ESTABLISHMENT AND DISPERSAL OF *MICROCTONUS HYPERODAE* LOAN (HYMENOPTERA: BRACONIDAE) IN OTAGO AND SOUTHLAND

C.M. FERGUSON[1], A.A. EVANS[1], B.I.P. BARRATT[1] and C.B. PHILLIPS[2]

New Zealand Pastoral Research Institute Ltd.,
[1]Invermay Agricultural Centre, PB 50034 Mosgiel
[2]Canterbury Agriculture and Science Centre, PO Box 60, Lincoln

ABSTRACT

During 1991-2 *Microctonus hyperodae* was released at four sites in Otago and Southland, New Zealand, as a biological control agent of *Listronotus bonariensis* (Argentine stem weevil). The parasitoid was first recovered from the field 17 and 19 months after release at Ophir and Sutton respectively. By April 1996 parasitism levels in *L. bonariensis* had reached 40% at Ophir and 33% at Sutton but radial sampling indicated that dispersal was limited to within a 1 km radius at Ophir and a 500 m radius at Sutton. No parasitism of non-target weevils by *M. hyperodae* has been recorded at either site. To date *M. hyperodae* has not been recovered from release sites near Mosgiel and Gore. The establishment levels and dispersal rates in Otago are less than those measured in Canterbury and Waikato and possible reasons for this are discussed.

Keywords: *Microctonus hyperodae, Listronotus bonariensis,* Argentine stem weevil biocontrol, non-target species

INTRODUCTION

Microctonus hyperodae Loan (Hymenoptera: Braconidae) is a solitary endoparasitoid of the adult stage of its host. It was introduced from South America into quarantine in New Zealand during 1989-90 as a potential biological control agent for *Listronotus bonariensis* Gyllenhal (Coleoptera: Curculionidae) (Argentine stem weevil) and first released in 1991 (Goldson *et al.* 1994). By 1994 it had been released at 12 sites and recovered from ten, with recoveries not being made from the southern-most sites near Mosgiel and Gore. From the Canterbury region northwards establishment at release sites appeared rapid with recovery of the parasitoid from the field occurring within six months. The exception to this was one site at Blenheim where only 700 parasitised weevils were released. Also by 1994 high levels (48-84%) of stem weevil parasitism from Canterbury northwards had generally been recorded with Blenheim (7%) and a site at Hororata (12%) being the exceptions (Goldson *et al.* 1994). In the Waikato region of the North Island, *M. hyperodae* had dispersed up to 19 km from release sites by 1995 (P. Addison unpubl.) and in Canterbury, up to 15 km by 1996 (J. Proffitt unpubl.). However, at Ophir (Central Otago), although the parasitoid was recovered 17 months after release, by 1994 the maximum parasitism level recorded was only 23%. At Sutton (Strath Taieri), *M. hyperodae* was first recovered 19 months after release, but by 1994 parasitism had not exceeded 1%.

This investigation measured parasitism levels and dispersal of *M. hyperodae* in *L. bonariensis* populations at the four southernmost release sites, and sought to explain why the parasitoid appears less successful in the region compared to areas further north.

METHODS

© 1997 New Zealand Plant Protection Society (Inc.) www.nzpps.org Refer to http://www.nzpps.org/terms_of_use.html

In October 1991, 8,650 parasitised adult *L. bonariensis* were released at Ophir, 5,200 at Sutton, and 5,560 at Gore. In November 1992, 6,700 parasitised weevils were released at Mosgiel. The techniques used to provide the parasitised weevils are given by Goldson *et al.* (1993). In all cases the parasitised weevils were distributed as evenly as possible over a 1 ha area of predominantly ryegrass/white clover pasture. The pastures at Ophir and Sutton were quantitatively sampled for weevils by taking 80 (Ophir) or 40 (Sutton) 150 mm x 150 mm turves 30 mm deep (Ferguson *et al.* 1996) on a regular basis until May 1997. The pastures near Mosgiel and Gore were similarly sampled until October 1993 and May 1992 respectively. Weevils were heat-extracted from these turves using modified Berlese funnels (Proffitt *et al.* 1993). *L. bonariensis* and any native weevils collected were dissected to determine if they were parasitised.

In April 1996 and April 1997, weevils from all four release sites were collected using Jonsered BV32 and Homelite HB-180 blower vacs to vacuum weevils from the pasture into gauze collecting bags. Vacuum samples were also collected from sites radiating out from the release sites as shown in Table 1. In 1996 vacuum sampling was carried out for 30 minutes at each site and in 1997 for one hour at each site. Since the release site at Gore was cultivated and sown in cereal in the 1996/97 season, a pasture immediately adjacent to it was sampled in 1997 by taking 125 0.04 m^2 turves 30 mm deep and extracting weevils from these in Berlese funnels.

All weevils collected during the radial sampling in 1996 and 1997 were maintained for 4-6 weeks in cages in the laboratory at 20±2 ^{o}C, 40-60% relative humidity with a photoperiod of 16 hours light and 8 hours dark. Parasitoids which emerged were recorded.

RESULTS AND DISCUSSION

Since the first recovery of *M. hyperodae* at Ophir in March 1993 the parasitoid appears to have become firmly established. With the exception of brief periods in late spring and mid-summer, parasitism levels have generally increased reaching a maximum of 41% to date (Fig. 1a). Conversely, the density of *L. bonariensis* has declined steadily since the parasitoid has established although factors other than those exerted by the parasitoid are probably involved. A scarcity of hosts in mid-summer when over-wintered *L. bonariensis* are dying off and the new generation of adult weevils has not yet emerged (Ferguson *et al.* 1996) may be an important limitation to parasitoid build up. However, this period of low host availability may be overcome to some extent by the longevity and high searching efficiency exhibited by *M. hyperodae* which is thought to be a reflection of its primitive South American existence (Goldson *et al.* 1995).

By 1996 *M. hyperodae* had established at levels of up to 15%, and dispersed 500 m north, west and east of the release site but only one individual was found at a distance of 1000 m (Table 1). No further dispersal was detected in 1997.

At Sutton, a single *M. hyperodae* was recovered from the release site in May 1993 but no more were recovered until December 1995, at which time parasitism was 18% (Fig. 1b). The parasitism level dropped in mid summer 1996, as at Ophir, before increasing to the highest recorded level at Sutton of 33% in late summer early autumn 1996 (Fig. 1b). This level, however, was not maintained and the parasitism level fell until, in spring 1996, it approached zero and remained there. This may be partly a reflection of very low *L. bonariensis* numbers (Fig. 1b) but none of the weevils collected by vacuum sampling in April 1997 were parasitised (Table 1). Dispersal sampling in 1996 recovered *M. hyperodae* at low levels from 300 m west and 500 m north of the release site and in 1997 from 500 m west and north (Table 1). This indicated that although not achieving high levels of parasitism *M. hyperodae* has established in the area.

It is possible that *M. hyperodae* has dispersed beyond the points sampled in this investigation at both localities and so far escaped detection.

TABLE 1: Number of *L. bonariensis* and *M. hyperodae* collected during dispersal sampling (*L. bonariensis*/*M. hyperodae*) in Otago and Southland 1996 and 1997.

© 1997 New Zealand Plant Protection Society (Inc.) www.nzpps.org Refer to http://www.nzpps.org/terms_of_use.html

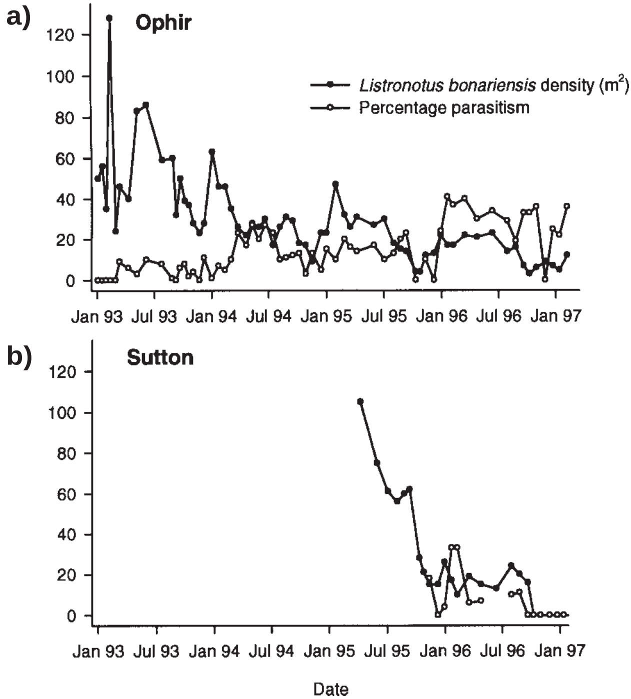

FIGURE 1: Adult *Listronotus bonariensis* density (/m^2) and parasitism by *Microctonus hyperodae* (%) at parasitoid release sites in Otago. (Standard errors for *L. bonariensis* density are not shown but in all cases SEMs were within 20% of the mean).

Date	Release site	Distance from release site (m)						
Ophir								
1996		500 N	500 E	500W	1000 N	1000 E	1000 W	
	107/12	59/6	146/23	169/3	43/0	75/0	142/1	
1997		1500 N	1500 E	1500 W				
	63/9	80/0	93/0	17/0				
Sutton								
1996		500 N	500 S	300 E	300 W			
	82/2	119/5	34/0	16/0	100/2			
1997		500 N	500 S	500 E	500 W	1000 N	1000 S	1000 W
	19/0	39/2	23/0	22/0	861/62	179/0	30/0	114/0
Mosgiel								
1996	24/0							
1997	65/0							
Gore								
1996	12/0							
1997	0/0							

The parasitoid has not been recovered from the release sites at Mosgiel and Gore. In both cases the *L. bonariensis* populations were low (23 and 20 adult weevils/m^2 respectively) at the time of parasitoid release and declined further over the period they were quantitatively sampled. Vacuum sampling in 1996 and 1997 did not recover any

© 1997 New Zealand Plant Protection Society (Inc.) www.nzpps.org Refer to http://www.nzpps.org/terms_of_use.html

parasitised weevils at either of these sites (Table 2). No *L. bonariensis* were found by turf sampling at Gore in 1997. Despite the high searching efficiency of *M. hyperodae*, weevil populations at these sites may be too low for the parasitoid to establish or persist particularly between generations in early summer (Ferguson *et al.* 1996). At Mosgiel this period, between the over-wintering weevil generation dying out and the next generation of adults emerging, appears to last longer than at Ophir and Sutton possibly because of less temperature accumulation occurring at Invermay (Ferguson *et al.* 1994). It may be longer at Gore where it is cooler. Lower temperatures also increase *M. hyperodae* generation time allowing three generations in Otago (unpubl. data) compared to five in Waikato (P. Addison unpubl. data). In retrospect, the release of the parasitoids in October in the southern South Island may have been inappropriate since only over-wintering, ageing adults were present. Parasitoids emerging from the hosts they were released in would have encountered older weevils and there may have been insufficient time available to complete the development of the next parasitoid generation before weevil death. New generation weevils do not appear until January (Ferguson *et al.* 1996). The more rapid build up and dispersal at release sites in the Canterbury and Waikato regions may have been enhanced by high host densities to which *M. hyperodae* exhibits strong density-dependent responses. Parasitism levels achieved by *M. hyperodae* remain constant despite increasing host density (Barlow *et al.* 1993) and this would result in higher densities of *M. hyperodae* being present where host density is high.

TABLE 2: Non-target weevil species collected from Ophir and Sutton during the investigation.

Site	Species	No weevils dissected	Weevil density[1] (No/m^2)
Ophir	**Brachycerinae: Entimini**		
	Brachyolus obscurus Sharp	2	<1
	Irenimus egens (Broun)	586	27-270
	Nonnotus albicans (Broun)	13	<1
	Otiorhynchus ovatus L.[2]	1	<1
	Brachycerinae: Rhytirhinini		
	Steriphus delaiguei Germain)[2]	36	<2
	S. diversipes lineata (Pascoe)[2]	1	<1
Sutton	**Brachycerinae: Entimini**		
	Irenimus stolidus Broun	200	20-35
	Nicaeana cervina Broun	395	41-50
	Nonnotus albicans (Broun)	1	<1
	Brachycerinae: Rhytirhinini		
	Listroderes obliquus Klug[2]	1	<1
	Steriphus delaiguei (Germain)[2]	12	<1
	S. variabilis Broun	1	<1

[1]range of maximum spring densities (4 years Ophir; 3 years Sutton)
[2]introduced species

There are preliminary indications that other factors may also be involved in the slow establishment and spread of *M. hyperodae* in southern South Island sites. Female *M. hyperodae* collected from Ophir and Sutton have been found to contain fewer eggs in their ovarioles (C. Phillips unpubl. data) than *M. hyperodae* from Canterbury and Waikato and also from the laboratory culture maintained from the original *M. hyperodae* introductions (Goldson *et al.* 1995; Phillips *et al.* 1996). Given that *M. hyperodae* exhibits proovigenesis (Goldson *et al.* 1995), *in situ* egg counts should approximate the species potential fecundity. There are at least two hypotheses which could explain the observed relatively low fecundity of parasitoids collected in Otago.

© 1997 New Zealand Plant Protection Society (Inc.) www.nzpps.org Refer to http://www.nzpps.org/terms_of_use.html

Firstly, *L. bonariensis* present in Otago may be lower quality hosts for *M. hyperodae* than weevils present elsewhere in New Zealand, with parasitoids poorly nourished and with reduced fecundity. Secondly, the ecotypic composition of *M. hyperodae* established in Otago could differ from those established elsewhere, such that ecotypes with relatively low fecundity have been most successful. These hypotheses are not mutually exclusive and data exists to support both. In a study of *L. bonariensis* genetic variation (Lenney Williams *et al*. 1994) weevil populations from Canterbury, Bay of Plenty, Waikato and Northland were genetically homogeneous, while a population from Southland (Gore) was genetically distinct. Morphometric analysis has suggested that generally throughout New Zealand, *M. hyperodae* derived from east of the Andes have been more successful than those derived from west of the Andes, while parasitoids collected in the Argentinean Andes at S. C. de Bariloche have had an intermediate degree of success (Phillips *et al*. 1997). At the Otago sites, however, parasitoids classified as being derived from S. C. de Bariloche tend to occur in higher proportions than elsewhere in New Zealand (C. Phillips unpubl. data). These differences, although not significant, are partly corroborated by fecundity data which indicate that parasitoids from S. C. de Bariloche tend to have lower potential and achieved fecundities than most other *M. hyperodae* ecotypes (Goldson *et al*. 1995; C. Phillips unpubl. data).

Although other species of weevils were common at the release sites at both Ophir and Sutton (Table 2) no parasitism of these by *M. hyperodae* was detected during the course of the investigation, supporting the contention of Goldson *et al.* (1992) that this parasitoid has a narrow host range and indicating that *M. hyperodae* has not switched to non-target weevils to bridge periods of target host scarcity.

M. hyperodae has established at both Ophir and Sutton in relatively sparse *L. bonariensis* populations and its successful establishment may be due to the attributes, longevity and searching ability, which may be necessary for it to survive in its native South America environment. It has not dispersed as far or reached the same levels of parasitism as further north, probably because of lower *L. bonariensis* population densities, lower accumulated degree days which limit the number of weevil and parasitoid generations per year, and possibly because of ecotypic or genetic differences between the parasitoids and hosts which occur in the southern South Island compared with elsewhere in New Zealand.

ACKNOWLEDGEMENTS

This investigation was funded by The Foundation for Science Research and Technology. The authors thank the farmers on whose properties the sampling was carried out especially Mr. A. Kinney, Ophir, and Mr R. Taylor, Sutton.

REFERENCES

Barlow, N.D., Goldson, S.L., McNeill, M.R. and Proffitt, J.R., 1993. Measurement of the attack behaviour of *Microctonus hyperodae* as a classical biological control agent of Argentine stem weevil, *Listronotus bonariensis*. *Proc. 6th Aust. Grassl. Invert. Ecol. Conf.*: 326-330.

Ferguson, C.M., Evans, A.A., Shand, J.A. and Barratt, B.I.P., 1994 Factors affecting the distribution of *Listronotus bonariensis* Kuschel (Coleoptera: Curculionidae) in Otago and Southland *Proc. 47th N.Z. Plant Prot. Conf.*. 279-281.

Ferguson, C.M., Evans, B.I.P. and Barratt, B.I.P., 1996. Phenology of *Listronotus bonariensis* (Kuschel) (Coleoptera: Curculionidae) in Otago. *Proc. 49th N.Z. Plant Prot. Conf.*: 270-274.

Goldson, S.L., McNeill, M.R., Phillips, C.B. and Proffitt, J.R., 1992 Host specificity testing and suitability of the parasitoid *Microctonus hyperodae* (Hym.: Braconidae, Euphorinae) as a biological control agent of *Listronotus bonariensis* (Col.: Curculionidae) in New Zealand *Entomophaga 37 (3)*: 483-498

Goldson, S.L., McNeill, M.R., Proffitt, J.R., Barker, G.M., Addison, P.J., Barratt, B.I.P. and Ferguson, C.M., 1993 Systematic mass rearing and release of *Microctonus hyperodae* (Hym.: Braconidae, Euphorinae) a parasitoid of the Argentine stem weevil *Listronotus bonariensis* (Col.: Curculionidae) and records of its establishment

© 1997 New Zealand Plant Protection Society (Inc.) www.nzpps.org Refer to http://www.nzpps.org/terms_of_use.html

in New Zealand *Entomophaga 38 (4)***:** 527-536

Goldson, S.L., Barker, G.M. and Barratt, B.I.P., 1994 The establishment of the Argentine stem weevil parasitoid at its release sites *Proc. 47th N.Z. Plant Prot. Conf.*: 274-276

Goldson, S.L., McNeill, M.R., Proffitt, J.R. and Hower, A.A., 1995. An investigation into the reproductive characteristics of *Microctonus hyperodae* (Hymenoptera: Braconidae), a parasitoid of *Listronotus bonariensis* (Kuschel) (Coleoptera: Curculionidae) *Entomophaga 40 (3/4)*: 413-426.

Lenney Williams, C.L., Goldson, S.L., Baird, D.B. and Bullock, D.W., 1994. Geographical origin of an introduced insect pest, *Listronotus bonariensis* (Kuschel), determined by RAPD analysis. *Heredity 72*: 412-419.

Phillips, C.B., Roberts, R., Macnab, H.R., McNeill, M.R. and Goldson, S.L., 1996. Fecundity of wild and laboratory-reared ecotypes of *Microctonus hyperodae* Loan (Hymenoptera: Braconidae) *Proc. 49th N.Z. Plant Prot. Conf.*: 285-290.

Phillips, C.B., Baird, D.B. and Goldson, S.L., 1997. South American origins of *Microctonus hyperodae* Loan (Hymenoptera: Braconidae) established in New Zealand as defined by morphometric analysis. *Bio. Sci. and Technol. 7*: (in press).

Proffitt, J.R, Ferguson, C.M., McNeill, M.R., Goldson, S.L., Macnab, H.R. and Barratt, B.I.P., 1993. A comparison of sampling methods for adult *Listronotus bonariensis* (Kuschel) *Proc. 6th Aust. Grassl. Invert. Ecol. Conf.*: 67-72.

© 1997 New Zealand Plant Protection Society (Inc.) www.nzpps.org Refer to http://www.nzpps.org/terms_of_use.html