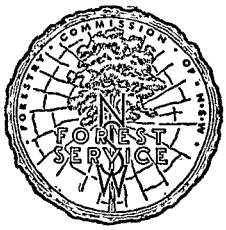

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The Cypress Pine Sawfly Subspecies *Zenarge turneri turneri* Rohwer and *Zenarge turneri rabus* Moore

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SYNOPSIS

During investigations into the taxonomy and biology of the cypress pine sawfly, previously known as *Zenarge turneri,* and which had caused extensive damage to stands of *Callitris hugelii* (Carr.) Franco on several State Forests in western New South Wales, on experimental plots of that host in highland and coastal districts and on ornamental *Cupressus* and *Callitris* spp., the sawfly species was found to consist of two subspecies.

The morphology, biology, distribution and hosts by which the subspecies may be determined, are given, and the revised taxonomic position has been presented previously (Moore 1962)a.

INTRODUCTION

Numerous species of sawflies occur in New South Wales, but *Zenarge turneri turneri* Rohwer and *Zenarge turneri rabus* Moore are the only sawflies recorded as attacking *Callitris* and *Cupressus* spp., and they are host-specific to these two genera. Large areas of the indigenous *Callitris hugelii* (Carr.) Franco (white cypress pine), and ornamental *Cupressus* and *Callitris* spp. have been severely attacked by sawfly larvae.

Experimental plots were planted with *C. hugelii* in several coastal and highland areas by the Forestry Commission of N.S.W. during the years 1936 to 1945, to determine the suitability of this species for planting in areas other than west of the Great Dividing Range where it occurs naturally.

Defoliation of this species by the cypress pine sawfly in western districts and in some of the experimental plots increased in severity during 1954, when it was observed that the coloration of female adults occurring in the experimental plots resembled that of the western specimens. The biology of the sawfly populations occurring in the various environments was then investigated.

From an examination of a large series of specimens of this insect collected throughout its known range of distribution in New South Wales during the incidence of large populations on State Forests, and an examination of its biology, it was determined that the description given by Rohwer was not applicable to specimens occurring in the western districts, and its biology was dissimilar in various environments.

On this evidence, the subspecies occurring naturally on the coast and highlands is now known as *Zenarge turneri turneri,* and the subspecies occurring in western areas as *Zenarge turneri rabus.*

BIOLOGY

(*a*) Hosts

Attack on the following hosts has occurred in the field:—

Z. t. turneri : *Cupressus macrocarpa* Hartweg
C. macrocarpa 'Aurea' cultivar.
C. m. lambertiana 'Aurea' cultivar.
C. sempervirens L.
Callitris rhomboidea R. Br. ex A. et L. C. Rich.
C. endlicheri (Parl.) F. M. Bail.
C. muelleri (Parl.) F. Muell.

Z. t. rabus : *Callitris hugelii* (Carr.) Franco.

Z. t. turneri has apparently attacked *Cupressus* spp. since their introduction into this country during the early nineteenth century, but *Z. t. rabus* is not known to attack species of this genus.

(*b*) Distribution

Z. t. turneri and *Z. t. rabus* are apparently confined to eastern Australia.

Armidale, on the Northern Tablelands, is the most northern area from which *Z. t. turneri* has been collected, and Mt. Rosea in the Grampian Mountains in Victoria, the most western and southern area. It is recorded from the following localities:—

Costal areas: Killara (type locality) 400 ft. altitude; Sydney; Pennant Hills; Maroota; Galston and Broke.

Highlands: Armidale (3,265 ft.); Wentworth Falls (2,844 ft.); Woodford (2,000 ft.); Kulnura (1,000 ft.).

Z. t. rabus is recorded from the following localities:—

Coastal areas: Mandalong (approx. 100 ft.), a Forestry experimental planting of *C. hugelii* on Olney East State Forest.

Highlands: Olney East S. F. (1,500 ft.); Red Hill S. F. (2,000 ft.). These are both Forestry experimental plantings of *C. hugelii.*

Western areas: *Z. t. rabus* is widespread from near Coonamble in the north-west to beyond the N.S.W.-Victorian border, and east of a line drawn approximately through Walgett and Hay, to the western slopes of the Great Dividing Range (see map). About one million acres of *C. hugelii* in the Pilliga Scrub (Baradine Forestry District) are beyond the area of known distribution.

(*c*) Damage

Complete defoliation of large trees and young regeneration of *C. hugelii* has occurred in the same area on State Forests, but young regeneration appears to be preferred to older trees. Large trees and areas of thick regeneration occurring in low-lying areas where natural drainage is inefficient in abnormally wet seasons, appear to be most heavily attacked. Heavy attack also occurs on trees and plants in areas of low site-quality.

Severe damage to stands of large trees appears to be cumulative over at least two years and when a number of generations of *Z. t. rabus* occur in the field during consecutive seasons. Most trees recover readily from a single defoliation, and the evidence does not suggest that trees die from a single attack. Partial defoliation is usual in most areas, and there is usually good recovery of attacked trees. However, large trees and regeneration growing under conditions which may be considered as

unfavourable (i.e., near dams or on low-lying areas) have been heavily attacked with some mortalities resulting during a series of wet years. There is thus a correlation between site-favourability and freedom from attack, and trees previously debilitated are most readily attacked.

During some heavy infestations, adjacent trees or groups of trees are often free from attack; and it is considered that death of attacked trees is usually due to factors other than attack by sawfly larvae. Infestations by *Diadoxus erythrurus* White (cypress pine jewel beetle) often follow heavy attack by *Z. t. rabus* and kill many trees.

Although trees of *C. hugelii* have been reported as dying solely because of attack by *Z. t. rabus*, no evidence to support this could be found, although it is recognised that such attack may be a contributing factor to death of trees.

No consistent pattern of attack by either subspecies was determined. The upper foliage of some trees is attacked primarily, but damage may occur initially to the lower foliage on other trees.

Heavy sawfly attack during spring, summer and autumn on *C. hugelii* throughout western districts was correlated with the incidence of temperatures less than the mean monthly average, and rainfall greater than the mean monthly average during the years 1952 and 1954 to 1956. Numerous instances of heavy attack in the West Wyalong, Narrandera, Forbes, Dubbo and Gilgandra areas were reported during those years. From December 1956 to April 1958 dry weather conditions prevailed, and there was no attack by *Z. t. rabus*. The heaviest and most extensive damage, cumulative over previous consecutive seasons was apparent during 1956.

(*d*) Life-Cycle and Habits

The observations given below apply to both subspecies unless stated otherwise.

Adults of *Z. t. rabus* do not emerge in western localities during comparatively dry seasons, whereas on the coast, adults of *Z. t. turneri* usually occur each spring and autumn, or sporadic emergences may occur from August to May. In both areas emergences are apparently dependent on the occurrence of a winter rainfall associated with a considerable period of moderate temperatures during spring, summer and autumn.

The length of the life-cycle is very variable and is determined by the length of time spent in diapause as a prepupa, in the cocoon, which may be 2 weeks to 18 months for *Z. t. turneri* or 1 month to 6 years for *Z. t. rabus*. Three consecutive generations of *Z. t. turneri* have been reared during the one year on the coast; one generation during each of the spring, summer and autumn. Two generations usually occur in the one year at Armidale and Wentworth Falls in the highlands.

Female adults commence to oviposit almost immediately after emergence from the cocoon. When a suitable site for oviposition is selected, usually in the current or the previous season's growth, eggs are inserted in the tissues of the shoot near the base of the leaf-scales, and to approximately half way towards the next leaflet attachment.

Eggs are laid singly, and after each is oviposited the female usually flies to another shoot where the procedure is repeated. Eggs are thus more or less randomly distributed over the tree. When oviposited, the

eggs are about 1·3 mm. in length and 0·4 mm. in diameter. They are pale yellow, soft, translucent and arcuate, with one extremity rounded and the other tapering to a blunt point. They are often inserted less than half an inch from the tip of the growing shoot, but may also be inserted further along the shoots.

About 5 days after oviposition, the eggs become enlarged to about 1·5 mm. in length and 0·7 mm. in diameter, so that the plant tissues surrounding them are forced apart and becomes brownish-yellow to dark brown in colour. That portion of the chorion exposed by the separation of the tissues of the plant stem become grey. The pale yellow, partly formed embryo surrounded by an almost colourless fluid is visible through the transparent chorion. Approximately 100 eggs may be laid by a single female.

(*e*) LARVAE

The young larvae emerge from the eggs through the expanded slit in the shoot and commence to feed externally on the younger plant tissues at the side and below the tip of the shoot at 8 to 11 days after oviposition. The distal ends of attacked shoots then wither and die, and may fall to the ground. When a large population of larvae is present, the ground beneath the attacked tree may be strewn with shoot tips. Larvae feed singly on the foliage, and there is no evidence of gregariousness as is the case with species of *Perga*.

During the second and subsequent instars, larvae feed on the distal extremities of the shoots, with the posterior abdominal segments curled partly around the shoot below, and move backward down the shoot as it is consumed distally.

A recently emerged larva is cream to almost white, shiny and translucent prior to feeding. Female larvae soon attain a greater size than the male larvae. Four days after eclosion larvae are about 3·5 mm. to 4·5 mm. in length and when feeding on *C. rhomboidea* are shiny and pale yellow. Eleven days after eclosion they are about 5·5 mm. to 7 mm. in length, shiny and pale yellow, and at 17 days they are about 15 mm. to 18 mm. in length and pale to dark green, shiny and suffused with pale yellow. Thirty days after eclosion they are about 18 mm. to 25 mm. in length, shiny and dark green.

The coloration of larvae is partly influenced by the host plant. On the golden-foliaged varieties of *Cupressus* spp. young larvae of *Z. t. turneri* are at first yellow, becoming suffused increasingly with green until the fourth instar, and are yellow-green during the last instar. On most green-foliaged varieties of host plants the young larvae are yellow or yellow-green, the yellow becoming less evident and the green more evident during the second and subsequent instars. *Z. t. rabus* larvae feeding on *C. hugelii* are dark green, suffused blue-green on the prothoracic and eighth abdominal segments. They are usually glaucous and similar in colour to the host plant foliage.

The two posterior abdominal segments of larvae are usually yellow to orange, this colouring being more pronounced on specimens of *Z. t. turneri*, or specimens of *Z. t. rabus* feeding on the golden-foliaged *Cupressus* spp. These segments on larvae feeding on *Callitris* spp. are pale yellow, glaucous, or a paler green than the remainder of the abdomen. The segments are always of a darker yellow on *Z. t. turneri* than those on *Z. t. rabus* on corresponding host plant species.

Fourth instar larvae of *Z. t. rabus* transferred from *C. hugelii* to *C. macrocarpa lambertiana* 'Aurea' showed a slight colour change before pupation, the glaucous suffusion disappearing; larvae transferred in first and second instars remained yellow until the third or fourth instars when they became suffused with pale green similar to those of *Z. t. turneri* normally occurring on this host plant.

During the feeding period larvae pass through four instars and into the fifth, with a total larval period of 23 to 35 days. The fifth instar is completed within the cocoon as a prepupa. When fully fed, larvae crawl down the foliage, or tree trunk, at times falling to the ground. In large populations, they may collect in a mass near the base of the tree before entering the soil. Most fully fed larvae in all areas, leave the foliage to enter the soil between 8 a.m. and 11 a.m. From oviposition to the formation of the cocoon is about 24 days during February, or up to 40 days during April and May.

Larvae of either subgenus may be present during any month except July. As female larvae are larger than male larvae, there is intergradation in the sizes of larvae in each subspecies, but those of *Z. t. turneri* are about 5 mm. longer than those of *Z. t. rabus* of the same sex and age.

The length of last instar larvae is from 15 mm. to 25 mm., the width across the meso-thoracic segment is from 2 mm. to 3·5 mm., and the head capsule is black and shiny. There is a pair of six-segmented legs on each thoracic segment, those on the pro-thorax being shortest. The distal segment of each of these legs is without claws, but bears a distal pad. Pseudopods are on abdominal segs. 2 to 8 and 10.

(*f*) PUPAE

Pupation occurs beneath the soil in cocoons of a white, parchment-like substance, and occupies from about 8 days during February to about 15 days during August or April. Cocoons are usually separate in the soil unless there is a large population, and no evidence of grouping of cocoons has been found, as is the case with species of *Perga*.

Cocoons of *Z. t. turneri* vary in size from 10 mm. to 16 mm. in length and 4 mm. to 7 mm. in diameter; those of *Z. t. rabus* are smaller than those constructed by the corresponding sex of the former subspecies. Because of adherence of soil particles, cocoons are externally of the same colour as the soil in which they occur. Larvae usually form the cocoon at depths of from one to three inches below the soil surface, and beneath the spread of the foliage of the attacked tree, but in western areas some cocoons of *Z. t. rabus* were collected at a depth of 7 inches in sandy soil.

(*g*) ADULTS

The principal adult emergence periods are during August to November and March to May, the greater number of adults usually occurring during the latter period, although this is apparently dependent on prevailing weather conditions. Emergences of *Z. t. turneri* on the coast may occur more or less continuously from August to May. Males do not necessarily emerge prior to females.

Emergences of adults of either subspecies may be very sporadic or may overlap to such an extent that larvae of all instars, adults, prepupae

and pupae may be present at the same time during the spring or autumn months.

Parthenogenetic reproduction by females of both subspecies was determined, and all progeny reared were males.

(*h*) DIAPAUSE

Diapause occurs in the prepupal stage in the cocoons.

The period from the formation of the cocoon to the emergence of the adult may be as short as 20 days for both subspecies. It was no longer than 18 months for *Z. t. turneri,* but may be 6 years for *Z. t. rabus.* In specimens of *Z. t. rabus* collected at Olney East S. F. the length of time in diapause approximated that of populations of *Z. t. rabus* occurring in western areas, and it had remained apparently unmodified by the altered environment during 17 years. The sawfly was probably introduced to that State Forest with the original plants of *C. hugelii.*

(*i*) PARASITES AND PREDATORS

Parasites reared from sawflies collected from various localities were identified as *Delta* sp. (Tachinidae : Diptera) from Wentworth Falls; *Protomeigenia* near *froggattimyia* (Tachinidae) from the coast and highlands.

A minute parasitic wasp *Melittobia* sp. (Eulophidae) destroyed numerous cultures being utilised for experiments.

A species of the Ichneumonidae was bred from western specimens.

Adults of *Polistes humilis* F. (paper nest wasp) (Vespidae) attacked sawfly larvae feeding on *C. hugelii* and *C. rhomboidea* on the coast.

An adult of *Ommatius angustiventris* Macq. (Asilidae : Diptera) attacked flying male sawfly adults on the coast.

The small black ant *Iridomyrmex rufoniger* Lowne and the red and black jumping bulldog ant *Myrmecia nigrocincta* Smith both destroyed numerous larvae on the coast.

A number of prepupae in opened cocoons, held in closed petri dishes with soil, were attacked by lepidopterous larvae (probably of the subfamily Amphipyrinae : Noctuidae).

Larvae of *Syrphus viridiceps* Macq. (Syrphidae : Diptera), adults of *Oechalia schellenbergii* Guer. (Pentatomidae : Hemiptera), a spider *Theridion* sp. and the bird *Pachycephala pectoralis* Latham (golden whistler) were also predatory on larvae of the sawfly.

CONCLUSION

Rearing experiments utilised to compare the general biology, adaptability to various host plants, parthenogenesis, the ability of the two subspecies to interbreed, and an examination of the possible factors inhibiting the occurrence of *Z. t. rabus* in the Pilliga Scrub, are reported elsewhere (Moore 1962)b.

From the morphological characteristics of *Z. t. turneri* and *Z. t. rabus* and the phylogeny of *Callitris* spp. these sawflies are regarded as comparatively primitive insects, and from the biological investigations it appears that the subspecies are at present undergoing speciation.

Z. t. turneri would be unlikely to survive in the hotter and drier western districts because of its host plant associations, and restricted diapause limits which would tend to inhibit survival during long, dry periods normally occurring in those areas, whereas *Z. t. rabus* populations are apparently able to survive in the cool, moist highland areas (Red Hill and Olney East S.Fs.) and in the warm, moist environment of the coast (Mandalong and Pennant Hills). Diapause appears to be a critical survival factor in *Z. t. rabus*, as it is less inhibitory to its survival in the coastal and highland areas, than would diapause in *Z. t. turneri* to its survival in western areas.

The following common names for the two subspecies are now suggested:— "cypress pine sawfly" for *Z. t. rabus* and "ornamental pine sawfly" for *Z. t. turneri.*

To facilitate separation of the two subspecies, their biological and morphological characteristics are summarised:—

Zenarge turneri turneri	*Zenarge turneri rabus*
HOSTS *Cupressus macrocarpa* *C. macrocarpa* 'Aurea' *C. m. lambertiana* 'Aurea' *C. sempervirens* *Callitris rhomboidea* *C. endlicheri* *C. muelleri*	*Callitris hugelii.*
NATURAL DISTRIBUTION Coast and highlands.	Western slopes and plains.
SIZE Usually larger than corresponding sex of *Z. t. rabus.*	Usually smaller than corresponding sex of *Z. t. turneri.*
COLORATION OF FEMALE Hind tibiae with proximal ¼ white.	Hind tibiae all black.
LIFE-CYCLE Not longer than 18 months.	May continue for 6 years.

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Research Note No. 2 — A. G. Floyd, 1960.
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Research Note No. 3 — A. G. Floyd and H. C. Hayes, 1960.
N.S.W. Rain Forest Trees. Part I: Family Lauraceae.

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MAP OF

NEW SOUTH WALES

SHOWING THE

KNOWN DISTRIBUTION OF THE CYPRESS PINE SAWFLY

Scale 48 miles to 1 inch

Zenarge turneri turneri

Zenarge turneri rabus