Boll. Zool. agr. Bachic.
Ser. II, 38 (2): 167-172

30 August 2006

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Interspecific competition between *Nasonia vitripennis* (Walker) and *Muscidifurax zaraptor* Kogan & Legner (Hymenoptera Pteromalidae)

Abstract - Groups of puparia of *Musca domestica* (100-150-200) were exposed for 48 hours to four couples of *Nasonia vitripennis* and *Muscidifurax zaraptor* associated in the ratios 4:0; 1:3; 2:2; 3:1; 0:4. Tests were carried out in a conditioned room at 27±1°C, 70±5% r.h. and photoperiod 14:10 (light:dark).
N. vitripennis and *M. zaraptor* caused a mortality of *M. domestica* higher than 90% when 100 puparia were exposed to four couples of the same species.
A significative decrease in *M. domestica* mortality was observed when the four couples of parasitoids were composed of individuals of the two species associated in the different ratios. The decrease was due to competition between the females of the two species.

Riassunto - *Effetti della competizione interspecifica fra* Nasonia vitripennis *(Walker) e* Muscidifurax zaraptor *Kogan & Legner (Hymenoptera Pteromalidae).*

Un numero crescente di pupari di *Musca domestica* (100-150-200) è stato esposto per 48 ore all'attività di quattro coppie di *Nasonia vitripennis* e di *Muscidifurax zaraptor* associate nei rapporti 4:0; 1:3; 2:2; 3:1; 0:4. Le prove sono state condotte in cella termostata a 27±1°C e 70±5% U.R., con fotoperiodo 14:10 (luce:buio).
N. vitripennis e *M. zaraptor* inducono una mortalità di *M. domestica* superiore al 90% quando sono utilizzate quattro coppie della stessa specie e 100 pupari.
Quando le quattro coppie di parassitoidi sono costituite da individui delle due specie in associazione con rapporti diversi, si registra una significativa riduzione della mortalità del Dittero a causa della competizione fra le femmine ovideponenti.

Key words: *Musca domestica*, parasitoids, offspring.

INTRODUCTION

Most part of researches on competition among Pteromalid parasitoids concerns interference among larvae, mainly in the case of super and multiparasitism (Hardin, 1960; Wylie, 1965a; Pawson *et al.*, 1987; Geden, 1996; Powell *et al.*, 2003), while competition among adults is less investigated (Wylie, 1976; Rivers, 1996; King, 1997).

The rate of reproduction of Pteromalidae is influenced by host density and by the ability of the parasitoids to find the host (De Bach & Smith, 1941). Pteromalid females

avoid super and multiparasitism as they are able to discriminate among already parasitized hosts (Ables & Shepard, 1974). *Nasonia vitripennis* (Walker) restrains from ovipositing in puparia parasitized by females of the same species and by females of *Muscidifurax zaraptor* Kogan & Legner (Wylie, 1965b; 1970); likewise females of *M. zaraptor* avoids puparia parasitized by female of the same species and by *N. vitripennis*. Both of them oviposite in puparia already parasitized by *Spalangia cameroni* Perkins (Wylie, 1972; Propp & Morgan, 1983). Legner (1981) observed that species belonging to the genera *Spalangia* Latreille and *Muscidifurax* Girault & Sanders are the most efficient and they can be released singly or associated.

In order to value the parasitization by singly or associated *N. vitripennis* and *M. zaraptor*, the emerging of *Musca domestica* L. and of the two species of parasitoids was observed with different numerical ratios of the parasitoids and various numbers of host puparia.

MATERIALS AND METHODS

Nasonia vitripennis (Walker), *Muscidifurax zaraptor* Kogan & Legner, and *Musca domestica* L. are reared in laboratory at Istituto di Entomologia agraria dell'Università degli Studi of Milan. Although *N. vitripennis* is indicated as a gregarious parasitoid (Smith, 1969), our strain is a solitary one.

Puparia of *M. domestica* (lenght 6 mm) 24-48 hours old and couples of 2-3 days old adult parasitoids were used.

Groups of puparia of *M. domestica* (100-150-200) were exposed for 48 hours to four couples of *N. vitripennis* and of *M. zaraptor* respectively in the ratio 4:0; 1:3; 2:2; 3:1; 0:4. Puparia and couples of parasitoids were placed in polyethylene jars (Ø: 12 cm, h: 6 cm), closed by a net (120 mesh).

Tests were carried out in a conditioned room at 27±1°C, 70±5% r.h. and photoperiod 14:10 (light:dark). Under these environmental conditions a female of *N. vitripennis* lives on average 7 days and a female of *M. zaraptor* 13.52 days, the mean number of offsprings is 80.9 and 118 individuals respectively (Bellini & Galgano, 2000).

Controls were carried out after 20 days for *M. zaraptor*, after 15 days for *N. vitripennis*, and after 8 days for *M. domestica*. Four repetitions were carried out for each test.

Percentage data were *arcsine* transformed before being submitted to analysis of variance. Data were subjected to ANOVA and Duncan's multiple range test (SPSS 10.0 per Windows). Student t-tests were used to compare means of emerged parasitoids (Microsoft Excell 2003).

RESULTS

Percentage of emerged adults of *Musca domestica* L. varied from 91,8 to 94,6 (Table 1) when puparia were not exposed to parasitoids.

The lowest number of emerged flies, from 100 puparia exposed to parasitoids, was observed with four couples of *Nasonia vitripennis* (Walker) or of *Muscidifurax zaraptor*

Table 1 - Mean number (±S.E.) of Musca domestica *L. adults emerged from 100, 150 and 200 puparia.*

Number of puparia	*Musca domestica*	
	Mean number (±S.E.)	Mean % (±S.E.)
100	94.6±1.26	94.6±1.56a
150	138.4±1.72	92.3±1.21a
200	183.5±1.69	91.8±0.87a

Values followed by different letters are significantly different with a confidence interval of 95% (Duncan's multiple rangeTest).

Table 2 - Mean number (±S.E.) of Musca domestica *L. adults emerged from groups of puparia exposed to four couples of Nasonia vitripennis (Walker) and Muscidifurax zaraptor Kogan & Legner with different ratios.*

Parasitoids		*Musca domestica*		
N. vitripennis	*M. zaraptor*	100	150	200
4	-	9.8±1.91a	34.2±2.78a	63.3±3.32a
-	4	8.9±1.53a	47.1±4.47b	87.5±4.77b
1	3	26.7±1.69b	47.6±5.19b	90±3.68b
2	2	26.5±3.98b	47±2.91b	83.4±4.29b
3	1	16.7±3.37a	47.3±1.8b	78.6±5.24b

Values followed by different letters are significantly different with a confidence interval of 99% (Duncan's multiple rangeTest).

Kogan & Legner (Table 2), while, varying the ratio between the species, the number of emerged flies increased, except with the ratio three couples of *N. vitripennis* and one couple of *M. zaraptor*. In tests with 150 and 200 puparia the lowest number of emerged flies was observed with four couples of *N. vitripennis*.

The number of emerged parasitoids, in the tests with four couples of the same species, significantly increases when the number of fly puparia rises from one hundred to two hundred (Table 3). Considering the mean number of emerged parasitoids of each species in the different ratios tests, values obtained with 100 puparia were significantly different (Table 4) and *M. zaraptor* was the predominant species with the ratio 1:3 (Student's t test; P= 0.001), while with the ratios 2:2 (P= 0.010) and 3:1 (P=0.000) *N. vitripennis* showed a higher number of emerged adults.

The predominant species was *M. zaraptor* with the ratio 1:3 (P=0.000) also with 150 puparia of *M. domestica*; competition was not observed between the two species with the ratios 2:2 and 3:1, in fact means were not significantly different (Table 5).

In the test with 200 puparia competition was observed with the ratios 1:3 (P=0.000) and 2:2 (P=0.005), *M. zaraptor* was the predominant species, while with the ratio 3:1 the mean numbers of adults of *N. vitripennis* and of *M. zaraptor* were not significantly different (Table 6).

Table 3 - Mean number (±S.E.) of parasitoids emerged from groups of puparia exposed to four couples of Nasonia vitripennis *(Walker) or* Muscidifurax zaraptor *Kogan & Legner.*

Number of puparia	*Nasonia vitripennis*	*Muscidifurax zaraptor*
100	63.7±2.1b	66.4±2.2b
150	71.5±3.2ab	70.7±3.3ab
200	79.4±3.6a	77.9±3.7a

Values followed by different letters are significantly different with a confidence interval of 99% (Duncan's multiple rangeTest).

Table 4 - Mean number (±S.E.) of parasitoids emerged from 100 puparia of Musca domestica L. exposed to four couples of Nasonia vitripennis *(Walker) and* Muscidifurax zaraptor *Kogan & Legner with different ratios and T test results.*

Parasitoids		Mean ± S.E.		t	P
N. vitripennis	*M. zaraptor*	*N. vitripennis*	*M. zaraptor*		
1	3	14.8±2.8	28.4±2.5	-3.64	0.001
2	2	29.5±3.1	15.9±3.6	2.86	0.01
3	1	41.1±4.6	8.5±1.5	6.76	0.000

Critical value of t 2.101; df 18.

Table 5 - Mean number (±S.E.) of parasitoids emerged from 150 puparia of Musca domestica L. exposed to four couples of Nasonia vitripennis *(Walker) and* Muscidifurax zaraptor *Kogan & Legner with different ratios and T test results.*

Parasitoids		Mean ± S.E.		t	P
N. vitripennis	*M. zaraptor*	*N. vitripennis*	*M. zaraptor*		
1	3	9.2±1.7	46.7±5.0	-7.08	0.000
2	2	25.3±2.3	31.7±3.4	-1.548	0.140 n.s.
3	1	28.6±4.5	28.2±4.8	0.061	0.952 n.s.

Critical value of t 2.101; df 18.
n.s.: not significant.

Table 6 - Mean number (±S.E.) of parasitoids emerged from 200 puparia of Musca domestica L. exposed to four couples of Nasonia vitripennis *(Walker) and* Muscidifurax zaraptor *Kogan & Legner with different ratios and T test results.*

Parasitoids		Mean ± S.E.		t	P
N. vitripennis	*M. zaraptor*	*N. vitripennis*	*M. zaraptor*		
1	3	11.8±1.5	36.1±3.6	-6.24	0.000
2	2	19.8±2.5	31.5±2.7	-3.13	0.005
3	1	30.4±3.2	22.2±2.8	1.93	0.069 n.s.

Critical value of t 2.101; df 18.
n.s.: not significant.

CONCLUSIONS

Nasonia vitripennis (Walker) and *Muscidifurax zaraptor Kogan* & Legner caused a mortality higher than 90% in *Musca domestica* L. when four couples of the same species were used with 100 puparia. With a higher number of puparia a decrease in the host mortality was observed, therefore host ratio higher than 1:25 are not useful. Morgan *et al.* (1989) observed in *Spalangia cameroni* an optimal parasitoid-host ratio between 1:10 and 1:15, and a considerable decrease of parasitisation with host ratio changing from 1:15 to 1:25.

The number of emerged parasitoids is higher when the four couples are made of individuals of the same species.

With the two combined species, a significantly decrease in the control of *M. domestica* was recorded. Parasitisation decrease is due to interspecific competition among adult females. Also Ables and Shepard (op. cit.) observed a number of attacked host by paired females of *Spalangia endius* Walker and *Muscidifurax raptor* Girault & Sanders lower than the number of host parasitized by a single female.

None of the two species is constantly prevalent when the number of the host varies. This behaviour could be due to the experimental conditions where the space remains the same.

It should be investigated in associated release in field if the rate of parasitisation increases, as previous studies have shown that *N. vitripennis* parasitize puparia on the surface while *M. zaraptor* is able to reach puparia even in the substrate (Limonta & Locatelli, 2004).

AKNOWLEDGEMENTS

The authors thank Ruggeri Luigi e C. s.a.s., Via Ghiaino 6, Crespellano (BO) that provided the first specimen for the laboratory rearing.

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Accepted 30 Juin 2006