台灣農業研究 (J. Taiwan Agric. Res.) 74(3):221–235 (2025)
https://doi.org/10.6156/JTAR.202509_74(3).0002

Feature Article

Egg Parasitoids as Important Natural Enemies of Auchenorrhynchan Insect Pests in East Asia

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Abstract

Triapitsyn, S. V. 2025. Egg parasitoids as important natural enemies of auchenorrhynchan insect pests in East Asia. J. Taiwan Agric. Res. 74(3):221–235.

Auchenorrhyncha (Hemiptera) contain some of the economically important agricultural pests worldwide, including many invasive ones. The great diversity of some auchenorrhynchan families such as leafhoppers (Cicadellidae) and planthoppers (Delphacidae) corresponds to at least an equal, but often even greater diversity of their natural enemies, particularly egg parasitoids. Whereas during the past 100 years scientists were able to properly identify and study most of the major and some minor auchenorrhynchan pests, research on their egg parasitoids, which are mainly responsible for their natural control, either has been lagging behind significantly or outright nonexistent. Recent developments in the identification of egg parasitoids (Hymenoptera: Mymaridae and Trichogrammatidae) in the four economically important agroecosystems of rice, grapevines, okra, and tea in East Asia are reviewed, along with their host associations, many of which being either newly established, updated, or corrected.

Key words: Leafhopper, Planthopper, Mymaridae, Trichogrammatidae, Biological control.

INTRODUCTION

Auchenorrhyncha (Hemiptera) contain some of economically most important agricultural pests worldwide, including many invasive ones that were established in other parts of the world from Asia and vice versa. Some of the examples of the most recent, notorious auchenorrhynchan invasive species are the spotted lanternfly, *Lycorma delicatula* (White) (Fulgoridae), in North America (whose known egg parasitoids, *Anastatus* spp. (Hymenoptera: Eupelmidae), are polyphagous and thus unlikely to be used in classical biological control programs due to possible non-target effects), the leafhoppers (Cicadellidae) *Orientus ishidae* (Matsumura) in Europe and North America and *Trifida bilobata* Ohara in Europe (all from Asia), and *Thabena brunnifrons* (Bonfils, Attié and Reynaud) (Issidae) in Taiwan (of unknown origin). The great diversity of some auchenorrhynchan families such as Cicadellidae and, to the lesser extent, planthoppers (Delphacidae) corresponds to at least an equal, but often even greater diversity of their natural enemies, particularly egg parasitoids. Whereas during the past 100 years scientists were able to properly identify and study most of the major and some minor auchenorrhynchan pests, research on their egg parasitoids, which are mainly responsible for their natural control, either has been lagging behind significantly or outright nonexistent. That can be explained in part by several factors, such as lack of taxonomic expertise, general poor knowledge of parasitic Hymenoptera biodiversity, predominant use of chemical pesticides in

Received: March 28, 2025; Accepted: May 7, 2025.
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conventional agriculture and limited nature of organic farming, lack of proper funding, etc. However, in the long perspective there is no alternative to more sustainable agricultural practices that would include biological control as an important part of integrated pest management. Knowledge of the native natural enemies and their correct identification is even more important for the exotic introduced pests beyond their natural distribution range, using classic biological control method.

This review overviews recent developments in the identification of egg parasitoids (Hymenoptera: Mymaridae and Trichogrammatidae) of leafhoppers and/or planthoppers in the four economically important agroecosystems of rice, grapevines, okra, and tea in East Asia. Whereas there is abundance of the published literature on egg parasitoids of the auchenorrhynchan rice pests, summarized in Chu & Hirashima (1981), Hirashima (1981), Gurr *et al*. (2011), Lou *et al*. (2013), Triapitsyn (2013), and Sann *et al*. (2018), identities of the listed mymarid and trichogrammatid taxa often have not been verified taxonomically and molecularly and also include many incorrect identifications, synonymized scientific names, and doubtful host association records. These have proven to be either very difficult, or outright impossible, to verify and/or re-identify because historical voucher specimens in insect collections are often missing (particularly primary molecular vouchers of the genetic studies) or are of very poor quality and thus unsuitable for both morphological and molecular identification. The latter also depends heavily on the presence of sequences deposited in public genetic databases that are based on specimens with verified taxonomic identities based on morphology, which are scarce at best. Thus, research had to be done from scratch that would include proper rearing methods from known leafhopper and planthopper hosts (such as sentinel eggs) and reliable taxonomic identifications based both on morphology and molecular studies, including availability and proper deposition of the primary molecular vouchers following non-destructive DNA extraction.

Besides the significant number of published studies on egg parasitoids of auchenorrhynchan pests of rice in East Asia, those on other crops were at most scarce but usually nonexistent. Historically, regional studies of egg parasitoids of rice leafhopper and planthopper pests in East Asia were limited to at most two countries (Hirashima 1981) but were predominantly conducted in one country or region within that country only. Identifications were often made by both non-taxonomists and professional taxonomists in the absence of proper identification keys and thorough generic revisions, this resulting either in misidentifications or descriptions of the same species from several countries. For instance, Pang & Wang (1985) described four new species of *Anagrus* Haliday (Mymaridae) from Guangdong, China, from eggs of rice planthoppers; however, all of these were later synonymized under existing, valid species described from other countries (Triapitsyn 2015). Among them, *A. nilaparvatae* Pang and Wang, the predominant egg parasitoid of the brown planthopper, *Nilaparvata lugens* (Stål), and other rice planthoppers throughout Asia was proven to be a synonym of *A. incarnatus* Haliday (Triapitsyn *et al*. 2018a).

To avoid confusion, only currently valid, named species of egg parasitoids are illustrated below, often with the lists of their main synonyms and the confirmed or presumed auchenorrhynchan hosts.

EGG PARASITOIDS OF RICE LEAFHOPPERS AND PLANTHOPPERS IN EAST ASIA

Surveys of egg parasitoids of rice leafhoppers and planthoppers using sentinel egg method were conducted in Taiwan during 2016–2018 (Triapitsyn *et al*. 2018b, 2020b, 2021b) and, more recently, on Kyushu Island in southern Japan by Hiroki Kusuhara (Kusuhara & Triapitsyn 2023; also H. Kusuhara, personal communication, unpublished data). In East Asia, most of the previous studies were conducted

in mainland China, as summarized by Gurr *et al*. (2011) and Lou *et al*. (2013), Japan (e.g., Vungsilabutr 1978; Yashiro 1979; Miura 1990; Vungsilabutr *et al*. 1996), the Philippines (e.g., Sann *et al*. 2018), South Korea (e.g., Chang 1980; Kim 1984), and Taiwan (e.g., Lin 1974; Miura *et al*. 1981; Chen & Yu 1989; Chen 1993; also summarized in Chu & Hirashima 1981). According to Triapitsyn *et al*. (2018a, 2018b, 2020a, 2021a, 2021b, 2023a) and Kusuhara & Triapitsyn (2023), the main egg parasitoids of rice leafhoppers and planthoppers in East Asia are as follows.

Mymaridae

Anagrus (*Anagrus*) *incarnatus* Haliday (Fig. 1) is by far the most common egg parasitoid of rice planthoppers throughout East and other parts of Asia: *Laodelphax striatella* (Fallén) (small brown planthopper), *Nilaparvata lugens*, and *Sogatella furcifera* (Horváth) (whitebacked planthopper) (Triapitsyn *et al*. 2018b, 2021b). It was also reared from eggs of the rice leafhoppers *Maiestas dorsalis* (Motschulsky) (zig-zag leafhopper) and *Nephotettix cincticeps* (Uhler) (green rice leafhopper) (Triapitsyn *et al*. 2018a, 2018b, 2021b) although its main hosts appear to be various Delphacidae. According to Triapitsyn *et al*. (2021b), this species was misidentified in Japan, the Philippines, and Taiwan as the New World species *Anagrus flaveolus* Waterhouse that does not occur in the Old World (Chu & Hirashima 1981; Miura *et al*. 1981; Zhu *et al*. 2020). The well-known *Anagrus nilaparvatae* Pang and Wang, on which numerous publications exist (primarily in mainland China), was proven to be a synonym of *A. incarnatus* based on a molecular study (Triapitsyn *et al*. 2018a).

Anagrus spp.: Other species of *Anagrus* Haliday, such as *A*. (*Anagrus*) *frequens* Perkins, *A*. (*Paranagrus*) *optabilis* (Perkins) (Fig. 2) and *A*. (*Paranagrus*) *perforator* (Perkins) (Fig. 3), were reported from eggs of rice planthoppers in East Asia, but these are probably at most occasional (at least in Taiwan) natural enemies of the three major rice planthopper pests *Laodelphax striatella*, *Nilaparvata lugens*, and *Sogatella furcifera* as their main hosts in paddy fields are likely to

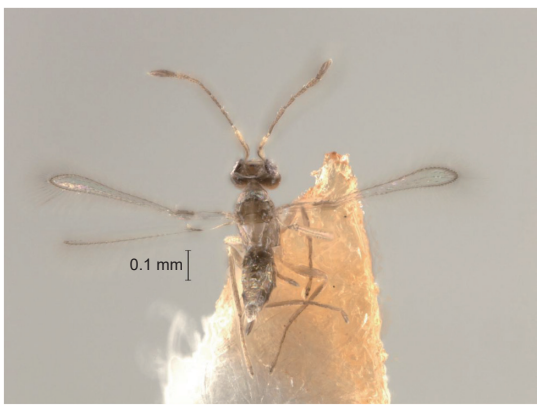

Fig. 1. *Anagrus* (*Anagrus*) *incarnatus* (female).

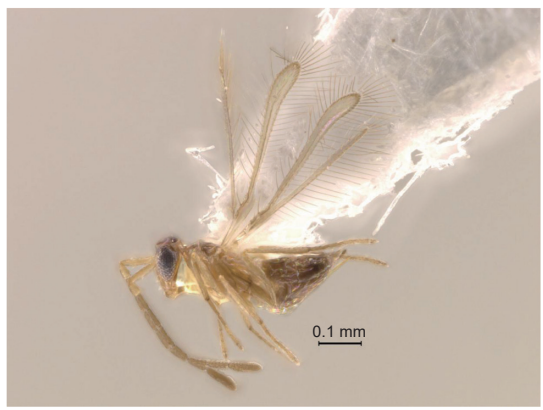

Fig. 2. *Anagrus* (*Paranagrus*) *optabilis* (female).

Fig. 3. *Anagrus* (*Paranagrus*) *perforator* (female).

be other Delphacidae, perhaps also on weeds, for instance *Perkinsiella* sp. for *A. frequens* in Taiwan (Triapitsyn *et al*. 2021b). These three *Anagrus* species can be collected by Malaise and yellow pan traps in rice fields in Japan and Taiwan, with *A. optabilis* being often abundant. However, only one specimen of *A. optabilis* was reared from thousands of sentinel eggs of *Nilaparvata lugens* exposed for parasitization in rice fields in various localities in Taiwan over the three years of surveys (Triapitsyn *et al*. 2021b).

Gonatocerus cincticipitis Sahad (Fig. 4) is a Palaearctic species which so far is known only from Japan and the Republic of Korea (Triapitsyn *et al*. 2023a); it was not reared from eggs of rice leafhoppers in Taiwan (Triapitsyn *et al*. 2021b). It is also likely to occur in the Palearctic part of mainland China and in the southern part of the Russian Far East where rice is cultivated, although there were no published reports of *G. cincticipitis* from there. There was a confusion about its identity (Triapitsyn *et al*. 2021a) that was later resolved by a molecular study (Triapitsyn *et al*. 2023a), since it is morphologically indistinguishable from an undescribed species of *Gonatocerus* Nees ab Esenbeck from Japan. The only known host of *G. cincticipitis* is the green rice leafhopper *Nephotettix cincticeps* (Triapitsyn *et al*. 2021a, 2023a).

Gonatocerus meghalayanus Zeya (Fig. 5) is an Oriental species, originally described from India, that was reared from eggs of the green rice leafhoppers *Nephotettix nigropictus* (Stål) and *N. virescens* (Distant) in the Philippines (Sann *et al*. 2018 [as *G. orientalis* Zeya]) (Triapitsyn *et al*. 2021a). In Taiwan it was collected in a Malaise trap in the organic rice field and misidentified initially as *G. saipanensis* (Triapitsyn *et al*. 2021b [as *G. aegyptiacus*, in part]), where its likely host is *N. nigropictus* (Triapitsyn *et al*. 2021a).

Gonatocerus longicornis Nees ab Esenbeck is present in paddy fields in Japan and Taiwan where its host associations are unknown; elsewhere it is a well-known egg parasitoid of the green leafhopper *Cicadella viridis* (Linnaeus) (Triapitsyn *et al*. 2021b).

Gonatocerus saipanensis (Doutt) (Fig. 6) is a common egg parasitoid of *Nephotettix* spp. green rice leafhoppers, including *N. cincticeps*

Fig. 5. *Gonatocerus meghalayanus* (female).

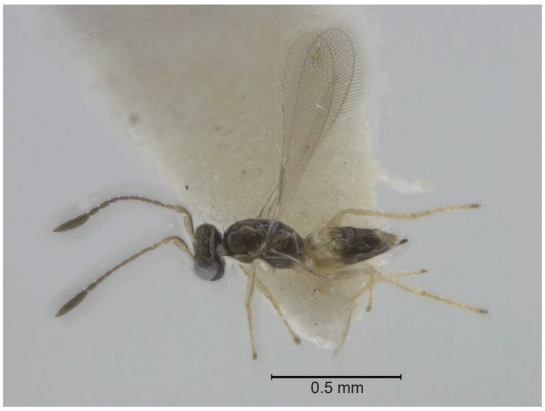

Fig. 4. *Gonatocerus cincticipitis* (female).

Fig. 6. *Gonatocerus saipanensis* (female).

and *N. virescens*, and it is also known from eggs of *Maiestas dorsalis* (Triapitsyn *et al*. 2021a). It is known from the Palearctic and Oriental regions, Australia, and Oceania, including Japan, Republic of Korea, the Philippines, and Taiwan in East Asia (Triapitsyn *et al*. 2021a). *Gonatocerus saipanensis* was previously misidentified (in part) as *G. aegyptiacus* Soyka (Triapitsyn *et al*. 2018b, 2021b) before the latter was proven to be genetically different (specimens from Egypt) from *G. saipanensis* (specimens from East Asia from paddy fields) (Triapitsyn *et al*. 2023b). Its synonyms include *G. alami* Shamim and Shafee and *G. tarae* (Narayanan and Subba Rao) (both originally described from India), and *G. miurai* Sahad (originally described from Japan) (Triapitsyn *et al*. 2021a). Host records of *G. tarae* from eggs of Delphacidae, such as *Nilaparvata lugens* and *Sogatella furcifera*, need confirmation and are almost certainly erroneous because *G. saipanensis* seems to parasitize only Cicadellidae (Triapitsyn *et al*. 2021b [as *G. aegyptiacus*]).

Two unidentified *Gonatocerus* spp. from the Philippines were reported in Sann *et al*. (2018) from eggs of *Nephotettix* spp. on rice; these could be proven to be undescribed species although they need to be thoroughly compared with all the described, little known species of *Gonatocerus* from South Asia and Australia (Triapitsyn *et al*. 2021a, 2023b).

Lymaenon aureus (Girault) (Fig. 7) was reared in Japan from eggs of zig-zag leafhopper *Maiestas dorsalis* in a rice field (Kusuhara & Triapitsyn 2023).

Lymaenon litoralis (Haliday) (Fig. 8) is a cosmopolitan species, arguably the most common fairyfly on grasses almost worldwide. In East Asia, this species was reared from eggs of zig-zag leafhopper *Maiestas dorsalis* in rice fields in Japan (Kusuhara & Triapitsyn 2023) and Taiwan (Triapitsyn *et al*. 2021b).

Mymar taprobanicum Ward (Fig. 9) is a cosmopolitan species which is a very common and abundant fairyfly in rice fields throughout East Asia, where its leafhopper hosts are *Maiestas dorsalis* and *Nephotettix cincticeps*, whereas its odd record from the brown planthopper *Nilaparvata lugens* in Taiwan (Lin 1974) is almost

Fig. 7. *Lymaenon aureus* (female) (image courtesy of H. Kusuhara).

Fig. 8. *Lymaenon litoralis* (female) (image courtesy of H. Kusuhara).

Fig. 9. *Mymar taprobanicum* (female).

certainly erroneous as this parasitoid seems to attack only eggs of Cicadellidae (Triapitsyn *et al*. 2021b).

Trichogrammatidae

Oligosita spp.: Several species were collected from rice fields and reared from eggs of some rice planthoppers throughout East Asia (Yashiro 1979; Lin 1994; Triapitsyn *et al*. 2020b) but their identification remains very problematic because taxonomy of the genus *Oligosita* Walker is in flux. In Japan, *O. japonica* Yashiro (Fig. 10) was collected on rice plants (Yashiro 1979), and in Taiwan presumably this species was reared from eggs of the rice planthoppers *Laodelphax striatella*, *Nilaparvata lugens* and *Sogatella furcifera* (Triapitsyn *et al*. 2020b); it was also reported from eggs of *Nephotettix cincticeps* (Lin 1974) although the latter host record has not been verified. *Oligosita shibuyae* Ishii (Fig. 11), originally described from Japan from specimens that had emerged from rice straw, was also recorded from mainland China and Taiwan by Lin (1994) who indicated *Nephotettix cincticeps* and *Nilaparvata lugens* as its hosts. Yashiro (1979) reported this species from eggs of *Nephotettix cincticeps* in Japan.

Paracentrobia (*Brachistella*) *bicolor* (Girault) (Fig. 12), originally described from Queensland, Australia, is a widespread species throughout East and South Asia and one of the most common egg parasitoids of rice leafhoppers *Nephotettix* spp. and several planthopper species including *Nilaparvata lugens* and *Sogatella furcifera* (Triapitsyn *et al*. 2020b). Its

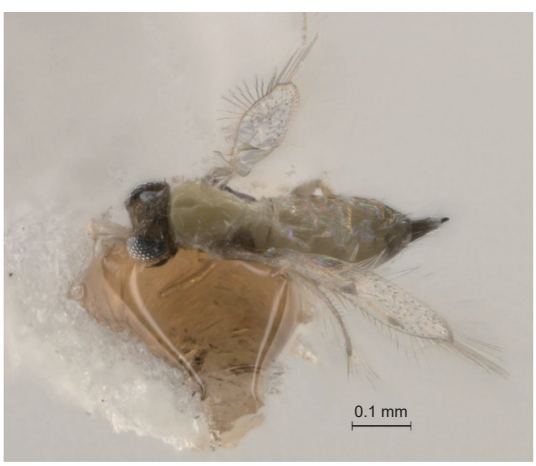

Fig. 10. *Oligosita japonica* (female).

Fig. 11. *Oligosita shibuyae* (female).

Fig. 12. *Paracentrobia* (*Brachistella*) *bicolor* (female).

synonyms include *Paracentrobia* (*Brachistella*) *andoi* (Ishii), originally described from Japan as *Japania andoi* Ishii, and *Paracentrobia* (*Brachistella*) *garuda* Subba Rao from Thailand (Triapitsyn *et al*. 2020b). Vungsilabutr *et al*. (1996) stated that it was *Paracentrobia yasumatsui* Subba Rao and not *P*. *andoi* that was definitely parasitic on eggs of *Nilaparvata lugens* in Taiwan, the true *P*. *andoi* being confirmed in Japan only as a parasitoid of *Nephotettix cincticeps*. Lin (1994) recorded *P*. *bicolor* (as *P*. *andoi*) from Fujian and Guangdong, China, also as a parasitoid of *N*. *cincticeps*.

Paracentrobia (*Paracentrobia*) *mira* (Girault) (Fig. 13), originally described from Queensland, Australia, has a broad distribution in Australasia, Oceania, and the Oriental and eastern Palearctic regions (Triapitsyn 2025). *Paracentrobia mira*, as its synonym *P*. (*Paracentrobia*) *yasumatsui* Subba Rao (originally described from a paddy field in Thailand), was reported from eggs of a number of rice leafhoppers and planthoppers (Lin 1994) but at least some of those records might need to be verified by using a sentinel egg method (Triapitsyn 2025).

Pseudoligosita nephotetticum (Mani) (Fig. 14) is also one of the most common egg parasitoids of rice leafhoppers and planthoppers throughout East Asia, as it is known from the leafhoppers *Maiestas dorsalis*, *Nephotettix cincticeps*, *N*. *virescens*, and the planthoppers *Laodelphax striatella*, *Nilaparvata lugens*, and *Sogatella furcifera* (Triapitsyn *et al*. 2020b). *Pseudoligosita nephotetticum*, which is known from mainland China, India, Japan, and Taiwan, was also reared from eggs of the leafhoppers *Kolla paulula* (Walker) (Triapitsyn & Shih 2014) and *Amrasca biguttula* (Ishida) (Adachi-Hagimori *et al*. 2023). Its confirmed synonym is *Oligosita tachikawai* Yashiro (originally described from Japan) (Triapitsyn *et al*. 2020b). The Oriental species *Pseudoligosita yasumatsui* (Viggiani and Subba Rao) quite likely is its other synonym (Triapitsyn & Shih 2014) because *P*. *yasumatsui* only differs from *P*. *nephotetticum* by a relatively longer ovipositor, and that could possibly be within intraspecific variation of the latter; thus, their genetic comparison is highly desirable.

Discussion

A key to the Mymaridae egg parasitoids (of both sexes) of rice leafhoppers and planthoppers is only available for Taiwan (Triapitsyn *et al*. 2021b), whereas no such keys exist for

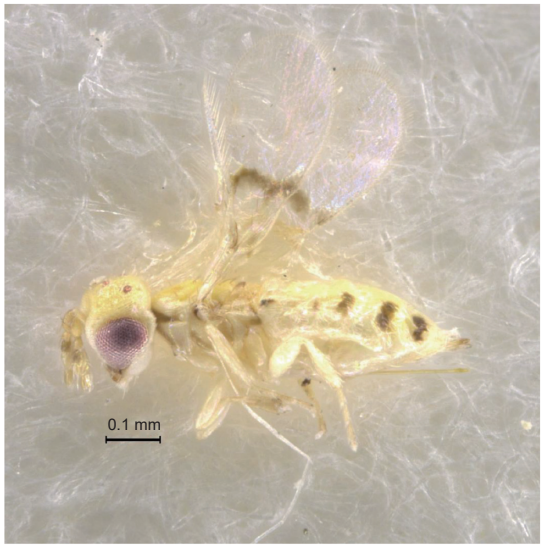

Fig. 13. *Paracentrobia* (*Paracentrobia*) *mira* (female).

Fig. 14. *Pseudoligosita nephotetticum* (female).

either Mymaridae or Trichogrammatidae for the entire Asian region where rice is cultivated. For the Trichogrammatidae, Triapitsyn *et al*. (2020b) overviewed taxonomy and host associations of such egg parasitoids for Taiwan, but essentially for the entire East Asia, without, however, providing a key to their identification. That makes correct identification of egg parasitoids reared from known rice pest hosts elsewhere often challenging. The aim of this review is to bring together useful information on the known, mostly verified identities of the egg parasitoids of rice leafhoppers and planthoppers in the entire East Asia, and on their trustworthy host associations. This is important because at least 50%, and perhaps up to 70%, of all the previously published records of the egg parasitoids of rice leafhoppers and planthoppers in Asia were apparently either misidentified or used currently outdated scientific names. Incorrect host association records, often resulting from unreliable rearing methods, also contributed to the confusing nature of the historical information on these parasitoids, exacerbated by poor taxonomy of some key genera and multiple descriptions of the same species under different names in single country publications, as well as by lack of regional taxonomic revisions of the key genera and of voucher specimens of the published studies in insect collections.

In summary, most species of Mymaridae and Trichogrammatidae that are main egg parasitoids of rice leafhoppers and planthoppers in the Old World have a wide Pan-Pacific distributions within eastern Palearctic and Oriental regions, and some also within Australasia and Oceania. However, *Gonatocerus cincticipitis* (Mymaridae) is known only from the eastern Palearctic region and *Paracentrobia mira* (Trichogrammatidae) mostly occurs in the Oriental region. Diversity of *Gonatocerus* spp. fairyfly egg parasitoids of *Nephotettix* spp. green rice leafhoppers is the greatest in southern Oriental and Australasian regions where it remains to be thoroughly studied and properly identified. Further synonymies in *Gonatocerus* spp. and some Trichogrammatidae are expected once poorly known Australasian and Oriental region species are revised, particularly in the trichogrammatid genera *Oligosita* and *Pseudoligosita* Girault.

Within each subregion or country, the number and composition of the predominant species of egg parasitoids of rice leafhoppers and planthoppers is quite limited in a given rice field or area and is generally somewhat similar throughout East Asia, while their diversity in southern regions is generally greater than in the northern areas of rice cultivation. However, their abundance and, to some extent, species composition could be expected to vary somewhat from country to country and even within different biogeographical and climatic areas within the same country, such as China and Japan which are situated within two major ecozones (Palearctic and Oriental).

The fairyfly *Anagrus incarnatus* and most Trichogrammatidae parasitize eggs of both Cicadellidae and Delphacidae, whereas *Gonatocerus* spp., *Lymaenon* spp. and *Mymar taprobanicum* (Mymaridae) parasitize only eggs of Cicadellidae on rice plants, so any published records of those from eggs of Delphacidae are likely incorrect due to inaccurate rearing methods. The predominant mymarid egg parasitoids of rice leafhoppers and planthoppers, such as the mymarids *Anagrus incarnatus*, *Gonatocerus saipanensis*, and *Mymar taprobanicum*, and the trichogrammatids *Paracentrobia bicolor* and *Pseudoligosita nephotetticum*, would likely be the same throughout these regions, with local variations.

According to Triapitsyn *et al*. (2021b), in Taiwan *Anagrus incarnatus* was by far the most common and abundant egg parasitoid among both Mymaridae and Trichogrammatidae reared from sentinel eggs of the five-rice leafhopper and planthopper pest species in both the organic and conventional rice fields during four crop seasons in Minxiong Township, Chiayi County. It was a particularly dominant parasitoid of the brown planthopper, *Nilaparvata lugens*, while rarely attacking eggs of the green rice leafhopper

Nephotettix cincticeps. *Gonatocerus saipanensis* and *Mymar taprobanicum* were not discriminating between eggs of the leafhoppers *Maiestas dorsalis* and *Nephotettix cincticeps* in the conventional rice field whereas in the organic rice field *M*. *taprobanicum* was clearly a dominant egg parasitoid of *M*. *dorsalis*. In the same survey but for the Trichogrammatidae (Triapitsyn *et al*. 2020b), *Pseudoligosita nephotetticum* was found to be the most common egg parasitoid of the same two leafhopper and three planthopper pests of rice in Taiwan, albeit in much lower overall numbers than *A*. *incarnatus*.

EGG PARASITOIDS OF THE GRAPE LEAFHOPPER *Arboridia apicalis* (Nawa) ON CULTIVATED GRAPEVINES IN JAPAN AND OF SOME CICADELLINAE IN JAPAN AND TAIWAN

There was no information on egg parasitoids of the leafhoppers feeding on cultivated grapes (*Vitis* spp., Vitaceae) prior to the surveys conducted on Honshu and Kyushu Islands in Japan in 2019 (Triapitsyn *et al*. 2020a), and in 2022 on Honshu and Tanegashima Islands and in 2023 on Honshu Island (S. V. Triapitsyn and T. Adachi-Hagimori, unpublished). While two grape leafhopper species had been previously reported in Japan, *Arboridia* (*Arboridia*) *apicalis* (Nawa) and *A*. (*Arboridia*) *suzukii* (Matsumura), only *A*. *apicalis* was found during these surveys on Honshu and Kyushu Islands. In a few existing organic vineyards, its eggs were parasitized by *Anagrus* (*Anagrus*) *arboridiae* Triapitsyn and Adachi-Hagimori (Fig. 15), which was described from the specimens reared in 2019 (Triapitsyn *et al*. 2020a). In that study the same authors also reared from eggs of *A*. *apicalis*, albeit in very low numbers, three trichogrammatid species, *Aphelinoidea* (*Aphelinoidea*) sp., *Oligosita pallida* Kryger, and *Oligosita* sp. As *A*. *apicalis* and other *Arboridia* spp. also occur, apparently as minor pests, in other countries in East Asia, similar studies of their egg parasitoids there are warranted.

The black-tipped leafhopper *Bothrogonia ferruginea* (Fabricius) is occasionally a minor pest in organic vineyards and kiwifruit orchards in Japan (Triapitsyn & Adachi-Hagimori 2024); it is a known vector of the phytopathogenic bacterium *Xyllella fastidiosa* (Xanthomonadales: Xanthomonadaceae) on cultivated grapes in Taiwan (Tuan *et al*. 2016). Egg parasitoids of *B*. *ferruginea*, a widespread species in parts of Asia, were previously unknown. Triapitsyn & Adachi-Hagimori (2024) reported *Cosmocomoidea tenuis* Xu, Lin and Hu (Mymaridae) (Fig. 16), originally described from Fujian, China (Aishan *et al*. 2016), as an apparent egg parasitoid of *B*. *ferruginea* in an organic kiwifruit orchard on Honshu Island in Japan and identified *C*. *tenuis* as an egg parasitoid of another sharpshooter leafhopper (Cicadellinae: Cicadellini) species, *Kolla paulula*, also a known vector of *X*. *fastidiosa* in Taiwan (Shih *et al*. 2009). *Cosmocomoidea tenuis* was previously reported (as *Gonatocerus* (*Cosmo-*

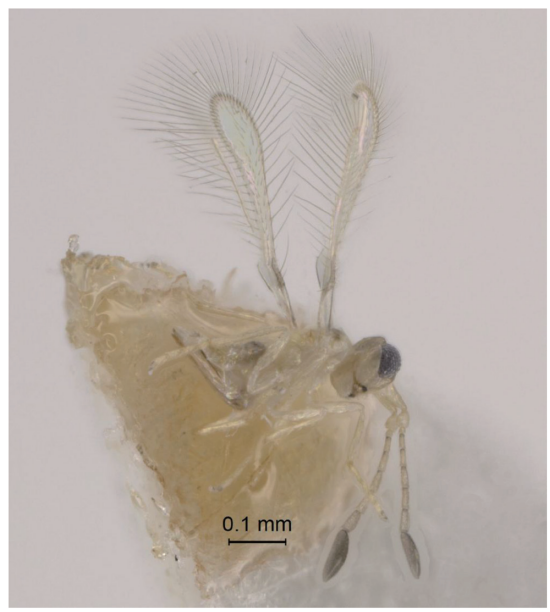

Fig. 15. *Anagrus* (*Anagrus*) *arboridiae* (female).

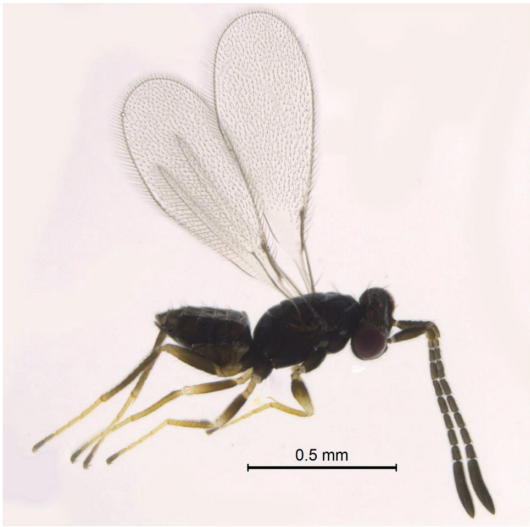

Fig. 16. *Cosmocomoidea tenuis* (female).

comoidea) sp.) from eggs of *K. paulula* in Taiwan along with the trichogrammatid *Pseudoligosita nephotetticum* (Fig. 14) (Triapitsyn & Shih 2014).

EGG PARASITOIDS OF THE OKRA LEAFHOPPER, *Amrasca biguttula* (Ishida), IN JAPAN

The okra leafhopper, *Amrasca* (*Sundapteryx*) *biguttula* (Ishida), is widely distributed across the Oriental region, Micronesia, and parts of the central and eastern Palearctic regions (Xu *et al*. 2017) as an economically important pest of okra, *Abelmoschus esculentus* (Malvaceae), as well as of other crops such as cotton, eggplant, and pepino, and of some ornamental plants such as *Hibiscus* spp. This leafhopper has recently invaded parts of Africa, so knowledge of its natural enemies in its native range in Asia is important for any classical biological control program there. Adachi-Hagimori *et al*. (2020, 2023, 2025) reported the following egg parasitoids of *A. biguttula* on okra in southern Japan (including Ryukyu and Ogasawara Islands): the fairyflies *Anagrus* (*Anagrus*) *atomus* (Linnaeus) (Fig. 17), *Anagrus* (*Anagrus*) *japonicus* Sahad (Fig. 18), *Anagrus* (*Anagrus*) *turpanicus* Triapitsyn and Hu (Fig. 19) (which was previously described in Hu & Triapitsyn (2016) from eggs of an invasive *Arboridia* sp. on table grapes in Xinjiang Uyghur Autonomous Region of China), *Arescon enocki* (Subba Rao and Kaur) (Fig. 20), and *Stethynium empoascae* Subba Rao (Fig. 21), as well as the trichogrammatid *Pseudoligosita nephotetticum* (Fig. 14) on Okinawa Island, Ryukyu Islands only. Adachi-Hagimori *et al*. (2025) also recommended introduction of *Anagrus japonicus* and *Arescon enocki* to the remote Ogasawara Islands from

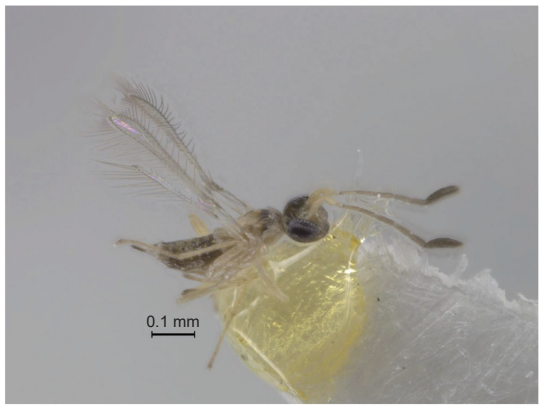

Fig. 17. *Anagrus* (*Anagrus*) *atomus* (female).

Fig. 18. *Anagrus* (*Anagrus*) *japonicus* (female).

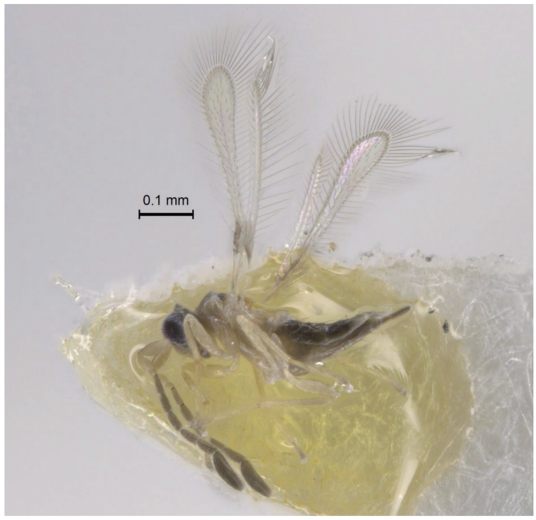

Fig. 19. *Anagrus* (*Anagrus*) *turpanicus* (female).

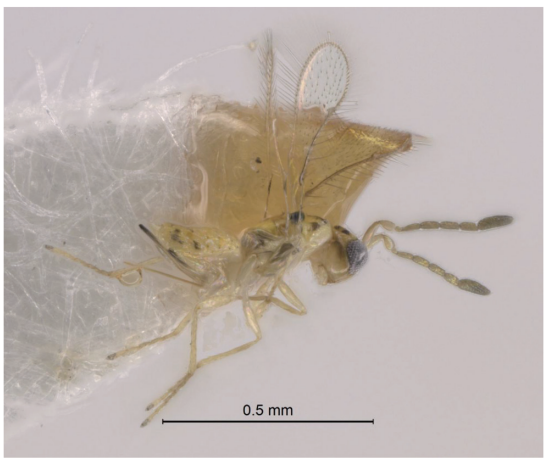

Fig. 20. *Arescon enocki* (female).

Fig. 21. *Stethynium empoascae* (female).

the Ryukyu Islands as classical biological control agents against *A. biguttula* on okra because only *Stethynium empoascae* was found to be parasitizing eggs of this pest on okra and *Hibiscus* sp. plants on Chichijima Island.

EGG PARASITOIDS OF THE TEA GREEN LEAFHOPPER *Empoasca onukii* (Matsuda) ON TEA PLANTS IN JAPAN

The tea green leafhopper, *Empoasca* (*Matsumurasca*) *onukii* Matsuda, is one of the major pests of tea plants in Japan, mainland China and Taiwan, and it also occurs in Vietnam (Qin *et al*. 2015). Takagi (1978) found fairyflies (Mymaridae) in tea fields in Japan, and Ojima *et al*. (2010) provided data on the population dynamics of three fairyfly species parasitizing eggs of *E. onukii* in tea plantations in Kochi Prefecture, Shikoku Island, Japan, but unfortunately no voucher specimens of their studies exist. *Anagrus* (*Anagrus*) *rugmanjonesi* Triapitsyn and Adachi-Hagimori (Fig. 22) was described from eggs of *E. onukii* on tea plants in Miyazaki Prefecture, Kyushu Island, Japan, in Triapitsyn *et al*. (2019), which likely corresponds to an "?*Anagrus* sp." reported from the same host by Takagi (1978) and to "Mymaridae sp. A (resembling *Anagrus*)" in Ojima *et al*. (2010). Other egg parasitoids of *E. onukii* in Japan, as identified in Triapitsyn *et al*. (2019), are the fairyflies *Arescon enocki* (Fig. 20), which was reported as "Mymaridae sp. C" in Ojima *et al*. (2010), and *Stethynium empoascae* (Fig. 21), which was reported as "Mymaridae sp. B (resembling *Anagrus*)" in Ojima *et al*. (2010). Triapitsyn *et al*. (2019) also recorded *S. empoascae* reared from eggs of *E. onukii* on Kyushu Island.

Because *E. onukii* is a known pest of tea plants in other countries in East Asia (Qin *et al*. 2015), surveys of its egg parasitoids are definitely highly warranted there as well, especially in the organic tea fields where deliberate leafhopper damage to the leaves is believed to achieve an exceptional, unique tea quality.

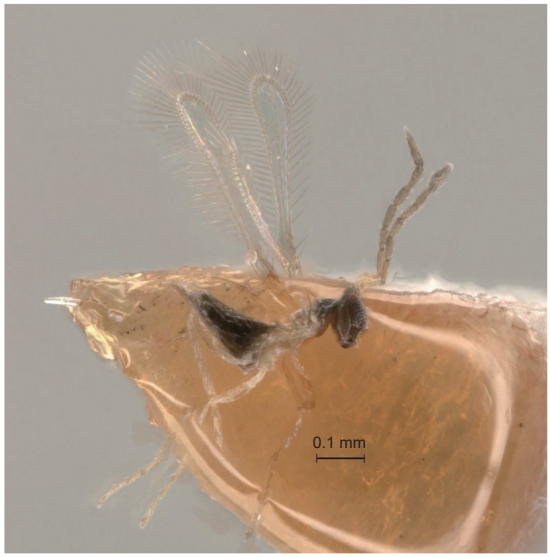

Fig. 22. *Anagrus* (*Anagrus*) *rugmanjonesi* (female).

ACKNOWLEDGMENTS

I thank Drs Hsien-Tzung Shih (Applied Zoology Division, Taiwan Agricultural Research Institute, Wufeng, Taichung, Taiwan), Shou-Horng Huang (Department of Plant Protection, Chiayi Agricultural Experiment Branch, Taiwan Agricultural Research Institute, Chiayi, Taiwan), Tetsuya Adachi-Hagimori (Laboratory of Applied Entomology, University of Miyazaki, Miyazaki, Japan) and Hiroki Kusuhara (Laboratory of Insect Natural Enemies, Faculty of Agriculture, Kyushu University, Fukuoka, Japan) for their support and collaboration in the field studies and collection of specimens, and Dr. Paul F. Rugman-Jones (Department of Entomology, University of California, Riverside, California, USA) for multi-year collaboration on the molecular identification of egg parasitoids.

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頸喙亞目昆蟲的重要卵寄生蜂天敵

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摘要

Triapitsyn, S. V. 2025。頸喙亞目昆蟲的重要卵寄生蜂天敵。台灣農業研究 74(3):221–235。

半翅目之頸喙亞目 (Auchenorrhyncha) 昆蟲中含有一些對世界各地而言，屬於重要經濟性的農業害蟲，其中包括許多入侵性害蟲。一些如葉蟬科 (Cicadellidae) 與稻蝨科 (Delphacidae) 這類頸喙亞目昆蟲，其豐富的物種多樣性對應著至少相等或是更多樣性的天敵昆蟲，特別是卵寄生性這類天敵。儘管在過去 100 年中，科學家已經能夠正確識別與研究頸喙亞目當中大多數的主要與次要害蟲，但對於可自然防治這類害蟲的卵寄生蜂相關研究卻已嚴重落後，甚至缺乏研究。最近有關東亞 4 大經濟重要農業生態系統 (稻米、葡萄、秋葵及茶) 中之膜翅目卵寄生蜂，包括纓小蜂科 (Mymaridae) 與赤眼蜂科 (Trichogrammatidae) 的最新進展，將於本文進行回顧綜述，同時說明它們的寄主關聯，其中許多寄主關聯資料為新確立、更新或已被修正。

關鍵詞：葉蟬、稻蝨、纓小蜂科、赤眼蜂科、生物防治。

投稿日期：2025 年 3 月 28 日；接受日期：2025 年 5 月 7 日。
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