CHARACTERIZATION OF THE LARVAL STAGES OF *Alphitobius diaperinus* (PANZER) (COLEOPTERA: TENEBRIONIDAE) USING HEAD CAPSULE WIDTH

FRANCISCO, O.1 and PRADO, A. P. do2

¹Programa de Pós-graduação em Parasitologia, Instituto de Biologia, Unicamp, C.P. 6109, CEP 13083-970, Campinas, SP, Brazil

²Departamento de Parasitologia, Instituto de Biologia, Unicamp, C.P. 6109, CEP 13083-970, Campinas, SP, Brazil
Correspondence to: Angelo Pires do Prado, Departamento de Parasitologia, Instituto de Biologia, Unicamp,
C.P. 6109, CEP 13083-970, Campinas, SP, Brazil, e-mail: odpret@obelix.unicamp.br
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ABSTRACT

The mean width (n = 5) of the cephalic capsule instar of *Alphitobius diaperinus* was determined. The larvae were reared at 27°C (\pm 0.1°C). The result showed that *A. diaperinus* has eight larval instars. The head capsule of the 1st instar larvae measured $\bar{x} = 0.228$ (SD = 0.0192) and the last instar larval measured $\bar{x} = 1.339$ (SD = 0.0436). The developmental rate, determined by Dyar-Hutchinson's rule, was 1.29. These data may be useful for studies on phenology and age structure of *A. diaperinus* in the field.

Key words: lesser mealworm, larval instars, cephalic capsule, caged layer manure.

RESUMO

Caracterização dos estádios larvais de *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae) usando a largura da cápsula cefálica

O valor médio da largura da cápsula cefálica de *Alphitobius diaperinus* foi verificado de acordo com seus estádios larvais, sendo medidos cinco indivíduos para cada estádio. O experimento foi conduzido em temperatura constante de 27°C (\pm 0,1°C). Os resultados obtidos mostraram que as larvas atingem oito estádios, com média de 0,228 mm (SD = 0,0192) para a larva recém-eclodida, até 1,339 mm (SD = 0,0436) no 8° estádio. Também foi observado que o fator de crescimento das larvas corresponde à regra de Dyar-Hutchinson, apresentando média de 1,29 para razões de crescimento ao longo do desenvolvimento. Esses dados poderão ser utilizados em estudos de fenologia e estruturação etária de populações de *A. diaperinus* no campo.

Palavras-chave: cascudinho, ínstares larvais, cápsula cefálica, esterco de aves poedeiras.

INTRODUCTION

The synantropic beetle *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae), also vulgarly known in Brazil as "Cascudinho" (Lesser Mealworm), is a cosmopolitan plague commonly found in stored grains and mealy products. Both adults and larvae are also abundant in manure from henneries and poultry farms (MacCreary & Catts, 1954; Legner & Olton, 1970; Pfeiffer & Axtell,

1980; Avancini & Ueta, 1990; Bruno et al., 1993; Lomônaco & Prado, 1994). This beetle is known as an important vector and transmitter of fowl diseases, such as the virus of leukosis or Marek's disease (Eidson et al., 1965) and other viruses (Snedeker et al., 1967; De las Casas et al., 1976; Despins et al., 1994; McAllister et al., 1995), bacteries such as Salmonella typhimurium (Loeffler) and Escherichia coli (Migula) (De las Casas et al., 1968, 1972; McAllister et al., 1994,

1996), protozoans, like *Eimeria* sp. (Reyns *et al.*, 1983), fungi (Eugenio *et al.*, 1970; De las Casas *et al.*, 1972), helminths as the nematode *Subulura brumpti* Lopes-Neira (Karunamoorthy *et al.*, 1994) and cestodes (Case & Ackert, 1940; Elowni & Elbihari, 1979). Besides, both adults and larvae of *A. diaperinus* can cause intestinal obstruction in poultry for slaughter, since these birds lack **chitinasis** (Despins & Axtell, 1994, 1995). This fact may eventually cause microscopic lesions along the bird's intestinal wall, thus damaging this economic activity.

In countries of temperate climate A. diaperinus is considered a structural plague due to damage caused by its habit of, prior to pupating, perforating the plates of polyurethane and polyestyrene, materials utilized in the walls of sheds for thermal insulation (Spilman, 1968; Ichinose et al., 1980; Le Torc'h & Letenneur, 1983; Vaughan et al., 1984; Turner Jr., 1986; Despins et al., 1987, 1989; Arends, 1987; Geden & Axtell, 1987). During the populational peak of these beetles, in summer, it is a common to find, in the USA (North Carolina), infestations in poultry farms of between 10,000 and 20,000 individuals per m² (Arends, 1984). Estimated losses in egg production have been attributed to damage caused by A diaperinus, which may be more than 1.35/dozen eggs per year (Vaughan et al., 1984). Thus, the presence of A. diaperinus may determine: a) loss in feeding efficiency (mainly during the cold months) due to gradual spoilage of thermal insulation; b) sharp loss while the shed in non-productive due to repairs; c) expenses with insulation maintenance; d) loss of energy; and e) depreciation of the building.

The development, growth and survival of the lesser mealworm according to humidity and temperature are reported in the papers of Wilson & Miner (1969), Preiss & Davidson (1971) and recently by Rueda & Axtell (1996).

Therefore this study has the objective of verifying the average size of each larval instar of *A. diaperinus* and thus contribute toward future population surveys of this plague beetle.

MATERIAL AND METHODS

To verify the average size each larval of *A. diaperinus*, the width of the cephalic capsules was measured on five specimens for each instar, obtaining

ned by means of daily individual observations as from the ova. The eggs were obtained from a mass breeding in a modified Arends' trap, as per Steinkraus & Cross (1993). The larva were bred individually in an environment of ground ration for mice contained in plastic flasks (2.5 cm diameter x 4.0 cm in height). The environmental humidity was maintained at a level of 40% (\pm 5%). The experiment was conducted at 27°C (± 0.1°C) and relative humidity of 70% (\pm 5%), in germination chamber. Each exuvia observed was considered an instar. The larvae obtained were killed in alcohol 70%, mounted between slide and minor slide in Canadian balsam, width "wedges" (small rectangles cut from glass slides) in order not to alter the dimension of cephalic capsule, which was then measured by means of micrometric ocular in stereoscopical microscope.

For each instar was considered the mean value of the width of cephalic capsules of the larvae. The data obtained were analysed by means of linear regression in the Minitab (1994) statistical program.

RESULTS AND DISCUSSION

The freshly-emerged larvae presented a milky colour. After the third instar a shade of brown is observed, which darkens as the larva develops. The pale colour tinge returns to that of first larva when in ecdysis, however it darkens again on the same day. In this experiment the larvae pupated after 8 larval instars, although Wilson & Miner (1969) observed 11 larval instars for A. diaperinus at a temperature of 15.5°C; however at temperature of 26.6°C, the same authors observed only a single individual (in 54 initial larvae) reaching the 9th stage. Several factors can influence the insects' growth. Lower temperatures may determine a reduction in width of the capsule of each larval instars, thus obviously increasing the number of instars in order for the insect to complete its development. Guppy (1969) noted a reduction in size of the cephalic capsules in larvae from Pseudaletia unipuncta Haworth (Lepidoptera: Noctuidae) when these were bred at lower temperatures. Maltais (1980) observed smaller dimensions in the cephalic capsule of Pristiphora erichsonii Hartig (Hymenoptera: Tenthredinidae) in observations made in New Brunswick, Canada, when compared, as per notes of Drooz (1955) in Minnesota, USA, suggesting that these differences may be determined by climatic conditions. Besides, other factors can influence the growth of the cephalic capsule of insects, such as endoparasitism (McGugan, 1954; Muldrew, 1967; Nealis, 1987).

Nutrition can also be determining factor in larval growth of insects (Scriber & Slansky Jr., 1981). Parra

et al. (1977) noticed that 20% of *Spodoptera eridania* Cramer (Lepidoptera: Noctuidae) caterpillars bred in soybean leaves attained seven instars while those bred in cotton leaves reached a maximum of six instars. According to Slansky Jr. & Rodriguez (1987), the increase in number of larval instars can be caused by a nutritional inadequacy.

 $\begin{tabular}{ll} TABLE\ 1 \\ Average\ width\ of\ cephalic\ capsule\ of\ Alphitobius\ diaperinus\ larvae\ and\ growth\ rate\ during\ larval\ development. \end{tabular}$

Larval instar	Width of cephalic capsule (mm) x (± SD)	Variation coefficient (VC)	Rate of growth
I	$0.228~(\pm~0.0192)$	0.0842	1.2631
II	0.288 (± 0.0225)	0.0781	1.2083
III	0.348 (± 0.0433)	0.1244	1.3735
IV	0.478 (± 0.0433)	0.1244	1.5083
V	0.721 (± 0.0216)	0.0299	1.4715
VI	1.061 (± 0.0536)	0.0505	1.1385
VII	1.208 (± 0.0769)	0.0603	1.1084
VIII	1.339 (± 0.0436)	0.0325	
Medium rate of growth			1.2904

The equation of a straight line for linear regression, done between the average of cephalic capsule measurements of five individuals for each instar, and the larval instars, was y = -0.0818 + 0.176 x, with F equal to 118.52 (p < 0.001). The r² verified was 0.952. Pearson's correlation verified between the size average of each instar and the larval instars was $r^2 = 0.976$.

These results demonstrated that *A. diaperinus* larvae have a development following the model of linear regression (Fig. 1), the width of cephalic capsules evolved according to the constant of Dyar (1.4) has been used to determine the number of instars in various species, however there are many exceptions to it, since the progression factor may change in successive instars (Gaines & Campbell, 1935; Ludwig & Abercrombie, 1940; Richards & Davies, 1977; Wigglesworth, 1965; Parra & Haddad, 1989; Ambrosano *et al.*, 1997).

Caltagirone *et al.* (1983) observed that in *Amyelois transitella* (Walker) (Lepidoptera: Pyralidae) the width of cephalic capsules cannot be used directly to determine the instar of individuals because the measurements of two consecutive instars

may superpose. In our experiment, observations were made only with exuviae. Our results showed, as per Fig. 1, that the inclination of the regression line was significant (p < 0.05), the progression of the line occurred within Dyar's constant. The differential growth from one instar to the other suggests to us that this occurs due to the superposition of niches, for, the fewer the larval instars, the greater will be the competition for food items of a given dimension studies in bird populations (MacArthur, 1958; Orians & Horn, 1969; MacArthur, 1971; Cody, 1974; Diamond, 1975; Hespenheide, 1975), in rodent populations (Brown, 1975; Rosenzweig et al., 1975; Mares & Williams, 1977), in lizard populations (Schoener & Gorman, 1968; Pianka, 1973; Schoener, 1975) and in fish populations (Zaret & Rand, 1971; Roughgarden, 1974; Werner, 1977), have suggested that competition exerts a major part regarding structure and function within the communities. These studies have shown that that the differential utilization of micro-habitat and food (size and/or taxons) were the factors that most influenced the minimization of competition and yet contributing to establish coexistence.

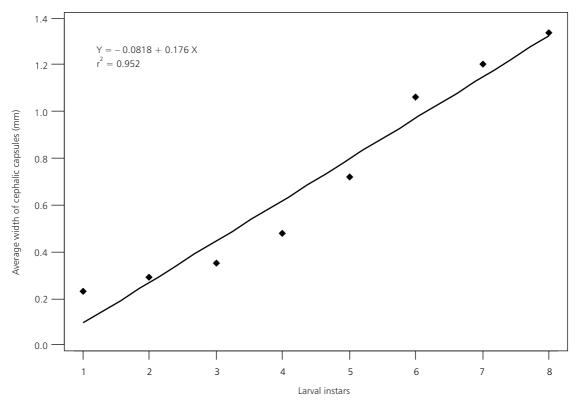


Fig. 1 — Regression between the average width of cephalic capsules and larval instars of Alphitobius diaperinus.

The sizes of prey or food items are related to the size of the predator's body and/or size of buccal apparatus. Hutchinson (1959) states that this way the size of the food resource (prey) in a community of predators could influence the number of niches, if members possessed morphological differences. The same author observed furthermore that sympatric species of a given genera tend to differ in the size of their feeding structures by a factor around 1.28, close to Dyar's constant. For Hutchinson (1959) this average represents this the lower limit of similatity between competing species. Horn & May (1977) proposed that Dyar's constant be denominated Dyar-Hutchinson's rule.

Maiorana (1978) postulated that this displacement between sizes of species or age classes diverges according to a relatively constant percentage, irrespective of absolute body size, wich is because they tend to show a relative constant originating from their morphological variability. If ecological separation according to size requires a certain minimum limit as to superposition of frequencies of two species or age classes, and if these tend to show the same degree of morpho-

logical variability, then their proportional divergence in average size will likewise be relatively constant.

Simpson *et al.* (1960) observed that the variation coefficient tends to remain between four and ten, more frequently between five and six. For two species in which the size of feeding structure of the larger one is 1.28 times the size of smaller one, VC of 5.5 produces a superposition of 1% or 2% in its distribution of frequency.

The results obtained in this study may be of great use in future surveys of etarian structuring in natural populations of *Alphitobius diaperinus*.

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