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Editorial Article

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Biology of Aquatic Insect of Order of Hymenoptera in the World A Systematic Review

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Abstract

The aquatic hymenoptera is a small, little-known group that adapts to the aquatic environment and interacts with water as part of its biological cycle. Aquatic hymenoptera are found in all geographical areas, except Antarctica. In total known species of aquatic Hymenoptera, 150 species from 11 families are recognized. Most of aquatic Hymenoptera species belong to the families of Chalcididae , Eulophidae, Mymaridae, Trichogrammatidae, Scelionidae and Pompilidae. In some family like Pteromalidae, Figitidae , Cynipoidea, Braconidae , Diapriidae , Proctotrupoidea limited number of aquatic genus was seen. Because of their short, dense pubescence on the body and wings and elongated, strongly curved claws they have been successful in life on the fresh water. Most of them are endoparasitoids of immature insects. Although little information is available about aquatic hymenopteran, these insects play an important role in human life. Therefore, knowledge of the biology, physiology and ecology of these insects can be of great help in advancing the field of biological control and its effects on human life.

Keywords: Aquatic Hymenoptera, Parasitoids, Biological Control

Introduction

In land waters cover less than 1 percent of the earth's surface but are home to more than 6 percent of all insect species: Approximately 100,000 species from 12 groups live in one or more stages of freshwater [1].

Aquatic insects are found at the intersection of terrestrial and predominantly freshwater ecosystems such as lentic systems, for example, lakes, ponds, lagoons, swamps, as well as aquatic systems such as springs, streams, and rivers, when only a few are actually they exist [2]. Aquatic insects contribute to the nutritional structure of ecosystems by performing functional roles from insectivores to predators, as well as food sources for vertebrates and invertebrates. Five insect orders that are often considered fully terrestrial are known to have aquatic representatives: Blattodea, Hymenoptera, Lepidoptera, Mecoptera, and Orthoptera [3].

In total known species of aquatic Hymenoptera, 150 species from 11 families are recognized as aquatic (0.13% of the total described species). This number is likely an underestimate, because of the high percentage of undescribed species and a lack of knowledge of host range and behaviour for most species. All Hymenoptera are parasitic aquatic animals. Many species have relatively dense maturity to trap air and elongate, tarsal claws to grip the substrate, when underwater [4].

Hymenopterans undergo a complete metamorphosis, and most species may be identified by having four membranous wings with a series of hook-like hairs known as homoli. Plesiomorphic biological status is vegetarianism (most saw flies) with transmission to parasitoidism and predation in more derived groups. Most ureters are parasitoids that grow inside or on a host arthropod and kill the host in the process. Some parasitoid species parasitize eggs or pupae, but most lay eggs in or on host larvae [3]. Most are endoparasitoids of immature insects that are actually embedded partly or almost completely inside the host plant tissue or other submersed substrates or on floating substrates [5]. There are at least two characteristics of aquatic Hymenoptera that appear to be adaptive to life underwater: 1- short, dense pubescence on the body and wings that allows the wasp to be hydrophobic, as well as to maintain a plastron of air around the body; 2- elongated, strongly curved claws that allow gripping of the substrate, so that the female does not float to the surface or be swept in currents when searching for hosts. Not all aquatic wasps have either or both of these features, but many do(4)Most of aquatic Hymenoptera species belong to the families Eulophidae, Mymaridae, Trichogrammatidae and Scelionidae [6].The hosts of these Hymenoptera egg parasitoids belong to the orders Coleoptera, Hemiptera and Odonata. Only Mymaridae was also collected on Lepidoptera eggs. The aquatic plants Eichhornia crassipes, Thurnia sphaerocephala, Tonina fluviatilis

and Urospatha sagittifolia were used as substrates by the hosts of the collected hymenoptera [7].

Methods

We searched published articles by search terms “aquatic hymenopteran” and “parasitoids” . Data were extracted from all articles 1983 to 2021 were used. An intensive search of scientific literature was reviewed using the search term in the following databases: “PubMed”, “Web of Knowledge”, “Scopus”, “Google Scholar”, “SID”, etc.

Results and Discussion

The aquatic hymenoptera is a small, little-known group that adapts to the aquatic environment and interacts with water as part of its biological cycle. they are known from six superfamilies and 11 families. The two largest families, Ichneumonidae and Braconidae, have the two greatest numbers of aquatic species. Hymenoptera parasitize at least 25 insect families in the orders Odonata, Hemiptera, Megaloptera, Coleoptera, Diptera, Lepidoptera and Trichoptera. Aquatic hymenoptera are found in all geographical areas, except Antarctica. Most aquatic Hymenoptera have been collected from lentic environments, but at least onethird of the species are associated with lotic habitats. For example, the 16 species of Agriotypus are only found in fast-running streams in Europe and Asia and species of the diapriid genus Psychopria Masner and Garcı´a occur in running water in the new world (4) (Figure 1). The most noteworthy area of aquatic wasp endemicity is Hawaii.

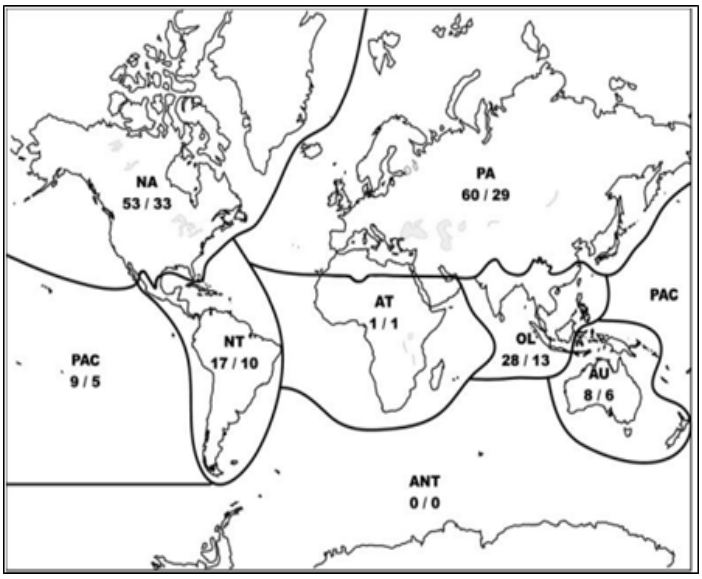

Figure 1: Distribution of aquatic Hymenoptera species and genera by zoogeographical region (species number/genus number). PA—Palaearctic; NA—Nearctic; NT—Neotropical; AT—Afrotropical; OL—Oriental; AU—Australasian; PAC— Pacific Oceanic Islands, ANT—Antartic(4).

All known aquatic Hymenoptera are parasitoids. female adults enter the water to search for hosts, those with endoparasitoid larvae inside aquatic larval hosts (even if oviposition is terrestrial); and those in which freshly eclosed adults must travel to the water’s surface following pupation (even if they develop inside stems of emergent vegetation)(4).

The superfamilies Chalcidoidea, Cynipoidea, Platygastroidea, Diaprioidea and Ichneumonoidea have aquatic representatives. In the neotropic region, aquatic egg parasites were found in Eulophidae, Mymaridae, Trichogrammatidae (Chalcidoidea) and Platygastridae (Platygastroidea). Ichneumonidae (Ichneumonoidea) parasitize the larvae and / or pupae of Lepidoptera. While Braconidae (Ichneumonoidea), Diapriidae (Diaprioidea) and Figitidae (Cynipoidea) parasitize pupae and / or pupae of aquatic insects(1). In addition, the adult Pompilidae (spider bee) of the genus Anoplius dives underwater to prey on semi-aquatic spiders(8).

Here we checked out aquatic hymenoptrans species from six superfamilies and 11 families.

Characteristic of aquatic Hymenopterans

1-Superfamily: Chalcidoidea

They are very diverse and more than 23,000 species have been described and more than 500,000 species estimated to exist. Chalcidoidea (Hymenoptera) are small wasps that are usually between 1-4 mm in size, with the smallest only 0.11 mm and the largest up to 45 mm. Most of them are parasitoids. They attack immature and adult stages of almost all insect orders, but have their greatest diversification on the Hemiptera and Holometabola. Because the individual host is killed by parasitoid growth, many calcid species are successfully used as biological control agents for agricultural and ornamental pests (such as Aphelinidae and Encyrtidae). Both economically and ecologically Chalcidoidea is extremely importat in both natural and managed ecosystems(9).

Family: Chalcididae

Prestivichia aquatica, is parasitic on the eggs of Notonectus and Dytiscris, and swims with its legs instead of its wings (10,11) (Fig.2).

Figure 2: Family: Chalcididae
https://en.wikipedia.org/wiki/Chalcididae

Family: Eulophidae

Eulophidae is a very diverse family of calcidoid parasitoids that are represented worldwide by 4 subfamilies, 324 genera and about 6000 species. The Palaearctic region contains about 2,000 species in 130 genera. The body of Eulophids is usually relatively weakly sclerotized, the whole tarsi is always 4 segmented. Antenna with funicle at most 4-segmented and often with branches in males. Mesoscutum of many species with distinct and complete notauli. scutellum with two sublateral grooves. The members of Eulophidae parasitize many hosts of different orders of insects, but a small number of them are parasitoid spiders, Erythroid mites and even nematodes. Tetrastichinae subfamily species are small calcides, 0.6 to 3. mm length. Their larvae parasitize other insects, first of all, representatives of Diptera, Lepidoptera, Coleoptera, and Hymenoptera. Tetrastichine wasps of the Middle Volga River Region can be subdivided into larval ecto-, endo-, and hyperparasitoids and also into larval-pupal and egg parasitoids. Tetrastichine wasps of the Middle Volga River Region is given, the species *Quadrastichus rosarum* sp. n. is described, and the rare species *Aprostocetus populi* (Kurdjumov), carina. n. is redescribed (12) (Fig.3).

Figure 3: Family Eulophidae
http://www.waspweb.org/chalcidoidea/eulophidae/index.htm

Family: Mymaridae

Mymaridae is one of the families of parasitic Hymenoptera that have species with aquatic habits [13]. Caraphractus cinctus Walker (Mymaridae), a parasitoid of dytiscid beetle eggs, has been extensively studied and is known to swim with its wings and mate inside submerged eggs, although both of these habits are unusual. Most aquatic female wasps walk along the substrate in search of aquatic hosts and mate out of water (Figure 4) [4].

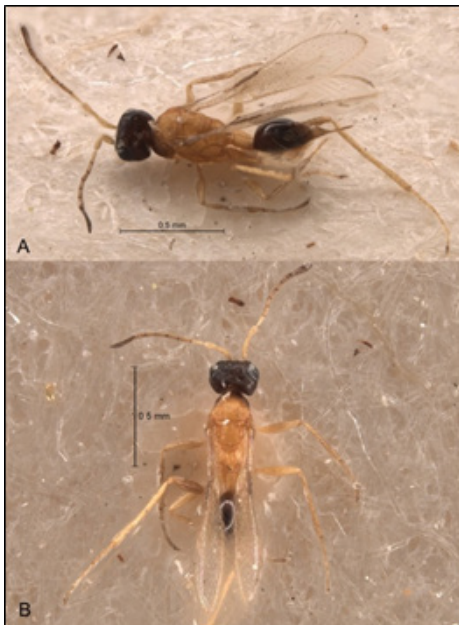

Figure 4: Family: Mymaridae, *Eustochus (Caraphractus) cinctus* (Walker, 1846), female (holotype of Caraphractus fl avicollis Hellén, 1974): A -habitus in dorsolateral view; B -habitus in dorsal view
(https://www.researchgate.net/figure/Eustochus-Caraphractus-cinctus-Walker-1846-female-holotype-of-Caraphractus-fl_fig5_346761044)

Polynema natans belongs to the Mymarine (Ploctotlypidre), and similar to the Marchal species in its swimming method, but its wings are somewhat defective and it is thought that it cannot fly well. Caloptrix eggs are parasitic with them (Figure 5) [10, 11].

Figure 5: Family: *Mymaridae Polynema sp.* http://www.waspweb.org/Chalcidoidea/Mymaridae/Polynema/Polynema_sp_nr_dikobraz.htm

Several species of Anagrus are important egg parasitoids of various pests belonging to Auchenorrhyncha (Hemiptera), and a few mirid and tingid bugs (Heteroptera: Miridae and Tingidae, respectively) [13]. Anagrus amazonensis (Hymenoptera, Mymaridae) is a parasitoid that uses aquatic insect eggs as a host for the development of its immature stages. the interaction between A. amazonensis and its hosts and the aquatic plants used by these hosts to lay their eggs A [6]. amazonensis emerged from eggs of Hemiptera, Lepidoptera, and Odonata. A. amazonensis parasitized eggs placed on the underside of the macrophyte's leaves, with the exception of lepidopteran eggs, which were placed on the upper surfaces of the leaves [6]. It was observed parasitizing Odonata (Zygoptera) eggs deposited on *Rhynchospora pubera* (Figure 6) [5].

Figure 6: Family: Mymaridae, genus (Anagrus) https://species.wikimedia.org/wiki/Anagrus_(Anagrus)

Family: Pteromalidae

Pteromalidae is one of the largest families of parasitic Hymenoptera, whose members are scattered throughout zoogeographical regions of the world. It currently contains 588 genera and 3506 species in 30 subfamilies. Pteromalidae is most diverse family of parasitic Hymenoptera and have different forms of parasitism: single and multi, ecto and endoparasitism. They parasiting eggs, larvae and pupae and imago of insect (imagobointy). Pteromalidae is an economically important family that regulates the abundance of many agricultural pests, as many species are primary parasitoids [14]. Pteromalidae is characterized by having 5-segmented tarsi. Four tibial spur curved and bifurcate, antenna usually 13-segmented if clava counted as three segments, ovipositor rarely strongly exserted. Postmarginal and stigma veins of fore wing usually well-developed and mesopleuron not swollen and convex (Figure 7) [15].

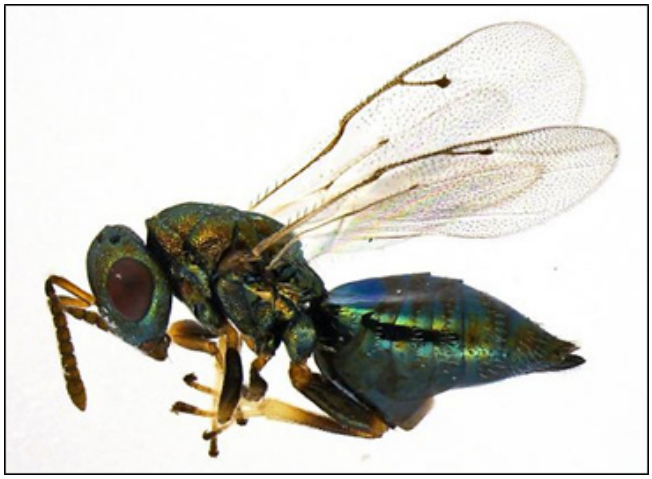

Figure 7: Family: Pteromalidae https://bugguide.net/node/view/1303828

They are predominantly primary or secondary, solitary or gregarious parasitoids in the larval and pupa stages or, rarely of eggs or adults, of holometabolous insects, most commonly of Lepidoptera, coleopteran and dipteral. Some of them are predators or parasitoids of eggs of different families of hemiptera, and few are related to the egg cocoons of spiders [15].

Family: Trichogrammatidae

Trichogrammatidae contains species that are parasitoids eggs of several insects' orders. It is one of the smallest families of Chalcidoidea, containing only about 55 genera in the New World. Except for the genus Trichogramma, which is used in biological control programs worldwide, this family is not well known in the neotropical region. However, some trichogrammatids attack eggs of aquatic insects laid in plant tissue (e.g. *Hydrophylita* and C*haetostrichelCa spp.* are parasitoids of odonate eggs) [16].

Centrobiopsis Girault in this family is aquatic Hydrophylita is a small genus of Trichogrammatidae which now includes four spe-

cies, all known to attack eggs of damselflies (Odonata: Zygoptera). *Hydrophylita Ghesquie`re* (Trichogrammatidae) in this genera is aquatic [5].

Hydrophylita neusae Querino and Pinto (Hymenoptera: Trichogrammatidae) was found associated to Odonata eggs deposited on leaves of *Thurnia sphaerocephala* Hook. (Thurniaceae) [5].

Hydrophylita sp. was found in aquatic habitats and parasitizes eggs of Zygoptera. The ratio most Anisoptera to Zygoptera species is an indication of a disturbed river. The importance of parasites and parasitoids as causes of mortality on these insects is not well understood. Although some work on adult impact has been done, their importance on the egg and larval stages of Odonata remains unknown. *Hydrophylita neusae* is widely distributed in the Neotropics and is commonly collected in aquatic habitats. This suggests that it is an important parasitoid of damselfly eggs (Figure 8) [5].

Figure 8: Family: Trichogrammatidae
A habitus of *Hydrophylita neusae* (female), arrow at ovipositor. B. habitus of *Hydrophylita* sp. A (female), arrow at ovipositor.
https://zenodo.org/record/175890

Pseudoligosita is a cosmopolitan genus, and like other Oligositinae genera in South America it found in Argentina, Bolivia, Brazil, Colombia, Uruguay and Venezuela . Species of this genus have been listed as parasitoids of eggs of Hemiptera (Auchenorrhyncha), Orthoptera (Tettigoniidae) and Coleoptera (Chrysomelidae: Hispinae) .*Pseudoligosita longifrangiata* (Viggiani) had only been collected previously in Argentina and Uruguay with no information on its host. Information on the biology of aquatic microhymenopterous parasitoids is scarce, especially in the Neotropics [8]. *Pseudoligosita longifrangiata* (Viggiani) (Hymenoptera, Trichogrammatidae) was recorded for the first time in Brazil that isparasitizing eggs of *Argia insipida* Hagen in Selys (Odonata, Coenagrionidae) deposited on *Tonina fluviatilis* [5]. Eggs of A. *insipida* are separately and endophytically laid both on leaves and on branches without sequential pattern . They are elongated, cylindrical and yellow, with relatively sharp ends, as is characteristic of species with endophytic egg laying . A translucent egg chorium allows detection of obvious differences in the Odonata or parasitoid development. Where Odonata embryos are present, the eggs have light coloration and the embryo body shape can be visualized, including the eyes, which are at the lateral sides at late stages of development . In the presence of the parasitoid, the egg has a darker in color and its pupa can be clearly visible through the chorium . Hatching of *A. insipida* larvae happens through the anterior end of the egg , while parasitoid emergence occurs through a lateral (Figure 9) [12].

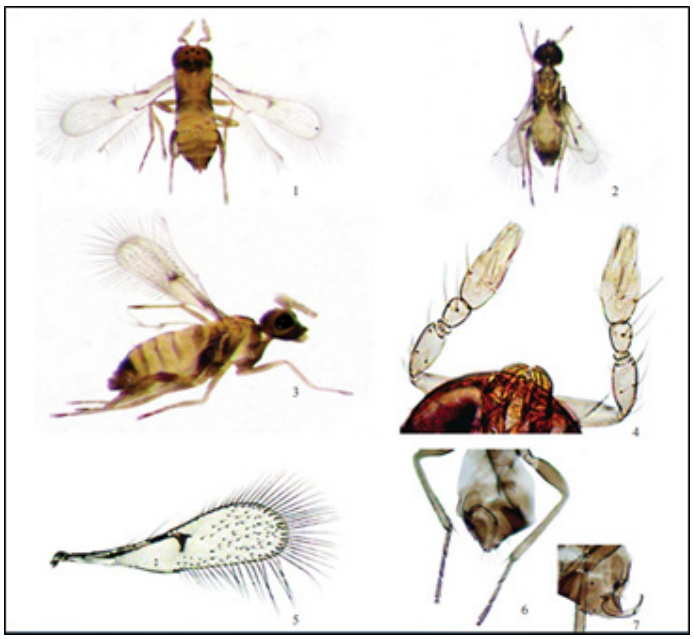

Figure 9: Family: Trichogrammatidae

Pseudoligosita longifrangiata, adult male. 1. Dorsal view. 2. Ventral view. 3. Lateral view. 4. Antenna. 5. Forewing. 6. Genitalia, ventral view. 7. Genitalia, lateral view [4].

In Brazil, the only Hymenoptera egg parasitoid of Odonata reported is *Hydrophylita lestesi* (Trichogrammatidae), which was observed parasitizing, eggs of *Lestes* sp. (Lestidae) on leaves of *Hedychium coronarium.* In addition *Lathromeroidea sp.* (Trichogramatidae) as a parasitoid of Gerridae eggs and Trichogramma species parasitizing eggs of Sialidae (Megaloptera) [4]. The genus Lathromeroidea (Trichogrammatidae) comprises five described species, of which only *L. odonatae* Ashmead is known from North America. This species was originally described from damselfly hosts of the genus Lestes [16].

2- Superfamily: Cynipoidea

Cynipoid wasps are a relatively diverse lineage of Hymenoptera. Species range from being internal parasitoids of endopterygote insect larvae, including hyperparasitoids, to gall inducers on higher plants [17].

Family: Figitidae

The family Figitidae (Hymenoptera: Cynipoidea) is a cosmopoli-

tan group that includes 1400 species in 132 genera, classified into 12 subfamilies. The subfamilies, Eucoilinae, Charipinae, Figitinae, Aspicerinae and Anacharitinae have worldwide distribution. Figitinae comprising of 170 species under 14 genera stands third in species diversity, is a heterogenous and paraphyletic group and are primary parasitoids of the Schizophoran flies.they can be distinguished by their second abdominal tergite being ring or collar-like, sclerotised and sometimes large, usually furrowed or carinate [18].

The four species of *Aspidogyrus Yoshimoto* (Figitidae) are endemic to Hawaii and parasitize fly larvae in streams (Figure 10).

Figure 10: Family: Figitidae
Figites aciculatus (Benoit): 1. Habitus; 2. Mesosoma in dorsal view; 3. Mesosoma in lateral view; Figs. 4-6. *Xyalophora provancheri* Jimenez & Pujade-villar: 4. Habitus; 5. Mesosoma in dorsal view; 6. Mesosoma in lateral view(18).

They are biologically characterized as parasitoids of the larvae of other insects, principally *Diptera* and Cyclorrapha, except for the subfamily *Charipinae*, which is parasitoids of Hemiptera [19].

3-Superfamily: Ichneumonoidea

Of 150 aquatic species, 39 are species of Ichneumonidae, representing the highest number of aquatic species among hymenopteran families. The life history and host-searching behaviour of aquatic Ichneumonids are well known only for two Agriotypus species (Agriotypinae) parasitic on caddisflies [4].

Within the Ichneumonidae, species in at least five genera appear to be exclusively aquatic: *Agriotypus Curtis (Agriotypinae)* on *Trichoptera Rhachioplex Bischoff (Campopleginae), Pseuderipternus Viereck (Cremastinae),Tanychela Townes (Cremastinae)*

Family: Braconidae

Braconidae is the second largest family (after Ichneumonidae) of Hymenoptera, includes at least 1500 species classified under 1000 genera in the world [14]. Most species are idiobiont ectoparasitoids of concealed larvae of xylophagous and stem-boring Coleoptera and Lepidoptera larvae and rarely of Diptera and Symphyta. Several genera are gregarious endoparasitoids of Lepidoptera pupae [20]. Most hosts of Braconine wasp are Coleoptera, Lepidoptera, Diptera, Hemiptera and phytophagous Hymenoptera

Subfamily: Alysiinae

The subfamily Alysiinae (Hymenoptera: Braconidae) is widely distributed around the world and has potentially be used as biological control agents of the cyclorrhaphous dipteran larvae. A total of 20 Alysiinae species under eight genera were successfully identified [21].

Subfamily: Braconinae :

The family Braconidae contains 46 subfamilies. Braconinae, one among them, is the largest and most diverse of the family Braconidae, comprising more than188 genera [21].

Subfamily: Microgastrinae

Microgastrinae are cosmopolitan braconid wasps, that contain solitary or gregarious koinobiont larval endoparasitoids which attack a wide range of Lepidoptera. Microgastinae ranks as the second most diverse and largest subfamily of Braconidae, with more than 2,230 described species. There are 757 species of Microgastrinae currently known in the Palaearctic region of which 529 are recorded from the western Palaearctic region and 496 from eastern Palaearctic region [22].

Dolichogenidea amaris (Figure11) and *Hygroplitis rugulosa* (Figure 12) are the wasps that parasitizing lepidopteran larvae which are aquatic (Figure11).

Figure 11: Dolichogenidea sp.

Figure 12: Hygroplitisrugulosa
https://www.commanster.eu/Commanster/Insects/Bees/SpBees/Hygroplitis.rugulosus.htm

Microgaster godzilla is an unusual new species from Japan which dives underwater to parasitize its caterpillar host (Lepidoptera, Crambidae, Acentropinae) It represents only the third known microgastrine to be aquatic, and the first one to be found entering the water. The female wasp searches for its hosts, aquatic larvae of *Elophila turbata* (Lepidoptera: Crambidae), mostly by walking over floating plants, but occasionally diving underwater for several seconds to force the larva out of its case, when it is quickly parasitized (parasitization was always observed above water). The wasp has simple tarsal claws, which are elongate and strongly curved, similar to those found in the related genus Hygroplitis; they seem to represent an adaptation for gripping to the substrate when entering the water (Figure13) [23].

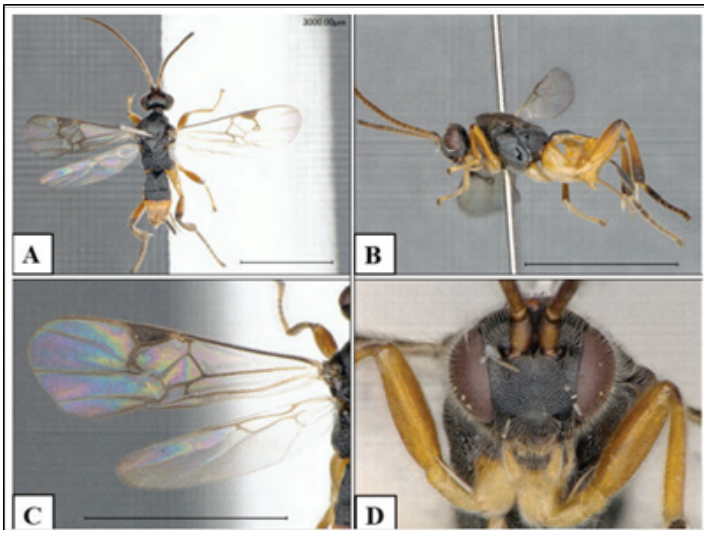

Figure 13: Microgaster godzilla (Hymenoptera, Braconidae, Microgastrinae)(24).

Subfamily: Opiinae

The Opiinae is one of the largest subfamilies containing about 2063 described species worldwide. Opiinae are important for biological control of Diptera, mostly belonging to the families Agromyzidae, Anthomyiidae, Drosophylidae, Ephydridae and Tephritidae). *Opius wesmael*, 1835 is the largest genus of Opiinae with 38 subgenera and more than 1000 described species worldwide. Some species are recognized as important biocontrol factors of leaf-miner flies (Agromyzidae) and fruit flies (Tephritidae) [24].

As part of a biological control programme against submerged aquatic weeds in South Africa, three undescribed species of hymenopterous parasitoids were reared from unidentified ephydrid flies, a group that includes important biological control agents of submerged macrophytes . All three species belong to the Braconidae and to two genera: *Ademon haliday*, (Opiinae) and *Chaenusa haliday*, (Alysiinae: Dacnusini). Ademon has a Holarctic (with extension in the North Oriental) and Afrotropical distribution; Chaenusa is a nearly cosmopolitan genus. Both contain aquatic parasitoids of Hydrellia spp. (Diptera: Ephydridae).. Both genera are new for South Africa; in the Afrotropical region Ademon is only reported from Angola and Chaenusa only from Madagascar [25].

The braconid genus *Ademon Haliday* (Opiinae) is almost exclusively associated with *Hydrellia spp.* larvae in emergent vegetation (Figures 14,15) [4].

Figure 14: Ademon lechrilophodes sp. nov., holotype, ♀. a. body, lateral aspect; b. mesosoma, dorsal aspect; c. abdomen lateral aspect; d. wings; e. head frontal aspect; f. head dorsal aspect;https://zenodo.org/record/226832

Figure 15: Chaenusa haliday
http://www.waspweb.org/ichneumonoidea/Braconidae/Alysiinae/Chaenusa/index.htm

Family: Ichneumonidae

Ichneumonidae is a large family of parasitic wasps with about 60, 000 species belonging to 35 genera worldwide. Ichneumonids are parasitoids of Lepidoptera, Hymenoptera, Diptera, Coleoptera and rarely spiders and other arthropod groups [26].

Subfamily: Agriotypinae

Agriotypus armatus, Walker, which is confined (as are the othels) to the European fauna, and has been observed swimming beneath the water, being parasitic on the larvae of various Trichoptera. It forms a farnily of its own, probably related most closely to the Ichneumonidae [11]. It laid its eggs underwater in the pupal cases of its caddis host, *Silo pallipes* (Fabricius), in May and June. because the female parasitoids ignored small rocks and always entered the water near or on large stones, they could choose stones that were suitable sites for their pupal hosts. However, when they were underwater, their search for hosts seemed random. When a caddis case was encountered, the parasitoid crawled over its surface and frequently touched it with her tarsi. If the case belonged to a species other than *Silo pallipes*, it was rejected within a minute, but a Silo larva was examined for several minutes and usually rejected when the larva started to move. After the case of a Silo prepupa or pupa had been examined for a few minutes, the parasitoid usually moved onto the upper surface and inserted her ovipositor between the stones of the case. Sometimes laying was done through the hole in the back of the case or through the silken strands holding the stone across the case mouth. The egg was attached by a short stalk to the integument of the host, usually on the dorsal surface of the abdomen. Although the parasitoid was able to detect the pupal case of its host, it was unable to detect between different occupants. In both the stream tanks and the field, eggs were laid in cases containing pharate adults of *Silo pallipes*, or larvae or eggs of the parasitoid, and in all these cases the new parasitoid would not develop [27,28].

A. gracilis Wtstn. of Japan attach its eggs to the host body, and the larvae feed externally throughout their period of activity. Although they are immersed in water, the early larval instars have no morphological adaptations for respiration, their oxygen needs are clearly being done by diffusion from the water that flows through the case (Figures16) [28].

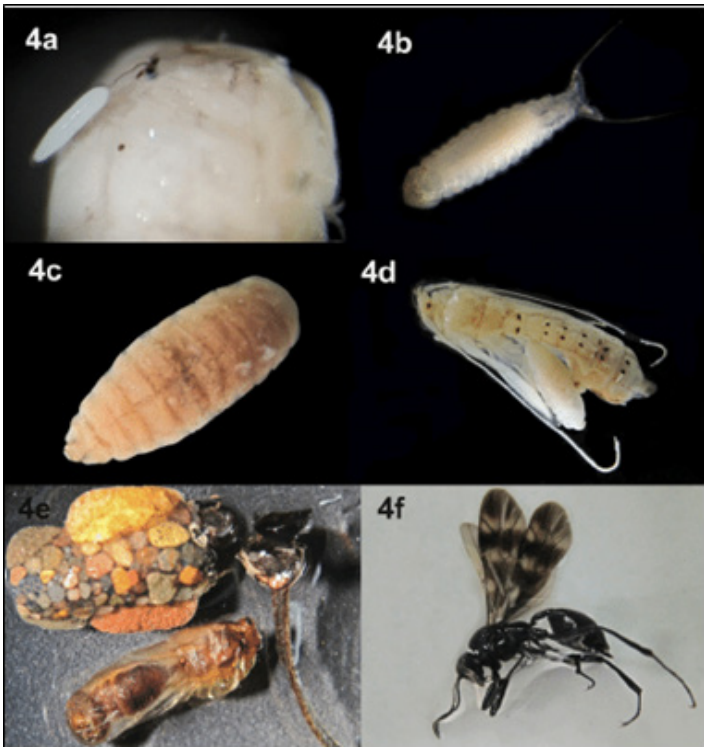

Figure 16: Agriotypus armatus
https://www.researchgate.net/figure/Developmental-stages-of-Agriotypus-armatus-4a-Parasitoid-egg-on-host-prepupa-4b_fig4_264785910

Subfamily: Campopleginae

Campoletis is a relatively large genus of the parasitoid wasps of the subfamily Campopleginae (Ichneumonidae) comprising more than 100 described species worldwide. Members of this genus parasitize mainly larvae of the families Noctuidae and Geometridae and less common of Pyralidae, Pterophoridae, Zygaenidae and Drepanidae. Some species are known as the most important biological control agents of crop pests such as *Heliothis* spp. The wasps of this genus have a body length of 5-9 mm with a prominent tooth at apical edge of clypeus in most species [29].

Subfamily: Cremastinae

The subfamily Cremastinae Förster, 1869 is a moderately rich group of species and comprising about 828 species worldwide, classified within 35 genera. The genus *Pristomerus Curtis* (1836), is among the largest genera of Cremastinae, with about 151 known species worldwide, of which 19 species occur in the West Palaearctic.

Subfamily: Cryptinae

The genus Apsilops is one of the ichneumonid genera that appears to be exclusively aquatic . However, although some of the eight described species have been recorded as parasitizing aquatic or semi-aquatic moths of the families Crambidae and Noctuidae the wasp attacks mature larvae and pupae of an aquatic crambid moth, *Neoshoenobia testacealis* Hampson (Lepidoptera: Crambidae), which bores the leaf petiole of yellow water lilies (Nymphaeaceae: Nuphar spp.) in Japan [30].

The life history and search behaviour of *Apsilops* japonicas parasitizing the aquatic moth *Neoshoenobia testacealis* were studied in the field and in the laboratory in Japan. Moth larvae first mine the floating leaves of the yellow water lily, later boring into the petiole and pupating in the petiole underwater. While the wasps did not attack leaf-mining larvae, they were idiobiont ectoparasitoids of the pupae or mature larvae of *N. testacealis* in the petioles. The wasps did not swim with their wings or legs when searching for underwater hosts, they walked down leaf petioles into the water. Adults of *A. japonicus* were usually found resting or walking on the floating leaves and sometimes flew between leaves (Figure17) [30, 31].

Figure 17: An Apsilops japonicus female on a floating leaf of yellow water lily in the study pond [20].

4-Superfamily:

Platygastroidea the first report of Inostemma walkeri (Figure 18) suppressing populations of wheat midge in the Peace River region, and provide the first report of this species as a parasitoid of Sitodiplosis mosellana (Géhin) (Diptera:Cecidomyiidae) [32].

Figure 18: Inostemma sp.
https://species.wikimedia.org/wiki/Inostemma

Family: Scelionidae

The Scelionidae is a large and relatively diverse group of parasitic wasps distributed all over the world [33]. Small parasitoid wasps are abundant and very diverse, yet their colors have not been analyzed. One of the more common color patterns observed in these wasps is a black-orange-black pattern, which is especially common among neotropical species of Scelionidae ranging in size from 2 to 10 mm [33]. All known scelionids are endoparasitic idiobionts of the eggs of arthropods, primarily insects but also arachnids, and a number of its species are important as biocontrol agents [32].The family is divided into three subfamilies, Scelioninae, Teleasinae, and Telenominae. Species of the scelionid genus Telenomus are parasites of important pests in agriculture, forestry, and human and veterinary medicine, the parasitism rates in the field often exceeding 50% [34].

As genus *Telenomus spp.* are aquatic, they are small wasps, often black, and exclusively parasitoids in the eggs of other insects. The genus currently contains about 500 described species. The *Telenomus spp.* Hosts are mostly Lepidoptera and Hemiptera, but they are also known from Diptera and Neuroptera [35].

Pseudanteris fouts, Thoron haliday, Thoronella masner Tiphodytes bradley (Scelionidae) are aquatic in this group (Figures 18,19). Tiphodytes swim underwater to find and parasitize the eggs of water striders. Similarly, at least one species of Thoronella has been shown to parasitize the submerged eggs of some dragonflies (Odonata: Aeshnidae) [36].

Figure 18: Tiphodytes

Figure 19: Thoron parasitizes the eggs of water scorpions of the genus Nepa (Heteroptera: Nepidae). These bugs oviposit in the substrate along the edge of the water, so their parasitoids may be better described as small aquatic [37].

5-Superfamily: Proctotrupoidea

Family: Diapriidae

Diapriid wasps are small endoparasitoids of flies, ants, and beetles. Following the key of the extant Proctotrupoidea from the specimen keys 170 out in Diapriidae because it possesses an elongated scape (more than 2.5 longer than wide); head in 171 lateral view with antennal shelf distinct; fore wing pterostigma linear [38].

6-Superfamily: Vespoidea

Family: Pompilidae

The family Pompilidae (spider wasps) includes about 120 described genera and about 5000 described species. It is divided into three cosmopolitan subfamilies (Pepsinae, Pompilinae, and Ceropalinae), whose members can be found almost everywhere, where their hosts/prey – spiders are present. Recent species are morphologically uniform and there is no large difference in habitus among the representatives. Typical characters are long running legs, slender body, and in the majority of females long curling antennae. A pompilid species is an exception in that it enters the water to obtain its prey which it then transports from the water to its terrestrial larval cell [39]. Spider wasps live on spiders as their ectoparsitoids, predators, or as cleptoparasites in nests of other pompilid species. One larva always feeds on one spider prey. Ectoparasitoid females paralyses their prey for a short term directly in the spider's burrow and do not modify it. Enliven spiders do not leave their shelter and are usually more stationary than those that are not paralyzed. Pompilid larva ecloses in two or three days and fastened to the spider's body sucks its haemolymph. In a short time the spider is killed and eaten. Behavior of predatory pompilids is not much different from the behavioral patterns mentioned above. They are only more advanced in preparation of prey deposition (nest), where the larvae finish their development [40].

Anoplius depressipes Banks (Pompilidae) is the only wasp known to parasitize ''non-insects'' (water-dwelling pissaurid spiders of the *Dolomedes latreille*) and the only one known to move its hosts to land prior to oviposition.

Adult Pompilidae (spider wasps) in the genus Anoplius dive underwater to prey upon semiaquatic spiders (Figure 20) [3].

Anoplius eous yasumatsu exhibits some outstanding nesting behavior. Females excavate a unicellular or multicellular nest in wet ground, or dig a single-celled nest in rotten wood, or build clustered mud cells in narrow spaces between walls of such substances as wood or vinyl sheets. Females prepare a nest-cell before hunting, and construct it further after hunting, leaving the prey near the nest. They transport their prey backward on the ground, grasping it in their mandibles by any part of the legs, and forward on the surface film of water or on the ground, grasping it by the middle part of the 1st or 2nd legs. Their only prey is the adult female semi-aquatic spider, *Pardosa pseudoannulata* (Lycosidae). These nesting and provisioning behavior patterns are compared with those of other pompilids [40].

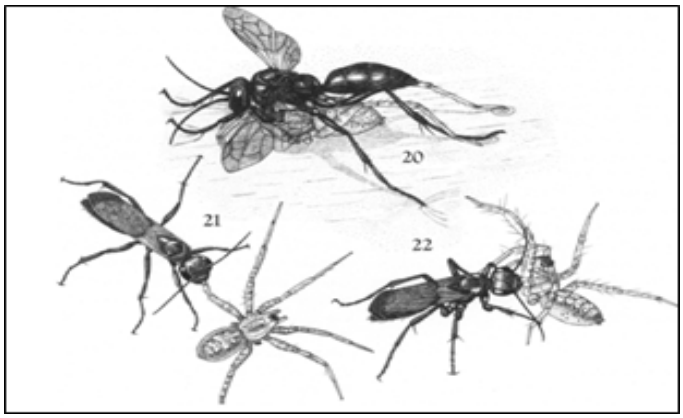

Figure 20: Various methods of prey transport by Anoplius eous (drawn from photograph) -- 20, Female transporting her prey forward on surface of water; 21, female dragging her prey backward over ground, spider grasped by middle part of 3rd leg; 22, spider grasped by base of 2nd leg.
https://link.springer.com/article/10.1007%2FBF02350113

Conclusions

Aquatic insect community diversity and integration are important because of the functional roles of ecosystems. They are a useful biomarker that provides a more accurate understanding of body water changes or chemical data of the river system. Parasitism is a highly specialized biological interaction that is still unknown. The knowledge of parasitoid host and their habitat is important for population dynamics studies because these organisms act as controls for their natural host population. The natural history of many aquatic insects, including microhymenopters, remains unknown, and systematic work on this group is worthwhile. Special attention as a prerequisite for the study of natural history that is required to achieve this knowledge. How these tiny, fragile parasitoid wasps can operate and overcome the forces of water current to find their host is still unknown.

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