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# SEASONAL PHENOLOGY AND NATURAL ENEMIES OF *MACONELLICOCCUS HIRSUTUS* (HEMIPTERA: PSEUDOCOCCIDAE) IN AUSTRALIA

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ABSTRACT

Foreign exploration for natural enemies of pink hibiscus mealybug, *Maconellicoccus hirsutus*, was conducted in Australia from 2000 to 2002. In Queensland, the predaceous beetle *Cryptolaemus montrouzieri*, the predaceous drosophilid fly, *Cacoxenus perspicax* and the encrytid parasitoid *Gyranusoidea indica* were recovered. In Western Australia and the Northern Territory a predatory noctuid, *Mataeomera* sp., an aphelinid parasitoid *Coccophagus* sp., and a probable encyrtid hyperparasitoid, *Coccidoctonus* sp. were reared from *M. hirsutus* on a native *Hibiscus* species. A field study was conducted from February 2000 to March 2002 in Sherwood, Queensland to document the seasonal phenology of *M. hirsutus* in its native habitat on its preferred host, *Hibiscus rosa-sinensis*. Populations of the mealybug stayed at or below detectable levels for most of the study with minor population peaks in the summer months.

Key Words: mealybugs, biological control, *Cryptolaemus, Gyranusoidea indica*, Australia

RESUMEN

Se llevo a cabo una exploración exótica de enemigos naturales del la cochinilla harinosa rosada de hibisco, *Maconellicoccus hirsutus*, en Australia de 2000 a 2002. En Queensland, se recubrieron el escarabajo depredador, *Cryptolaemus montrouzieri*, la mosca drosofílida depredador, *Cacoxenus perspicax* y el parasitoide encírtido *Gyranusoidea indica*. En Australia Occidental y en el Territorio del Norte, un noctuido depredador, *Mataeomera* sp., un parasitoide afelínido, *Coccophagus* sp., un encírtido, *Coccidoctonus* sp. lo cual es probablemente un hiperparasitoide, fueron criados de *M. hirsutus* sobre una especie nativa de *Hibiscus*. Se llevo a cabo un estudio del campo en febrero 2000 a marzo 2002 en Sherwood, Queensland para documentar la fenología estacional de *M. hirsutus* en su hábitat nativa sobre su hospedero preferido, *Hibiscus rosa-sinensis*. Poblaciones de la cochinilla harinosa se mantenia al nivel de o debajo del nivel detectable para la mayor parte del estudio con cumbres menores de población en los meses de verano.

The pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae) invaded Caribbean islands, during the mid 1990s, was detected in Belize, Mexico, and the Imperial Valley of California in 1999, and the Bahamas in 2000 (Meyerdirk 2000; Michaud & Evans 2000; Roltsch et al. 2001). In the absence of effective natural enemies, the highly polyphagous *M. hirsutus* can reach very high population levels (Stibick 1997). At outbreak densities, damage to agricultural crops and ornamental landscape plantings can be quite extensive, actually killing hibiscus and some trees such as soursop, *Annona muricata* L. and *Samanea saman* (Jacq.) Merr. (Meyerdirk 1999; Kairo et al. 2000). In the presence of natural enemies, Michaud & Evans (2000) report that the host range of the mealybug in the field is much reduced and that noticeable damage was restricted to its preferred host, hibiscus, *Hibiscus rosa-sinensis* L. The parasitoids *Anagyrus kamali* Moursi and *Gyranusoidea indica* Shafee, Alam & Agarwal (Hymenoptera: Encyrtidae), and predator *Cyrptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) were introduced into the Caribbean and are providing excellent control of *M. hirsutus* (Kairo et al. 2000; Meyerdirk, 1999, 2000; Michaud & Evans 2000).

The two parasitoid species *A. kamali* and *G. indica* were recently introduced into the Imperial Valley of California within one month after the initial detection of *M. hirsutus*. It is not known how well these natural enemies will perform in

the hot, dry Imperial Valley climate, although preliminary results are positive (Roltsch et al. 2001). In anticipation of the need for new natural enemy species that are climatically adapted to the environment in the Imperial Valley, a search for new natural enemies was conducted in climatically similar parts of Australia. *Maconellicoccus hirsutus* is believed to be native to Australia and is distributed throughout the wet and dry subtropical and tropical areas of Queensland, Northern Territory, and Western Australia (Williams 1985).

In Australia, *Maconellicoccus hirsutus* is under excellent natural control by predators and parasitoids and rarely reaches pest status. It has been collected from *Annona squamosa* L., *Citrus* spp., *Erthryina* sp. *Glycine max* L., *Gossypium* spp., *Sida Acuta* Burm. f., *Parkinsonia* sp. *Parthenium hysterophorus* L., and *Hibiscus* spp. (Williams 1985) Radunz & Allwood (1981) report that it is an occasional pest of ornamentals in the Northern Territory. Perhaps due to its minor pest status, very little is known about the seasonal phenology of *M. hirsutus* in its native range. A field study of *M. hirsutus* was conducted in subtropical southeast Queensland (Goolsby 2000) where it is native, on its preferred host—hibiscus. The study is designed to be used as a comparison for studies of *M. hirsutus* where it is invasive.

## Materials and Methods

### Seasonal Phenology

Garden sites with hibiscus, *H. rosa-sinensis* were selected in suburban Brisbane, Queensland to study the seasonal phenology of *M. hirsutus*. Monthly collections over a two-year period from April 2000 to March 2002 were made in Sherwood, Graceville, Chelmer and Indooroopilly, Queensland, all residential suburbs in the Brisbane metropolitan area. Each garden site had mature plantings of hibiscus. Corrugated cardboard bands were used to estimate the density of *M. hirsutus*. This technique has been used in several biological control programs to monitor population densities of mealybugs and evaluate the impact of their natural enemies (DeBach 1949, Browning 1959, Furness 1976, Berlinger 1977). Banding has the advantage of being the least destructive measure of pest density. Destructive sampling of plant terminals on individual hibiscus plants could have an effect on the mealybug population. Six bands per site (ea. $10 \times 7$ cm) were wrapped around the main trunk and limbs of the hibiscus plants and secured with wire garden tie. Bands were left on the plants for a period of one month. Counts of mealybugs in the bands were conducted in the laboratory. All stages of mealybugs on the surface of the bands were counted; however, the counts overwhelmingly represent mature ovipositing females. Bands were held in paper cartons streaked with honey for emergence of the natural enemies.

Arthropods collected by the Australian Biological Control Laboratory (ABCL) were assigned a specific site collection number. Each accession is unique prefaced by the acronym for the laboratory with the year collected and a serial number associated with the field collection (i.e., ABCL 2000809). If an organism is later exported to the U.S. for a biological control program, the number is used as an identifier in the ROBO (Releases of Beneficial Organisms) database that is maintained by USDA-Agricultural Research Service. Genbank accession numbers for the exported agents are also included as an identifier in ROBO (i.e., GENBANK-1786201). This method allows biological control workers to track the identity of the organism, including its DNA profile, from field collection through quarantine evaluation and release.

### Foreign Exploration

Natural enemies were collected from bands used in the *M. hirsutus* field study conducted in Brisbane, Queensland from Jan 2000 to March 2002. After field collection, the bands were held in paper cans streaked with honey for emergence of the natural enemies. In addition, two distinct collections were made in the Northern Territory and Western Australia in July 2000 and May 2001. Leaves, terminals and roots were sampled for *M. hirsutus* in these collections. Mealybugs of all stages were transferred to cotton stoppered vials with honey and held in a humiditron (Debach & Rose 1985) at 70% RH for emergence of parasitoids. Mealybugs were sent to the Queensland Department of Primary Industries for identification. Parasitoids and predators were sent to the ARS—Systematic Entomology Laboratory (SEL) in Beltsville, MD for identification. *Gyranusoidea indica* collected in Queensland was compared to material from rearing colonies in the California Dept. of Food and Agriculture in Brawley, CA. Molecular sequencing of the D2 expansion domain of the 28S rRNA gene was used to compare the two populations. The method was employed by Babcock & Heraty (2000) and De Barro et al. (2000) to distinguish *Encarsia* species of parasitic Hymenoptera.

## Results and Discussion

### Seasonal Phenology

Three of the six garden sites were originally selected because they had visible populations of mealybugs on the terminals of the hibiscus plants. The terminals of the plants were impacted and exhibiting bunchy growth, but no leaf loss.

The population density in February 2000 at these three sites were the highest encountered in the study with 100, 92, & 102 *M. hirsutus* individuals collected in the bands respectively. The high population levels at these three sites were not sustained. For the remainder of the study, populations at all the sites remained at very low levels for most of the year with two small peaks occurring during the summer months (November-January) of 2001 (3.2 ± 0.8 *M. hirsutus* per band) and 2002 (3.3 ± 0.9 *M. hirsutus* per band) (Fig. 1). Populations were below detectable levels during the winter months (June-August) in 2001-02. *Cryptolaemus montrouzieri* was consistently recovered from the bands throughout the study when mealybugs were present. The characteristic larvae were also commonly observed on infested terminals. The parasitoid, *G. indica* was rarely recovered. It may have been underrepresented in our study due to predation by *C. montrouzieri* in the bands, or due to the tendency of the bands to harbor later instar mealybugs that are not preferred by the parasitoid. The adult female *M. hirsutus* often uses the bands for shelter during production of ovisacs. Our observations of the natural enemies suggest that *C. montrouzierri* plays the key role in regulating *M. hirsutus* in this environment.

Retrospectively, we compared population levels in our study to those in Puerto Rico post release of *A. kamali* and *G. indica* (Michaud & Evans 2000). We concluded that for most of the two-year study, hibiscus stands showed light or no damage with less than 5% of the plants with live *M. hirsutus*, which is far below levels detected post release of natural enemies in Puerto Rico.

### Foreign Exploration

The predators, parasitoids and hyperparasitoids reared from all the collections of *M. hirsutus* are listed in Table 1. In Queensland (QLD), *C. montrouzieri* was the most commonly encountered natural enemy. Populations of the beetle persisted year round, responding to even low densities of *M. hirsutus*. *Cryptolaemus montrouzieri* is highly polyphagous in its native habitat. Larvae and adults feed on crawlers and immature soft scales, armored scales, wax scales, fluted wax scales, and all stages of many mealybug species (Smith et al. 1997). However, its preference appears to be for mealybugs (Don Sands, CSIRO

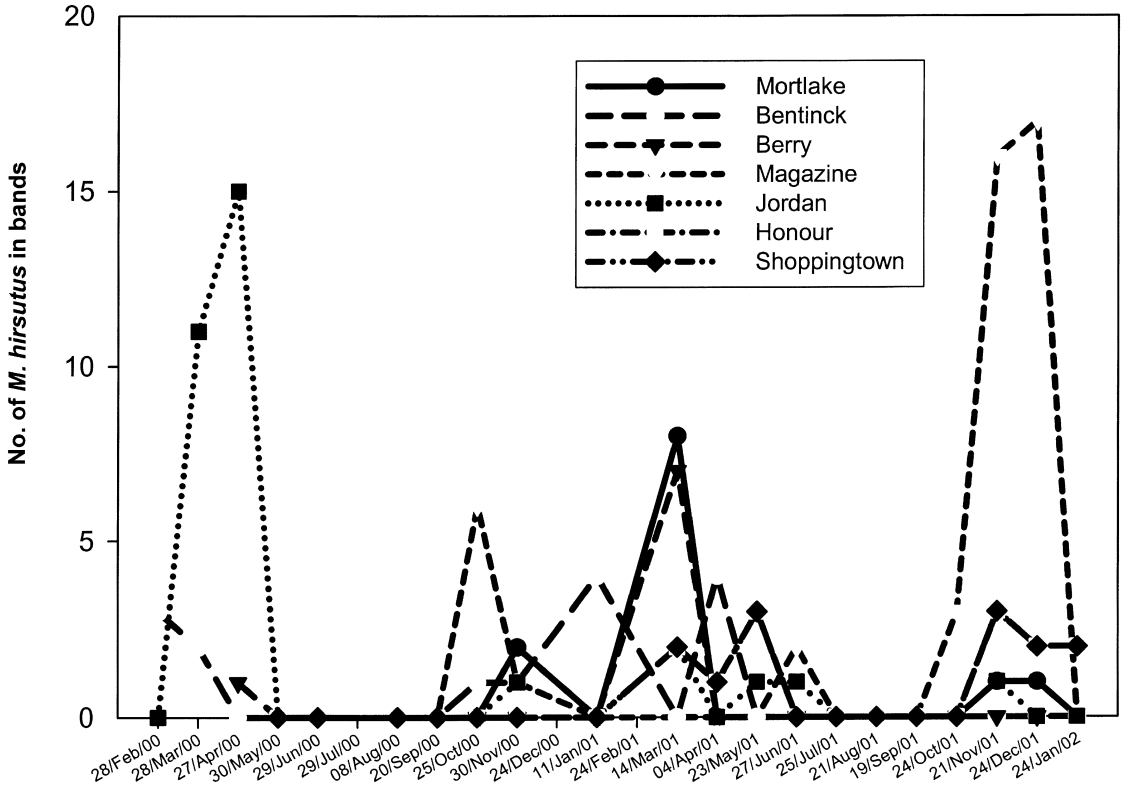


Fig. 1. Total number of *Maconellicoccus hirsutus* caught in bands at six locations in Southeast Queensland over a two-year period. The seasons are as follows, Winter (June-August), Spring (September-November), Summer (December-February) and Fall (March-May).

TABLE 1. NATURAL ENEMIES RECOVERED FROM *MACONELLICOCCUS HIRSUTUS* IN AUSTRALIA.

| Species | ABCL #* | Location | Date | Comments |
|---|---|---|---|---|
| *Gyranusoidea indica*<br>Hym: Encyrtidae | 2000809 | Sherwood, QLD<br>27°31.80 S 152°58.80 E | 28-II-2000 | D2 sequences identical to colony in Brawley, CA |
| *Cacoxenus perspicax*<br>Diptera: Drosophilidae | 2000809 | Sherwood, QLD<br>27°31.80 S 152°58.80 E | 28-II-2000 | Common predator found associated with high densities of pink hibiscus mealybug |
| *Ophelosia bifasciata*<br>Hymenoptera: Pteromalidae | 2000803 | Sherwood, QLD<br>27°31.80 S 152°58.80 E | 28-II-2000 | Not commonly recovered may be a parasitoid of *Crytpolaemus* |
| *Crytpolaemus montrouzieri*<br>Coleoptera: Coccinellidae | 2000809 | Sherwood, QLD<br>27°31.80 S 152°58.80 E | 28-II-2000 | Very common predator |
| Encyrtidae: Hymenoptera<br>*Coccidoctonus* sp. | 2000892 | Kununurra, WA<br>15°40.12 S 128°39.57 E | 8-X-2000 | Collected from native *Hibiscus* sp. and may be a hyperparasite |
| *Coccophagus* sp.<br>Hymenoptera: Aphelinidae | 2000892 | Kununurra, WA<br>15°40.12 S 128°39.57 E | 8-X-2000 | Collected from native *Hibiscus* sp. |
| *Mataeomera* sp.<br>Lepidoptera: Noctuidae | 2000892 | Kununurra, WA<br>15°40.12 S 128°39.57 E | 8-X-2000 | Collected from native *Hibiscus* sp. |

*ABCL # = site collection number for the USDA-ARS, Australian Biological Control Laboratory.

Entomology, pers. comm.). *Cryptolaemus montrouzieri* is extant in parts of California; therefore there are no plans to introduce this species. A predaceous drosophilid fly, *Cacoxenus perspicax* Knab was collected, but only at high *M. hirsutus* densities. The host range of *C. perspicax* and its impact on *M. hirsutus* is not known. No plans were made to introduce this species to the United States. The encrytid parasitoid *G. indica* was occasionally collected from *M. hirsutus* in Queensland. There were no differences in the D2 sequences between the *G. indica* populations from Queensland and those in culture in California; therefore we elected not to ship this population to U.S. quarantine facilities. Representative specimens of *G. indica* from Queensland were vouchered at SEL and the colony was terminated.

Collections of *M. hirsutus* in the Northern Territory (NT) and Western Australia (WA) revealed different species of natural enemies from those found in Queensland. Several potential wild malvaceous hosts were surveyed in addition to ornamental hibiscus including, *Gossypium australe* F. Muell, *Gossypium sturtianum* J. H. Willis, *Gossypium robinsonii* F. Muell., *Hibiscus panduriformis* N.L. Burman var. *australis* Hochr., *Hibiscus* sp. C and *Abutilon lepidum* (F. Mueller) A. Mitch. *Maconellicoccus hirsutus* was collected from ornamental hibiscus, at several locations in the NT and WA, but no parasitoids emerged. Collections made of *G. australe* in northwestern Western Australia near Derby and Broome revealed substantial numbers of *M. hirsutus* just below ground level feeding on the roots and crown of the plant. Populations of *M. hirsutus* on the roots were heavily defended by ants. Near Kununurra, WA, *M. hirsutus* was collected from the terminals of a wild malvaceous host identified using the Flora of the Kimberley (Wheeler et al. 1992) as *Hibiscus* sp. C. A predaceous noctuid larvae, *Mataeomera* sp., an aphelinid parasitoid *Coccophagus* sp., and a probable hyperparasitoid, *Coccidoctonus* sp. were reared from *M. hirsutus* on this native host plant (Table 1). *Mataeomera* sp. could have potential as a biological control agent as some species in this genus are believed to have a narrow host range and can be quite damaging to mealybug populations (Don Sands, CSIRO Entomology, pers. comm.). This species, as well as the primary parasitoid *Coccophagus* sp. might be considered for importation if additional natural enemies are needed for control of *M. hirsutus* in California.

## CONCLUSION

In its native range, *M. hirsutus* is rarely a pest and under excellent natural control by indigenous natural enemies. The predator *C. montrouzieri* appears to be the key natural enemy in subtropical eastern Australia on ornamental stands of hibiscus. More intensive sampling is needed to determine the impact of parasitism by *G. indica*. In addition, the natural enemies *Mataeomera* sp. (Lepidoptera: Noctuidae), and *Coccophagus* sp., (Hymenoptera: Aphelinidae) from the hot, monsoonal environment of northern Australia and could be useful in biological control efforts in California if *A. kamali* and *G. indica* do not provide adequate control.

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