General News

Glassy-Winged Sharpshooter K.O.'ed – First Round – in French Polynesia

Glassy-winged sharpshooter (GWSS), *Homalodisca coagulata*, has proven to be an extraordinary and highly invasive insect pest with a well documented ability to achieve incredible population densities in new areas when dislocated from its suite of natural enemies. This xylem feeding cicadellid is native to the southeast USA and northeast Mexico and in its native and invaded ranges is a major threat to agricultural, native, and urban landscapes because of its ability to acquire and transmit a lethal xylem-dwelling plant pathogenic bacterium, *Xylella fastidiosa*. This bacterium is native and widespread within the Americas and may exist in other countries outside of the native range having been unknowingly imported in ornamental plants from areas with endemic *X. fastidiosa* populations.

GWSS began its range expansion in the late 1980s, moving into California, USA, probably from the southeastern USA, on ornamental plants. Unparasitized egg masses on the undersides of leaves or small flightless nymphs were mostly likely the original inoculative propagules into California. Adult GWSS are extremely flighty and unlikely to stay on plants that are being subjected to vigorous handling and transport. Inordinate densities of GWSS developed in California and began to spread rapidly out of southern California where populations were originally highly localized. Despite widespread insecticide use in ornamental nurseries to produce uninfested plants for sale and citrus orchards to reduce immigration into vineyards and other crops, immense propagule pressure still resulted and California was most likely the source for GWSS entering Tahiti (Society Islands of French Polynesia) in 1999, and Hawaii in 2004. Easter Island (GWSS detected in 2005) was probably infested with material originating from French Polynesia.

Distribution in French Polynesia

In French Polynesia, GWSS reproduced and spread very rapidly and is currently found in almost all islands in the Society Island group (Tahiti [invaded in 1999], Moorea [2002], Tahaa, Raiatea, Huahine, Bora Bora, Maupiti [2001–2005]) and has also been recorded in Nuku Hiva in the Marquesas (2004), and in Tubuai and Rurutu (both 2005) in the Australs (2005). It is unknown if GWSS is in the Tuamotu group of islands. Widespread and rapid movement of GWSS in French Polynesia most likely occurred via unregulated movement of plants that carried GWSS egg masses or nymphs between islands and island groups by plane and boat. GWSS populations in Tahiti and Moorea reached densities far exceeding those observed in its native range or even California where populations were much greater than those observed in the southeastern USA.

The Problems Caused by GWSS in French Polynesia

High GWSS densities are a major annoyance for people in French Polynesia because feeding adults and nymphs produce astonishingly high quantities of watery excreta that 'rains' from heavily infested trees. This makes utilization of shade trees impossible when trying to find respite from the hot sun and has earned GWSS the common local name *mouche pisseuse* ('pissing fly'). Buildings and vehicles under infested trees are drenched with excreta to the point that water runs off structures and pools on the ground. Such high and continuous removal of xylem fluids by thousands of feeding nymphs and adults is thought to have had a detrimental impact on many plant species in French Polynesia. GWSS is suspected of retarding plant growth and causing declines in fruit production, especially in mangoes and other fruit trees. Large numbers of flying adults are attracted to lights at night, and they invade houses and businesses through open windows and doors, and on occasion adults may 'bite' people as they presumably probe salt glands. But the major concern for French Polynesia is the possibility that this pest could acquire and vector *X. fastidiosa*, which potentially would have a disastrous impact on the agriculture and biodiversity of these isolated islands. Finally, the immense propagule pressure emanating from French Polynesia represents a major invasion threat to other South Pacific countries. Adult *H. coagulata* have been found on planes originating from Tahiti arriving in Japan and in Australia.

Factors Promoting Establishment, Proliferation and Spread

The rapid proliferation and spread of *H. coagulata* in French Polynesia can be explained by four main factors: First, environmental conditions in these tropical islands are ideal for reproduction. Moderate temperatures and high rainfall in some areas ensure ideal breeding conditions year round on abundant native and exotic host plants. We estimate that in Tahiti, there are 6–8 overlapping *H. coagulata* generations a year, compared to 2–3 generations in California and northern-central Florida (USA). In California, cold winters retard egg production and egg laying in *H. coagulata*. Consequently, cold temperatures do not inhibit reproduction by *H. coagulata* in French Polynesia. Instead, reproductive potential appears to be more strongly influenced by wet and dry seasons, with greater populations being observed during wet periods.

Second, our surveys in French Polynesia indicate that there appear to be no effective natural enemies regulating *H. coagulata* populations. Surveys of *H. coagulata* egg masses on Tahiti and Moorea in 2003 showed very low levels of parasitism; less than 5% of the egg masses were attacked by parasitoids. The parasitoid species that was reared from *H. coagulata*

egg masses was an unidentified encyrtid. Female parasitoids only exploited 1–3 eggs in an attacked egg mass (egg masses typically contain on average around 7–10 eggs) and only male eggs were oviposited suggesting that parasitism was opportunistic and that *H. coagulata* eggs were assessed to be of low quality as only haploid male eggs were laid. This obvious dearth of effective indigenous natural enemies is highly likely to have facilitated the establishment and rapid spread of *H. coagulata* in French Polynesia.

Third, *H. coagulata* may pose a substantial risk to generalist arthropod predators on invaded islands in French Polynesia. Controlled feeding experiments have revealed that some species of spiders can be killed following predation on *H. coagulata.* Mortality in both the native crab spider *Misumenops melloleitao* and the pan-Pacific orb-weaving spider *Cyrtophora moluccensis* appeared to result from lethal intoxication, although no form of chemical defence has been reported in *H. coagulata*. In both spider species, approximately half of all spiders that attacked individual *H. coagulata* nymphs or adults died. As *H. coagulata* populations increase in size and range on invaded islands in French Polynesia, this insect will be increasingly encountered by these and other arthropod predators, raising the possibility of population-level impacts on susceptible predator species.

Fourth, the cicadellid fauna of French Polynesia is impoverished with few known native species and a substantially greater number of exotic species that have established accidentally. Consequently, competition by other proconiine cicadellids is non-existent as this tribe within the Cicadellidae is unique to the Americas and lacks naturally-occurring representation in the South Pacific. When taken together, these four major factors, permissive environment (mild climate and abundant year-round feeding and oviposition substrates), natural enemy free space, predator intoxication, and lack of competition have facilitated invasion, a situation that is common for many successful invasive species.

Biological Control Decided as a Sustainable Management Strategy for GWSS in French Polynesia

Consequently, there is an urgent and immediate need to control high density populations of GWSS in French Polynesia. By reducing population densities many problems, both actual (human nuisance, and continued range expansion) and potential (widespread vectoring of *X. fastidiosa*) would be mitigated. A review of potential control options was commissioned in 2003 by the French Polynesian Ministry of Agriculture. The conclusion reached by Ministry officials was that biological control potentially offered the most effective and permanent management solution for GWSS. In 2004, a classical biological control programme using the mymarid egg parasitoid *Gonatocerus ashmeadi* was given approval. This biological control programme was initiated by the University of California (Berkeley and Riverside campuses) via the University of California Richard B. Gump South Pacific Research Station on Moorea. An alliance between University of California personnel and scientists with the French Polynesian Agricultural Research and Plant Protection departments guided the development of the GWSS biological control programme.

Determining the Risk Posed by GWSS Egg Parasitoids to Native Insects

An over-riding requirement for classical biological control of GWSS in French Polynesia is safety and a demand for minimal to non-existent non-target impacts. Particular attention is being paid to the identification and assessment of risk to non-target native fauna, in particular native cicadellids. As with many small isolated islands, French Polynesia is extremely susceptible to invasions by exotic organisms. Unfortunately, French Polynesia has a poor track record in biological control safety and programme efficacy. Consequently, this pest control technology is viewed with scepticism by many officials managing invasive species in French Polynesia. The most egregious example of a 'biological control disaster' in French Polynesia was the unintentional extirpation of native *Partula* snails on many islands by the predatory snail, *Euglandina rosea*, which was released for the biological control of the giant African land snail, *Achatina fulica*, in 1977. Biological control programmes for arthropod pests are consequently being held accountable for greater levels of safety than has been required in the past, and determination of host specificity and assessment of expected levels of safety and impact are emerging as rapidly developing new areas in classical biological control of arthropod pests.

Gonatocerus ashmeadi is a specialized parasitoid that attacks cicadellid eggs in the tribe Proconiini. Hence introduction of *G. ashmeadi* in French Polynesia is considered low risk for native cicadellids as there are no known indigenous representatives in the tribe Proconiini that may be potential hosts for these parasitoids. Furthermore, all the known native cicadellids are relatively small compared with GWSS and survey results indicate that they lay small eggs, often singly and not in egg masses typical of GWSS. This difference in egg laying biology is important as non-target impact research in California indicates that *G. ashmeadi* does not recognize small single cicadellid eggs as potential hosts. While the *a priori* risk appears to be low based on phylogenetic, morphological, and ecological criteria, a major caveat is our limited knowledge of the native cicadellid fauna (most notably in the Society Islands). Consequently, surveys and preparation of an inventory of native species have been initiated to reduce the possibility that overlooked indigenous species that could be inadvertently put at risk are not overlooked in French Polynesia.

Importation and Release of Gonatocerus ashmeadi

In September 2004, the classical biological control programme against *H. coagulata* commenced when populations of *G. ashmeadi* (adult parasitoids and parasitized GWSS egg masses) sourced from the University of California Riverside were established in the Service du Développement Rural (SDR) quarantine facility at Papara (Tahiti). Following intensive field survey work and difficult lab studies on native

cicadellids it was concluded that *G. ashmeadi* posed negligible risk to native cicadellids. The apparent lack of potential non-target impacts combined with increasing public and political pressure to release *G. ashmeadi* from quarantine resulted in the decision to begin parasitoid introductions in Tahiti and Moorea. However, at the time of the release decision, the risk posed by *G. ashmeadi* to non-target cicadellids was shown to be very low for several native species, but some level of uncertainty persists because the inventory of native species was not completed, and some collected species were undescribed and in need of detailed studies. To have a more accurate assessment of the potential non-target impact of *G. ashmeadi*, studies would have needed to be continued, but indeterminant continuation of this work could delay indefinitely the introduction of *G. ashmeadi* and increase substantially risks associated with unregulated proliferation and spread of GWSS.

Consequently, available data on native species and potential non-target impacts were presented to the Council of Ministers and the Conservation Committee (composed of representatives from: Commission of Natural Monuments and Sites, the Environment, Research, Tourism and Equipment ministries, etc.) in April 2005 for a decision to release *G. ashmeadi* in French Polynesia against *H. coagulata* in May 2005. The two main factors taken into account by regulatory authorities when assessing the risk of releasing *G. ashmeadi* in French Polynesia were: (1) the likelihood of continued unregulated population growth and rapid spread of *H. coagulata* through French Polynesia and elsewhere in the South Pacific, and the possible acquisition and vectoring of *X. fastidiosa* to agricultural, ornamental and native plants by high density pest populations; and (2) the risk that *G. ashmeadi* would cause substantial and unexpected collateral damage to rare native non-target cicadellid species.

The French Polynesian Government considered that the benefits of controlling *H. coagulata* with *G. ashmeadi* outweighed possible negative ecological impacts on native species and decided releases of *G. ashmeadi* from quarantine for liberation and establishment in the field should be initiated in May 2005. The first releases of *G. ashmeadi* commenced on 2 May 2005 in Tahiti. A total of 13,786 parasitoids has been released in 27 sites located all around the island of Tahiti (except in the southwestern part of the island where non-release control sites were located) between May and October 2005. The released parasitoids were between 1 and 4 days old, and the sex ratio was about 70% female. Surveys indicated that *G. ashmeadi* readily established at release sites.

Assessing the Impact of G. ashmeadi on GWSS in French Polynesia

The impact of *G. ashmeadi* on GWSS and possibly on native cicadellids is currently being monitored. GWSS abundance at parasitoid release sites paired with control parasitoid non-release sites was assessed by examining ten shrubs of a preferred plant species (i.e. *Scaevola* sp.) on which GWSS readily feeds and lays eggs. The same ten trees were sampled each time at each survey site when census data were collected. GWSS adults, nymphs and egg masses were searched and counted on each tree for a fixed time: 2.5 minutes for the adults and nymphs, and 2 minutes for egg masses. Egg masses found during visual counts were collected and returned to the laboratory where the number of eggs in each egg mass was counted with a microscope and the percentage of eggs parasitized determined.

By October 2005, the parasitoid had completely colonized Tahiti (including non-release control sites), and was even found in the mountains at elevations of 1400 m. Survey results indicate that *G. ashmeadi* has had a catastrophic impact on GWSS populations. Prior to parasitoid release, GWSS densities on Tahiti were averaging around 100 to 240 nymphs being collected in a sweep net per minute of sampling effort. After the parasitoid release, an abrupt decline in GWSS abundance was observed at all release sites. Parasitism of GWSS eggs has averaged around 88–100%, and since December 2005, the number of GWSS nymphs has been maintained at a very low level with less than three nymphs per site on average. This represents a decrease of ~97–99% in GWSS nymph densities.

Conclusions

The results obtained from this classical biological control project have demonstrated that the parasitoid *G. ashmeadi* readily established in Tahiti and rapidly colonized the whole island including high elevation mountainous interior sites. The results of egg parasitism and the comparison of GWSS abundance before and after releases at the release sites and parasitoid invasion into control sites indicated clearly an extremely large decrease in *H. coagulata* abundance in Tahiti (>95%). This observed population collapse is due directly to the action of the introduced egg parasitoid. As *G. ashmeadi* attacks the eggs of its host, the initial impact on pest population structure was first seen on the abundance of nymphs (maximum impact observed 2–3 months after the parasitoid arrival), then on adults (maximum impact observed 5–6 months after the parasitoid arrival) and finally on the number of egg masses (maximum impact observed 6–7 months after parasitoid release) being counted in surveys. Since very good results were obtained by *G. ashmeadi* in Tahiti, the biological control programme will now be extended to all islands in French Polynesia infested with GWSS. More information on the GWSS biological control programme in French Polynesia can be found on the Internet at: http://moorea.berkeley.edu/research/health/.

By: Mark S. Hoddle[1], Julie Grandgirard[2], Jérôme N. Petit[2], George K. Roderick[3] and Neil Davies[2]

[1]Dept. of Entomology, University of California, Riverside, CA 92521, USA.
Email: mark.hoddle@ucr.edu

[2]Richard B. Gump South Pacific Research Station, University of California, Berkeley, BP 244, 98728 Moorea, French Polynesia.

[3]Environmental Science, Policy and Management, Division of Insect Biology, University of California, Berkeley, CA 94720, USA.