NOTES ON MOSQUITOES OF NEW ZEALAND
I. MAORIGOELDIA ARGYROPUS WALKER (DIPTERA, CULICIDAE, SABETHINI)

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Investigations in Westland have produced evidence for arbovirus infections in man (Hogg **et al.**, 1963) in wild and domestic birds (Ross **et al.**, 1964). Ross **et al.**, (1963) have isolated viral agents from two species of mosquitoes, **Culiseta (Climacura) tonnoiri** Edwards and **Culex (Culex) pervigilans** Bergroth, which breed in very large numbers in Westland during the warmer months of the year.

Only one other species of mosquito has been recorded hitherto from Westland, the rare and aberrant **Corethrella novae-zealandiae** Tonnoir, which was collected by Tonnoir near Otira in 1922. During the last two years however, a sylvan species, **Maorigoeldia argyropus** has been found, both at Whataroa and the Okarito Lagoon, which appears to be one of the main foci of epizootic viruses in Westland.

Maorigoeldia is an endemic genus known only by the monotypic species **argyropus** Walker. The genus is placed in the tribe Sabethini, a primitive group of mosquitoes predominantly neotropical in distribution. They are almost entirely restricted to breeding places in dead and living plant material. A few species have become adapted to breeding in artificial containers, snail shells, and rock holes.

Belkin (1962) has discussed the systematic position of **M. argyropus.** It is regarded as one of the most primitive sabethines known, representing an ancient phylad becoming isolated in New Zealand in the same manner as **Opifex** in the geological past. Its closest relatives are the tree-hole breeding **Tripteroides** known from Eastern Australia and the Pacific Islands.

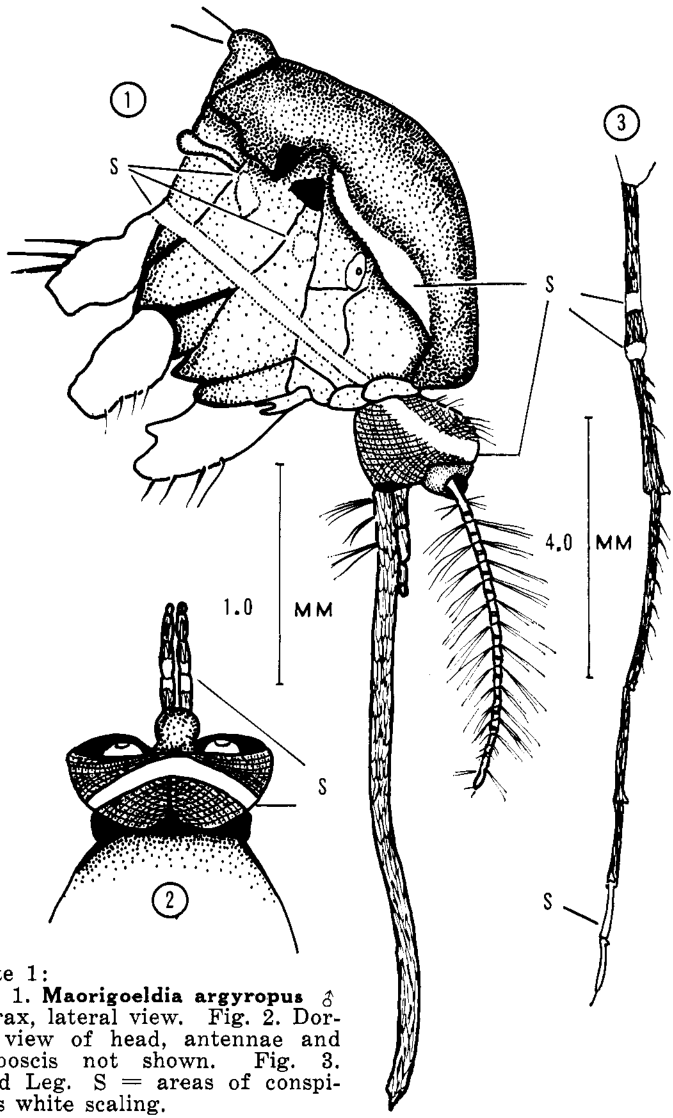

Plate 1:
Fig. 1. **Maorigoeldia argyropus** ♂ thorax, lateral view. Fig. 2. Dorsal view of head, antennae and proboscis not shown. Fig. 3. Hind Leg. S = areas of conspicuous white scaling.

Maorigoeldia has been previously recorded from Auckland, Ohakune, Wellington and Nelson. Larvae have been found in the Auckland area alone, breeding in water-filled wooden barrels and in galvanised water-storage tanks from sylvan surroundings (Graham, 1929).

Detailed descriptions of the adult and immature stages have been given by Belkin (1962; 1965). They can easily be distinguished from other New Zealand mosquitoes by their striking colour and ornamentation. Only a brief account of the main features of the 4th instar larva and the adult thorax will be included here.

The 4th instar larva is characterised by the following features: head light brown in colour, eye spots black. Thorax white and tubercules brown. The trumpet is clearly visible two to three days before pupation. Abdominal segments I-IV white or off-white. Segment V white to yellow. Segments VI-VIII yellow. The siphon is darker brown than the head capsule. Saddle same colour as head capsule.

The adult is distinctively ornamented with scales on scutum and pleuron. The white or pale-blue scaling presents a striking contrast to the darker exoskeleton. A scutal band of white scale extends from the fossa to the antalar region and another band runs diagonally from the anterior pronotal lobe to the metapleuron. Another semicircular band on the orbit of the eye. White scaling is also prominent on the leg (Pl. 1).

ECOLOGY

The larva of **Maorigoeldia** has been encountered in the field during the winter months both on the West Coast and the south-eastern coast of the South Island. A single 4th instar larva was discovered breeding in a quart-size preserving jar about 20 ft. high on a tree in the middle of a scenic reserve in Westland. The jar had been intentionally planted in the position a few months earlier to invite mosquito acivity as a routine investigational procedure in the study of vector biology of arboviruses in Westland. Another batch of 40 larvae were found in earthenware and other similar utensils from inside a stable trap used for mosquito trapping on the Okarito Lagoon. The trap was located on a well-shaded ledge on the bank of one of the creeks emptying into the lagoon (Pl. 2, Figs. 3 & 4) and the posts were used as feeding receptacles for fowls intended as bait to attract mosquitoes into the trap. Rain-water seeping through the plywood roof of the trap had collected on the floor and in utensils, which probably contained some wheat or remains of some other fowl-feed.

A further batch of 37 larvae were found in a forested area on the south-eastern coast of Otago, approximate latitude 46° 35′ S. Of these 34 were collected from two separate knot-holes in dead

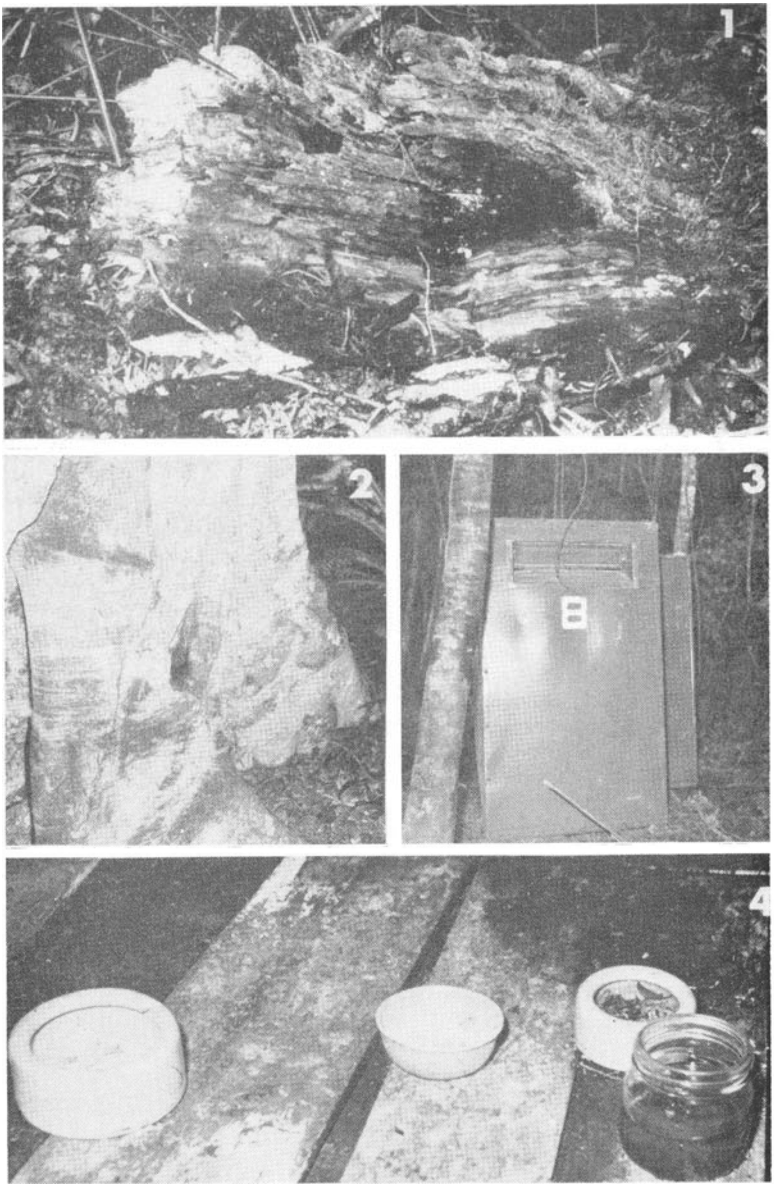

Plate 2: Fig. 1. Decaying **Nothofagus** stump felled to the ground; note central cavity which was filled with water contained 3 **argyropus** larvae. Fig. 2. Recess in living **N. fusca** stem containing water but no larvae. Fig. 3. Stable trap for catching mosquitoes Okarito Lagoon, Westland. Fig 4. Utensils inside Stable trap containing **argyropus** larvae.

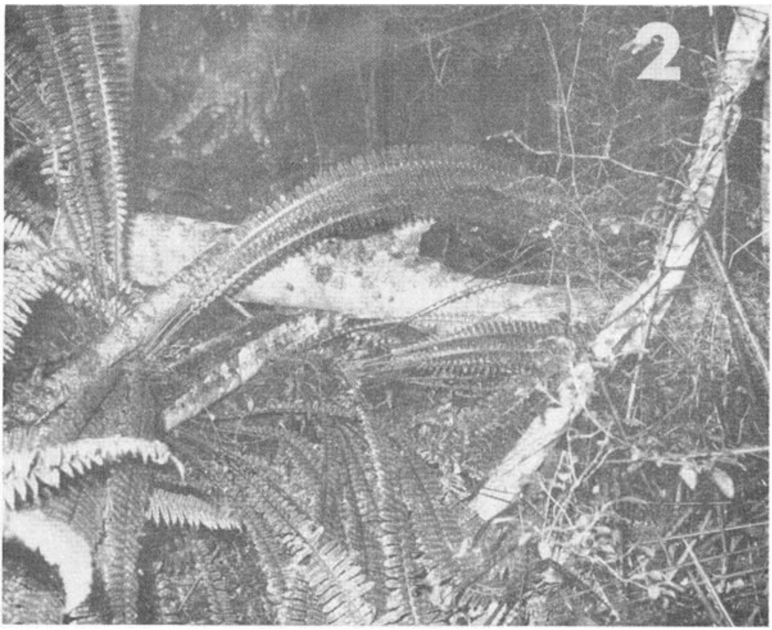

Plate 3: Fig. 1. Prostrate **N. fusca** log with knothole utilised by **argyropus**,. coastal broadleaf forest, S. E. Otago. Fig. 2. Dense growth surrounding the log.

limbs of a red beech **(Nothofagus fusca)** lying on the forest floor in a well-shaded situation (Pl. 3, Figs. 1 & 2). Three more larvae were found in the hollow of a dead bole of the same species of beech (Pl. 2, Fig. 1). The locality records and other relevant data are summarised in Table 1.

It appears that tree-hole-forming types of timber are either rare or absent altogether from the Westland forests. Though occasionally borer holes contain a narrow column of water these have been examined and found not to contain mosquito larvae.

In the coastal broadleaf forest of South Otago the red beech **(Nothofagus fusca)** in its decaying stages appears to provide both knotholes and cavities in the heartwood large enough to hold water. As many as 27 **Maorigeldia** larvae were extracted from a single knothole containing approximately a pint of water. The presence of **Cyclops** in the medium indicates the semi-permanent nature of the pool. By contrast cavities capable of holding water in living beech were rare. One was barely five yards away from a dead limb with a knothole containing larvae. The hole was situated about 18 in. from the ground in a recess of the main trunk (Fig 2, Pl. 2). About 300 cc of acidic medium (pH, 4.2) was extracted from this cavity, but it contained no larvae.

Water temperature of **Maorigoeldia** pools varied from 4.5°C in South Otago to 6.5°C in Westland. Although these recordings were carried out during the winter months there was no evidence of ice formation in any of the breeding pools. Outside the forest corresponding bodies of water in utensils or on the ground were found to be frozen on numerous occasions. All the larval finds in Westland and South Otago forest were from heavily shaded parts of the forest with ground covered in ferns or other forest-floor plants.

The batch of 40 larvae of all ages collected in Westland in early June were reared individually in the laboratory at an average daily temperature of 20°C. By the end of August (28 out of the 40) 70 per cent produced imagines, 4 larvae were continuing development, and another larva had died. Details of this rearing appear in summary form in Table 2.

In view of the higher temperature at which these larvae were reared as compared to the 6.5°C figure recorded when they were collected in the field, it was not clear at this stage what effect (if any) a lower temperature would have on the breeding. It seems likely that the larvae could be adapted to a lower temperature threshold of development as a mechanism to promote the winter cycle of **Maorigoeldia.** When a fresh batch of larvae were obtained soon afterwards from the South Otago forest it was possible to determine the effect of lower temperatures on development.

A group of 18 4th instar larvae collected on September 2 were divided into 3 batches of 6 randomly chosen specimens.

TABLE 1

TABLE SHOWING A SUMMARY OF DETAILS OF FIELD COLLECTION OF **MAORIGOELDIA** LARVAE IN WESTLAND AND SOUTH OTAGO, 1964-65.

Date	**Locality**	**No. of Larvae**	**Habitat**	**Temp. of Pool**	**pH Value**	**% NaCl.**
July, 1964	Whataroa	1 -4th instar	Agee jar (1 qt.) placed 20 ft. on tree	6°C	6.8	—
May, 1965	S. Otago	3 larvae	Hole in beech log **(N. fusca)**	6.5°C	6.5	0.0041
June, 1965	Westland Okarito Lagoon	2 -4th instar 40 larvae	Earthenware pots inside mosquito traps	6°C	7.35	0.009
June, 1965	S. Otago	8 larvae	Hole in beech log **(N. fusca)**	5°C	6.3	—
July, 1965	S. Otago	3 larvae	Hole in dead beech stump **(N. fusca)**	4.5°C	—	—
September, 1965	S. Otago	23 larvae	Hole in beech log **(N. fusca)**	4.5°C	7	.012

TABLE 2
SUMMARY OF DEVELOPMENT DETAIL OF BATCH 40 LARVAE COLLECTED FROM OKARITO LAGOON, WESTLAND, 6.6.65

Number pupated	35/40	(87.5%)	
Number adults emerged	28/40	(70%)	
Number dead pupa	7/40	(17.5%)	total mortality =8/40 (20%)
Number dead larva	1/40	(2.5%)	

Each batch was placed in a 300 ml polystyrene flask with the sides darkened with black paper to simulate treehole conditions. The medium consisted of 150cc of a mixture containing 1 part of treehole extract and 1 part distilled water. One batch was kept at 20°C, another at 7-10°C, and a third at 4°C, in a cold room. The results being as follows: The larvae in the 20°C treatment were far more active than either the 7-10°C or 4°C treatments. Movement in the 7-10°C batch was slow and in the 4°C one sluggish. By the end of September 5 out of the 6 specimens in the 20°C treatment produced adults and the fifth had reached the pupal stage. No such development was evident in the lower-temperature treatments even as late as the end of October (Table 3).

TABLE 3
SHOWING DEVELOPMENT RATE OF 4th INSTAR LARVAE AT 20°C, 7-10°C AND 4°C

Treatment	20°C	7-10°C	4°C
Number larvae in each Experiment	6	6	6
Number produced imagines in 4 weeks	6/6	0/6*	0/6*

* no developmental change observed after 8 weeks.

DISCUSSION

There seems to be little doubt that **Maorigoeldia argyropus** is strictly a sylvan species. The new distribution pattern which emerges from the present observations indicates that it is now confined to a number of relic areas where the endemic forests have been left intact (Pl. 4). In the pre-European era it was probably more generally dispersed at least in the coastal areas.

The effect of temperature on development, and the biological limitations imposed by its restricted habitat, are probably the key to our understanding the distribution pattern and bionomics of **Maorigoeldia.**

An average daily temperature in the vicinity of 20°C is probably well above the normal parameter for a **Maorigoeldia** pool,

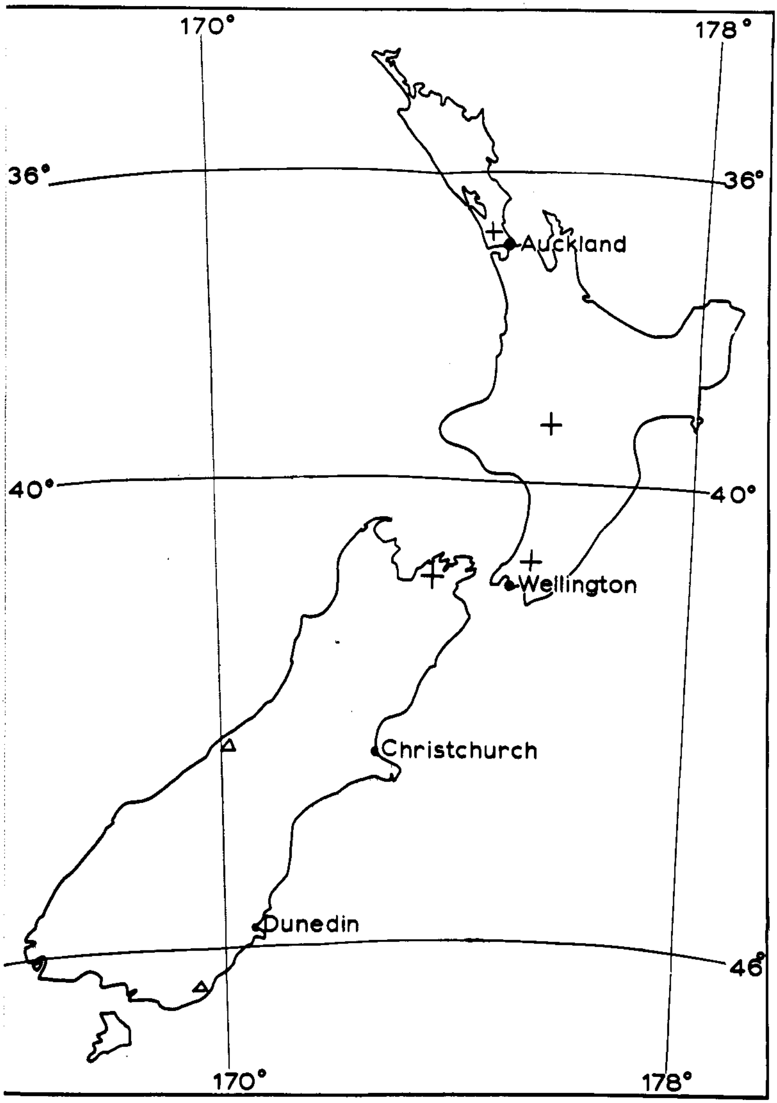

Plate 4: Known distribution of **argyropus** in New Zealand. +, after Graham (1929). ∇, new records.

situated as they are in sylvan surroundings, in Westland or in South Otago even under mid-summer conditions. The fact that the larvae grow more rapidly at this temperature than below it indicates that a favourable zone of temperature exists for the species at about 20°C. The survival of larvae at the lower range is equally significant, as this suggests that they are capable of tolerating temperatures well below their favoured zone of development. There is an obvious advantage in this adaptation, especially in mid-winter when the pool temperature probably descends to levels not far removed from 4°C. Temperature figures for **Maorigoeldia** pools in the North Island are unknown. However, owing to the latitudinal differences, they are likely to have a higher average than the south. Even the winter temperature parameter is liable to be more conducive for **Maorigoeldia** development in the north than in the south. In a place like Auckland this difference in environmental temperatures could give rise to more generations of **Maorigoeldia** annually. Some of the adults probably emerge even during the winter months. Indeed this appears to be the case, as shown by the presence of "hibernating" adults both in summer and winter months at the Waitakeres (Graham, 1929).

The finding of the larvae in winter months in Westland and South Otago is obviously an indication that the eggs are laid towards the end of the autumn in these areas. Presumably the larvae emerge during early winter and develop throughout the cooler season, the adults appearing during spring. There is no evidence to suggest that the larvae hibernate in the winter here. They simply continue development at a slow rate dependent on low temperature.

A winter adaptation to larval stage is a well-known characteristic of some culicids in the temperate zone. In the South Island **Aëdes (Ochlerotatus) antipodeus** Edwards and **Aëdes (Och.) subalbirostris** Klein & Marks follow this cycle (Pillai, unpublished observations). Several species in Europe and Britain pass winter in the larval stage (Bates, 1949). In the southern parts of Australia the Northern **Aëdes (Ochlerotatus) sagax** Skuse overwinters as larva (Dobrotworsky, 1965).

The finding of the larva in a tree-hole habitat is particularly significant. This is probably the original habitat of the species and is in keeping with the natural characteristics of the sabethines as a group. The paucity of the knothole—or rothole—forming type of timber in our native forest communities could account for a lack of success in previous attempts to link **Maorigoeldia** with a natural-container series. All the findings up till now have been in artificial containers. This is probably a (recent?) adaptation by the species.

In the South Island at least it is probable that the red beech **(Nothofagus fusca)** offers a limited access to a natural container for breeding. Under the forest canopy this type of habitat is unaffected by the sub-zero temperatures in midwinter, and a stable environment is achieved.

In the tree-holes water fluctuations are not as abrupt as in open-ground pools, and the change in the adult population is probably correspondingly more gradual. The slow rate of development under the climatic conditions of the south would rather restrict the population size of the species. Assuming that the adults emerge sometimes in spring, the largest concentrations of adults can be expected mainly before summer. Even so the density is unlikely to be anything resembling the peak populations of **C. (Climacura) tonnoiri** and **C. (Culex) pervigilans** experienced in summer months. The rarity could account for **Maorigoeldia's** absence from mosquito pools, and it is thus unlikely to play a significant role in the ecology of arboviruses.

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