Parasitism of Neosilba perezi (Diptera: Lonchaeidae) Larvae by a Braconid, Phaenocarpa neosilba (Hymenoptera: Braconidae: Alysiinae)

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PARASITISM OF *NEOSILBA PEREZI* (DIPTERA: LONCHAEIDAE) LARVAE BY A BRACONID, *PHAENOCARPA NEOSILBA* (HYMENOPTERA: BRACONIDAE: ALYSIINAE)

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ABSTRACT

Neosilba perezi (Romero & Ruppel) is known as the cassava shoot fly or shoot fly, because, unlike other species of its genus, its larvae feed exclusively on shoots of cassava (*Manihot esculenta* Crantz). These larvae kill the affected cassava shoots. Natural parasitism by a braconid, *Phaenocarpa neosilba* Arouca & Penteado-Dias, 2006, on shoot fly larvae was studied at 3 locations in the southwestern region of the state of São Paulo, Brazil. Larvae-infested shoots of cassava were collected at 3 distinct locations where cassava crops were grown. The shoots were kept in plastic boxes for pupation and emergence of adult flies and the parasitoid. The percentage of parasitism was separately correlated with temperature, rainfall, and age of the cassava plants. The average percent parasitism was 24.36%. A negative correlation between temperature and percent parasitism was observed at 1 location. At all 3 study areas percent parasitism of *N. perezi* showed a negative correlation with plant age. Therefore, given the high percent parasitism observed at the 3 locations, natural biological control may be an important factor in the population dynamics of *N. perezi*.

Key Words: *Neosilba perezi*, *Phaenocarpa neosilba*, biological control, cassava

RESUMEN

Se conoce *Neosilba perezi* (Romero & Ruppel) como la mosca del brote de la yuca o la mosca del brote, porque al contrario de otras especies de su género, sus larvas se alimentan exclusivamente de los brotes de yuca (*Manihot esculenta* Crantz). La infestación por estas larvas mata los brotes de las yuca afectadas. El parasitismo natural por bracónidos sobre las larvas de la mosca del brote fue estudiado en 3 lugares de la región suroeste del estado de São Paulo, Brasil. Se recogieron brotes de yuca infestadas por larvas en 3 lugares diferentes donde se siembran yuca. Se mantuvieron los brotes en cajas de plástico para la pupación y la emergencia de moscas adultas y parasitoides. Se correlacionó el porcentaje de parasitismo separado según la temperatura, la precipitacion y la edad de las plantas de yuca. El porcentaje de parasitismo fue un promedio de 24.36%. Se observó una correlación negativa entre la temperatura y el porcentaje de parasitismo en un lugar, pero todas las 3 áreas estudiadas mostraron una correlación negativa entre la edad de la planta y el porcentaje de parasitismo. Por lo tanto, dado el alto porcentaje de parasitismo observado en los 3 lugares, el control biológico natural puede ser un factor importante en la dinámica de la poblacion de *N. perezi*.

Palabras Clave: *Neosilba perezi*, *Phaenocarpa neosilba*, control biologico, yuca

The cassava shoot fly, *Neosilba perezi* (Romero & Ruppel) (Diptera: Lonchaeidae), is commonly found in southeastern Brazil, where it occurs mainly in the coastal and inland regions of the state of São Paulo (Graner 1942; Lourenção et al. 1996; Gisloti & Prado 2011a). The larvae of this species feed exclusively on shoots of cassava, *Manihot esculenta* Crantz (Malpighiales: Euphorbiaceae), and the herbivorism of these immatures often leads to the complete destruction of infested shoots (Bellotti et al. 1999).

However, despite its broad distribution in Brazil and high prevalence in cassava crops, *N. perezi* has been the subject of few studies, and many aspects of its bioecology remain unknown. As regards the natural enemies of this species, a study in an inland region of the state of São Paulo reported *Aganaspis pelleranoi* Brethes (reported as *Ganaspis pelleranoi)* (Hymenoptera: Figitidae) as a parasitoid of larvae of *N. perezi* (Lourenção et al. 1996).

Gisloti & Prado (2011a) recently discovered a new species of braconid (Alysiinae) causing an intense infestation of *N. perezi* larvae in agricultural systems of southwestern São Paulo. This study aimed to discover some aspects of the parasitic interaction between *N. perezi* larvae and the braconid parasitoid in cassava crop systems of southwestern São Paulo. The characterization of hosts and their parasitoids is fundamentally important to elucidate the dynamics of the populations involved in such complex ecological interactions.

Materials and Methods

The study was carried out in 3 organic cassava crops located in the municipalities of Jaguariúna/São Paulo (Area 1, S 22° 40' 20' W 46° 59' 09"; average 584 m asl), Mogi Mirim/São Paulo (Area 2, S 22° 25' 55" W 46° 57' 28"; average 588 m asl), and Mogi Guaçu/São Paulo (Area 3, S 22° 22' 20" W 46° 56' 32"; average 640 m asl). Area 1 is located approximately 50 km from Area 3, which in turn is located roughly 10 km from Area 2. All 3 areas were equivalent in terms of crop size (approximately 100 ha) and plant age at the start of sampling (2 mo after planting).

On a monthly basis from Jun to Dec 2008, 50 shoots visibly damaged by the presence of shoot fly larvae were collected from each studied area. The samples were kept at room temperature and humidity, stored in plastic boxes (25 × 50 × 10 cm) sealed with nylon organza and lined with moist, autoclaved fine sand (± 2 cm layer) as a substrate for larval pupation. After the larvae had pupated 15 to 25 d after the material was brought in from the field, the substrate was sieved to collect the puparia, which were counted and transferred to emergence boxes kept under the same environmental conditions. Daily over a period of 40 d, substrate humidity was checked and the emergence of flies and parasitoids was monitored. The emerged parasitoids were fed with honey and water for 3 d, to fix the coloring that would allow their correct identification. They were then killed and preserved in 70% ethanol in labeled flasks for subsequent counting and species identification.

Daily meteorological reports with temperature and rainfall data were provided by the Agrometeorology Information Center (CIIAGRO - Jaguariúna; S 22° 40' W 46° 59") for Area 1, by the Mogi Mirim Weather Station for Area 2 (Agritempo, S 22° 43' W 46°95"), and by the Ecological Station of Mogi Guaçu (S 22° 22' W 47° 47") for Area 3. For each sampling event, we calculated the average daily recorded temperature (°C) and rainfall (mm) over the previous mo.

Percent parasitism was calculated as the proportion of emerged parasitoids to total number of pupae obtained at each sampling event. The data were analyzed through variance testing. The Kolmogorov-Smirnov (Lilliefors) test was used to check for normality, and the samples that presented normal distribution and similar variances underwent ANOVA testing.

The percent parasitism on *N. perezi* larvae was separately correlated with plant age, average local temperature, and local rainfall for each studied area. The correlations were tested using Pearson's correlation coefficient. The software used to process and analyze the data was BioEstat v5.0 (Ayres et al. 2007), with a significance level of 5%. All specimens are deposited in the Entomological Collection of the Departamento de Biologia Animal, Universidade Estadual de Campinas (Unicamp).

Results

After 7 collections, a total of 1,412 pupae of *N. perezi* were obtained, from which emerged 544 shoot fly adults and 367 parasitoids. Approximately 36% (501) of the puparia failed to produce live adults (Table 1). The average percent parasitism considering the 3 analyzed areas was 24.36%. All of the emerged parasitoids belonged to the same species, which was found to be *Phaenocarpa neosilba* Arouca & Penteado-Dias, 2006 (Arouca & Penteado-Dias 2011).

In the comparative analysis of the 3 studied areas, the variance analyses did not detect a statistically significant difference in percent parasitism ($P > 0.05$), i.e., all 3 areas presented very similar average values. Area 1 showed the highest values compared to the other 2 in all the analyzed parameters: the highest total number of pupae (535) and non-viable pupae (181), total number of emerged adult flies (203), and percent parasitism (28.2%). On the other hand, Area 3 showed the lowest percent parasitism (23.6%) and the smallest number of emerged flies (169), total pupae (406), and non-viable pupae (141) (Table 1, Fig. 1).

There was a negative linear correlation between average temperature in the month prior to sampling and percent parasitism, but only in Area 1 ($r = -0.8$; $P = 0.02$), where higher temperatures (above 20 °C) had a negative effect on parasitism on *N. perezi* larvae (Fig. 2). Rainfall does not appear to influence parasitism of these larvae ($P > 0.05$).

Also, Pearson's correlation coefficient showed a negative correlation between plant age and percentage of parasitism in Areas 1, 2 and 3 ($r = -0.89$, $P = 0.006$; $r = -0.88$, $P = 0.007$; and $r = -0.84$, $P = 0.017$, respectively). In other words, on older plants the *N. perezi* larvae were less subject to parasitism than those on younger plants (Fig. 3).

Discussion

Parasitoids were present on larvae of *N. perezi* at every month of sampling, and every parasitoid belonged to the same species. They were identified as an undescribed species and were submitted to specialists, who described them as *Phaenocarpa neosilba* **sp. nov.** Arouca & Penteado-Dias, 2006. However, the parasitoids found during this work were different from those observed by Lou-

TABLE 1. TOTAL NUMBER OF *NEOSILBA PEREZI* PUPAE OBTAINED (P), EMERGED FLIES (F), EMERGED *PHAENOCARPA NEOSILBA* PARASITOIDS (PAR), NON-VIABLE PUPAE (NP) (*), AND THEIR RESPECTIVE PERCENTAGES (**) IN JAGUARIÚNA (AREA 1), MOGI MIRIM (AREA 2), AND MOGI GUAÇU (AREA 3), FROM JUNE TO DECEMBER 2008.

	P	F	PAR	NP	P	F	PAR	NP	P	F	PAR	NP
Date	Área 1				Área 2				*Área* 3			
Jun	112	50* 44,6**	47* 41,9**	15* 13,3**	110	47* 42,7**	50* 45,4**	13* 11,8**	91	44* 48,3**	35* 38,4**	12* 13,1**
Jul	87	32* 36,7**	27* 31**	28* 32,1**	69	30* 43,4**	19* 27,5**	20* 28,9**	63	41* 65**	19* 30,1**	03* 4,7**
Aug	81	27* 33,3**	28* 34,5**	26* 32**	65	20* 30,7**	13* 20**	32* 49,2**	55	19* 34,5**	09* 16,3*	27* 49**
Sep	71	25* 35,2**	13* 18,3**	33* 46,4**	70	22* 31,4**	16* 22,8**	32* 45,7**	68	20* 29,4**	11* 16,1**	37* 54,4**
Oct	63	22* 34,9**	15* 23,8**	26* 41,2**	59	19* 32,2**	09* 15,2**	31* 52,5**	43	18* 41,8**	08* 18,6**	17* 39,5**
Nov	60	25* 41,6**	11* 18,3**	24* 40 **	52	17* 32,6**	08* 15,3**	27* 51,9**	44	16* 36,3**	06* 13,6**	22* 50**
Dec	61	22* 36**	10* 16,3**	29* 47,5**	46	17* 36,9**	05* 10,8**	24* 52,1**	42	11* 26,1**	08* 19**	23* 54,7**
Total	535	203* 37,9**	151* 28,2**	181* 33,8**	471	172* 36,5**	120* 25,4**	179* 38**	406	169* 41,6**	96* 23,6**	141* 34,7**

renção et al. (1996), who found *N. perezi* larvae to be parasitized by *Ganaspis pelleranoi* Brethes (Hymenoptera: Eucoilidae), which is a parasitoid of Tephritidae fruit flies.

Some species of *Phaenocarpa* are parasitoids of *Drosophila* (Prince 1976; Janssen et al. 1988; Ideo et al. 2008) and *Anastrepha* fruit flies (Canal Daza et al. 1994; Leonel et al. 1996; Carrejo & Gonzáles 1999; Trostle et al. 1999). Costa et al. (2009) found *Phaenocarpa pericarpa* infesting larvae of *Neosilba* sp. that were feeding on fruits of *Eschweilera atropetiolata* (Ericales: Lecythidaceae).

When we investigated the influence of temperature on percent parasitism, we observed a negative correlation between parasitism and temperature in only one of the studied areas (Area 1), where temperatures above 20 °C had a negative effect on the number of emerged parasitoids. This means that temperature may affect

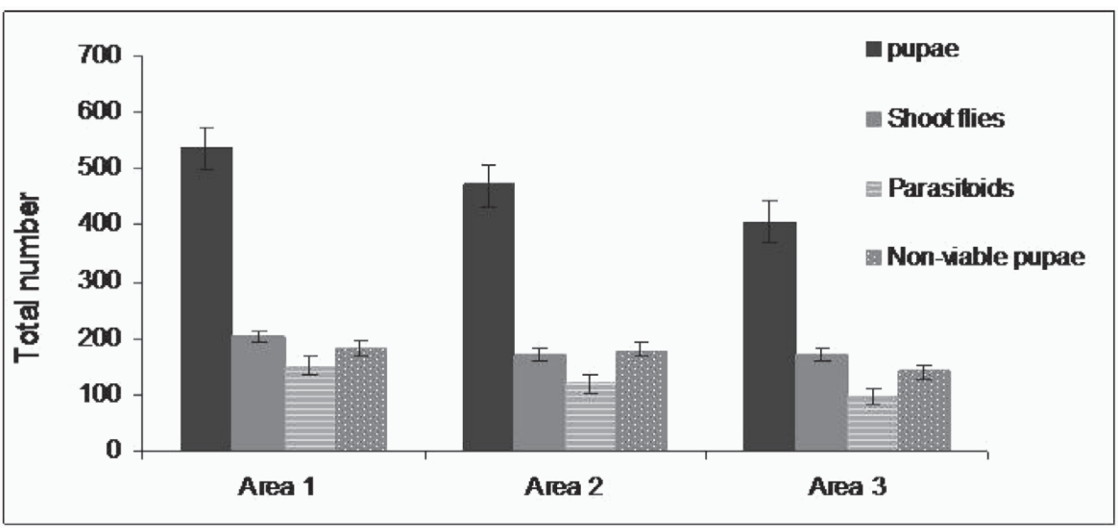

Fig. 1. Total number of pupae obtained, emerged flies, emerged parasitoids, and non-viable pupae from cassava shoots collected in Jaguariúna (Area 1), Mogi Mirim (Area 2), and Mogi Guaçu (Area 3), from Jun to Dec 2008. *P* > 0.05.

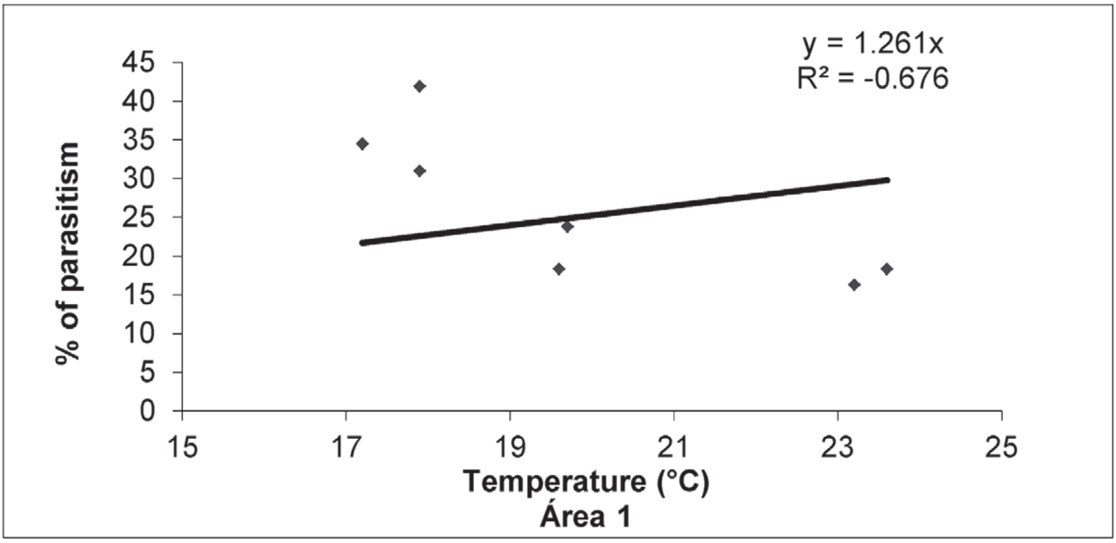

Fig. 2. Correlation between average temperature during the month prior to sampling and percent parasitism in Area 1, Jaguariúna/SP, 2009. (y = -3.0614x + 87.135; r^2 = 0.6612; r = -0.8 and P = 0.02).

the prevalence of parasitism on shoot fly larvae, but in practice, the effects of environmental conditions may be strongly contingent on the response of other members of the community, such as the availability of resources—host larvae, in this case. Gisloti & Prado (2011a, b) observed the same negative correlation between temperature and shoot fly populations, which indicates that the high prevalence of parasitism found in this

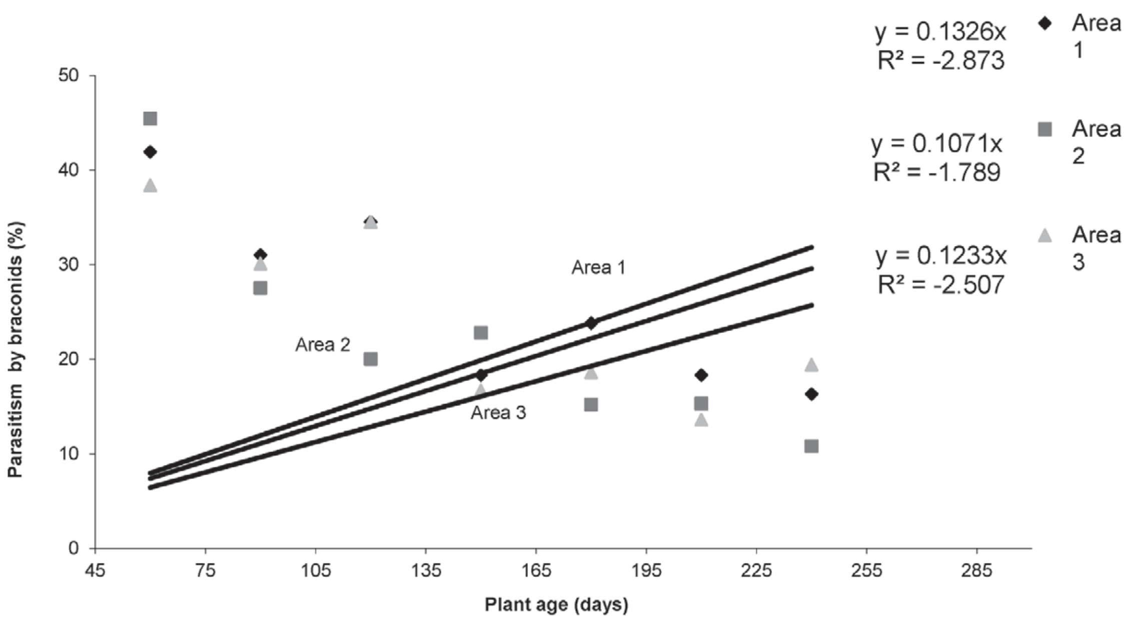

Fig. 3. Correlation between cassava plant age and parasitism by braconids (%) in Jaguariúna (Area 1), Mogi Mirim (Area 2), and Mogi Guaçu (Area 3), from Jun to Dec 2008. (y = -0.1344x + 46.461; r^2 = 0.803; r = -0.89; P = 0,006 for Area 1), (y = -0.1583x + 46.179; r^2 = 0.7919; r = -0.88; P = 0.007 for Area 2), (y = -0.1261x + 43.382; r^2 = 0.7089; r = -0.84; P = 0.017 for Area 3).

work at moderate temperatures may have to do with the high availability of larvae.

De Moraes et al. (1998) observed that plants damaged by herbivores attract parasitoids through the volatile compounds that are secreted by the damaged plant tissues. Area 1 presented the highest number of pupae and adult flies throughout the experiment, suggesting that the plants in this area were more intensely infested by *N. perezi*. Accordingly, the high infestation of shoot flies in this area induced a higher production of volatile compounds liberated by the consumed plants, which attracted more parasitoids.

Plant age is also negatively correlated with parasitism, i.e., young cassava plants attract more parasitoids. This explains the low percent parasitism observed during the later sampling events, which were conducted on old cassava plants. Gisloti & Prado (2011a, b) observed the same correlation between host plant age and infestation by larvae of *N. perezi*. As suggested by Boza & Waddil (1978), young plants are probably more attractive to insects for oviposition because their shoots are more tender, facilitating the penetration of larvae. Consequently, young plants probably host a considerably larger number of host larvae, thus increasing the rate of parasitism.

Finally, the high percentage of parasitism observed in the 3 areas suggests that natural biological control may be an important factor in the population dynamics of *N. perezi*.

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