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Possibilities for the Biological Control of the Breadfruit Mealybug, *Icerya aegptiaca*, on Pacific Atolls

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Abstract—The introduced breadfruit mealybug, *Icerya aegyptiaca* is a major pest in Kiribati and some other Micronesian atolls. It has been brought under effective biological control in the high islands of Micronesia by the introduction of a predatory ladybird beetle, *Rodolia pumila*. Like most other ladybirds, this species searches effectively at high prey densities, but inefficiently at low densities. When introduced to the relatively restricted atoll environment it soon reduces *I. aegyptiaca* populations to low levels. It then dies out, apparently being unable to find prey, whereupon there is an upsurge in mealybug populations.

One control strategy would be to re-introduce *R. pumila* whenever mealybug populations reach a pre-determined action level. However, and preferably, other natural enemies could be introduced that might co-exist at low scale densities. In particular, the parasitic fly, *Cryptochetum grandicorne*, may have appropriate characteristics.

Origin and Distribution

The Egyptian fluted scale or breadfruit mealybug, *Icerya aegyptiaca* (Douglas) is, despite its name, probably of Indian or Oriental origin. It was, however, first described in 1890 from specimens collected from a heavy infestation on fruit trees in Egypt. It now occurs widely in Asia, in tropical and subtropical Africa, in Australia and in Micronesia, but does not appear to be present in neighbouring Tuvalu. Doubt has recently been thrown on the authenticity of earlier records from Vanuatu, Fiji, and Tahiti (D. J. Williams pers. comm. 1990). In Micronesia it is known from the Federated States, the Marianas, Marshall Islands, Wake Island, Nauru and Kiribati (Waterhouse 1991).

Beardsley (1955) suggests that *I. aegyptiaca* may have gained entry into Micronesia from Taiwan. This was early this century or possibly late last century. At all events, the first record for the general region is 1893 from New South Wales (Maskell 1894). The first record from Kiribati, the country currently most seriously affected, is 1950 (Hall 1953).

Life Cycle

Most stages of *I. aegyptiaca* are present all year round in Micronesia. Only females are known: several casual references to males must be treated as dubious, since there are no specimens in collections. Unlike two related major pest species, *I. purchasi* Maskell and *I. seychellarum* (Westwood), which are both hermaphroditic, *I. aegyptiaca* is parthenogenetic.

It has about 3 generations a year, with a peak of adult abundance in summer. Up to 200 eggs are laid into a waxy egg sac attached ventrally to the tip of the abdomen. The adult female is deep orange in color and has blackish legs. Marginally it has long, white, waxy processes and the body surface is covered with a white mealy secretion consisting of wax.

Pest Status

The greatest impact of *I. aegyptiaca* in the Pacific is on the breadfruit tree, *Artocarpus altilis,* which, together with coconut, provides essential food in low coral atolls. Although it may infest the fruit, the mealybug is usually situated along the midribs and larger veins on the underside of the breadfruit leaves. Large quantities of sap are sucked out by the mealybugs and this causes immature leaves and stems to dry up and die. Prolonged dry weather appears to favor the build up of heavy infestations. Heavy infestations have been reported to kill even mature breadfruit trees but, more often, trees are partially defoliated and the crop reduced, sometimes by more than 50%. In addition to direct effects from sap removal, the mealybugs produce large quantities of honeydew which acts as substrate for an abundant growth of sooty molds. This black growth covers the surfaces of all but the youngest leaves of heavily infested trees, seriously interfering with photosynthesis.

Important food plants other than breadfruit that may suffer from heavy mealybug attack include banana, young coconut plants and citrus. Infestations may also occur on wild fig (te boro), babai, taro and many other plants.

In its presumed Indo-Oriental native range *I. aegyptiaca* seldom causes damage and is most often found at low elevations in coastal regions. Nor is it a pest in Australia, although it is found from time to time on economic plants in the Northern Territory.

Chemical Control

Sprays containing white oil or some of the modern synthetic pesticides will control breadfruit mealybug but, under atoll conditions, these are expensive and difficult to apply to large trees.

Natural Enemies

The most important predators of *Icerya* are coccinellids of the genus *Rodolia* (Table 1), although several chrysopids also contribute to mortality. Of the ladybirds, *R. cardinalis* is best known for its spectacular control of the cottony cushion scale, *Icerya purchasi* in California, but *R. pumila* has been employed more often for biological control of *I. aegyptiaca* in Micronesia. Both species make massive

Table 1. Natural enemies of *Icerya aegyptiaca* (after Waterhouse 1990).

Predators	Parasitoids
COLEOPTERA	DIPTERA
Coccinellidae	Cryptochetidae
Coelophora inaequalis (Fabricius)	*Cryptochetum grandicorne* Rondani
Cryptolaemus montrouzieri Mulsant	Tachinidae
Harmonia arcuata (Fabricius)	Masicera sp.
Pullus coccidovora (Anyar)	HYMENOPTERA
Rodolia breviuscula Weise	Eulophidae
R. cardinalis (Mulsant)	*Tetrastichus* sp.
R. pumila (Weise)	Pteromalidae
R. ruficollis Mulsant	*Oricoruna arcotensis* (Mani and Kurian)
Rodolia sp.	
Scymnus sp.	

inroads into heavy *Icerya* infestations, but search inefficiently when prey densities are reduced to low levels. Of the other predators, *R. ruficollis* is reported in Pakistan to feed voraciously on *I. aegyptiaca*, but only in heavy infestations, whereas *Pullus coccidovora* attacks eggs and first instar larvae in both high and low populations and might be worthy of further investigation.

Among the parasitoids (Table 1) the fly *Cryptochetum grandicorne* appears to be the most important, causing 20 to as high as 90% parasitisation of *I. aegyptiaca* in India and 3 to 10% in Pakistan. This suggests that, under appropriate conditions, it could be very important in population regulation, although it has not so far been employed as a biological control agent. The related species, *C. iceryae* (Williston), is a very important parasitoid of *Icerya purchasi* and, in coastal areas of California, is a far more effective biological control agent than the much publicized *R. cardinalis* (Quezada & De Bach 1973). *C. iceryae* was introduced into Chile, where it alone is reported to keep *I. purchasi* under effective control (Gonzalez & Rojas 1966). All of the 200 or so species of the family Cryptochetidae whose biology is known are parasitoids of the scale family Margarodidae (Ferrar 1987).

C. grandicorne ranges in distribution from the Mediterranean to Asia, but does not occur in the oceanic Pacific. It is easy to rear in small cages in the laboratory, adults mating readily in sunshine, but rarely otherwise. Sometimes more than one egg is inserted, always into first instar mealybugs, but only one larva develops per host (Thorpe 1934). Insufficient is known about the other parasitoids to comment on their possible value as biological control agents.

Attempts at Biological Control

The first attempt at biological control of *I. aegyptiaca* was of the outbreak in Egypt in 1892. *Rodolia cardinalis*, which had recently had such a spectacular impact on *I. purchasi* in California, was introduced and soon led to successful control.

Micronesia is the only other region of the world where *I. aegyptiaca* has proved to be a serious problem. In this region there have been many attempts at biological control, a few of the early ones involving *Rodolia cardinalis*, but, more recently, *Rodolia pumila* has been the species used. The history of introductions is somewhat confused for several reasons. One is uncertainty relating to which of the three pest species of *Icerya* was actually present, namely *I. aegyptiaca, I. purchasi,* or *I. seychellarum.* Another complicating factor is that *R. pumila*, the only widespread coccinellid now attacking *I. aegyptiaca* in Micronesia, was brought in 1941 to Saipan, probably from Taiwan, but was at that time referred to as *R. cardinalis*, although lacking the latter's characteristic spots (Beardsley 1955). Actually *R. cardinalis* from Hawaii had been released against *I. purchasi* in 1926 on Guam and rapidly brought this mealybug under control. However it was last recorded in the region in 1945 (Nafus & Schreiner 1989).

At all events, the outcome of the releases was that *R. pumila* had become established on most of the high islands of Micronesia by the 1950's (Beardsley 1955, Chapin 1965) and that *I. aegyptiaca* is no longer regarded as a pest in these high islands (Schreiner 1989). In contrast with these results, are those for atolls, where *R. pumila* has been repeatedly introduced, but appears not to be able to persist.

Information is scanty on whether or when it has really become securely established, whether it has died out at some time after temporary establishment, or whether it might even have been present from an earlier introduction, but overlooked because of its low numbers. Sample records (Table 2) suggest that it

Table 2. Some introductions of *Rodolia pumila* to Micronesia (after Waterhouse 1990).

	Source	Year	Established (recovery date)	Comment
Palau State				
Ulithi Atoll	Saipan	1948	+ (1950)	
	Palau	1954	+ (1957)	but serious outbreak in 1964
	Palau	1964	+	but serious outbreak in 1984
Truk State				
Nama	Losap	1954	+	later reported absent
Marshall Is				
Jaluit	Palau	1953	+ (1954)	
		1958	−	
		1961	+	but eliminated by typhoon
		1964	+	

is unable to maintain itself on atolls for more than, at most, a few years. The situation is, perhaps, best documented in Kiribati (Table 3) where *R. cardinalis* was definitely established for a period on both Butaritari (1953) and Marakei (1962), but a few years later could not be found. *R. pumila* was introduced on at least 5 occasions and was established at least twice, leading both times to control, although it could not be found a year or two afterwards when *I. aegyptiaca* once again built up to pest numbers. The most likely explanation is that of Schreiner (1989), that on small atolls *R. pumila* died from starvation once mealybug populations were reduced to very low levels. Since *Rodolia* spp. are reported to be specific predators of *Icerya* and related scales, they would find it difficult, if not impossible, to find suitable alternative prey on most atolls which generally have a very limited insect fauna compared with that of high islands with their far more diverse habitats. Schreiner (1989) also suggests that typhoons may play a part in eliminating *R. pumila*, as apparently one did in Jaluit after the 1961 introduction. Although they may play an important role in some regions, typhoons occur only rarely near the equator, as in Kiribati, where elimination of *R. pumila* can occur without their intervention.

Whatever the explanation, if *Rodolia pumila* is to be relied upon for the biological control of the breadfruit mealybug, arrangements will be necessary for re-introductions every few years, as suggested much earlier by Vandenburg (1928). If this tactic is to be adopted, mealybug populations should be monitored at regular intervals and introductions arranged when a pre-determined level of abundance is attained. A procedure should be established for regularly obtaining healthy stocks of *R. pumila* from a convenient source, possibly from Guam or Palau. Adequate precautions would be essential to prevent the introduction of damaging parasitoids or diseases at the same time.

An alternative strategy would be to investigate the possibility of using as yet untested natural enemies, the first choice being the parasitic fly *Cryptochetum grandicorne*. Although it parasitizes only members of the scale family Margarodidae to which *Icerya* belongs, and hence on atolls would have few, if any, hosts other than *Icerya* available to it, it appears to have characteristics (such as

Table 3. Introductions to Kirbati of *Rodolia* spp. (after Waterhouse 1990).

	Source	Year	Established	Comment
Rodolia cardinalis	Fiji	1953	+	Established on Butaritari, but later died out
	Hawaii	1962	+	Established on Marakai, but later died out
Rodolia pumila	Marianas	(?)1971	+	Established briefly
	Guam	1975	?	
	Palau	1977	–	
	Guam	1978	–	
	Palau	1979	+	Established briefly on Butaritari, but later died out

requiring a single host only for development as contrasted with many for *Rodolia*) which may enable it to co-exist with *I. aegyptiaca* at low population densities. Thus, it might well survive at the low host densities, which *R. pumila* brings about. *R. pumila* should not be introduced simultaneously, but might be considered if *C. grandicorne* alone fails to produce an adequate reduction in mealybug populations.

It is hoped that, in the near future, the Australian Centre for International Agricultural Research will fund the CSIRO Division of Entomology to evaluate *C. grandicorne*, and perhaps other natural enemies, for the control of breadfruit scale in Kiribati.

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