



Tropical Pest Management

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/ttpm19>

Recent work on biological control in Papua New Guinea and some suggestions for the future

G. R. Young^a

^a Department of Primary Industry, Agriculture Research Centre, Bubia, P.O. Box 73, Lae, Papua New Guinea

Available online: 13 Nov 2008

To cite this article: G. R. Young (1982): Recent work on biological control in Papua New Guinea and some suggestions for the future , *Tropical Pest Management*, 28:2, 107-114

To link to this article: <http://dx.doi.org/10.1080/09670878209370686>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.tandfonline.com/page/terms-and-conditions>

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae, and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Recent Work on Biological Control in Papua New Guinea and Some Suggestions for the Future*

G. R. Young

Department of Primary Industry,
Agriculture Research Centre,
Bubia, P.O. Box 73, Lae,
Papua New Guinea.

Abstract. The biological control of some insect crop pests in Papua New Guinea from the late 1950s to 1979 is reviewed. The pests are considered according to the crops affected, which include coconut, citrus, cocoa, coffee, legumes, rice, sugarcane, grain sorghum, cruciferous vegetables and forest trees. The distribution in Papua New Guinea of each pest and the damage it causes are briefly described. Potential biological control agents are discussed with reference to the effects of any past introductions and some comments on possible future use. The biological control of some weed species, in particular lantana (*Lantana camara* L.) and salvinia (*Salvinia molesta* Mitchell), the giant snail (*Achatina fulica hammondi* Bowditch), and cattle dung is also considered.

Introduction

Wilson (1960) reviewed biological control in Papua New Guinea (PNG) up to the late 1950s. This paper deals with work since then, and makes suggestions for future biological control.

Catley (1966) listed parasites and predators of some insects found in PNG, and included some notes on the introduction of exotic parasites and predators. Rao *et al.* (1971) reviewed biological control in southeast Asia and the Pacific region. Simmonds (1971) discussed the major insect and weed pests of PNG and examined the possibilities for biological control. A review of biological control in the Pacific was written by Cochereau (1972) which made some reference to work in PNG.

Pests of tree crops

Coconut

1. Coconut treehoppers (Orthoptera: Tettigoniidae)

Various species of the genera *Segestes* and *Segestidea* periodically cause serious defoliation to coconut on the north coast of PNG and in the Bismarck Archipelago.

O'Connor (1959) recorded the strepsipteran, *Stichotrema dallatorreana* Hofeneder (Strepsiptera: Myrmecolacidae) parasitising up to 60% of *Segestes decoratus* Redtenbacher and *Segestidea novaeguineae* (Brancsik) on the Madang Coast. He attempted to introduce the parasite to Pak Island, Manus Province, before World War II in an attempt to control *Segestidea uniformis* (Willemse), but investigations in 1945 failed to find it. With an outbreak of *Segestidea gracilis* (Willemse) on oil palm in the West New Britain Province, there has been renewed interest in this parasite (Prior, personal communication). *S. dallatorreana* was thought to be parthenogenetic, although Luna de Carvalho (1959) described dimorphism in the triungulin larvae and concluded that this was probably sexual dimorphism. Luna de Carvalho (1972) later stated that the male was *Caenocholax acutipennis* Kogan and Oliveira (Strepsiptera: Myrmecolacidae), a conclusion based on a male genital organ found in the cephalothorax of a female

*A slightly different version of this article was presented at the Regional Workshop on Biological Control, South Pacific Commission, Noumea, New Caledonia, 6–10 August 1979.

Stichotrema. Recently, a male *S. dallatorreana* was captured in copula (Young, unpublished data). Further studies of the life cycle could lead to a successful introduction into the Bismarck Archipelago (O'Connor, 1959).

The egg parasite *Leefmansia bicolor* Waterson (Hymenoptera: Encyrtidae) has been shipped from New Hanover to West New Britain in an attempt to control *S. gracilis* (Prior, personal communication). It is not known if this parasite has become established.

A culture of the protozoan parasite *Nosema locustae* Canning was imported into PNG from the USA for testing against treehoppers, but it was found to be nonviable (Smith, personal communication).

2. Rhinoceros beetle, *Oryctes rhinoceros* L. (Coleoptera: Scarabaeidae)

This dynastine beetle is a serious pest of coconut in New Britain, New Ireland and the Admiralty Islands.

The predator *Platymeris laevicollis* Distant (Hemiptera: Reduviidae) has been released on New Britain (Anonymous, 1970, 1971). No recoveries have been made.

The baculovirus of *Oryctes* was imported from Western Samoa and released in the Manus Province, and New Britain and New Ireland Province during 1978. Infected beetles have since been recovered from Manus and New Ireland (Gorick, personal communication).

3. Coconut leafminer, *Promecotheca papuana* (Csiki) (Coleoptera: Chrysomelidae)

Perry and Prior (personal communication) investigated the possibility of using the fungal pathogen *Synnematum jonesii* Speare against periodic outbreaks of *P. papuana* in East New Britain. They conducted field trials, but concluded that successful field application was unlikely.

4. Coconut leaf hopper, *Zophiuma lobulata* Ghauri (Hemiptera: Lophopidae)

This toxicogenic leafhopper is thought to be responsible for 'Finschhafen disease' of coconuts. The fronds of affected palms turn a bronze colour and in severe cases young palms die. It is only consistently serious in a restricted area of the Finschhafen coast, Morobe Province, although a severe outbreak has been recorded from Popondetta, Northern Province (Anonymous, 1971). In some areas of the Finschhafen sub-province egg masses of *Z. lobulata* are heavily parasitised by *Ooencyrtus malayensis* Ferrière (Hymenoptera: Encyrtidae). It has been suggested that *O. malayensis* could be raised and released in areas of low parasitism (Smith, in preparation).

5. Coconut spathe bug, *Axiagastus cambelli* Distant (Hemiptera: Pentatomidae)

The coconut spathe bug has been recorded from the Bismarck Archipelago, Bougainville, Solomon Islands, Misima Island and the New Hebrides (Baloch, 1973). It is of economic significance only in restricted areas of its distribution (O'Sullivan, 1973). The bug feeds on both male and female flowers and the resultant nut fall is thought to be due to loss of sap (Lever, 1969). O'Sullivan (1973) showed that the most important egg parasite of this species was *Trissolcus painei* Ferrière (Hymenoptera: Scelionidae), which had attacked 39.1% of all the eggs he examined. Tachinid parasites were also important biocontrol agents in all areas except the Lihir Islands. Introductions of *Pentatomophaga bicincta* de Meij (Diptera: Tachinidae) were made to the Lihir Islands from New Britain, but no recoveries were recorded.

O'Sullivan (1973) also noted that palms colonised by the ant *Oecophylla smaragdina* (F.) supported low populations of *A. cambelli*, while palms colonised by crazy ant, *Anoplolepis longipes* (Jerdon), invariably supported large populations of *A. cambelli*. If introductions of parasites into areas where *A. cambelli* is of economic significance fail, the most promising approach would appear to be to encourage populations of *O. smaragdina*.

Citrus

1. Citrus white wax scale, *Gascardia destructor* Newstead (Hemiptera: Coccidae)

White wax scale is a widespread pest of citrus, mango, guava, gardenias, fuchsias and many ornamental plants throughout the Eastern Highlands Province. Predation of the larvae by several species of coccinellid beetles appears to be significant, but parasitism rarely exceeds 5%. After further studies a decision will be made whether to introduce parasites from Australia, where *Gascardia* has been successfully controlled.

Cocoa

1. *Pantorhytes* spp. (Coleoptera: Curculionidae)

Several species of this apterous genus attack *Theobroma cacao* L. The adult weevils feed on the leaves and bark, but the main damage is caused by the larvae. Female *Pantorhytes* lay their eggs in cracks and crevices in the bark of the trunk or branches and the larvae bore into the sap wood. Chemical control of *Pantorhytes* spp. has proved expensive and difficult (Szent-Ivany, 1961; Smith, personal communication).

Baker (1972) suggested the use of crazy ant, *Anoplolepis longipes* (Jerdon), to control *P. szentivanyi* Marshall. He showed that *P. szentivanyi* adults were harassed by the ant and as a result dispersed out of areas newly occupied by *A. longipes*. The occupation of cocoa by crazy ant is unstable (Baker, 1972), and further work is needed in order to be able to manipulate crazy ant populations (Smith, personal communication). Meanwhile, the use of crazy ant is being actively promoted in the Northern Province, and East and West New Britain Provinces.

Smith and Prior (personal communication) have used the entomogenous fungus *Beauveria bassiana* (Balsamo) Vuillemin in laboratory experiments with *P. plutus* Oberthur. Preliminary results have indicated up to 90% infection of *P. plutus* under laboratory conditions, and field trials are currently under way.

2. Cocoa defoliators, *Tiracola plagiata* (Walker) (Lepidoptera: Noctuidae) and *Achaea janata* L. (Lepidoptera: Noctuidae)

The larvae of these moths defoliate cocoa and occasionally coffee. The damage is more severe on cocoa shaded by *Leucaena leucocephala* since this tree is an alternative host of *T. plagiata* (Catley, 1962; Smith, personal communication). In 1962 *Trichogramma minutum* Riley (Hymenoptera: Trichogrammatidae) was introduced into PNG from California and released at Popondetta (Northern Province), Lae (Morobe Province), and the Gazelle Peninsula (East New Britain Province) in an attempt to control *T. plagiata*, *A. janata* and other cocoa defoliators. *T. minutum* has not been recovered in the field (Catley, 1966).

Six consignments of *Drino inconspicuoides* Baranov (Diptera: Tachinidae) puparia were shipped to Popondetta from the Commonwealth Institute of Biological Control (CIBC), Bangalore, India, to be used against *T. plagiata* but they did not survive the journey (Catley, 1962). During 1965–66 several shipments of *Apanteles priscus* Nixon and *Apanteles* sp. (*glomeratus* group), (Hymenoptera: Braconidae) were received from CIBC, India. Some were released, but one shipment was found to be contaminated and was destroyed (Fenner, personal communication).

Van Velsen (1966) examined the possibility of controlling *T. plagiata* using a nuclear polyhedrosis virus. At Wau, Morobe Province, up to 50% mortality of *T. plagiata* larvae due to a virus infection was recorded (Anonymous, 1970).

The egg parasites *Telenomus* sp. (Hymenoptera: Scelionidae), *Trichogramma australicum* Girault and *Trichogramma achaeae* Nagaraja and Nagarkatti (Hymenoptera: Trichogrammatidae), and the larval parasite (*Microplitis maculipennis* Szepilgeti (Hymenoptera: Braconidae) were shipped from CIBC, India, to Popondetta, PNG, and released against *A. janata*. There have been no recoveries of any of these parasites (Rao *et al.*, 1971).

Approximately 40 puparia of *Winthemia* sp. ?*diversa* Malloch (Diptera: Tachinidae) were reared from *T. plagiata* larvae at Popondetta and sent to Wewak, East Sepik Province (Anonymous, 1970). There are no records of the success or failure of this shipment.

3. *Amblypelta theobromae* Brown (Hemiptera: Coreidae)

No egg or larval parasites of *A. theobromae*, a pest of cocoa in the Northern Province, have been found, although in other parts of PNG and the Solomon Islands a number of parasites of *Amblypelta* spp. have been recorded. During 1974 eggs of *Amblypelta lutescens papuensis* Brown were collected from the Central Province. These eggs were found to be over 60% parasitised by five species of egg parasite, three of which accepted *A. theobromae* as a host in the laboratory. One species, *Ooencyrtus malayensis* Ferrière (Hymenoptera: Encyrtidae), was released in the Northern Province, but it is not known if this has become established as an egg parasite of *A. theobromae* (Smith, personal communication). Simmonds (1971) suggested that egg parasites of *Pseudothraupis* sp. (Hemiptera: Coreidae) from East Africa could be tested as potential control agents for *Amblypelta* eggs.

Coffee

1. Green scale, *Coccus viridis* (Green) (Hemiptera: Coccidae)

In some highland areas of PNG this scale is a major pest of arabica coffee. The recommended method of dealing with *C. viridis* has been to control the ground-nesting ant species tending the scale by spraying the base of the coffee and shade trees with 2% chlordane or 0.75% dieldrin, thus allowing natural enemies to attack the scale without harassment from the ants. Unfortunately, indigenous coffee growers find this method difficult to implement.

Fabres (personal communication) and Beardsley (personal communication) both contend that the introduction of exotic parasites and predators would probably not be successful as the ants would render them ineffective. Although Bennett (personal communication) and Greathead (personal communication) refer to the introduction of *Azya orbiger* Mulsant (Coleoptera: Coccinellidae) into Hawaii from Mexico as giving substantial control, the parasites and predators available do not appear promising.

Fabres (personal communication) advocated increasing the amount of shade to raise the humidity and make the environment more favourable for entomogenous fungi. In 1978 three strains of the entomogenous fungus *Verticillium lecanii* (Zimmerman) were imported from the Glasshouse Crops Research Institute, UK. Field trials are in progress, but so far the results are not encouraging (Simpson and Young, unpublished data).

Pests of spices

Vanilla

1. *Hypolycaena danis* (Felder) (Lepidoptera: Lycaenidae)

Larvae of *H. danis* cause extensive damage to the flowers of vanilla and other orchids. No parasites have been reared from either eggs or larvae, and this butterfly appears to be a good target species for biological control (Young, unpublished data).

Pests of ornamentals

Hibiscus

1. Hibiscus mealy bug, *Maconellicoccus hirsutus* (Green) (Hemiptera: Coccidae)

Hibiscus, *Hibiscus rosa-sinensis* L., is an important traditional ornamental in PNG. *M. hirsutus* was accidentally introduced into Rabaul, East New Britain Province, from the mainland. Ornamental hedges of hibiscus became heavily infested and were severely damaged. The coccinellids *Brumoides suturalis* (F.), *Scymnus pallidicollis* Mulsant, *Scymnus coccidivora* Agya and *Hyperaspis maindroni* Sicard were imported from CIBC, Bangalore, and releases of all these species were made at Rabaul between 1966 and 1969. *H. maindroni* was also released at Popondetta in 1968 and Port Moresby in 1969 (Anonymous, 1970, 1971; Rao *et al.*, 1971). *M. hirsutus* is believed to have been brought under control at Rabaul by an indigenous *Scymnus* sp. (Bourke *et al.*, 1973).

Pests of field crops

Legumes

1. Green vegetable bug, *Nezara viridula* F. (Hemiptera: Pentatomidae)

N. viridula is a serious pest of legumes in the Markham Valley, Morobe Province. The egg parasite *Trissolcus basalis* (Wollaston) (Hymenoptera: Scelionidae) is present in this area, but the percentage parasitism is usually below 30%. In 1978 a strain of *T. basalis* from Kununurra, Western Australia, was imported and released, but it failed to increase the percentage parasitism (Young, unpublished data).

Two shipments of puparia of the parasite *Trichopoda pilipes* Fabricius (Diptera: Tachinidae) were received from Hawaii. The majority of adults emerged with malformed wings, and those which were intact failed to mate (Young, unpublished data). The possibility of importing live parasitised *Nezara* from Hawaii is being investigated.

2. *Riptortus annulicornis* Boisduval (Hemiptera: Alydidae)

This pod sucker is recorded from most coastal provinces of mainland PNG. Late instar larvae and adults attack legume pods, causing the developing seeds to shrivel. Almost all grain, vegetable and pasture legumes are affected. Other species of *Riptortus* attack legumes in the highlands and outer islands.

Three species of egg parasite, *Anastatus* sp. (Hymenoptera: Eupelmidae), *Gryon* sp. (Hymenoptera: Scelionidae), *Ooencyrtus* sp. (Hymenoptera: Encyrtidae), and two species of egg predator, *Conocephalus* spp. (Orthoptera: Tettigoniidae), attack *R. annulicornis* eggs. It is not known if the natural egg mortality can be increased (Young, unpublished data), or if there are exotic parasites of larvae and adults of the *Riptortus* genus in other parts of the Old World tropics.

3. *Henosepilachna signatipennis* Boisduval (Coleoptera: Coccinellidae)

H. signatipennis is a leaf eating coccinellid which attacks a wide variety of vegetable, grain and forage legumes. The percentage parasitism of eggs and larvae is low (Young, unpublished data). Once indigenous parasites have been identified, the importation of exotic species can be considered.

4. *Maruca testulalis* Geyer (Lepidoptera: Pyralidae)

The bean pod borer *M. testulalis* occasionally causes severe damage to the pods of cowpea and winged, dwarf and jack bean. Almost nothing is known of its natural enemies.

5. *Ophiomyia phaseoli* (Tryon) (Diptera: Agromyzidae)

The bean fly *O. phaseoli* is a serious pest of *Phaseolus vulgaris* and *Vigna angularis* (Gagne, personal communication; Young, unpublished data). *Vigna unguiculata* var. *sesquipedalis* (L.) Walp., *Vigna mungo* (L.) Hepper and *Psophocarpus tetragonolobus* (L.) DC. all have some degree of resistance to *O. phaseoli*. While parasites have been recovered from the pupae, the level of control is inadequate. In view of the success of *Opius importatus* Fischer and *Opius phaseoli* Fischer (Hymenoptera: Braconidae) in controlling this pest in Hawaii (Greathead, 1975), these parasites could be tried in PNG.

Rice

1. Rice bugs, *Leptocoris* spp. (Hemiptera: Alydidae)

Three species of *Leptocoris* attack developing grains of rice in PNG. Of these, *L. oratorius* is by far the most important (Sands, 1977). *Gryon nixon* Masner (Hymenoptera: Scelionidae), an egg parasite of *L. oratorius*, has been recorded parasitising up to 65% of eggs at high host densities. The polyphagous egg parasite *Ooencyrtus malayensis* Ferrière (Hymenoptera: Encyrtidae) parasitised up to 31% of *L. oratorius* eggs (Sands, 1977). Additionally two species of *Conocephalus* (Orthoptera: Tettigoniidae) are predators of *Leptocoris* spp. eggs (Young, unpublished data), accounting for up to 67% of *L. oratorius* eggs (Sands, 1977). It is not known if the egg mortality can be increased, but the introduction of exotic natural enemies should be investigated.

2. Brown planthopper, *Nilaparvata lugens* Stål (Hemiptera: Delphacidae)

N. lugens is a serious pest of paddy rice in PNG. An egg predator, *Cyrtorhinus lividipennis* Reuter (Hemiptera: Miridae), has been found but its importance is unknown (Dori, personal communication).

Sugarcane

A sugar industry is about to start in the upper Ramu Valley of the Madang Province. Initially the most serious insect problem appears to be stem borer, and a biological control project against sugarcane stem borers started in early 1981. Three species of sugarcane stem borer are found in the area.

1. *Chilo terrenellus* Pagenstecher (Lepidoptera: Pyralidae)

The indigenous egg parasites of the stem borer *C. terrenellus* appear to be reasonably efficient in controlling populations (Sands, personal communication). At least four species of egg parasite have been recorded, the most important being *Telenomus* sp. (Hymenoptera: Scelionidae) and *Trichogramma* sp. (Hymenoptera: Trichogrammatidae). Larval parasites are rare; *Apanteles* sp. nr *chilonis* Munikata (Hymenoptera: Braconidae) parasitises less than 3% of larvae, while an unidentified tachinid is occasionally recovered (Li, personal communication; Sands, personal communication). There is scope for the introduction of exotic larval parasites for testing against *C. terrenellus* (Simmonds, 1971; Li, personal communication; Sands, personal communication).

2. *Sesamia grisescens* Walker (Lepidoptera: Noctuidae)

This species of borer is relatively uncommon on *Saccharum officinarum* L., the main host being *S. robustum* Brandes and Jeswiet ex Grassl. However, *S. grisescens* may become more important as larger tracts of land are put under sugarcane (Sands, personal communication). Szent-Ivany and Ardley (1962) reported rearing three species of *Enicospilus* (Hymenoptera: Ichneumonidae) from pupae of *S. grisescens*, and Sands (personal communication) recorded a rare unidentified tachinid from the larvae.

3. *Maliarpha separatella* Ragonot (Lepidoptera: Pyralidae)

This is an important stem borer during periods of high rainfall; no parasites are known from the larvae (Sands, personal communication).

Grain sorghum

1. *Heliothis armigera* (Hubner) (Lepidoptera: Noctuidae)

H. armigera is a serious pest of grain sorghum in the Morobe Province, feeding on the flowering heads. At present there does not seem to be much prospect of biological control, although the entomogenous fungus *Paecilomyces farinosus* (Dickson ex Fries) Brown and Smith may warrant further investigation (Dori, personal communication).

Pests of vegetables

Crucifers

1. *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae)

Initially consideration had been given to the possibility of using a granulosis virus, which has been used in Taiwan, to control *P. xylostella*. However, this virus would require extensive safety testing and would not be available in sufficient quantities for use in PNG.

The feasibility of importing a nuclear polyhedrosis virus of *P. xylostella*, possibly *Autographa californica* NPV, is being examined. If it is ascertained that there are likely to be no adverse effects on native Lepidoptera, especially butterflies (Entwistle, 1978; Thistleton, personal communication), the introduction is expected to proceed.

Pests of forest trees

1. *Lymantria ninayi* Bethune-Baker (Lepidoptera: Lymantriidae)

During 1976 and 1977 an outbreak defoliated nearly 500 ha of *Pinus patula* (Pinaceae) at Lapegu in the Eastern Highlands Province. A naturally occurring nuclear polyhedrosis virus disease of *L. ninayi* larvae caused heavy mortality and was involved in terminating the outbreak. A programme aimed at developing this nuclear polyhedrosis virus for the control of future outbreaks of *L. ninayi* has been recommended (Entwistle, 1978; Roberts, personal communication).

Biological control of weeds

1. Puncture vine, *Tribulus cistoides* L. (Zygophyllaceae)

The seed weevil *Microlarinus lareyni* Jacquelin-Duval and the stem weevil *M. lypriformis* (Wollaston) (Coleoptera: Curculionidae) were introduced into the Central Province in 1966 and 1967. Only *M. lypriformis* has become established (Anonymous, 1970, 1971; Bourke *et al.*, 1973).

2. Lantana, *Lantana camara* L. (Verbenaceae)

In most parts of PNG lantana is not the serious weed it has become in other Pacific countries (Henty, personal communication). *Teleonemia scrupulosa* Stål was introduced from the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Canberra, Australia, during 1973. Field releases were made in the Morobe, Milne Bay, East New Britain, New Ireland, West New Britain and Central Provinces. Only on Goodenough Island, Milne Bay Province, has satisfactory control been achieved (Smith, personal communication). Other insects which feed on lantana may be imported after their evaluation by CSIRO (Fenner, personal communication).

3. Salvinia, *Salvinia molesta* Mitchell (Salviniaceae)

This aquatic weed is a native of southern Brazil and is now well established in the Sepik River system where it is having a serious economic and sociological impact (Mitchell, personal communication). Once the results of CSIRO research on natural enemies of salvinia become available, it is likely that introductions of biocontrol agents will be made to PNG (Fenner, personal communication).

4. Other weeds

In 1971 the CIBC in Trinidad did some surveys of natural enemies of the weeds *Bidens pilosa* L. (Compositae), *Euphorbia geniculata* Ort (Euphorbiaceae), *Mimosa pudica* L. (Leguminosae) and *Portulaca oleracea* L. (Portulacaceae) (Simmonds, 1971). There have been no follow-up studies as the preliminary findings were not encouraging (Fenner, personal communication).

Sida rhombifolia L. (Malvaceae) is found from low altitudes to 2000 m elevation (Henty and Pritchard, 1975), and is a serious weed of subsistence gardens in PNG (Gagne, personal communication). In view of the current interest in subsistence agriculture, *S. rhombifolia* may receive attention from biocontrol workers in the future.

Other biological control projects

1. Giant snail, *Achatina fulica hammondi* Bowdich

This mollusc can cause considerable damage to crops such as cocoa, rubber and vegetables, particularly in the seedling stage (Dun, 1966). It is established on New Ireland, Bougainville, East and West New Britain, as well as the Central, Madang and Morobe Provinces of the mainland.

The predatory snail *Gonaxis quadrilateralis* Preston has become established at Keravat, East New Britain Province and appears to be controlling *Achatina* (Smith, personal communication). Attempts have been made to introduce *Gonaxis* to other parts of the country. Another predatory snail, *Euglandia rosea* Ferussac, and the beetles *Selasius* sp. (Coleoptera: Drilidae) and *Tefflus planifrons* Murray (Coleoptera: Carabidae) were introduced to Keravat but it is not known if they are established (Dun, 1966). No recoveries have been made during the past decade (Fenner, personal communication).

2. Cattle dung

The buffalo fly, *Haematobia exigua* (de Meij) (Diptera: Muscidae) is established in the Madang, Morobe, East New Britain and parts of the Manus Province (Wong, personal communication). Additionally, *Musca inferior* Stein (Diptera: Muscidae), another blood sucking fly which causes considerable irritation to cattle, is abundant in PNG (Norris and Ferrar, 1974). The larvae of both these species live in cow dung and it is thought that dung burial by beetles would reduce populations of adult flies.

Onthophagus gazella (F.) (Coleoptera: Scarabaeidae) was imported from CSIRO stocks in Australia, and is now established in the Central, Northern, Madang, Morobe, East New Britain and Eastern Highlands Provinces.

O. obliquus Olivier was released at Popondetta in the Northern Province and Baiune, Buba, Bulolo, Erap and Wau in the Morobe Province in 1978 (Smith, personal communication; Young, unpublished data). It is not known if *O. obliquus* has become established in any of these localities. *Onitis alexis* Klug (Coleoptera: Scarabaeidae) was released at Kokoda in the Northern Province in 1975, but no recoveries have been made (Smith, personal communication). Neither *Sisyphus spinipes* (Thunberg) nor *Onitis vanderkelleni* Langsberge (Coleoptera: Scarabaeidae) thrived in culture, and no significant releases were made.

It is anticipated that other species of dung beetles will be imported as they become available from CSIRO, Australia.

Acknowledgements

The author gratefully acknowledges the assistance of Mr T. Fenner, Chief Entomologist, Department of Primary Industry (DPI), Konedobu; Mr E.S.C. Smith, Senior Entomologist, DPI, Lowlands Agriculture Experiment Station, Keravat, East New Britain Province; Dr B. Thistleton, Entomologist, Kuk Tea Research Station, Western Highlands Province; Dr H. Roberts, Officer-in-Charge, DPI, Forestry Research Station, Bulolo, Morobe Province; Dr W.C. Gagne, Wau Ecology Institute, Wau, Morobe Province and Dr U. Wong, Area Veterinary Officer, DPI, Live-stock, in the preparation of this paper.

References

- ANONYMOUS (1970). *Insect pest survey for the year ending 30 June 1967*. Department of Agriculture, Stock and Fisheries, Port Moresby. pp. 26.
- ANONYMOUS (1971). *Insect pest survey for the year ending 30 June 1968*. Department of Agriculture, Stock and Fisheries, Port Moresby. pp. 22.
- BAKER, G. (1972). The role of *Anoplolepis longipes* Jerdon (Hymenoptera: Formicidae) in the entomology of cacao in the Northern District of Papua New Guinea. p. 327. In *14th International Congress of Entomology. Abstracts*, Canberra, 22–30 August 1972. Australian Entomological Society, Canberra.
- BALOGH, G. M. (1973). Natural enemies of *Axiagastus cambelli* Distant (Hemiptera: Pentatomidae) on the Gazelle Peninsula, New Britain. *Papua New Guinea Agricultural Journal* 24(1): 41–45.
- BOURKE, T. V., FENNER, T. L., STIBICK, J. N. L., BAKER, G. L., HASSAN, E., O'SULLIVAN, D. F. and LI, C. S. (1973). *Insect pest survey for the year ending 30 June, 1969*. Department of Agriculture, Stock and Fisheries, Port Moresby. pp. xii + 57.
- CATLEY, A. (1962). *Tiracola plagiata* Walk. (Lepidoptera: Noctuidae): a serious pest of cacao in Papua. *Papua New Guinea Agricultural Journal* 15(1/2): 15–22.
- CATLEY, A. (1966). Parasites and predators of some insects recorded from the Territory of Papua New Guinea. *Research Bulletin, Department of Agriculture, Stock and Fisheries, Papua New Guinea* No. 2: 18 pp.
- COCHEREAU, P. (1972). La lutte biologique dans le Pacifique. *Cahiers de l'Office de la Recherche Scientifique et Technique Outre-Mer* (Série Biologie) No. 16: 89–104.
- DUN, G. S. (1966). The giant snail. *Papua New Guinea Agricultural Journal* 18(4): 123–125.
- ENTWISTLE, P. F. (1978). *Report on a visit to Papua New Guinea. The use of baculoviruses for the control of: – 1. Lymantria ninayi on pines. 2. Plutella xylostella on brassicas. 3. Oryctes rhinoceros and Scapanes australis on coconut palms*. Oxford Unit of Invertebrate Virology, Natural Environment Research Council, Oxford. pp. 76.
- GREATHEAD, D. J. (1975). Biological control of the beanfly *Ophiomyia phaseoli* (Diptera: Agromyzidae) by *Opius* spp. (Hym: Braconidae) in the Hawaiian Islands. *Entomophaga* 20(3): 313–316.

- HENTY, E. E. and PRITCHARD, G. H. (1975). *Weeds of Papua New Guinea and their control*. 2nd Edn. Division of Botany, Department of Forests, Lae, Papua New Guinea. (*Botany Bulletin* No. 7.) pp. 123.
- LEVER, R. J. A. W. (1969). *Pests of the coconut palm*. pp. 43–44. Food and Agriculture Organization of the United Nations, Rome.
- LUNA DE CARVALHO, E. (1959). Segunda contribuição para o estudo dos estrepsípteros angolenses (Insecta Strepsiptera). *Publicações Culturais da Companhia de Diamantes de Angola* 41: 125–154.
- LUNA DE CARVALHO, E. (1972). Algumas considerações sobre mirmecolacídeos da Nova Guiné. *Ciência Biológica* 1: 1–6.
- NORRIS, K. R. and FERRAR, P. (1974). *Musca inferior*, a livestock fly new to Papua New Guinea. *Australian Veterinary Journal* 50(8): 363–364.
- O'CONNOR, B. A. (1959). The coconut treehopper, *Sexava* sp. and its parasites in the Madang District. *Papua New Guinea Agricultural Journal* 11(4): 121–125.
- O'SULLIVAN, D. F. (1973). Observations on the coconut spathe bug *Axiagastus cambelli* Distant (Hemiptera: Pentatomidae) and its parasites and predators in Papua New Guinea. *Papua New Guinea Agricultural Journal* 24(3): 79–86.
- RAO, V. P., GHANI, M. A., SANKARAN, T. and MATHER, K. C. (1971). A review of the biological control of insect and other pests in south-east Asia and the Pacific region. *Technical Communications of the Commonwealth Institute of Biological Control* No. 6: xiii + 149 pp.
- SANDS, D. P. A. (1977). The biology and ecology of *Leptocoris* (Alydidae: Hemiptera) in Papua New Guinea. *Research Bulletin, Department of Primary Industry, Papua New Guinea* No. 18.
- SIMMONDS, F. J. (1971). *Report on a tour of Asian and Pacific Commonwealth Countries, September 1970–January 1971*. Commonwealth Agricultural Bureaux, Farnham Royal, Bucks. pp. 85.
- SZENT-IVANY, J. J. H. (1961). Insect pests of *Theobroma cacao* in the Territory of Papua New Guinea. *Papua New Guinea Agricultural Journal* 13(4): 127–147.
- SZENT-IVANY, J. J. H. and ARDLEY, J. H. (1962). Insects of *Saccharum* spp. in the Territory of Papua New Guinea. pp. 690–694. In *Proceedings of the 11th Congress of the International Society of Sugarcane Technologists*, Mauritius, 1962. Ed. J. R. Williams. Elsevier, Amsterdam.
- VAN VELSEN, R. J. (1966). A nuclear polyhedral virus disease affecting the larvae of *Tiracola plagiata* Walk. *Papua New Guinea Agricultural Journal* 18(4): 134–141.
- WILSON, F. (1960). A review of the biological control of insects and weeds in Australia and Australian New Guinea. *Technical Communications of the Commonwealth Institute of Biological Control* No. 1: viii + 102 pp.