REPORT

ON THE LEVELS OF THE SCALE INSECT *PULVINARIA URBICOLA* AND ITS NATURAL ENEMIES ON *PISONIA GRANDIS*

IN THE CORINGA-HERALD NATIONAL NATURE RESERVE 16-23 MARCH 2001

View from SW Herald (D Papacek)

Male Greater Frigatebird (M Hallam)

Dan Smith and Dan Papacek

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Report on the Levels of the Scale Insect *Pulvinaria urbicola* and its Natural Enemies on *Pisonia grandis* in the Coringa-Herald National Nature Reserve 16-23 March, 2001

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North East Herald, South West Herald, Coringa and South East Magdelaine Islands were visited between 16-23 March, under the leadership of Mark Hallam assisted by Mark Armstrong and Clinton Dengate with transport provided by the Navy patrol boat HMAS Gladstone.

SUMMARY

Pulvinaria urbicola levels on *Pisonia grandis* on North East Herald Islet in the Coral sea have increased 150 fold since the last assessment in December 1997.

- The infestation has spread through the islet with many hot spots with scale numbers over 100 per leaf.
- No parasitoids were recorded and there is little if any predation.
- Similar scale levels were recorded on Coringa Islet in December 1997 where there is now only one small heavily infested tree left.
- There is a serious threat of major damage occurring on North East Herald during the next 6-12 months followed by total destruction of the Pisonia forest.
- The scale can be regarded as an exotic pest to Australia normally biologically controlled by two small wasp parasitoids *Coccophagus ceroplastae* and *Euryischomyia flavithorax* and the ladybird *Cryptolaemus montrouzieri.*
- These natural enemies effectively control the scale in Eastern Australia and the two parasitoids are very effective on islands of the Capricorn Group.
- The only exception to this is Tryon Island where until recently, parasitoid numbers were low or absent.
- It is recommended that immediate action be taken to introduce *C. ceroplastae, E. flavithorax* and *C. montrouzieri* primarily to North East Herald but also to Coringa and South West Herald Islet.
- The parasitoids need only to be released in numbers of several hundred to 3000. These should be reared from green coffee scale and from *P. urbicola* on the mainland and released as soon as possible- either before winter or in the spring 2001.
- The ladybird *C. montrouzieri* is commercially available and can be released at similar times.

- The scale attacking fungus *Verticillium lecanii* is another biocontrol option.
- Dispersal of *P. urbicola* to the Coral Sea Islets may have been by sea birds. Human involvement appears less likely.
- South East Magdelaine Islet appears to be free of the scale and particular care must be taken by visitors not to accidentally infest the islet.
- Two ant species, *Tetramorium* sp. and *Monomorium* sp. were collected in close association with *P. urbicola* infestation. They currently appear to be playing a minor role in the population dynamics of the scale.
- The former *P. grandis* forest area on Coringa Islet is now dense herbland. *Achyranthes aspera, Portulaca oleracea* and *Ipomoea* spp. were heavily infested with *P. urbicola* on Coringa.
- *A. aspera* on South West Herald had been heavily infested but levels had subsided and a new scale generation was present on young growth.
- Revegetation of Coringa with *P.grandis* trees will depend initially on successful biocontrol of *P. urbicola* on the alternate hosts. A programme of rooted plant establishment and minimal horticultural maintenance will need to be considered. The heavy herbland growth will require control at planting sites. *Pisonia* would best be reestablished in stands where care could be concentrated and the typical undertree environment fostered.
- Visitors to the Coral Sea Islets should be aware of a quarantine protocol which should prelude introduction of soil, firewood or vegetative material. All fresh fruit and vegetable scraps including the rind of fruit should be carried off the islets. Equipment should be clean and free of dirt, insects, spiders or small animals. Visitors should be careful not to transfer organisms between the islets particularly at this stage to SE Magdelaine Islet.

BACKGROUND

Surveys

1. **25 November to 18 December-1997 Survey of *P. urbicola* in the Coral Sea (O'Neill, Olds and Elder, 1997).**

- *P. urbicola* present on 2 islets-North East Herald and Coringa.
- *P. urbicola* infestation first noted by Mark Hallam on Coringa in 1991, heavy damage by 1992.
- *P. grandis* forest on Coringa in 1997, 80% destroyed.
- Scale levels 0.45 per cm of leaf on Coringa, 0.003 on North East Herald.
- No parasitoids observed; low levels of a Coccinellid ladybird.
- Often other hosts infested with scale included *Boerhavia tetrandra* and *Tribulus* sp.-on total of 10 islets visited (SE Magdelaine not visited in 1997).
- Infestations were severe enough on these hosts to result in dead patches of vegetation being observed.

2. **1996 study of *P.urbicola* on *P. grandis* on Tryon Island (Olds, Elder, Charles, Platten and Bell 1996)**

- 65% of *P. grandis* killed by *P. urbicola*
- infestation first observed in 1993.
- low levels of parasitism.

3. **27th April to 5th May 1998 survey of *P.urbicola* on islands in the Capricorn group of the Great Barrier Reef-North West, Tryon, Wreck, Heron, West Hoskyn and Lady Musgrave (Olds, Elder, Bell, Chambers and Smith-report in preparation).**

- Only small patch of *P. grandis* (15%) alive on eastern end of Tryon Island.
- Low scale levels on the other islands; infestation concentrated on isolated shoots and causing no damage.
- Parasitism levels on Tryon 13% and on all other islands over 90%.
- Over 90% of the parasitism by the Aphelinid wasp *Coccophagus ceroplastae* (Howard)(Fig 5), the rest by the Aphelinid *Euryischomyia flavithorax* (Girault)(Fig 8) with low numbers of the Encyrtid, *Metaphycus* sp.,The hyperparasitoids *Myiocnema comperei* Ashmead and *Cheiloneurus mackayensis* (Girault) were present in small numbers.
- Parasitism occurring in second and third instar scales.
- Parasitism levels on Tryon, especially by *C. ceroplastae,* low in comparison to the other islands.
- Low level of coccinellid ladybird predators (Cryptolaemus sp.?) on most islands.
- Coastal brown ant *Phediole megacephala* (Fabricus) recorded as present on all the islands associated with the scale infestations feeding on the honeydew (also farming and protecting them). Very high numbers of ants were present on Tryon Island on the end of the island with the remnant patch of heavily infested *P. grandis.* They were also present on other islands but in low numbers.

***Pisonia grandis* Forest**

The estimated area of *P. grandis* forests on Australian Islands is about 200ha (160ha in islands of the Coral Sea and the Capricorn Group). The loss of most trees on Tryon and Coringa Islands (24ha) is then about 15% of the great Barrier Reef Marine Parks and the Coral Sea National Nature Reserves.*P.grandis* occurs between 24^0S and 24^0N in the Indo-Pacific Region but many island forests have been cleared for human habitation and coconut plantations (Olds *pers comm* 2001). For this reason, the Australian forests are now particularly important.

Pisonia trees grow to about 15m and are vital for the nesting of a wide range of boobies, frigate birds, terns and shearwaters (Fig 11). In the Coral sea, *P. grandis* occurs on North East Herald, South West Coringa and South East Magdelaine (Environment Australia 2000). It is recorded from 44 of about 900 islets within the Great Barrier Reef region and is rare on reef islands in the north of this region.

Other significant vegetation types are listed (Environment Australia 2000) and are mainly the small tree, *Argusia argentea* on the island fringes with a grassy understorey and the low shrubs, *Boerhavia tetranda* and *Abutilon indicum,* the tree *Cordia subcordata,* the vines *Ipomoea macrantha* and *I.pes-caprae* and low growing plants like *Portulaca oleracea, Tribulus cistoides* and *Achyranthes aspera*.

***Pulvinaria urbicola* (Cockerell) - Scale Insect**

This scale was first described in 1893 from specimens collected in Kingston, Jamaica (Ben Dov 1993). It has almost worldwide distribution through the Austro Oriental Region -PNG, Solomon Islands, Northern Territory, Queensland, Caroline Islands, Cook Islands, Fiji, Hawaii, Mariana Islands, New Caledonia, Vanuatu, Western Samoa and in Central America and West Indies, Cuba, Galapagus Islands, Southern USA and Israel.

It has a wide host range and in Australia is recorded from maiden hair fern, capsicum, tomato, dahlia, dianthus, lantana and blackberry nightshade. Other known hosts include guava, frangipanni, taro, pineapple, milk thistle, cobblers peg and cape gooseberry. It has been recorded as causing limb death on *Tecoma* stands in PNG (Quin and Gullan 1992).

The scale is probably a native of the West Indies which has become distributed through the central American-Southern pacific Region. Its means of arriving on islets like North East Herald and Coringa can only be speculative but seabirds are a strong possibility.

P. urbicola produces up to a thousand eggs per adult female (Fig 10). These are contained in prominent white egg sack up to 8mm in length. They hatch into mobile 'crawlers' with 3 pairs of legs,and paired eye spots and antennae. They are attracted by the light to the shoots and tops of the tree. They drop off into the air currents and are dispersed over hundreds of metres to fresh hosts. With heavy infestations such as have occurred on Coringa and Tryon Islands, many crawlers would also find their way on to nesting or alighting seabirds. Their lifespan away from a suitable plant host is probably less than 24 hours and they are easily desiccated but if there is a passage of birds within this period between islands, then it may be a means of their dispersal.

When the crawlers settle, they extend a feeding tube into the sap and lose antennae and eye spots. There are 3 instars the third being the adult. Male scales when present, produce a fragile short lived winged adult which mates with the female and dies. The lifecycle takes about two months in the summer and there are probably, 2-4 generations per year.

In spite of its wide host range and distribution, *P. urbicola* is not regarded as a serious pest. This is because it is normally controlled by 2 or 3 parasitoids and also by predatory coccinellids (ladybeetles)like *Cryptolaemus montrouzieri* (Mulsant).

In Eastern Australia a related species, the cottony citrus scale *Pulvinaria polygonata* is an occasional coastal pest of coastal citrus (Fig 6). It has 2-3 major generations per year and sometimes the spring generation reaches significant levels before it is overwhelmed by 2 ladybird species-*C. montrouzier*i and *Rhizobius chalybeus* (Smith *et al* 1997). The ladybirds feed voraciously on the egg masses and young scales and quickly destroy an infestation. *Pulvinaria psidii* is another species that attains some pest status overseas.

Natural Enemies

Worldwide, the main parasitoid of *P. urbicola* is the small black (2mm long) Aphelinid wasp,***Coccophagus ceroplastae*** (Howard) first described-1895 (Fig 5). It is a primary parasitoid of *P. urbicola*, pink wax scale, long soft scale, Florida wax scale, soft brown scale, citricola scale, green coffee scale, nigra scale, black scale, cottony citrus scale and hemispherical scale.These scale insects are from thegenera *Ceroplastes, Saissetia, Coccus* and *Pulvinaria* (Malipatil 2000). Its distribution is very widespread-Afrotropical, Australia/Pacific, Neartic, Neotropical, Oriental and Paleartic.

Euryischomyia flavithorax. This is a small (2mm long) brown and yellow Aphelinid wasp recorded from Australia (Fig 8). It occurs on *P. urbicola,* pink wax, soft brown, hemispherical and black scale (Malipatil 2000).

Metaphycus spp. This worldwide genus is a well recognised valuable group of small (2mm long) yellow Encyrtid wasps that help control a wide range of soft scales. The species from *P. urbicola* on *P. grandis* on Queensland Islands has not yet been identified.

Cryptolaemus montrouzieri Mulsant. This coccinellid native to Australia (Figs 6 &13), is an extremely valuable predator of mealybugs like the citrus mealybug and soft scales like cottony citrus scale. While both adults and larvae feed on younger scales, it does best on the large exposed egg masses and sacs produced by mealybugs and pulvinaria scales. In the Australian mainland environment it persists throughout the year usually at moderate levels. When one of the hosts increases noticeably, the ladybird is then attracted and begins to feed and lay. Within about 2 months it reaches high numbers which totally consume the prey; the high beetle concentration then subsides and the adult beetles disperse. This predator tends to act in a 'boom and bust' situation ie with heavy infestation of *Pulvinaria* scale, larval numbers of the ladybird explode and destroy the host within weeks.

This natural control is in some contrast to control giving by parasitoids. A parasitoid like *C. ceroplastae* builds up in large numbers in response to a high scale infestation but with more normal or 'acceptable' scale levels, the parasitoid works steadily and unspectacularly in its maintenance of these levels. 'Boom and bust' situations which can be damaging to the host plant are avoided as the parasitoid is better equipped to locate infestations than most predators. In citrus in Queensland there is a wide range of scale and mealybug pests and many parasitoids and predators. Both parasitoids and predators; find their own niche and complement each other (Smith *et al* 1999).

C. montrouzieri is commercially mass reared in Queensland and is a very significant option to use in releasing into a 'disturbed' heavily scale infested situation where rapid results are needed. The parasitoids are vital in biocontrol for a stable longterm result.

Very small numbers of *C. montrouzieri* were observed on Tryon and other Capricorn Islands in a late 1990 visits by Olds and Elder (Elder *pers comm* 2001). There did not appear to be multiplication. Observations on the ladybird feeding on *P. urbicola* at Mundubbera in April 2001 indicated the ladybird feeds voraciously on the scale and multiplies rapidly (Fig13).

Verticillium lecanii. *V. lecanii* is a specific scale fungus (Fig 7) which kills mostly soft scales particularly in the wetter areas of eastern Australia. It is an important natural enemy of *Pulvinaria polygonata, Coccus longulus* and *Parasaissetia nigra.* It has been recorded from the Heron Island on *P.urbicola* but its significance not quantified (R.Elder pers comm 2001).

Host specificity of *C.ceroplastae, E.flavithorax ,C. montrouzieri* and *V. lecanii.*

C.ceroplastae and *E.flavithorax* are host specific to scale insects (Homoptera-the soft scales only in the genera -*coccidae,ceroplastes saissetia* and *pulvinaria*). *C.ceroplastae* is recorded from about a dozen of these scales and *E.flavithorax* from half as many.They do not attack insects (or any other organisms) outside this narrow niche (Malipatil *et al* 2000). *C.ceroplastae* is a cosmopolitan species known worldwide as a safe reliable parasitoid of some of these scales.To date no other soft scales have been observed on the Coral Sea Islets.

C.montrouzieri feeds on some soft scales and mealybugs and is particularly attracted to egg sacs.It is an Australian native well documented in its occurance (Smith *et al* 1997) usually confining its activities to half a dozen mealybugs and 3-4 soft scales.

V. lecanii. occurs worldwide on soft scales (scale strain) and aphids and related homoptera (aphid strain).It is totally inoccuous to most other insects and to all other organisms.

Objectives

- Assess the size of the scale populations on *Pisonia grandis* on NE Herald and assess the current situation on Coringa and SE Magdelaine. Check for scale activity on other hosts.
- Assess predation and parasitism levels of the scale insects.
- Identify natural predators and/or parasites – (make collections for identification back on mainland).
- Estimate whether the ant population plays a role in scale insect population dynamics.
- Estimate the size of the ant population on NE Herald; identify species.
- Prepare a report on the findings, present conclusions on the status of the problem and make recommendations for any future actions.
- Advise on possible causes of scale outbreaks-natural or human induced
- Provide recommendations on quarantine protocols to minimise human visitation impacts.
- Assess the potential for regeneration of *P. grandis* on Coringa.

Methods

- Use was made of the existing seabird monitoring transects in NE Herald (the A line)(Fig 1) to obtain trees and leaves for counting and sampling for scale, ants and natural enemies utilising as far as possible the systems, sampling cards etc. already used by John Olds and Rod Elder on a previous visit and in the Capricorn Bunker Group.
- Counts were made every 30m.
- Scale/leaf samples and other relevant insects specimens were collected and stored in mesh lidded plastic tubes or tubs (Fig 9); 2-3 ant samples were made every transect and stored in 70% alcohol.
- Parasitoid samples reared out on return to mainland.

The transect was located and every 30m, three trees were randomly selected and

(a) from each tree there was collected

(1) 1 x upper canopy leaf (a length of the pruner extended 3-4m)

(2) 1 x lower canopy leaf (<2m high).

(b) for each leaf sampled, recorded the:-

(1) tree number and leaf number

(2) leaf blade length in cm

(3) scales touching the midrib – recorded as first, second and third instar(immature adults) and adults with egg sacs.

(4) All adults with egg sacs on the whole leaf and the number of these that were spent

(5) Live scales per cm of midrib

(6) Total ant count on the leaf by species

(7) Ladybirds on the leaf - adults and/or larvae

(8) Parasitoid adults on the leaf

(9) Other relevant insects or mites eg hawkmoth eggs or larvae, grasshoppers

(10) Other relevant observations eg. scales present (although not actually counted in the leaves selected)

On Coringa two random traverses were made across the island looking for live P. *grandis* and for collecting *P. urbicola* on other hosts.

On SE Magdelaine a single traverse was made through each of the two main concentrations of *P. grandis* looking carefully for evidence of *P. urbicola* infestation. Aerial observation on March 15 (Hallam *et al* 2001) showed a 'grey' or defoliated patch in the *P. grandis* forest and this area was observed during the traverses. Particular care was taken while visiting SE Magdelaine to ensure no scale or other organisms were transferred – researchers showered, donned fresh clothes and gear.

On SW Herald (where there is no *P. grandis*) the island was circled just inside the *Argusia* rim and scale activity observed on nearby vegetation.

Results

North East Herald Island

Counts:

Counts of the transects of NE Herald made on 17-18 March are listed in Appendix 1. Results are summarized in Tables 1 & 2. The average scale per cm of leaf blade for the whole island was 0.43 .

The most heavily infested transects were 1,8, 2 and 5, the lightest transects 4,6 and 11. Of all leaves sampled, 22.9% were infested and 62.5% of sites infested (77.0% if positive presences of the scale at 10 of the sites but not recorded on the actual sampled leaves are included).

Hot spots:

Ten sites had more than 200 scales in the count on the 6 leaves. Three sites in transect 1 recorded 273, 301 and 273 scales; 1 site in transect 2 had 341 scales; 2 sites in transect 5 had 223 and 333 scales; 1 site in transect 6 had 392 scales; 1 site in transect 7 had 304 scales; 2 sites in transect 8 had 309 and 386 scales. Although transect 6 was mostly free of scale there was at least one serious 'hot spot ' recording 392 scales. The results include 28 sites with scale counts over 100. About 8 of these 'hot spots' were near the sea edge of the forest and a further 4 near the edge of vine and *Abutilon* patches in the middle of the island.

Table 1.

Summary of *P. urbicola* Counts on NE Herald, April 2001

Transect	**Total scale count on midribs**	**Scale average per cm leaf**	**Scale average per leaf**	**% infested leaves**	**% infested sites**
1	847	1.09	23.5	30.5	50.0
2	848	0.63	11.8	43.0	100.0
3	576	0.34	6.4	17.8	86.7
4	146	0.11	1.9	16.7	61.5
5	950	0.48	9.3	23.4	88.2
6	170	0.09	1.9	11.1	20.0
7	341	0.30	5.7	15.0	70.0
8	994	0.74	15.1	39.4	90.1
9	416	0.32	6.3	24.2	63.4
10	175	0.26	4.9	19.4	66.7
11	50	0.07	1.4	5.5	33.3
Total	**5511**	**0.43**	**7.5**	**22.9**	**68.5***
					*77.0 if nearby infested included

Another heavily infested site occurred in transect – where a large *P. grandis* had been blown down delivering a lot more light in through the canopy. While at least half the scale occurred in 'hot spots' on about 28 out of the 122 sites, the infestation nevertheless was widespread – 22.9% of all sampled leaves infested and 68.5% of all sites were positive.

Scale numbers in the worst 'hot spots' notably the 10 sites recording over 200 scales were massive with hundreds of scales of all stages infesting every shoot. Leaf drop was already occurring and some shoot death. In the more heavily infested transects, it was common to see heavily infested and dead shoots within 1 m of ground level. Usually, leaves from higher in the canopy were less infested. High leaves had an average 2.1 - scales per leaf and low leaves 13.1-scales. The scale appears to have multiplied in wind protected edges of the forest or where gaps in the canopy had allowed more light but does not prefer the tree tops which are exposed more to extremes of wind, humidity and temperature.

Ants:

Ants were concentrated where there was scale. Species A –*Tetramorium* sp. was the most common-in transects 1,2,3,5,7, 9 and 10 (total of 691 recorded) but species B- *Monomorium* sp. occurred in transects 10 and 11 (total of 31 recorded). As many as 60 ants occurred per leaf where the scale infestation was heavy.

Hawkmoths:

There had been a significant infestation of hawkmoth larvae throughout the island with evidence in every transect. Identification is not confirmed but the species could be either *Theretia latreilli* or *T.tryoni*. There was a total of 11 live larvae, 4 viable eggs, 1 pupa and 82 emerged eggs recorded in the leaf samples with most records in transect 4, 6,9 and 10. Feeding damage to leaves in the canopy (with over 50% tissue loss) was quite noticeable and feacal pellets still readily seen carpeting the ground. It would appear the bulk of the attack had occurred in January –February. About 10 adult hawkmoths came to the tent lights each night.

Natural Enemies:

No adult parasitoids were observed on the leaves or associated with the scale infestations.

On return to the mainland *P.urbicola* on Pisonia were exposed to *C. montrouzieri* in laboratory cages.Adult beetles fed voraciously,laid eggs and after 2 weeks larvae were observed .These also fed readily on the scale

Table 2

Average Percentage Live Scale and Parasitism *on NE Herald

Transect	1st instar % alive (scales counted)	2nd instar % alive (scales counted)	3rd instar % alive (scales counted)	Adults-eggs spent % (scales counted)
1	100.0 (408)	100. (176)	100.0 (121)	17.3 (110)
2	96.7 (618)	99.6 (272)	100.0 (67)	44.8 (257)
3	98.2 (335)	97.7 (133)	98.9 (89)	26.1 (165)
4	98.7 (321)	78.9 (159)	97.9 (95)	7.5 (53)
5	99.8 (609)	95.0 (479)	97.7 (174)	13.6 (242)
6	94.4 (215)	100.0 (120)	100.0 (40)	20.0 (50)
7	100.0 (53)	79.2 (24)	100.0 (2)	33.3 (3)
8	96.11 (332)	93.9 (248)	97.6 (126)	7.4 (67)
9	96.8 (155)	100.0 (123)	100.0 (96)	14.7 (68)
10	95.0 100)	100.0 (50)	100.0 (50)	28.6 (7)
11	97.0 (67)	100.0 (30)	100.0 (12)	28.6 (7)
Total Live % live	3146 (3213) 97.9	1807 (1814) 99.6	852 (862) 98.8	255 (1030) 24.7

- No parasitoids detected in samples or subsequently reared out.

The percentage of live scale (first, second and third insters) was very high (see Table 2). 24.7% of adults egg sacs were spent (ie. eggs hatched).

There was no evidence of fungal or other disease pathogens in the scale. No adults of the coccinellid ladybird *Coelophora mulsanti* (Montrouzier) were observed on the leaf samples. However the beetle was observed nearby on 1 or 2 occasions. It was not feeding on the scale and is considered a predator of aphids (R.Storey *pers comm* 2001).

No other predators were confirmed and spiders were relatively few (only 4 observed); 35 small green mirids were recorded. Spiders are general predators –more on motile insects rather than sedentary insects like scales. Mirids are often predatory on thrips, sometimes phytophagous..

Other insects

The only other insects or mites noted were 5 records of a diaspid scale (possibly *Lepidosaphes* sp.) with 1 or 2 scales on each occasion, 7 records of a small cockroach species and 6 records of a Phytoseiid predatory mite. Phytoseiids are important predators of phytophagous mite pests. The grasshopper (identification not yet confirmed) but probably *Valanga irregularis* (Walker) was collected but appeared to be doing little damage to *P. grandis*.

Coringa Islet

Damage:

Coringa was visited on 21 March. A traverse was first made from the NE corner across the centre in a SW direction. Only low herbland remains of the once extensive *P. grandis* forest. In another traverse, a single surviving *P. grandis* tree was found growing up from the base of an original tree near the northern end. It was heavily infested with *P. urbicola* with ants present and no evidence of parasitoids.

Other hosts:

The scale was observed heavily infesting some of the low growing vegetation notably *Achyranthes aspera, Portulaca oleracea* and *Tribulis cistoides*.

Even some of the grasses were infested. The heaviest infestation was on *A. aspera* which continued to thrive in spite of numerous 1 m diameter dead patches throughout the island (Fig 12). There was no sign of parasitism again in the scale on these other hosts and ants were abundant. Other hosts observed on NE Herald were *Boerhavia tetrandra* and *Ipomoea* spp. but infestation mainly occurred where these hosts were adjacent to very heavily infested *P.grandis*. The same ladybird as on NE Herald- *C. mulsanti* was collected in Coringa but was not present in significant numbers.

South East Magdelaine Islet

This islet was visited on 21 March. A traverse were made through the main *P grandis* patch on the Western end where the defoliated patch had been observed from the air and then a second traverse back through the next section to the west. No scale had been previously observed on the island (M.Hallam *pers comm* 2001) and particular care were taken from a hygiene point of view to avoid introducing it. No *P. urbicola* was observed on *P. grandis* or other hosts. Ants were not specifically collected and were not in evidence. The defoliated patch had been heavily damaged by hawkmoth larvae probably during January – February. The damaged area appeared to be recovering well with lots of new shoots.

South West Herald Islet

This islet was visited on 22 March. There are no *P. grandis* but the herbland was examined just inside the peripheral *Argusia* on the southern and western sides and there were numerous dead patches. The scale appeared to have reached high levels and then subsided. First and second instar *P. urbicola* could readily be seen on fresh *A. aspersa* shoots.

Discussion

Scale levels

The average *P. urbicola* infestation on NE Herald was 0.43 scales per cm of leaf midrib comparing with 0.003 scales in the 1997 survey and the 0.451 scales on Coringa in 1987. This 150 fold increase is mirrored in the wider distribution throughout the island and the detected presence of at least 28 ‘hot spots’ with scale counts of over 100 per leaf. Considering that *P. grandis* on Coringa has been reduced to one last tree in 4 years by similar numbers in 1997, there is much cause for alarm on NE Herald.

It is evident a similar course is being followed on NE Herald and tree destruction will rapidly accelerate. Mark Hallam (*pers. comm* 2001) suggests that initial noticeable infestation of Coringa was observed in 1991 and by 12 months later there had been noticeable tree destruction. It is possible that severe damage will occur on NE Herald during the next 12 months. The impact of the imminent loss of another significant area of *Pisonia* forest on bird life in the region cannot be overdramatized.

Exotic pests, damage and dispersal

Total destruction of its plant host by an insect like *P. urbicola* is an unusual but not unique phenomenon. Insect pests are almost always in balance with their host with population checks applied by weather, competition and natural enemies. Homoptera like *P. urbicola* are particularly susceptible to biological control by hymenopterous parasitoids (encyrtids and aphelinids). Scale insects can greatly multiply in their absence (if weather and food resources are ideal).

This situation occurs usually when the pest insect is transferred or imported to a new region or country without its natural enemies ie it becomes an exotic pest. A similar form of imbalance can be induced with careless pesticide use which kills natural enemies but not the pest insect.

In the Coral Sea, *P. urbicola* should be regarded as an exotic scale. On the Australian mainland it is a nonentity because of the impact of natural enemies (that have followed it from overseas.) and also some native species like *C. montrouzieri* (that have adapted to it). The scale have spread to islands throughout the Capricorn group close to that Queensland coast and in most cases, vital natural enemies have followed it and given control. The exception has been Tryon Island which may well have received the scale too much in advance of its parasitoids ie there was a fatal delay in the parasitoids catching up. Parasitoids were observed on Tryon Island as early as 1993 albeit it is thought at low levels (Olds *pers comm* 2001).There is no good explanation why they did not multiply over the following 5 years and only did so since 1998 in time to save the remaining 15% of the forest. Ant populations were extremely heavy while the scale was rampant and this may have played a part.

The means of dispersion of the scale to the islands is totally speculative but dissemination of crawlers by seabirds (as earlier discussed) is a possibility.The Coral Seas Islets are much further off shore at 300-500km and transferral on sea birds would appear to offer the best explanation of initial dispersal. The greater distance, however, appeared to have precluded parasitoid dispersal and these islets have been left very vulnerable to the scale. It is notable that *P. urbicola* has not yet reached SE Magdelaine Islet suggesting the scale is not a long term natural inhabitant of the islets.The apparent freedom of SE Magdelaine is remarkable in view of the the fact that virtually every other islet in the region is infested (Elder *pers comm* 2001).This islet is the most easterly in the Reserve.

Pandanus flatid case

Smith and Smith (2000) discuss the case of infestation of *Pandanus tectorius* in coastal South East Queensland by the homopterous flatid *Jamella australae*. Noosa and Burleigh Heads National Parks, council and public pandanus from Noosa to Coolangatta were infected from the early 1990's. The insect built up in huge numbers and killed 10m high, 50 year old trees within 12-18 months. 75% of pandanus in Noosa National Park were lost before the pest and its damage were contained. Pandanus species occurs up the Queensland coast to Cape York

and on the coastal islands. In North Queensland they are lightly infested by *J. australae*. The pest was kept at low levels by a small wasp egg parasitoid. In the late 1980's, housing developers transferred large bagged pandanus from Cairns to the Gold and Sunshine Coast.It would appear that these plants carried the pest in the growing points but not the parasitoid. This area is separated from the wet tropics by the dry tropics which acts as a form of geographical barrier. *J australiae* became in effect an exotic pest, freed from its natural controls and it multiplied to hundreds of thousands of insects per tree. The solution lay in collecting the vital egg parasitoid from North Queensland and establishing it in South East Queensland. This was a perfectly natural procedure without which (apart from the continued use of a systemic pesticide treatment) every pandanus in SE Queensland would have been soon destroyed. There is a strong likelihood the egg parasitoid would with time have traversed the dry tropics gap itself but by then nearly all the pandanus would have died.

Predation and parasition

There appears to be no parasitoids in any of the scale infested islets in the Coral Sea.

No actual predation was observed. There were no pathogens such as *Verticillium lecanii* in evidence. The almost total lack of any natural enemies in the presence of an increasing scale population gives increased cause for alarm.

Ants

The two species collected are attracted strongly to feed on the honeydew produced by *P. urbicola*. It is common for ants to farm such scales picking up young stages or adults and moving then to other sites. They disturb or even attack parasitoids and predators and so give protection to the scale. On Tryon Island, the large population of scale encouraged large numbers of ants (reportedly *Phediole megacephala*). During the 1998 visit, the ants were observed disturbing the parasitoids. The effect tends to be cyclical – more scale, more ants, more disturbance of natural enemies leading to more scale again. The cycle can be broken by controlling the ants eg with baits which takes pressure off the natural enemies leading to less scale then less ants again. The natural enemies will for a time be impaired by ants but if at all effective, they will eventually break the cycle and give control. The absence of effective natural enemies on NE Herald and Coringa means that ants probably currently play a minor role in the scale population dynamics.Their role may change if natural enemies become established

P. urbicola on other hosts

The heavy infestation of shrub and herb vegetation like *A aspersa* on Coringa and SW Herald indicates that natural revegetation (on Coringa) by *P. grandis* is very unlikely to occur. The scale has persisted on other perennial hosts without killing them off and could continue so indefinitely. *P. grandis* is obviously a well favoured host and any new plants would soon be infested and destroyed . It would be impossible to re-establish *P. grandis* on Coringa without first establishing biocontrol of the scale on the islet. If the scale has in fact been dispersed by sea birds there is a possibility that SE Magdelaine will eventually also be infected.

Other pests

The only other significant pest was the hawkmoth. In this season at least, it has caused noticeable leaf damage and leaf drops in both NE Herald and SE Magdelaine. In spite of this, the forests appear to be recovering and are releafing in the worst affected areas. The main hawkmoth biocontrol agents are egg parasitoids and larval and pupal parasitoids. It was possible to collect only a few unhatched eggs and about 6 larvae.

Recommendation for future actions

(1) Urgent attention should be given to the release of natural enemies of *P. urbicola* from mainland Australia.

(2) The parasitoid *Coccophagus ceroplastae* has the highest priority as being the main natural enemy currently giving long term control of the scale on the mainland and on the islands of the Capricorn group. *Euryischomyia flavithorax* is also a significant parasitoid that should be considered for release. Most scale insects have a number of natural enemies that combine to give control. Single 'once up' releases may be all that is necessary.The enigma on Tryon Island suggests that instant success is never a forgone conclusion but there is every indication that without good parasitoid establishment the future of the Pisonia forest on NE Herald is looking bleak.

(3) The ladybird *Cryptolaemus montrouzieri* is an Australian native species, reliable and proven against a small number of mealybugs and soft scales (particularly those producing egg sacs). It is commercially available and can be released almost immediately. Indications are that it would multiply rapidly in response to the heavy infestations building on NE Herald and produce a rapid reduction within 2-3 months. Again 'once up' releases should be all that are necessary. *C. montrouzieri* persists on a long term basis in mainland situations but it is difficult to predict how it will behave on the Coral Islets once the scales host becomes very scarce.

(4) The insect pathogen V*erticillium lecanii* should also be considered for a 'once up' release as part of a long term biocontrol strategy.

(5) Action should be taken first on NE Herald but also on Coringa then possibly on other infested islets including SW Herald. The situation on SE Magdelaine should be carefully observed and should scale appear there, releases also made.

(6) Ant control is a future possible option using ant baits. There is a strong possibility, however, that such action will not be necessary if natural enemy introduction is successful. Ant baits are now becoming available based on cereal grains like polenta carrying extremely low rates of pesticide and distributed at rates of about 2.5 kg per ha. The pesticide dosage with such rates is almost undetectable and the threat to other wildlife extremely low. The ants carry the bait back to the nests where the queen and its colony is destroyed. There would need to be some testing of particular baits on the ant species involved to ensure the bait was attractive.

(7) *P. urbicola* has spread to the Coral Sea Islets more likely on sea birds than through human visitation. However, there should be guideline protocols for

visitors to minimize the possibility of introducing pests and disease.Some possible protocols are described below:

- No vegetative plant material,firewood or soil to be taken on to or transferred between islets (this may have to be temporarily ignored between, NE Herald and Coringa if some sort of revegetation programme of Coringa is attempted).

- SE Magdelaine appears to be free of the scale and extreme care should be exercised in moving from infected islets to this islet as regards foot wear, clothes and equipment.Where more than one islet is visited in one day, SE Magdelaine should be first.

- Equipment that is landed on the islets for camping etc should be clean and free of dirt or insects, spiders or other small animals.

- A little care and common sense should be exercised with fresh fruit and vegetables. The residues of these -rind, old leaves, unused produce should not be disposed on the island but carried off.

  Rind, fruit and leaves can carry live scale insects, fruitfly, mites or thrips respectively.

(8) Revegetation of Coringa Islet:

There is only one small *P. grandis* tree left on Coringa and the former forest is now a mass of *Achyranthes, Portulaca, Ipomoea, Canovalia* and grasses.

Most of these are heavily infested with *P. urbicola* and action should be taken to bring the scale under biocontrol with suitable releases.

Once this is achieved, consideration could be given to helping *P. grandis* re-establish. Some options are

- Do nothing except secure the one existing tree by immediately removing the scale infestation at the next visit by circumspect insecticidal treatment of the foliage and twigs.

- Look at the possibility of hygienic production of young *P. grandis* plants (rooted mist bed cuttings may be most likely to reestablish- the larger the better) in sterile plant tubes or tubs depending on size for re-establishing in a trial or pilot area. Propagating material would be best selected from a nearby source eg. NE Herald but actual propagation may be most efficiently done on the mainland.Particular care of course would be necessary to ensure that fresh organisms were not thus introduced. The heavy cover of herbaceous plants will compete with young seedlings or transplanted plants and some control of these competitors would be necessary probably with a carefully chosen weedicide like glyphosate. Replanting preferably should occur in blocks to give a better chance of reestablishing the *Pisonia* forest beneath tree environment. The size of a block may be initally about 25 by 25m or more ambitiously 50 by 50 m. Planting of the young *P. grandis* would be best timed just before or at the beginning of the wet season in November. If this programme looked promising, an increasing area could be reclaimed**.**

Programme and foreseeable costs for introductions

1. Parasitoid collecting, rearing and release

The aim would not be to produce large numbers of *C. ceroplastae* or *E. flavithorax* for releasing but rather numbers from several hundred to 3000. Many *Coccophagus* species have a complex life cycle (with males hyperparasitic on females) which demands staggered releases. *C. ceroplastae* does not appear to exhibit this phenomenon and establishment should be relatively simple from small releases of 100-200 adult parasitoids. The actual life cycle of *C. ceroplastae* will need some checking to confirm this.

E. flavithorax has no facultative hyperparasitisation and again establishment should be possible with small release of 100-200 adult parasitoids.

These would initially be best reared out from alternative hosts particularly green coffee scale *Coccus viridis*; *P. urbicola* on lantana is another possible source.

Considerable quantities of these scales on pruned host material would be stockpiled in a constant temperature room and the emerging parasitoids attracted to light at a window and collected by aspiration. Timing would be critical ie. a good emergence would need to be timed to coincide with visit to the Coral Sea Islets so that significant numbers could be transported in tubes for releasing.

An alternative or supplementary method of collecting could be to build up a *P. urbicola* colony on suitable plant hosts on the mainland and then expose them to the required parasitoids and build up nuclei for releasing on the islands.

Following the March 16-23 trip some alternative hosts observations have been made and a colony of *P. urbicola* established at Nambour mainly on gardenia. Blackberry nightshade and capsicum will also be good hosts.

2. Release of *Cryptolaemus montrouzieri*

The "Bugs for Bugs" insectary run by Dan Papacek at Mundubbera produces this ladybird commercially for releasing in citrus, custard apples at other fruit crops.This Insectary is prepared to donate several thousand *C.montrouzieri* for release on the Coral Sea Islets.These ladybirds are currently available and could be released at relatively short notice.

3. Release of the fungus *Verticillium lecanii*

There are commercially available preparations of the fungus available in Europe and the USA but the strain used is for aphid control. Use of the soft scale strain effective in SE Queensland would require collection and some preparation. If it was possible to obtain some viable material in step with operations 1 & 2 then its transferral could be expediently done on an inexpensive 'low key basis' at the same time. If not it could remain a future option.

4. Release timing

Severe damage could occur rapidly within months on NE Herald and if natural enemies are to be released, the sooner the better. Temperatures don't vary that much seasonally in the Coral Sea and the advent of winter may only be a problem for parasitoid collection and rearing on the mainland.

If an autumn collection of parasitoids during April-June can be organized, then release of ladybirds and some small nuclei of parasitoids could be aimed at for a May visit. Release would be concentrated on NE Herald, unless there are very good numbers of parasitoids in which case release could be made also at Coringa. There should be no limits to releasing *C. montrouzieri* on any of the islets.

If no parasitoids can be organized before the spring, then release of *C. montrouzieri* alone could be considered. The time on the islets needed for the actual task of releasing would be 1 day in NE Herald and 1 day on Coringa. A full scale count probably would not need repeating within 2-3 months of the one just completed. Other tasks could be combined eg spraying the lone *P. grandis*, left on Coringa, perhaps some trial spot- spraying with a suitable weedicide on Coringa (if revegetation is envisaged) and perhaps some thought given as to seed and/or shoot (for mistbed propagation) collection of *P. grandis* on NE Herald.

A second visit could then be aimed for in early Spring as soon as parasitoid nuclei for release were available. Scale counts could be repeated and the progress of the *C. montrouzieri* assessed. This visit could require 2 days on NE Herald for data collection and 1 on Coringa. This second visit would also be valuable even if the May visit includes parasitoid release but could be delayed perhaps to early or late summer if costs dictated.

The ideal situation would be a release of parasitoids and ladybird as soon as possible within the next 3 months and then assessment conducted in succeeding years during early summer. Providing release and establishment go to plan, assessment could be adequate in conjunction with other more normal operations by Environment Australia.

With such a critical situation, there should be at least one ongoing assessment per year until the problem is resolved. Most of the effort and time will be involved in initial establishment. It is then up to the natural enemies.

A visit by R.Elder and colleagues is planned to the Capricorn Group on May 6 (R.Elder pers comm) and this could facilitate some parasitoid collection.Short visits to Heron Island to collect parasitoids (with Qld Nat Parks permission) should not be ruled out.

5. The revegetation issue on Coringa

This would need its own organisation should it proceed. More than 1 or 2 visit initially may be required.The means of producing vigorous potted plants on the coast and transporting them to Coringa would need to be explored.

6. Consultancy costs

Consultancy costs of about $400 per day should be allowed for each visit; costs for collecting and rearing *C. ceroplastae* and *E. flavithorax* are difficult to predict. Establishment may be achieved at little cost eg less than $1000-2000.

Acknowledgments

We thank that Royal Australian Navy, notably officers and crew of HMAS Gladstone for their generous assistance and the Marine Protected Areas Section officers – Mark Hallam and Clinton Dengate who assisted in all our data collection and deliberations.

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