Non-target impact assessment of the introduced green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) on the indigenous sibling species, *C. nipponensis* (Okamoto) through interspecific predation

Atsushi MOCHIZUKI^{1,*} and Takayuki MITSUNAGA²

¹ National Institute for Agro-Environmental Sciences; Tsukuba, Ibaraki 305–8604, Japan

² National Agricultural Research Center; Tsukuba, Ibaraki 305–8666, Japan

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Abstract

As a part of a risk assessment of the non-target effect of the introduced green lacewing on native ecosystem, we performed a laboratory experiment to characterize the symmetry of the interspecific predation between the introduced green lacewing, *Chrysoperla carnea* and the native sibling species, *C. nipponensis* among different stages. The elder and larger larvae always ate the younger and smaller individuals, regardless of species. When the same instar and similar sized larvae were paired, almost equal predation rates between the two species was observed. Our results suggest that size was the most important factor to determine the symmetry of the interspecific predation between *C. carnea* and *C. nipponensis*. Populations of *C. nipponensis* will not be decreased by interspecific predation with *C. carnea* without extreme mass releases of *C. carnea* in a small arena.

Key words: Non-target impact assessment; green lacewing; introduced natural enemy; interspecific predation

INTRODUCTION

The use of natural enemies for pest management is regarded as safer than chemicals and antibiotics from the viewpoint of human health. Introduction of natural enemies from overseas has been successfully used to suppress invasive pests (Van Driesche and Bellows, 1996). However, since Howarth (1983) pointed out that attacks by introduced natural enemies on non-target organisms resulted in their extinction in Hawaii, serious concerns over the non-target impacts of introduced natural enemies on native ecosystems have been raised by a number of prominent ecologists and conservation biologists (Follett and Duan, 2000; Wajnberg et al., 2001; Louda et al., 2003). In Japan, an increasing number of new exotic biological control agents are being introduced as biological pesticides without any prior assessment of their non-target impacts on the native environment.

A green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera; Chrysopidae), one of generalist predators, has been commercially imported from Germany and sold as a biological pesticide since 2001. A native sibling species is widely distributed in Japan. It was described as *Chrysopa*

nipponensis Okamoto (Okamoto, 1914), treated synonymous with *C. carnea* by Tsukaguchi (1985) but later revised the status to *Chrysoperla nipponensis* (Okamoto), since the adult wing gradate crossveins are green in *C. carnea* but black in *C. nipponensis* (Brooks, 1994).

There is abundant ecological data for each species (e.g. Canard et al., 1984; Fujiwara and Nomura, 1999), however little is known on interspecific predation among chrysopids species, especially between *C. carnea* and *C. nipponensis*. As a part of a risk assessment of the non-target effect of the introduced green lacewing on the native ecosystem, we performed a laboratory experiment to characterize the symmetry of the interspecific predation between the introduced green lacewing, *C. carnea* and the native sibling species, *C. nipponensis* at different stages.

MATERIALS AND METHODS

C. nipponensis pupae were provided by Dr. K. Niijima of Tamagawa University. *C. carnea* larvae (Kagetaro[®]) were purchased from Arysta Life-Science Corporation. The two species were reared in a similar manner. About 50 paired adults were

* To whom correspondence should be addressed at: E-mail: lepi@affrc.go.jp

maintained in a 30×30×30 cm cage, supplied with water and a diet of 50% honey/water solution mixed with 3 g/20 ml Yeast Extract (DIFCO) and applied to defatted cotton according to a modified version of Henry's method (Henry, 1979). Larvae were individually reared by supplying about 20 mg of Entofood® (frozen eggs of *Ephestia kuehniella*, Arysta LifeScience Corporation) every two days. Rearing and experiments were carried out under conditions of 16L:8D at 25°C.

The experiment to investigate intespecific predation was performed on only larval stages without any prey, because adults of both species are not predacious. Larvae of a specific age were obtained by rearing newly hatched larvae on Entofood® until they reached the desired stage. Larvae were used within one day after hatching or molting. Larvae of a given instar were similar in size for both species. For distinguishing the two species, larvae were anesthetized with ether and marked on the mid-leg with blue paint (Water Colors F, cobalt blue, Pentel) using a thin brush under a binocular microscope, and isolated in a new polystyrene case without food for 12 h to recover from the anesthesia, and to allow the paint to dry. The anesthetization and color marking were determined to have no effect on larval behavior in a preliminary experiment. The two different species were paired in the same polystyrene case (65×35×17.5 mm). Twenty replicates were carried out. The paint-marked species was changed in half of the replicates to reduce the experimental error: a paint-marked *C. carnea* larva was paired with a non-marked *C. nipponensis* larva in ten replicates, and a paint-marked *C. nipponensis* larva was paired with a non-marked *C. carnea* larva in the remaining ten replicates. Data were tested using the χ^2 test, after Yates' correction (Sokal and Rohlf, 1995).

RESULTS AND DISCUSSION

Results are shown in Table 1. When different-instar larvae were paired, the elder larvae always ate the younger individual, regardless of species ($\chi^2=10.8$, $p=0.001$). When the same instar larvae were paired, 45% of first instar *C. carnea* larvae ate first instar *C. nipponensis* larvae ($\chi^2=0$, $p=0.999$), 45% of second instar *C. carnea* larvae ate second instar *C. nipponensis* larvae ($\chi^2=0$, $p=0.999$), and 40% of third instar *C. carnea* larvae ate third instar

Table 1. Percentages of predation by *Chrysoperla carnea* larvae when paired with *C. nipponensis* larvae

Larval instar of <i>C. carnea</i>	Larval instar of <i>C. nipponensis</i>		
	1st	2nd	3rd
1st	45	0**	0**
2nd	100**	45	0**
3rd	100**	100**	40

** indicates significant difference from 50% predation in each pair by χ^2 test ($p<0.01$).

C. nipponensis larvae ($\chi^2=0$, $p=0.999$). Interactions between individuals were symmetrical in the same developmental stage and asymmetrical between different stages. At the species level, the competitive relationship between the two species could be considered symmetric.

There are many data on intraguild predation among predacious insects, suggesting that predator's mobility, size, and feeding specificity largely determine the prevalence and symmetry of intraguild predation (e.g. Sengonca and Frings, 1985; Lucas et al., 1998). Our results suggest that the size was the most important factor to determine the symmetry of the interspecific predation between *C. carnea* and *C. nipponensis*. Populations of *C. nipponensis* should not be decreased by interspecific predation with *C. carnea* without extreme mass releases of *C. carnea* in a small arena. Our data will contribute to the risk assessment of introduced *C. carnea* on native ecosystem.

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