SEASONAL ABUNDANCE AND MORTALITY OF *Oebalus poecilus* (DALLAS) (HEMIPTERA: PENTATOMIDAE) IN A HIBERNATION REFUGE

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ABSTRACT

Oebalus poecilus (Dallas) is an important pest affecting irrigated rice in Rio Grande do Sul, Brazil. It hibernates during the coldest months of the year in refuges such as bamboo litter. This study examined *O. poecilus* hibernation to determine the causes of mortality during this period. The study was conducted in a 140 m^2 bamboo plantation located in a rice-growing area in Eldorado do Sul County (30° 02' S and 51° 23' W), RS. During June 2000 to April 2002, 63 samples of litter were taken in weekly or fortnightly intervals, and the number of bugs recorded in the laboratory. The arrival at the hibernation site (bamboo litter) began in the first fortnight of March, and was completed in the beginning of May. *O. poecilus* left this refuge from middle October to the end of December. Parasitism by tachinid flies and *Beauveria bassiana* (Bals.) Vuill. fungus were the most important mortality factors.

Keywords: overwintering, small rice stink bug, parasitism, *Beauveria bassiana*.

RESUMO

Abundância sazonal e mortalidade de *Oebalus poecilus* (Dallas) (Hemiptera: Pentatomidae) no refúgio de hibernação

Oebalus poecilus (Dallas) é praga importante do arroz irrigado no Rio Grande do Sul, Brasil. Este inseto hiberna durante os meses mais frios em refúgios como o folhedo de bambu. Este estudo objetivou elucidar a hibernação de *O. poecilus* e determinar as causas de mortalidade durante este período. O estudo foi realizado em um bambuzal com cerca de 140 m^2, situado em área orizícola, em Eldorado do Sul (30° 02' S e 51° 23' W), RS. De junho/2000 à abril/2002, foram realizadas 63 amostragens de folhedo, em intervalos semanais ou quinzenais e o número de percevejos registrado em laboratório. A entrada no refúgio de hibernação (folhedo de bambu) iniciou na primeira semana de março, completando-se no início de maio. *O. poecilus* abandonou o refúgio da metade de outubro até o final de dezembro. O parasitismo por mosca (taquinídeos) e o fungo *Beauveria bassiana* (Bals.) Vuill. foram os principais fatores de mortalidade.

Palavras-chave: hibernacão, percevejo-do-arroz, parasitismo, *Beauveria bassiana*.

INTRODUCTION

The small rice stink bug, *Oebalus poecilus* (Dallas), occurs in almost all South American countries (Becker & Grazia-Vieira, 1971; Grazia-Vieira & Casini, 1973). It feeds on developing grains of various plant species, both wild and cultivated (Albuquerque, 1991), and is a major pest in irrigated rice (Gallo *et al*., 2002).

Most studies on *O. poecilus* have concentrated on the active phase of its life cycle, the damages it inflicts, and the testing of its control by insecticides (Sutherland *et al*., 2002). Few data are found on survival strategy of this bug when rice is not available, and when inactive during winter. Diapause strategy presented by a heteropterous species (Pentatomidae) has been investigated for many other species worldwide. In Japan, Kiritani *et al*. (1962) and Kiritani (1963) reported that adults of the third generation of *Nezara viridula* (L.) spend the winter in tussocks, resuming their feeding and reproduction activities in the spring, with hibernating females presenting atrophied ovaries and a great amount of body fat. In Canada, *Oebalus pugnax* (F.) hibernates in grass tussocks from October to April, showing great body fat amounts in the abdominal cavity and immature reproductive organs (Nilakhe, 1976). Aner (1991) in Eldorado do Sul, RS, reported grass tussocks as the hibernation site of adult *Tibraca limbativentris* Stäl. In northern Paraná State, Panizzi & Niva (1994) observed, from June to October, under foliage litter high densities of *Euschistus heros* (F.) (more than 50 individuals/m^2) with altered color. Panizzi & Vivan (1997), besides characterizing the dormancy of *E. heros* as an oligopause, verified that the population of this insect increases under pigeon pea, *Cajanus cajan* (L.), foliage litter from April to August, gradually decreasing from September to November, with no individuals found in the site during December-March. Mourão & Panizzi (2000) verified that during the fall/winter, *E. heros* presents immature reproductive organs and little-developed humeral spines that indicate diapausing individuals.

Information on *O. poecilus* dormancy is essential to explain its population dynamics, and to design integrated management programs. Therefore, a study was conducted on this insect's hibernation and to determine mortality causes during this period.

MATERIAL AND METHODS

The study was conducted from June 2000 to April 2002 in a bamboo tussock, 260 m long, 2 m wide and east-west orientation, formed by *Bambusa tuldoides* (Munro) (Gramineae), in Eldorado do Sul County, RS (30° 02' S and 51° 23' W). The litter layer averaged 6.7 cm along the entire bamboo growth used as a hibernation site by *O. poecilus* (Santos *et al*., 2003).

The study area consisted of 70 m of bamboo growth in which seven areas, 10 m long on each side (north and south) were demarcated, totaling 14 areas, each one of which was subdivided into ten 1 m x 1 m areas. Each sub-area was subdivided into 20 cm portions, perpendicularly to the bamboo growth length, totaling five 0.2 m^2 sections/m.

A random sampling stratified system was used, with four 300 cm^3 units of foliage litter taken from each of the 14 areas, from the subareas, and from portions previously turned over at weekly or fortnightly intervals, totaling 56 sampling units on each sampling occasion. In the laboratory, the bugs (live and dead) were extracted from the samples, sexed, and counted. The live individuals were dissected to confirm the diapause state.

O. poecilus hibernation periods were identified and subdivided by using G statistics to examine frequency distribution homogeneity of the number of individuals/sample unit. The observed proportions of dead individuals along hibernation and the sexual ratio at each sampling were compared by chi-square statistics ($P \leq 0.05$). The trend test was used to determine variation of the dead insect proportion along the study. Microsoft Excel and Bioestat 2.0 software were used for calculations.

RESULTS AND DISCUSSION

Adult capture and sex ratio

During the study period, 63 samplings were taken and 4,162 *O. poecilus* adults were collected from the bamboo litter. The high number of bugs captured in a diapause state indicates that the bamboo litter is a favorable place for its hibernation. Mielitz *et al.* (1996) registered the rice water weevil, *Oryzophagus oryzae* Costa Lima (Coleoptera: Curculionidae), hibernating in similar conditions in a location from which they infested rice plantations.

The sex ratio of bugs collected (live or dead) did not differ statistically from the expected 1 female: 1 male ($P > 0.05$) in over 90% of the sampling occasions. The sex ratio during hibernation represents an important component of population dynamics. Kiritani *et al*. (1962) verified that in different hibernation sites the survival of *N. viridula* females was 11% higher than that of males. The difference in the mortality rate in relation to sex changed the sex ratio from 48.3% to 54.4%, before and after dormancy, respectively. Negron & Riley (1991) registered a sex ratio of 1:1 during hibernation of *Blissus leucopterus leucopterus* (Say) (Hemiptera: Lygaeidae) in Louisiana, USA. Results obtained for the small stink bug indicate that both females and males hibernate in the same place and are equally vulnerable to mortality factors during this period.

Seasonal abundance of adults

Temporal variation in the number of *O. poecilus*/sampling of litter (Fig. 1) allowed distinguishing three periods during the hibernation phase: active occupation (arrival); relative populational stability in the refuge (intermediate); and departure from the refuge (departure). From January to February (summer), no live individuals were found in the refuge, similar to what was recorded for *E. heros* in a hibernation site during the summer months (Panizzi & Vivan, 1997).

In 2001, the number of *O. poecilus* adults in the bamboo litter tended to rise from the second fortnight of March (beginning of fall) until the first fortnight of May (end of fall), which is the arrival period in the refuge (ca. 60 days) (Fig. 1). From the end of the first fortnight of May until the second fortnight of October (spring), the relative populational stability period in the site (ca. 180 days) was observed. Departure from the refuge occurred from the second fortnight of October until the second fortnight of December (end of spring), when bugs started feeding and reproduction.

In 2002, the arrival period of adults at the hibernation site began in the second fortnight of April. This delay in relation to the preceding year was due to a late rice seeding period. Movement into

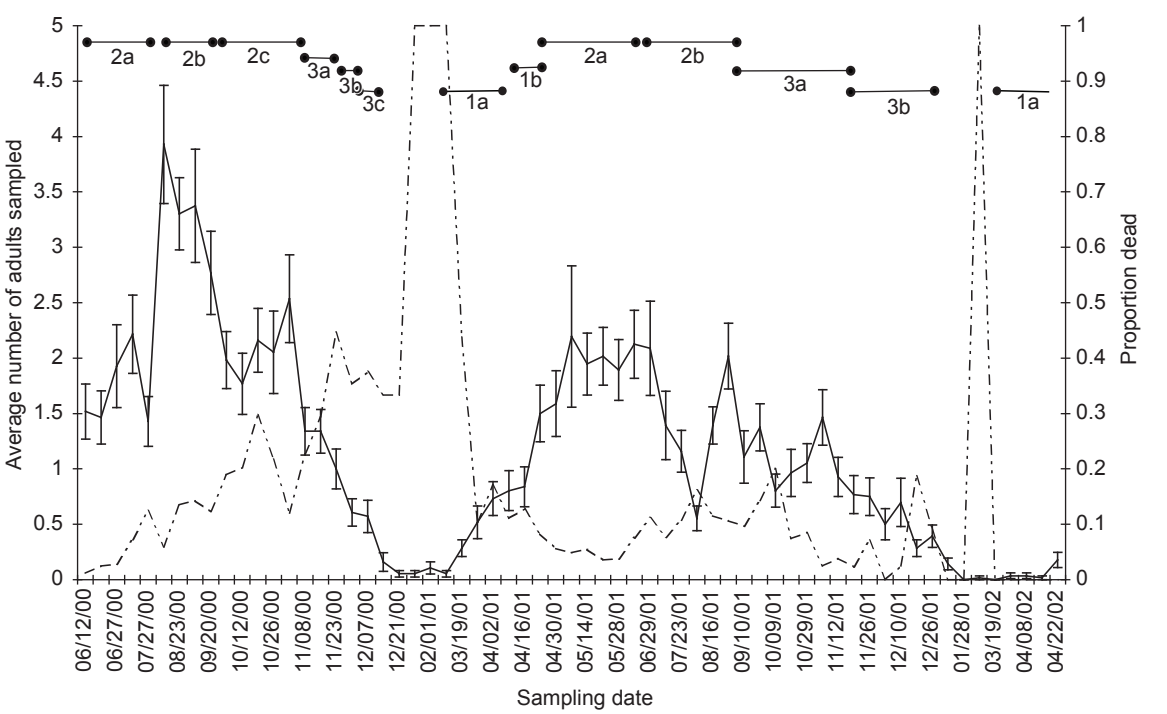


Fig. 1 — Temporal variation of the average number (± EP) (——) and of the proportion of *Oebalus poecilus* adults dead (----) sampled in the bamboo litter. (1a: beginning of arrival; 1b: end of arrival; 2a: beginning of intermediate; 2b: intermediate; 2c: end of intermediate; 3a: beginning of departure; 3b: intermediate of departure; 3c: end of departure). Eldorado do Sul, RS, Brazil, 2000-2002.

hibernation sites at the end of summer, and out of it in the spring, has been observed for other heteroptera such as *N. viridula* (Kiritani *et al*., 1962), *O. pugnax* (Nilakhe, 1976), *B. l. leucopterus* (Negron & Riley, 1991), and *E. heros* (Panizzi & Vivan, 1997).

When the present study began on June 2000, *O. poecilus* was already in the intermediate hibernation period. Based on the frequency distribution of the number of individual/sampling unit, on the total number on each sampling occasion, and on the insect's phenology, the periods described above were subdivided (Fig. 1).

The subdivisions in the arrival and departure periods indicate a gradual process of occupation and departure from the site by the bugs, which can be explained as an intrapopulational differential response to the diapause induction stimulus, which for *O. poecilus* occurs during the first three instars if individuals are exposed to photophases ≤ 13:00 hL; in photophases ≥ 13:50 hL non-hibernating adult-form emergence is induced (Albuquerque, 1989). Intermediate photoperiods induce emergence of both forms. Overlapping summer *O. poecilus* generations are estimated to be present in the field, giving rise to hibernating populations composed of individuals that perceive the stimulus at different moments.

The hibernation period of *O. poecilus* lasted between 7 and 8 months, close to that registered for *O. pugnax* in the Northern Hemisphere (Nilakhe, 1976). The duration of the hibernation period in Pentatomidae may be variable. Aner (1991) pointed out, for the same latitude as that of the present study, that *Edessa meditabunda* (De Geer) and *T. limbativentris* go through a 4 and 10 month hibernation period, respectively. Panizzi & Vivan (1997) demonstrated that *E. heros* hibernation in Londrina, PR, Brazil, lasts 6 months. The differentiated hibernation period may also be related to a species' feeding behavior.

Adult mortality

Along the 1st year of study, a trend towards proportional increase of dead individuals during the hibernation period was observed (A = 67.0366; χ^2 = 68.0584; gl = 1; P < 0.001), which was not confirmed in the second year (A = - 9.4247; χ^2 = 1.0644; gl = 1; P = 0.3022) (Fig. 1). The total proportion of dead individuals obtained for *O. poecilus* varied among the years, being significantly higher in 2000 (χ^2 = 51.8919; gl = 1; P < 0.001) (Table 1). For *N. viridula* Kiritani *et al*. (1962) registered mortalities of 38 and 86%, depending on the hibernation site. For *O. poecilus* mortality was 15.8% in 2000 and 8.4% in 2001 (Table 1), allowing survivorship during hibernation in bamboo litter during the adverse periods.

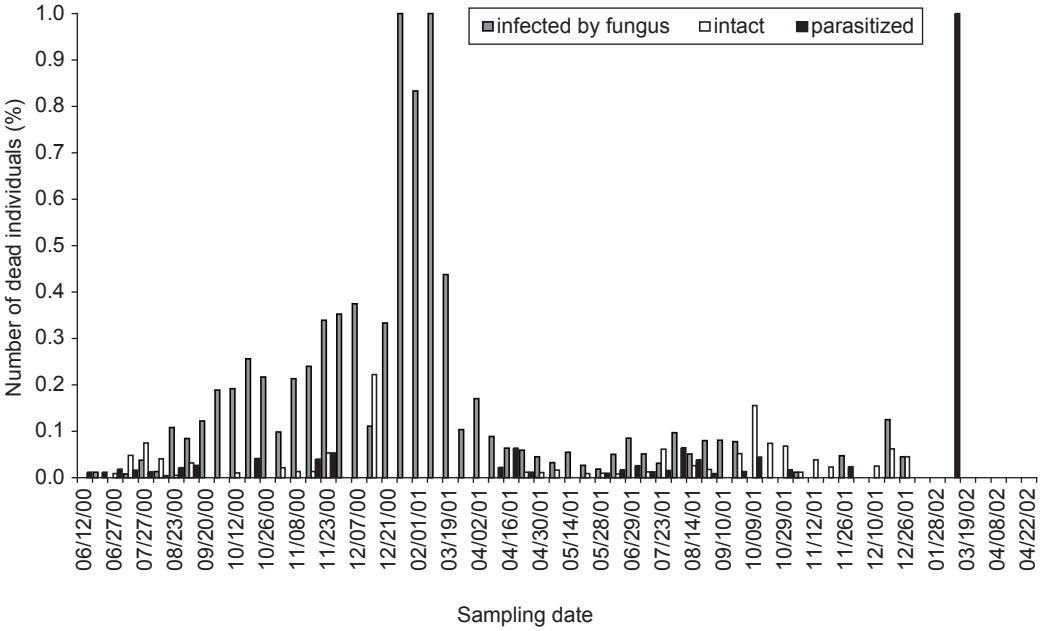
The dead *O. poecilus* observed were grouped into three categories: intact (did not show any external alteration); parasitized (presented abdominal perforation); fungus-infected (showed fungus growth on external body surface) (Table 1).

The proportion of intact dead individuals was *ca.* 2% and did not differ between 2000 and 2001 (χ^2 = 0.1579; gl = 1; P = 0.6911) (Table 1). When comparing this proportion in periods and subperiods, a significant difference (P < 0.01) was verified for subperiods 2a and 3a (2001), with the latter being higher. This suggests that at the end of hibernation natural mortality increases due to insufficient previously accumulated reserves to survive this period. Mielitz *et al*. (1996) also verified higher mortality when hibernation period of *O. oryzae* ended.

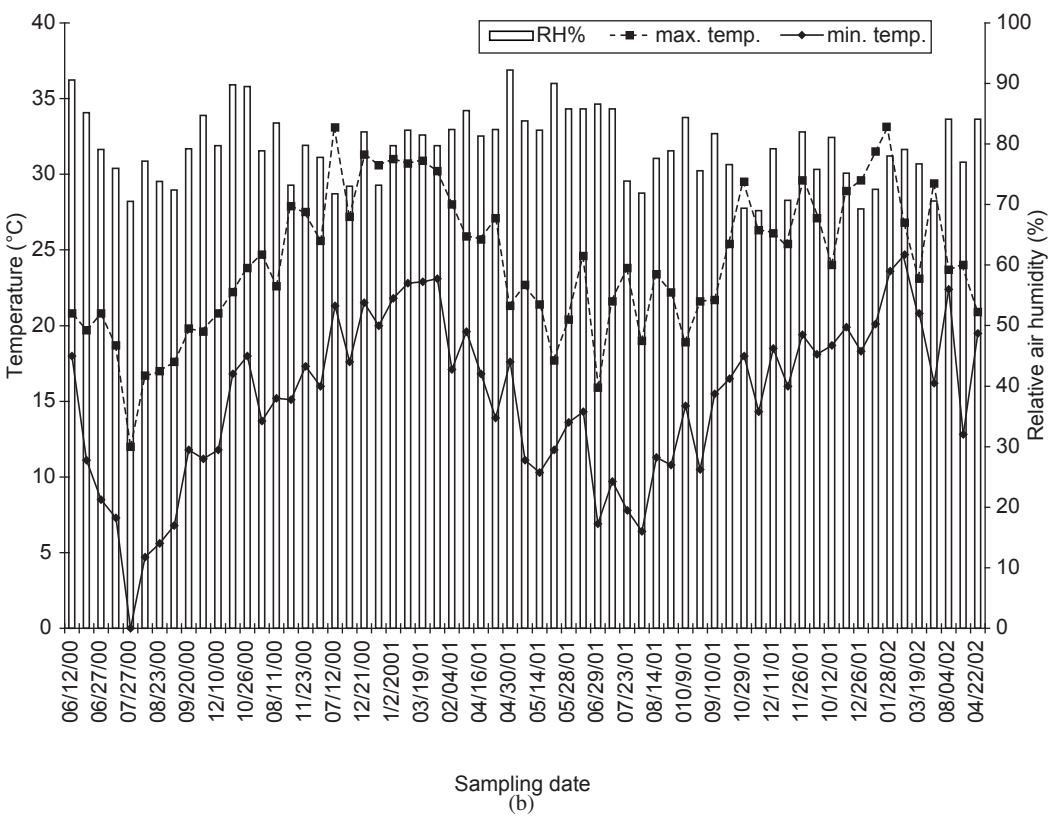
The proportion of parasitized individuals was *ca.* 1.3% and did not differ between years (χ^2 = 6.0703; gl = 1; P = 0.7910) (Table 1); 3.8% of the insects presented tachinid larvae in the abdominal cavity, with the greatest occurrence of these individuals when hibernation ended (Fig. 2).

TABLE 1
Total number of adults of *Oebalus poecilus* and dead individuals sampled in bamboo litter. Eldorado do Sul, RS, Brazil, 2000/02.

Year	Number of adults sampled	Dead individuals							
		Intact		Parasitized		Infected by Fungus		Total	
		n	%	n	%	n	%	n	%
2000	2101	40	1.9	29	1.4	263	12.5	332	15.8
2001	2037	42	2.1	26	1.3	103	5.1	171	8.4
2002	24	0	0	1	4.2	0	0	1	4.2
Total	4162	82	2.0	56	1.3	366	8.8	504	12.1



(a)



(b)

Fig. 2 — a) Temporal distribution of *Oebalus poecilus* dead individuals (proportion) sampled in the bamboo litter; and b) maximum (max. temp.) and minimum (min. temp.) air temperature and relative air humidity (RH%) along the study. Eldorado do Sul, RS, Brazil, 2000-2002.

The proportion of individuals infected by the fungus *Beauveria bassiana* (Bals.) Vuill. was 79.2% in 2000 and 60.2% in 2001 ($\chi^2 = 910.0765$; gl = 1; P < 0.001) (Table 1). (The fungus was pathogenic to *O. poecilus* in the laboratory (Santos *et al*., 2002). Records of *B. bassiana* in hibernating populations of other insects are common (Tsuzuki *et al*., 1984; McGiffen & Meyer, 1986; Lafleur *et al*., 1987; and Mielitz *et al*., 1996).) The proportion of individuals infected with *B. bassiana* increased with rising temperatures, mainly in 2000 (Fig. 2). This was also observed for *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae) (McGiffen & Meyer, 1986) and *O. oryzae* (Mielitz *et al*., 1996) during hibernation. The development of fungi as biological control agents in natural conditions is critically dependent on temperature and air humidity variations (Hallsworth & Magan, 1999). The greater proportion of dead individuals infected with fungus in the 1st year may have resulted from favorable temperature and relative air humidity conditions within the bamboo litter, and its high organic content coupled with the high bug-population density.

In spite of the majority of studies pointing to *B. bassiana* as an important mortality factor during hibernation, McCoy *et al*. (1988) report that this fungus is able to live on dead organic material (vegetation, and vertebrate and invertebrate organisms). Therefore, saprophytic action could be restricted to the end of a hibernation period.

Adults of *O. poecilus* remained in imaginal reproductive diapause from March to October at 30° 02' S latitude. Since mortality was estimated as *ca.*12%, bamboo litter was demonstrated to be an important hibernation site for *O. poecilus* in the study area. In addition, increasing mortality factor effects on *O. poecilus* in hibernating sites may reduce infestation potential of this species in rice planted in Southern Brazil.

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