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[Mini Review] Family Ampulicidae (Insecta: Hymenoptera) as a parasitoid of cockroaches (Insecta: Blatidae)

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Abstract

The species of the Famíly Ampucilidae has developed truly incredible behavior, being able to grab the cockroach with powerful jaws and sting it directly into two precise parts of the nervous system. The first partially and reversibly paralyzes the first pair of legs while the second obliterates only the flight reflexes, leaving the cockroach unharmed but converted into a kind of zombie. The aim of this article is to describe the parasitoid behavior of the Ampulicidae Family (Insecta: Hymenoptera). In terms of the type of research source, scientific articles published in national and international journals were used. This modality of production, in addition to being commonly the most valued in the set of bibliographic production, is the most easily accessed. Access to articles was through virtual libraries such as Scielo, the University of São Paulo, Latin American Literature and the University of Brasilia. In this library, there is a specific section for Hymenoptera, with eight journals, with texts of articles available in full and theoretical books, these banks, university dissertations, and scientific journals.

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1. Introduction

The Spheciformes wasps, make up a cosmopolitan group of wasps that hunt insects, spiders and springtails with a generally solitary habit. This group presents a great morphological, ecological, biological and behavioral diversity; for these reasons, systematic classifications of the spheciform wasps in the Superfamily Apoidea along with the bees and

currently recognize four families: Heterogynaidae, Ampulicidae, Sphecidae and Crabronidae. These wasps share morphological characteristics with most bees, however, these have feathery hairs and the spheciform wasps have smooth hairs (Figures 1-3) [1][2][3].

Figure 1. The emerald cockroach wasp or jewel wasp Ampulex compressa Fabricius, 1781 is a parasitoid solitary wasp of the family Ampulicidae.

Source: https://www.etawau.com/Insects/2_pairWings/Family_Ampulicidae/Genus_Ampulex/Ampulex_Compressa.htm

Figure 2. *Ampulex dementor* Ohl, 2014,

Sources: Bernard Schurian / Wikimedia Commons and https://indianapublicmedia.org/amomentofscience/dementor-wasps-are-strange-and-fascinating.php

Figure 3. *Ampulex assimilis* Kohl, 1893 Distribution: Iraq, Oman, Saudi Arabia, United Arab Emirates, Yemen. Biology: Unknown, but probably preys on cockroaches, which is typical for the genus

Source: *http://www.waspweb.org/apoidea/ampulicidae/Ampulicinae/Ampulex/Ampulex_assimilis.htm*

1.1. Description

The members of the family are characterized by their metallic green body and can measure up to 33 mm in length; winged females hind wings with closed cells, hindwing with small or absent jugal lobe, tarsal claws notched or divided along the inner margin, mesotibia with two apical spines, metasoma sessile or with petiole composed of tergum and sternum. They have elongated jaws, a neck-like constriction behind the head, gutters on the thorax, and an abdomen (Figures 4-8) [4][5][6].

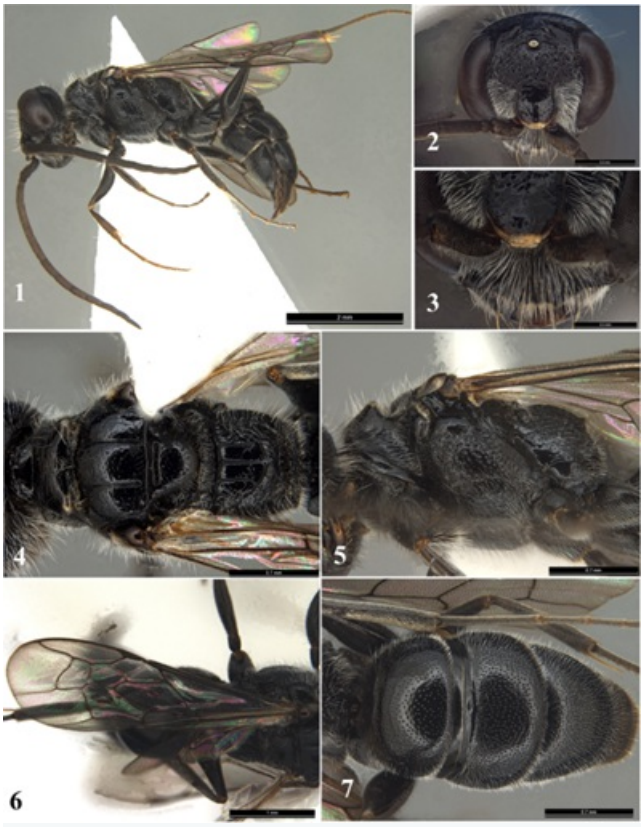

Figure 4. *Dolichurus chareshi* Anagha and Girish Kumar sp. nov. Holotype male. (1). Habitus, lateral view; (2). Head, frontal view; (3). Lower half of head, frontal view; (4). Mesosoma, dorsal view; (5). Mesosoma, lateral view; (6). Fore wing; (7). Metasoma, dorsal view

Source: *http://treatment.plazi.org/id/2D07879EFFA0FF95AE87FA9C52ACAE4E*

Figure 5. *Dolichurus sahyadriensis* Anagha and Girish Kumar sp. nov. Holotype ♂. (8). Habitus, lateral view; (9). Head, frontal view; (10). Antenna; (11). Clypeus; (12). Mesosoma, dorsal view; (13). Mesosoma, lateral view; (14). Fore wing; (15). Metasoma, dorsal view

Source: http://treatment.plazi.org/id/2D07879EFFA0FF95AE87FA9C52ACAE4E

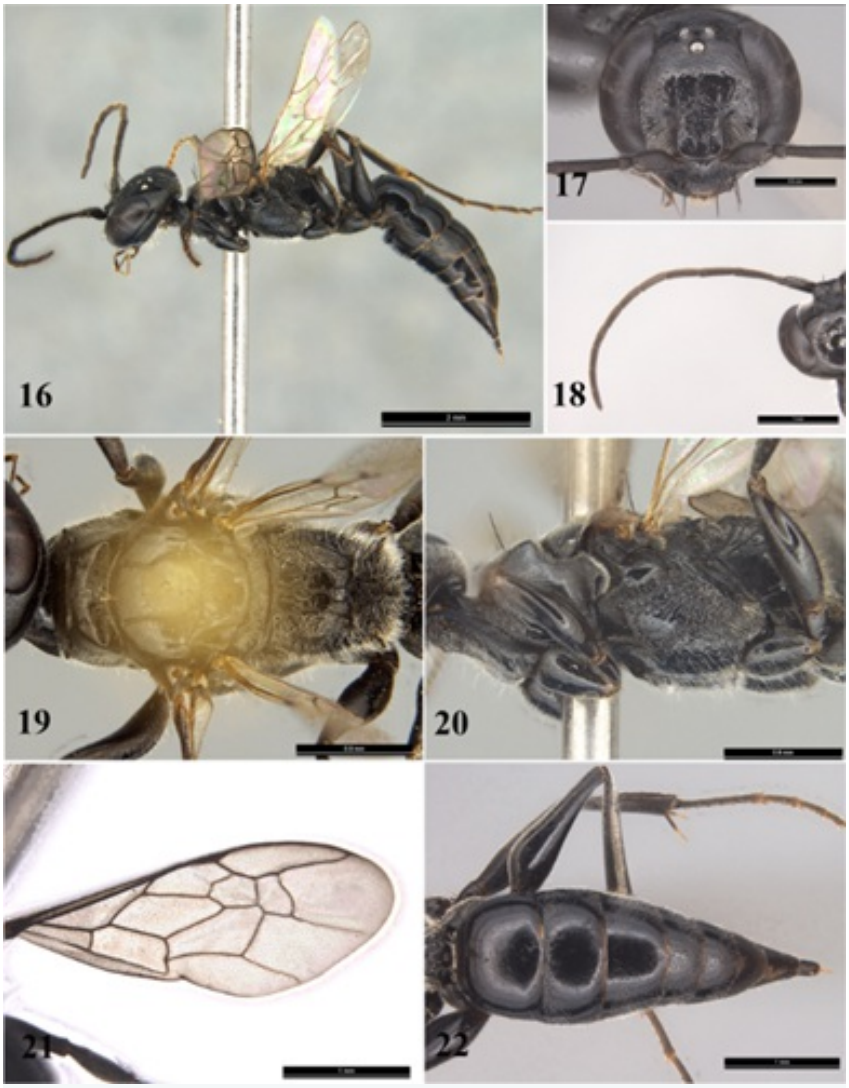

Figure 6. *Dolichurus sahyadriensis* Anagha and Girish Kumar sp. nov. Paratype ♀. (16). Habitus, lateral view; (17). Head, frontal view; (18). Antenna; (19). Mesosoma, dorsal view; (20). Mesosoma, lateral view; (21). Fore wing; (22). Metasoma, dorsal view

Source: http://treatment.plazi.org/id/2D07879EFFA0FF95AE87FA9C52ACAE4E

Figure 7. *Dolichurus gilberti female*. (20); body in profile. (21): Head, frontal view. (22): Clypeus, (23): Antenna up to F7. (24): Head and mesosoma, dorsal view, (25): Mesosoma, lateral, lateral view. (26): Metasoma, dorsal view

Source: https://en.wikipedia.org/wiki/Dolichurus#/media/File:Dolichurus_gilberti.jpg

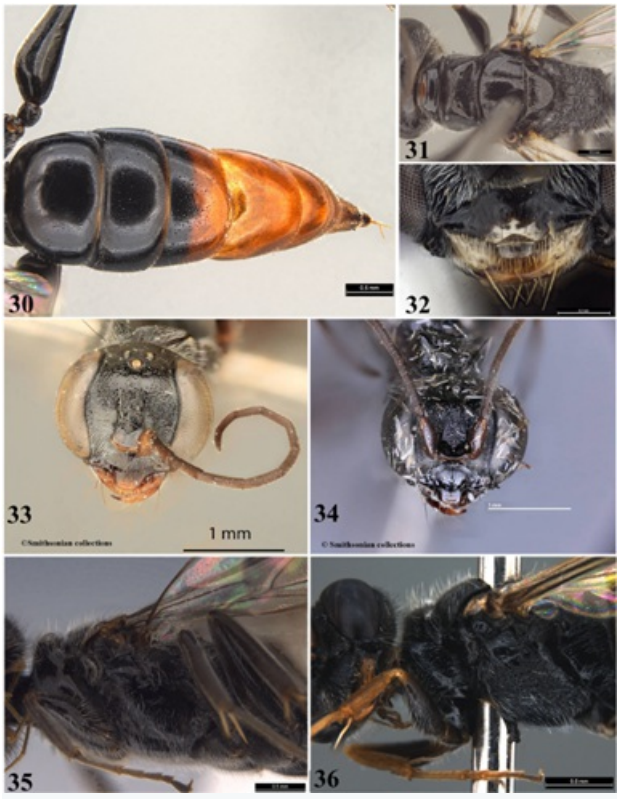

Figure 8. *Dolichurus gilberti* Turner 1912, female metasoma;

(31). *Dolichurus amamiensis* Tsuneki and Iida, femle mesosoma; (32). *Dolichurus albifacies* Krombein, 1979, female Clypeus; (33). *Dolichurus aridulus* Krombein, 1979, female head, frontal view; (34). *Dolichurus lankiness* Krombein, 1809, female head, frontal view; (35). *Dolichurus taprobanae* Smith, 1994, female mesopleuron; (36). *D. aridulus* female, mesopleuron

Source: https://zenodo.org/record/4398312#.ZBIVcsjMLIU

The genus *Dolichurus* is one of the most primitive groups among sphecoid wasps. Sexual dimorphism is not so strong in this genus. In females, antenna 12 segmented and in males 13 segmented. While females have 6 visible metasomal segments, males usually have only three visible segments. In females metasomal punctures are usually fine, almost impunctate with very sparse delicate punctures, surface glossy but that of males are usually coarser (Figure 9) [7][8][9].

Figure 9. Genus *Dolichurus*. Distribution: Oman, Saudi Arabia, United Arab Emirates. Biology: Unknown, but probably prey on cockroaches, as do other species in the genus

Source: http://www.waspweb.org/apoidea/ampulicidae/Dolichurinae/Dolichurus/Dolichurus_arabicus.htm

1.2. Biology

The agile cockroaches are located by the female who seizes one with a cervix or leg, then stings it in the throat or thorax. Since only partial paralysis occurs, the cockroach can continue with slow movements. The wasp then grabs an antenna near the base and carries or drags the prey back to the nest. The female places the prey in the nest and lays an egg quite obliquely on one of the central coxae. After hatching in 1-2 days, the feeding period of the larvae is completed in 4-5 days (Figure 10) [10][11][12].

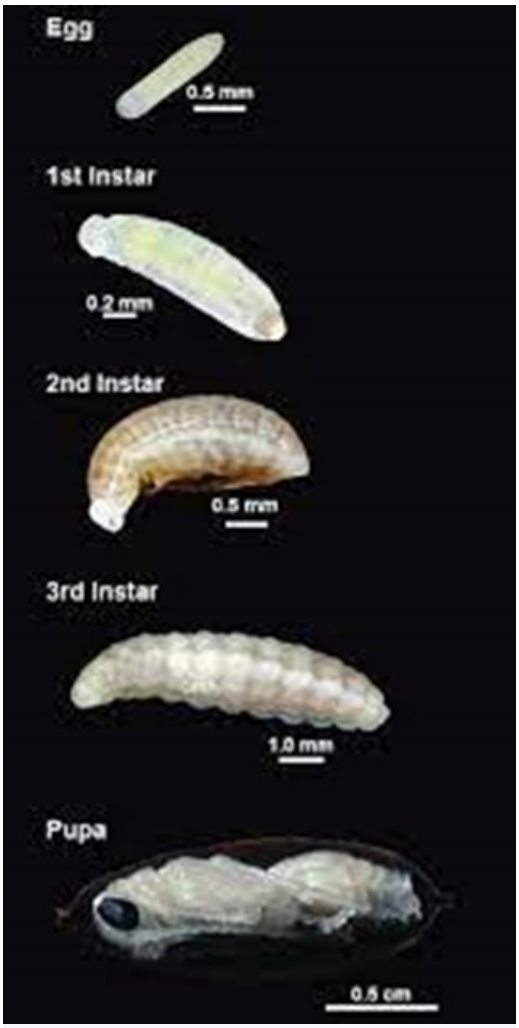

Figure 10. *Ampulex compressa* Fabricius, 1781 life cycle. Life cycle is depicted from egg to pupa.

Source: https://www.researchgate.net/figure/Images-of-the-Ampulex-compressa-life-cycle-Life-cycle-is-depicted-from-egg-to-pupa_fig3_324850197

The females of these wasps are hunters and use their sting to paralyze their prey, providing them while they are still alive, to feed their offspring in nests that range from simple excavations in the ground or the occupation of pre-existing cavities, to the construction of nests with clay or even with vegetable fibers. Although most species exhibit solitary behavior,

various levels of sociality are observed in the group, ranging from simple aggregations to an example of eusociality recorded for *Microstigmus* (Figures 11-12) [10].

Figure 11. Prey on cockroaches, which are weakly paralyzed and dragged backwards by the wasp to the nest. The nest is provisioned with only one cockroach and the egg is laid on the mid-thigh. The nest is closed with plant debris

Source: http://www.waspweb.org/apoidea/ampulicidae/index.htm

Figure 12. Scientific electronic library online first Electronic Library Online First report of “jewel wasp” *Ampulex compressa* (Fabricius, 1781) (Hymenoptera: Ampulicidae) in the Amazon Biome of Brazil

Sources: Scielo and http://old.scielo.br/scielo.php?script=sci_arttext&pid=S1519-69842014003000032&lng=pt&nrm=iso

Many of the insect orders are used as prey, including Thysanopetera, Heteroptera, Psocoptera, Orthoptera, Blattaria, Lepidoptera, Diptera, Coleoptera and Hymenoptera, as well as some families of Araneae and Collembola. For the genus *Microbembex* Patton, 1879, the scavenging behavior is recorded. Due to these habits, one of the most evident ecological roles of this group of wasps is the population regulation of the species they use as prey (Figures 13-18) [10].

Figure 13. *Ampulex compressa* Fabricius, 1781

Source: https://www.anura.it/works/ampulex/

Figure 14. *Ampulex compressa* Fabricius, 1781, female devouring "zombi" sting to the cockroach *Periplaneta americana* (Linnaeus, 1758)

Source: https://www.anura.it/works/ampulex/

Figure 15. After a few minutes and begins to grasp its antenna, cutting them and holding them like a leash

Source: https://www.anura.it/works/ampulex/

Figure 16. The cockroach is taken along a golem and transported toward a hole in the ground

Source: https://www.anura.it/works/ampulex/

Figure 17. The cockroach is taken along a golem and transported toward a hole in the ground

Source: https://www.anura.it/works/ampulex/

Figure 18. The *Ampulex compressa* Fabricius, 1781, female then deposits the cockroach's body and begins to bury it alive using ground and leaves

Source: https://www.anura.it/works/ampulex/

Ampulex compressa Fabricius, 1781, the female needs large, heavy cockroaches *Periplaneta americana (Linnaeus, 1758)* to feed her larva, but cannot carry it to the burrow as other wasps do with their hosts. This species has developed truly incredible behavior, being able to grab the cockroach with powerful jaws and sting it directly into two precise parts of the nervous system. [10].

The first partially and reversibly paralyzes the first pair of legs while the second obliterates only the flight reflexes, leaving the cockroach unharmed but converted into a kind of zombie. That way, she will be able to pick it up in an antenna and take it to a burrow, where she will lay an egg and then bury it alive to avoid predation. [10].

After a few days, the larva emerges and begins to feed on the cockroach from the outside. Upon entering the body of the cockroach, the parasitoid will eat it from the inside. In the end, the big fat larva in the empty dead cockroach will turn into a pupa to give birth in a month to a new beautiful Emerald wasp, which will emerge from the cockroach. (Figures 19-23) [10].

Figure 19. The roach remains buried alive in this role, apparently healthy but carrying on one leg is the future cause of death

Source: https://www.anura.it/works/ampulex/

Figure 20. The *Ampulex compressa* Fabricius, 1781larva starts as an ectoparasitoid, just like a vampire

Source: https://www.anura.it/works/ampulex/

Figure 21. The *Ampulex compressa* Fabricius, 1781, larva starts feeding as an ectoparasitoid, just a vampire

Source: https://www.anura.it/works/ampulex/

Figure 22. The *Ampulex compressa* Fabricius, 1781.larva starts feeding as an ectoparasitoid feeding, just a vampire

Source: https://www.anura.it/works/ampulex/

Figure 23. In it will only emerge after about as one and sadly formed wasp (pupa)

Sources: Ana-Emanuelle Biggi. © Emanuele Biggi All Rights Reserved - P. Iva 01720170990 And https://www.anura.it/works/ampulex/

1.3. Taxonomy

Seven species are recorded under this genus from the Indian subcontinent of which only two species, namely,*Dolichurus gilberti* Turner, 1912 and *Dolichurus taprobanae* Smith, 1869 are recorded from India. In this paper, the genus*Dolichurus* is reviewed from India with the description of a new species, namely, *Dolichurus venkataraman* sp. nov. from Kangra

Valley, Himachal Pradesh. The species *Dolichurus albifacies* Krombein, 1979 and *Dolichurus amamiensis* Tsuneki & Iida, 1964, are recorded here for the first time from India [13][14][15].

The Ampulicidae family is represented by six genera: *Ampulex, Aphelotoma, Dolichurus, Paradolichurus, Riekefella*, and *Trirogma* (Figure 24).

Figure 24. Genus *Paradolichurus*

Source: https://ecuador.inaturalist.org/taxa/250769-Paradolichurus

The genus *Ampulex* has 16 species reported in the Neotropics. the genus *Dolichurus* based on the type species *Pompilus corniculus* Spinola, 1808. This is a cosmopolitan genus with about 50 species worldwide (Nearctic (1), Neotropical (2), Palearctic (6), Ethiopian (10), Oriental (27), and Australian (4) [13][14][15].

1.4. Objective

The aim of this article is to describe the parasitoid behavior of the Ampulicidae Family (Insecta: Hymenoptera).

2. Methods

In terms of the type of research source, scientific articles published in national and international journals were used. This modality of production, in addition to being commonly the most valued in the set of bibliographic production, is the most easily accessed. Access to articles was through virtual libraries such as SciELO, the University of São Paulo, Latin American Literature and the University of Brasilia. In this library, there is a specific section for Hymenoptera, with eight

journals, with texts of articles available in full and theoretical books, these banks, university dissertations, and scientific journals.

3. Selected articles

3.1. Study 1

Classification of Afrotropical Hymenoptera (Wasps, Bees, Ants)

Subfamilies: Ampulicinae and Dolichurinae.

Distribution: Worldwide.

Biology: Nest in stems and crevices. Prey on cockroaches, which are weakly paralyzed and dragged backward by the wasp to the nest. The nest is provisioned with only one cockroach and the egg is laid on the mid-coxa. The nest is closed with plant debris [16][17].

Genus: *Ampulex*

ALgumas especies: *Ampulex assimilis* Kohl, 1893 and *Ampulex bredoi* Arnold, 1947 and *Ampulex* species (Figures 25-26).

Figure 25. *Ampulex assimilis* Kohl, 1893

Source: http://www.waspweb.org/apoidea/ampulicidae/Ampulicinae/Ampulex/Ampulex_assimilis.htm

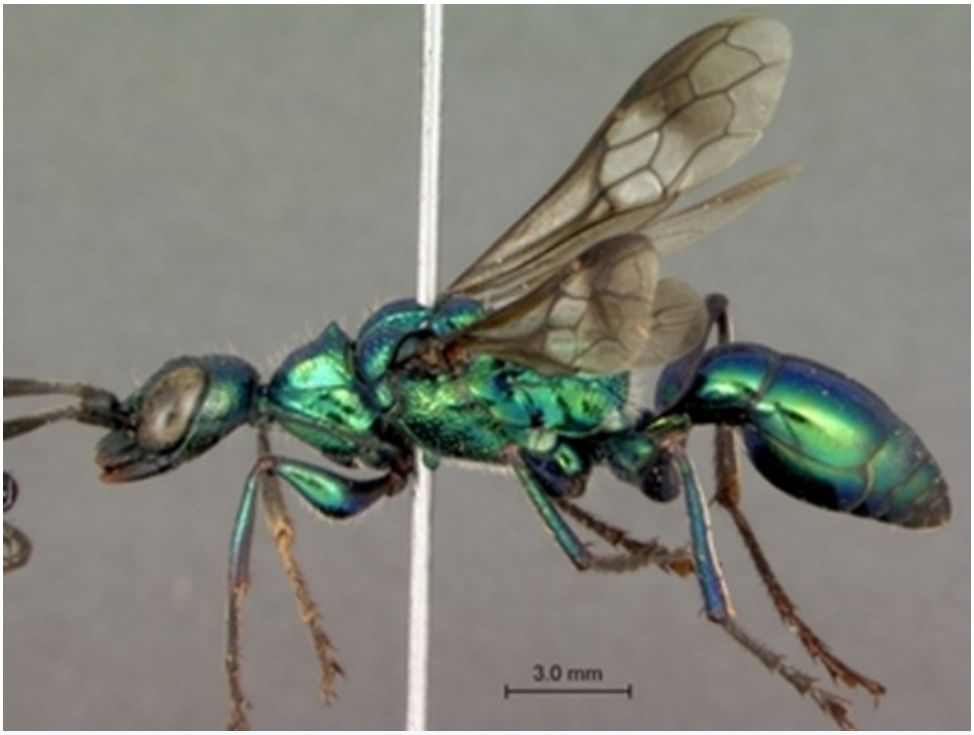

Figure 26. *Ampulex bredoi* Arnold, 1947

Source: http://www.waspweb.org/apoidea/ampulicidae/Ampulicinae/Ampulex/Ampulex_bredoi.htm

Distribution: Worldwide, but most diverse in the tropics.

Biology: Nest in hollow stems and crevices. Prey on cockroaches, which are paralyzed and dragged backward by the wasp to a suitable nest site in a crack or crevice. The nest is provisioned with one or more cockroaches, each prey item being separated with a loose plug of plant debris [16][17].

Genus: *Trirogma* (Extralimital: Oriental, Palaearctic regions).

Distribution: Extralimital: Oriental, Palaearctic regions, present in the Arabian Peninsula (Saudi Arabia, United Arab Emirates), but not reaching the Afrotropical section.

Biology: Nest in stems and crevices. Prey on cockroaches, which are dragged backward by the wasp to the nest[16][17].

Specie: *Trirogma caerulea* Westwood, 1841 (Figure 27).

Figure 27. *Trirogma caerulea* Westwood, 1841

Source: https://www.inaturalist.org/observations/33743277

Distribution: Worldwide

Biology: Nest in stems and crevices. Prey on cockroaches, which are weakly paralyzed and dragged backward by the wasp to the nest. The nest is provisioned with only one cockroach and the egg is laid on the mid-coxa. The nest is closed with plant debris [16][17].

Genus: *Dolichurus*

Distribution: Worldwide

Biology: Nest in stems and crevices. Prey on cockroaches, which are dragged backward by the wasp to the nest.

Algumas especies: *Dolichurus arabicus* Ohl, 2011 and *Dolichurus basuto* Arnold, 1952 (Figure 28) [16][17].

Figure 28. *Dolichurus arabicus* Ohl, 2011

Source:

http://www.waspweb.org/apoidea/ampulicidae/Dolichurinae/Dolichurus/Dolichurus_arabicus.htm

Distribution: Worldwide.

Biology: Nest in stems and crevices. Prey on cockroaches, which are dragged backward by the wasp to the nest[16][17].

3.2. Study 2

The emerald wasp, also called the jewel wasp, is a terrible insect for the cockroach because when it approaches it, with two stings, it paralyzes and makes the cockroach go into “zombie” mode. With the cockroach paralyzed, the wasp drags it to a hiding place and makes a nest of its prey, depositing its eggs in the body of the cockroach. When the larvae are born, the cockroach serves as food for the wasp's offspring (Figure 29) [18].

Figure 29. A cockroach wasp *Ampulex ferruginea* Bradley, 1934 stings and subdues a wood cockroach (*Parcoblatta* sp.)

Sources: Clarence Holmes Wildlife / Alamy Stock Photo File size:82.2 MB (2 MB Compressed download) Releases: Model - no | Property - noDo I need a release? Dimensions:6565 x 4379 px | 55.6 x 37.1 cm | 21.9 x 14.6 inches | 300dpi Date taken:2 April 2022. Location: Oak Point Park and Nature Preserve, Plano, TX, United States

The scene of the wasp preying on the cockroach is sinister and makes us feel sorry for this insect, which, even though it is 4 times larger than its predator, is completely inert and defenseless! Even if it is saved before being dragged away by the jewel wasp, still, the cockroach is totally groggy, like a living dead that can't move (based on real events, because witnessed it) (Figure 30) [18].

Figure 30. Emerald cockroach wasp, *Ampulex dementor* Ohl, 2014, Insect, Ampulicidae, Hymenopterans. The few species whose biology is known are parasitoids of cockroaches; they typically inject venom into the roach that subdues or immobilizes it and then lay an egg on the defenseless roach

Source: https://alchetron.com/Ampulex

It all starts when a female jewel wasp realizes that she is close to the egg-laying season and goes looking for a safe place to have her young. "When finding a cockroach, the jewel wasp attacks it by stinging its brain, thereby inhibiting the insect's senses so that it is at the mercy of its commands. "They sting the prey not with the aim of killing, but of anesthetize. The poison is a neurotoxin, which paralyzes the cockroaches" (Figure 31) [18].

Figure 31. The poison is a neurotoxin, which paralyzes the cockroaches

Source: https://alchetron.com/Ampulex

By applying the stings to the cockroach's brain, the jewel wasp starts to guide the animal, pulling it by the antennae and directing it to a place where its offspring's nest and refuge will be. The strategy keeps the victim's body still warm, to serve as a nursery for its young and also as food, because the jewel wasp will deposit its eggs in the joints of the cockroach's legs. When the eggs hatch, the chicks begin to feed on the entire interior of the victim, leaving only an empty shell of the cockroach [18].

3.3. Study 3

The jewel wasp is the species *Ampulex compressa* Fabricius, 1781, of the Ampulicidae family. The species is also known in northwest Hawaii as the kanassa wasp [19].

3.3.1. Origin

Ampulex compressa is believed to be native to South Asia, Africa and the Pacific Islands, and is believed to have spread around the world via cargo ships (Figure 32) [19].

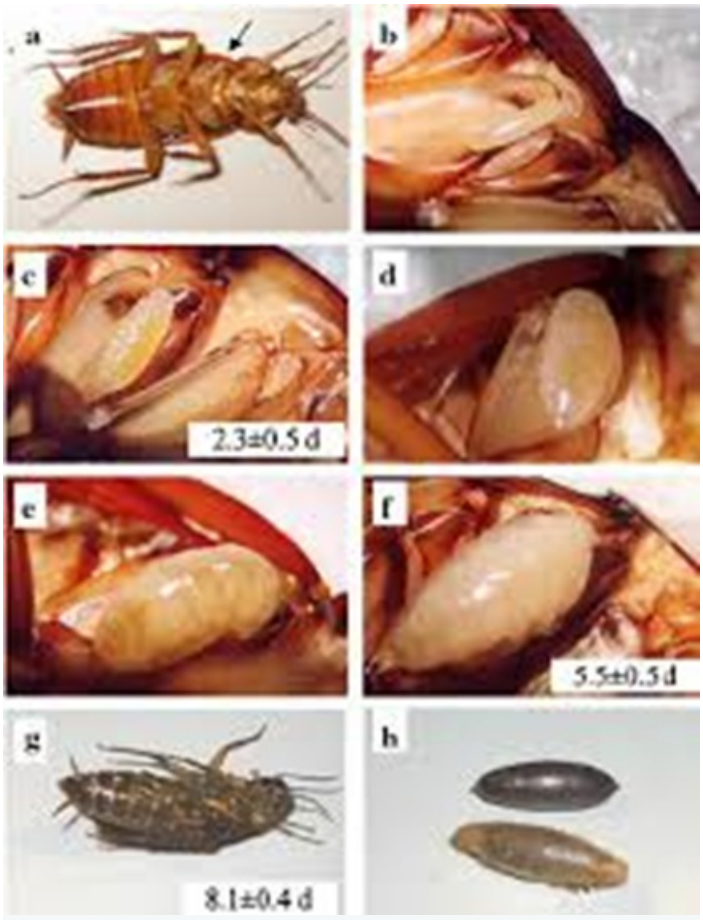

Figure 32.

(a) A single egg laid by A. compressa on each stung cockroach.

(b) The egg is glued to the middle coxa of a cockroach (higher magnification of (a). This exact spot is unreachable by the cockroach.

(c) A larva, as big as the egg, hatches within about 2 days.

(d), (e) The larva bites a hole in the cockroach coxa and feeds on hemolymph.

(f) About 5 days after the egg was laid, the larva is ready to penetrate the cockroach.

(g) The larva consumes the organs of the cockroach and pupates inside the cockroach, which dies at this stage. The pupa fills most of the cockroach's abdomen

Source: https://www.researchgate.net/figure/Development-of-Ampulex-compressa-larva-a-A-single-egg-arrow-is-laid-by-A-compressa_fig1_7872778

3.3.2. Characteristics

This insect has an emerald green color and has solitary habits[19].

3.3.3. Predation

This insect species is considered a nightmare for cockroaches, despite being able to attack several other insect species, depending on the ecosystem in which it is found [19].

3.3.4. Procreation

After they are born, the jewel wasp larvae feed on the hemolymph of the still-living cockroach, and after about a week, they invade the interior of the cockroach, feeding on its organs, until only the exoskeleton (external layer) remains. /insect body shell). If you find the remains of a cockroach without its head, “belly” and legs, it was probably caught by a jewel wasp [19].

3.4. Study 4.

Ampulicidae of Egyptian.

Ampulicidae; Ampulicinae; Ampulicini.

Dolichurus Latreille, 1809

Dolichurus species may be recognized readily by the U-shaped frontal platform which covers the antennal sockets, by the filiform antennae, the long pronotum, the presence of notauli (a pair of longitudinal grooves) on the mesonotum and the very shiny appearance. The genus occurs on all continents. Its members nest in stems and crevices and prey on cockroaches. They are usually seen running or skipping over leaf litter or on trunks of trees in search of their prey [20].

Only one species has been recorded from Egypt.

Dolichurus haemorrhous Costa, 1886 (Figure 33).

Figure 33. *Dolichurus haemorrhous* A. Costa, 1886, ♀. Collection data: Mellieħa (St Maria Estate), 25.vii-25.viii.2017 (malaise trap), leg

Sources: D. Mifsud and https://www.researchgate.net/figure/Dolichurus-haemorrhous-A-Costa-1886-Collection-data-Mellieca-St-Maria-Estate_fig1_348199591

Male. Morphology: Upper part of mesopleurae punctate-rugose. Clypeus with shining median carina, anterior edge emarginate; the emargination contains a median tooth. (T1) strongly punctate, the spaces 1-2 times as large as the punctures; (T2) less strongly punctate, the spaces as large as the punctures; (T3) even more finely punctate, the spaces smaller than the punctures; S3 elongate posteriorly, its margin convex. Length: 5.5mm [20].

Female. Morphology: Upper part of mesopleurae punctate-rugose. (T1) punctate-rugose, particularly above and behind the spiracle. Length: 6.5mm [20].

Range: Italy, Portugal, Egypt

Distribution: Giza. [20].

3.5. Study 5

In the following work, the biology of *Ampulex angusticollis* Spinola, 1842, is disclosed, where reference is made to parasitism on *Lamproblatta albipalpus* Hebard, 1919 (: Blattodea: Blatiidae) (Figure 34) [21].

Figure 34. *Ampulex angusticollis* Spinola, 1842

Source: https://sv.wikipedia.org/wiki/Ampulex_angusticollis

It was possible to observe three individuals of parasitized L. albipalpis, one egg was observed in each parasitized cockroach, in the three individuals observed. The three parasitized hosts (cockroaches) were hidden in nests (pre-existing cavities of trunks, and in the ground) [21].

During the observations, images were taken in the field and the three parasitized hosts were collected, with the aim of obtaining an adult of the parasitoid and in the same way identifying the three hosts. The collected *L. albipalpis* individuals were placed in containers for transport to the laboratory [21].

In the laboratory they were kept in adequate conditions of temperature and humidity so that the parasitoid continued its life cycle, after three days the egg hatched and the larvae began to devour their hosts; after five additional days the larvae of the parasitoids pupated; after an additional seven days, the adults of the parasitoid *A. angusticollis* emerged (Figure 35) [21].

Figure 35. *Ampulex angusticollis* Spinola, 1842

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

Once classified, the specimens were mounted and deposited in the MIUP collection. The parasitism behavior of one of the *A. angusticollis* wasps was visually observed when it attacked a nymph that initially injected its venom into the ventral part, from the base of the head, to paralyze the cockroach. The wasp injects the venom so that it reaches the part of the brain, gets paralyzed, but still stays alive and immediately tows or drags it to its nest to place an egg in the part ventral between the first and second coxa, causing ectoparasitism in the nymph of the cockroach *L. albipalpis* [21].

Figure 36. Parasitism of *Ampulex angusticollis* Spinola, 1841 (Ampulicidae: Hymenoptera) on *Lamproblatta albipalpis* Hebard, 1919 Blatodea:Blatidae)

Source: https://www.nationalgeographic.com/science/article/the-wisdom-of-parasites

Hatched the larva is nourished by absorbing the internal fluids of the cockroach that still. It was still alive, after a few days the larva of *A. angus*ticollis continued to feed inside the body of its host (*L. albipalpis*) to finish its larval stage and start to pupate. The larvae pupated in the same chamber that had been initially built. Twelve days after the *A. angusticollis* larvae pupated, three individuals emerged that were preserved in alcohol for identification and mounting [21].

4. Conclusion

The Spheciformes wasps, make up a cosmopolitan group of wasps that hunt insects, spiders and springtails with a generally solitary habit. This group presents a great morphological, ecological, biological and behavioral diversity; for these reasons, systematic classifications of the spheciform wasps in the Superfamily Apoidea along with the bees and currently recognize four families: Heterogynaidae, Ampulicidae, Sphecidae and Crabronidae.

References

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