STUDIES ON THE FLATID *JAMELLA AUSTRALIAE* KIRKALDY CAUSING DIEBACK IN *PANDANUS TECTORIUS* VAR. *PEDUNCULATUS* (A.BR.) DOMIN ON THE SUNSHINE AND GOLD COASTS IN SOUTHEAST QUEENSLAND

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Summary

The flatid *Jamella australiae* Kirkaldy has caused extensive dieback of pandanus *Pandanus tectorius* var. *pedunculatus* on Queensland's Sunshine Coast and Gold Coast. *J. australiae* is a native species that has spread to these areas from north Queensland within the last 10 to 15 years. Flatid populations on pandanus in north Queensland are low and non-damaging.

A survey of 3220 pandanus trees in Noosa National Park during 1995 showed a high correlation between tree health and flatid numbers ($P<0.001$). The percentage of trees dead or in poor health increased from 45.8% in October 1995 to 66.4% in September 1996 and 75% in July 1997. By March 1998, 45% of trees had died.

Predatory syrphids and lacewings commonly attacked young flatids but did not control damaging populations. No parasitoids were found in southeast Queensland early in the study but, in 1996, the egg parasitoid *Aphanomerus* sp. was recorded parasitising up to 20% of egg rafts and 10% of eggs within a raft. At Dimbulah in northeast Queensland two other species, *Aphanomerus* sp. nr *pusillus* Perkins and *Ooencyrtus sp.* were recorded parasitising up to 80% of the egg rafts and 80% of eggs within a raft.

The Dimbulah parasitoid species were released at sites in southeast Queensland in April 1996 and April 1997. *Ooencyrtus* sp. established at one site but has remained at relatively low levels. *A.* sp. nr. *pusillus* was established in 1997 at 20 release sites from where it has dispersed to most infested areas on the Sunshine and Gold Coasts. In most instances, it is giving high parasitism levels similar to those at Dimbulah and at a third of the sites, an 80% reduction in flatid numbers.

INTRODUCTION

Severe dieback has occurred in *Pandanus tectorius* var. *pedunculatus* (R. Br.) Domin on the Sunshine Coast in southeast Queensland from about 1990 to 1998 (Smith 1996). The dieback coincided with the appearance of large numbers of a flatid identified as *Jamella australiae* Kirkaldy (Homoptera : Flatidae). Pandanus in Noosa National Park have been severely affected since about 1993.

A similar pattern of infestation by the same insect has been observed on pandanus trees in parks at Broadbeach and Miami on the Gold Coast since about 1990. It was concluded that poor growing conditions such as lack of water and prop-root damage and soil compaction caused by the public were stressing the trees, making them more susceptible to attack by *J. australiae* (King 1993). Feeding by the insects caused tissue damage at the base of the leaves and accumulations of plant debris, honeydew and water. Secondary fungal infections, death of the growing points and finally, plant death followed.

Seventeen species of *Pandanus* and 4 species of the related genus *Freycinetia* are listed as occurring in Queensland (Anon 1994; Stone 1978; Tucker 1992). There is some confusion concerning the taxonomy of the group and it is currently being revised (A. Wilson, *pers. comm.* 1996). *Pandanus tectorius* Parkinson currently has 4 varieties with *P. tectorius* var. *pedunculatus* dominant close to the seashore on dunes and rocky headlands from northern New South Wales along the Queensland coast to Cape York. The most common species in sub-coastal areas north of Rockhampton is *P. spiralis* R. Br. *P. monticola* F. Muell. and *P. gemmifer* H. St. John occur in rainforest in north Queensland and *P. solmslaubachii* F. Muell grows in swampy coastal areas (J. Dowe, *pers. comm.* 1995).

The flatid *J. australiae* was first described in 1906 from specimens collected at Cairns and Townsville (Kirkaldy 1906; Medler 1990). There are no further records until collection on the Gold Coast and at Noosa in 1992–95 (J. Donaldson, *pers. comm.* 1995). Identification of specimens from this study was confirmed by Medler in 1992 and by M. Fletcher of the NSW Department of Agriculture, Rydalmere in 1995.

J. australiae feeds between the tightly packed leaves of pandanus growing points and is difficult to control with contact insecticides, even with high volume spray application. Additionally, this practice applied to coastal plant communities is not environmentally sound. Alternative treatments with systemic insecticides, particularly imidacloprid, applied as a spot-spray to pandanus growing points or by injection into the trunk or limbs are described by Smith (1998) and Smith and Smith (2000).

In this study, pandanus trees, particularly in Noosa National Park, were surveyed intensively from

mid 1995 to mid 1998 to establish correlations between flatid numbers and other factors related mostly to public use of the park and pandanus health. Surveys were also conducted from Hervey Bay to Tweed Heads to establish the extent of the problem. Natural enemies were surveyed and their impact assessed in southeast Queensland and also in north Queensland at Dimbulah, where the flatid was located on *P. spiralis*. This study also reports on the introduction and the establishment of egg parasitoids collected at Dimbulah and introduced to southeast Queensland.

MATERIALS AND METHODS

Surveys in Noosa National Park

From August to October 1995 all pandanus in the park greater than 50 cm high were surveyed and each tree's location, characteristics and level of flatid infestation was recorded on a separate card. Characteristics associated with location were:

(1) density of pandanus within a 20 m radius;
(2) distance to the beach;
(3) degree of shelter from wind;
(4) proximity to public paths and/or roads; and
(5) soil type.

Tree characteristics recorded were:

(1) tree height
(2) a general health rating: 0–healthy, 1–fair, 2–poor, 3–very poor, and 4–dead;
(3) prop-root health: 0–healthy, 1–fair, 2–poor, and 3–very poor.

Flatid infestations were rated as not present or present; and light (1 and <30), moderate (>30) or heavy (>100).

For each of the variables, the frequencies for each value were calculated. Subsequently, cross tabulations between each variable and the health rating were made.

Further surveys to assess any change in tree health were carried out in late November 1995, September 1996, July 1997 and March 1998, to record the health rating of the trees covered in the original survey.

Surveys in other areas

A similar survey (using the same sample cards) of about 900 trees was conducted in other areas of southeast Queensland outside Noosa National Park in 1995. Areas surveyed included Noosa district, Sunshine Beach, Sunrise Beach, Peregian, Coolum, Maroochydore, Mooloolaba, Caloundra, Noosa North Shore, Cooloola, Rainbow Beach, Hervey Bay, Broadbeach to the Spit (Gold Coast) and North Stradbroke Island. Similar frequency percentages and cross tabulation with the health rating (as for Noosa National Park) were calculated.

Information on the production, supply and movement of *Pandanus* species was obtained from approximately twenty-four plant nurseries and landscapers were investigated from the Sunshine and Gold Coasts, Brisbane and north Queensland.

With the help of other biologists, botanists and parks and garden attendants, observations were recorded on the occurrence of the flatid and of dieback in other areas of the state at Yeppoon, Clairview, Carmilla, Cape Hillsborough, Bowen, Townsville, Cardwell, Tully, Innisfail, Cairns, Ellis Beach, Mareeba, Dimbulah, Lake Eacham, Bamaga (Cape York), Thursday Island, Horn Island and York Island in the Torres Strait, Northeast Island, Tryon Island, Wreck Island and Heron Island in the Capricorn Group and Fraser Island, South Stradbroke Island and Bribie Island in southeast Queensland.

Sampling of macro and micronutrient levels, tests for viruses, viroids, mycoplasmas, phytophthora and nematodes

To isolate possible stress factors on the trees, leaf and trunk samples were collected at Teatree Bay (Noosa National Park) from approximately ten trees infested with *J. australiae* showing leaf yellowing and necrosis and from ten trees with fair health and no or low numbers of *J. australiae*. These were analysed for carbohydrate levels and macro micronutrients by Agricultural Chemistry Branch, Queensland Department of Primary Industries (QDPI) at Indooroopilly. Similar leaf samples together with the flatid were presented for an electron microscopic search for viral particles to Plant Pathology Section (QDPI, Indooroopilly). Material was checked by researchers at the University of the Northern Territory, Darwin for mycoplasma.

A sample was also sent to the Waite Institute, University of Adelaide for checking for DNA virus and RNA viroids. Three small living infested plants and a growing point from a large infested tree were also placed in quarantine facilities at the Waite Institute.

Five root samples from Noosa National Park taken from pandanus rated from healthy to dead were tested for the presence of Phytophthora root rot, *Phytophthora* spp. and nematodes by QDPI Nambour and Indooroopilly respectively.

Survey of natural enemies of J. australiae

Southeast Queensland: Natural enemies were assessed on 25 randomly tagged trees in Noosa National Park commencing in August 1995. Adults, nymphs and eggs of *J. australiae* were collected and held in ventilated plastic vials at 25°C for parasitoid emergence. First instar flatid nymphs emerge through the fine skin covering the base of the eggs against the

Host preference: A host preference test was conducted using 6 different pandanus species and a closely related member of the genus *Freycinetia*. The potted plants were 0.5–0.75 m high, except the *Freycinetia* sp., which were 0.2 m high. Single uninfested plants of *P. tectorius* var. *pedunculatus*, *P. monticola*, *P. tectorius* var. stradbrookensis, *P. aquaticus*, *P. veitchi*, *P. conicus* and *F. scandens* were placed in a 1×1×0.6 m aluminium and gauze cage with 2 heavily infested *P. tectorius* var. *pedunculatus*. An additional 50 adult *J. australiae* were introduced to each cage. The trial was replicated 3 times. Numbers of live adults, early instar nymphs, late instar nymphs and egg rafts on each plant were counted after 2 months.

RESULTS

Surveys in Noosa National Park

1995: Of the 3220 trees surveyed in October 1995, 6.2% were rated healthy, 48% fair, 21.7% poor, 17% very poor and 6.7% dead. In total, 45.4% were either poorly and rapidly deteriorating or already dead (Figure 1).

Tree health and flatid levels were strongly correlated (P<0.001; Table 1), with 22% of lightly infested plants rated poorly in health in comparison to 87% of heavily infested plants rated poorly (Figure 2).

There was a much lower correlation (P<0.001) between tree health and:
(1) density of trees;
(2) proximity to the beach/high tide mark;
(3) exposure to wind; and
(4) proximity of path (Table 1).

Trees that were not growing on the beach (in pure sand), exposed to the prevailing winds or clinging to bare rock tended to be healthier.

Dark green foliage and healthy prop-roots were good indicators of overall tree health. During the survey it was considered that significant public impact on the prop roots was not occurring and most of the damage to the above ground roots was caused by wind and salt erosion.

Drought was not an important factor, as the rainfall fell below the mean annual rainfall for Tewantin for the last 100 years (about 1500 mm) only once in the last decade.

1996–98: By September 1996, the percentage of trees in poor health was 41% and the percentage of dead trees had increased to 25.4%. By July 1997, the percentage of trees in poor health was 38%, with a further 37% dead. By March 1998, 9% of trees were in poor health and 45% dead (Figure 1).

Surveys in other areas

Pandanus surveyed outside Noosa National Park on the Sunshine Coast (Table 1) were significantly less infested and healthier. 12.1% of trees outside the park were in poor health, compared to 39.1% within. Outside Noosa National Park tree health and flatid levels were again strongly correlated (P<0.001), with only 8.8% of lightly infested or uninfested plants rated as poor in health, compared to 87.1% of heavily infested plants. There was a low correlation (P<0.001) between health and plant density, proximity of the beach, exposure to wind and proximity to other pandanus, paths and roads.

In Burleigh Heads National Park in June 1997, 32% of trees were in poor health and 18% were dead.

J. australiae was recorded also at Dimbulah, Tully and Horn Island (Torres Strait) and near the Bruce Highway at Camilla (south of Sarina) and just south of Bowen.

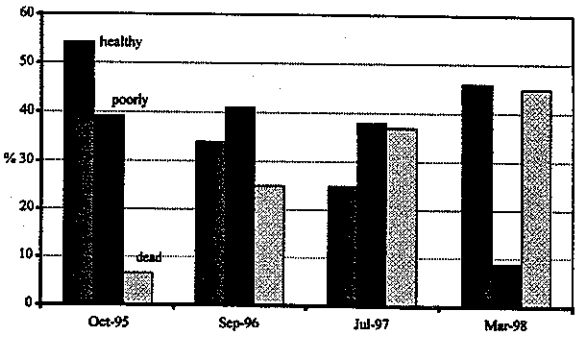

Figure 1. Percentage of pandanus in NNP, 1995–1998, rated healthy, poorly or dead.

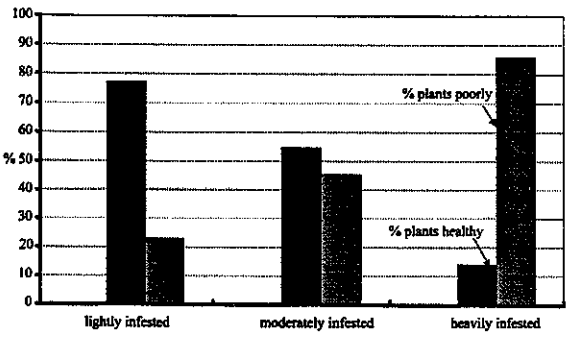

Figure 2. Percentage of pandanus in lightly, moderately, or heavily infested categories rated healthy or poorly, October 1995, NNP.

Table 1. The percentage frequencies of nine variables relating to pandanus in Noosa National Park and on the Sunshine Coast outside Noosa National Park and cross tabulation with the health ratings.

Variable		Noosa National Park			Sunshine Coast — outside Noosa National Park		
		Percentage	Cross tabulation with health — % in poor health	Significant differences P < 0.001	Percentage	Cross tabulation with health — % in poor health	Significant differences P < 0.001
Density within 20 m (No. trees)	0 – 10	10.0	41.8	Slight preference for low density	44.6	21.8	Slight preference for high density
	11 – 20	21.8	47.3		16.6	12.7	
	21 – 50	67.8	45.9		15.4	0	
	>50	0.3	~		23.4	4.3	
Distance from Beach (m)	0 – 10	67.3	53.2	Preference away from beach	33.9	16.9	Slight preference for 11 – 20m
	11 – 20	19.4	34.2		28.3	4.3	
	21 – 50	10.4	30.4		28.0	11.4	
	>50	2.9	~		11.8	18.4	
Sheltered vs exposed (to wind)	sheltered	41.7	32.4	Preference for less exposed	70.7	11.7	Slight preference for less exposed
	intermediate	20.0	49.9		13.5	11.5	
	exposed	38.3	58.4		15.8	18.9	
Proximity to pedestrian path (m)	0 – 1.9	13.8	48.4	Slight preference for close to path	36.2	11.0	Slight preference for close to path
	2.0 – 4.9	9.6	41.2		39.9	3.1	
	5.0 – 10	7.1	~		23.9	21.8	
	>10	69.5	51.9		0	~	
Soil type	loamy soil	72.6	43.0	Preference for sandy soil and not rock	28.5	20.6	Preference for soil or sandy loam
	sandy soil	7.3	18.3		32.3	5.1	
	sand	4.3	49.2		38.1	9.0	
	rock	15.8	70.0		1.1	~	
Plant height (m)	0 – 1.9	32.8	38.5	Slightly lower preference in trees 2.0–5.5 m	19.9	134	Slightly lower preference in trees 2.0–5.5 m
	2.0 – 3.9	40.7	49.3		38.0	140	
	4.0 – 5.5	22.8	51.0		36.8	10.2	
	>5.5	3.7	40.8		5.3	16.7	
Health rating	healthy	6.2			38.1		
	fair	48.1			49.0		
	poor	21.7	N/A	N/A	6.3	N/A	N/A
	very poor	17.4			5.8		
	dead	6.6			0.8		
Health of prop roots	healthy	4.6	1.3	Health of tree and prop roots closely linked	57.0	0.8	Health of tree and prop roots closely linked
	fair	27.3	26.7		32.5	14.9	
	poor	30.5	49.5		8.8	~	
	very poor	7.8	71.7		1.7	~	
	no prop roots	29.8	~		0	~	
Flatid infestation level	not present	0.1	22.9	Health of tree and flatid infestation level closely linked	94.0	7.9	Health of tree and flatid infestation level closely linked
	moderate	51.1	22.0		1.7	~	
	light	18.0	46.0		2.2	~	
	heavy	30.8	80.0		2.1	~	

By early 1996, a small infestation was located in a patch of 1–2 m high pandanus on the foredunes about 5 km north of the Noosa River, and on Goat Island in the Noosa River. Infestation on the Sunshine Coast had spread as far south as Point Arkwright at Coolum, with smaller infestations at Maroochydore and at Currimundi, north of Caloundra. Pandanus at Southbank in Brisbane were also observed to be infested. On the Gold Coast infestation occurred from The Spit to south of Burleigh Heads.

Surveys completed in July 1997 of pandanus along the coastline from the southern end of Cooloola National Park to Fingal Head in New South Wales showed most of the Sunshine and Gold Coast trees to

be infested. A small outbreak was also recorded on the western side of South Stradbroke Island.

Macro and micronutrient levels, viruses, viroids, mycoplasmas, phytophthora and nematodes

In the chemical analysis, calcium, sodium, chlorine and manganese levels were 40% higher in healthy plants than in plants with poor health. Plants in poor health contained 6.4% starch compared to 3.7% in healthy plants. The higher starch levels in the sickly pandanus suggest a low level of growth and respiration (T. Rasmussen *pers. comm.* 1995).

The rapid onset of leaf yellowing and necrosis in all ages of infested plants was symptomatic of viral or mycoplasma infection. However, all tests for viruses, viroids and mycoplasma were negative.

Tests for the presence of *Phytophthora* using Leif's lupin baiting technique were also negative and nematode counts were not considered to be high. Nematode species found to be present were—*Meloidogyne* sp., *Helicotylenchus* sp., *Criconemella* sp., *Paratylenchus* sp. and *Colbranium truncatum*. *Paratylenchus* sp. was the most common at an average 65 nematodes per 200 g of soil.

***Natural enemies of* J. australiae**

Southeast Queensland: The most common predators observed on *J. australiae* were syrphid larvae (*Allobacca* sp.) with up to a dozen per pandanus leaf. Other predators included lacewing larvae, *Oligochrysa lutea* (Walker) and huntsman spiders (family Sparassidae).

No parasitoids were observed in southeast Queensland during 1995 but during 1996–97, low numbers of an egg parasitoid, *Aphanomerus* sp. (Hymenoptera: Platygasteridae) were removed.

North Queensland: In October–November 1995, two hymenopterous parasitoids (*A.* sp. nr. *pusillus* and *Ooencyrtus* sp. (Hymenoptera: Encyrtidae) were recovered from the egg rafts sent to Mareeba. In December 1995, these two species were collected from very light infestations of *J. australiae* in the Dimbulah–Wolfram Camp area near Mareeba. Over 80% of the 100 egg rafts collected were parasitised, mainly by *A.* sp. nr. *pusillus*. Approximately 80% (up to 100%) of eggs within each raft were parasitised.

In early April 1996, further collections of the two parasitoids were again made at Dimbulah. Parasitism levels in about 200 egg rafts were similar to those recorded in December 1995. In late January 1997, further collections of about 1000 egg rafts containing the parasitoids were made at Dimbulah. The flatids were very scarce at most sites visited, as with previous visits, but moderate infestations were located at 2 sites. Again there was a high level of parasitism—mostly of *A.* sp. nr. *pusillus*. *A.* sp. nr. *pusillus* was also observed heavily parasitising eggs of the flatid at Camilla (south of Sarina) and just south of Bowen on the Bruce Highway in August 1998 (C. Freebairn *pers. comm.* 1998).

Rearing and release of north Queensland parasitoids

The April 1996 releases of about 50 parasitoids of each species at Teatree Bay and Castaways Creek in Noosa Shire resulted in establishment of *Ooencyrtus* sp. at Teatree Bay.

The early 1997 releases of up to 500 *A.* sp. nr *pusillus* at Teatree Bay, north and south Alexandria Bay, Coolum, Currimundi and Burleigh Heads were successful. Later releases were also made and were successful at another 12 sites from Noosa to Coolangatta.

Parasitism

Parasitoid and *J. australiae* levels at 6 sites are shown in Figures 3–8. From August 1995 to April 1996, no egg parasitism was detected. Following the small release of *Ooencyrtus* sp. at Teatree Bay in April 1996, there was some build-up of that species (Figure 8). The percentage of parasitism by Ooencyrtus sp. rarely exceeded 20% and the percentage of eggs parasitised within a raft, averaged 9.6%. There has been some spread of *Ooencyrtus* sp. within Noosa National Park but its impact has so far been negligible.

A small release of *A.* sp. nr. *pusillus* was made at Teatree Bay in April 1996 but it failed to establish. At the 4 sites where parasitism levels were assessed during 1996, Castaways Creek and Teatree Bay, north and south Alexandria Bay, up to 25% of egg rafts had been parasitised—mainly by *Aphanomerus* sp. except at Teatree Bay where *Ooencyrtus* sp. was more common. Most of the egg rafts yielded fewer than ten parasitoids per raft. The *Aphanomerus* sp. observed was a local species which parasitised another flatid species—the citrus planthopper, *Colgar peracutum* (Walker).

The larger releases of *A.* sp. nr. *pusillus* from early 1997 were much more successful and from April 1997 at south Alexandria Bay, Coolum and Burleigh Heads, parasitism levels began to increase (Figures 3–5). At south Alexandria Bay (Figure 3) over 50% of egg rafts were parasitised with an average 54.9% of eggs parasitised within a raft. Parasitism has subsequently had a significant impact on flatid populations which have fallen from about 80 flatids per pandanus head to fewer than 20.

At Coolum (Figure 4) parasitism rose to 20% by June but remained at this level until May 1998 when it rose to 93%. Flatid populations dropped from 80 to fewer than 40 per head during the first 12 months and to lower than 20 as a result of the higher parasitism levels.

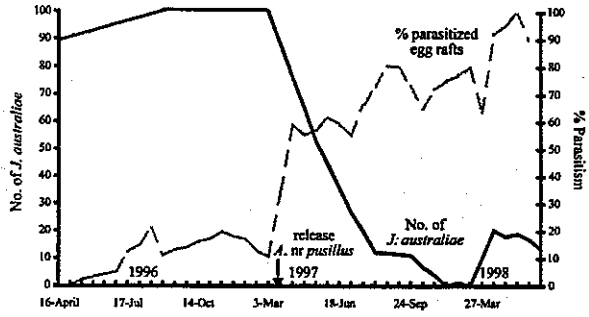

Figure 3. Numbers of *J. australiae* (adults and nymphs) per pandanus head and percentage of egg rafts parasitized at south Alexandria Bay NNP. Mean percent eggs parasitized within a raft: 9.2 in July 1996, 54.7 in November 1998.

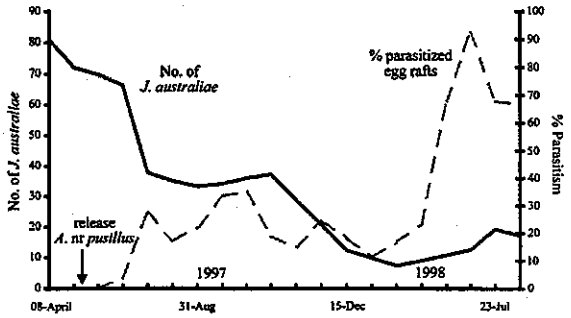

Figure 4. Numbers of *J. australiae* (adults and nymphs) per pandanus head and percentage of egg rafts parasitized at Coolum. Mean percent eggs parasitized within a raft, 53.9 in December 1997.

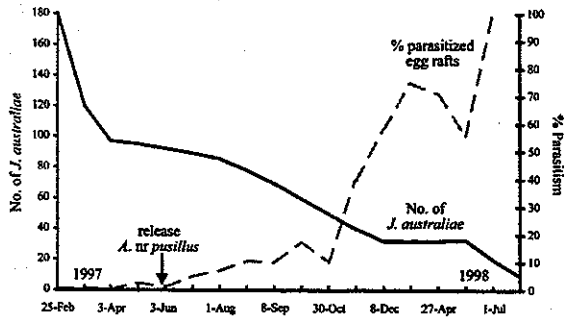

Figure 5. Numbers of *J. australiae* (adults and nymphs) per pandanus head and percentage of egg rafts parasitized at Burleigh Heads. Mean percent eggs parasitized within a raft, 59.6 in October 1997.

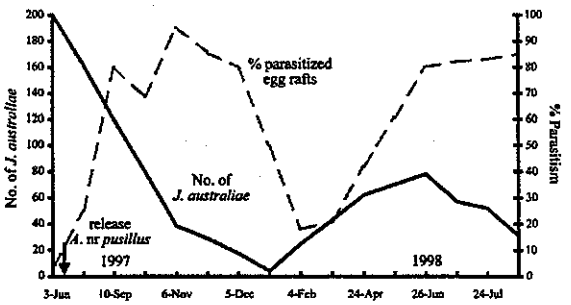

Figure 6. Numbers of *J. australiae* (adults and nymphs) per pandanus head and percentage of egg rafts parasitized at Maroochydore. Mean percent eggs parasitized within a raft, 48.1 in March 1998.

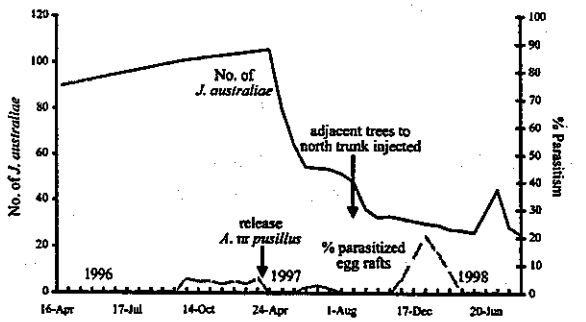

Figure 7. Numbers of *J. australiae* (adults and nymphs) per pandanus head and percentage of egg rafts parasitized at north Alexandria Bay, NNP. Mean percent eggs parasitized within a raft, 49.4 in October 1997.

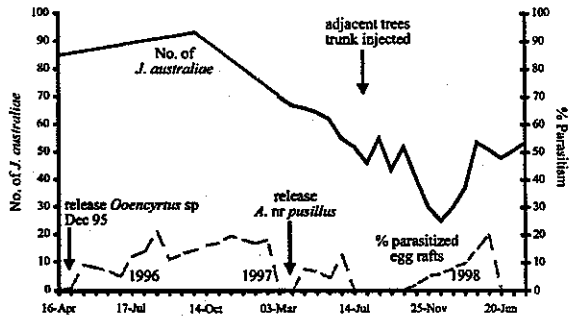

Figure 8. Numbers of *J. australiae* (adults and nymphs) per pandanus head and percentage of egg rafts parasitized at Tea Tree Bay, NNP. Mean percent eggs parasitized within a raft: 9.6 in August 1996, 49.4 in November 1997.

At Burleigh Heads (Figure 5) establishment was confirmed by June 1998 and parasitism levels rose to over 50% by December 1997. Flatid populations dropped from 180 to fewer than 10 per head. An average 59.6% of eggs within a raft were parasitised.

At Maroochydore (Figure 6) releases made in June 1997 resulted in rapid establishment, and parasitism exceeded 50% by September 1997. Flatid numbers fell from 200 to fewer than 10 per head by early 1998 but resurged during Autumn to 40 per head. This was accompanied by reduced parasitism in

this period. In September 1998, flatid numbers were just over 20 per head and parasitism levels near 80%.

At north Alexandria Bay (Figure 7), *A.* sp. nr. *pusillus* had difficulty establishing and did not build up numbers again until October 1997. Parasitism levels have remained low (5–20%), but flatid numbers have still dropped from 100 per head to fewer than 30.

At Teatree Bay (Figure 8), *A.* sp. nr. *pusillus* has been recorded since April 1997 but again at low levels (5–20%). Flatid numbers have also dropped slightly from an initial 85 per head to 40–50. Reduction in flatid numbers at these two sites was possibly caused by treatment of adjacent trees by trunk injection with imidacloprid.

J. australiae ***life cycle studies***

The eggs of *J. australiae* are laid in flat rafts 5 mm in diameter and comprised of 40–80 eggs. There are five nymphal instars with average head capsule widths of 0.32, 0.5, 0.68, 0.92 and 1.22 mm. Corresponding average body lengths are 1.33, 2.1, 2.75, 4.0 and 5.0 mm. The adults average 8 mm in length.

Under constant temperature regimes, development only occurred between 20 and 29°C. First instar nymphs quickly perished at a constant 32 and 36°C. At 20°C, nymphs reached the second and third instars while at 8, 11 and 15°C some first instars survived for up to a month without developing further. Egg rafts failed to hatch at a constant 5, 11, 15, 32 and 36°C. Development of all stages at 20, 23, 26 and 29°C was successful and is shown in Figure 9. The fastest development from egg, through nymphal stages and adult, to egg occurred at 29°C and took about 8 weeks. These data suggest that there are about 4–5 generations per year in southeast Queensland.

Host preference for *J. australiae*: The attractancy of six pandanus species and of *Freycinetia scandens* to *J. australiae* is shown in Table 2. Over 4 weeks, flatid colonies established on all species except *F. scandens*. *P. tectorius* var. *pedunculatus* was the heaviest infested, significantly more so than *P. conicus* and *P. monticola*. *P. tectorius* var. *stradbrookensis*, the species occurring on Stradbroke Island, was almost as susceptible as *P. tectorius* var. *pedunculatus*. In January 1996, a further species, *P. spiralis*, was tested separately and proved to be almost as susceptible as *P. tectorius*.

The challenge to the test plants was severe in that each of the 7 plants per replicate was placed close to 2 heavily infested *P. tectorius* var. *pedunculatus* in a 1 m×1 m×0.6 m cage.

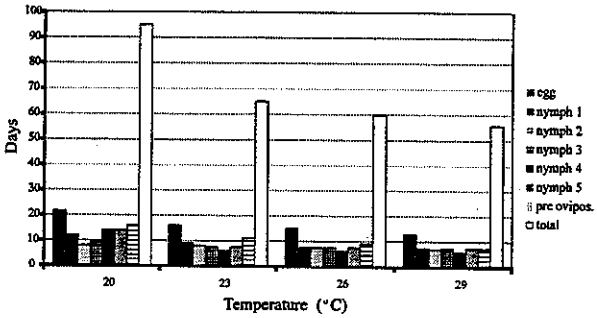

Figure 9. Life cycle of *J. australiae* at four constant temperatures.

Table 2. Attractancy of different Pandanus species and *Freycinetia scandens* to *Jamella australiae*.

Species	Mean no. of live adults and nymphs	
P. tectorius var *pedunculatus*	243.3	a
P. tectorius var *stradbrookensis*	152.7	a b
P. aquaticus	97	a b
P. monticola	26.7	b
P. veitchii (imported species)	98	a b
P. conicus	10.3	b
F. scandens	0.3	b
LSD P = *0.05*	167.2	

Means within columns followed by same letter are not significantly different (P=0.05)

DISCUSSION

Surveys

In Noosa National Park, the decline in pandanus health was very severe with nearly 75% of trees in poor health or already dead by late 1997. This decline in health was undoubtedly caused by infestation by the flatid *J. australiae*. Symptoms may have been exacerbated by other stress factors but these could only be regarded as secondary. Populations in the order of thousands of insects developed on each pandanus terminal. It is likely that feeding by *J. australiae*, combined with secondary rot caused the rapid decline. Poor health could not be linked to viruses, viroids, mycoplasmas, phythopthera root rot or nematodes. A population estimate of 0.5 million adults, nymphs and eggs was made on one large 5 m high tree near Peregian Beach. Young trees usually die within 6 months after becoming heavily infested, older trees within 12 months.

The much lower levels of correlation between tree health and growing conditions (proximity to public ways, proximity to the beach, soil type etc.) noted in this study differs slightly from the conclusions of the Gold Coast report. At Miami and Broadbeach on the

winter but there is a drop in egg production prior to heavy oviposition in spring–summer. There would be a tendency for parasitoids to be less abundant over winter with the lower temperatures and smaller numbers of host eggs available for parasitising.

It is still too soon to confirm the overall impact of the parasitoid releases in southeast Queensland. Many threatened pandanus in areas other than Noosa National Park are inaccessible for chemical treatment. Therefore, biological control offers the best long term sustainable solution.

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