

APHIDS (HEMIPTERA: APHIDIDAE) AND ASSOCIATED BIOTA FROM THE KINGDOM OF TONGA, WITH RESPECT TO BIOLOGICAL CONTROL

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Abstract.—Surveys of the aphid and associated insect fauna of The Kingdom of Tonga were conducted as part of a biological control program against the banana aphid, *Pentalonia nigronervosa* Coquerel, using the polyphagous aphidiine parasite, *Aphidius colemani* Viereck. Ten aphid species were collected, plus three species of primary parasites (Hymenoptera: Aphelinidae and Braconidae: Aphidiinae); one species of hyperparasite (Hymenoptera: Charipidae); coccinellid, hemerobiid, and syrphid predators (Coleoptera: Coccinellidae; Neuroptera: Hemerobiidae; and Diptera: Syrphidae); parasites of syrphids (Hymenoptera: Ichneumonidae and Encyrtidae); and eleven species of aphid-attendant ants. The aphids *Brachycaudus helichrysi* (Kaltenbach), *Hyperomyzus carduellinus* (Theobald), *Hysteroneura setariae* (Thomas), *Myzus persicae* (Sulzer), and *Toxoptera citricidus* (Kirkaldy) are new records for Tonga. *Aphis craccivora* Koch, *A. gossypii* Glover, *Brachycaudus helichrysi*, *Myzus persicae*, *P. nigronervosa*, *Rhopalosiphum maidis* (Fitch), *Toxoptera aurantii* (Boyer de Fonscolombe) and *T. citricidus* are all known to be suitable hosts for *A. colemani*. Compiled distributional data of aphids on South Pacific islands show that these species are present throughout the region, which suggests that *A. colemani* could be a useful addition to the insect fauna of the region. *Aphidius colemani* was recovered in 1992 from *Aphis gossypii*. The hyperparasite *Alloxysta darci* (Girault) is unlikely to parasitize *A. colemani* or any other Aphidiinae.

Key Words.—Insecta, *Aphidius colemani*, biological control, Aphididae, Tonga, *Pentalonia nigronervosa*, distribution of aphids, natural enemies of aphids

The banana aphid, *Pentalonia nigronervosa* Coquerel, is an important pest of banana in the Pacific and South-East Asian region and can cause major crop losses either through direct damage or as a transmitter of banana bunchy top virus disease. In the Pacific region, the aphid is locally important in the Cook Islands, Fiji, French Polynesia, Kiribati, Marianas, New Caledonia, Niue, Papua New Guinea, American and Western Samoa, Tonga, Tuvalu and the Wallis Islands (Waterhouse & Norris 1987b). In areas with bunchy top, the favored method of control is the destruction (roguing) of infected plants and aphid infestations. However, successful implementation of these control practices has proved difficult, especially when aphid populations are epidemic.

Biological control of *P. nigronervosa* may be a more suitable control strategy, particularly if it can be integrated with cultural control practices and the use of virus-free planting material. To date, two biological control programs have been attempted: in Western Samoa, using two species of coccinellid predators (Waterhouse & Norris 1987b), and, in Tonga, using two species of aphidiine parasites (Stechmann & Völkl 1988). These programs have produced no evidence for establishment of any of the introduced agents.

In April 1990, CSIRO Division of Entomology (PJH & PWW) took laboratory

stock of the aphidiine parasite *Aphidius colemani* Viereck from Canberra, A.C.T., Australia to Tongatapu Island, Tonga. In Tonga, the first generation was reared and screened in quarantine, and then mass-reared for field release. Concurrently, surveys were conducted to 1) determine the range of aphid infestation levels in banana plantations around the island, 2) seek evidence for establishment of agents released in the earlier biological control program in Tonga and 3) ascertain what other aphid species and associated biota are present in Tonga. This paper focuses on the third objective and documents the aphids, natural enemies and associated ants collected principally during short surveys made during 1990–1992. As *A. colemani* is a polyphagous species, the results provide information about the potential host range in Tonga of this biological control agent. These data are important as successful biological control may depend on the presence of alternative hosts at times of scarcity of the target pest and on the absence of hosts that are acceptable for oviposition but unsuitable for successful development of progeny (Carver 1984). In addition, we provide an overview of the known distribution of aphids throughout the South Pacific region.

METHODS AND MATERIALS

Surveys were done at a number of locations on Tongatapu Island (21° 09'S 175°14' W) over a four-week period in April and May 1990 and a two-week period in April 1991. Collections were also made on Tongatapu in November and December 1991, and in July and August 1992; and at one location on Vava'u in April 1991 and on 'Eua in March 1992. Some specimens were located on weeds growing in the understory and surrounds of banana plantations; others were found by inspecting plants in greenhouse areas or in the grounds of the Ministry of Agriculture, Forests and Fisheries (MAFF) Research Station, Vaini. A Moericke-type, yellow pan/water trap was used on one occasion. The collectors were P. J. Hart, V. Kami, W. Liebrechts, D. Morneau and P. W. Wellings. Plant species were identified on site or later in the laboratory and predatory larvae were reared to adulthood. The aphids and associated insects, except mummies (dead, mummified aphids containing developing hymenopterous parasites), were preserved in 80% ethanol or in gelatine according to the method described by Milne (1984). Mummies were carefully removed from the plant material, placed individually into gelatine capsules (size 00) and adult parasites allowed to emerge. The collected and reared insect specimens were transferred post mortem to Canberra for identification. All are presently lodged in the Australian National Insect Collection, CSIRO, Canberra. The aphid species recorded from other, mostly intertropical, oceanic Pacific Islands were tabulated. Abbreviations used: apt. = apterae viviparae; al. = alatae viviparae; * = new aphid records for Tonga.

RESULTS AND DISCUSSION

Ten aphid species were collected during the study, plus three species of primary parasites (Hymenoptera: Aphelinidae and Braconidae: Aphidiinae); one species of hyperparasite (Hymenoptera: Charipidae); coccinellid, hemerobiid, and syrphid predators (Coleoptera: Coccinellidae; Neuroptera: Hemerobiidae; and Diptera: Syrphidae); parasites of syrphids (Hymenoptera: Ichneumonidae and Encyrtidae) and eleven species of aphid-attendant ants (Hymenoptera: Formicidae):

Aphis craccivora Koch, cowpea aphid

Persea americana (avocado) (Lauraceae), Vaini Research Station, 30 Apr 1990, apt., al.

Phaseolus sp. (bean) (Fabaceae), Lapaha, 26 Apr 1990, apt., al.

Synedrella nodiflora (Asteraceae), Vaini Res. Stn, 30 Apr 1990, apt.

Aphis gossypii Glover, cotton/melon aphid

Cassia occidentalis (Caesalpiniaceae), Kolonga, 23 Apr 1991, apt., al.;

Ants: *Pheidole megacephala* (Fabr.) (Myrmicinae).

Colocasia esculenta (tarotonga) (Araceae), Utulau, 24 Apr 1990, 1 May 1990, apt., al.;

Parasites: *Aphelinus gossypii* Timberlake (Aphelinidae);

Hyperparasites: *Alloxysta darci* (Girault) (Charipidae);

Predators: *Micromus timidus* (Fabr.) (Hemerobiidae), larvae.

Colocasia esculenta, Kolomatua, 24 Apr 1991, apt.;

Parasites: *Aphelinus gossypii*;

Hyperparasites: *Alloxysta darci*.

Colocasia esculenta, Ngeleia, Nuku'alofa, 17–19 Aug 1992, apt.;

Parasites: *Aphelinus gossypii*; *Aphidius colemani* (Aphidiinae);

Hyperparasites (via *Aphelinus gossypii*): *Alloxysta darci*;

Predators: *Harmonia octomaculata* (Fabr.) (Coccinellidae), adult.

Colocasia esculenta, Pa'hu, 25 Aug 1992, apt.;

Parasites: *Aphelinus gossypii*; *Aphidius colemani*;

Hyperparasites (via *Aphelinus gossypii*): *Alloxysta darci*.

Commelina sp. (Commelinaceae), Utulau, 21 Aug 1992, apt., al.

Hibiscus sp. (Malvaceae), Fatai, 1 May 1990, apt.;

Ants: *Pheidole megacephala*.

Persea americana (avocado) (Lauraceae), Vaini Res. Stn, 30 Apr 1990, al.

Salvia coccinea (Lamiaceae), Vaini Res. Stn, 22 Apr 1991, al.

undetermined host, Lapaha, 26 Apr 1990, apt.

ex yellow pan trap, Vaini Res. Stn, 16 Jul 1992, al.

Brachycaudus helichrysi (Kaltenbach), leafcurl plum aphid *

Ageratum sp. (Asteraceae), Fungafonua, 'Eua, 5 Mar 1992, apt.

ex yellow pan trap, Vaini Res. Stn, 16 Jul 1992, al.

Hyperomyzus carduellinus (Theobald) *

Sonchus sp. (Asteraceae), Tatakamotonga, 26 Aug 1992, apt., al.

Hysteroneura setariae (Thomas), rusty plum aphid *

Sorghum halepense (Johnson grass) (Poaceae), Lapaha, 16 Apr 1991, apt., al.

Myzus persicae (Sulzer), green peach aphid *

Brassica oleracea Capitata gp (cabbage) (Brassicaceae), Vaini Res. Stn, 16 Jul 1992, apt., al.

ex yellow pan trap, Vaini Res. Stn, 16 Jul 1992, al., male.

Pentalonia nigronervosa Coquerel, banana aphid

Musa × *paradisiaca* (banana) (Musaceae), eastern Tongatapu, 26 Apr 1990, apt.;

Ants: *Pheidole megacephala*, *P. umbonata* Mayr, *Solenopsis geminata* (Fabr.),

Monomorium floricola (Jerdon) (Myrmicinae); *Paratrechina longicornis* (Latreille) (Formicinae).

Musa × *paradisiaca*, Vaini Res. Stn, 19 Apr 1991, apt.;

Ants: *Pheidole megacephala*.

Musa × *paradisiaca*, Ha'asini, 23 Apr 1991, apt.;

Predators: *Micromus timidus*, larvae;

Ants: *Pheidole megacephala*; *Technomyrmex albipes* (Smith) (Dolichoderinae).

Musa × *paradisiaca*, Fatai, 24–27 Nov 1991, 11 Dec 1991, apt.;

Predators: *Ischiodon scutellaris* (Fabr.) (Syrphidae);

Parasites of *I. scutellaris*: *Diplazon laetatorius* (Fabr.) (Ichneumonidae); *Ooencyrtus guamensis* Fullaway (Encyrtidae);

Ants: *Pheidole umbonata*, *Solenopsis geminata*, *Tetramorium simillimum* (Smith) (Myrmicinae); *Paratrechina vaga* (Forel) (Formicinae); *Tapi-noma melanocephalum* (Fabr.) (Dolichoderinae).

Musa × *paradisiaca*, Te'ekiu, 18 Aug 1992, apt.;

Ants: *Monomorium floricola*; *Technomyrmex albipes*; *Tetramorium bicarinatum* (Nylander) (Myrmicinae).

Musa × *paradisiaca*, Tatakamotonga, 26 Aug 1992, apt.;

Ants: *Anoplolepis longipes* (Jerdon) (Formicinae).

Zingiber officinale (white ginger) (Zingiberaceae), on flowers, Nuku'alofa, 22 Apr 1991, apt.

ex yellow pan trap, Vaini Res. Stn, 16 Jul 1992, al.

Rhopalosiphum maidis (Fitch), maize aphid

Sorghum halepense, Lapaha, 26 Apr 1990, apt., al.

Zea mays (corn) (Poaceae), Te'ekiu, 18 Aug 1992, apt., al.

Toxoptera aurantii (Boyer de Fonscolombe)

Synedrella nodiflora, Vaini Res. Stn, 30 Apr 1990, al.

undetermined host, Vaini Res. Stn, 30 Apr 1990, 22 Apr 1991, apt., 27 Aug 1992, apt., al.;

Ants: *Pheidole megacephala*.

Toxoptera citricidus (Kirkaldy), black citrus aphid *

Citrus aurantifolia (Tahitian lime) (Rutaceae), MAFF Expt Stn, Vava'u, 4 Apr 1991, apt.

Citrus sp., Vaini Res. Stn, 30 Apr 1990, apt., al.

Without host data

Parasite: *Lipolexis scutellaris* Mackauer (Aphidiinae), Vaini Res. Stn, 17 May 1990; one live adult female on banana sucker in banana plantation.

Twelve species of Aphididae are now recorded from Tonga (Table 1): *Brachycaudus helichrysi*, *Hyperomyzus carduellinus*, *Hysteroneura setariae*, *Myzus persicae*, and *Toxoptera citricidus* are new records; *Tetraneura nigriabdominalis* and *Astegopteryx nipae*, which have been previously recorded, were not collected during the present study. Ours was not an intensive survey; more aphid species are undoubtedly to be found in Tonga, especially those known from elsewhere in the region (Table 1), and from Hawaii, which has a larger and more diverse aphid

Table 1. Aphididae of some south Pacific islands.

References	Islands																	Aphid Species									
	Caroline Is.	Cook Is.	Easter I.	Fiji	Johnston I.	Kiribati	Mariana Is.	Marquesas	Marshall Is.	New Britain	New Caledonia	Niue	Phoenix Is.	Pitcairn Is.	Samoa/West Samoa	Society Is.	Solomon Is.		Tokelau	Tonga	Tuvalu	Vanuatu	Wake I.	Wallis Is.			
																										Aphidinae	
3-6, 8, 11, 13, 16	•	•	•	•	•	•	•		•	•					•	•	•		•	•			•			<i>Aphis craccivora</i> Koch	
2-16, 18-21	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•			•		<i>Aphis gossypii</i> Glover	
17								•																		<i>Aphis mumfordi</i> Takahashi	
2, 5-6, 8-9, 11	•			•		•					•				•	•	•					•				<i>Aphis nerii</i> Boyer de Fonscolombe	
4						•																				<i>Aulacorthum circumflexum</i> (Buckton)	
4-5, 16				•																						<i>Aulacorthum solani</i> (Kaltenbach)	
16		•																		•						<i>Brachycaudus helichrysi</i> (Kaltenbach)	
2, 4, 8, 16		•		•		•					•															<i>Brevicoryne brassicae</i> (L.)	
2											•															<i>Capitophorus elaeagni</i> (del Guercio)	
6, 18	•					•																				<i>Hyalopterus pruni</i> (Geoffroy)	
5				•																•						<i>Hyperomyzus carduellinus</i> (Theobald)	
12											•															<i>Hyperomyzus lactucae</i> (Kaltenbach)	
3-4, 11, 16			•	•		•										•	•		•							<i>Hysteroneura setariae</i> (Thomas)	
11																•										<i>Ipuka dispersum</i> (van der Goot)	
4-6, 8, 16				•		•				•							•									<i>Lipaphis erysimi</i> (Kaltenbach)	
																										[= <i>pseudobrassicae</i> (Davis)]	
2											•																<i>Macrosiphum rosae</i> (L.)
7																										<i>Micromyzus katoii</i> (Takahashi)	
2-6, 8, 11, 16		•	•	•		•	•			•	•					•	•		•							<i>Myzus persicae</i> (Sulzer)	
4-6, 8, 10, 11, 13-16, 18, 22	•	•		•		•	•		•			•			•	•	•	•	•	•	•	•		•		<i>Pentalonia nigronervosa</i> Coquerel	
1				•											•											<i>Rhodobium porosum</i> (Sanderson)	
2-6, 8, 10, 11, 15-16, 18-19, 21	•	•	•	•		•			•	•						•	•		•				•			<i>Rhopalosiphum maidis</i> (Fitch)	

Table 1. Continued.

References	Islands															Aphid Species									
	Caroline Is.	Cook Is.	Easter I.	Fiji	Johnston I.	Kiribati	Mariana Is.	Marquesas	Marshall Is.	New Britain	New Caledonia	Niue	Phoenix Is.	Pitcairn Is.	Samoa/West Samoa		Society Is.	Solomon Is.	Tokelau	Tonga	Tuvalu	Vanuatu	Wake I.	Wallis Is.	
5, 8, 16				•																					<i>Rhopalosiphum nymphaeae</i> (L.)
3, 12		•	•								•	•													<i>Rhopalosiphum padi</i> (L.)
4-5, 8, 16				•		•																			<i>Rhopalosiphum rufiabdominalis</i> (Sasaki)
8				•																					<i>Schizaphis rotundiventris</i> (Signoret) [= <i>cyperi</i> (van der Goot)]
1				•																					<i>Sitobion lambersi</i> David
1, 11				•												•									<i>Sitobion luteum</i> (Buckton)
1, 5, 11		•		•												•									<i>Sitobion miscanthi</i> (Takahashi)
2, 4-6, 8-9, 15-16, 18-21	•	•		•		•	•		•	•					•		•		•		•		•		<i>Toxoptera aurantii</i> (Boyer de Fonscolombe)
4-5, 8-9, 16, 20		•		•											•				•						<i>Toxoptera citricidus</i> (Kirkaldy) [= <i>Aphis tavaresi</i> del Guercio]
																									Pemphiginae
1																	•								<i>Geoica lucifuga</i> (Zehntner)
1																	•								<i>Patchiella reaumuri</i> (Kaltenbach)
6						•																			<i>Tetraneura akinire</i> Sasaki
1, 8, 16, 19				•															•						<i>Tetraneura nigriabdominalis</i> (Sasaki)

fauna (Beardsley 1979), a probable reflection of its greater commercial and political association with the Northern Hemisphere.

Aphidius colemani was recovered in 1992 from *Aphis gossypii* on tarotonga at two sites. An account of its establishment will be provided at a later date.

Aphelinus gossypii has previously been recorded from Tonga (Stechmann & Völkl 1988, 1990). We reared it in abundance from *Aphis gossypii* on *Colocasia esculenta* (tarotonga) at four sites. *Aphelinus gossypii* was described from Hawaii and is also recorded from Australia and New Zealand, and probably elsewhere under other names.

At each of the sites where collected, *Aphelinus gossypii* was parasitized by the cynipoid *Alloxysta darci*, to the extent of 30% at Kolomatua, and at least 60% at Ngeleia. *Alloxysta darci* was described from Australia, where it parasitizes *Aphelinus* spp., but not species of Aphidiinae, within diverse aphid hosts (Carver 1992). In the absence of other distribution records, it is not possible to say whether *A. darci* is naturally occurring in Tonga and Australia or has been accidentally introduced to these countries. True aphid hyperparasites such as Alloxystinae can be expected to be normally host-specific to either *Aphelinus* or Aphidiinae because of the vast disparity in morphology, ontogeny, behavior etc., between the two groups of parasites. One can, therefore, confidently predict that *A. darci* will not normally parasitize *Aphidius colemani* or any other Aphidiinae in Tonga. *Alloxysta darci* is very closely related to *A. brevis* (Thomson), a Palaearctic species parasitic in Aphidiinae. Stechmann & Völkl (1990) have recorded what is evidently the same species heavily parasitizing the same host species in Tonga under the name *A. brevis*.

Lipolexis scutellaris is an Oriental species previously known from China and India (Raychaudhuri 1990). The records indicate a wide host range and a preference for *Aphis* species.

The syrphid *Ischiodon scutellaris* is widespread in the Pacific region, its range extending to Australia, Japan and India (Thompson & Vockeroth 1989).

Diplazon laetatorius is an obligate, solitary, primary parasite of Syrphidae. Presumed to be of Nearctic origin, it is now almost cosmopolitan in distribution. Oviposition takes place in the egg or early instar of the host, and the adult emerges from the host puparium. Males are unknown outside the Nearctic region; all specimens collected in Tonga were female.

Most *Ooencyrtus* spp. parasitize eggs of Lepidoptera, Heteroptera and spiders, but a number are parasites of insect larvae and pupae. *Ooencyrtus guamensis* is also known from Guam and sub-Saharan Africa as a primary parasite of puparia of Syrphidae (Noyes & Hayat 1984, Prinsloo 1987 and personal communication). Several adults emerged per host puparium in the present study.

The coccinellid *Harmonia octomaculata* [= *Coccinella arcuata* Fabr.] is widespread in tropical and subtropical areas of Asia, Australia and the South Pacific (Pope 1988).

The hemerobiid *Micromus timidus* [= *Archaeomicromus navigatorum* (Brauer)] is a common predator of aphids in Tonga (Stechmann & Völkl 1990) and is widespread throughout the region (New 1988).

The ants are exotic 'tramp' species, most of which are already known from Tonga and are widespread in the region (Wilson & Taylor 1967). The high incidence of attendance on *P. nigronervosa* is noteworthy. Eleven ant species were

collected in association with *P. nigronervosa*, most colonies of which were attended in abundance. *Aphis gossypii*, *P. nigronervosa* and *T. aurantii* are also ant-attended in other areas of their distribution; so, also, are *A. craccivora*, *H. setariae* and *T. citricidus*.

The prognosis for the effective establishment of *A. colemani* in Tonga, especially as a generalist, is very good, although this could be impeded by ant attendance. No evidence was found indicating that populations of either *A. colemani* or *Lysiphlebus testaceipes* (Cresson), released in earlier biological control studies, were established on Tongatapu Island (Stechmann & Völkl 1988, Völkl et al. 1990). *Aphidius colemani* is believed to be a parasite of east Mediterranean–Indian origin, which is now widely distributed in warmer parts of the world (Starý 1975). In Australia, it is a common, widespread parasite of members of the subfamily Aphidinae, successfully parasitizing many species of Aphidini, Rhopalosiphini and Myzini (known exceptions: *Aphis spiraecola* Patch and *Hysteroneura setariae*) but not those of Macrosiphini. Its host spectrum elsewhere is similar. In Tonga, *Aphis craccivora*, *A. gossypii*, *Brachycaudus helichrysi*, *Myzus persicae*, *Pentalonia nigronervosa*, *Rhopalosiphum maidis*, *Toxoptera aurantii*, and *T. citricidus* are available as potential hosts. On the other islands in the region, the recorded species of *Aphis*, *Brachycaudus*, *Lipaphis*, *Myzus*, *Pentalonia*, *Rhopalosiphum* and *Toxoptera* are known hosts of *Aphidius colemani*. Aphidophagous parasites are poorly represented in the fauna of the Pacific Islands and the records of aphids presented in Table 1 indicate that there is a strong case to make systematic introductions of *A. colemani* and other selected parasites throughout the region. Most, if not all, of the recorded Aphidinae in the region are exotic and many of these are well known pests. The further introduction of Aphidiinae, which are obligate parasites of aphids, could assist in their control and would not pose a threat to the native or the beneficial fauna.

ACKNOWLEDGMENT

We are indebted to G. L. Prinsloo, R. W. Taylor and T. R. New, respectively, for identification or confirmation of identification of *O. guamensis*, ants, and hemerobiid larvae; and to V. Kami, W. Liebrechts and D. Morneau for assistance in collecting specimens. This research was supported by the Australian Centre for International Agricultural Research (ACIAR).

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Received 18 September 1992; accepted 18 March 1993.