Effect of body weight on fecundity and longevity of the stinkbug predator *Podisus rostralis*[1]

José Cola Zanuncio[2], Adrián José Molina-Rugama[2], Germi Porto Santos[3] and Francisco de Sousa Ramalho[4]

Abstract – Considering the importance of predatory Pentatomidae as biological control agents it is necessary to optimize mass production facilities of these species. The objective of this research was to evaluate the influence of body weight on survival and reproductive parameters of females of *Podisus rostralis* (Stål) (Hemiptera: Pentatomidae). Treatments were represented by females of this predator with the following mean weight: 39.5 mg, 45.5 mg, 51.5 mg, 57.5 mg and 63.5 mg. Heavier females of *P. rostralis* showed shorter preoviposition period while the number of eggs and of nymphs per day presented a positive linear relationship with female weight of this predator. Longevity of females of *P. rostralis* was similar between treatments with no tendency of variations as a function of body weight of these females. Since the objective of mass rearing facilities of predatory bugs is to produce the maximum possible number of nymphs per day it is recommended to use females of *P. rostralis* with weight above 60.0 mg.

Index terms: biological control, mass rearing, reproductive performance, survival.

Efeito do peso corporal na fecundidade e na longevidade do percevejo predador *Podisus rostralis*

Resumo – Considerando a importância dos percevejos predadores como agentes de controle biológico e a necessidade de se otimizar sua produção massal, realizou-se o presente trabalho para avaliar a influência do peso corporal sobre a sobrevivência e a reprodução de fêmeas de *Podisus rostralis* (Stål) (Hemiptera: Pentatomidae). Os tratamentos foram constituídos por fêmeas desse predador com peso médio de: 39,5 mg, 45,5 mg, 51,5 mg, 57,5 mg e 63,5 mg. O período de preoviposição foi menor nas fêmeas mais pesadas, enquanto o número de ovos e de ninfas por dia apresentou relação linear positiva com o peso das fêmeas de *P. rostralis*. A longevidade das fêmeas desse predador foi semelhante entre tratamentos, porém não apresentou tendência de variação em razão do seu peso corporal. Como o objetivo de uma criação massal é produzir o maior número possível de ninfas por dia, recomenda-se o uso de fêmeas de *P. rostralis* com peso acima de 60,0 mg.

Termos para indexação: controle biológico, criação massal, desempenho reprodutivo, sobrevivência.

Introduction

The potential of predatory insects as biological control agents has been demonstrated by several authors (Biever & Chauvin, 1992; Cloutier & Bauduin, 1995). According to Bach (1968), main forms of using biological control in Integrated Pest Management (IPM) are: conservation and augmentation of available natural enemies through manipulation of their environment; mass rearing, introduction, and colonization. In this context, the family Pentatomidae has many predatory species in the subfamily Asopinae which attack larvae of Lepidoptera and Coleoptera, plus many other insect species in various agricultural and forest ecosystems (Woodward et al., 1970; Thomas, 1992). Although all species of Asopinae are predators, these insects have been observed ingesting plant material even in the

[1] Accepted for publication on April 22, 2002.

[2] Universidade Federal de Viçosa (UFV), Dep. de Biologia Animal, CEP 36571-000 Viçosa, MG. E-mail: zanuncio@mail.ufv.br, ajmolina@insecta.ufv.br

[3] Embrapa/Epamig-Centro Tecnológico da Zona da Mata, Vila Gianetti, casa 46, Campus da UFV, CEP 36570-000 Viçosa, MG. E-mail: germi@mail.ufv.br

[4] Embrapa-Centro Nacional de Pesquisa de Algodão, Unidade de Controle Biológico, Caixa Postal 174, CEP 58107-720 Campina Grande, PB. E-mail: framalho@cnpa.embrapa.br

presence of prey (Moreira et al., 1996/1997). According to Dunbar & Bacon (1972), the plant feeding behavior does not improve development of these species, but it can provide water and specially nutrients from plants not found in preys. However, Legaspi & O'Neil (1993) found better survival of the predator *Podisus maculiventris* (Say) (Heteroptera: Pentatomidae) when fed pieces of beans compared to individuals receiving no food.

Podisus rostralis (Stål), an important species of this group, and *Podisus nigrispinus* (Dallas) (Hemiptera: Pentatomidae) have been studied for mass rearing and release for pest control by some Brazilian forest companies (Zanuncio et al., 1994). Individuals of this species were collected in 1995 in eucalyptus plantation in the Municipality of Niquelândia, State of Goiás, Brazil, during an outbreak of Lepidoptera defoliators. Léo (1997) described some morphophysiological and predatory aspects of *P. rostralis* when fed with the eucalyptus defoliator caterpillar *Euselasia apisaon* Dalman (Lepidoptera: Riodinidae). Although some authors have found that fecundity of insects can be affected by their body weight (Evans, 1982; Honek, 1993), the fecundity of females of *P. rostralis* with different body weight has not yet been studied.

The objective of this research was to evaluate the influence of body weight on survival and reproductive parameters of females of *P. rostralis*.

Material and Methods

This work was conducted at the Laboratory of Biological Control of the Instituto de Biotecnologia Aplicada à Agropecuária (Bioagro), of the Universidade Federal de Viçosa (UFV), in Viçosa, State of Minas Gerais, Brazil. After being collected in 1995 in Niquelândia, State of Goiás, Brazil, *P. rostralis* has been reared in the laboratory with *Tenebrio molitor* L. (Coleoptera: Tenebrionidae) larvae, at 25±2ºC, 70±10% RH and 12 hours photophase. Newly emerged adults of *P. rostralis* were selected on basis of their body size, and separated by sex. Females of this predator were placed in 500 mL plastic pots with a ventilated cover. *T. molitor* larvae were placed inside these pots with a slice of green bean pod (*Phaseolus vulgaris*) as a humidity source. Larvae and beans were changed daily. Four days after emergence females of *P. rostralis* were mated with males of similar age and weight between 45 and 55 mg, and they were kept together until death.

This study was performed in completely randomized design with five treatments and six replications, each experimental unit consisting of one pair of *P. rostralis* per plastic pot. Treatments consisted of females of this predator with the following mean weight: 39.5±3.0 mg; 45.5±3.0 mg; 51.5±3.0 mg; 57.5±3.0 mg and 63.5±3.0 mg. *P. rostralis* females were weighed after 24 hours of their emergency with a four decimal scale. Weight of these females was defined according to the variation amplitude of their weight obtained at the beginning of this research. Survival and oviposition of each female of this predator were daily observed in order to determine the following parameters: preoviposition and oviposition periods; number of egg masses; number of eggs per egg mass; total number of eggs and nymphs produced and longevity of *P. rostralis* females. Data were submitted to analysis of variance of linear regression. Significance of this regression parameter was tested by the Student's t test at 5% probability level.

Results and Discussion

Analysis of variance regression showed that the preoviposition period of *P. rostralis* presented a negative linear relationship with female weight of this predator (Figure 1). Thus, heavier females of this predator laid their first egg batch earlier than females of the lightest weight classes. This suggests that those females were better in assimilating nutrients from prey and/or accumulating enough energy (lipids) to supply its metabolic demands than smaller females (Legaspi & O'Neil, 1994). The oviposition period ($F = 1.42$ and $P>0.05$) and number of eggs per egg mass ($F = 1.69$ and $P>0.05$) were not affected by the weight of *P. rostralis* females. Regardless of weight, females of this predator had an average oviposition period of 19.12 days and produced 12.51 eggs per egg mass (Figure 1).

Although oviposition period and number of eggs per egg mass were not dependent on female weight, other reproductive characteristics of *P. rostralis* such as number of egg masses and total number of eggs increased or showed a positive linear relationship with female weight of this predator (Figure 2). Furthermore, the total number of nymphs also showed a positive linear relationship with female weight; with higher numbers of nymphs produced per day (2.88) by females weighing 63.5±3.0 mg, while only 1.69 nymphs/day were produced by females

weighing 39.5±3.0 mg (Figure 2). Thus, heavier females of *P. rostralis* (63.5±3.0 mg) produced higher number of eggs and nymphs, which was approximately, 80.0% greater than those females of the lightest weight class (39.5±3.0 mg). These results are consistent with other reports emphasizing the importance of body size on certain ecological and physiological aspects of organisms. For example, Evans (1982) observed a positive correlation between fecundity and body size for the Asopinae *P. maculiventris* and Juliano (1985) showed that egg production of *Brachinus lateralis* (Coleoptera: Carabidae) females was positively and significantly correlated with length of their elytra. Likewise, Haukioja & Neuvonen (1985) reported that the defoliator *Epirrita autumnata* (Borkhausen) (Lepidoptera: Geometridae) had a linear relationship between egg production and weight of pupae from which females of this species emerged. However, the relation between weight and reproductive potential of *P. rostralis* is different from results of Ohgushi (1996) and Klingenberg & Spence (1997), who found that the reproductive period of *Epilachna niponica* (Lewis) (Coleoptera: Coccinellidae) and *Gerris buenoi* Kirkaldy (Hemiptera: Gerridae) was not related to female body weight. These authors concluded that insect size has secondary importance for

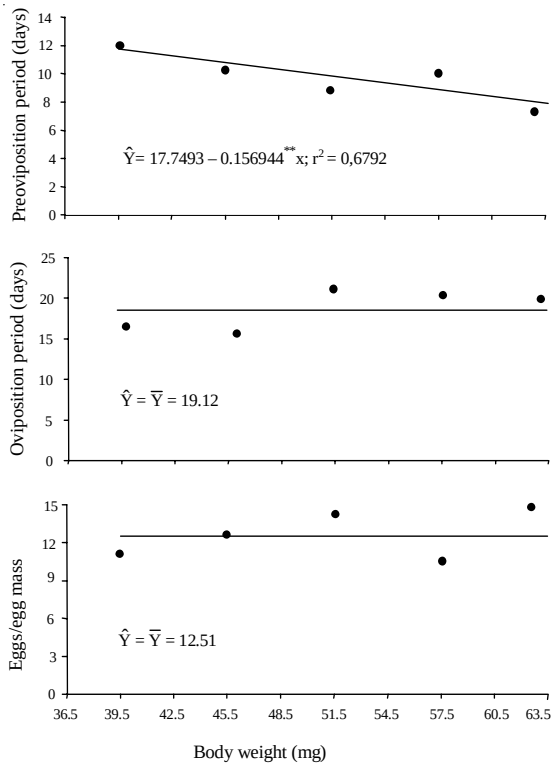

Figure 1. Preoviposition and oviposition periods and number of eggs per egg mass as a function of *Podisus rostralis* (Hemiptera: Pentatomidae) female weight when fed larvae of *Tenebrio molitor* (Coleoptera: Tenebrionidae) and a continuous supply of beans.

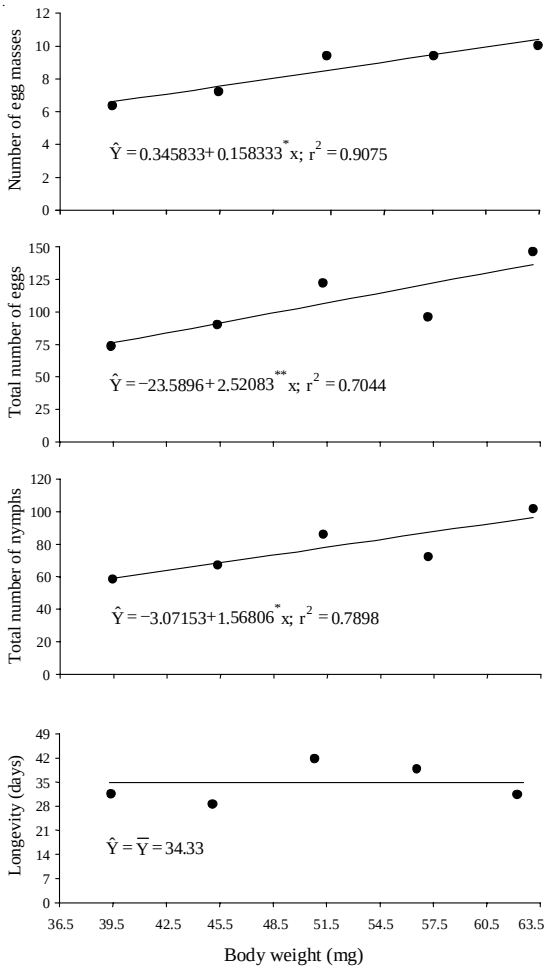

Figure 2. Number of egg masses, total number of eggs and nymphs and longevity as a function of *Podisus rostralis* (Hemiptera: Pentatomidae) female weight when fed larvae of *Tenebrio molitor* (Coleoptera: Tenebrionidae) and a continuous supply of beans.

reproductive performance of Coccinelidae species, and that this factor could be more related to genetic factors in the Gerridae. Thus, it can be concluded, that during mass rearing of *P. rostralis*, any biotic or abiotic factor which reduces their female weight will also reduce the reproductive performance of this predator. This agrees with a previous report about the importance of prey quality and of using more than one prey to produce heavier females of *P. nigrispinus* (Zanuncio et al., 1997). Zanuncio et al. (2001) pointed out that females of this species were heavier when its nymphs were fed on *T. molitor* or provided with *T. molitor* and *Musca domestica* L. (Diptera: Muscidae) on alternated days. These authors suggested, still, that consumption of different prey species during the adult stage of predatory Pentatomidae can improve their development and reproductive rate.

On the other hand, the addition of sliced beans as source of humidity or nutrients with *T. molitor* larvae was enough to allow survival and reproduction of *P. rostralis* females, without water, suggesting that the use of this vegetal can increase performance of this predator in mass rearing. Léo (1997), and Molina-Rugama et al. (1998) reported values around of 190 eggs per female and longevity between 40 and 50 days for this predator when reared with caterpillars of *E. apisaon* or *T. molitor* larvae and water as a humidity source, respectively. Other studies also have showed the importance of adding plant material to the diet of predatory pentatomid bugs; for instance, Moreira et al. (1996/1997) observed that females of *Tynacantha marginata* Dallas (Heteroptera: Pentatomidae) reared with *Eucalyptus urophylla* leaves and *T. molitor* larvae laid more eggs and showed higher net reproductive rate (Ro) than those reared without plant material. Zanuncio et al. (2000) recommended to rear the stinkbug *Brontocoris tabidus* (Signoret) (Heteroptera: Pentatomidae) with prey and seedlings of *Eucalyptus* in order to reduce nymphal mortality and to increase adult longevity and number of eggs and nymphs produced per female of this predator. Therefore, these results suggest that pentatomid predators can obtain nutrients from plants, as well as from prey which agree with reports of other authors (Valicente & O'Neil, 1995; Lemos et al., 2001).

Longevity of *P. rostralis* females was not significantly affected by their weight within the intervals studied ($F = 0.41$ and $P>0.05$). Thus, longevity of light weight *P. rostralis* females was similar to that of heavier ones with a mean of 34.33 days (Figure 2), suggesting that longevity of *P. rostralis* might be controlled by genetic factors rather than female weight. This also indicates, in an indirect way, an allocation of energy between survival and reproduction (Stearns, 1994). Lower weight females may reduce their egg laying rate in order to maintain their longevity, because this would allow them to survive longer in the field, which is a desirable trait for biological control agents. Finally, priority should be given to the use of *P. rostralis* females weighing 63.5±3.0 mg or more for mass rearing programs because these females have a shorter preoviposition period, longer oviposition rate, and produce more nymphs.

Conclusions

1. Any biotic or abiotic factor which reduces female weight of *P. rostralis* will also reduce the reproductive performance of this predator.

2. There is no relation of oviposition period, size of egg mass and longevity with weight of *P. rostralis* females.

3. The preoviposition period, number of egg masses and of eggs and nymphs produced are affected by weight of females of this predator.

4. The use of females with weight above 60.0 mg is important to optimize mass rearing of *P. rostralis*.

Acknowledgements

To the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), to the Federação das Indústrias do Estado de Minas Gerais (Fiemg) and to the Fundação de Amparo à Pesquisa do Estado de Minas Gerais (Fapemig) for financial support.

References

BACH, P. de. **Control biológico de las plagas de insectos y malas hierbas**. México: Continental, 1968. 927 p.

BIEVER, K. D.; CHAUVIN, R. L. Suppression of the Colorado potato beetle (Coleoptera: Chrysomelidae) with augmentative releases of predaceous stinkbugs (Hemiptera: Pentatomidae). **Journal of Economic Entomology**, Lanham, v. 85, n. 3, p. 720-726, June 1992.

CLOUTIER, C.; BAUDUIN, F. Biological control of the Colorado potato beetle *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae) in Quebec by augmentative releases of the two-spotted stinkbug *Perillus bioculatus* (Hemiptera: Pentatomidae). **Canadian Entomologist**, Ottawa, v. 127, n. 2, p. 195-212, Mar./Apr. 1995.

DUNBAR, D. M.; BACON, O. G. Feeding, development, and reproduction of *Geocoris punctipes* (Heteroptera: Lygaeidae) on eight diets. **Annals of the Entomological Society of America**, Lanham, v. 65, n. 4, p. 892-895, July 1972.

EVANS, E. W. Consequences of body size for fecundity in the predatory stinkbug, *Podisus maculiventris* (Hemiptera: Pentatomidae). **Annals of the Entomological Society of America**, Lanham, v. 75, n. 4, p. 418-420, July 1982.

HAUKIOJA, E.; NEUVONEN, S. The relationship between size and reproductive potential in male and female of *Epirrita autumnata* (Lep., Geometridae). **Ecological Entomology**, Oxford, v. 10, n. 3, p. 267-270, Aug. 1985.

HONEK, A. Intraspecific variation in body size and fecundity in insects: a general relationship. **Oikos**, Copenhagen, v. 66, n. 3, p. 483-492, Sept. 1993.

JULIANO, S. A. The effects of body size on mating and reproduction in *Brachinus lateralis* (Coleoptera: Carabidae). **Ecological Entomology**, Oxford, v. 10, n. 3, p. 271-280, Aug. 1985.

KLINGENBERG, C. P.; SPENCE, J. R. On the role of body size for life-history evolution. **Ecological Entomology**, Oxford, v. 22, n. 1, p. 55-68, Feb. 1997.

LEGASPI, J. C.; O'NEIL, R. J. Life history of *Podisus maculiventris* given low numbers of *Epilachna varivestis* as prey. **Environmental Entomology**, Lanham, v. 22, n. 5, p. 1192-1200, Oct. 1993.

LEGASPI, J. C.; O'NEIL, R. J. Lipids and egg production of *Podisus maculiventris* (Heteroptera: Pentatomidae) under low rates of predation. **Environmental Entomology**, Lanham, v. 23, n. 5, p. 1254-1259, Oct. 1994.

LEMOS, W. P.; MEDEIROS, R. S.; RAMALHO, F. S.; ZANUNCIO, J. C. Effects of plant feeding on the development, survival and reproduction of *Podisus nigrispinus* (Dallas) (Heteroptera: Pentatomidae). **International Journal of Pest Management**, London, v. 47, n. 2, p. 89-93, Apr./June 2001.

LÉO, E. A. **Aspectos morfofisiológicos e de predação do percevejo *Podisus rostralis* (Heteroptera: Pentatomidae) sobre a lagarta-de-eucalipto *Euselasia apisaon* (Lepidoptera: Riodinidae)**. 1997. 53 f. Dissertação (Mestrado) - Universidade Federal de Viçosa, Viçosa.

MOLINA-RUGAMA, A. J.; ZANUNCIO, J. C.; ZANUNCIO, T. V.; OLIVEIRA, M. L. R. Reproductive strategy of *Podisus rostralis* (Stål) (Heteroptera: Pentatomidae) females under different feeding intervals. **Biocontrol Science and Technology**, London, v. 8, n. 4, p. 583-588, Aug. 1998.

MOREIRA, L. A.; ZANUNCIO, J. M.; PICANÇO, M. C.; GUEDES, R. N. C. Effect of *Eucalyptus* feeding in the development, survival and reproduction of *Tynacantha marginata* (Heteroptera: Pentatomidae). **Revista de Biología Tropical**, San José, v. 44/45, n. 3/1, p. 253-257, Sep. 1996/1997.

OHGUSHI, T. Consequences of adult size for survival and reproductive performance in a herbivorous ladybird beetle. **Ecological Entomology**, Oxford, v. 21, n. 1, p. 47-55, Feb. 1996.

STEARNS, S. C. **The evolution of life histories**. Oxford: Oxford University Press, 1994. 249 p.

THOMAS, D. B. **Taxonomic synopsis of the Asopinae Pentatomidae (Heteroptera) of the Western Hemisphere**. Lanham: Entomological Society of America, 1992. 156 p.

VALICENTE, F. H.; O'NEIL, R. J. Effects of host plants and feeding regimes on selected life-history characteristics of *Podisus maculiventris* (Say) (Heteroptera: Pentatomidae). **Biological Control**, San Diego, v. 5, n. 3, p. 449-461, Sept. 1995.

WOODWARD, I. F.; EVANS, J. W.; EASTOP, V. F. Hemiptera. In: THE INSECTS of Australia: a textbook for students and research workers. Melbourne: Melbourne University Press, 1970. p. 387-457.

ZANUNCIO, J. C.; ALVES, J. B.; ZANUNCIO, T. V.; GARCIA, J. F. Hemipterous predators of eucalyptus defoliator caterpillars. **Forest Ecology and Management**, Amsterdam, v. 65, n. 1, p. 65-73, May 1994.

ZANUNCIO, J. C.; MOLINA-RUGAMA, A. J.; SERRÃO, J. E.; PRATISSOLI, D. Nymphal development and reproduction of *Podisus nigrispinus* (Heteroptera: Pentatomidae) fed with combinations of *Tenebrio molitor* (Coleoptera: Tenebrionidae) pupae and *Musca domestica* (Diptera: Muscidae) larvae. **Biocontrol Science and Technology**, London, v. 11, n. 3, p. 331-337, June 2001.

ZANUNCIO, J. C.; TORRES, J. B.; BERNARDO, D. L.; DE CLERCQ, P. Effects of prey switching on nymphal development of four species of predatory stinkbugs. **Mededelingen Faculteit Landbouwkundige & Toegepaste Wetenschappen Universiteit Gent**, Gent, v. 62, n. 2b, p. 483-490, 1997.

ZANUNCIO, J. C.; ZANUNCIO, T. V.; GUEDES, R. N. C.; RAMALHO, F. S. Effect of feeding on three *Eucalyptus* species on the development of *Brontocoris tabidus* (Het.: Pentatomidae) fed with *Tenebrio molitor* (Col.: Tenebrionidae). **Biocontrol Science and Technology**, London, v. 10, n. 4, p. 443-450, Aug. 2000.