The associations of *M. persicae* with the parasitoid *D. rapae* and the hyperparasitoids *A. fuscicornis* and *S. aphidivorus*, and *B. brassicae* with the hyperparasitoid *A. fuscicornis* are recorded for the first time in Passo Fundo-RS [13].

2.1.7. Study 7

However, little is known about the faunal opposition in agroecosystems, which justifies the accomplishment of this study, which aimed to know the families of parasitoid hymenoptera in a cotton crop and their relative frequencies. These devices are composed of two Moericke traps (Figure 32).

A total of 16,166 parasitoid hymenopterans were collected belonging to 22 families, distributed in eight superfamilies Chalcidoidea, Platygastroidea, Ichneumonoidea, Cynipoidea, Ceraphronoidea, Chrysidoidea, Proctotrupoidea and Evanioidea. The most abundant families were Encyrtidae, Trichogrammatidae, Mymaridae and Scelionidae, which represented 45.14%, 19.11%, 14.33% and 6.57% of the total number of parasitoid hymenoptera collected, respectively. The remaining eighteen families had relative frequencies below 5% (Figure 33) [14].

Source: https://simonleather.wordpress.com/2015/01/12/entomological-classics-the-moericke-yellow-pan-trap/

Figure 32 Moericke (Yellow) Pan trap in use in the far north

Source: https://www.biodiversity4all.org/taxa/63187-Braconidae

Figure 33 Specimen of Ichneumonoidea

In the superfamily Chalcidoidea, the families Encyrtidae, Trichogrammatidae and Mymaridae. In the family Encyrtidae, it was observed that a single unidentified species of the genus *Copidosoma* Ratzeburg, 1844, represented 94.18% of the total of 7,297 encyrtids captured. Trichogrammatidae and Mymaridae are parasitoids of eggs of other insects and together represented 33.44% of the total of hymenoptera parasitoids collected Figure 34) [14].

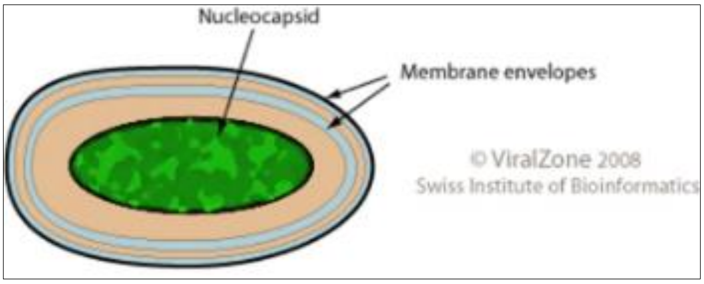
Source: https://tr.pinterest.com/pin/809170258023635179/

Figure 34 Superfamily Ichneumonoidea - Braconidae and Ichneumonidae wasps. Common hosts are larvae and pupae of Coleoptera, Hymenoptera and Lepidoptera

In the superfamily Platygastroidea, the family Scelionidae (6.57% of the collected parasitoid hymenoptera). The other superfamilies collected had relative frequencies below 5%, especially the families Eucoilidae (Cynipoidea), Ichneumonidae and Braconidae (Ichneumonoidea) and Bethylidae (Chrysidoidea) with 2.13%, 1.68%, 0.88% and 0.72%, respectively, of the total number of parasitoid hymenoptera collected [14].

2.1.8. Study 8

The larval endoparasitoid *Cotesia chilonis* (Matsumura, 1912). (Hymenoptera: Braconidae) injects venom, calyx fluid and bracoviruses into its host *Chilo suppressalis* (Walker, 1863) (Lepidoptera: Crambidae) during oviposition (Figures 35, 36 and 37) [15].



Source: https://viralzone.expasy.org/147?outline=all_by_species

Figure 35 Enveloped, prolate ellipsoid form (ichnovirus) and cylindrical (bracovirus). Depending on the species, a virion contains one or several nucleocapsids

Source: https://species.wikimedia.org/wiki/Cotesia

Figure 36 *Cotesia chilonis* (Matsumura, 1912) (Hymenoptera: Braconidae)

Source: https://onlinelibrary.wiley.com/doi/epdf/10.1111/imb.12227

Figure 37 *Chilo suppressalis* (Walker, 1863) (Lepidoptera: Crambidae)

Polydnavirus (PDV)-carrying endoparasitoid *C. chilonis* parasitism, venom and calyx fluid on host cellular and humoral immunity, specifically hemocyte composition, cellular spreading, encapsulation and melanization (Figure 38) [15].

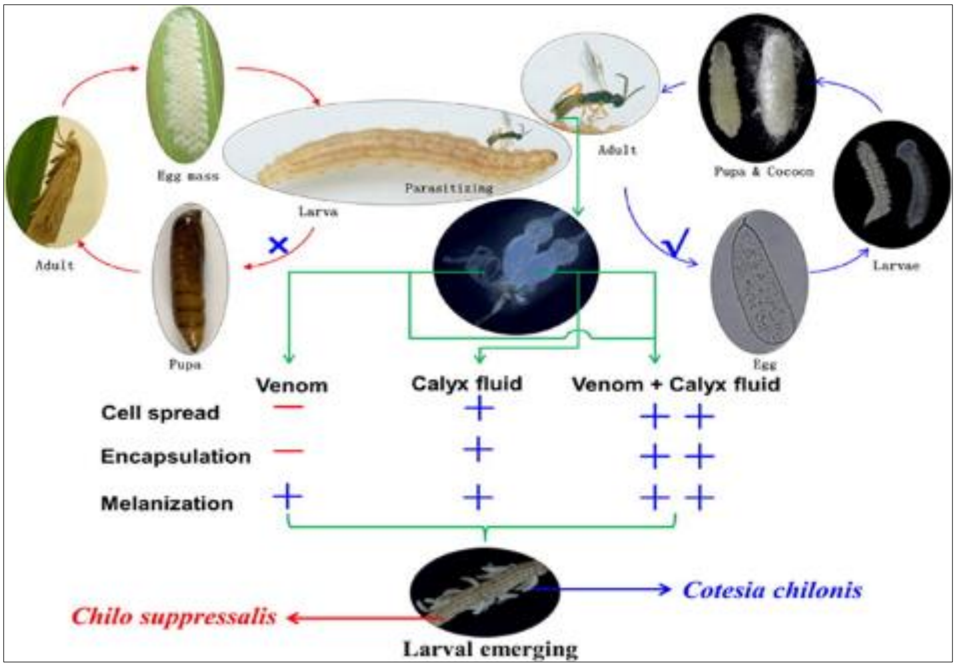


Figure 38 The endoparasitoid *Cotesia chilonis* (Matsumura, 1912). (Hymenoptera: Braconidae) parasitism, venom, and calyx fluid on cellular and humoral immunity of its host *Chilo suppressalis* (Walker, 1863) (Lepidoptera: Crambidae) larvae

3. Conclusion

The Braconidae Family have a symbiotic relationship with polydnaviruses that they inject into their host, preventing the host from rejecting the parasitoid. Many species of this family have considerable use in controlling insects that represent pests. The classification of Braconidae is currently the subject of review. The gregarious forms of Macrocentrinae all appear to be polyembryonic. Cheloninae are parasites of eggs and larvae: the female lays on the host's egg and the parasite matures and emerges from the late-stage larva or pupa. Certain braconids even belong to Müllerian mimicry rings.

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