INTRODUCTION AND ESTABLISHMENT OF *MICROPLITIS CROCEIPES*, A LARVAL PARASITOID OF *HELIOTHIS*, IN NORTH ISLAND PINE FORESTS

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ABSTRACT

Heliothis (Helicoverpa armigera) is a periodic pest of young pine trees (*Pinus radiata*). In response to a recent outbreak of this pest, *Microplitis croceipes*, a parasitoid of *heliothis* larvae, was introduced into forests of the North Island volcanic plateau to augment biological control of *heliothis*. A total of 13,600 *M. croceipes* pupae were released at monthly intervals over three seasons (1995-98). Successful overwintering of *M. croceipes* populations confirmed establishment in the forests. Mean monthly parasitism reached 10.7% in the third season. Surveys at points radiating out from the release sites indicated that *M. croceipes* was spreading at approximately 1 km per year.

Keywords: biological control, *Pinus radiata*, *Helicoverpa armigera*.

INTRODUCTION

Heliothis (Helicoverpa armigera), Lepidoptera: Noctuidae) is a common pest of vegetable crops (Butcher 1984). *Heliothis* has a wide host range (Zalucki *et al.* 1986) and is periodically reported as a pest of young pine trees (*Pinus radiata*) (Alma 1977). The infestation of young pine trees occurs in seasons when *heliothis* larval populations consume their preferred understorey hosts (predominantly lotus, *Lotus pedunculatus*) before they complete their development. The larvae then move on to young pine trees and weeds that are not commonly hosts, defoliating the trees and reducing their growth, especially if they damage the terminal bud of the leader (Alma 1972).

Microplitis croceipes (Hymenoptera: Braconidae), a larval parasitoid of *heliothis*, was introduced to cropping regions around Gisborne and Hawke's Bay in the mid 1980s to augment biological control of *heliothis* (Walker and Cameron 1989). Prior to its introduction, parasitism of *heliothis* larvae by *Cotesia kazak* averaged 42-52% in tomato and soybean crops in Pukekohe (Cameron and Valentine 1985). After *M. croceipes* was introduced, parasitism of *heliothis* larvae, by both parasitoids, increased to 60-80% in processing tomato crops in Gisborne and Hawke's Bay (P.J. Cameron, unpubl. data). *M. croceipes* had spread at least 20 km by the 1990/91 season (P.J. Cameron, unpubl. data).

The impact of a parasitoid should be assessed as the percentage of susceptible hosts attacked for a generation (Van Driesche 1983). *M. croceipes* prefers third instar larvae (*Heliothis zea* and *H. virescens*), although it can successfully parasitise all five larval instars (Hopper and King 1984). *C. kazak* prefer first and second instar *heliothis* larvae (< 10 mm) (Cameron and Valentine 1985) and out competes *M. croceipes* for *heliothis* larvae in this size range (Walker and Cameron 1989).

Surveys in 1994/95 (T.J.B. Herman, unpubl. data) at the onset of a new *helio* this outbreak in forests across the North Island volcanic plateau showed that while *C. kazak* was present in the forests, *M. croceipes* was not. This paper describes the introduction and subsequent establishment of *M. croceipes* to four forests of the North Island volcanic plateau over a three-year period.

METHODS

Rearing

Heliothis were sourced from a laboratory colony (HortResearch, Auckland) and *M. croceipes* was sourced from both Gisborne and Hawke's Bay lucerne crops and a laboratory colony (Southern Insect Management Laboratory, Mississippi). Methods used for rearing were based on those described by Singh *et al.* (1982) for heliothis and Lewis and Burton (1970) for *M. croceipes*. Heliothis larvae were reared individually from the second instar on a lima bean diet (McManus *et al.* 1995). The HortResearch Insect Rearing Unit reared both species in the second and third years.

Release

M. croceipes were released monthly from January to April in the first season (1995/96) and December to April in the second and third seasons (1996/97 and 1997/98) in stands of young pine trees through four forests (Matahina, Tarawera, Kinleith and Kaingaroa). The release stations consisted of 'delta' pheromone trap bodies hung from a stand, one metre off the ground. A plastic jar containing 100 laboratory-reared *M. croceipes* pupae was strapped inside the trap body each month. Each jar also contained shredded paper and parasitoid food for adults as they emerged. The adults exited through a hole in the lid of the jar.

In the second season the release stations were sited approximately 500 m from where they had been in the first season and within the same age class of pine trees. In the third season the release stations were placed into new stands of pine trees or at least 1 km from the earlier release sites.

Recovery

Heliothis larvae were collected once a month during each summer season to document the establishment and spread of *M. croceipes*. We aimed to collect at least 50 heliothis larvae around each site, but did not spend more than an hour collecting when numbers were low. The larvae were collected from forest understorey by sweep net and visual searching and were placed in tubes containing lima bean diet. Collected larvae were taken back to the laboratory and reared to determine parasitism rate.

As the larvae parasitised by *C. kazak* are unavailable to *M. croceipes* for parasitism (Walker and Cameron 1989), the mean monthly parasitism by *M. croceipes* was calculated using the following formula:

$$M. \text{ croceipes parasitism rate} = Mc / (n - Ck)$$

where Mc = number of larvae parasitised by *M. croceipes*, n = total number of heliothis larvae collected and Ck = number of larvae parasitised by *C. kazak*.

Collections of heliothis larvae and/or *M. croceipes* adults were also taken in the third season (1997/98) at points radiating out from the original release sites (1 km spacing) to assess the spread of the parasitoid. Collected larvae were treated as above.

RESULTS

Rearing

A major problem in the first season (1995/96) of the study was contamination of the heliothis colony with a naturally occurring virus brought back from the forests which, despite strict hygiene practices, reduced the production of *M. croceipes* pupae. This problem did not occur in the second and third seasons (1996/97 and 1997/98) when a virus-free laboratory colony of heliothis was used (HortResearch Insect Rearing Unit).

Release

A total of 4400 *M. croceipes* pupae were released at 11 sites across four forests in the first (1995/96) and second (1996/97) seasons (Table 1). In the third season (1997/98) 4800 *M. croceipes* pupae were released at ten sites across the four forests. On some occasions during the third season fewer than 100 *M. croceipes* were released at a site, but this number never fell below 75, and these smaller releases did not occur more than once for any site.

TABLE 1: Number of release sites and total number of *M. croceipes* pupae released in each forest.

Forest	1995/96		1996/97		1997/98	
	no. sites	no. released	no. sites	no. released	no. sites	no. released
Tarawera/Matahina	4	1600	4	1600	3	1440
Kinleith	4	1600	4	1600	5	2400
Kaingaroa	3	1200	3	1200	2	960
TOTAL	11	4400	11	4400	10	4800

Recovery

M. croceipes was collected in 1996/97 at most of the 1995/96 release sites in Tarawera and Matahina forests (Table 2), but took longer to collect in Kinleith and Kaingaroa forests. *M. croceipes* was found again in 1997/98 at the 1996/97 release sites in Tarawera, Matahina and Kaingaroa forests (Table 2). However, *M. croceipes* did not appear to survive the winter as well in Kinleith forest, only being found at one 1996/97 site by February.

TABLE 2: Number of release sites from the previous season where *M. croceipes* was found in 1996/97 and 1997/98 (includes adults collected directly and those reared from collected heliothis larvae).

	1996/97 (at 1995/96 release sites)				1997/98 (at 1996/97 release sites)			
	December	January	February	Total	December	January	February	Total
Tarawera/ Matahina	3	2	-	4	3	4	0	4
Kinleith	1	2	2	3	-	1	1	1
Kaingaroa	-	0	2	2	-	3	2	3

The mean monthly parasitism by *M. croceipes* increased in all four forests over the three seasons, from 2.6% in 1995/96 to 10.7% in 1997/98 (Table 3). *M. croceipes* was having more effect in Tarawera/Matahina and Kaingaroa forests by the end of the third season (11.5% and 15.7% respectively) than in Kinleith forest (4.9%).

TABLE 3: Total number of heliothis larvae collected (H), total number of *M. croceipes* (Mc) reared and the mean monthly parasitism by *M. croceipes* (% P) in four forests over three seasons.

Forest	1995/96			1996/97			1997/98		
	H	Mc	% P ¹	H	Mc	% P ¹	H	Mc	% P ¹
Tarawera/ Matahina	471	3	0.9	704	32	5.4	627	90	11.5
Kinleith	470	4	2.5	551	13	2.5	413	49	4.9
Kaingaroa	201	10	4.3	265	13	5.5	997	26	15.7
TOTAL	1142	17	2.6	1520	50	4.5	2037	165	10.7

¹see text for calculation.

M. croceipes was found to have spread at least 2-3 km from 10 of the 11 original release sites (Fig. 1). The spread was similar in all four forests. An adult *M. croceipes* was also collected by sweep net at a third season (1997/98) release site before the actual release at that site. The site was approximately 1 km from the 1996/97 release site and 2 km from the 1995/96 release site.

FIGURE 1: The recovery of *M. croceipes* at points radiating out from release sites in pine forests of the North Island volcanic plateau.

DISCUSSION

Rearing

The contamination of the heliothis colony with a virus disease reduced the production of *M. croceipes* pupae for release. This was in spite of hygiene measures in both the laboratory and the field. The complete segregation of the rearing operation from the field work by sub-contracting the rearing to HortResearch for the second and third seasons overcame the virus problem. However, if the rearing had continued the *M. croceipes* colony would have required the input of fresh field populations because it had been noted that the fecundity and fitness of females in the existing colony had declined (A. Barrington, pers. comm.).

Release

Initially 18,000 *M. croceipes* were introduced in New Zealand over two seasons (1986/87 and 1987/88), leading to the successful establishment of the parasitoid in cropping regions around Gisborne and Hawke's Bay (Walker and Cameron 1989). This achievement was followed by the successful release of the 13,600 *M. croceipes* pupae in pine forests on the North Island volcanic plateau reported here. Both of these successes support the analysis of Cameron *et al.* (1993) on biological control introductions in New Zealand which found a greater likelihood of establishment if more than 1000 individuals were released.

However, Hopper and Roush (1993) reported that the establishment rate for ichneumonids did not improve much as the total number released increased, but that releasing more than 100 ichneumonids per release did improve establishment rates. For this reason we concentrated on releasing 100 *M. croceipes* pupae per month rather

than the total per season or over all three seasons. This monthly target was hard to meet later in the third season because of lower production of *M. croceipes* from the colony as noted above.

Recovery

M. croceipes was recovered immediately following its release in the forests, as was the case for the original introduction of *M. croceipes* into New Zealand (Walker and Cameron, 1989). This suggests that the parasitoid was already well adapted to the New Zealand environment.

The demonstration that *M. croceipes* had established in the forests was confounded by the fact that we continued to release the parasitoid as we were trying to recover it. Although these activities occurred at separate sites, we were aware of the possibility that the recoveries we made could have been from the releases in the current season. For this reason the data in Table 2 showing successful over-wintering, does not include the March and April recovery data for the 1996/97 and 1997/98 seasons.

We had collected a *M. croceipes* adult 200 m from the release station one month after the very first release in 1995/96 which suggested the parasitoid was spreading 200 m per month. In 1996/97 the release stations were placed at least 500 m from where they were in 1995/96, meaning the *M. croceipes* released in 1996/97 would have taken 2.5 months to spread to the 1995/96 release sites. Therefore, the *M. croceipes* recoveries for December and January 1996/97 are from over-wintering populations, while the February recoveries may be a mixture of parasitoids from over-wintering populations and new releases.

Because the release stations in 1997/98 were at least 1 km from the 1995/96 and 1996/97 sites the *M. croceipes* recovery data for 1997/98 is most unlikely to have been contaminated by the current season's releases.

C. kazak was present at all release sites and, along with a nuclear polyhedrosis virus, was the dominant cause of mortality of heliothis larvae over the three seasons. However, three seasons after its introduction *M. croceipes* was parasitising 10.7% of heliothis larvae each month and was becoming an important mortality factor for collected heliothis larvae. A fungal disease (*Zoophthora radicans*) and death from unknown causes also contributed to the mortality of collected heliothis larvae (T.J.B. Herman, unpubl. data). These data will be presented in a subsequent publication.

M. croceipes parasitism appears to be following the trend seen with the original introduction of *M. croceipes* into New Zealand, where monthly parasitism of heliothis larvae by *M. croceipes* increased over the first few seasons and then fluctuated between 15 and 60%, although there were some months where *M. croceipes* parasitism was less than 10% (P.J. Cameron, unpubl. data). Reasons for the lag in parasitism rates in Kinleith forest were not identified, but could be caused by factors such as differences in climate or forestry management. It should be noted that the heliothis populations were lower (smaller collections) in Kinleith forest than the other three forests.

The 2-3 km spread of *M. croceipes* over three seasons suggests a spread of at least 0.6 km per season. The capture of an adult at a new release site prior to *M. croceipes* being liberated, and 1 and 2 km from the 1996/97 and 1995/96 release sites, respectively, suggests that the rate of spread is 1 km per season. *M. croceipes* had spread at least 20 km within four seasons of its release in Gisborne and Hawke's Bay (P.J. Cameron, unpubl. data), an average of 5 km per season. However, this was across areas of agriculture and horticulture on flat alluvial plains and the spread across forests, including stands of mature pine trees, on undulating hills is likely to be at a lower rate.

M. croceipes has been successfully introduced into the pine forests of the North Island central plateau and is expected to disperse throughout the forests and make an important contribution to the biological control of heliothis in this habitat.

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