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(REVIEW ARTICLE)

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Study of the life cycles of parasitoids, the manipulation of the behavior of spiders, the parasitoids of bees and intraspecific competition: Collections

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Abstract

The aim of this study is to describe the life cycles of parasitoids, manipulation of spider behavior, bee parasitoids and Intraspecific competition. The mini review consists of a bibliographic summary of parasitoids of the Order Hymenoptera Parasitical. The research was carried out in studies related to the theme with an emphasis on the quantitative and Conceptual aspects of the Superfamily, Family, Subfamilies, Genera, and Species (Taxonomic groups). A literature search was carried out containing articles published from 2005 to May 2021. The mini review was prepared in Goiânia, Goiás, from July to August 2021, using the Electronic Scientific Library Online (Scielo) and internet.

Keywords: Taxonomic Groups; Scielo; Bibliographic Summary; Natural Enemies

1. Introduction

1.1. Parasitoids

Parasitoids are organisms that cause the death of their hosts to complete their development and act as parasites only in the larval stage when they develop into only one host, with the adults having free life. For comparison purposes, predators, both adults and larvae, are free-living and need to consume several prey to reach the adult stage [1].

When a species of parasitoid has as its host an insect considered to be a pest, it becomes a potential biological control agent. It is estimated that there are approximately 200,000 species of parasitoids distributed mainly in the orders Hymenoptera and Diptera. Several families are sources of parasitoids for agents of biological control, such as Aphelinidae, Braconidae, Encyrtidae, Eulophidae, Ichneumonidae, Pteromalidae, Platygastridae, and Trichogrammatidae among Hymenoptera [1].

1.2. Intraspecific competition

Intraspecific competition occurs when different individuals of the same species compete for a resource. These interactions can be fierce because the individuals require the same limited resources to survive and reproduce. When different species are vying for the same food, habitat, or some other environmental resource it is called interspecific competition [2].

Although they are not particularly closely related, the lives of two parasitoid wasp species, *Melittobia digitata* Dahms, 1984 (Hymenoptera: Eulophidae). and *Nasonia vitripennis* (Walker, 1836) (Hymenoptera: Pteromalidae), are quite similar. Both species lay their eggs on the pupal stages of host insects. In nature, *Nasonia* use *Neobellieria bullata* (Parker, 1916) (Dptera: Sarcophagidae), as well as other related species of flies as their hosts [2].

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Objectives

The aim of this study is to describe the life cycles of parasitoids, manipulation of spider behavior, bee parasitoids and Intraspecific competition.

2. Methods

The methodology used in this study was that of Marchiori (2021) [3]**.** The collection was built from articles from 2005 to 2021 with the themes: life cycles of parasiroids, wasp larvae, manipulate spider behavior and bee parastoids and intraspecific competition**.**

3. Description of Studies

3.1. Study 1

Although they are not particularly closely related, the lives of two parasitoid wasp species, *Melittobia digitata* Dahms, 1984 (Hymenoptera: Eulophidae). and *Nasonia vitripennis* (Walker, 1836) (Hymenoptera: Pteromalidae), are quite similar. Both species lay their eggs on the pupal stages of host insects. In nature, *Nasonia* use *Neobellieria bullata* (Parker, 1916) (Dptera: Sarcophagidae), as well as other related species of flies as their hosts (Figure 1) [4].

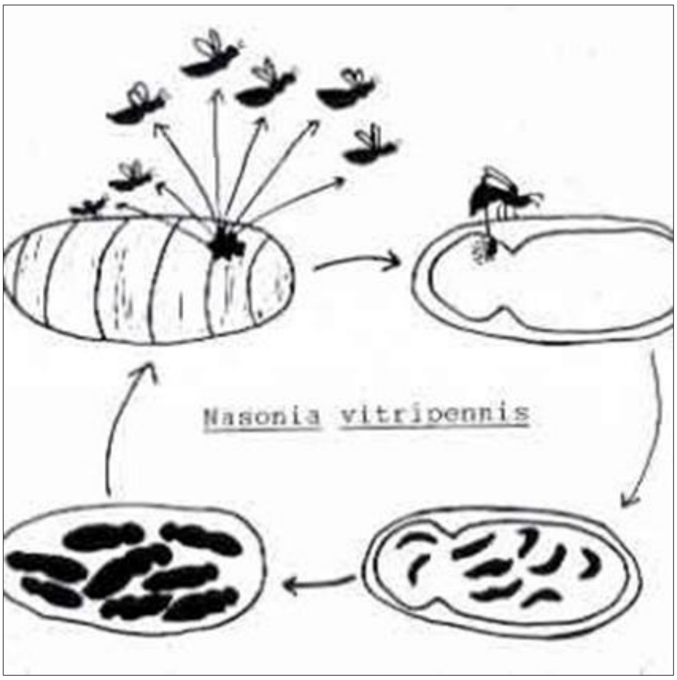

Figura 1 The life cycle of *Nasonia vitripennis* (Walker, 1836) (Hymenoptera: Pteromalidae), (drawing by Bethia King). The life cycle of *Melittobia* (Hymenoptera: Eulophidae) is the same, though individuals at all stages are smaller. Competition within and between species of parasitoid wasps; (Source: https://www.researchgate.net/figure/The-life-cycle-of-Nasonia-vitripennis-drawing-by).

3.2. Study 2

The use of chemical cues and signals is essential for communication in insects. Wasps of the genus *Nasonia* (Hymenoptera, Pteromalidae) are gregarious parasitoids that lay their eggs into puparia of cyclorrhaphous flies (Figure 2) [4].

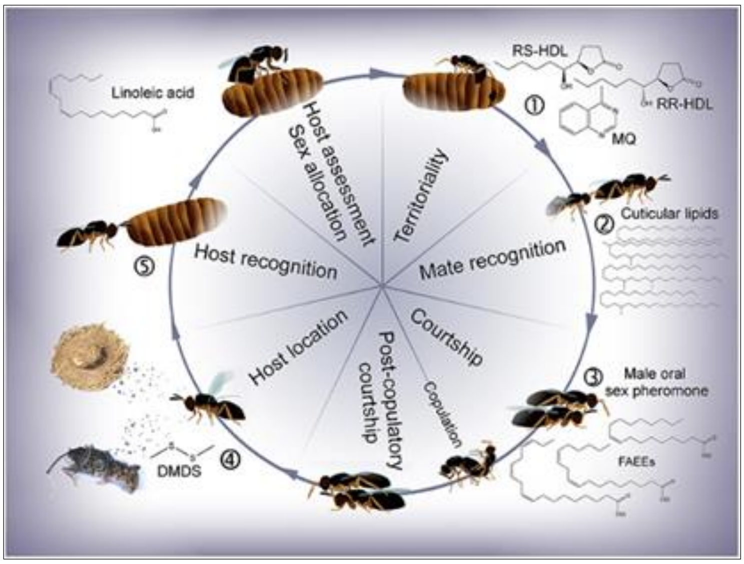

Figure 2 During its life cycle, several types of semiochemicals are used: (1) a male abdominal sex pheromone that attracts women and induces local fidelity in men, (2) a female-derived contact sex pheromone that induces courtship behavior in males, (3) an oral male aphrodisiac triggering receptivity signaling in females and causing a shift in female olfactory preferences, (4) host habitat-derived chemicals and host puparia used in olfactory host discovery by female wasps and (5) chemicals used by females to assess the quality and parasitism status of potential hosts; (Source: https://www.researchgate.net/figure/The-life-cycle-of-Nasonia-vitripennis-drawing-by).

3.3. Study 3

The parasitoid's successful stings, however, leave the cockroach free of resistance and in the perfect position for the wasp and its larva to reap the benefits of the energy. This resistance-free relationship is presumably ideal for a host-parasite interaction, but many parasites lack this control over their hosts (complex neurological command) (Figure 3) [5].

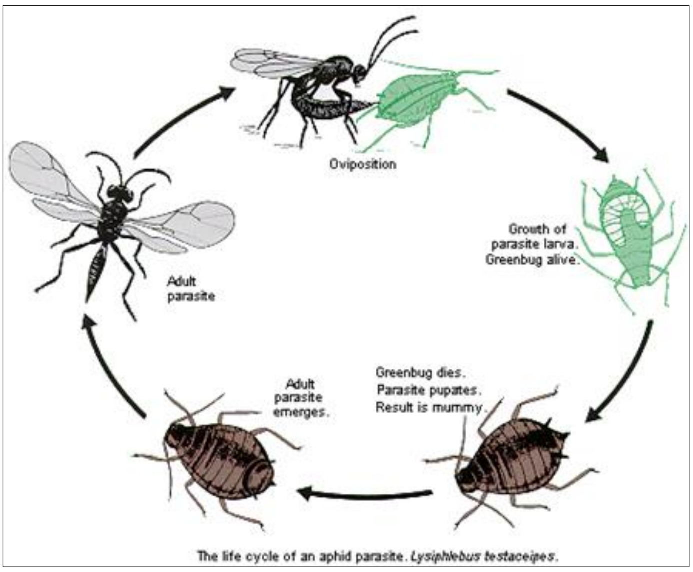

Figure 3 Perhaps the primary reproductive value of the parasitic behavior of this wasp species is that of "free" oviposition. By placing the egg inside the cockroach, the mother wasp does not have to worry about caring for its developing larva; everything the larva needs is kept within the host organism and is kept alive long enough to provide for the larva without the mother's intervention. A huge energy charge is therefore removed from the mother's shoulders; (Source: https://www.reed.edu/biology/professors/srenn/pages/teaching/web_2010/bpls_site-final/Adaptive%20Value.html).

3.4. Study 4

The *Aphelinus* (Hymenoptera, Braconidae) are small-sized chalcid wasps sometimes measuring less than 1mm. They are solitary koinobiont endoparasitoids. The egg is laid following a specific behaviour. With her antennae the female palpates her future host, briskly turns 180° and while moving backwards performs her egg-laying using a long tapering ovipositor. The larva accomplished its whole development inside the aphid which is also the site for undergoing nymphosis. The aphid then becomes black and oblong as if mummified. The adult emerges after cutting a round opening, often in the hind area of the mummy (Figures 4 and 5) [5].

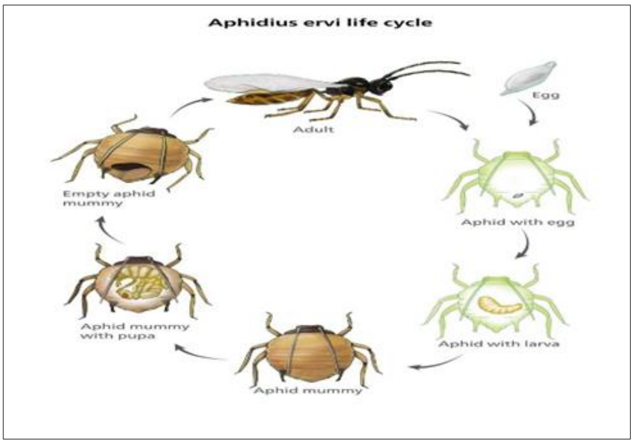

Figure 4 *Aphidius ervi* (Haliday 1834) (Hymenoptera, Braconidae) life cycle; (Source:https://twitter.com/koppertus/status/1192820316713766912).

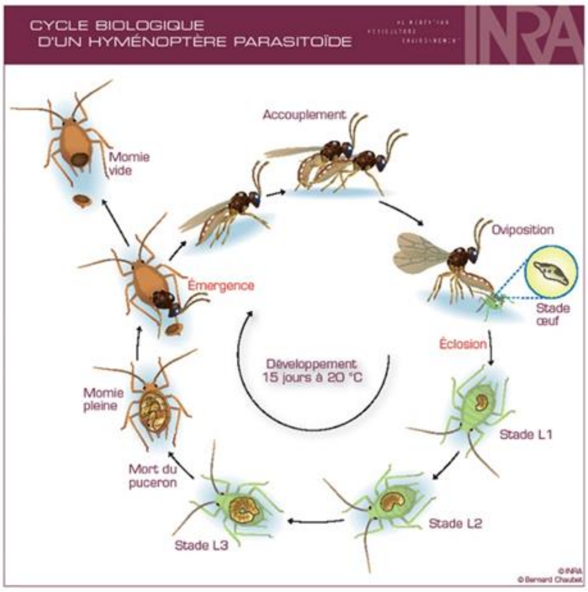

Figure 5 *Aphelinus* (Hymenoptera: Aphelinidae); Source: https://www6.inrae.fr/encyclopedie-pucerons_eng/Aphids-and-their-environment/Antagonists/Parasitoids/Life-cycle.

3.5. Study 5

Life cycles of the parasitoid *Dinocampus coccinellae* (Schrank, 1802) (Hymenoptera; Braconidae: Euphorinae) and its endosymbiotic virus *D. coccinellae* paralysis virus, (DcPV) together with responses to parasitism and infection of the ladybeetle host *Cissites maculata* (Swederus, 1787) (Coleoptera: Meloidae) (Drawing by Franz Vanoosthuyse). The DcPV is stored in abundance in the oviduct of *D. coccinellae* female. Following oviposition and egg hatching, DcPV replicates in the parasitoid larva and is transmitted to *C. maculata*. The antiviral immune system of the ladybeetle is then suppressed, which allows DcPV to replicate in glial cells in the host's nervous system (Figure 6) [6].

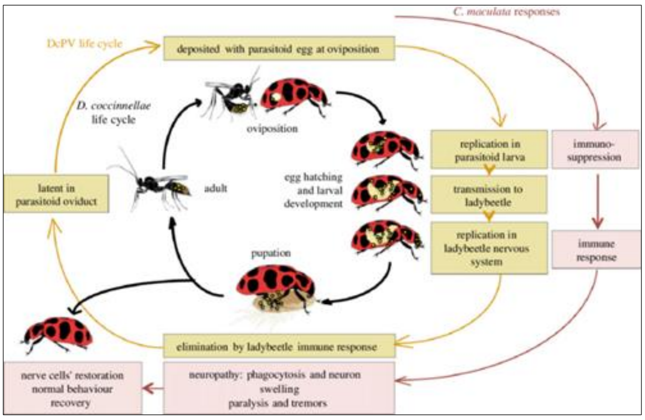

Figure 6 Life cycles of the parasitoid *Dinocampus coccinellae* (Schrank, 1802) (Hymenoptera; Braconidae: Euphorinae).

3.6. Study 6

The present review outlines how the cellular and body surfaces of organisms commonly used as biological control agents, such as the bacterium *Bacillus thuringiensis* (Bt), entomopathogenic fungi (EPF), entomopathogenic nematodes (EPN), and wasps, are central to their success in killing the hosts. We describe in detail the role played by these pathogens' surface molecules and molecular complexes as key elements in preventing immune recognition, and therefore the activation of molecular switches that control the triggering of effector processes. We also outline the contribution of secretions and secondary metabolites released during the infection and that are involved in the immunological interference [7].

Some entomopathogen wasps reproduce sexually, then when they find a host, the females inject eggs into it; together with the gametes, they inject polydnaviral (PDV), virus-like particles (VLPs), and venom compounds. The compounds and viruses help the egg to not be recognized by the host immune system. In this manner, the eggs can hatch, and the larvae can develop undisturbed by feeding on the corpse of the parasitized insect (Figure 7) [7].

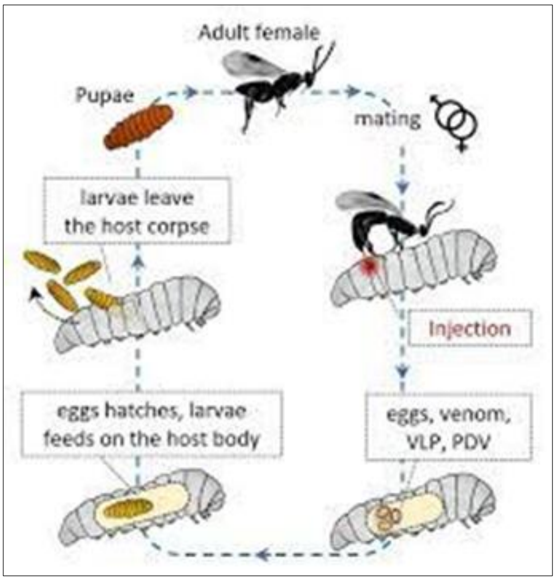

Figure 7 *Ichneumonid wasps*

3.7. Study 7

Life cycle and genome organization of BVs. (A) In pupal and adult stage wasps, the proviral genome consists of two components: a domain of core genes (red, yellow, purple) and a domain of tandemly arrayed proviral DNAs (green) that encode virulence genes. The borders of these proviral DNAs are identified by conserved, flanking excision motifs (black). (B) Wasps inject virions plus one or more eggs containing the proviral genome into the host insect. The egg hatches into a wasp larva that feeds on the host. (C) Upon completing development, the wasp larva emerges from the host to pupate, while the host larva dies (Figure 8) [8].

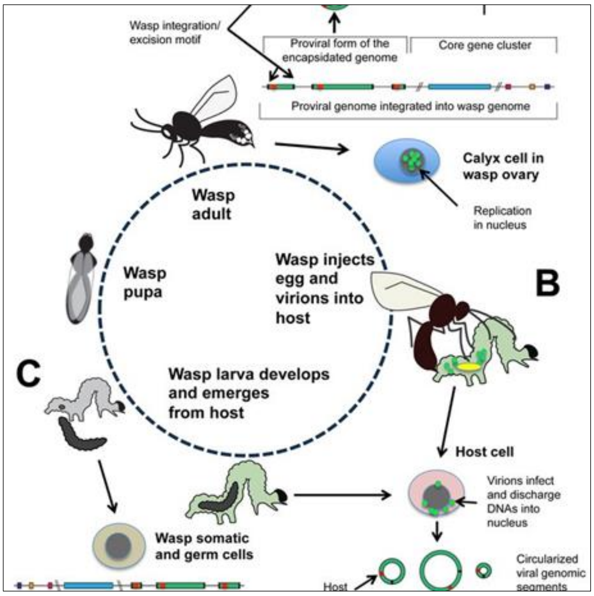

Figure 8 Life cycle and genome organization of BVs; (Source: https://www.researchgate.net/figure/Life-cycle-and-genome-organization-of-BVs-A-In-pupal-and-adult-stage-wasps-the_fig2_229083062/download.

3.8. Study 8

Melittobia digitata Dahms, 1984 (Hymenoptera: Eulophidae) are small parasites whose tiny stingers are used only to pierce the immature insects that serve as their hosts. Your life is accelerated; just 17-21 days after being placed in the host, the eggs mature into adults capable of repeating the cycle. Males - which cannot fly and are blind - spend their short lives entirely inside the host cocoon, but after they mate, the winged females leave (Figure 9) [9].

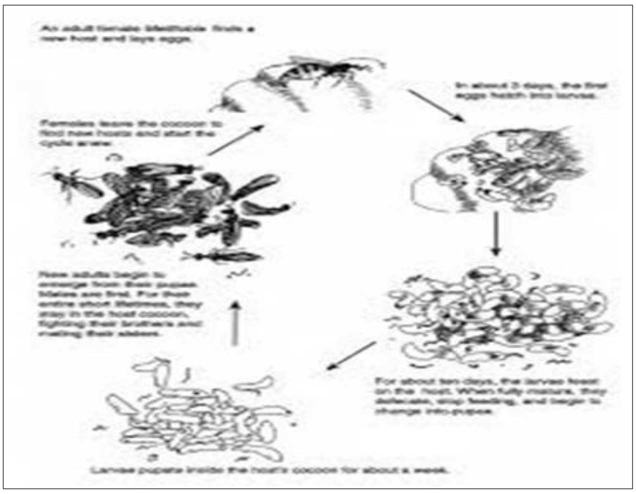

Figure 9 The life cycle of the WOWBug, *Melittobia digitata* Dahms, 1984 (Hymenoptera: Eulophidae). Under classroom and laboratory conditions, the cycle usually takes about three weeks. However, developmental timing is influenced by temperature. Outdoors it can be as short as 14 days or as long as several months; (Source: downloads/Matthews_C_Moser_S_1996_LongInvestFamBackIntSmFirmOwn_JSBM_34_2_29_43.pdf).

Figure 10 Life cycle of *Melittobia digitata* Dahms, 1984 (Hymenoptera: Eulophidae); (Source: https://br.pinterest.com/pin/571957221410656505/).

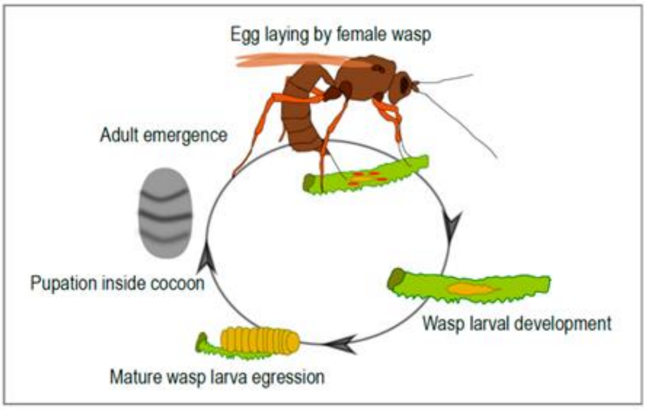

Figure 11 Life cycle of an ichneumonid parasitoid wasp associated with mutualistic viruses. The adult female wasp injects virus particles along with the eggs during parasitization. The progeny develops within the body of the parasitized insect. At the end of larval development, the mature larva egresses from the host and spins a cocoon where pupation takes place. A free-living adult then emerges from the cocoon; (Source: https://www.mdpi.com/1999-4915/12/10/1170/htm).

Amazingly, in many cases the parasitized insect continues its development, and usually only dies once the parasitoid has completed its larval development. This life history strategy presents several challenges for the parasitoid. In particular, the developing wasp needs to escape the immune response of its host and modulate host development and metabolism in a way that is beneficial to its own development. There are many strategies parasitoids employ to inhibit host immune defenses and to finely tune host development to suit their own. The females of some species, for instance, produce specific immunosuppressive proteins in their venom gland and inject them into the host during parasitization (Figures 10 and 11) [10].

4. Manipulating the spider

The wasp *Hymenoepimecis* sp. belongs to the family Ichneumonidae, a family with many parasitoid wasps (organisms that spend only part of their life cycle as parasites), several of which I intend to show here. This one in particular has as food for its larvae, spiders, specifically the species *Plesiometa argyra* (Walkenaer,1841) (Araneae: Tetragnathidae). It attacks the spider in its web, paralyzes it and deposits an egg in its abdomen. During the next two weeks, the larva hatches from its egg and starts to suck the hemolymph from its host. At the end of this period, the larva apparently releases chemical substances in the spider that induce a change in behavior [11].

5. Wasp larvae manipulate spider behavior

5.1. Study 1

A fly was caught by the web, the spider emerged from the coiled leaf that served as its shelter, and before it reached the day's meal, it was attacked. The wasp grabbed the spider and inserted the ovipositor into the web owner's mouth, releasing a paralyzing substance long enough for it to stick an egg to the back of the victim's abdomen is a complex procedure that involves manipulation of the host by the wasp. After paralyzing the spider (the venom reaches the central nervous system via the subesophageal ganglion), the wasp inspects the victim's abdomen and, if necessary, kills and removes any competing larvae. Afterwards, it deposits an egg there from which a larva comes out and adheres to the spider's body, makes holes in its abdomen and feeds on hemolymph, a fluid corresponding to blood [12].

Two weeks later, when the larva forms the cocoon in which it will become an adult wasp, the spider suddenly changes the structure of its web. It practically stops producing the spiral of viscous threads that capture prey and assembles a simpler and more resistant structure – in some cases, it even creates a silk barrier protecting the cocoon. The larva then attaches itself to the strands of the web with hook-like structures that appear on its carapace in the last molt, kills the spider and forms its cocoon (Figures 12 A, B, C, D) [12].

A

B

C

Figure 12 (A, B, C, D) Modification of *Nephila clavipes* (Linnaeus, 1767) (Araneae: Nephilidae) webs induced by the parasitoids Hymenoepimecis bicolor and *Hymenoepimecis robertsae* Gauld, 1991 (Hymenoptera: Ichneumonidae); (Source: Gonzaga et al. Modification of *Nephila clavipes* (Araneae Nephilidae) webs induced by the parasitoids *Hymenoepimecis bicolor* and H. robertsae (Hymenoptera: Ichneumonidae). Ethology Ecology & Evolution**.** 2010; 22: 151-165).

5.2. Study 2

This work aimed to record the activities of mutilids of the genus *Traumatomutilla* sp, the proof of parasitoidism and its host specificity in *Monoeca xanthopyga* Harter-Marques, Cunha & Moure, 2001 (Hymenoptera, Apidae, Tapinotaspidini) aggregations. The presence of *Traumatomutilla* sp. was recorded before the appearance of the first individuals of *M. xanthopyga* being that after the period of activity of the bees, females of *Traumatomutilla* sp. continued to patrol M. xanthopyga aggregations. Host founders were seen expelling females of *Traumatomutilla* sp. from inside their nests. This proves its specificity, and in three consecutive years this species was seen in the same aggregations, in the same period of activities of the bees [13].

Insects associated with nests of *M. xanthopyga*, found from emergence in traps, belong to the genus *Traumatomutilla* André, 1903 (Mutillidae). From the fifteen nests followed, three males and one female of *Traumatomutilla* emerged. The excavations carried out in three nests, with the collection of 27 host cells, could prove the presence of a *Traumatomutilla* sp. inside the cocoons of *M. xanthopyga* (Figures 13 A, B, C) [13].

A

B

Figure 13 (A, B, C) *Monoeca xanthopyga* (Hymenoptera, Apoidea, Tapinotaspidini), first host record for parasitoid genus *Traumatomutilla* (Hymenoptera: Mutillidae); (Source: https://www.researchgate.net/publication/339071928).

6. Conclusion

Parasitoids, which mainly include taxa belonging to Hymenoptera, play an important role in the maintenance of other arthropod populations, acting as regulators of host densities. However, the large-scale patterns of these insects and the factors that shape them are still not well established.

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