From JC.

BIOLOGY OF THE JARRAH LEAF MINER (*Perthida glyphopa*)

The Jarrah leaf miner *Perthida glyphopa* (Lepidopt : Incurvariidae) is a parasite of the jarrah (*Eucalyptu marginata*) forest of Western Australia. Its range ha been defined to the north as far as the Murchison River, south to Augusta and east to the Stirling Ranges. Figure 1 shows areas of this range where damage by *P. glyphopa* has occurred.

Life history of *P. glyphopa* is described as univoltine (Mazanec, 1980) and consists of a cycle exemplified by Figure 2: Life Cycle of Jarrah Leaf Miner. This cycle was described by Wallace (1970) as lasting for twelve months and consisting of egg, four larval instars, pre-pupa, pupa and adult phases. Reference to Figure 2 will help the description that follows.

Each adult female has two ovaries with four polytrophic ovarioles joined by terminal filaments containing equal numbers of mature and immature eggs. The germarium is the site of egg development from primordial cells which differentiate into oocytes and a nurse cell. This nurse cell provides oocyte nourishm until the follicular cells formed around the oocyte, take on this role. The follicular cells later form the chorionic layer of the egg which is barrel shaped and has dimensions of 0.27mm in length and 0.17mm in width. Figure 3: Ovary of the Jarrah Leaf Miner shows these structures in detail.

The female moths wait in the forks and a of the trees and are located there by the male. Immediat by after mating time of two to three minutes, the fem makes close contact with a leaf surface by bending

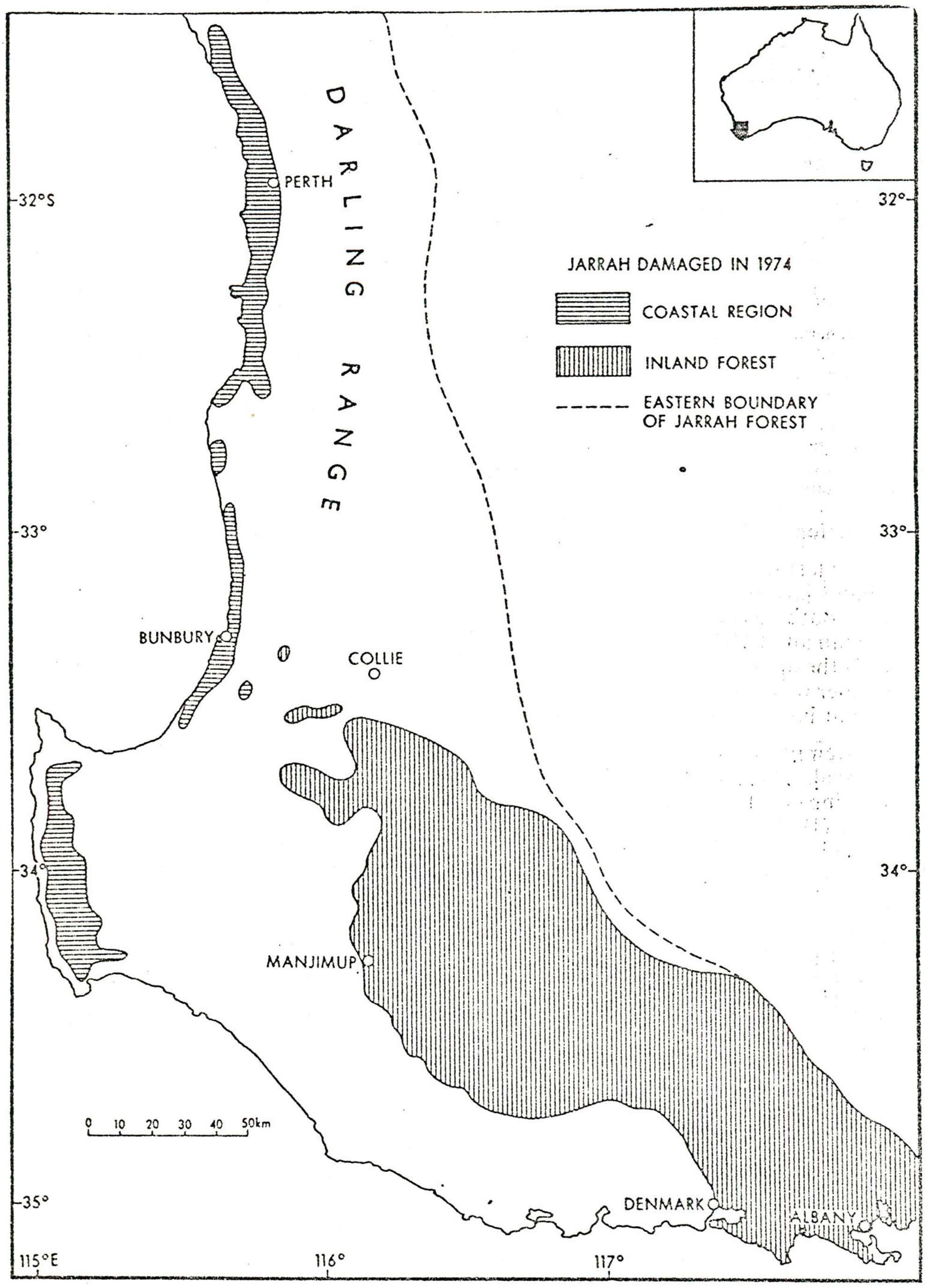


FIG. 1—Areas of damage by the jarrah leaf miner.

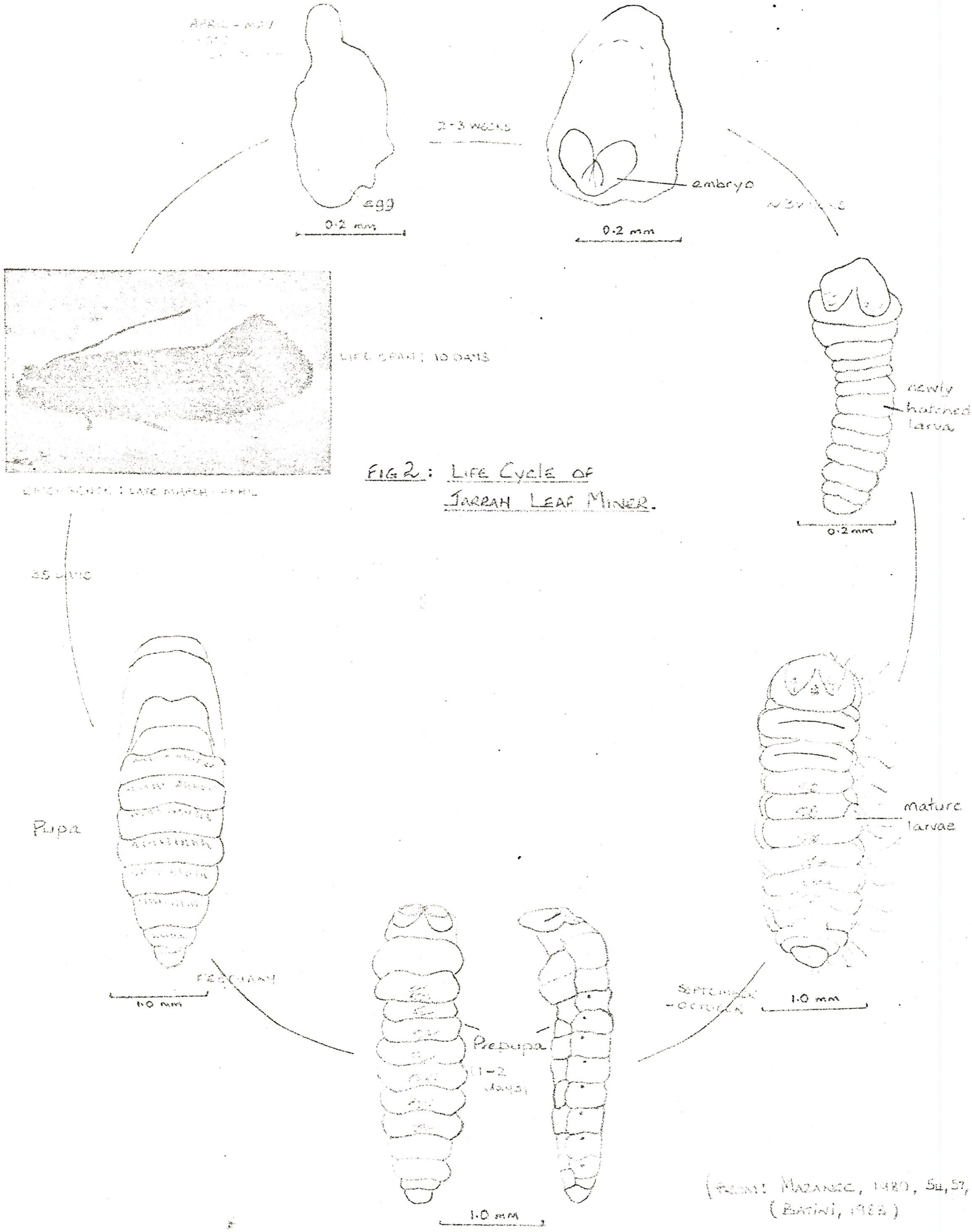
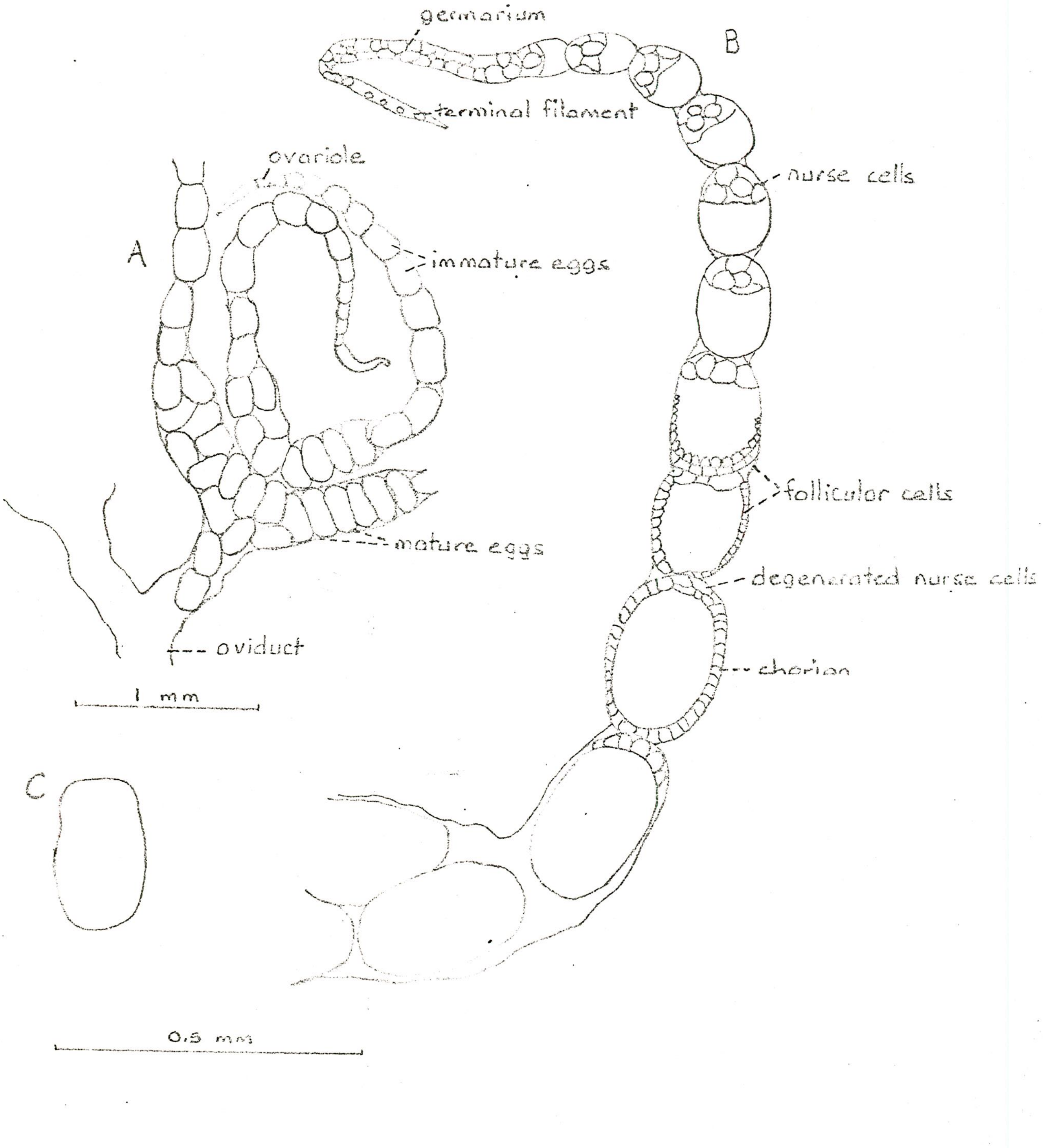


FIG 2: Life Cycle of Jarrah Leaf Miner.

(FROM: MAZANEC, 1980, 56, 57, 69)
(BATINI, 1988)



<u>FIG 3</u> : <u>Ovary of the jarrah leaf miner</u>

A. A portion showing the arrangement of mature and immature eggs
B. The development of eggs in the ovariole
C. The shape of mature eggs.

(FROM: Mazanec, 1980, 54)

the abdomen at 90°. Drilling through the cuticle and leaf epidermis she oviposits after separating the palisade - epidermal layer, a time span of approximately 150 seconds. A single egg is deposited and the female moves to another site on the same leaf.

The deposited egg becomes flattened and within two days of egg deposition the dislodged leaf epidermal cells die and dry out. The egg then swells and develops a pear shape on the leaf lower surface. After two - three weeks an embryo is observed present, formed in the centre of the egg. This embryo develops into a larva, recognizable by a brown sclerotized head, which commences to move and feed on the egg liquid, followed by the chorion and finally the leaf tissue. Eclosion of the larva occurs six weeks after egg deposition and is of low tolerance to high and low temperatures.

The first instar larva feeds on the palisade and mesophyll tissues between the two epidermi. At the second instar, small veins of the leaf are cut, oil globules and frass are compacted by mandibles into old sections of the mine and the cleaned mine is lined by silk. The fourth instar larva matures after the third moult. This larval feeding occurs from late May through to September/October.

The mature larva constructs a cell to spend summer by lining both surfaces of the mine with silk. The dry remains of palisade tissue are bitten out in semi-circular fashion and fastened with silk. An elliptical chamber fastened to the leaf by two silk threads is the result of this activity.

At night the larva cuts the threads and the cell falls to the ground; this requires no leaf moisture present. On grounding, the larva protrudes from an unsealed portion and seeks moist, organic laden sandy soil. It burrows head first drawing the cell to a depth of 20 to 30 mm. once buried the larva withdraws into the cell and seals itself in by silk and remains positioned with its head towards the surface. The larva enters diapause for five months (affected by temperature and photo-period) until the end of February when the pre-pupal stage (one - two days) is entered followed by full pupation. The adult moth emerge April to May, with males emerging before the females. Figures 4A and 4B show stages of the larval feeding in mines and evacuated mines.

The adults are small inconspicuous grey Lepidopterous insects, three to five mm in length having a wingspan of 7mm and a lifespan of 10 days. Figure 5 shows the form of an adult moth displayed with wings fully extended. The female is more robust and has a stout truncated abdomen of average length 4·17 mm; while the male has a more slender abdomen with two claspers, of average abdomen length 3·55 mm. Little adult dispersal occurs and congregation takes place in the outer extremes of crowns and new leaves. The adults feed from leaf and twig surfaces. Adult *P. glyphopa* shelter in litter or in bark crevices becoming active on warm dry days. The females prefer leaves in warm sunny positions and select young leaves four to six months old over leaves one to two years old. Some dispersal occurs due to

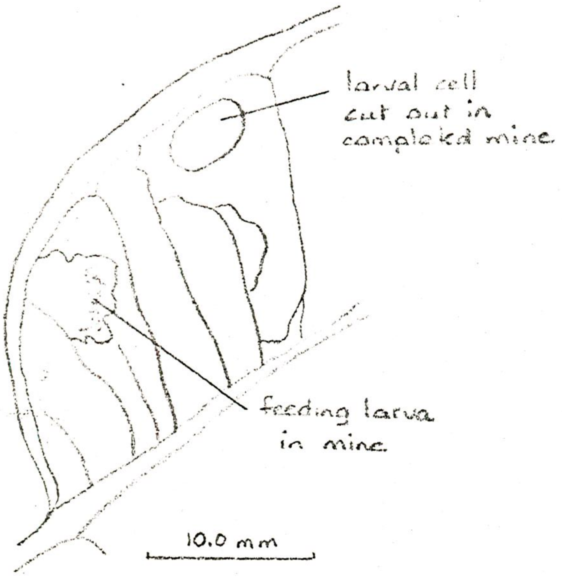


FIG 4 : A. Portion of Jarrah Leaf
showing mines

(FROM: MAZANEC, 1980, 57)

B. JARRAH LEAVES SHOWING
EVACUATED MINES.

(FROM: MATTINI, 1983)

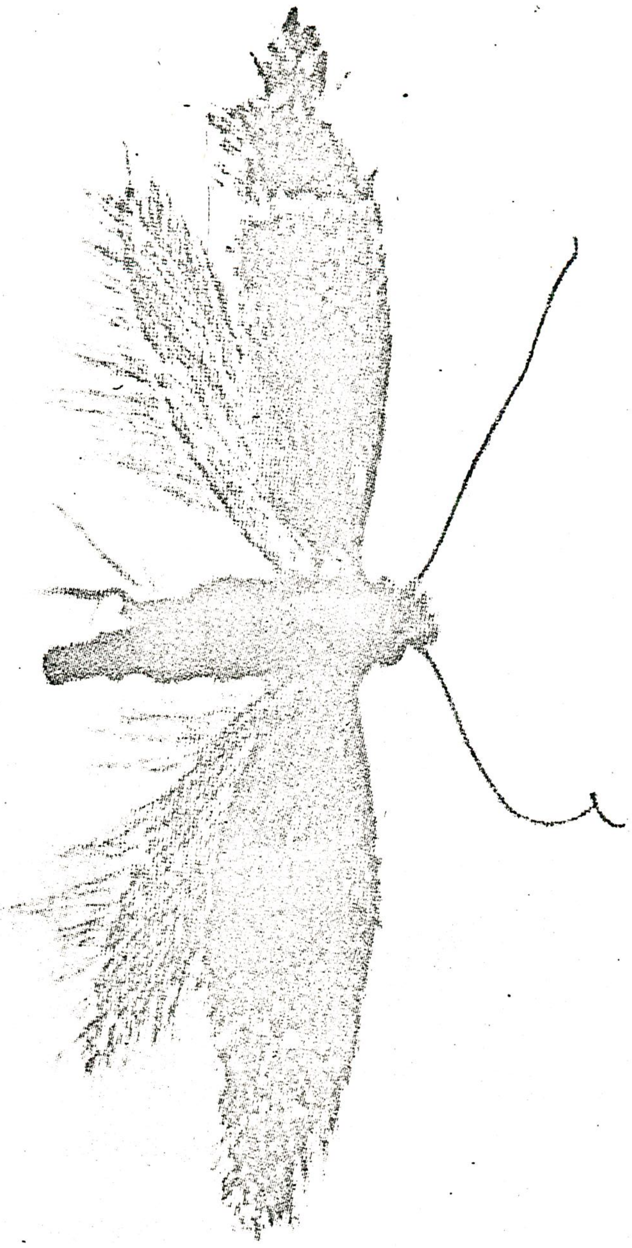


FIG 5: Adult Moth (16x)

(FROM: JENKINS AND CURRY, 1971, 123)

wind assistance when the adults are active.

PEST STATUS.

The Australian eucalypts suffer far greater damage from insects when compared to trees of the northern hemisphere. According to Mazanec (1980) this is due to their growth habits ie allowing phytophagous insects to attack trees throughout their growth cycle. Pate and McComb (1981) expand on this concept by referring to the importance of lignotubers of eucalypt seedlings acting as regeneration pools for harsh environmental conditions. Rapid eucalypt growth occurs after stress and insects are able to maintain a food source due to this adaptive mechanism. The shoot may die back many times but will be continually replaced from dormant bud strands in the woody ma

This supports the view expressed by Pate and McComb that insect predation evolved opportunistically in response to adaptations already developed by eucalypts. These nutrient reserves found in sapwood give rise to flushes of new growth even if soil nutrient levels are very low. Continual growth attracts insect populations and even when insect predation restricts growth benefits accrue in the form of recycling of nutrients. An alternative view expressed by Springett (1978) (Pate and McComb p
is that the high level of insect grazing compensates

by efficient conservation of nutrients in the eucalypt biomass by rapidly recycling a proportion of the available nutrients via a frass mineralization pathway. This view suggests that insects, such as *P. glyphopa*, allow eucalypts to maintain life in poor nutrient status sites. This is especially important for *E. marginata* as it subsists on poor soil sites of lateritic origin.

Whatever view is accepted as to the original evolution of this particular insect parasite, the damage done to *E. marginata* is reported to be widespread. Mazanec (1981b) identifies the present area of forest and partially cleared land on which jarrah is being damaged as approximately 19 000 square kilometres, an increased of nearly 5 000 square kilometres as reported by Mazanec in 1980. Batini (1983) points out that two other leaf miners may be confused with *P. glyphopa*. Thus the total area identified as being affected by P. glyphopa may be exaggerated by the presence of these other "mine" producing parasites. Pate and McComb (1981) emphasize that as *E. marginata* occurs predominately in pure stands this provides optimum conditions for *P. glyphopa*. The area affected by this parasite needs to be further delimited to identify if *P. glyphopa* is the only source of damage. Alternative evidence needs to be presented to indicate if the areas affected by *P. glyphopa* are pure stand *E. marginata*. This would enable identification of the extent of pest status of *P. glyphopa* with respect its other host complexes.

P. glyphopa has been identified by a number of authors as being the causal agent of mine based damage outbreaks in *E. marginata*. Mazanec (1980) identifies significant outbreaks in 1914, the 1920's, the 1950's and a current outbreak located around Perth, west of the Darling Range; Mt. Barker, west of Manjimup; south of Collie and north of Albany. *P. glyphopa* has been recorded by Neumann and Marks (1976) who cite Neumann and Clarke (1920), Wallace (1970) and Mazanec (1974). Thus *P. glyphop* status as a pest of some recurring significance has been well documented.

Actual damage to the host species appears to be incapacitating the tree only for a limited period. The trees survive repeated attacks due to the timing of the damage and uneven distribution through the crown. Damage occurs by larvae prior to annual leaf production; new leaves produced after the attack provide *P. glyphopa* with a recurrence of habitat for the next generation. Mazanec (1981a) reports that repeated attacks by *P. glyphopa* reduces wood increment and permanent crown damage. This will influence the production of eggs as quantity and quality of food, and overcrowding decrease fecundity. Mazanec's observations indicate that food shortage is not a serious problem but weather directly affects the flights of moths; as does low temperature, decreasing activity and reducing female opportunity to deposit eggs. Severe infestations not only interfere with food production and transpiration, checking growth and also rendering the tree susceptible to secondary attacks.

Thus the status of *P. glyphopa* as a pest can be directly and indirectly related to influences on the host species.

Mazanec (1981 b) and Wallace (1970) found that not all trees are attacked to the same extent, some trees being more "resistant" as mines with dead larva were present. Wallace compared "resistant" trees to "susceptible" on the basis of damage received and numbers of larvae hatching; no reason for resistance was stated. Mazanec postulates that resistance may be due to trees being less attractive to female *glyphopa* due to lack of chemical stimulus from the leaf or a physical barrier to oviposition, with resistant trees responding rapidly, forming fast healing tissue around mines and so restricting feeding larvae. Mazanec (1974) established that 23% of trees appear resistant and use epicormic growth as a possible defence mechanism to overcome attacks. However, the influence on susceptible trees was established by four years (1968-1971) of measurements on girth increments. Susceptible trees seem to be decreasing from 64 - 83% in forest and 33 - 47% on coast plain sites, less influenced by insect density. Again evidence such as this suggests *P. glyphopa* warrants classification as a pest, especially if the forest areas affected are utilized as millable stands and are required for exploitation for forestry purposes.

Adding to the problem of *P. glyphopa* pest status is the various protection mechanisms that enable it to be successful in the host species. Factors that enhance survival are stated by Mazanec (1980) as including : • single egg deposition

- egg placement under the lower epidermis so resisting enemy and insolation damage.
- water absorption from the leaf.
- palisade placement reducing predator contact.
- shelter from the mine structure against predation and dessication.
- diapause underground enabling shelter and protection.

If these factors are linked with P. glyphopa ability to respond to tree growth patterns, then these adaptations enhance its pest status, making forms of control difficult, expensive and with reduced chance of success.

Wallace (1966) identified the components of P. glyphopa life system where the susceptibility for control may be selected as host/forest situation; climate (temperature and rainfall) and natural enemies (parasites and predators). Chemical treatment of control where also attempted with mixed results. Wallace (1966) attempted control by injection of host with systemic insecticide, Dicrotop which proved 100% effective in trial but aerial applications failed. Van Didden (1967) conducted aerial spraying with dimetheate and achieved mortality of P. glyph larvae. The prohibitive cost of killing 80% of the larvae (≈$70 per acre) made the widespread use of this uneconomic. Control of P. glyphopa reported in Rural Research (1967, 60, 17-18) by trunk injection of 30% emulsifiable concentrate of dimetheate (Rogor 40) was found to control the pest in E. marginata and E. calo. However the area under infestation and the scope requi to control *P. glyphopa* by this method is impracticable. Chemical methods utilized to date do not appear to be successful as a large scale control strategy.

The feasibility of use of natural and biologi control is being considered. Changes to the tree/forest conditions favourable to *P. glyphopa* are affected by forestry pursuits but any change in this area would be of minor immediate significance. Reliance on control utilizing climatic factors is unpredictable and of negligible application. Use of natural enemies has been studied by Mazanec (981b) and a number identified. These include internal parasites, external parasites and direct predators. Only one internal parasite and none of the external parasites are host specific to *P. glyphop*. Predation by silvereye, pardalottes, thornbills, honeyeaters, red wattle bird and 28 parrot is constan from year to year. However, Mazanec concludes that control through natural predators is not promising. Geographic distribution of *P. glyphopa*, dependance on the weather for their life cycle and alternate hosts allows the maintenance of low population densities. Furthermore, the ability of *E. marginata* to recover from damage and provide *P. glyphopa* with new leaves, even after repeated attacks, favours the continuation of outbreaks.

REASONS WHY DEVELOPED TO PEST STATUS.

For an analysis to establish why *P. glyphopa* has become a pest of *E. marginata*, especially in pure stands, the nature of the pest species must be summarized. It is an organism that is opportunistic, able to extract full benefit from immediate and localized changes in the jarrah forest. Factors that contribute to its life system: temperature, rainfall, larval survival mechanisms, oviposition times, parasitism and predation all tend to enhance its ability to take full advantage of its opportunities. Coupled with adult dispersal enabling colonization, reduced fire effects on diapaused larva and high fecundity makes it a formidable parasite. The success of *P. glyphopa* is primarily due to environment and the growth cycle of the host, plus the parasites own life cycle attributes. Both the host and pest have "in tuned" cycles (Mazanec, 1980) benefitting the pest species.

Florence (1981) quotes Chilvers and Brittain (1972) as postulating an "ecological feedback mechanism" whereby soil organisms and leaf eating insects might regulate species mixtures. The theory states that where environmental conditions fall below the optimum for a given species, that species is likely to attract a larger than normal complement of antagonistic or parasitic organisms. Where clearing, thinning and fire has gone through *E. marginata* stands and optimum conditions no longer exist for E. marginata then P. glyphopa can capitalize and greatly increase its population density.

Natural enemies such as parasites, birds and predacious insects have been unable to respond as rapidly and so do not influence P. glyphopa populations in proportion to their increase. The conditions of the forest, described in earlier sections, are now conducive to egg laying and adult dispersion. Thinning and clearing allow rapid increases in eggs and as population density has been found to depend on the number of eggs the female produces and how the female distributes eggs, a rapid increase of P. glyphopa results.

Finally, reasons why P. glyphopa has become a serious pest of the jarrah forest may be best summed up this concluding paragraph from Mazanec (1981d).

"The most important feature of egg deposition by the leafminer females is their ability to respond to the local conditions of the forest. In the outbreak and adjacent non-outbreak areas the response is directed toward situations where new leaves are more abundant in relation to the surroundings and where the forest canopy has become a more preferred habitat as a result of thinning and partial clearing. The response aids the maintenance of old outbreaks by rapid re-invasion of areas recently depopulated by fire and also initiation of new ones in situations adjacent to the source of moths."

Thus man's influence on the E. marginata and other forest habitats seems to have enhanced P. glyphopa and raised it to pest status of increasing [illegible].

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