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BREEDING OF THE CLERID *THANASIMUS FORMICARIUS* FOR THE CONTROL OF THE BARK BEETLES *HYLASTES ATER* AND *HYLURGUS LIGNIPERDA* IN NEW ZEALAND

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ABSTRACT

In September 1976, 214 adults and 165 larvae of the predatory clerid **Thanasimus formicarius L.** were received from the Commonwealth Institute of Biological Control station in Austria. A successful breeding and rearing technique was developed; by July 1977, 364 adults had been reared and by June 1978 a further 1081. Liberations have been made in several forests in the North Island (176 adults were released in 1977 and 616 in 1978) but no field recoveries have yet been made, and the breeding will continue for at least another year.

The difficulties encountered with the breeding are discussed, and suggestions are made on how the technique could be improved.

INTRODUCTION

In 1971 the N.Z. Forest Service negotiated with the Commonwealth Institute of Biological Control (CIBC) on the possibility of introducing parasites and predators for the control of *Hylastes ater* (Paykull).

Hylastes ater has been implicated in the mortality of regeneration and planted stock of pines in clearfelled and newly established areas. The chief problem with this bark beetle, however, is that it causes rejection of export logs. New Zealand's Forest Produce

Import and Export Regulations (1966) prohibit the export of insect-infested logs, and such material is either refused export or must be fumigated before it leaves the country. It has been estimated that, in the Bay of Plenty alone, *H. ater* can cause expenditure of up to $250,000 per year on fumigation. Infestations of this bark beetle and other insects in logs could be considerably reduced by changes in logging practices and improvements in forest hygiene, but it is not easy to change long-established customs. *Hylurgus ligniperda* (Fabr.), another European bark beetle, was found established near Auckland in 1973 and has spread rapidly north and south.

In 1975 the CIBC forwarded seven consignments of the pteromalids *Rhopalicus tutele* (Walker) and *Dinotiscus eupterus* (Walker). The former was successfully bred in the laboratory on billets infested with *Hylastes ater* and/or *Hylurgus ligniperda* and several hundreds were released. However, the ovipositors of these parasites could not reach bark beetle larvae developing under the bark in close contact with the soil, nor under bark thicker than 3 mm. For these reasons there was little hope that they would exert some control on the bark beetles (Zondag *et al.,* 1976). Breeding of the pteromalids was discontinued in November 1976 and all the parasites that emerged after this date were released. About 9000 were released in five forests in the North Island.

Because *Hylastes ater* and *Hylurgus ligniperda* breed mainly under that part of the bark in contact with the soil, a predatory beetle should be more effective than the parasites in controlling them. In 1933 three species of *Rhizophagus* (Nitidulidae) were introduced from England (Miller and Clark, 1935) but they have never been recovered.

The CIBC station in Austria located a source of *Thanasimus formicarius* L. and it was decided to introduce it into New Zealand in September 1976. Enough of its life history was known to develop a breeding technique compatible with the facilities and manpower available.

Specimens Received

The *T. formicarius* forwarded in September 1976 came from logs of *Pinus sylvestris* L. and *Pinus nigra* Arnold cut in June 1976 and exposed in the field at Innermanzing, Vienna Forest, until August 1976. The logs were then transferred to heated rooms and the emerging insects caught. A week before shipment to New Zealand the logs were dissected to check for further parasites and predators, but mainly to obtain larvae (Scheibelreiter, 1976). More pteromalids, *R. tutele* and *D. eupterus,* were also forwarded.

Between 13 and 28 September 1976 three consignments, totalling 214 adults and 165 larvae of *T. formicarius* and 230 live pteromalids, were received. Consignments took 2-3 days to arrive. The *T. formicarius* arrived in excellent condition, and soon after they were unpacked the adults were fed on live adult *Hylastes ater.* Many of them had attacked and consumed one or more *H. ater* before they were put on billets in cages in the temperature- and humidity-controlled (temp./R.H.-controlled) rooms. The larvae were placed in petri dishes with bark pieces and *H. ater* larvae.

The pteromalids, after being fed on a mixture of sugar and honey, were placed in breeding cages with others which had been bred here from previous consignments.

All other insects, such as a few weevil larvae and some scolytid larvae and adults which had been packed with *T. formicarius* as a food source were destroyed and all the packing material was burnt.

BREEDING AND REARING OF THE CLERID

Rearing Facilities

The *T. formicarius* adults were reared on billets infested with *Hylastes ater* and/or *Hylurgus ligniperda* and held in rearing cages in temp./R.H.-controlled rooms. The wooden-framed cages (approx. 0.5 × 0.5 × 0.5 m) were gauze-covered, except for the front which was a removable sheet of perspex with a small door, and the bottom which was hardboard. Temperature, humidity, and light in these rooms (2.75 × 2.90 m) were controlled by time switches. The temperature was maintained at 20-21°C from 0600 to 1800 hours and at 17°C for the remainder of the time. Light was provided during the daytime, and the humidity was set at 75%.

After the billets had been exposed to the insects in the cages they were transferred to wooden huts (4.20 × 3.00 m and 3.35 × 1.95 m); eventually four were used. Two huts were equipped with extractor fans and all had thermostatically controlled heaters.

Shaded sandpits and several "open-insectary" compartments were available for the storage of the billets and for the breeding of sufficient quantities of *Hylastes ater* and *Hylurgus ligniperda.*

Preparation of Billets

Billets 10-22 cm in diameter and 45-48 cm long were cut from *P. nigra* trees. Occasionally *Pinus radiata* D. Don billets were used, but *P. nigra* was preferred because its bark is thicker, it adheres better to the wood, and is not so easily damaged during handling. Care was taken to see that large knots were not included and the billets were often cut between the internodes.

The billets used in the breeding programme were buried up to about half their diameter for exposure to *Hylastes ater/Hylurgus ligniperda* attack in the sandy soils of Woodhill and Waiuku State forests, as those exposed in the pumice soils of the central plateau (e.g., Kaingaroa State Forest) were very often infected with a yellow basidiomycete fungus. This fungus, which is as yet unidentified, develops under the bark and renders the billets unsuitable for the growth of bark beetle larvae. The incidence of the fungus in sandy soils is practically nil. In order to avoid any possible contamination. *Hylastes ater* reared from logs attacked by this fungus were not used to feed *T. formicarius.*

After about 4 weeks the billets were examined; those that had obviously been attacked and contained eggs and small larvae were brought back to the Forest Research Institute. Sand adhering to the billets was removed and they were then placed vertically in the cages in the temp./R.H.-controlled rooms. About nine billets were placed in each cage, arranged so that they did not touch each other. Usually nine cages were used.

To help prevent drying of the wood, pieces of filter paper were placed on the tops of the logs and at the front of the cages. This was kept moist and the logs were sprayed twice a day during the week and once during the weekends.

Breeding

Some of the information on the life history of *T. formicarius* given by Escherich (1923) and Gauss (1954) and that supplied by Scheibelreiter (1976) proved useful in developing a suitable technique for breeding the insect.

After they had been sexed, the available *T. formicarius* were divided between the cages holding the prepared billets. To provide food, three to six live *Hylastes ater* adults per clerid were added to the cages every 2 days. The rearing cages were otherwise left undisturbed for 4 weeks. The billets were then removed and the *T. formicarius* adults collected. Usually these were hard to find and the scales of bark had to be removed before most of them were located and caught. After collection they were fed on some *H. ater* adults and sexed again before being placed back in the cages with the next batch of logs.

The recovered insects were used again in the breeding programme along with new emergences when available. However, in April 1978 all the insects recovered from the cages were released in the field and recently emerged ones were substituted for breeding.

The previous billets used were placed for at least 2 days in a room kept at 20°C, and during this period more beetles were generally recovered. The billets were then stacked on battens in one of the four huts which was maintained at 20°C during the day and 15°C at night for the development of the larvae.

Rearing of Larvae

Initially, the imported larvae were reared in pine bark "sandwiches" in petri dishes. The humidity in the dishes was kept fairly high by adding damp filter paper. *Hylastes ater* larvae were added to the "sandwiches" to provide the clerid larvae with food, and the lids of the dishes were held shut with rubber bands. These dishes were examined weekly and more *H. ater* larvae added as required.

Several of the clerid larvae excavated small niches in the bark and remained in them for some months, apparently without feeding on the *H. ater* larvae. Many died and only a few developed into adults. Because of these problems and the difficulty of locating the clerid larvae in their niches, another method of rearing them was adopted.

This method involved drilling tangential holes 3-5 cm deep under the bark of billets containing eggs and small larvae of *Hylastes ater* and/or *Hylurgus ligniperda.* Clerid larvae, the remainder of the imported ones and later those found in the huts or recovered from the billets used in the breeding programme, were induced to crawl into these holes which were then plugged with cellosene. About 20 larvae were inserted into each billet. The billets were moistened regularly and checked for adults. but no detailed records were kept. Adults were recovered after several months, some of them 6 months after insertion. It is estimated that at least 40% of the larvae transferred in this way completed their development.

Emergences

The huts and the temp./R.H.-controlled rooms were checked daily and the emerged *T. formicarius* collected. Because many predators have a tendency towards cannibalism, these adults were placed individually in 2.5-cm diameter tubes, with a small strip of paper towelling and some live *Hylastes ater* adults. Once a week dead *H. ater* adults were removed and replaced with live ones, when necessary in clean tubes. Prior to liberation of the *T. formicarius* in the cages or the field, the insects were sexed and a number of both sexes were placed in larger containers where mating occurred readily. Before redistribution in the cages they were sexed again so that a known number of each sex were placed in each cage.

This method was found somewhat cumbersome. After April 1978 adults collected were sexed soon afterwards and eight of each sex were placed in a 500-ml (approx.) glass jar provided with a gauze top. Crumpled paper towelling and some live *H. ater* adults were added. Fresh *H. ater* adults were supplied twice a week and the dead and remnants removed. The *T. formicarius* were held in these jars until required for breeding in the cages or for field release. No cannibalism occurred.

Between September 1976 (when the first consignment was received from Austria) and June 1977, 357 *T. formicarius* were reared. In the last week of July 1977 seven adults emerged. Between October 1977 and May 1978 a further 1081 were reared. Table 1 shows the number of adults collected each week.

TABLE 1—Weekly emergences of **Thanasimus formicarius**

	Week ending	Emergences (1)		Week ending	Emergences (2)		Week ending	Emergences (3)
1977			1977			1978		
Apr	1	30	Oct	7	1	Jan	20	2
	8	44		14	2		27	1
	15	66		21	—	Feb	3	3
	22	40		28	10		10	35
	29	38	Nov	4	18		17	15
May	6	26		11	15		24	25
	13	15		18	36	Mar	3	14
	20	48		25	34		10	44
	27	33	Dec	2	22		17	19
Jun	3	7		9	15		24.	59
	10	5		16	22		31	111
	17	4		23	10	Apr	7	111
	24	1		30	6		14	92
Jul	23	6	1978				21	89
	30	1	Jan	6	9		28	89
				13	10	May	5	73
				20	2		12	33
				27	1		19	20
			Feb	3	3		26	16
				10	4			
TOTALS		364			220			861
		(158,206)			(95,125)			(440,431)

Totals in parenthesis are for males and females, in that order.

(1) All storage huts.

(2) Single batch of logs kept in temp./R.H.-controlled room, exposed 15 June to 17 July 1977.

(3) Storage huts plus caged logs in which larvae were inserted.

Because of the limited number of heated rooms available for storage and breeding, logs from different batches could not be kept separate. Further complications arose because the same groups of adults were used on more than one batch of billets. As a result it is not possible to give figures for times and progeny gains from the different batches of billets. The only exception is a group of billets exposed between 10 June

and 7 July 1977 and then held separately in one of the temp./R.H.-controlled rooms to check for emergencies (*see* Table 1). The first emergence from this group was recorded in early October 1977, with the majority about late November/early December; emergences continued until early February 1978. At the end of March 1978 the bark was removed from these billets and about 60 fully grown larvae were obtained. These were transferred to billets containing pine bark beetles.

The only generalisation that can be made regarding the emergences from the billets in the huts is that they took place over quite a protracted period; they began about 3-4 months after exposure, seemed to peak at 5-6 months, and continued for several months after this.

The peak emergence occurred in or close to autumn, which is an indication that the insects were still out of phase with the seasons.

Field Releases

Reared *T. formicarius* adults surplus to breeding requirements were released in the field (Table 2). Altogether 176 adults were released in 1977 and 616 until June 1978. It is felt that most liberations were made at the wrong time of the year but this was when excess numbers were available, and it was feared that insects could not be held in jars in the laboratory until spring without heavy losses. Experience since then has shown that it is possible to keep the adults for 6 months, and even longer, provided they are given adequate food.

No recoveries of *T. formicarius* from the field have been made so far.

TABLE 2—Releases of **Thanasimus formicarius** in 1977 and 1978

Date	Forest	Cpt	Number released		
			Total	Males	Females
1977					
13 Apr	Woodhill S.F.	24	40	20	20
25 Jul	Kaingaroa S.F.	33	47	21	26
	Kaingaroa S.F.	1135	47	21	26
5 Jul	Woodhill S.F.	118	42	12	30
		Total	176	74	102
1978					
31 Mar	Kaingaroa S.F.	1080	58	28	30
4 Apr	Kaingaroa S.F.	1080	92	46	46
10 Apr	Waiuku S.F.		83	42	41
14 Apr	Whakarewarewa S.F.	17	77	42	35
26 Apr	Kaingaroa S.F.	48	44	23	21
		124	38	21	17
		131	44	23	21
		1115	56	28	28
		1119	28	14	14
23 May	Rotoehu S.F.	58	48	24	24
	Tauhara Forest		48	24	24
		Total	616	315	301

DISCUSSION

Between September 1976 and the end of May 1978 about 23 batches of billets were placed in cages with *T. formicarius*. There were usually 6-10 female adults per cage, eight on average. An approximately equal number of males were placed with them but on several occasions there were fewer males than females. After the cages were emptied the number of live *T. formicarius* adults recovered averaged 82%, varying from 69 to 89%. The other 18% were either dead or missing.

Most of the recovered adults were used again in the breeding programme. Gauss (1954) states that after the initial egg-laying period (30 eggs in about 10 days) the female can mate again and then lay another five to nine eggs. Examination of some females damaged during billet exchange and known to have been in the cages 3-4 months showed that they contained five to six eggs still. For this reason the older adults were not discarded.

A major problem of the project was the provision of live *Hylastes ater* adults to feed the clerid adults being used in the cages or held in tubes or jars. In late autumn and winter (say, May to October) the collection of sufficient *H. ater* adults usually presents no problem as large numbers of them can be found congregated together undergoing their maturation feeding under the bark of logging slash, etc. At other times of the year feeding congregations do not occur so it was necessary to strip the bark off a large amount of material to obtain sufficient. The problem was usually overcome by inducing *H. ater* attack through burying either fresh billets or offcuts from a portable batten-mill operating in Kaingaroa State Forest. These billets were held until the majority of the *H. ater* had completed their development; the bark was then stripped off and the adults were collected using aspirators. The adults could be held in the cool-store in tubes with crumpled paper toweling for 2-3 weeks.

The method of recovering *T. formicarius* adults from the cages was not entirely satisfactory. Not only was it very labour intensive and time consuming but there was also a distinct possibility that eggs would be removed with the bark scales in the search for the adults. It could be preferable to catch all the adults visible when the billets are removed from the cages, and then place the logs in an empty heated room where emerging insects could be collected over the following 3 weeks. This would save a great deal of time and eliminate the possibility of removing eggs with the bark scales.

The rearing of *T. formicarius* larvae by inserting them under the bark of bark-beetle-infested billets deserves more attention. This method showed much promise and seems greatly superior to that using petri dishes, but lack of manpower precluded much work on it. With more time and storage space, more of the older logs could have been held for examination and the larvae recovered for insertion in infested billets.

Thanasimus formicarius has much better prospects for controlling *Hylastes ater* and *Hylurgus ligniperda* than do the previously introduced pteromalid parasites. The larvae of this predator are able to move under the bark and the adults can lay their eggs on any suitable material containing bark beetles, irrespective of the thickness of the bark. The breeding programme will continue for at least another 12 months so that as many adults as possible can be released in various forests throughout the country. However, in view of the great numbers of *Hylastes ater* in any clearfelled area in Kaingaroa State

Forest alone it is hard to imagine *T. formicarius,* even if it does become established, having a notable effect on populations of the bark beetle. In the long term the major control measure may need to be an increase in the standard of logging hygiene.

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