ZOPHIUMA LOBULATA GHAURI (HOMOPTERA: LOPHOPIDAE) AND ITS RELATION TO THE FINSCHHAFEN COCONUT DISORDER IN PAPUA NEW GUINEA

E.S.C. Smith*

ABSTRACT

*Coconut palms (*Cocos nucifera*) in the Finschhafen area of the Morobe Province of Papua New Guinea are frequently affected by the feeding activities of* Zophiuma lobulata *Ghauri (Homoptera: Lophopidae), which causes bronzing of fronds, reduction in yield, marked stunting of growth and occasionally, the death of young palms. Typical symptoms were induced 7-15 months after caging adult and immature leaf hoppers over potted coconut palms.*

Studies on the life history and egg parasitism rates in the field showed that the total generation time was about four months, and included an 8-9 day egg incubation, 82-85 days in the immature nymphal stages and a 30 day preoviposition period. Egg masses were found to be heavily parasitised by an encyrtid wasp Ooencyrtus malayensis *Ferriere which, in conjunction with entomophagous fungi may possibly exert a controlling influence on* Z. lobulata *populations occurring in other areas. A second encyrtid, gen. nr.* Epiencyrtoides *was also found to parasitise an egg mass in the Northern Province.*

INTRODUCTION

During the early 1960's, many coconut palms in the Finschhafen area of the Morobe Province became affected with an unknown disorder. Fronds of affected palms turned a bronze colour and, in severe cases, young palms died. After intensive checking by soil chemists (DASF 1966), plant nutritionists (DASF 1963), pathologists (DASF 1965) and entomologists (DASF 1968, 1969, 1972) the disorder was linked to a sucking bug *Zophiuma lobulata* Ghauri (Homoptera: Lophopidae) (Ghauri 1966). Although the species occurs on coconuts along the North Coast from Alotau to Finschhafen (Bourke *et al.* 1973), only in the Finschhafen area does the insect cause significant damage. There is some evidence that it may be sporadically serious in other areas, one minor outbreak being reported from Popondetta (Bourke *et al.* 1973), but it is not known what factors keep numbers down under normal circumstances. Relatively poor growing conditions in the Finschhafen area may help to explain the frequently observed severity of symptoms there.

Over the years, many Department of Primary Industry officers investigated the problem and this paper summarises the information now available on *Z. lobulata*, some of which was extracted from unpublished reports in Departmental files.

DAMAGE SYMPTOMS

The condition was first noticed near Finschhafen in 1960 (DASF 1963), but was not considered particularly serious until 1965 when many older coconut palms began dying and the affected area increased. In the area where it was first

* Entomologist, Department of Primary Industry, Popondetta, Northern Province. Present address: Senior Entomologist, Lowlands Agricultural Experiment Station, Keravat, East New Britain Province, Papua New Guinea.

noticed, up to 10% of older palms died as a result of the disorder, and at least 80% of all palms showed damage symptoms.

At the onset, the disorder is difficult to recognise, and may be confused with normal yellowing of fronds due to adverse climatic conditions, nutritional deficiencies, insect damage or other factors. Within several months however, the symptoms appear as an advanced senescence, with yellowing and necrosis occurring exactly where they would normally occur in an ageing frond, and in the same sequence, but greatly accelerated and more pronounced. Leaflets first show a yellow bronzing from the tip, and as the condition advances, the bronzing extends toward the petiole. The yellowing spreads much more rapidly in the distal leaflets than in the proximal ones, and the distal leaflets often become bronzed along their entire length (DASF 1966; Anon. 1969). Successively less yellowing in the proximal leaflets gives an arrow-head shape to the affected area which is evenly coloured over the affected portion of the leaflets.

As the condition advances, the leaflet tips become necrotic and this necrosis gradually spreads until all the former bronzed area may be replaced by necrotic material. Rarely does the necrosis invade the former green areas. The symptoms are most evident in lower fronds, but as the condition develops, appear to spread upwards to the younger fronds (Anon. 1969).

In severe cases, the petiole appears to become soft and the frond may bend above the basal expansion of the petiole, causing an affected frond to droop much more than a healthy one. The lower fronds die prematurely, and frequently, normal abscission does not occur. A marked reduction in nut production is evident in the later stages (Anon. 1969).

Palms which have recovered from an attack are characterised by a large amount of necrotic tissue on otherwise healthy fronds.

RELATIONSHIP BETWEEN THE DISORDER AND *Z. LOBULATA* INFESTATION

In the Finschhafen area, *Z. lobulata* was associated with palms affected by the unthrifty condition described, but on healthy palms adults and nymphs were observed in only small numbers (Anon. 1969). It was also noted that in areas which had previously been free of the disorder, a large build up of the insect preceded damage symptoms. Both the lophopid and the unthrifty condition appeared to be absent from a small island off the coast near Finschhafen. In addition, where previously affected palms recovered from the condition, the improvement appeared to be related to a general decrease in *Z. lobulata* populations throughout the affected areas (Anon. 1971).

Both nymphs and adult *Z. lobulata* fed on the fronds, and showed a marked preference for the oldest frond on the palm. There was also a general insect movement upward from old debilitated fronds towards younger healthy ones and confinement to the healthy portion of debilitated fronds. These trends are similar to those shown by the yellowing symptoms during the progress of the condition.

Further evidence was gathered when a very debilitated young coconut palm was removed from Finschhafen to Port Moresby. The palm was potted with its own soil and grown in an insect proofed cage for four months, during which time the old affected fronds died but newly emerging ones were perfectly healthy and showed no signs of yellowing. Sap extracts from this palm were also examined for virus infection by electron microscopy, with negative results.

Although the bronzing of fronds associated with reduced nut production and the occasional death of palms in the Finschhafen area were assumed to be caused by the feeding of *Z. lobulata*, the evidence was only circumstantial.

SYMPTOM INDUCEMENT EXPERIMENT

In an attempt to induce the symptoms of the 'Finschhafen coconut condition', *Z. lobulata* were caged on potted coconut seedlings at Popondetta in the Northern Province.

MATERIALS AND METHODS

In early 1974, 20 seed nuts were planted in 30 cm plastic pots and divided at random into two groups, each placed within a 4 m x 4 m x 3 m high field cage constructed of insect screening. Two months later, when the seedlings were at the two to three leaf stage, *Z. lobulata* adults and nymphs were collected locally and placed on the 10 palms in one of the cages. Over the next three months leafhoppers were added until a viable colony of some 120 nymphs and 15 adults was maintained on the palms. This situation existed from July 1974 to August 1975 when the tent cages were dismantled. The 10 seedlings in the second cage were maintained as a control group without leafhopper feeding. Weeding of the pots and cages was carried out regularly and urea fertiliser (about 20 g per seedling) was applied in October, 1974.

RESULTS AND DISCUSSION

The first signs of yellowing on the fronds were noticed in January 1975 after six to seven months of intensive feeding by the lophopids, and by February 1975, bronzing of the fronds was readily noticeable. Two months later, the bronzing was general over all the fronds in the cage containing the leafhoppers, while the control palms displayed no yellowing symptoms. By August 1975, some 14-15 months after intensive feeding was initiated, the potted seedlings were very stunted, many fronds had died and the palms looked very unthrifty. All fronds had turned a bronze colour and no green fronds were present. In contrast, the control palms appeared healthy, were growing vigorously and the fronds were a deep green colour.

In late August, 1975, after the coconuts were sprayed to run off with 0.1% lindane insecticide to kill the leafhoppers, the number of fully expanded, unexpanded and dead fronds were counted and the height from the emergence of the stem to the tip of the unfurled fronds (spear) was

Plate I.—**Inducement of symptoms in potted coconut seedlings by *Z. lobulata*. Infested plants on left, uninfested plants on right** recorded for each seedling. These measurements are presented in *Table 1*.

Feeding by *Z. lobulata* was shown to induce bronzing symptoms very similar to those noticed on young palms at Finschhafen, but the symptoms did not start to appear until some six to seven months after intensive feeding had begun. Insect feeding was also shown to reduce the vigour of the palms and to cause stunting (*Plate I*). The average height of the control palms was significantly higher (P < 0.001, Students 't' test) than that of the seedlings which had been exposed to leafhopper feeding for 14-15 months (*Table 1*). Slightly more fronds were produced and more dead fronds counted on the seedlings exposed to leafhopper feeding, but these differences were not significant (*Table 1*).

Following the termination of the experiment all palms were field planted, and the damaged seedlings subsequently appeared to recover fully and produce green fronds. After three years in the field, all palms were completely healthy and were producing only green fronds, but the control palms had maintained their height advantage over the previously affected palms.

CONCLUSIONS

The results from this experiment suggest that *Z. lobulata* is intimately involved in the Finschhafen coconut disorder, and that feeding by large numbers of this insect cause symptoms to be expressed that are very similar to those observed on young palms at Finschhafen. The remission of symptoms indicated that a viroid or a mycoplasma-like organism (MLO) was unlikely to have been involved in the disorder, although some MLO-like diseases on coconut palms have been known to exhibit symptom remission (e.g. Harries 1978). The findings by Dr D.E. Shaw that an obviously debilitated palm produced only healthy fronds after being removed from the range of *Z. lobulata* and that sap extracts showed negative results also suggest the absence of an MLO in the Finschhafen coconut disorder.

The production of healthy fronds after insect removal would indicate that any toxicogenic substance which may be introduced by the leafhoppers was not translocated within the palm.

It is probable that the symptoms are caused by a localised toxic reaction to *Z. lobulata* feeding on the frond and that the effects may not be manifest for many months, or unless large numbers of insects are involved. This situation has been reported in other insect/host relations (Carter 1962).

It is also possible that under light feeding pressure from the leafhoppers, the symptoms may only be expressed in palms which are initially unthrifty due to nutrient imbalances, poor soil drainage, climatic or other factors. For instance, palms may suffer mild mineral deficiences without exhibiting any visual symptoms except for reduced yield (Southern and Dick 1969). In the Finschhafen area, coconut palms which have shown the disorder symptoms grow in a rendzina

Table 1.—**Effect on potted coconut seedlings exposed to feeding by *Z. lobulata* (Means of 10 palms for control treatment and 9 palms for exposed treatment)**

Parameter	Control (no exposure)	Exposed to leafhoppers	(s.e.)[1]	
Height (cm)	157.0	84.1	±10.74	***
No. of fully expanded fronds	4.6	5.9	± 0.76	NS
No. of fronds unexpanded	0.7	0.8	± 0.21	NS
No. of dead fronds	4.9	3.1	± 0.69	NS
Total No. of fronds	10.2	9.8	± 0.43	NS

[1] Levels of significance NS = not significant *** = P < 0.001

type coral derived soil which is likely to be deficient in potassium (DASF 1966) and sulphur (Gallasch, pers. comm.). Since these soils are slightly alkaline (Fahmy pers. comm.), some minor elements such as iron or manganese may be unavailable to the palm and the poor growth may be partially due to a lime induced iron deficiency (DASF 1966; Southern and Dick 1969).

BIOLOGY AND ECOLOGY OF *Z. LOBULATA*

LIFE HISTORY STUDIES

Techniques

In an attempt to rear *Z. lobulata* in the laboratory, egg masses were collected from lightly infested palms in the Northern Province and placed in petri dishes in the laboratory. After the nymphs had emerged, small sections of coconut leaflet in vials of water were offered as a food source, and although the nymphs moved onto the fresh leaflets, most died within a few days and only one insect reached the third instar stage.

A more successful technique was then used to rear nymphs to the adult stage on potted coconut seedlings enclosed in insect screening cages 40 cm x 40 cm x 1 m high. Egg masses, which adults had deposited onto potted palms in a large field cage, were removed daily and, still attached to a small portion of coconut leaflet, were stapled to coconut fronds in the small outside cages. Daily records were kept as nymphs developed through to adult leafhoppers. Data on the instar durations are presented in *Table 2*.

Results

The total generation time was about four months, and included an 8-9 day egg incubation, 82-85 days in the immature stages and a 30 day preoviposition period.

Egg. In the field, egg masses were usually deposited on the fibrous material at the base of the petiole or on the lower surfaces of terminal leaflets. However, egg masses were also commonly encountered on the corrugated iron walls and wooden super structure of copra dryers, where the often very hot conditions did not appear to affect viability. The eggs, covered by a white woolly secretion, are a translucent pale green in colour, ovoid in shape and measure about 2 mm by 1 mm. The number of eggs in an egg mass varies greatly, and in one 500 egg mass sample, ranged from 1-217, averaging 38.8 eggs per mass.

Nymphal stages. Five immature stages are passed before the insect becomes adult. First instar nymphs (*Figure 1A*) tended to remain in the vicinity of the egg masses, but older nymphs moved onto the older fronds of an infested palm. All nymphs, and especially the first instars, have two very long, waxy filaments extending from the posterior end of the abdomen but these frequently break off even under natural conditions. Each of the nymphal stages has two horizontal red bands on the frons, and two longitudinal red bands on the prothorax. There is much variation in the duration of the nymphal instars (*Table 2*), but on average, the nymphal period lasts about 12 weeks.

Table 2.—**Duration of various life cycle stages of *Z. lobulata***

Life history stage	Mean duration (days)	Range (days)	No. of measurements
Egg mass	8.3	7 - 10	27
1st instar	12.9	3 - 17	191
2nd instar	8.2	4 - 14	131
3rd instar	17.9	11 - 27	112
4th instar	17.7	7 - 35	50
5th instar	25.4	13 - 37	32
Egg to adult	85.9	69 - 112	30

Adult. Both sexes of *Z. lobulata* were described by Ghauri (1966). The adults (*Figure 1B*) are 16-18 mm in length, brownish in colour and also have the two horizontal red frontal bands. A characteristic black spot with a sub-central white dot is easily noticeable on the apical portion of the tegmen.

FEEDING HABITS AND ALTERNATE HOSTS

The insects are mainly found on the oldest frond on the palm, and are most abundant on the lower surface of the petiole and to a lesser extent, on the terminal portion of the frond. The central area is usually less densely populated. Most feeding occurs on the petiole, midrib or central veins of the leaflets. In some cases, extremely heavy infestations of leafhoppers occur, and populations exceeding 1,000 per frond have been recorded on several occasions.

Besides coconuts, the leafhopper has been observed in moderate numbers on betel nut (*Areca catechu*) and on granadilla (*Passiflora quadrangularis*) (Bourke *et al.* 1973). Adults and nymphs have also been reported from pandanus (probably *Pandanus lerum*).

NATURAL ENEMIES

It is probable that a range of general predators feed on *Z. lobulata*, but only one unidentified salticid spider has actually been observed preying on a nymph. Two species of wasp parasitoid have been reared from egg masses of the coconut leafhopper. In the Popondetta area about 10% of all eggs in one egg mass collected from a leaf of cultivated sugar cane (*Saccharum officinarum*) were parasitised by an unidentified micro-hymenopteran (gen. nr. *Epiencyrtoides*, Fam. Encyrtidae). During 1973, egg masses of *Z. lobulata* in areas near Finschhafen were found to be heavily parasitised by another encyrtid wasp, *Ooencytrus malayensis* Ferriere, an

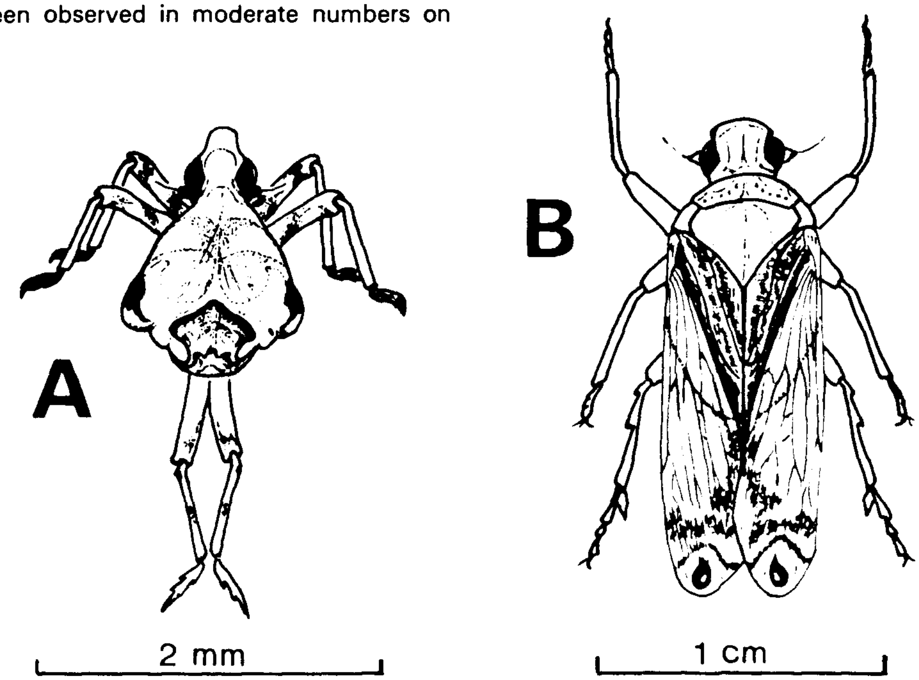

Figure 1.—Zophiuma lobulata **Ghauri**
A — first instar, B — adult

egg parasitoid of several hemipteran and lepidopteran pests in Papua New Guinea (Sands 1977).

The level of egg parasitism by *O. malayensis* was measured over a 10 month period from September 1973 to July 1974 in two localities of the Finschhafen area (*Table 3*). It ranged from 45 to 82% and averaged 65.5% and 69.9% of all eggs sampled in the two localities. It seems that, at any given time, there may be wide variation in levels of parasitism between different sites in the Finschhafen area. Two species of entomophagous fungi have also been collected from *Z. lobulata* at Finschhafen (infected nymph) and Popondetta (infected adult) and are awaiting identification at the Commonwealth Mycological Institute.

POSSIBILITIES OF CONTROL

A major difficulty with coconut pests is that the crop has a relatively low value per hectare, so that effective control treatments are often uneconomic to apply. Several small- scale spraying trials at Finschhafen showed that Ultra Low Volume malathion applied through a misting machine achieved good control of adult and nymphal *Z. lobulata* on young palms five to seven metres in height for up to two weeks, and it is probable that aerial spraying using this insecticide would be effective. However, ULV malathion had no ovicidal effect and a follow up spray two weeks after the first would be required for effective control (DASF 1972). In recent years, several coconut pests have been controlled by trunk injections of the organophosphate insecticide monocrotophos, which is effective against frond feeding (Stelzer 1970; Rai 1973; Ooi *et al.* 1975) and sap sucking insects (Perry, pers. comm.). It is likely that this or other systemic chemicals would be effective against *Z. lobulata*, but the considerable costs involved would probably preclude treatment except in very damaging infestations or in a small outbreak area.

A very similar coconut disorder in Solomon Islands appears to be associated with the lophopid *Painella simmondsi* Muir. When palms infested with *P.*

Table 3. — **Rates of parasitism in *Z. lobulata* eggs collected from two localities in the Finschhafen area**

Locality and collection date	No. egg masses collected	No. and type of insect emerging from eggs			
		Nil	Leafhoppers	Wasps	%Parasitism
ELIMO					
September 1973	120	10	1,388	1,292	48.2
October 1973	100	10	926	3,811	80.5
November 1973	100	16	1,387	1,138	45.1
January 1974	107	11	1,158	2,235	65.9
February 1974	116	12	777	2,340	75.1
April 1974	110	18	1,053	2,653	71.6
June 1974	101	4	763	2,668	77.8
July 1974	120	12	2,116	3,242	60.5
SALANKAUA					
September 1973		—	—	—	—
October 1973	70	38	164	670	80.3
November 1973	87	32	283	1,311	82.2
January 1974	124	11	879	2,608	74.8
February 1974	119	17	660	2,247	77.3
April 1974	120	29	568	1,127	66.5
June 1974	80	13	929	777	44.9
July 1974	120	5	1,661	2,888	63.5

simmondsi were injected with monocrotophos, all leafhoppers died or disappeared within 24 hours, and the treated palms recovered several months before a general recovery in the affected block began (Stapley, pers. comm.).

Attempts at biological control may prove successful, and would of course be preferable in the long term. It may be possible to collect parasitised leafhopper egg masses from 'non-out-break' areas in order to release the emerging parasites in badly affected coconut blocks elsewhere in the Finschhafen area. If the parasitised egg masses are held for emergence in a container covered with a medium size mesh (e.g. 1 mm x 1 mm), the parasites could escape through the holes, leaving the newly hatched leafhoppers trapped in the container in which they could easily be destroyed. Introductions of the other encyrtid parasite (gen. nr. *Epiencyrtoides*) could also be made to the Finschhafen area, and if parasites of *P. simmondsi* are found, they could perhaps be introduced to Papua New Guinea for laboratory screening against *Z. lobulata*.

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