MICROCTONUS HYPERODAE: A SUMMARY OF RELEASES AND DISTRIBUTION IN NEW ZEALAND PASTURE

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ABSTRACT

The braconid parasitoid *Microctonus hyperodae* was released in New Zealand for biological control of Argentine stem weevil *Listronotus bonariensis*. The initial 1991 research introduction involved the release of 99 000 parasitised *L. bonariensis*. Between 1991 and 1998, a further 660 000 *M. hyperodae* were released as part of commercial contracts and research programmes. Commercial contracts resulted in the widespread release of the parasitoid in the North Island with South Island releases mainly confined to mid-Canterbury. There were eight geographic populations originally collected from South America and these were maintained separately in the laboratory. Excluding the Mendoza population, which was founded on a single female, an average of 91 040 *M. hyperodae* was released from each of the seven remaining populations. Parasitised *L. bonariensis* were released at a total of 121 sites and the parasitoid established at 118 (97.5%). Based on the distribution of releases in New Zealand and the results of surveys it is estimated that *M. hyperodae* is now very widely distributed in the North Island, with more limited distribution in the South Island.

INTRODUCTION

The South America parasitoid *Microctonus hyperodae* Loan (Hymenoptera: Braconidae) is a natural enemy of Argentine stem weevil *Listronotus bonariensis* (Kuschel) (Coleoptera: Curculionidae). The weevil was accidentally introduced to New Zealand in the early 1900s and became a significant pest of several economically important graminaceous plants including ryegrass (*Lolium* spp.) (Prestidge et al. 1991). *Microctonus hyperodae* was collected from eight South American regions and introduced into New Zealand quarantine in 1989 for assessment as a biological control agent (Goldson et al. 1990). After extensive host range testing and submission of an Environmental Impact Assessment, permission for introduction was received in 1991 (Goldson et al. 1993a). That winter, 99 000 parasitised adult *L. bonariensis* were released at nine sites and *M. hyperodae* subsequently established at eight of these sites (Goldson et al. 1993a). The thelytokous reproduction of *M. hyperodae* simplified laboratory culturing and mass rearing and enabled the geographic populations to be maintained and mass reared separately. The parasitoid populations originated from Porto Alegre (Brazil), Colonia (Uruguay), Ascasubi, General Roca and Bariloche (Argentina), Concepcion and La Serena (Chile), and a line based on a single female collected from Mendoza (Argentina). Two hundred and forty seven individual iso-female lines were established in quarantine (Goldson et al. 1990) of which 141 were used in the initial research releases (Phillips & Baird 1996). However, the logistics and cost of maintaining all lines meant that by 1992 this number was reduced to 55.

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Between 1991 and 1998, further releases were made both as part of government funded research projects and as commercial contracts with primary industry (McNeill et al. 2002a). This paper summarises the release locations and the numbers of *M. hyperodae* released.

MATERIALS AND METHODS

Research and commercial releases 1991-98

The mass rearing of *M. hyperodae* for the initial 1991 introductions and for the subsequent commercial programme has been described by Goldson et al. (1993a) and McNeill et al. (2002a) respectively.

Following commercial releases, paddocks were sampled to confirm establishment. Several paddocks were re-sampled to monitor the increase in parasitism of *L. bonariensis*. This was generally carried out at least twice and facilitated an analysis of regional differences in parasitoid build-up. *Listronotus bonariensis* adults were collected using a blower-vacuum (Homelite HB 180V) with a net attached to the inlet of the tube to trap litter. Weevils were then extracted from the litter and forwarded to Lincoln where they were maintained in parasitoid rearing containers (McNeill et al. 2002b). In addition to the commercial programme, *M. hyperodae* establishment and build-up was monitored following research releases in Wairarapa (Phillips et al. 2000). In Taranaki the effect of altitude on parasitoid population growth was examined by comparing results from 23 release sites. Sites were classified as low, medium or high altitude (25-45, 80-140 and 200-280 m above sea level (a.s.l.) respectively). A binomial distribution with a logit link function was fitted to the proportion of *L. bonariensis* parasitised from each site and the time of collection. A fuller description of the analysis is provided in Goldson et al. (1999a).

Dispersal of *M. hyperodae* in Taranaki

The Taranaki commercial programme involved the release of *M. hyperodae* at 40 sites in 1996 and 1997, with the initial releases being made at seven sites on 9 October 1996. A survey to confirm establishment at the seven sites was made on 25 March 1997 with the parasitoid recovered from six of them. Two of these sites were selected to monitor dispersal of the parasitoid. These were near Waiiti (38° 07' S, 174° 27' E) on the Taranaki coastline at ca 50 m a.s.l. and near Eltham (39° 25' S, 174° 16' E) in inland Taranaki at an altitude of ca 260 m a.s.l. The 1997 survey to confirm establishment found parasitism levels of 30 and 4 % at Waiiti and Eltham respectively.

Microctonus hyperodae dispersal was measured over three years (1997-99) with sampling carried out in autumn-winter when the majority of adult parasitoids had ceased oviposition and the parasitoid population consisted predominately of larvae inside diapausing adult *L. bonariensis* (Goldson et al. 1993b). At each location, the release paddock and several surrounding paddocks were sampled, with collections made as close as possible to the main compass bearings around each release paddock. Based on the previous year's results, the distances at which samples were taken increased each year, with paddocks re-sampled if the parasitoid had not been recovered in the previous year's survey. A total of 13 paddocks were sampled at each location over the three years.

Collections of *L. bonariensis* for the dispersal study were made on 08 July 1997, 20-23 April 1998 and 20 April 1999. The distance from the release paddock and area occupied by the parasitoid was determined by plotting the paddocks where the parasitoid was recovered onto a topographical map (1:50 000) and the areas measured using video image analysis (Video Pro 32).

Distribution of *M. hyperodae*

The estimate of the current distribution of the parasitoid in New Zealand is based on emergence of *M. hyperodae* from field collections of *L. bonariensis* made in both North and South Islands between 1992 and 2002 and projections on the rate of dispersal from release paddocks between the date when establishment was confirmed and the winter 2002. Surveys to measure the spread of *M. hyperodae* were undertaken in the Gisborne

region and Hawke's Bay in 1996 and 2000 respectively after releases had been made at three sites in the Gisborne region and two sites in Hawke's Bay in 1993 and 1995 respectively. A number of surveys were also conducted in the upper North Island (P.J. Addison, unpubl. data). The distribution of *M. hyperodae* in Canterbury was estimated from field collections and a rate of dispersal of 1.5-3 km/ year (Goldson et al. 1999), and that in Otago was based on research by Ferguson et al. (1997).

RESULTS AND DISCUSSION

Research and commercial releases 1991-98

Excluding the initial research releases (Goldson et al. 1993a), a total of 660 000 *M. hyperodae* parasitoids were released, of which 613 000 were for commercial contracts (McNeill et al. 2002a). The balance consisted of research releases in Marlborough (800), Northland (11 365), Canterbury (5000), Otago (Mosgiel) (6700) (Ferguson et al. 1997) and a larger release in Wairarapa (23 000) (Phillips et al. 2000). The Wairarapa release marked the end of the *M. hyperodae* colonies being maintained in the Lincoln insect rearing facility. All releases established with the exception of one in Wairarapa (Phillips et al. 2000), one at Mosgiel (Ferguson et al. 1997) and three in Canterbury. In Canterbury, the parasitoid was re-released on the same or an adjacent paddock and subsequently established at the three sites (McNeill et al. 2002a). Including the initial introductory release of 1991, a total of 759 000 *M. hyperodae* were released in New Zealand.

The number of parasitoids released in each region is shown in Table 1. Releases were made on 121 paddocks with the majority in the North Island. Taranaki received the greatest number of parasitoids, followed by Canterbury then Bay of Plenty. However, the Canterbury total includes 43 500 parasitoids that were released at seven sites in 1997/98 where there was no establishment or the level of parasitism failed to increase for two consecutive years after establishment (McNeill et al. 2002a). The majority of commercial releases were on dairy farms in the North Island, with 59% of the releases made on dairy farms across both islands.

Establishment rates were high, especially in the North Island, with parasitism after ca 12 months averaging 13.3% compared to 1.2% for Canterbury (McNeill et al. 2002a). The greatest increase in parasitism between release and confirmation of establishment

TABLE 1: Number of releases of *M. hyperodae* in New Zealand by location, year (1991-1998) and land use.

Region	Year	No. released	Landuse			Total
			Dairy	Sheep/Beef	Cropping/ Stock ¹	
North Island						
Northland	1997	11 300	2			2
Waikato	1994	32 700	6			6
Bay of Plenty	1996-97	136 000	24			24
East Coast	1993	13 000			3	3
East Coast	1996	5000			1	1
Hawke's Bay	1995	9800	0		2	2
Taranaki	1996-97	215 000	30	10		40
Manawatu	1994-95	35 700	4	2		6
Wairarapa	1998	23 700	1	11		12
South Island						
Malborough	1991	800		1		1
Canterbury	1995-96	172 000	4	3	16	23
Otago	1992	6700		1		1

¹Stock = either dairy or sheep.

occurred at Murapara (Bay of Plenty) where parasitism of *L. bonariensis* at three sites averaged 52% (range 46-61%) after 12 months. The difference in parasitism between the North Island and Canterbury was attributed to climate, with more parasitoid generations occurring in the warmer North Island (Barlow et al. 1994).

Overall, there was a highly significant regional effect ($P < 0.001$) on the rate of parasitoid build-up with the rates of build-up being higher in Waikato, Bay of Plenty and Wairarapa than in Taranaki. In Taranaki there was a significant altitude effect ($P < 0.05$) on the initial levels of parasitism, being higher for the low and mid altitude sites. However, thereafter the rates of build-up in parasitism for the low, medium and high altitude sites (25-280 m) were not significantly different. Overall, the rate at which parasitism increased at sites in the North Island was substantially greater than that found at Lincoln, Canterbury (Goldson et al. 1999a).

Releases of *M. hyperodae* geographic populations

Excluding the Mendoza population, an average of 91 040 parasitoids was released from each of the seven main geographic populations, with the majority originating from La Serena followed by General Roca then Ascasubi (Table 2). The Ascasubi population, having six lines available, produced the greatest number of offspring, followed by Concepcion then Bariloche (Table 2). An effort was made to ensure that equal numbers of each geographic population were included in each release (Goldson et al. 1993a; McNeill et al. 2002a). At the conclusion of the programme, there was only $\pm 5\%$ variation among the seven main geographic populations in the total number released, although the mean number from each line that was released varied by $\pm 23\%$. Due to availability, not all lines were represented in each release, particularly where releases of less than 15 000 parasitoids were undertaken. The Marlborough (Ward) release was exceptional in that only seven parasitoid lines (six from General Roca) were represented. Establishment at Ward was confirmed three years later, although only 5% parasitism was detected at that stage. The number of lines released in other regions varied from 23 in Northland to 49 in the Gisborne region of the North Island.

TABLE 2: Number of parasitoid lines, total number of parasitoids and mean number of parasitoids per line of each *M. hyperodae* geographic population released across New Zealand between 1991 and 1998. Numbers exclude the initial 99 000 released in 1991.

Geographic population ¹	No. of lines	Total released	Mean per line
Ascasubi (AR)	6	91 578	15 550
Bariloche (AR)	6	86 750	14 628
General Roca (AR)	10	95 294	9 883
Mendoza (AR)	1	23 064	23 064
Porto Alegre (BR)	8	88 360	11 220
Colonia (UY)	8	90 900	11 806
La Serena (CL)	10	96 353	10 306
Concepcion (CL)	6	88 050	14 878

¹AR= Argentina, BR = Brazil, CL = Chile and UY = Uruguay.

At the start of *M. hyperodae* mass-rearing in 1991, 5-8 generations had been completed in quarantine. When the colonies were terminated at the end of 1998, between 67-70 generations had been completed. Based exclusively on establishment success, there appeared to be no loss of vigour of the cultures in the interval between 1991 and the final releases in 1998 (Phillips et al. 2000). Problems that can occur in culture with sexually reproducing insect species, such as inbreeding depression, reduced fecundity and change in male: female ratios, were avoided because *M. hyperodae* is thelytokous.

Dispersal of *M. hyperodae* in Taranaki

Twelve months after release, *M. hyperodae* was found to have established and begun to disperse at both locations. At Waititi the parasitoid had dispersed in all four directional bearings and was found up to 200 m from the release paddock (Fig. 1a). At Eltham a similar dispersal pattern was observed, although the maximum distance from which the parasitoid was recovered was ca 100 m from the release paddock (Fig. 1b). The mean

FIGURE 1: Distribution of *M. hyperodae* in *L. bonariensis* in the autumn-winter of 1997, 1998 and 1999 at (a) Waititi and (b) Eltham in Taranaki region of the North Island.

percentage parasitism at sites where *M. hyperodae* was recovered was 1.2 and 2.8% at Eltham and Waiiti respectively. Surveys in 1998 and 1999 confirmed the continued dispersal of the parasitoid at both locations (Figs 1a & 1b). The area occupied by *M. hyperodae* at Waiiti was 9, 49 and 194 ha for 1997, 1998 and 1999 respectively. At Eltham, the increase in area occupied by *M. hyperodae* was 4, 37 and 184 ha for 1997, 1998 and 1999 respectively. These colonised area estimates are likely to be conservative for both sites, as parasitism greater than 15% was found at two of the most distant sites north and south east of the Waiiti release paddock, while parasitism at the most distant point on the south axis from the Eltham release paddock was 38%. At both sites, levels of parasitism and the increase in parasitism with time were substantially higher than those recorded at Lincoln, Canterbury (Goldson et al. 1993a). However, the area covered by *M. hyperodae* at the two sites was significantly less than that recorded at Lincoln where the area colonised by the parasitoid after two years was 60 ha and after three years was 2330 ha

FIGURE 2: Estimated distribution of *M. hyperodae* in New Zealand at the end of 2002. Commercial releases in Bay of Plenty, Taranaki and Canterbury (black circles) and research release in Wairarapa (white circles) signify two release sites.

(Goldson et al. 1999a). In the Canterbury study there was a strong dispersal bias to the south-west aided by the prevailing north-easterly wind (Goldson et al. 1999a). A greater propensity for flight by *L. bonariensis* in Canterbury (Goldson et al. 1999b) appeared to enable the parasitoid to more quickly colonise a given area over time, despite a slower increase in the parasitism rate.

Distribution of *M. hyperodae* in New Zealand

The parasitoid appears to be widely distributed throughout the North Island, based on field collections and projections on the mean rate of dispersal from release paddocks (Fig. 2). Dispersal in Wairarapa is estimated to have been more limited because releases only took place in 1998. Due to a combination of fewer releases, cooler climate and a slower rate of spread in Otago (Ferguson et al. 1997), *M. hyperodae* is estimated to have more limited coverage across the South Island (Fig. 2).

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