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Aphid Parasitoids (Hymenoptera: Aphidiidae) on Guam

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Abstract—The aphidiid parasitoids of Guam and their associated host aphids are documented. *Lipolexis oregmae* (Gahan), *Lysiphlebus testaceipes* (Cresson) and *Aphidius matricariae* Haliday were collected from Guam, with the latter being represented by a single specimen. The aphidiids *Aphidius colemani* Viereck and *Diaeretiella rapae* (M'Intosh) have been released as biological control agents on Guam. *A. colemani* was reared from *Aphis gossypii* Glover mummies collected from the release area shortly after its initial introduction, but has not been recovered in subsequent samples. Likewise, *D. rapae* was recovered at several release sites about a month after release, but not since. All aphidiid parasitoids observed on Guam are introduced species, as are the aphids they attack. A synonymy between *L. scutellaris* (Mackauer) and *L. oregmae* (Gahan) is provided, as is a key to Guam aphid parasitoids.

Aphelinid parasitoids were occasionally collected in this study. While listed in the collection index , they were not identified to species level or dealt with further in the analysis.

Introduction

The flora and fauna of oceanic islands exhibit unique characteristics, composition, development and origin. While the natural development of insular populations on small islands may be rather slow (MacArthur & Wilson 1967), human activities frequently affect the colonization rate and alter the structure of island ecosystems through the introduction of alien and invasive plant and animal species (Schreiner & Nafus 1986, Nafus 1991, 1993). Aphid pests of islands in the

Pacific Basin are represented by several cosmopolitan and pan-tropical species. All aphid species identified from the Mariana Archipelago islands of Guam, Saipan, Tinian and Rota are introduced, invasive pest species, a few of which consistently attain high population densities on crop and ornamental hosts (Pike et al. 2000a). However, the number of species present in the natural enemy complexes in the Mariana Islands and on other Pacific islands varies considerably, as does their effectiveness at locating and successfully attacking prey items (Stechmann & Voelkl 1990, Carver et al. 1993).

This paper describes the current state of knowledge of the identity, distribution and host range of aphidiid parasitoids currently associated with aphids on Guam. It includes information on the release of two aphidiid parasitoids as part of a classical biological control program for crop aphids on Guam.

Materials and Methods

Parasitoids were reared from an extensive collection of aphids taken from crop and non-crop plants throughout the tropical island of Guam in the Western Pacific Basin (13º N 144º E) from 1997 through 2000 (Pike et al. 2000a). Aphid colonies were collected from most of the island's crops as well as from many ornamentals and uncultivated plants and maintained at room temperature in the laboratory in plastic containers. Colonies were inspected daily and emerging parasitoids collected and preserved in 70% ethanol for subsequent identification. Determinations of aphids and parasitoids were made by the authors and support staff. Voucher specimens are maintained at Washington State University, Prosser, Washington and by the Agricultural Experiment Station, University of Guam (UOG), Mangilao, Guam. Host plant determinations were made by the authors, with assistance from C.L. Raulerson of the Division of Natural Sciences, University of Guam. Morphological nomenclature of aphidiids follows Huber & Sharkey (1993), while aphid nomenclature follows Remaudière & Remaudière (1997).

The parasitoids *Aphidius colemani* Viereck and *Diaeretiella rapae* (M'Intosh) were released on Guam as part of a biological control activity charged with seeking to reduce pesticide usage against aphids on Guam. Parasitoids were obtained from founder populations mass reared at Washington State University in insectaries at Prosser, WA and Pullman, WA (Northwest Biocontrol Insectary & Quarantine, T. Miller - Manager). After transshipment, species purity was reexamined at the Western Pacific Biological Control Quarantine Laboratory on the University of Guam campus in Mangilao, GU. Parasitoids were released on infested plants under gauze mesh cages on farms in the middle and northern agricultural regions of the island (Fig. 1). Cage material was removed after three days. Confinement under the cages insured immediate exposure of the parasitoids to aphids, and was intended to increase the chances of successful parasitoid establishment in the new environment. The release area was inspected weekly for one month to ascertain mummy formation by the introduced parasitoids. After one

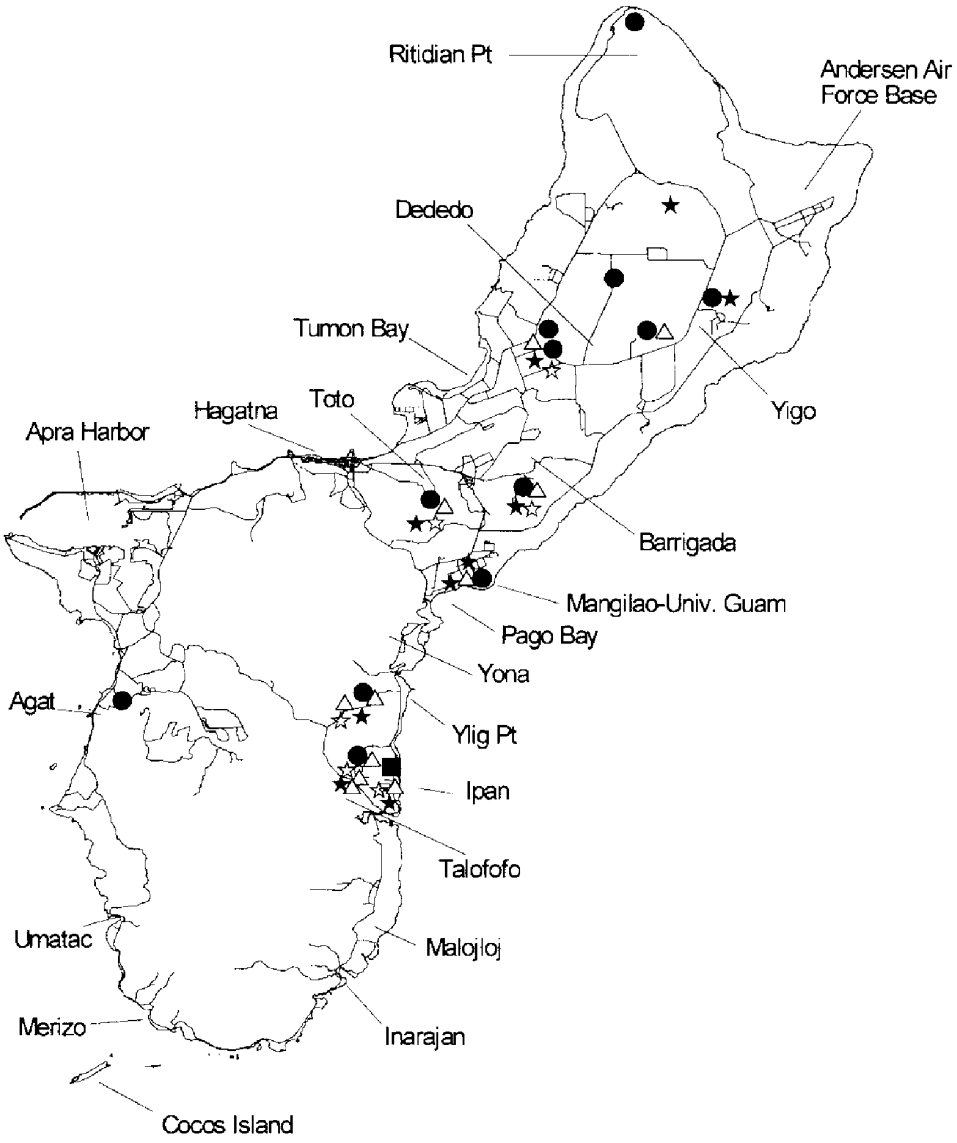

Fig 1. Map of Guam showing parasitoid collection sites (Δ = *L. testaceipes*, (● = *L. oregmae*, (■ = *A. matricariae*) and biocontrol agent (☆ = *D. rapae*, ★ = *A. colemani*) release/recovery sites.

month, aphid samples and parasitoid rearing procedures were conducted in the release areas once per month for the duration of the study.

A total of 19,270 aphidiid parasitoids were released on Guam between June 1998 and November 1999. Of these, 16,170 were *A. colemani* and 3,100 were *D. rapae* – both species have their origin in the Old World, but are now rather widely

distributed on various continents. There were two strains of *A. colemani* released on Guam. Releases in June 1998 were of *A. colemani,* obtained from Novartis (UK) via Rincon-Vitova Insectaries (California, USA), on *A. gossypii* on taro in June 1998 in northern Guam, and the remainder were *A. colemani* obtained from the WSU - Prosser insectaries. Washington cultures were reared on *Myzus persicae* (Sulzer) and *Rhopalosiphum padi* (L.). Founder parasitoids came from Chile via the P. Star´y Insectary, Czech Republic, and were released at numerous Guam sites on *A. gossypii, A. craccivora, Pentalonia nigronervosa* Coquerel, and *Toxoptera citricida* (Kirkaldy). WSU-Prosser cultures of *D. rapae* were started with parasitoids reared from *Diuraphis noxia* (Kurdjumov) on wheat in central Washington.

Results

The present review of Guam aphidiid parasitoids is organized alphabetically by aphidiid parasitoid (Parasitoid x Aphid Index) and by aphid (Aphid x Parasitoid Index) using scientific names. Aphelinid parasitoids, only rarely collected in this study, were not identified to species level, and while listed in the following review are not dealt with further.

Parasitoid x aphid index

***Aphelinus* sp.**

Aphis craccivora Koch on *Abelmoschus esculentus:* Talofofo, 13º20'33"N 144º45'23"E, 8-VII-98 (98R303); on *Citrus* sp: Dededo, 13º32'45"N 144º51'20"E, 10-X-97 (97R094); on *Phaseolus vulgaris:* Barrigada, 13º27'59"N 144º49'17"E, 15-III-98 (99R595); Talofofo, 13º20'52"N 144º45'23"E, 25-VI-98 (98R286).

Aphis gossypii Glover on *Abelmoschus esculentus:* Talofofo, 13º20'33"N 144º45'23"E, 2-VII-98 (98R297), 8-VII-98 (98R303); 13º21'35"N 144º46'7"E, 30-IV-99 (99R719); Yigo, 13º34'10"N 144º52'48"E, 7-V-99 (99R727); on *Capsicum annuum:* Yigo, 13º31'53"N 144º53'25"E, 23-IX-98 (98R359); on *Chromolaena odorata:* Yona, 13º23'11"N 144º45'33"E, 23-II-99 (99R557); on *Colocasia esculenta:* Talofofo, 13º20'50"N 144º45'22"E, 26-VIII-98 (98R340); on *Cucumis sativa:* Mangilao, 13º25'44"N 144º47'54"E, 21-X-97 (97R100); Talofofo, 13º21'35"N 144º46'7"E, 30-IV-99 (99R718); UOG, 13º25'44"N 144º47'54"E, 8-X-97 (97R091); Yigo, 13º31'35"N 144º52'21"E, 16-IX-97 (97R070), 29-IX-97 (97R078), 6-X-97 (97R084); 13º31'53"N 144º53'25"E, 4-V-99 (99R723); on *Solanum melongena:* Barrigada, 13º27'59"N 144º47'10"E, 3-II-99 (99R523); Dededo, 13º32'46"N 144º51'22"E, 30-IX-97 (97R081); UOG, 13º25'44"N 144º47'54"E, 8-X-97 (97R093).

Aphis spiraecola Patch on *Chromolaena odorata:* Yona, 13º23'11"N 144º45'33"E, 8-XII-98 (98R484).

Toxoptera citricida (Kirkaldy) on *Citrus limon:* Barrigada, 13º27'59"N 144º47'10"E, 13-I-99 (99R512); on *Citrus madurensis:* Dededo, 13º32'46"N 144º51'22"E, 30-XI-98 (98R467); Talofofo, 13º21'51"N 144º45'32"E, 22-II-99 (99R542); on *Citrus sinensis:* Barrigada, 13º28'10"N 144º49'8"E, 21-II-99 (99R530); on *Citrus* sp: Barrigada, 13º27'56"N 144º49'13"E, 3-X-97 (97R083); Dededo, 13º32'45"N 144º51'20"E, 6-X-97 (97R088).

(no aphid sample) on *Abelmoschus esculentus:* Agat, 13º22'37"N 144º39'35"E, 14-X-97 (97R097); on *Citrus limon:* Barrigada, 13º27'59"N 144º47'10"E, 16-XII-98 (98R492); on *Nerium oleander:* Barrigada, 13º28'24"N 144º46'48"E, 28-II-99 (99R566).

***Aphidius colemani* Viereck**

Aphis craccivora Koch on *Phaseolus vulgaris:* Barrigada, 13º27'59"N 144º49'17"E, 12-VI-99 (99R743).

***Aphidius matricariae* Haliday**

Aphis gossypii Glover on *Solanum melongena:* Talofofo, 13º21'35"N 144º46'7"E, 13-X-98 (98R382).

***Diaeretiella rapae* (M'Intosh)**

Aphis craccivora Koch on *Mimosa pudica:* Yona, 13º23'11"N 144º45'33"E, 23-II-99 (99R550).

Aphis gossypii Glover on *Chromolaena odorata:* Yona, 13º23'11"N 144º45'33"E, 23-II-99 (99R557); on *Trichosanthes cucumerina:* Talofofo, 13º21'51"N 144º45'32"E, 22-II-99 (99R544).

Hysteroneura setariae (Thomas) on *Cyperus rotundus:* Mangilao, 13º25'48"N 144º48'0"E, 1-III-99 (99R578).

***Lipolexis oregmae* (Gahan)** (= *L. scutellaris* Mackauer)

Aphis craccivora Koch on *Citrus limon:* Barrigada, 13º27'59"N 144º47'10"E, 29-XII-98 (98R503); on *Citrus* sp: Dededo, 13º32'45"N 144º51'20"E, 10-X-97 (97R094); on *Mimosa pudica:* Yona, 13º23'11"N 144º45'33"E, 23-II-99 (99R550); on *Phaseolus vulgaris:* Barrigada, 13º28'16"N 144º49'8"E, 22-XI-98 (98R456); Talofofo, 13º20'52"N 144º45'23"E, 25-VI-98 (98R286); 13º21'51"N 144º45'32"E, 22-II-99 (99R543); Yigo, 13º31'35"N 144º52'21"E, 29-IX-97 (97R079); on *Portulaca oleracea:* Yona, 13º23'11"N 144º45'33"E, 23-II-99 (99R558); on *Pueraria phaseoloides*: Talofofo, 13º21'51"N 144º45'32"E, 26-V-99 (99R736), 4-VI-99 (99R739).

Aphis gossypii Glover on *Abelmoschus esculentus:* Yigo, 13º34'10"N 144º52'48"E, 17-III-98 (99R626); on *Chromolaena odorata:* Barrigada, 13º27'59"N 144º49'17"E, 27-IX-98 (98R362); Guam National Wildlife Refuge, 13º39'9"N 144º51'40"E, 3-XII-98 (98R478); Yona, 13º23'11"N

144º45'33"E, 23-II-99 (99R557); on *Colocasia esculenta:* Talofofo, 13º20'50"N 144º45'22"E, 2-XII-98 (98R476); on *Cucumis sativa:* Mangilao, 13º25'44"N 144º47'54"E, 21-X-97 (97R100); UOG, 13º25'44"N 144º47'54"E, 8-X-97 (97R091); Yigo, 13º31'35"N 144º52'21"E, 16-IX-97 (97R070), 21-VIII-97 (97R049), 26-VIII-97 (97R056), 29-IX-97 (97R078), 6-X-97 (97R084); on *Garcinia livingstonei:* Inarajan, 13º18'30"N 144º45'43"E, 23-II-99 (99R554); on *Solanum melongena:* Barrigada, 13º27'59"N 144º47'10"E, 25-I-99 (99R522); Dededo, 13º32'46"N 144º51'22"E, 30-IX-97 (97R081); Mangilao, 13º25'44"N 144º47'54"E, 9-XII-97 (97R113); UOG, 13º25'44"N 144º47'54"E, 8-X-97 (97R093); Yigo, 13º31'53"N 144º53'25"E, 11-IX-97 (97R068); on *Trichosanthes cucumerina:* Talofofo, 13º21'51"N 144º45'32"E, 22-II-99 (99R544); on *Tridax procumbens:* Yona, 13º23'36"N 144º45'36"E, 27-II-99 (99R563).

Aphis spiraecola Patch on *Chromolaena odorata:* Yona, 13º23'11"N 144º45'33"E, 22-II-99 (99R547), 23-II-99 (99R556), 8-XII-98 (98R484).

Pentalonia nigronervosa Coquerel on *Chromolaena odorata:* Yona, 13º23'11"N 144º45'33"E, 22-II-99 (99R547).

Toxoptera citricida (Kirkaldy) on *Citrus limon:* Barrigada, 13º27'59"N 144º47'10"E, 13-I-99 (99R512), 21-III-98 (99R634), 29-XII-98 (98R503), 6-XII-98 (98R480); 13º27'59"N 144º49'17"E, 12-X-98 (98R381); Talofofo, 13º21'51"N 144º45'32"E, 29-V-99 (99R737), 4-VI-99 (99R740); Yona, 13º23'11"N 144º45'33"E, 21-X-98 (98R396), 23-II-99 (99R553), 28-XII-98 (98R501); on *Citrus madurensis:* Dededo, 13º31'2"N 144º49'37"E, 14-I-99 (99R515); 13º32'46"N 144º51'22"E, 13-XII-98 (98R488), 9-XI-98 (98R435); Talofofo, 13º21'51"N 144º45'32"E, 22-II-99 (99R542); on *Citrus sinensis:* Barrigada, 13º28'10"N 144º49'8"E, 21-II-99 (99R530); on *Citrus* sp: Barrigada, 13º27'56"N 144º49'13"E, 11-XII-97 (97R117), 23-IX-97 (97R075), 3-X-97 (97R083); Dededo, 13º32'45"N 144º51'20"E, 6-X-97 (97R088); 13º32'46"N 144º51'22"E, 30-IX-97 (97R080).

[no aphid sample] on *Abelmoschus esculentus:* Agat, 13º22'37"N 144º39'35"E, 14-X-97 (97R097); on *Citrus limon:* Barrigada, 13º27'59"N 144º47'10"E, 16-XII-98 (98R492).

***Lysiphlebus testaceipes* (Cresson)**

Aphis craccivora Koch on *Abelmoschus esculentus:* Talofofo, 13º20'33"N 144º45'23"E, 8-VII-98 (98R303); on *Acacia confusa:* Mangilao, 13º27'15"N 144º49'59"E, 8-III-99 (99R589); on *Cassia alata:* Yona, 13º23'11"N 144º45'33"E, 12-V-99 (99R733), 17-XI-98 (98R445), 22-II-99 (99R546), 24-XI-98 (98R459), 9-XI-98 (98R432); on *Citrullus lanatus:* Talofofo, 13º20'33"N 144º45'23"E, 2-VII-98 (98R298); on *Malpighia glabra:* Yona, 13º23'11"N 144º45'33"E, 13-X-98 (98R384), 21-X-98 (98R395); on *Mimosa pudica:* Yona, 13º23'11"N 144º45'33"E,

23-II-99 (99R550); on *Phaseolus vulgaris:* Barrigada, 13º27'59"N 144º47'10"E, 16-III-98 (99R607), 21-III-98 (99R632), 23-XI-98 (98R457), 25-I-99 (99R521), 26-X-98 (98R403), 29-XII-98 (98R502), 30-VIII-98 (98R344), 9-VIII-98 (98R328); 13º27'59"N 144º49'17"E, 12-VI-99 (99R743), 14-III-98 (99R590), 15-III-98 (99R595) (99R605), 4-VI-99 (99R741); 13º28'16"N 144º49'8"E, 22-XI-98 (98R456); Mangilao, 13º27'59"N 144º47'10"E, 20-IV-99 (99R702), 29-IV-99 (99R708), 4-VI-99 (99R742); Talofofo, 13º20'50"N 144º45'22"E, 22-VII-98 (98R315); 13º20'52"N 144º45'23"E, 25-VI-98 (98R286); 13º21'35"N 144º46'7"E, 14-VII-98 (98R308); UOG, 13º25'47"N 144º48'0"E, 20-I-99 (99R520), 24-III-98 (99R655); Yigo, 13º34'10"N 144º52'48"E, 30-IV-99 (99R715); on *Portulaca oleracea:* Yona, 13º23'11"N 144º45'33"E, 23-II-99 (99R558); on *Solidago* sp: Yona, 13º23'11"N 144º45'33"E, 21-X-98 (98R393), 27-X-98 (98R406).

Aphis gossypii Glover on *Abelmoschus esculentus:* Talofofo, 13º20'33"N 144º45'23"E, 8-VII-98 (98R303); 13º21'35"N 144º46'7"E, 13-X-98 (98R383), 30-IV-99 (99R719); Yigo, 13º34'10"N 144º52'48"E, 17-III-98 (99R626), 21-IV-99 (99R703), 24-III-98 (99R663), 30-IV-99 (99R714), 7-V-99 (99R727); on *Chromolaena odorata:* Yigo, 13º31'35"N 144º52'21"E, 29-XII-98 (98R506); on *Citrullus lanatus:* Talofofo, 13º20'33"N 144º45'23"E, 2-VII-98 (98R298); on *Colocasia esculenta:* Barrigada, 13º28'10"N 144º49'8"E, 15-III-98 (99R602); Talofofo, 13º20'50"N 144º45'22"E, 18-XI-98 (98R448), 26-VIII-98 (98R340); UOG, 13º25'46"N 144º47'53"E, 22-III-98 (99R644); on *Cucumis sativa:* Merizo, 13º14'54"N 144º42'29"E, 18-III-98 (99R631), 22-III-98 (99R642); Talofofo, 13º20'50"N 144º45'22"E, 18-XI-98 (98R449), 21-IV-99 (99R706); 13º21'35"N 144º46'7"E, 30-IV-99 (99R718); Yigo, 13º31'53"N 144º53'25"E, 27-V-99 (99R735), 4-V-99 (99R723); on *Hibiscus rosa-sinensis:* Agat, 13º22'59"N 144º39'36"E, 17-III-98 (99R624), 23-III-98 (99R645); on *Phaseolus vulgaris:* Talofofo, 13º21'35"N 144º46'7"E, 14-VII-98 (98R308), 7-VII-98 (98R301), 8-VII-98 (98R302); on *Solanum melongena:* Barrigada, 13º27'59"N 144º47'10"E, 13-I-99 (99R513), 20-I-99 (99R518), 25-I-99 (99R522), 3-II-99 (99R523); 13º28'16"N 144º49'8"E, 23-III-98 (99R647); Mangilao, 13º27'59"N 144º47'10"E, 10-V-99 (99R734), 12-VI-99 (99R744), 19-V-99 (99R738), 28-IV-99 (99R717); Talofofo, 13º21'35"N 144º46'7"E, 13-X-98 (98R382); Yigo, 13º34'10"N 144º52'48"E, 30-IV-99 (99R713), 7-V-99 (99R726); on *Tridax procumbens:* Barrigada, 13º28'10"N 144º49'8"E, 15-III-98 (99R598), 26-IV-99 (99R704); Mangilao, 13º25'48"N 144º48'0"E, 1-III-99 (99R579); UOG, 13º25'46"N 144º47'53"E, 22-III-98 (99R643); Yona, 13º23'36"N 144º45'36"E, 27-II-99 (99R563).

Aphis nerii Boyer de Fonscolombe on *Nerium oleander:* Yigo, 13º33'36"N 144º55'12"E, 5-V-99 (99R725), 10-V-99 (99R730).

Aphis spiraecola Patch on *Chromolaena odorata:* Yona, 13º23'11"N 144º45'33"E, 8-XII-98 (98R484).

Hysteroneura setariae (Thomas) on *Dactyloctenium aegyptium:* Barrigada, 13º28'10"N 144º49'8"E, 15-III-98 (99R599); Mangilao, 13º25'48"N 144º48'0"E, 1-III-99 (99R576); on Dichanthium bladhii: Mangilao, 13º25'48"N 144º48'0"E, 1-III-99 (99R577).

Pentalonia nigronervosa Coquerel on *Alpinia purpurata:* Yona, 13º23'11"N 144º45'33"E, 12-V-99 (99R731), 23-II-99 (99R549).

Toxoptera aurantii (Boyer de Fonscolombe) on *Citrus limon:* Barrigada, 13º28'16"N 144º49'8"E, 23-III-98 (99R649); on *Citrus madurensis:* Dededo, 13º32'46"N 144º51'22"E, 23-III-98 (99R646).

Toxoptera citricida (Kirkaldy) on *Citrus limon:* Barrigada, 13º27'59"N 144º47'10"E, 21-III-98 (99R634); 13º28'16"N 144º49'8"E, 23-III-98 (99R649); Yona, 13º23'11"N 144º45'33"E, 13-X-98 (98R385), 23-II-99 (99R553); on *Citrus madurensis:* Dededo, 13º31'2"N 144º49'37"E, 14-I-99 (99R515); 13º32'46"N 144º51'22"E, 19-IV-99 (99R700); on *Phaseolus vulgaris:* Barrigada, 13º27'59"N 144º47'10"E, 30-VIII-98 (98R344).

[no aphid sample]: on *Nerium oleander:* Barrigada, 13º28'24"N 144º46'48"E, 28-II-99 (99R566); on *Phaseolus vulgaris:* Talofofo, 13º20'52"N 144º45'23"E, 19-VI-98 (98R283).

Aphid x Parasitoid Index

***Aphis craccivora* Koch**

Aphelinus sp.
Aphidius colemani Viereck
Diaeretiella rapae (M'Intosh)
Lipolexis oregmae (Gahan)
Lysiphlebus testaceipes (Cresson)

***Aphis gossypii* Glover**

Aphelinus sp.
Aphidius matricariae Haliday
Diaeretiella rapae (M'Intosh)
Lipolexis oregmae (Gahan)
Lysiphlebus testaceipes (Cresson)

***Aphis nerii* Boyer de Fonscolombe**

Lysiphlebus testaceipes (Cresson)

***Aphis spiraecola* Patch**

Aphelinus sp.
Lipolexis oregmae (Gahan)
Lysiphlebus testaceipes (Cresson)

***Hysteroneura setariae* (Thomas)**

Diaeretiella rapae (M'Intosh)
Lysiphlebus testaceipes (Cresson)

***Pentalonia nigronervosa* Coquerel**
Lipolexis oregmae (Gahan)
Lysiphlebus testaceipes (Cresson)
***Toxoptera aurantii* (Boyer de Fonscolombe)**
Lysiphlebus testaceipes (Cresson)
***Toxoptera citricida* (Kirkaldy)**
Aphelinus sp.
Lipolexis oregmae (Gahan)
Lysiphlebus testaceipes (Cresson)

Discussion

Synonymy of *Lipolexis oregmae* (Gahan) and *Lipolexis scutellaris* Mackauer

Diaeretus oregmae Gahan, 1932, Ann. Ent. Soc. Amer. 25: 736-737. Starý, 1960 (to *Lipolexis*).
Lipolexis scutellaris Mackauer,1962, Entomophaga 7:43-44. N. Syn.

Lopez (1931) reared *Diaeretus* sp. from *Ceratovacuna lanigera* on sugarcane in the Philippines, and Gahan (1932) described the material as *Diaeretus oregmae* Gahan. Starý (1960) revised the material and transferred the species to the genus *Lipolexis*.

Lipolexis scutellaris Mackauer was described by Mackauer (1962) from material reared from *Aphis gossypii* in Hong Kong, and the same species was referred to as *Lipolexis* sp. by Flanders & Fisher (1959) from South China. The species has become known later as a parasitoid on a number of host aphids in various countries of the Orient, i.e., Malaysia (Ng & Starý 1986), Taiwan (Chiu & Liu 1969), India (Shuja Uddin 1977, Starý 1975, Starý & Bhagat 1978, Raychaudhuri 1990), India and adjacent countries (Starý & Ghosh 1983), Far East (Starý & Schlinger 1967), Bangladesh (Starý & van Harten 1983), Vietnam (Starý & Zeleny 1983), and Taiwan (Tao & Chiu 1971).

We have found *L. oregmae* to be a widely distributed parasitoid of several aphid species in Guam. We have also obtained material that is obviously conspecific with *Ceratovacuna lanigera* reared in the Philippines by V.J. Calilung (specimens and letter sent to P. Starý, 1975) and determined by Starý as *L. scutellaris* which highlights possible faunal relationships. However, because the occurrence of two very similar species of *Lipolexis* in the Philippines is highly unlikely, P. Starý reexamined the paratypes of *L. oregmae* in the United States National Museum (USNM), Washington, D.C. (Labelling: ex *Oregma lanigera,* Panay, P.I., rec'd fr. A.W.Lopez 6186, Paratype No. 43433 USNM, Paratype, *Diaeretus oregmae* Gahan) and found that important characters had been overlooked earlier and incompletely to poorly drawn by Starý (1960). These characters included the first metasomal terga on female parasitoids which manifested longitudinal carinae along their margins, a character typical only of *L. scutellaris.* Both species were determined to be identical on the basis of both ethanol-preserved slide-mounted

specimens and dry-mounted specimens. Because of priority, *L. scutellaris* (Mackauer 1962) must therefore be classified as a junior synonym of *L. oregmae* (Gahan 1932).

L. oregmae, as determined from the host ranges described in previously cited works, is oligophagous. The key host insects belong to the Aphidini aphids, namely *Aphis* (*A. craccivora, A. fabae, A. gossypii, A. nerii, A. spiraecola,* and others), *Rhopalosiphum* (*R. maidis, R. nymphaeae*), and *Toxoptera* (*T. aurantii, T. citricida, T. odinae*). There are additional minor host associations on other aphid groups as well.

Origins of Guam's parasitoid fauna

Because no indigenous aphid or parasitoid fauna was found during the course of this study and in past surveys (Pike et al. 2000a), the aphid and aphidiid fauna of the Mariana Archipelago may be presumed to originate from outside the immediate region. This would account for the presence of *Lipolexis oregmae,* a species widely distributed throughout southeastern Asia and in the Philippines. Possible sources of *L. oregmae* on Guam include accidental introductions of the parasitoid on aphid hosts inadvertently imported into Guam on plant hosts, or perhaps even dispersed on strong southwesterly winds that commonly occur in the western Pacific during the rainy season months of July, August, September and October (Lander 1994).

However, our initial observations on Guam that have shown that *Lysiphlebus testaceipes* is a common aphid parasitoid with a broad host range and distribution, caused us to question its origin in the Mariana Islands. *L. testaceipes* is originally a North American species whose range extends through Central America into South America (Mackauer & Starý 1967, Starý 1995). While we suspected that it was accidentally introduced to Guam from the continental USA, or perhaps from Hawaii where it has been purposely introduced as a biological control agent (Starý 1970), we have subsequently concluded that Guam populations likely originated from intentional releases made on Guam in the mid-1970s. R. Muniappan, then a faculty entomologist at the University of Guam, released approximately 160 individuals on citrus and bean aphids on January 20, 1975 near the University of Guam main campus in the village of Mangilao (R. Muniappan, personal communication, CALS-AES, University of Guam, Mangialo, GU). The insects released at this time originated from *Schizaphis graminum* (Rondani) collected on small grains in central Oklahoma. No establishment was noted in the months following its release, and it was assumed that the population had died out until the present study revealed its presence. It is also likely that *L. testaceipes* collected in the Sabana agricultural area of Rota from *A. gossypii* on cucumber (R.H. Miller, unpublished data) may originate from the Guam release, having been transported to Rota on winds transversing the 55 km wide Rota strait from Guam to the immediate south.

The origin of the third species, *Aphidius matricariae,* is not clear as it was determined from a single female specimen. *A. matricariae* is a common species in the west and southwest Palearctic region (Mackauer & Starý 1967). Its pres-

ence on Guam is probably a result of accidental introduction from nearctic America, where it is a rather common introduced biocontrol agent.

Of the numerous parasitoids released on Guam as aphid biocontrol agents, *A. colemani* from the WSU-reared strain has been recovered in post-release samples at one release site in central Guam about a month following its release at Barrigada on *A. craccivora* on cowpea. *D. rapae* has also been recovered in samples about one month post-release at three release sites on three aphid hosts. Since then no recoveries have been made of either parasitoid. The possible lack of establishment may be in part due to interference by aphid-tending ants which have been observed at numerous sites, the fire ant, *Solenopsis geminate* F. being the most commonly observed. *S. geminate* is an invasive ant probably introduced to Guam from the US Gulf Coast sometime within the last century. *S. geminate* is also frequently observed tending mealybugs of various species on a variety of host plants. Surveys of ant-aphid-parasitoid relationships on Guam are currently in progress. Establishment of *A. colemani* and *D. rapae* may yet occur on Guam as evidenced by the long time lag between the release of *L. testaceipes* and its recovery, and by its apparent establishment on Rota.

L. oregmae collected from Guam has been successfully reared and released on *T. citricida* in Florida (M. Hoy, personal communication, Department of Entomology, University of Florida, Gainesville). *L. oregmae* and *L. testaceipes* are presently being mass reared in the University of Guam insectary for release throughout Guam, and for use in aphid biological control in the Northern Mariana Islands and Republic of Palau.

Species richness and guilds

The relationship between the number of Aphidinae hosts and the number of species comprising parasitoid guilds differs in island ecosystems from that observed in large land masses. This suggests that the relatively depauperate parasitoid guild oberved on Guam might be enhanced by introducing additional parasitoid species. A comparison of the world parasitoid fauna to the number of aphid species demonstrates interaction among the factors that guide parasitoid variation. Starý & Rejmanek (1981) determined that each aphid species in the West-Palearctic region was attacked by an average of 2.4 parasitoid species, and further concluded that the number of parasitoid species associated with an aphid species complex within a region is proportional to the number of aphid species in that particular complex. Parasitoid behavior, including foraging strategies and other unique species characteristics, may in conjunction with aphid phylogeny, determine the ratio of parasitoid species to prey species (Starý 1981). Potter & Hawkins (1998) estimated a ratio of 1.7 parasitoid species per aphid species when they examined the relationship between parasitoids and aphid species from Europe and North America. Starý & Rejmanek (1981) and Potter & Hawkins (1998) agreed that the Aphidinae hosts generally larger parasitoid guilds than other aphid subfamilies.

Islands in close proximity to continents harbor a parasitoid fauna that is phylogenetically related to that of nearby continents, but with reduced species richness. More isolated oceanic islands generally possess a depauperate parasitoid fauna that frequently lacks indigenous species, accidental immigrant species or intentionally introduced species (Starý 1970). Guam and other islands in the Mariana Archepelago lack native aphid parasitoids. *L. oregmae* is an obvious accidental immigrant from Asia or the Philippines. Guam's aphid fauna, though relatively more numerous than the parasitoids, is represented primarily by common cosmopolitan, pan-tropical species and a few less common alien species (Pike et al. 2000a). The number of species comprising Guam's aphid parasitoid guild is very low, as would be expected from the limited number of aphid hosts on Guam which are all in the subfamily Aphidinae. *L. oregmae* and *L. testaceipes*, which comprise the bulk of the aphid parasitoid guild on Guam, are both relatively recent introductions. The number of aphid species on Guam suggests that other aphid parasitoids may be released into the extant aphid population as biological control agents to build up the level of species richness to that observed in aphid complexes elsewhere.

Host range patterns and peculiarities

The host range patterns of *Lipolexis oregmae* in Guam is consistent with that described from Southeast Asia and from the Philippines. However, the original host of the starter population of *L. testaceipes* in Guam, *S. graminum,* is not present on Guam (Pike et al. 2000a). Consequently, initial *L. testaceipes* populations on Guam had to switch to other host aphids immediately upon their release on citrus and bean aphids. The known host range of *L. testaceipes* in Oklahoma is poorly known and thus relatively restricted compared to that of North America as a whole. However most of the aphids present on Guam are present in the Pacific Northwest USA region where the host range of *L. testaceipes* has been well established (Pike et al. 2000b).

The only aphid attacked by *L. testaceipes* on Guam that is not documented from the Pacific Northwest is *Toxoptera citricida*. *L. testaceipes* has been determined to be a parasitoid of *T. citricida* in Florida (Yokomi et al. 1994, Evans & Stange 1997). This host association corroborates other unpublished data from Florida and from Brazil (P. Starý, unpublished data). That *L. testaceipes* was able to make the host switch observed on Guam is therefore not surprising. Host range development and disperal patterns for *L. testaceipes* on Guam are very similar to those documented in southern France following its release and establishment there. During the course of a few years in France, the host range of *L. testaceipes* gradually expanded to include a number of native and exotic aphid species. *L. testaceipes* is now widespread along the coast of mainland Portugal and Spain and extends across France to the coast of southern Italy. *L. testaceipes* is also established on many of the coastal islands of this region, and likely has dispersed significantly since last reports were published. (Starý et al. 1988a,b).

Parasitoid-aphid distribution patterns

There are significant differences in the underlying causes of aphid and aphid parasitoid dispersion. Aphid parasitoids generally locate their hosts in a range of different environments, although ecosystem effects may affect species composition and searching effectiveness. Previous studies on the aphids of Guam (Pike et al. 2000a) revealed that they were primarily concentrated on crops, weeds, and ornamentals and were relatively uncommon in undisturbed indigenous ecosystems. Our data for parasitoids derived from the aphid samples documented in Pike et al. (2000a) show a similar pattern.

The distribution of an aphid species generally follows the distribution of its host plants, while parasitoid distribution frequently incorporates several aphid species and multiple plant combinations. Aphid parasitoids are therefore not necessarily dependent on a certain aphid host plant species and may be more eurytopic than the individual host aphid species (Starý 1972). *L. testaceipes* on Guam comprises a model example of such a situation and may serve to, in part, explain its successful establishment on Guam and apparent success on Rota. This has implications for the further development of classical biological control of aphids on Guam and other Micronesian islands.

Key to Primary Parasitoids of Aphids of Guam

1 Forewing anal vein present (Fig. 2a-d) **[Aphidiidae]** 2
Forewing anal vein absent (Fig. 2e) **[Aphelinidae]** . . . . . ***Aphelinus* sp.**

2(1) Forewing r-m vein present (Fig. 2a-b) 3
Forewing r-m vein absent (Fig. 2c-d). 5

3(2) Forewing M and m-cu vein complete (Fig.2a); propodeum distinctly areolate (Fig. 2f, dorsal view); metasomal tergum I more or less rugose (Fig.2j, dorsal view) 4

Forewing M and m-cu vein incomplete (Fig. 2b); propodeum smooth (Fig. 2g, dorsal view); metasomal tergum I smooth (Fig. 2k, dorsal view). . . . . ***Lysiphlebus testaceipes*** (Cresson)

4(3) Anterolateral area of metasomal tergum 1 costate (Fig. 2n, lateral view); maxillary palpi 4-segmented . . . . . ***Aphidius colemani*** Viereck

Anterolateral area of metasomal tergum 1 costulate (Fig. 2o, lateral view); maxillary palpi 3-segmented. . . . . ***Aphidius matricariae*** Haliday

5(2) Forewing radial sector vein (Rs) longer than 2/3 of its possible lengt so that pterostigmal cell almost complete (Fig. 2c); propodeum

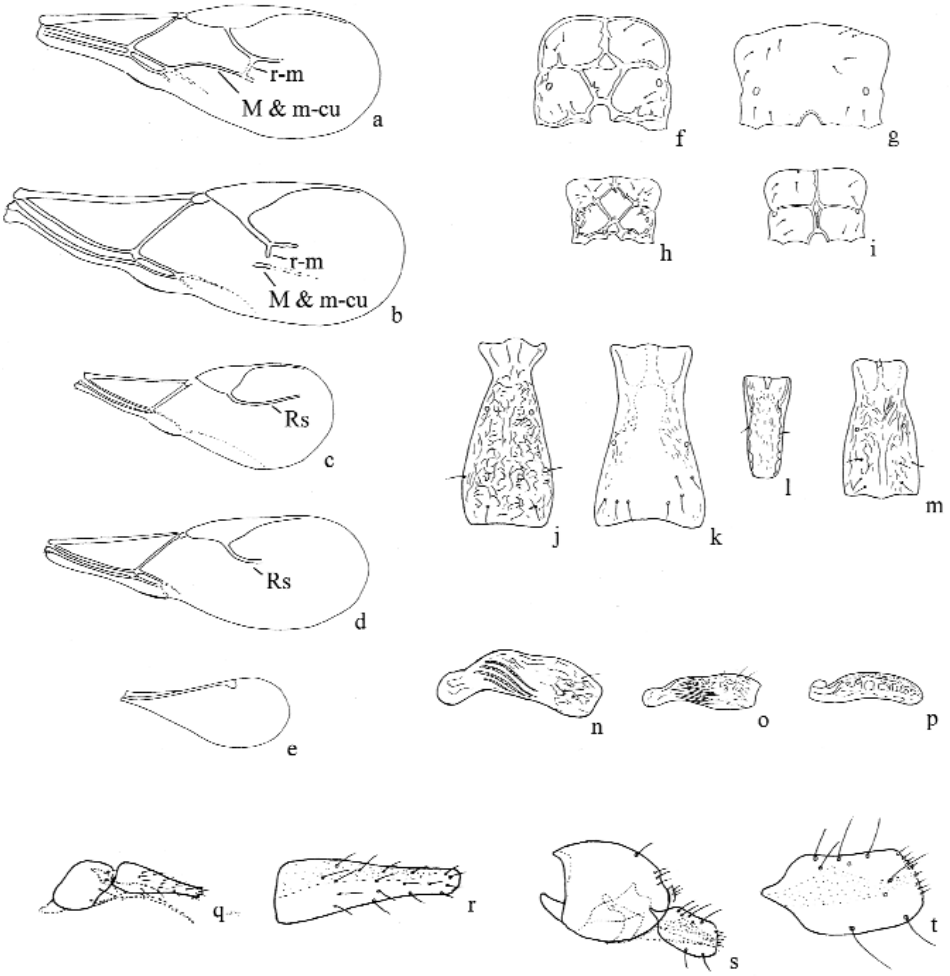

Fig. 2. Aphidiid Parasitoid features (terminology after Huber & Sharkey 1993). FOREWING (dorsal view): (a) *Aphidius colemani,* (b) *Lysiphlebus testaceipes,* (c) *Lipolexis oregmae,* (d) *Diaeretiella rapae,* (e) *Aphelinus* sp.; PROPODEUM (dorsal view): (f) *A. colemani,* (g) *L. testaceipes,* (h) *L. oregmae,* (i) *D. rapae;* METASOMAL TERGUM I (dorsal view j-m; lateral view n-p): (j, n) *A. colemani,* (k) *L. testaceipes,* (l, p) *L. oregmae,* (m) *D. rapae;* (o) *Aphidius matricariae;* GENITALIA & OVIPOSITOR SHEATH (lateral view): (q, r) *L. oregmae,* (s, t) *D. rapae.*

with relatively wide central areola, carinae often irregular (Fig. 2h, dorsal view); metasomal tergum 1 narrow, parallel-sided, almost smooth, with longitudinal carinae along its margin (Fig. 2l dorsal view; 2p lateral view); genitalia with ovipositor sheath slightly curved downward, upper portion more strongly sclerotized (Fig. 2q-r, lateral view) . . . . . ***Lipolexis oregmae*** (Gahan)

Forewing radial sector vein (Rs) short, pterostigmal cell distinctly incomplete (Fig. 2d); propodeum regularly areolated, with narrow small central pentagonal areola (Fig. 2i, dorsal view); metasomal tergum 1 slightly dilating to the apex, rugose (Fig. 2m, dorsal view); genitalia with ovipositor sheath suboval, slightly curved upward (Fig. 2s-t, lateral view) . . . . . ***Diaeretiella rapae*** (M'Intosh)

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