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First records of *Gonatocerus dolichocerus* Ashmead, *Palaeoneura* sp., *Anagrus* sp. (Hymenoptera: Mymaridae), and *Centrodora* sp. (Hymenoptera: Aphelinidae) in French Polynesia, with notes on egg parasitism of the glassy-winged sharpshooter, *Homalodisca vitripennis* (Germar) (Hemiptera: Cicadellidae)

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Abstract. The glassy-winged sharpshooter, *Homalodisca vitripennis* (Germar) [= *H. coagulata* (Say)] (Hemiptera: Cicadellidae: Proconiini), invaded Tahiti in 1999 and at the time of writing this pest was widespread in French Polynesia being extremely abundant in Tahiti and Moorea. *Homalodisca vitripennis* is a major threat for agriculture and biodiversity. In 2004, a classical biological control program against *H. vitripennis* was initiated with the goal of introducing and establishing the exotic egg parasitoid *Gonatocerus ashmeadi* Girault (Hymenoptera: Mymaridae) in French Polynesia. As part of the preliminary studies for this program, a survey was conducted of existing natural enemies, in particular egg parasitoids of *H. vitripennis*. Pan trap surveys and monitoring parasitism of *H. vitripennis* egg masses was performed in Tahiti. The results of the pan trap surveys provide the first record of the presence of *Gonatocerus dolichocerus* Ashmead (Hymenoptera: Mymaridae) in French Polynesia, but surveys of *H. vitripennis* egg masses revealed that it does not attack eggs of this pest. However, *H. vitripennis* egg masses were found to be parasitized by three parasitoid species: *Centrodora* sp. (Hymenoptera: Aphelinidae) (on average 30%) as well as *Palaeoneura* sp. (> 1%) and an undescribed species of *Anagrus* Haliday (Hymenoptera: Mymaridae) (> 1%). All three parasitoid species were recorded for the first time in French Polynesia. Implications of these results for the biological control program of *H. vitripennis* are discussed.

Key Words. *Centrodora*, Aphelinidae, *Anagrus*, *Gonatocerus dolichocerus*, *Palaeoneura*, Mymaridae, *Homalodisca vitripennis*, Cicadellidae, egg parasitism.

INTRODUCTION

The glassy-winged sharpshooter, *Homalodisca vitripennis* (Germar) (= *H. coagulata* (Say)] (Hemiptera: Cicadellidae: Proconiini), invaded Tahiti in 1999 and is now widespread in French Polynesia being extremely abundant in Tahiti and Moorea (Grandgirard et al. 2006a). This pest is a major threat for agriculture and biodiversity in French Polynesia because of its ability to acquire and vector the plant bacterium, *Xylella fastidiosa* (Wells et al. 1987). This insect is also an unpopular urban pest because of profuse production of watery excreta and attraction to lights at night. Further, *H. vitripennis* represents a serious invasion threat to other South Pacific countries (e.g., New Zealand and Australia) because extremely high densities in Tahiti are a major propagule source.

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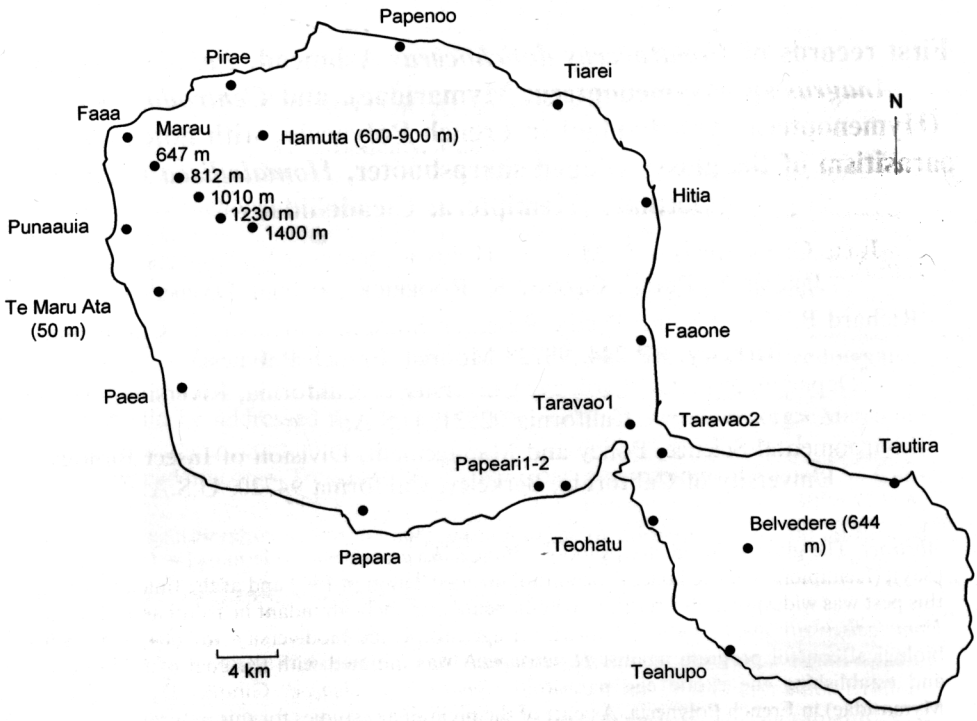

Figure 1. Sites sampled for egg parasitoids (Hymenoptera: Mymaridae) of *Homalodisca vitripennis* in Tahiti between June 2004 and February 2005 (above sea level altitude in m is shown).

In 2004, a classical biological control program against *H. vitripennis* was initiated with the goal of introducing and establishing the exotic egg parasitoid *Gonatocerus ashmeadi* Girault (Hymenoptera: Mymaridae) in French Polynesia. As part of the preliminary studies for this program, a survey was conducted of existing natural enemies, in particular egg parasitoids of *H. vitripennis*. It was considered possible that *H. vitripennis* egg masses were being parasitized by resident parasitoids prior to releasing imported natural enemies for *H. vitripennis* suppression. *Homalodisca vitripennis* likely invaded Tahiti as eggs on ornamental plants imported from California, raising the possibility that egg parasitoids may also have invaded Tahiti as parasitized *H. vitripennis* eggs (Grandgirard et al. 2006a). A similar situation occurred in Hawaii, where *G. ashmeadi*, the main egg parasitoid of *H. vitripennis* in California, was detected a few months after high density populations of *H. vitripennis* were first observed. This parasitoid is likely to have provided almost immediate control of this leafhopper pest in Hawaii (Bautista et al. 2005).

Methods and Materials

Pan trap surveys. Field investigations in Tahiti and Moorea using yellow pan water traps were conducted between June 2004 and January 2005 to survey for resident mymarid parasitoids that may attack eggs of *H. vitripennis*. A total of 24 sites were sampled in Tahiti and 4 in Moorea (Fig. 1 and 2). Fifty traps were placed in each site for about 24 h, after which traps were removed and the insect contents sorted. Most of the sites sampled were along the coast of both islands, approximately

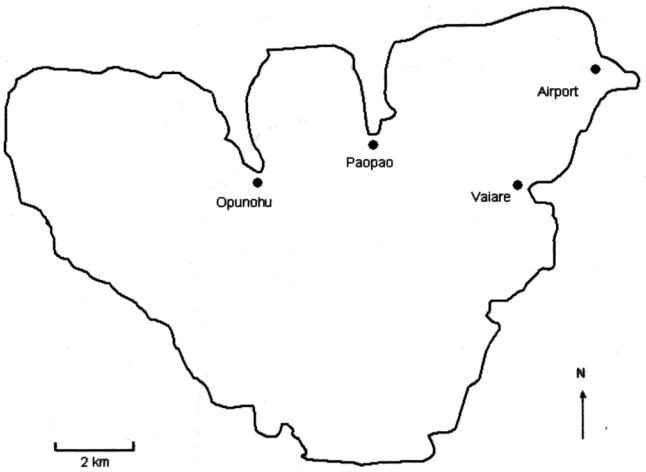

Figure 2. Sites sampled for egg parasitoids (Hymenoptera: Mymaridae) of *Homalodisca vitripennis* in Moorea between June 2004 and February 2005.

10 km from apart. Nine inland sites were sampled at elevations ranging from 0 to 1400 m in the mountains. Collected Hymenoptera from pan traps were identified, curated, and deposited at the Entomology Research Museum, University of California at Riverside.

Monitoring parasitism of H. vitripennis egg masses. Parasitism of *H. vitripennis* egg masses by resident parasitoids was monitored at eight sites in Tahiti. Four sites were at sea level: two were *Gardenia tahitiensis* (Rubiaceae) plantations (Papenoo and Papara) and two were public gardens (Tapahi and Maraa). Four sites were located in the mountains: two each at 800 m (Hamuta and Te Maru Ata) and 1400 m (Marau and Fare Mato) (Fig. 3). Ten trees were monitored for *H. vitripennis* egg masses at each site (trees were always the same); they were *G. tahitiensis* at the gardenia plantation, *Scaevola* sp. (Goodenacieae) in the public gardens, *Metrosideros collina* (Myrtaceae) at 800 m, and *Vaccinium cereum* (Ericaceae) at 1400 m. Each tree was examined for two minutes and all unemerged *H. vitripennis* egg masses found visually were collected and brought to the laboratory. Harvested egg masses were placed individually in Petri dishes on water-moistened filter paper and maintained at 23°C until *H. vitripennis* nymphs or parasitoids emerged. The percentage of *H. vitripennis* egg masses parasitized was calculated as the number of parasitized egg masses/total number of parasitized and unparasitized eggs masses.

Results and Discussion

Pan trap surveys. A total of 27 specimens of exotic species of the genus *Gonatocerus* Nees were collected during this survey of Tahiti and Moorea. All collected specimens were *Gonatocerus dolichocerus* Ashmead. This species is morphologically very similar to *G. ashmeadi* and can be easily misidentified as such, but is not a known parasitoid of *H. vitripennis*. *Gonatocerus dolichocerus* belongs to the *ater* species group, which has no natural representation in Oceania or Australia.

The results of the pan trap surveys have provided the first record of the presence of *G. dolichocerus* in French Polynesia. *Gonatocerus dolichocerus* is an egg parasitoid native to eastern Canada, U.S.A. and northern Mexico (Huber 1988). Its hosts in the

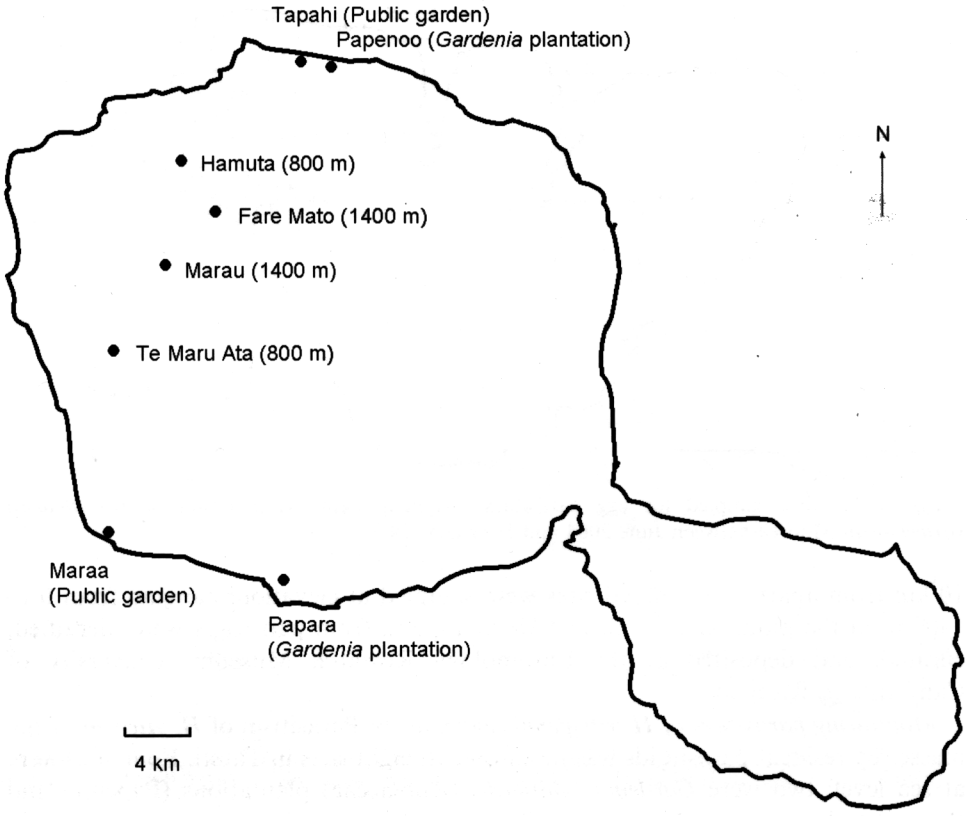

Figure 3. Location of the sites monitored for parasitism of *Homoladisca vitripennis* egg mass between August 2004 and April 2005.

native range are not well known. *Gonatocerus dolichocerus* has been recorded attacking the eggs of a *Gyponana* sp. (Hemiptera: Cicadellidae) in Georgia, U.S.A., laid in twigs of *Prunus* spp. (Rosaceae) and from several treehopper species (Hemiptera: Membracidae) in the U.S.A. (Huber 1988). In the Pacific region, *G. dolichocerus* was first recorded in Hawaii (Oahu) in 1979, and is now present on the larger islands of this archipelago. Previous work suggested that *G. dolichocerus* was most likely introduced into Hawaii accidentally with exotic plants harboring parasitized cicadellid eggs imported from the mainland U.S.A. (Huber & Beardsley 2000). A similar scenario may have facilitated invasion of French Polynesia by *G. dolichocerus*.

Gonatocerus dolichocerus appears to be widespread in Tahiti and Moorea, which suggests that its introduction is not recent (Fig. 1 and 2). *Gonatocerus dolichocerus* was more abundant along the coast than in higher altitude mountainous areas, where it has not observed higher than 812 m (Fig. 1 and 2). Along the coast of Tahiti and Moorea, the vegetation is mainly exotic, while in relatively undisturbed high altitude natural areas, native plants predominate. This suggests that *G. dolichocerus* may be mainly associated with exotic hemipteran hosts which lay eggs on exotic host plants. The cicadellid and membracid faunas of French Polynesia are not well known (Grandgirard et al. 2006b). Native French Polynesian cicadellids are usually found

on native plants (e.g., *Tharra* spp. on *Metrosideros collina* and *Weinmannia parviflora*) (Grandgirard & Petit, personal observation), making it most likely that *G. dolichocerus* attacks exotic membracid or cicadellid species within the Iassinae or Deltocephalinae which both have been discovered recently in Tahiti (Grandgirard & Petit, unpublished).

To determine whether *G. dolichocerus* would attack *H. vitripennis* eggs and thus be a potential host, egg masses of *H. vitripennis* were collected from 12 field locations where *G. dolichocerus* was observed. A minimum of 12 *H. vitripennis* egg masses were collected at each location. Collected egg masses were placed individually in Petri dishes on water-moistened filter paper and maintained at 23°C until nymphs or parasitoids emerged. Of a total of 631 egg masses collected and held in the laboratory for emergence (approx. 6500 eggs), no *G. dolichocerus* emerged. Therefore, we conclude that *H. vitripennis* is not a host for *G. dolichocerus* and this parasitoid will likely not interact with *G. ashmeadi*, the natural enemy chosen for the classical biological control of this sharpshooter.

Monitoring of H. vitripennis egg masses parasitism. Survey results indicated that *H. vitripennis* egg masses found in the *G. tahitiensis* plantation located in the north Tahiti at Papenoo were parasitized by resident parasitoid species. One egg mass was parasitized by an undetermined parasitoid species (4 specimens, probably Mymaridae), and also a *Centrodora* sp. (Hymenoptera: Aphelinidae) from the poorly known *idioceri* species group was reared from 149 collected *H. vitripennis* egg masses. This is the first record of a *Centrodora* Foerster in French Polynesia. The *idioceri* species group is mainly Australasian (with species known also from South Africa). Hosts for *Centrodora* spp. include Cicadellidae, Membracidae, and various other hemipterans (Hayat 1998). Therefore, it is possible that this species is exotic to French Polynesia and arrived in parasitized eggs of exotic hemipterans on imported plants. There is a remote possibility that this species could be native to French Polynesia, but based on biogeography records of this genus its endemic status is unlikely. The *Centrodora* sp. reared from *H. vitripennis* eggs is most likely a generalist and opportunistically exploiting abundant *H. vitripennis* egg masses in Tahiti. Unfortunately, its positive identification to species is impossible due to the current poor state of knowledge of *Centrodora* taxonomy. Females of this species (no males have been collected) are characterized by the following features: head as well as parts of mesosoma and metasoma bright yellow; mesoscutum, scutellum, several gastral terga, and appendages orange-yellow; setae on mesonotum dark, conspicuous; antennal clava rounded, ovipositor occupying almost entire length of the gaster and a little exserted beyond its apex; length 0.66–0.76 mm. Specimens are deposited at the Entomology Research Museum, University of California at Riverside.

We found that *Centrodora* sp. emerged approximately four weeks after *H. vitripennis* egg collection and typically two or three parasitoids emerged from each egg. *Centrodora* sp. parasitized on average 30% of the egg masses of *H. vitripennis* per tree during the period studied (28.6 ± 2.7% [m ± SE]; $n = 466$). In parasitized egg masses, about 60% of the eggs were parasitized by *Centrodora* sp. (56 ± 3%; $n = 122$), while less than 5% (3 ± 1%; $n = 122$) were unparasitized (nymphs of *H. vitripennis* obtained), and about 40% of the eggs died (41 ± 3%; $n = 122$). These results suggest that the parasitoid might oviposit in almost all the eggs of an egg mass and that many parasitoids died during development either because *H. vitripennis* is not a very suitable host for *Centrodora* sp. or because leaves and host eggs

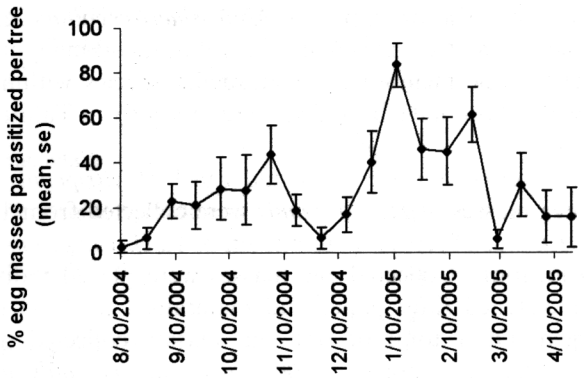

Figure 4. Mean (± SE) percentage of *Homalodisca vitripennis* egg masses parasitized by *Centrodora* sp. per tree in a *Gardenia taitiensis* plantation at each monitoring (Papenoo, Tahiti).

deteriorated in Petri dishes over the 4-week developmental period. Sixty-eight of the ~ 300 parasitoids obtained from egg mass rearing were kept in 95% ethanol for identification. Examination revealed that all kept specimens were females, which suggests that this species might be thelytokous. *Centrodora* sp. appeared to have two generations during the survey period (Fig. 4). In August 2004, parasitism was very low (2.5 ± 2.7%), then a peak in parasitism was observed between September and November 2004 (30 to 50% parasitism), and another peak between January and March 2005 with high parasitism (83.3 ± 9.9%) of egg masses recorded in mid-January 2005. Maximum parasitism was observed during the warmest season in French Polynesia, which suggests that this parasitoid may initiate reproduction when temperatures increase (Fig. 4 and 5). *Centrodora* sp. was also found parasitizing *H. vitripennis* eggs in three other study sites located at altitude, but that was very rare (4 egg masses found parasitized at 800 m [Hamuta and Te Maru Ata] and one at 1400 m [Marau]). *Centrodora* sp. was also found in several other locations at sea level in Tahiti (Punaauia, Paea) and in Moorea (Paopao, Hauru).

Centrodora sp. may be a minor competitor with *G. ashmeadi* for *H. vitripennis* eggs after this parasitoid has been released. Interspecific competition could affect the

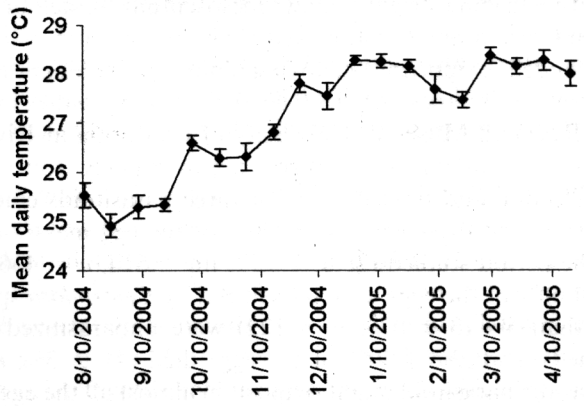

Figure 5. Mean (± SE) daily temperature recorded in Faaa (Tahiti) between August 2004 and April 2005.

establishment and efficiency of *G. ashmeadi* in locations where *Centrodora* sp. is abundant, especially during the warmest season when parasitism by *Centrodora* sp. is high. However, *G. ashmeadi* develops at least two times faster than *Centrodora* sp. (egg to adult emergence ~ 10 to 12 days at temperatures ≥ 25°C) (Pilkington & Hoddle 2006), and in this regard *G. ashmeadi* would be expected to outcompete *Centrodora* sp. In addition, should classical biological control of *H. vitripennis* by *G. ashmeadi* be successful, pest egg masses would become less abundant because of parasitism by *G. ashmeadi* and *Centrodora* sp. would most likely continue to exploit hosts used before the invasion of *H. vitripennis* into French Polynesia.

Two other parasitoid species were reared from *H. vitripennis* eggs collected from *Scaevola* sp. (Maraa and Tapahi) in January 2005 (11th and 25th) and *M. collina* at 800 (Hamuta) on the 15th February 2005, but only one egg mass was found parasitized at each site. One of the parasitoids was in the genus *Palaeoneura* Waterhouse (Hymenoptera: Mymaridae); it belongs to a group of species that comprised the recently synonymized genus *Chaetomymar* Ogloblin (Triapitsyn & Berezovskiy 2007). 15 parasitoids were obtained from 3 egg masses for a total of 17 eggs (sex undetermined). This species is close in identity to *P. sophoniae* (Huber) and *P. indopeninsularis* (Mani & Saraswat), which are known parasitoids of leafhoppers in the Old World (Huber 2003). The other parasitoid was in the genus *Anagrus* Haliday (Hymenoptera: Mymaridae), 18 females and 5 males of which were reared from one egg mass of *H. vitripennis* containing 8 eggs collected at Tapahi Point (January, 11th, 2005). This species of *Anagrus* is a new, undescribed species in the *incarnatus* species group of the nominate subgenus of *Anagrus*. It is somewhat similar morphologically to *A. antipodus* Triapitsyn, described from Australia, and also to *A. oahuensis* Triapitsyn & Beardsley, described from Hawaii.

Specimens of G. dolichocerus *collected.* Tahiti - Urbanized area (sea level) - Faaa : 1 female, 1 male; Paea: 2 females, 1 male; Te Marau Ata: 2 females; Papara: 2 females, 1 male; Taravao1: 1 female; Tiarei: 2 females; Tautira: 6 individuals. Preserved area – Belvedere: 4 females; Marau 2: 1 female. Moorea – Airport: 1 female; Vaiare: 2 females.

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