Assessment of the Potential Efficiency of Parasitism in
Two Competitive Scelionid Parasites of *Nezara viridula* L.
(Hemiptera : Pentatomidae)

Fusao NAKASUJI,¹ Nobuhiko HOKYO¹ and Keizi KIRITANI¹

Asso Research Station, Wakayama Agricultural Experiment Station,
Nishimuro, Wakayama-Pref., Japan

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In order to assess the parasitic efficiencies of two egg parasites, *Asolcus mitsukurii* ASHMEAD and *Telenomus nakagawai* WATANABE, which compete with each other for the egg of *Nezara viridula*, a large number of hosts were artificially placed in the fields and exposed to parasites for a short period, i.e. one week. The host finding ability of *T. nakagawai* was superior to that of *A. mitsukurii* and the period of residence on the egg mass was shorter in the former than in the latter. The percentage parasitism of egg masses increased more rapidly in *T. nakagawai* than *A. mitsukurii* with an increase in their densities. *T. nakagawai* was able to parasitize the egg masses more efficiently than *A. mitsukurii* during the limited exposure of the egg masses. These facts show that *T. nakagawai* would be a more promising egg parasite, if there were no competition with *A. mitsukurii*.

INTRODUCTION

It is very difficult to evaluate the potential efficiency of a parasite when it competes with another species for the same host(s). In the present study, we attempted to assess the specific efficiencies of two egg parasites of *Nezara viridula*, viz. *Asolcus mitsukurii* ASHMEAD and *Telenomus nakagawai* WATANABE, under natural conditions by removing the interspecific interference caused by the aggressive behavior of *A. mitsukurii* against *T. nakagawai* (HOKYO and KIRITANI, 1963). For this purpose, we placed a large number of egg masses in the study fields for a short period to utilize the slight differences in the host finding ability and residency between those two species. This is analogous to the biological check method employed by DEBACH *et al.* (1951).

METHODS

Fresh and healthy egg masses of *N. viridula* were supplied by keeping adults in

¹ Present Address: Division of Entomology, Prefectural Institute of Agricultural and Forest Science, Ōsone, Nangoku, Kōchi-Pref., Japan.

a large cage (1.5 m³ in volume) placed indoors. Egg masses within 24 hr after oviposition, were attached to pieces of parchment paper, 1 cm in width and 5 cm in length, by paste which left no smell after drying. Each of these was attached by a paper fastener on the back surface of a leaf of the host plant of *N. viridula*.

Fields of potato and early paddy were selected for the artificial placement of those egg masses. These plants are utilized by *N. viridula* as oviposition sites for the first and second generations. Two stations 1,000 m apart were chosen for this study. The first, referred to as Station I, is on the slope of a low hill and the other, referred to as Station II, is on a flat plane. Three fields of potato and one paddy field were located at each station (Table 1).

Table 1. STUDY FIELDS AND EXPERIMENTAL DESIGN

Station	Field	Total no. of plants	Nos. of plants and egg masses per placement	Method of distribution of egg masses
I	Potato	235	5	} at random
	Ditto	71	3—4	
	Ditto	79	3—4	
	Paddy	1,500	5	in clump ^a
II	Potato	507	4	} at random
	Ditto	55	3—4	
	Ditto	80	3—4	
	Paddy ^b	3,600	5	in clump ^a

^a Two clumps, each composed of 5 stubbles arranged in crosswise, were used alternatively.

^b This was composed of 3 fields of different varieties of early planted paddy. Each contained 1,200 stubbles and cultivated side by side.

On each date that eggs were placed in the field, 4 or 5 masses were placed at each field. The location of these placements is shown in Table 1. The placement of egg masses was carried out every 4 days from early May till late August in 1965. These egg masses were observed daily for 1 week with regard to the appearance of parasites. The incubation period for eggs of *N. viridula* is 10–14 days for the first generation and about 1 week for the second generation (HOKYO and KIRITANI, 1963). Therefore, the exposure period of the placed egg masses, *viz.* 1 week, was 3 to 7 days shorter than the incubation period of the first generation. Then these egg masses were brought back to the laboratory and kept separately in glass tubes under room temperatures and about 90 per cent relative humidity to assess the amount of parasitism. The parasitized eggs which did not give rise to parasites were dissected to allow identification of the species involved. Simultaneously, weekly censuses of host egg masses to evaluate their natural density and percentage parasitism were conducted for all potato plants in St-I and St-II and for 100 rice stubbles (10×10) of each of the varieties in St-II.

RESULTS

1. *Host finding ability and residency on eggs*

The relative abundance of egg masses artificially placed and those of naturally deposited were compared in Table 2. Apparently, the number of egg masses artificially placed much exceeded the number which was naturally deposited.

Table 2. RELATIVE ABUNDANCE OF EGG MASSES PER PLANT ARTIFICIALLY PLACED AND THOSE NATURALLY DEPOSITED IN THE STUDY FIELDS

	Station I		Station II	
	Potato	Paddy	Potato	Paddy
Artificially placed egg masses	0.43	3.90	0.14	5.50
Naturally deposited egg masses	0.06	—	0.00	0.09

The incidence of parasites with regard to the times elapsed after placement is shown in Fig. 1. The largest number of *T. nakagawai* were found on or near the egg masses 1 or 2 days after their placement, but the number decreased thereafter. On the other hand, the peak incidence of *A. mitsukurii* was observed 4 days after the placement and the number remained at a constant high level thereafter.

Fig. 1. Numbers of wasps of the two species observed on the egg masses placed in relation to the days elapsed.

The high frequency of *T. nakagawai* in the early period indicated that this species is superior to *A. mitsukurii* in its ability to find hosts. Whereas, the strong residency of the latter on host egg mass resulted in a high and constant frequency of *A. mitsukurii* in the following period.

When the relative abundance of both species in the potato fields was about the same, the mean days required for these parasites to discover host egg masses were significantly shorter in *T. nakagawai* than in *A. mitsukurii* (Table 3). The difference, however, was not significant in the paddy fields though *T. nakagawai* discovered hosts a bit earlier than *A. mitsukurii*. This is considered due to the fact that the density of *T. nakagawai* was low as compared with *A. mitsukurii* (Table 3).

Table 3. MEAN DAYS REQUIRED FOR THE PARASITES TO REACH THE EGG MASSES ARTIFICIALLY PLACED

	Potato fields			Paddy fields		
	No. of parasites observed	Density of parasites per egg mass	Mean $\pm$ 95% Fid. (days)	No. of parasites observed	Density of parasites per egg mass	Mean $\pm$ 95% Fid. (days)
<i>A. mitsukurii</i>	98 ^a	0.38	3.42 $\pm$ 0.62	56	0.60	3.23 $\pm$ 0.56
<i>T. nakagawai</i>	111 ^a	0.43	2.57 $\pm$ 0.35	11	0.12	2.80 $\pm$ 1.07

* $p < 0.05$ (T-test).

^a The wasps which were successively observed on the egg mass were regarded as the same one.

Mean durations of residence of both species on egg masses are shown in Table 4 together with the figures calculated from HOKYO and KIRITANI's (1963) data. Here, the duration of residence of a parasite which was found only once is regarded as zero. Generally, the mean residence period of *A. mitsukurii* was considerably longer than that of *T. nakagawai*. The mean durations of residence of *T. nakagawai* in 1962 and 1965 coincided well with each other in both potato and paddy fields respectively. While, the mean duration of *A. mitsukurii* in the potato

Table 4. MEAN DURATIONS OF RESIDENCE OF PARASITES ON HOST EGG MASSES

		Potato fields		Paddy fields	
		No. of parasites observed	Mean $\pm$ 95% Fid. (days)	No. of parasites observed	Mean $\pm$ 95% Fid. (days)
1962 ^a	<i>A. mitsukurii</i>	32	1.47 $\pm$ 0.68	37	0.29 $\pm$ 0.24
	<i>T. nakagawai</i>	32	0.25 $\pm$ 0.20	37	0.19 $\pm$ 0.06
1965	<i>A. mitsukurii</i>	98	0.71 $\pm$ 0.27	56	0.64 $\pm$ 0.32
	<i>T. nakagawai</i>	111	0.27 $\pm$ 0.10	11	0.18 $\pm$ 0.41

* $p < 0.05$ ** $p < 0.01$ (T-test).

^a Calculated from Table 7 in HOKYO and KIRITANI (1963).

fields of 1965 was one half that of 1962. This is explained by the shortening in the exposure period of the placed egg masses, because *A. mitsukurii* usually remains on the parasitized egg masses even after the appearance of symptoms of parasitism.

2. *Efficiencies of parasites with regard to their percentage parasitism*

Analysis was made only for the data obtained at St-I, because the parasite densities were insignificant at St-II. Placements were repeated twenty six times at St-I from 8th May to 10th August. As the egg masses were placed every 4 days and left for 1 week in the fields the first and last 3 days of the exposure period overlapped between the two successive placements. Therefore, the percentage parasitism and number of wasps per egg mass on each census were expressed by a two-point moving average.

The correlation between the percentage parasitism of egg masses (Y) and the densities of the wasps (X) was significant for both species, *e.g.* $Y=0.27X+0.02$ and $Y=0.56X+0.17$ for *A. mitsukurii* and *T. nakagawai* respectively ($p=0.01$). However, the relation should theoretically be expressed by an exponential curve (Fig. 2).

Fig. 2. The correlation between the percentage parasitism of egg masses and the number of wasps per egg mass.

The slopes of the regression lines show the potential efficiency of the wasps. The percentage parasitism of both species increased with an increase in the density of the wasps, but the slope was steeper in *T. nakagawai* than *A. mitsukurii*. This means that *T. nakagawai* is a more efficient parasite compared with *A. mitsukurii*.

If the parasite parasitizes all eggs of an egg mass, the percentage parasitism of egg masses should be equal to the percentage parasitism of eggs. The relation between the percentage parasitism of egg masses and eggs is shown in Fig. 3. The line of 45 degrees indicates the point at which all egg masses are completely parasitised. The correlations between the percentage parasitisms of egg masses and eggs were significant for both species ($p=0.01$). The regression coefficient of *T. nakagawai*, viz. 0.77, was greater than 0.58 of *A. mitsukurii* ($p=0.10$). This indicates that *T. nakagawai* parasitized the egg mass to a greater extent than in the case with *A. mitsukurii*.

Fig. 3. The correlation between the percentage parasitism of egg masses and eggs.

DISCUSSION

It is very important to evaluate the potential efficiency of parasites in biological control. In this study, we proposed a method to assess the potential efficiency of a single species whose efficiency seems to be suppressed by another competing species.

HOKYO and KIRITANI (1966) mentioned that females of *A. mitsukurii* are aggressive during their reproductive phase. If the short residency of *T. nakagawai* is at all due to the interference by *A. mitsukurii*, the potential efficiency of *T. nakagawai* should be affected negatively by *A. mitsukurii*. However, this was not the case in the present study. Out of 166 total egg masses placed in the potato fields of St-I, *T. nakagawai* was observed on 58 egg masses of which 11 were

cases where *T. nakagawai* was replaced by *A. mitsukurii*. Therefore, the short residence of *T. nakagawai* is of her own making rather than the result of interference by *A. mitsukurii*.

The mean fecundity of *T. nakagawai* is about 100 eggs, which is about 1.6 times that of *A. mitsukurii* and the former lives 11 days on the average, or 3 days longer than *A. mitsukurii* (HOKYO *et al.*, 1966 a). Furthermore, *T. nakagawai* has a higher searching ability and can parasitize almost completely the whole egg mass inspite of her short residence. Therefore, taking into account the mean egg mass size of *N. viridula* in the first generation, *viz.* 74 per egg mass (KIRITANI and HOKYO, 1962, 1965), the female of *T. nakagawai* may parasitize more than one egg mass but *A. mitsukurii* attacks usually only one egg mass.

By contrast, the fact that the percentage parasitism of *T. nakagawai* was low as compared with *A. mitsukurii* in the first host generations in 1961 and 1962 suggested the existence of interspecific interference between the two (HOKYO and KIRITANI, 1963). Furthermore, HOKYO *et al.* (1966 b) has shown experimentally that the ability of discrimination of the parasitized eggs from unparasitized eggs disappears interspecifically, and this results in a multiparasitization of host eggs by both species. This follows with the interspecific larval competition within host eggs and gives rise to *A. mitsukurii* as the victor. Therefore, the potential efficiency of *T. nakagawai* would be suppressed by the existence of *A. mitsukurii*, if it were not for the peculiar situation provided by the artificial placement of abundant host eggs.

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