SPREAD OF *BRACON PHYLACTEOPHAGUS*, A BIOCONTROL AGENT OF *PHYLACTEOPHAGA FROGGATTI*, AND IMPACT ON HOST

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ABSTRACT

Bracon phylacteophagus Austin (Hym:Braconidae) was first established in New Zealand in 1988 as a biocontrol agent for the introduced Eucalyptus leaf-mining sawfly *Phylacteophaga froggatti* Riek (Hym:Pergidae). By June 1991 the parasitoid had spread throughout much of the sawfly-infested area, and in most areas where the parasitoid had been established for more than 1 year the sawfly population collapsed.

Keywords: biocontrol; population change; *Bracon phylacteophagus; Phylacteophaga froggatti.*

INTRODUCTION

Eucalyptus leaf-mining sawfly, *Phylacteophaga froggatti*, was first discovered in New Zealand in 1985 (Kay 1986) and was established in most of the North Island north of Tokoroa by June 1989 (Faulds 1990). Larvae of this Australian insect feed inside the leaves of many *Eucalyptus* species. Kay (1986) described the life history, habits, and type of injury caused by *P. froggatti* and concluded that this insect could have serious consequences for the establishment of *Eucalyptus* plantations. In 1988 *Bracon phylacteophagus*, a parasitoid wasp specific to the sawfly, was imported and established in New Zealand as a biocontrol agent. An account of the importation, rearing, release, and establishment of *B. phylacteophagus* has been given by Faulds (1990), who noted that early indications were that it should spread rapidly and might dramatically reduce the sawfly population by late summer 1990. Releases of the parasitoid in 1989 included two releases made specifically to assess its impact on the host. Also, natural spread of the parasitoid was monitored in some areas.

This paper describes the impact of *B. phylacteophagus* on *P. froggatti* and reports its natural spread. Details of releases made after 1989 are also given.

ASSESSMENT OF IMPACT

Methods

The only reliable method for judging a parasite's effectiveness is by using comparisons of host density before introduction and after introduction (Legner 1969). It was considered that sawfly populations could best be monitored by measuring damage to the leaves of the host plant.

Two areas of sawfly-infested trees of a suitable height were selected for assessment. At the time they were the areas of known severe sawfly infestation nearest to the Forest Research Institute.

(1) An area of approximately 2 ha of 1-m-high (average) *Eucalyptus saligna* Smith on farmland 2.5 km west of Cambridge. The trees had been planted in 50 rows of eight. Six rows chosen at random were assessed. On 6 February 1989, 200 male and 57 female *B. phylacteophagus* were released at this site.

(2) An area of various-aged mixed *Eucalyptus* species on farmland 5 km north of Te Puke. A portion of the area contained trees of the same age (seven rows of 11 trees approx. 1-m-high) from which two rows were selected at random for assessment. On 17 January 1989, 500 male and 66 female *B. phylacteophagus* were released.

Each assessment involved estimating the percentage of leaves of the current year's foliage damaged by sawfly. A leaf with any sawfly damage at all was regarded as damaged. In both areas the first assessment was made immediately prior to the release of *B. phylacteophagus*. and assessments thereafter were made bi-annually in January and May until the final assessment in May 1991. No controls were possible (*see* Discussion).

Some observations of changes in sawfly populations were recorded in the areas monitored for the spread of the parasitoid and in other localities.

Results

Parasitoid cocoons were found both sites in May 1989. Sawfly damage was considerably reduced 1 year after the release of *B. phylacteophagus* and by May 1991 was insignificant (Table 1). Observations in areas monitored for the spread of *B. phylacteophagus* and in other localities showed that trees severely damaged by sawfly before establishment of the parasitoid had no or insignificant damage when it had been established for more than one season.

TABLE 1–Assessment of current year's foliage damaged by sawfly

Date assessed	Foliage with sawfly damage (average %)	
	Cambridge	Te Puke
February 1989	79.5	40.5
January 1990	7.5	7.5
May 1990	7.0	50.0
January 1991	0.0*	0.5
May 1991	0.0†	3.0‡

* A total of three mines found; all of which contained *B. phylacteophagus* cocoons.

† Three very small mines found; smaller than the size required for parasitism.

‡ All sawfly mines contained parasitoid cocoons

SPREAD

Methods

The natural spread of *B. phylacteophagus* was monitored from releases made in Tauranga, Hamilton, Matata (Bay of Plenty), and Rotorua (Table 2).

TABLE 2–Releases of *B. phylacteophagus* in monitored areas

Date released	Locality	Number released	
		Males	Females
February 1988	Near Tauranga	500	17
June-July 1988	Near Tauranga, 5 km east of first release	200	36
March 1989	Near Tauranga, 3 km east of first release	600	64
January 1989	Hamilton	500	90
February 1989	Hamilton, 3 km north of first release	75	17
March 1989	Hamilton, 2 km south of first release	250	20
April 1989	Matata	50	24
February 1990	Matata	181	90
December 1989	Rotorua, near FRI	289	113
January 1990	Rotorua, near FRI	159	81
February 1990	Rotorua, near FRI	99	33

Sawfly-infested trees were examined on site for the presence of *B. phylacteophagus* cocoons. The trees examined were at progressively greater distances from the release site and beyond where the parasitoid had previously been found. Inspections were usually continued in a direction away from the release site until no parasitoids were recorded. After April this method was unreliable in areas recently invaded by *B. phylacteophagus* because the few cocoons present were difficult to find among the whole season's sawfly damage. A more reliable method at that time was to collect leaves with intact sawfly pupal chambers or large larval mines, which made up a very small part of the sawfly-damaged foliage but were easily seen, and examine these microscopically at the FRI for the presence of *B. phylacteophagus* larvae or eggs. Positive records were recorded on 1:50 000 Department of Survey and Land Information Infomaps 260 series.

Positive records were also compiled from areas associated with release sites other than those monitored for spread. Releases made before December 1989 have been detailed by Faulds (1990). From December 1989 releases were made in many localities (Table 3). Although most of these releases were made on request, as commercial sales to local bodies, companies, and private individuals, the release localities were well distributed throughout sawfly-infested areas.

Results

Spread from Tauranga

Bracon phylacteophagus was well established at the release site by August 1988. In January 1989 it was recovered 1.5 km west of the site. Other releases were made in the Tauranga - Mt Maunganui district from January to March 1989 before it was known that the rapid spread of the parasitoid from the original release site would soon include this area. By August 1989 the parasitoid had spread throughout approximately 60 km^2 and by June 1990

TABLE 3–Releases of *B. phylacteophagus* from December 1989 to February 1991

Date released	Locality	Number released	
		Males	Females
1989 December	Rotorua, near FRI	289	113
1990 9 January	Coromandel	200	50
12 January	Rotorua, near FRI	159	81
15 January	Albany	206	56
15 January	Te Kohanga	170	54
15 January	Okahukura Peninsula, Kaipara Harbour	205	55
22 January	Silverdale	123	26
22 January	Wellsford	100	25
30 January	Opononi	163	75
30 January	Auckland	151	50
30 January	Auckland	160	72
31 January	Auckland	138	72
7 February	Auckland	147	75
7 February	Auckland	153	79
7 February	Te Hana	149	75
8 February	near Albany	101	81
12 February	Tikoki	184	88
19 February	Matata	181	90
23 February	Hastings	331	142
February	Rotorua	99	33
13 March	Palmerston North	75	44*
19 March	Huntly	42	20†
5 April	Kaitaia	several hundred cocoons	
1991 22 January	Mamaranui Forest	172	76
22 January	Matarangi Beach Whitianga	211	58
24 January	Tairua Forest	553	119
20 February	Whiritoa	477	126

* plus 100 cocoons
† plus 200 cocoons

it was established in an area approximately 500 km^2 from Paengaroa to Te Puna. At that time sawfly damage was very severe beyond Te Puna. In May 1991 sawfly damage was still severe in Waihi when *B. phylacteophagus* was recovered there but was insignificant in most of the area between Te Puna and Waihi. Spread from Tauranga is shown in Fig. 1.

Spread from Hamilton

Establishment of the parasitoid was recorded at the three release sites in March, September, and December 1989 respectively and cocoons were found up to 1.5 km east of the first release site by September 1989. By the end of February 1990, *B. phylacteophagus* was found throughout an area of approximately 65 km^2 which included most of the Hamilton urban area. Spread after February was rapid. A release for the assessment of the impact of the parasitoid was made near Cambridge in February 1989 and by late May 1990 the population was continuous from Hamilton to Cambridge. Spread east of Cambridge can therefore only be regarded as an extension of the Hamilton-Cambridge population. In some localities (e.g., areas of Hamilton City, Ngaruawahia, Otorohanga) large sawfly populations were present when *B. phylacteophagus* was first found there, but by the following year

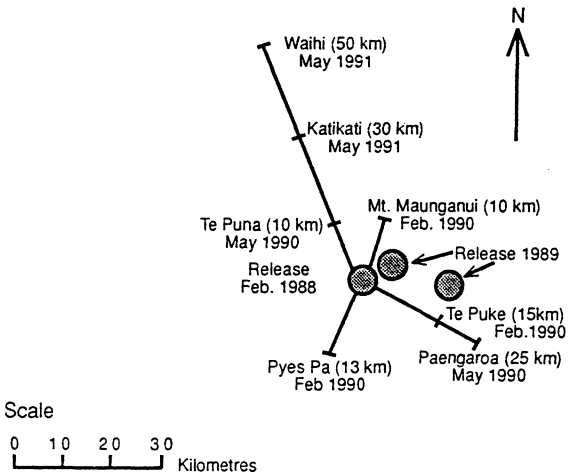

FIG. 1–Natural spread of *Bracon phylacteophagus* from Tauranga release.

sawfly mines were scarce. Large sawfly populations were present in Bombay, Thames, and Bennydale when *B. phylacteophagus* was recovered at these localities in 1991. Spread from the Hamilton releases up until June 1991 is indicated in Fig. 2.

Spread from Matata

Because no parasitoids were found during inspections of the release area in December 1989 and February 1990, a further release was made at Matata in February 1990. However, when *B. phylacteophagus* was found at Ohope and Taneatua in May 1990, it was recognised that establishment from the 1989 releases had probably been successful as this recovery was very unlikely to be a result of the later release. Spread from Matata is shown in Fig. 3.

Spread from Rotorua

Bracon phylacteophagus cocoons were found at the release site 1 month after the first release. During February 1990 cocoons were commonly found in the FRI grounds and by the end of May the parasitoid had spread around Lake Rotorua and to most of the Rotorua basin throughout an area of approximately 140 km^2 wherever sawfly was present. Spread after this was limited by the extent of the host population.

Spread and establishment in other areas

By July 1991 *B. phylacteophagus* was established in most areas north of a line from Houpoto-Murupara-Bennydale-Piopio (the southern boundary of the main sawfly infestation) to Auckland.

Although no examination of release localities on the Coromandel Peninsula has been made, it seems that the parasitoid is established in Tairua Forest (release in January 1989) as in January 1991 it was reported that the sawfly population had declined to the point where it was difficult to find a suitable area for a further release (Forest Research Institute unpubl. data).

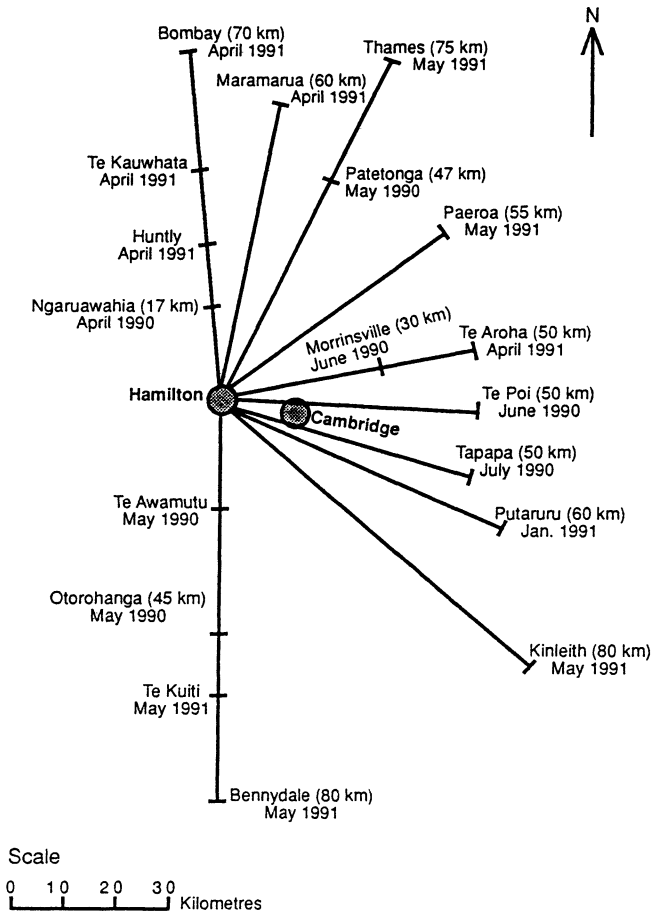

FIG. 2–Natural spread of *Bracon phylacteophagus* from Hamilton release.

North of Auckland *B. phylacteophagus* has been recovered up to 50 km from a release site but, as many areas have not been inspected, distribution records are incomplete. Some of the more notable recoveries from north of Auckland are:

(1) Whangaroa Harbour, 40 km from the release site at Waitangi.

(2) Dargaville, 50 km from the nearest release site.

(3) Mangawhai, 15 km from the nearest release site.

In Hastings and Palmerston North *B. phylacteophagus* was recovered up to 10 km and 14 km respectively from release sites, i.e., throughout the sawfly-infested area in those localities, and was found in Gisborne in February 1991, approximately 150 km from the nearest release sites at Hastings and Matata. Areas where *B. phylacteophagus* is established are shown in Fig. 4.

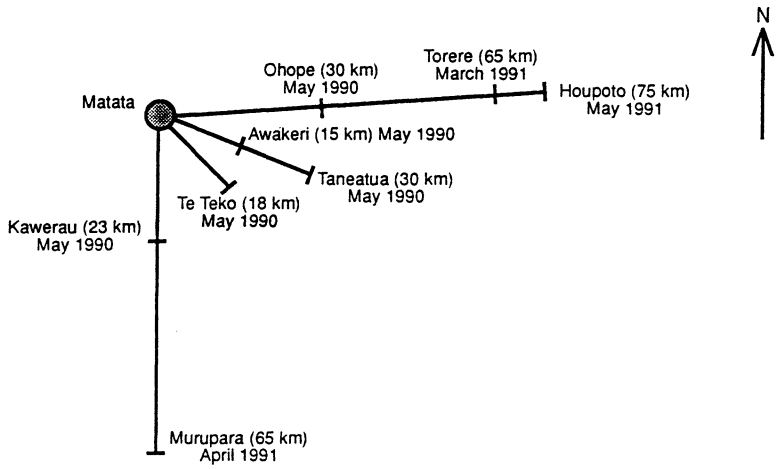

FIG. 3–Natural spread of *Bracon phylacteophagus* from Matata release.

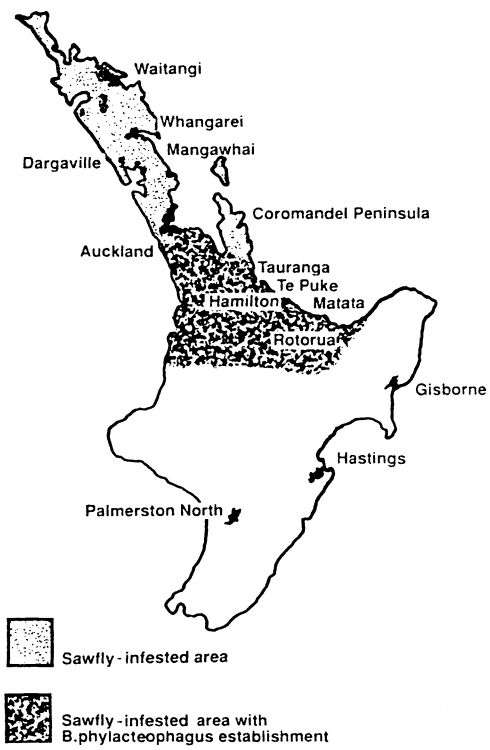

FIG. 4–Sawfly-infested area and *Bracon phylacteophagus* establishment as at May 1991 in the North Island of New Zealand.

DISCUSSION

When *B. phylacteophagus* was first established in New Zealand the possibility of a dramatic reduction in the sawfly population was forecast by Faulds (1990). The results of the assessments, and a decrease to insignificant levels of sawfly damage in other areas, have confirmed this prediction.

Although sawfly damage did increase in the Te Puke assessment area by May 1990, this was possibly due to reinfestation from surrounding areas where the parasitoid was not established.

No controls were possible for the assessments. Firstly, no comparable trees were available: controls would need to be the same species and of similar height to the experimental trees as sawfly infestation varies with height and species (Kay 1986). Secondly, no information was available on the likely spread of *B. phylacteophagus* and controls might become infested by it. In retrospect its rapid spread justified this assumption. The only possible comparison was to confirm that there was no widespread collapse of the sawfly population outside the parasitoid-infested area.

Generally, the spread of *B. phylacteophagus* has been spectacular. Further spread from areas where it is now well established, and also from the more recent release sites, should ensure that the population will be practically continuous throughout the sawfly-infested area by May 1992. However, for a while there could be geographically isolated areas within which there are no parasitoids and sawfly damage continues to be severe.

Now that *B. phylacteophagus* is established at what appears to be the southern boundary of the main sawfly infestation, further southward spread of sawfly should be restrained. But invasion of new areas well south of this boundary could occur, either by sawfly adults carried in and on motor vehicles, or by the transport of sawfly-infested trees. This might be how sawfly became established in Hastings, Palmerston North, and Gisborne.

Braconphylacteophagus is probably far more widespread north of Auckland than records show. Only a very limited search has been made for the parasitoid in that area.

The rate of spread from Tauranga is probably best represented by spread toward Waihi. In other directions there are either geographical barriers (e.g., the Kaimai Range beyond Pyes Pa) or interference by spread from other releases.

Bracon phylacteophagus has spread over a greater area from Hamilton than from Tauranga, despite being established in Tauranga a season earlier. Dairy farming is the predominant type of agriculture in the Waikato. In comparison, the Tauranga district has large areas of intensive horticulture, especially kiwifruit orchards, which are sprayed at least monthly with pesticide from January to April. Because of the small size of most kiwifruit orchards, and as individual orchardists spray whenever it suits, i.e., spraying in an area is not simultaneous, there is probably some pesticide in the air most days during this period of the year. January-April is also the time of greatest activity for *B. phylacteophagus* and it is possible that the presence of pesticide is responsible for the slower spread of the parasitoid in the Tauranga area. Also, the Waikato is generally a flatter region with fewer geographical barriers. The release at Huntly did not influence spread from Hamilton as by the time *B. phylacteophagus* was established at the Huntly release site spread from Hamilton had reached this area.

The spread in Rotorua in the season of release was greater than that recorded in the season of release in either Tauranga or Hamilton. This could be because the parasitoid was released in December at Rotorua, compared with February at Tauranga and January at Hamilton, and might have had time for at least one extra generation.

The most logical explanation for the establishment of *B. phylacteophagus* in Gisborne is that immature stages were taken into the area on sawfly-infested plants.

By May 1993 Eucalyptus leaf-mining sawfly in New Zealand should be a non-pest insect because of effective control by *B. phylacteophagus*.

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