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Review Article

ACIAR-supported biological control projects in the South Pacific (1983-1996): an economic assessment

Godfrey Lubulwa and Susan McMeniman
Economic Evaluation Unit, Australian Centre for International Agricultural Research, GPO Box 1571, Canberra ACT 2601, Australia

Abstract

This paper presents estimates of benefits (to the year 2013) from ten biological control projects the Australian Centre for International Agricultural Research (ACIAR) supported in the South Pacific between 1983 and 1996. The projects aimed to control the following: (1) fruit-piercing moths (*Eudocima fullonia*) [8802A]; (2) fruit-piercing moths [9308]; (3) banana skipper (*Erionota thrax*) [8802C]; (4) breadfruit mealybug (*Icerya aegyptiaca*) [9111]; (5) banana aphids (*Pentalonia nigronervosa*) [8802-E]; (6) banana aphids [CS2-92828]; (7) leucaena psyllid (*Heteropsylla cubana*) [8802D]; (8) *Mimosa invisa* [8569]; (9) passion fruit white scale (*Pseudaulacaspis pentagona*) [8718]; and (10) banana weevil borer (*Cosmopolites sordidus*) [8802B]. The numbers in square brackets are ACIAR project identifiers. Four projects made a quantifiable impact with rates of return ranging from 9% to 81%; three projects made unintended impacts; and three projects made no impact. Overall, ACIAR's experience with biological control in the South Pacific (1983-1996) has been a success. ACIAR and its partners spent about $A1.87 million on the ten projects which are estimated to generate at least $A25 million. These estimates are over 30 years, in 1990 Australian dollars, and discounted at a real discount rate of 8% p.a. (In December 1994, $A1 = $US0.73, and $A1 = £0.45.)

Introduction

The Australian Centre for International Agricultural Research (ACIAR), from 1983 to 1996, invested significantly in biological control research in the South Pacific. This paper presents estimates of the welfare benefits from ten biological control projects supported by ACIAR over this period.

The paper starts with a discussion of the approach taken in estimating the benefits from research. This is followed by an overview of the projects under discussion. The paper ends with some concluding remarks.

Methodology for the Estimation of the Research Impacts

The evaluation relies on economic surplus techniques to estimate the benefits to producers and consumers due to the biological control of various pests and weeds. A research evaluation model in Microsoft Excel and Visual Basic (Lubulwa & McMeniman, 1997a) is used to estimate the research benefits. The methodology adopted has three main features.

First, it is commodity based with the advantage that it relies on observable and measurable variables. However this methodology includes only a portion of the benefits from biological control. For example, the estimates here do not include the ecological, biodiversity and health benefits of switching from chemical to biological control.

Second the methodology is supply-oriented. Biological controls enable a producer to substitute biological control for chemicals.

Third, the methodology focuses on the economics of biological control. The following equation (Lubulwa & McMeniman, 1997a) is used to estimate annual benefits accruing to producers and consumers of an agricultural commodity:

$$\Delta ES_c = k_c Q_{fc} + 0.5(Q_{fc}/P_{fc})[\varepsilon_s \varepsilon_d k_{cf}^2/(\varepsilon_s+\varepsilon_d)]$$

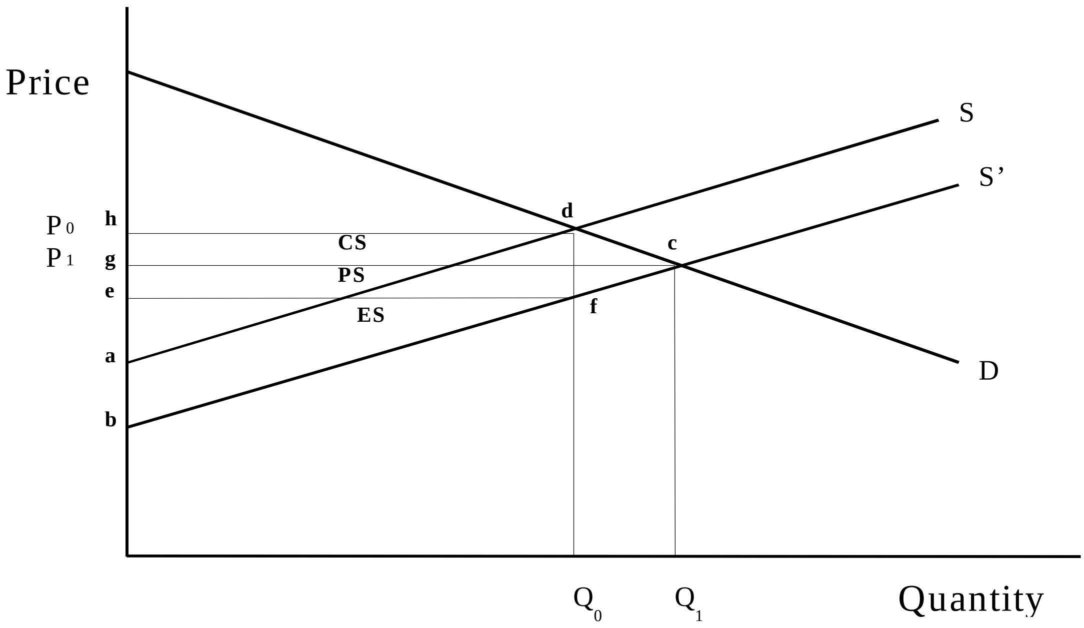

Figure 1. Figure showing supply before (S) and supply after (S′) for an agricultural commodity and the benefits from research/economic surplus (abcd).

The following notation is used: P_0 = price before research; P_1 = price after research; Q_0 = quantity of the product before research; Q_1 = quantity of the product after research; D = demand function for the agricultural product; S = supply curve for the agricultural commodity before research; (S′) = supply curve for the commodity after research.

where ΔES_c is the change in economic surplus due to better control of a pest or weed; k_c is the cost saving, per tonne, due to better control of a pest or weed; Q_{fc} is the quantity of a commodity affected by a pest or weed before research; P_{fc} is the price of the commodity; ε_s is the elasticity of supply; and ε_d is the elasticity of demand. Research benefits are larger the larger the production affected, and the larger the cost saving per tonne achieved.

Figure 1 shows the key aspects of the methodology. The supply for a commodity, before research, is shown in Figure 1 by the line S. The supply curve shows the relationship between the price of the commodity and the quantity a farmer produces of the commodity. If the supply curve shifts to the left the total supply at each price decreases. However when the supply curve shifts to the right, say to (S′) in Figure 1, then total production of the commodity increases. Better control of weeds and pests in the agricultural sector leads to a shift to the right in the supply curve, and thus to an increase in the total supply of agricultural commodities affected.

The line D represents the demand curve for a commodity in Figure 1. The demand curve shows the hypothesized relationship between the price of a commodity and the quantity consumed of the commodity. The two curves S and D in Figure 1 represent the market situation before research for the commodity. The price P_0 is the market price of the commodity before research. Where the commodity is not marketed in a given country, the analysis uses an imputed price.

The benefits to producers accrue because biological controls reduce the costs of production per tonne by the distance ‘df’ in Figure 1. Producers also gain because they can produce more of the commodity. Instead of producing Q_0 before research, farmers can produce Q_1 after research.

Consumers gain from biological control research because where biological controls are successful, they lead to increased output which in turn leads to reduced prices, from P_0 to P_1, in Figure 1.

The total annual benefit from biological control research is equal to the area ‘abcd’ in Figure 1. This area is equal to the sum of the benefits to producers, PS, and the gains to consumers, CS, where:
PS is the change in producer surplus and is given by the area ‘efcg’
CS is the change in consumer surplus and is given by the area ‘gcdh’.

An Overview of the Projects

Fruit-piercing moths in the South Pacific (8802A and 9308)

The situation before research

Fruit-piercing moths (FPM) (*Eudocima fullonia* (Clerck); Lep., Noctuidae) have been recorded as attacking over 40 fruits worldwide. Before this project, they were serious pests of most tropical and subtropical fruit in the South Pacific region.

The control agents for fruit-piercing moths

Projects 8802A and 9308 introduced two parasites (*Ooencyrtus* sp. (Hym., Encyrtidae) and *Telenomus* sp. (Hym., Scelionidae)) of the fruit piercing moth into Tonga, Fiji, and Western Samoa. A parasite endemic to Samoa (*Ooencyrtus crassulus* Prinsloo & Annecke) was also released in Tonga.

The evidence of impact

ACIAR (1995a) confirmed that progress towards biological control of the moth has been achieved in Fiji following establishment of the two exotic parasitoids from Papua New Guinea (PNG) – *Ooencyrtus* sp. and *Telenomus* sp.

ACIAR (1995a) and Sands (1995, p. 4) indicated that in Western Samoa the biological controls against the moth have not worked.

Three parasites of the moth – *Telenomus* sp., *Ooencyrtus* sp. and *O. crassulus* – have established in Tonga. However, parasitoids have only recently begun to have an impact on the moth. (Sands, 1995; ACIAR, 1995a).

The economic data used

Research benefits from the control of the fruit-piercing moth derive from the control agents' impact on the three commodities for which production and other data were available: oranges, pineapples, and pawpaws.

According to FAO (1994), the annual production of oranges in Fiji and Tonga is about 541 tonnes and 2700 tonnes respectively; that of pineapples in Fiji, Tonga, and Western Samoa is about 4050 tonnes, 1520 tonnes, and 3000 tonnes respectively, and that of pawpaw for Fiji is about 2600 tonnes.

The total cost per hectare of producing the three fruits, estimated from Asian Development Bank (1996), was not changed as a result of better control of the moth. However, the cost of production per tonne of commodity was changed as a result of better biological control of the moth. The yields for oranges, pineapples, and pawpaw, before research, were estimated at 23.5 t/ha, 36 t/ha, and 10.1 t/ha respectively. Based on Sands (1995) better control of the moth led to increases in the crop yields per hectare of 36%, 54%, and 25% for oranges, pineapples, and pawpaw respectively in the South Pacific countries.

The yield increases due to research translate into estimated cost savings of about $A4/t, $A23/t, and $A24/t for oranges, pineapples, and pawpaw respectively in the South Pacific countries.

The price of oranges is estimated at $A115/t. Prices of $A200/t for pineapple and $A150/t for pawpaw are from Asian Development Bank (1996). The elasticity of supply and demand, assumed to be 0.4 and –0.4 respectively, are from ACIAR's economic database on these commodities.

Research benefits – the base case scenario

The base case scenario reflects the most likely values (according to the authors) for the parameters in the analysis. Using the model in Figure 1, it was estimated that the research benefits from the biological control of the fruit-piercing moth in Fiji, Tonga and Western Samoa was about $A0.66 million (Table 1). The research cost expenditure for the two projects was about $A0.67 million. Thus the net loss from research was about –0.01, and the associated internal rate of return was 7.9% which is less than the real discount rate for ACIAR of 8%.

Sensitivity analysis

A number of parameters are uncertain in this analysis. Sensitivity analyses indicate how the estimated research benefits would change if values of the key parameters varied. The most important two parameters are the size of the cost savings and the sizes of the affected industries.

Doubling the cost saving per tonne attributable to these projects increases the net research benefit from –$A0.01 million to $A0.09 million. However, halving the cost saving per tonne in the base case decreases the net benefit from research from –$A0.01 million to –$A0.05 million. In the base case scenario the industries affected by these projects do not grow over time. The net research benefits increase from –$A0.01 million to $A0.05 million and to $A0.11 million if one assumes that the industries, over the 30 year period, will grow by 2% p.a. and 3% p.a. respectively.

Table 1: A summary of research projects – control targets, countries involved and estimated benefits and rates of return.

ACIAR project number	8802-A 9308	8802-C	9111	8802-D	8802-E CS2-92-828	8569	8718	8802-B
Control target	fruit-piercing moth	banana skipper	breadfruit mealybug	leucaena psyllid	banana aphid	*Mimosa invisa*	passion fruit scale	banana weevil borer
Estimated benefits ($A x 10^6, 1990)	0.66	22.50	2.57	unintended benefit, not estimated	unintended benefit, not estimated	0	small benefit to subsistence sector, not estimated	0
Research expenditure ($A x 10^6, 1990)	**0.67**	**0.27**	**0.63**	**0.06**	**0.059**	**0.03**	**0.08**	**0.07**
Net benefit ($A x 10^6, 1990)	-0.01	22.23	1.94	not estimated	not estimated	-0.03	not estimated	-0.07
Estimated rate of return (%)	7.9%	81%	26%	not estimated	not estimated	negative	not estimated	negative
Countries involved in the research project	Fiji, Western Samoa, Tonga	Papua New Guinea	Kiribati and FSM[1], Marshall Islands, Palau	Western Samoa	Tonga	Western Samoa	Western Samoa	Tonga

[1] FSM: the Federated States of Micronesia.

Banana skipper (8802C)

The situation before research

Banana skipper (*Erionota thrax* (L.); Lep., Hesperiidae), of Southeast Asian origin, was first recorded in PNG in 1983. In two years it spread from the north coast to near Port Moresby, from where it threatened to spread across Torres Strait to Australia where a banana industry worth about $A150 million per annum was at risk. Since 1987, it has spread throughout mainland PNG from sea level to 2500 m. The larvae feed on all species of bananas reducing yields and preventing the traditional use of leaves for other purposes. (Sands & Sands, 1991). Severe infestations may strip the plant, and subsequently affect yield depending on the extent of defoliation.

This paper estimates that about half of bananas in PNG were affected by the banana skipper before research. This estimate is based on:

- Waterhouse & Norris (1989) who indicated that some parts of PNG were not affected by the banana skipper; and
- information indicating that in the wet season in PNG mainland, between January and April of each year, the banana skipper was controlled by the rain since the skipper is sensitive to rain (D. Sands, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Brisbane, pers. comm., 1997).

The control agents for banana skipper

ACIAR (1992) concluded that all objectives of the original project had been met. Waterhouse (1998) noted that there are two parasitoids that attack the banana skipper effectively. One of these two species (*Ooencyrtus erionotae* Ferrière; Hym., Encyrtidae) attacks skipper eggs and was found, during a survey early in the ACIAR project, to have accompanied the banana skipper into PNG, where it was known to kill approximately 30% of skipper eggs. The other species, a larval parasitoid (*Cotesia erionotae* (Wilkinson); Hym., Braconidae) was tested and found to be host specific and recommended for introduction into PNG.

The evidence of impact

PNG quarantine authorities approved the release of the parasite, which readily became established. However, its natural rate of spread was found to be slow, so it has had to be distributed far and wide. Wherever it has established, a dramatic drop in *E. thrax* populations has followed – to a level at which banana leaf damage is minor and generally well below that at which fruit weight is affected.

The economic data used

The banana production data used in estimating the research benefit are from FAO (1994). While according to ACIAR (1992) banana is not a significant commercial crop in PNG, it is a major commodity for subsistence use there. About 1.15 million tonnes are produced and consumed in PNG every year.

Estimates of the cost of production of bananas per hectare were based on PCCARD (1986). Farmers in PNG did not incur additional costs to control banana skipper before or after research. However, the introduction of an effective control for the banana skipper increases the yield per tonne for bananas from about 0.023 t/ha to 0.03 t/ha. The reference yields of bananas (without the banana skipper) in subsistence farming in Papua New Guinea are from Densley (1978, p. 48).

The yields after research were estimated from the before research reference yield and an estimate of the extent of weight loss attributable the banana skipper. Waterhouse & Norris (1989) state that:
"The banana plant produces leaves in excess of its needs for fruit production. Defoliation at 0, 10, 20, 30 and 40 percent at 35 day intervals for four years showed that there was no significant loss in fruit weight until 20% or more leaf area had been removed. Defoliation at the time of appearance of the fruiting bud caused the greatest reduction in fruit weight. Fifty percent defoliation at this time caused 28 percent loss in fruit weight."
Based on this information it was estimated that the yields of bananas per hectare were reduced by about 10% by the banana skipper.

Most of the bananas that were affected by the banana skipper are in the subsistence sector, are not commercially traded, which means that price data is not available. The price of banana used is an imputed price, and gives an indication of the monetary value of bananas if they were traded.

Research benefits – the base case scenario

Using the model in Figure 1, it was estimated that the research benefits from the biological control of the banana skipper in Papua New Guinea were about $A22.50 million (Table 1).[1] The research cost expenditure for the project was about $A0.27 million. Thus the net benefit from research was about $A22.23 million and the internal rate of return is 81%.

Sensitivity analyses

The estimates of benefits in the base case scenario depend on three key assumptions:

- the yield decrease (before research) due to the banana skipper;
- the effectiveness of the control for banana skipper; and
- the proportion of bananas affected by the banana skipper, before research.

Modifying the yield decrease from 10% (assumed in the base case) to 5% and then 20% changes the net research benefit from $A22.23 million (base case) to $A10.37 million and $A50.58 million respectively.

On the basis of Sands & Bakker (1993) who reported the parasitoid attacking up to 67% of larvae of the skipper, this paper assumes 70% as the effectiveness of control. Modifying the effectiveness of the control for banana skipper from 70% (assumed in the base case) to 30% and then 80% changes the net research benefit from $A22.23 million (base case) to $A10.70 million and $A24.29 million respectively.

Finally, modifying the proportion of bananas affected by the banana skipper, before research, from 0.5 (assumed in the base case) to 0.3 and then 0.8 changes the net research benefit from $A22.23 million (base case) to $A13.23 million and $A35.72 million respectively.

[1] These are benefits to PNG only. This project has been re-evaluated by Adamson & Davis (1998) to include benefits accruing to Australian farmers from pre-emptive, preventative biological control research.

Breadfruit mealybug in the South Pacific (9111)

The situation before research

Breadfruit (*Artocarpus* spp.; Moraceae) is a staple food in smaller Pacific nations and one of the few crops that grows well on island atolls. However, supplies were jeopardized by the introduced mealybug, *Icerya aegyptiaca* Douglas (Hom., Margarodidae). Heavy infestations of the pest, which kills young leaves and stems, reduce fruit yields by 50% or more, and may kill mature trees.

The control agent for breadfruit mealybug

The two projects introduced a predacious beetle (*Rodolia limbata* Blackburn; Col., Coccinellidae) which attacks only the mealybug, and which bred easily and was suitable as a biological control agent, to the Federated States of Micronesia (FSM), Kiribati, and other South Pacific islands.

The evidence of impact

ACIAR (1995b) summed up the project as follows:
"A predacious beetle (*Rodolia limbata* Blackburn) specific to the mealybug bred easily and was suitable as a biological control agent. Introductions were made to the Federated States of Micronesia (FSM), then to Kiribati shortly after the review. Monitoring in FSM has shown rapid and spectacular control of the mealybug, to the extent that members of the public there have commented on the success."

The economic data used

Unfortunately, despite the importance of breadfruit in the South Pacific, breadfruit production data is not readily available. In this analysis, production of breadfruit in the FSM, Kiribati, Marshall Island, and Palau is estimated using the following equation:

$Q_0 = C*R*T*F*W$

In this equation, C is the number of household clusters in a South Pacific country (Norman & Ngaire, 1994); R is the proportion of household clusters in the rural areas; T is an estimate of the number of breadfruit trees per household cluster estimated by Sands & Brancatini (CSIRO, pers. comm., 1997); F is an estimate of the number of fruits per breadfruit tree per year; and W is the average weight per fruit. Estimates of the number of fruits per tree, and the weight of a breadfruit are from Verheij & Coronel (1991). Lubulwa & McMeniman (1997b) estimated that annual production of breadfruit in the FSM ranges from a low level of 6900 tonnes to a high estimate of 12,000 tonnes. For Kiribati production ranges from 8300 to 14,000 tonnes, for Marshall Island production ranges from 5700 to 10,000 tonnes, and for Palau production ranges from 1900 to 3000 tonnes. Lubulwa & McMeniman (1997b) give the details of the parameters used in the estimation of breadfruit production.

Estimates of the cost of production per hectare for breadfruit were based on ANZDEC (1994). The production cost per hectare before and after research is the same. However, the biological control of breadfruit mealybug increased fruit yields by about 50%. This yield increase translates into a reduction in farm level costs of production of about $A8.80/t.

Breadfruit is a subsistence staple food in the South Pacific and is generally not traded, not even in village markets (D. Sands, CSIRO, pers. comm., 1997). An approximation of the price of breadfruit of about $A650/t is based on the prices of staple foods in the region (Asian Development Bank, 1996).

Research benefits – the base case scenario

Using the model in Figure 1, it was estimated that the research benefits from the biological control of the breadfruit mealybug in the South Pacific was about $A2.57 million (Table 1). The research cost expenditure for the projects on the biological control of the breadfruit mealybug was about $A0.63 million. Thus the net benefit from research was about $A1.94 million and the internal rate of return is about 26%.

Sensitivity analyses

The estimates of benefits in the base case scenario depend on two key assumptions:

- the saving in farm level production cost per tonne due to research; and
- the total output of breadfruit.

The net research benefits change from $A1.94 million in the base case to $A4.46 million if the base case cost saving is doubled. If the cost saving is halved the net research benefits drop to $A0.66 million.

In the estimation of production three parameters are critical. These are:

- the weight of fruit ranging from 0.4 to 1.2 kg;
- the number of trees per village cluster ranging from 12 to 20; and
- the number of fruits per tree ranging from 200 to 700.

In the base case scenario the estimate of production was based on the upper values for each of the three parameters above. If the weight of the fruit is changed to the average of the low and high values for fruit weight (keeping other parameters at base case level), the net research benefit falls to $A1.09 million. If the average number of trees per village cluster is changed to the average of the low and high values (keeping other parameters at base case level), the net research benefit falls from $A1.49 million to $A1.43 million. However if the number of fruits per tree is changed to the average of the low and high values for this parameter (keeping other parameters at base case level), the net research benefit falls from $A1.94 million to $A1.02 million.

Leucaena psyllid (8802-D)

The situation before research

Leucaena is used as a fodder, a shade for cocoa and other plants, and its destruction had serious consequences. In the early 1980s, the leucaena psyllid, *Heteropsylla cubana* D. L. Crawford (Hom., Psyllidae), had spread to a number of Pacific islands and to Australia, from the psyllid's native range in Central America. The psyllid feeds by sucking the sap from the soft, growing tips of *Leucaena leucocephala* (Fabaceae) (a multi-purpose tree legume).

The control agents for leucaena psyllid

The parasites tested (*Psyllaephagus yaseeni* Noyes (Hym., Encyrtidae) and *Tamarixia leucaenae* Boucek (Hym., Eulophidae)) by the project were not host-specific enough and seemed to feed on *Heteropsylla spinulosa* Muddiman, Hodkinson & Hollis which had been introduced earlier in Australia and Western Samoa to control *Mimosa invisa* (Fabaceae). Furthermore, *L. leucocephala* is regarded as a weed in some countries in the South Pacific (Western Samoa included) and as a useful plant in only a selection of South Pacific countries.

The evidence of impact

Overall, ACIAR (1992) found that: "the results of this sub-project do not favour the potential for biological control of *Heteropsylla cubana* in Australia". However there were other positive, unintended benefits, from the project, not dealt with in this paper. For example, ACIAR (1992) concluded that:
"The research outputs of this project have now enabled Australia to gauge the potential threat of *Psyllaephagus yaseeni* and *Tamarixia leucaenae* (the two parasites tested in the project) to the biological control of *M. invisa* in Australia and Western Samoa. This is a tremendous benefit. By having this information to decide against their introduction, the potential negative impacts of these parasites have been avoided."

Banana aphids (8802E and CS292828)

The situation before research

The banana aphid (*Pentalonia nigronervosa* Coquerel; Hom., Aphididae) not only causes damage by feeding on banana palm, but also is the vector for banana bunchy top, a serious virus disease in the South Pacific.

The control agent for banana aphid

The projects used the aphid's known parasite, *Aphidius colemani* Viereck (Hym., Braconidae), from Australia to reduce its numbers in Tonga.

The evidence of impact

ACIAR (1992) concluded that:
"Had the parasite (*Aphidius colemani*) not established on melon aphid (and taro), the returns on this sub-project would be minimal, since the banana aphid seems to have remained unaffected by its release."

Wellings *et al.* (1994) confirmed the result that the parasite does not have any impact on banana aphids, but suggested that the project results may be useful in the future in controlling plant virus disease of pumpkin squash crops.

This project falls in the category of projects which have had positive impacts but which are unquantifiable at this stage.

Mimosa invisa in Western Samoa (8569)

The situation before research

Mimosa invisa is among the worst weeds in Western Samoa, Vanuatu, Solomon Islands, PNG, New Caledonia, and French Polynesia. It also occurs in several other Pacific islands and various countries in Southeast Asia

The control agents for Mimosa invisa

Under this project two biological control agents against *M. invisa* were discovered in South America, and released in Western Samoa: *Scamurius* sp. (Het., Coreidae) and *Heteropsylla spinulosa*.

The evidence of impact

Neither of the two control agents prospered. One agent failed to establish altogether. The other became established but failed to build up numbers that could have an effect in Western Samoa. There were no other documented results and consequently no research benefits flowed from the activity.

Passion fruit white scale in Western Samoa (8718)

The situation before research

Passion fruit (*Passiflora* spp.; Passifloraceae) was introduced into Samoa in 1977 as an alternative cash crop to coconut and cocoa whose prices were declining rapidly (Opio, 1987). In late 1984, the passion fruit industry in Western Samoa suddenly collapsed. Vines throughout the island were engulfed and destroyed by white scale insects (*Pseudaulacaspis pentagona* (Targioni-Tozzetti); Hom., Diaspididae).

The control agent for passion fruit white scale

This project identified a suitable biological control agent – a minute parasitic wasp, *Encarsia diaspidicola* (Silvestri) (Hym., Aphelinidae), which can live only on the passion fruit scales.

The evidence of impact

The control agent multiplied rapidly after its release in mid-1986, and 18 months later the population of scale insects showed a major decline.

The export and local consumption passion fruit industry in Samoa collapsed due to (a) rising costs of production (b) decreasing prices of passion fruit (c) other diseases which were not controlled by the agent in question (Opio, 1987) (d) cyclones which repeatedly destroyed plantations for seven years and (e) the sale of the government passion fruit pulping plant which was the sole commercial buyer of passion fruit in Samoa.

However, there is a small quantity of passion fruit produced to meet subsistence demand in Samoa (Wilco Liebregts, pers. comm., 1998). This small benefit was not estimated due to lack of data.

Banana weevil borer (8802B)

The situation before research

Banana weevil borer (*Cosmopolites sordidus* Germar; Col., Curculionidae) causes considerable trouble as a major pest of bananas in Tonga and elsewhere in the tropics. It tunnels into the corm, producing physical damage and promoting fungal and bacterial rots. Damaged banana plants also blow over readily during storms. Chemical control is difficult, unsatisfactory and expensive, and no natural enemies are known.

The control agent for banana weevil borer

ACIAR (1992) concluded that no suitable control agent was discovered under the project

The evidence of impact

There is no impact to date from this research. Part of the reason for this was because of the failing Tongan banana industry, which resulted in the view that there was little point in doing more work in that country.

Concluding Remarks

This paper has discussed economic evaluations of ten completed ACIAR-supported research activities funded between 1983 and 1996 in the South Pacific. Table 1 summarizes results for the selected projects. The research benefits and costs are discounted at 8% per annum based on the Department of Finance (1991). While ACIAR and its partners have spent about $A1.87 million on the ten projects, these ten projects are likely to generate at least $A25 million over a 30 year period. Thus the benefits likely to be generated from the whole programme exceed the research investment.

Out of a total of ten discrete research activities in the area of biological control in the South Pacific, only three failed to generate significant economic impact. Two of those that failed did so, not because the projects did not discover appropriate control agents, but rather because the targeted industries collapsed after the start of the project. It is appropriate to end with a quotation from ACIAR (1992) summing up one of the failed projects as follows:
"It is noted that the actual economic impact of this work has so far been limited because passion fruit is no longer an important crop in Western Samoa. However, it is one of the advantages of classical biological control that it is a permanent solution. Should the industry be revived, Western Samoan farmers can be confident that the scale will not be a constraining factor."

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