

NO DIRECT EFFECTS OF RESISTANT SOYBEAN CULTIVAR IAC-24 ON *Podisus nigrispinus* (HETEROPTERA: PENTATOMIDAE)

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The parameters of survival, development and reproduction of *Podisus nigrispinus* Dallas, 1851 (Heteroptera: Pentatomidae) may be affected by feeding on soybean (*Glycine max* [L.] Merr.; Fabaceae) cultivars. The direct effect was evaluated of the insect-resistant soybean 'IAC-24' (insect-susceptible soybean 'UFVS-2006' + pupae of *Tenebrio molitor* L., 1758 [Coleoptera: Tenebrionidae] versus 'IAC-24' plants + pupae of *T. molitor*) in the nymph and adult stages of the predator *P. nigrispinus*. The duration of the nymph stage was similar between treatments, but 'IAC-24' reduced the duration of the IV instar of this predator. The survival of *P. nigrispinus* was similar between treatments in the instars I, II, IV and V and in the nymph stage, but the survival of the III instar was longer with 'IAC-24' plants. The body mass of nymphs in the first day of the III, IV, and V instars after ecdysis and newly emerged adults; reproductive characteristics (periods of pre-oviposition, oviposition, post-oviposition and egg incubation; egg laying interval, number of egg masses per female, nymphs per female, nymphs per egg mass and percentage of nymphs hatching) and life span of males and females of *P. nigrispinus* were similar between treatments. The resistant soybean 'IAC-24' showed no direct deleterious effects on *P. nigrispinus*, which implies its innocuity and compatibility with this predator.

Key words: Asopinae, biological control, integrated pest management, predator, soybean.

Podisus nigrispinus Dallas, 1851 (Heteroptera: Pentatomidae) is an important predator for the control of defoliating caterpillars in soybean crops, *Glycine max* (L.) Merr. (Fabaceae), such as *Anticarsia gemmatilis* Hübner, 1818 (Lepidoptera: Noctuidae) (Saavedra *et al.*, 1997; Ferreira *et al.*, 2008). This natural enemy may also feed on soybean plants, although some of its biological parameters are affected in resistant cultivars (Matos Neto *et al.*, 2002). *Podisus nigrispinus* and other predators of this group are reared in the laboratory with an alternative prey, pupae of *Tenebrio molitor* L., 1758 (Coleoptera: Tenebrionidae), and released into the field in soybean crops for the pest control (Neves *et al.*, 2010).

The soybean 'IAC-24' was obtained from the cross between 'IAC 80-1177' and 'IAC 83-288' by researchers at the 'Instituto Agronômico de Campinas (IAC)' in Campinas, São Paulo State, Brazil. This cultivar is suitable for cultivation in São Paulo and Minas Gerais States, Brazil, and in areas with similar soil and climatic

conditions, with resistance to lepidopteran pests and *Euschistus heros* F., 1798; *Edessa mediatubunda* F., 1794 and *Nezara viridula* L., 1758 (Hemiptera: Pentatomidae) and with high productivity (Miranda *et al.*, 2003). However, the effects of the soybean 'IAC-24' on biological parameters of *P. nigrispinus* are unknown. The resistance of plants and biological control can be combined in integrated pest management (IPM) programs of soybean crops (Bartlett, 2008; Piubelli *et al.*, 2009; Tavares *et al.*, 2011).

The compatibility of plant resistance and biological control is due to ingestion of deleterious substances from resistant plants by the pests, without effects on zoophytophagous predators and selectivity to other predators and parasitoids (Matos Neto *et al.*, 2002; Tavares *et al.*, 2009). Predatory insects can be affected by deleterious substances when feeding on resistant plants or phytophagous insects reared with these plants (Rogers and Sullivan, 1986; Pfannenstiel and Yeargan, 1998). The predators *Cyrtorhinus lividipennis* Reuter, 1885 (Hemiptera: Miridae) and *Microvelia douglasi atrolineata* Bergroth, 1918 (Hemiptera: Veleiidae) reduced the population of *Nilaparvata lugens* Stål, 1854 (Hemiptera: Delphacidae) on susceptible plants of *Oryza* sp. (Poaceae) more than on resistant plants (Kartohardjono and Heinrichs, 1984). The life span of adults can be shorter and fecundity and predation lower in resistant plants. The insect-resistant soybean PI227687 increased the oviposition period of the predator *Podisus*

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maculiventris Say, 1832 (Heteroptera: Pentatomidae) (Orr and Boethel, 1986). Plants can reduce the nymph period and increase weight, fecundity and longevity of adult predators (Zanuncio *et al.*, 2000).

The objective of this study was to evaluate duration, survival, body mass, reproductive characteristics and life span of nymphs and adults of *P. nigrispinus* feeding on pupae of *T. molitor* on plants of insect-resistant soybean 'IAC-24', compared to the insect-susceptible soybean 'UFVS-2006'.

MATERIALS AND METHODS

Seeds of the insect-susceptible soybean 'UFVS-2006' were obtained from the Universidade Federal de Viçosa (UFV) in Viçosa, Minas Gerais, Brazil, and the insect-resistant 'IAC-24' from the Instituto Agrônômico de Campinas (IAC) in Campinas, São Paulo, Brazil. These cultivars were sown in vases of 5 L capacity in an experimental area of the Insectarium of the Departamento de Biologia Animal (DBA) of the UFV. The soil was fertilized according to the guidelines of the Soil Fertility Commission of the State of Minas Gerais and the plants used were in the stages V6 or V7 (vegetative) until stage R6 (reproductive). These stages of soybeans are the most commonly attacked by pests in the field (Corrêa-Ferreira, 2005).

The pupae of *T. molitor* were obtained from a rearing facility of this prey fed with wheat bran and brewer yeast from the Laboratório de Controle Biológico de Insetos (LCBI) (DBA-UFV). Egg masses were obtained from the mass rearing of *P. nigrispinus* from the LCBI where this insect was fed with *T. molitor* pupae. The eggs were sorted in Petri dishes (9 cm diameter x 1.2 cm height) with moistened cotton pads to avoid desiccation. The first and second instar of *P. nigrispinus* received soybean folioles from cultivars 'UFVS-2006' or 'IAC-24' and *T. molitor* pupae in Petri dishes. After the third instar, the predators were placed in organza bags with 10 pupae of *T. molitor* and replaced as necessary and submitted to the field experiment. Pupae of *T. molitor* were used because this insect is an alternative prey to predators in the laboratory (Neves *et al.*, 2010).

Experiment and parameters evaluated

The direct action of the insect-resistant 'IAC-24' on characteristics such as survival, body mass, reproduction, and longevity of *P. nigrispinus* was analyzed with pupae of the alternative prey *T. molitor*. This field assay was performed with individuals of *P. nigrispinus* and pupae of *T. molitor* in white organza bags (30 cm length x 20 cm diameter) containing a soybean branch per unit in the treatments: T1- *P. nigrispinus*, pupae of *T. molitor* and one branch of the 'UFVS-2006' (non-resistant) and T2- *P. nigrispinus*, pupae of *T. molitor* and one branch of the 'IAC-24' (resistant), with 11 replicates, each inside an organza bag with a couple of *P. nigrispinus*. Prey were supplied *ad libitum* and replaced when necessary. Vases of soybean plants were placed in the field and covered with organza.

We evaluated and analyzed biological parameters such as duration and survival of the I, II, III, IV, and V instars; total nymph stage, body mass of nymphs at the first day of I, IV, and V instars and newly emerged males and females; pre-oviposition, oviposition, and post-oviposition periods and egg incubation; interval between egg-laying; number of egg masses per female, of eggs per egg mass, of eggs per female, nymphs per female, nymphs per egg mass, percentage of nymph hatching and life span of males and females of *P. nigrispinus*. The body mass of this predator was determined with a Coleman FA1604 scale with precision of 0.1 mg.

The parameters were measured daily from 08:00 am to 12:00 pm. Organza bags were opened to record data in a datasheet attached to a clipboard. The climatic conditions of the cultivation site were evaluated (Table 1).

Statistical analysis

The experimental design was completely randomized and the data submitted to ANOVA with the means compared by the student's t-test at 5% probability. The data of nymph survival and body mass were submitted to a non-parametric ANOVA by the Wilcoxon test at 5% probability because they did not present the presuppositions of variance homogeneity and normal distribution. Analyses were processed using SAS (SAS Institute, 1989) (Supplier: UFV).

Table 1. Monthly mean, maximum, and minimum temperature, relative humidity; mean daily rainfall and photoperiod per month. Municipality of Viçosa, Minas Gerais, Brazil. March to November 2010.

Months	Mean temperature	Maximum temperature	Minimum temperature	Relative humidity	Rainfall	Photoperiod
	°C			%	mm	h d ⁻¹
March	23.00	30.00	19.06	80.79	1.06	11.88
April	21.86	29.86	16.95	77.65	1.12	11.52
May	19.12	26.31	14.69	78.96	1.91	11.02
June	17.92	25.61	13.30	80.71	0.01	10.76
July	16.84	25.00	11.70	77.91	0.06	10.87
August	18.33	26.53	12.41	74.81	0.21	11.03
September	19.07	25.87	14.28	74.05	2.67	11.89
October	20.49	26.72	16.19	74.29	4.91	12.49
November	22.18	27.70	18.68	81.73	7.71	13.00
Mean	19.55	26.77	14.86	77.58	2.29	11.61

RESULTS

The duration in days of the I, II, III, and V instars and of the nymph stage of *P. nigrispinus* did not differ between treatments ($p > 0.05$), but the duration of the IV instar was shorter on insect-resistant 'IAC-24' plants ($p < 0.05$). The survival of *P. nigrispinus* did not differ between treatments in the I, II, IV, and V instars and the nymph stage ($p > 0.05$). However, the survival rate of the III instar was higher with plants 'IAC-24' plants ($p < 0.05$) (Table 2).

The body masses of individual male and female nymphs of *P. nigrispinus* were similar between treatments ($p > 0.05$) (Table 3).

Periods of pre-oviposition ($t = 0.23$, $gl = 20$ and $p > 0.05$), oviposition ($t = 0.24$, $gl = 20$ and $p > 0.05$) and post-oviposition ($t = 1.49$, $gl = 10.4$ and $p > 0.05$) of *P. nigrispinus* females did not differ between treatments (Table 4).

The interval between egg mass laying ($t = 1.29$, $gl = 20$ and $p > 0.05$), egg incubation period ($t = 0.49$, $gl = 20$ and $p > 0.05$); number of egg masses per female ($t = 0.50$, $gl = 20$ and $p > 0.05$), eggs per female ($t = 0.08$, $gl = 20$ and $p > 0.05$), eggs per egg mass ($t = 1.30$, $gl = 20$ and $p > 0.05$); percentage of nymph hatching ($t = 0.02$, $gl =$

Table 2. Duration and survival (mean \pm standard error of the mean) of instars I, II, III, IV, V, and nymph stage of *Podisus nigrispinus* (Heteroptera: Pentatomidae) fed with pupae of *Tenebrio molitor* (Coleoptera: Tenebrionidae) on plants of the insect-susceptible soybean 'UFVS-2006' (T1) or insect-resistant 'IAC-24' (T2).

Stages	Duration (d)	
	T1 ('UFVS-2006')	T2 ('IAC-24')
I ^{ns}	2.75 \pm 0.19	2.63 \pm 0.17
II ^{ns}	4.12 \pm 0.18	4.13 \pm 0.17
III ^{ns}	4.12 \pm 0.20	4.38 \pm 0.33
IV [*]	5.32 \pm 0.19A	4.76 \pm 0.16B
V ^{ns}	6.73 \pm 0.15	6.65 \pm 0.08
Nymphal stage ^{ns}	23.04 \pm 0.44	22.55 \pm 0.50
	Survival (%) ^{ns}	
I ^{ns}	98.18 \pm 1.22	98.18 \pm 1.22
II ^{ns}	98.08 \pm 1.29	95.45 \pm 3.66
III ^{**}	88.28 \pm 3.51B	97.40 \pm 2.60A
IV ^{ns}	97.69 \pm 1.56	97.27 \pm 2.73
V ^{ns}	100.00 \pm 0.00	97.56 \pm 1.64
Nymphal stage ^{ns}	82.45 \pm 3.50	85.86 \pm 5.36

Means followed by the same capital letter per line do not differ according to the F test.

^{ns}Non-significant at 5% according to the F test.

^{*}Significant at 5% according to the F test.

^{**}Significant at 1% according to the Wilcoxon test.

Table 3. Body mass of nymphs (mean \pm standard error of the mean) in the first day of III, IV, and V instars after ecdysis and newly-emerged adults of *Podisus nigrispinus* (Heteroptera: Pentatomidae) fed with pupae of *Tenebrio molitor* (Coleoptera: Tenebrionidae) on plants of the insect-susceptible soybean 'UFVS-2006' (T1) or insect-resistant 'IAC-24' (T2).

Stages	Body mass (mg)	
	T1 ('UFVS-2006')	T2 ('IAC-24')
III ^{ns}	3.71 \pm 0.28	3.92 \pm 0.34
IV ^{ns}	10.13 \pm 0.43	10.94 \pm 0.53
V ^{ns}	27.02 \pm 1.14	26.71 \pm 1.46
Male ^{ns}	44.17 \pm 0.86	44.66 \pm 0.52
Female ^{ns}	63.31 \pm 1.23	63.69 \pm 0.96

^{ns}Non-significant at 5% according to the Wilcoxon test.

Table 4. Reproductive characteristics (mean \pm standard error of the mean) of *Podisus nigrispinus* (Heteroptera: Pentatomidae) fed with pupae of *Tenebrio molitor* (Coleoptera: Tenebrionidae) on plants of the insect-susceptible soybean 'UFVS-2006' (T1) or insect-resistant 'IAC-24' (T2).

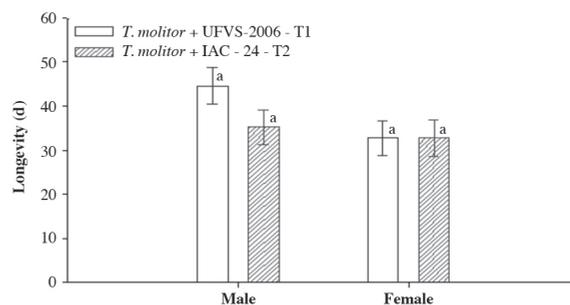
Characteristics evaluated	T1 ('UFVS-2006')	T2 ('IAC-24')	Prob. [†]
Pre-oviposition periods, d	7.09 \pm 0.31	7.18 \pm 0.23	0.41
Oviposition periods, d	25.45 \pm 3.91	24.09 \pm 4.10	0.41
Post-oviposition periods, d	0.18 \pm 0.12	1.45 \pm 0.85	0.08
Interval between egg-laying, d	2.27 \pm 0.15	1.99 \pm 0.15	0.11
Egg incubation periods, d	4.75 \pm 0.04	4.71 \pm 0.06	0.32
Number of egg masses per female	11.73 \pm 1.57	13.18 \pm 2.42	0.31
Number of eggs per female	336.64 \pm 46.81	342.73 \pm 57.42	0.47
Number of eggs per laying	28.69 \pm 1.30	26.45 \pm 1.14	0.10
Nymph hatching, %	89.36 \pm 2.54	89.29 \pm 2.07	0.49
Number of nymphs per female	298.27 \pm 41.27	304.55 \pm 52.51	0.46

[†]Student's t-test.

20 and $p > 0.05$) and number of nymphs per female of *P. nigrispinus* ($t = 0.09$, $gl = 20$ and $p > 0.05$) were similar between treatments (Table 4).

The life spans of males ($t = 1.64$, $gl = 20$ and $p > 0.05$) and females ($t = 0.00$, $gl = 20$ and $p > 0.05$) of *P. nigrispinus* were similar between treatments (Figure 1).

The mortality rates of *P. nigrispinus* females were similar between treatments and with higher values between days 35 and 45 on the insect-resistant soybean 'IAC-24' (Figure 2).



Columns followed by the same letter do not differ according to Student's t-test ($p > 0.05$).

Figure 1. Life span (mean \pm standard error of the mean) of males and females *Podisus nigrispinus* (Heteroptera: Pentatomidae) fed with *Tenebrio molitor* (Coleoptera: Tenebrionidae) pupae on plants of the insect-susceptible soybean 'UFVS-2006' (T1) or insect-resistant 'IAC-24' (T2).

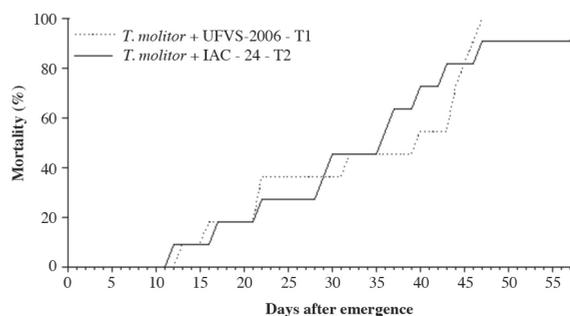


Figure 2. Mortality of *Podisus nigrispinus* (Heteroptera: Pentatomidae) females fed with *Tenebrio molitor* (Coleoptera: Tenebrionidae) pupae on plants of the insect-susceptible soybean 'UFVS-2006' (T1) or insect-resistant 'IAC-24' (T2).

DISCUSSION

The shortest duration of the IV instar of *P. nigrispinus* with insect-resistant 'IAC-24' did not reduce the duration of the nymph stage of this predator. However, the shortest duration of IV instar of *P. maculiventris* reduced the duration of the nymph stage of this predator with pupae of *T. molitor* (De Clercq *et al.*, 1998). The xylem and parenchyma in the primary and secondary veins of the leaves are two of the feeding sites of predatory hemipterans on plants (Torres *et al.*, 2010). Leaves of the resistant 'IAC-24' soybean showed signs of the insertion of the stylet bundle of *P. nigrispinus* and pupae of *T. molitor* were preyed, showing that this insect feeds on both food types.

The absence of direct deleterious effects of the resistant 'IAC-24' soybean on *P. nigrispinus* nymphs allows this predator to reach the adult stage and to reproduce more quickly and with a higher number of generations per soybean cultivation crop. This differs from the longer duration of the nymph stage of males and females of this predator with the resistant 'IAC-17' soybean to insects compared to the susceptible 'UFV-16' by direct effect (Matos Neto *et al.*, 2002), indicating a different degree of resistance between the 'IAC-24' and 'IAC-17'. These cultivars have, in their genealogy, the lineage 'D 72-9601-1', selected for resistance to *Pseudoplusia includens* Walker, 1857 (Lepidoptera: Noctuidae) in the USA. This lineage descended from the 'PI 229358' lineage, which is a genotype with multiple resistances to insects (Miranda *et al.*, 2003). Cultivar 'IAC-24' also has this resistant 'PI 227687' lineage, constituting an additional source of genetic variability and a broader genetic base for resistance to insects and biotic factors. 'IAC-24' and 'IAC-17' had similar levels of antibiosis-type resistance to *A. gemmatalis* (Fugi *et al.*, 2005). Phytophagy on the insect-resistant soybean genotype 'PI 229358' also increased the duration of nymph stage of females of the predator *Nabis roseipennis* Reuter, 1872 (Hemiptera: Nabidae) (Pfannenstiel and Yeorgan, 1998).

The higher survival rate of *P. nigrispinus* in the III instar on insect-resistant 'IAC-24' plants differs from the reduction of this parameter for the predator *Geocoris punctipes* Say, 1832 (Hemiptera: Lygaeidae) with the insect-resistant soybeans 'PI171451' and 'PI229358' (Rogers and Sullivan, 1986), but the latter did not affect the survival of the predator *N. roseipennis* (Pfannenstiel and Yeorgan, 1998). The soybean 'IAC-24' can supplement nutrients for *P. nigrispinus*, as reported for the survival of adults of *Brontocoris tabidus* Signoret, 1852 (Hemiptera: Pentatomidae) with leaves of *Eucalyptus* spp. (Myrtaceae) and pupae of *T. molitor*, suggesting that the combination of prey and plants can improve breeding predatory insects in laboratory (Zanuncio *et al.*, 2000). Plant quality is important, because survival of *B. tabidus* nymphs was higher with *Gossypium hirsutum* L.

(Malvaceae) than with *Phaseolus vulgaris* L. (Fabaceae) and similar with *Amaranthus lividus* L. (Amaranthaceae) (Coelho *et al.*, 2009).

The similar body mass of males and females *P. nigrispinus*, during the III, IV, and V instars showed that 'IAC-24' may not have deleterious effects on the reproductive capacity of this predator. However, the weight of male and female *N. roseipennis* was lower with larvae of *P. includens* and the insect-resistant soybean 'PI229358' (Pfannenstiel and Yeorgan, 1998). This is in accordance with the lower weight of female *P. nigrispinus* in the resistant 'IAC-17' soybean (Matos Neto *et al.*, 2002), showing that the resistant plant and natural enemies must be analyzed separately. The weight of 15-d-old female *B. tabidus* was higher with pupae of *T. molitor* on plants of *Eucalyptus cloeziana* F. Muell., *Eucalyptus urophylla* S.T. Blake or *Psidium guajava* L. (Myrtaceae) than only with pupae of this prey. Females of 21-d-old of this predator presented higher weight with plants of *E. cloeziana* or *P. guajava* compared to *E. urophylla* and pupae of *T. molitor* or only pupae of this prey, although the protein content in the hemolymph of females of this predator was similar between treatments (Lemos *et al.*, 2009). Heavier predatory females are important because there is a direct relationship in *P. nigrispinus*, *Supputius cincticeps* Stål, 1860 and *Podisus rostralis* Stål, 1860 (Heteroptera: Pentatomidae) between weight and fecundity (Mohaghegh *et al.*, 1999; Zanuncio *et al.*, 2002). Furthermore, adults with heavier body mass have better chances to survive in periods of prey scarcity (Molina-Rugama *et al.*, 1998).

The similar pre-oviposition period of *P. nigrispinus* females with the resistant 'IAC-24' soybean agrees to that for this predator with soybeans 'IAC-17' and 'UFV-16', resistant and susceptible to insects respectively, without deleterious effect (Matos Neto *et al.*, 2002) and the lack of effect of the soybean 'PI227687' resistant to insects on the pre-oviposition period of *P. maculiventris* (Orr and Boethel, 1986). A shorter pre-oviposition period may avoid reduction of population growth of this predator.

The lack of impact of the soybean 'IAC-24' resistant to insects in the oviposition period of *P. nigrispinus* differs from the deleterious effect of resistant 'IAC-17' for this predator, indicating variations in levels of resistance between cultivars (Matos Neto *et al.*, 2002). Simultaneous comparison of these cultivars in the field is not possible since they have different maturity cycles. Therefore, experiments have been separately made. 'IAC-24' is also resistant to the whitefly *Bemisia tabaci* Gennadius biotype B (Hemiptera: Aleyrodidae) because of which it was recommended for cultivation in regions and/or periods with problems or with cultures susceptible to this whitefly and cultivated simultaneously or in sequence with this crop (Valle *et al.*, 2012).

The lowest post-oviposition values of *P. nigrispinus* with the insect-resistant soybean 'IAC-17' (Matos Neto *et al.*, 2002) indicate that females live only briefly after their last egg mass, which reduced the possibility of lower population growth of this predator. Short post-oviposition and longer oviposition periods of *P. nigrispinus* are desirable in biological control programs to reduce multiplication costs. Nevertheless, nymphs of predatory insects with low nutritional prey produce adults with low fertility (Wittmeyer *et al.*, 2001) compared to one with prey of better quality or different types (Zanuncio *et al.*, 2001).

The same interval between egg-laying and egg incubation of *P. nigrispinus* with 'IAC-24' to those with 'IAC-17' (Matos Neto *et al.*, 2002) indicates the compatibility of resistant soybean plants with the biological control of this predator.

The similar numbers of egg masses and eggs per egg masses per *P. nigrispinus* female shows the compatibility of insect-resistant 'IAC-24' with the reproduction of this predator, and differs from the deleterious effect of resistant 'IAC-17' on the number of egg mass and eggs per egg masses per female of this predator (Matos Neto *et al.*, 2002). Females of *B. tabidus* laid an average of 4.2 eggs per day and a total of 601.1 eggs with prey and leaves of *Eucalyptus* spp., suggesting that this plant is an adequate substrate for oviposition of this insect (Zanuncio *et al.*, 2006). The higher number of eggs and nymphs of *B. tabidus* with *A. lividus*, *G. hirsutum*, or *P. vulgaris* and prey than only with these plants can improve its reproduction (Coelho *et al.*, 2009).

The similar number of eggs per *P. nigrispinus* female shows the compatibility of 'IAC-24' to this predator as observed with 'IAC-17' (Matos Neto *et al.*, 2002) and of *P. maculiventris* with insect-resistant 'PI227687' (Orr and Boethel, 1986). The number of eggs per female (357.79 at 554.00) of *P. nigrispinus* was higher with caterpillars of *A. gemmatilis* and soybean leaflets (Matos Neto *et al.*, 2002) and plant material with prey increased the fecundity of *B. tabidus* (Zanuncio *et al.*, 2000) and of *P. nigrispinus* (Lemos *et al.*, 2001; Freitas *et al.*, 2006). Predatory insects can use plants as supplementary food to increase their sustainability in prey-scarce habitats (Coll and Guershon, 2002; Zanuncio *et al.*, 2004; Lemos *et al.*, 2009).

The numbers of eggs and nymphs per *P. nigrispinus* female with the insect-resistant soybean 'IAC-24' resistant and the insect-susceptible 'UFV-2006' are similar to those for the resistant 'IAC-17' (Matos Neto *et al.*, 2002). On the other hand, the reproductive capacity of *S. cincticeps* was lower when exposed to permethrin, indicating the deterring effect of this insecticide and that it may be harmful to this insect (Zanuncio *et al.*, 2005). *Macrolophus melanotoma* Costa, 1853 (Hemiptera: Miridae) laid 69.55 eggs per female with leaves of *Dittrichia viscosa* L. (W. Greuter) (Asteraceae) or this plant with *Capitophorus*

inulae Passerini, 1860 (Hemiptera: Aphididae) and only 10.80 eggs with leaves of this plant, showing the need for prey (Perdifeis *et al.*, 2007). The number of eggs per *B. tabidus* female was also higher with prey and plants of *A. lividus* or *G. hirsutum* than with *P. vulgaris*, showing different results with this association for predatory insects (Coelho *et al.*, 2009).

The similar life span of *P. nigrispinus* females is in accordance with that for this predator on 'IAC-17' (Matos Neto *et al.*, 2002) and for *P. maculiventris* with 'PI 227687' (Orr and Boethel, 1986), both resistant to insects. The compatibility of insect-resistant 'IAC-24' with longer life span and lower initial mortality of *P. nigrispinus* females with this cultivar was similar to that for this predator with IAC-17 (Matos Neto *et al.*, 2002). The longer life span and higher number of nymphs per female of *B. tabidus* with prey and plants of *A. lividus* or *G. hirsutum* and lower with those of *P. vulgaris* suggests the effect of plant type on these parameters (Coelho *et al.*, 2009).

CONCLUSIONS

The insect-resistant soybean 'IAC-24' presented no direct deleterious effects on the majority of characteristics of *P. nigrispinus*, except in the duration of the IV instar and survival of the III instar, which implies its innocuousness and compatibility with this predator.

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Efectos no directos de resistencia del cultivar de soya IAC-24 sobre *Podisus nigrispinus* (Heteroptera: Pentatomidae). Los parámetros de supervivencia, desarrollo y reproducción de *Podisus nigrispinus* Dallas, 1851 (Heteroptera: Pentatomidae) pueden verse afectados por la alimentación en cultivos de soya (*Glycine max* [L.] Merr.; Fabaceae). Se evaluó el efecto directo de la soya 'IAC-24' resistente a insectos (soya 'UFVS-2006' susceptible a insectos + pupas de *Tenebrio molitor* L., 1758 [Coleoptera: Tenebrionidae] vs. plantas 'IAC-24' + pupas de *T. molitor*) sobre los estados de ninfa y adulto del depredador *P. nigrispinus*. La duración del estado ninfal fue similar entre tratamientos, no obstante 'IAC-24' redujo la duración del IV estado de este depredador. La supervivencia de *P. nigrispinus* fue similar entre los

tratamientos en los estados I, II, IV y V y en el estado de ninfa, la supervivencia del estado III fue mayor con las plantas 'IAC-24'. La masa corporal de las ninfas en el primer día, en los estados III, IV, y V después de la ecdisis y adultos recién emergidos; características reproductivas (períodos de pre-oviposición, oviposición, post-oviposición e incubación de los huevos; intervalo de colocación de los huevos, número de masa de huevos por hembra, ninfas por hembra, ninfas por masa de huevos y porcentaje de eclosión de ninfas) y vida útil de machos y hembras de *P. nigrispinus* fueron similares entre los tratamientos. La soja resistente 'IAC-24' no mostró efectos nocivos directos en *P. nigrispinus*, lo que implica su inocuidad y compatibilidad con este depredador.

Palabras clave: Asopinæ, control biológico, depredadores, manejo integrado de plagas, soja.

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