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INITIAL DEVELOPMENT OF THE DIPLOPOD *PLUSIOPORUS SETIGER* (BROLEMANN, 1901) UNDER POPULATIONAL EXPANSION IN COFFEE PLANTATIONS (SPIROSTREPTIDA, SPIROSTREPTIDAE)

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ABSTRACT

The present study describes the initial development of the millipede *Plusioporus setiger* (Brolemann, 1901) until stage V or juvenile V. Diplopod development is anamorphic and, in the Spirostreptidae, it is probably hemianamorphic, meaning that new segments are added up to a certain stage but in the subsequent molts there is no acquisition of new segments.

KEY WORDS: Millipedes, anamorphism, *Plusioporus setiger*, diplopods.

RESUMO

DESENVOLVIMENTO INICIAL DO DIPLÓPODE *PLUSIOPORUS SETIGER* (BROLEMANN, 1901) SOB EXPANSÃO POPULACIONAL EM PLANTAÇÕES DE CAFÉ (SPIROSTREPTIDA, SPIROSTREPTIDAE). O presente trabalho traz a descrição do desenvolvimento inicial do milípede *Plusioporus setiger* (Brolemann, 1901), até o estádio V ou juvenil V; o desenvolvimento dos diplópodos é anamórfico e ao que tudo indica nos Spirostreptidae, é do tipo hemianamórfico, em que novos segmentos são adicionados até um certo estádio, não tendo nas mudas subsequentes, a aquisição de novos segmentos.

PALAVRAS-CHAVE: Milípedes, anamorfose, *Plusioporus setiger*, diplópodos.

INTRODUCTION

Several studies about diplopod development have been reported, although most of them were accomplished with members of the order Julida (HOPKIN & READ, 1992; ENGHOFF et al., 1993). In the order Spirostreptida few studies have been carried out on the growth of millipedes. BERCOVITZ & WARBURG (1985) studied the developmental pattern of two populations of *Archispirostreptus syriacus* (De Saussure) in Israel and CRAWFORD et al. (1987) observed three subtropical spirostreptids from arid regions, these being, *Orthoporus ornatus* (Girard), *Archispirostreptus tumuliporus judaicus* (Attems) and *Harpagophora nigra* (Attems).

This study proposes to describe the initial development of the Brazilian species *Plusioporus setiger* (Brolemann), a spirostreptid of wide distribution in the state of São Paulo that is having a large populational expansion in coffee farms of the state of Minas Gerais, causing problems to the farmers (BOCCARDO et al., 1997). Therefore, the study of the biological development of this species is indispensable in Brazil, especially if aimed at developing techniques that facilitate the populational control of these myriapods.

[2]Iniciação Científica

MATERIAL AND METHODS

The specimens were collected in Rio Claro, state of São Paulo, Brazil by M. Zirondi in October, 1998. The individuals were maintained at room temperature in a terrarium containing periodically humidified earth substratum, decomposing organic matter, leaves and wood chips. The terrarium was mixed every two days, with the intention of avoiding substantial interference in the natural habitat. The different stages were photographed under a Zeiss stereomicroscope.

RESULTS

The pair of *Plusioporus setiger* were brought to captivity while copulating. During a one month period, copulation was observed about five times. The duration of the copulation was variable, being on average three hours.

After 15 (±2) days, the first oviposition was observed. The female placed the eggs in a depression in the substratum, covering them with earth. About 60 eggs were laid, each one covered by an ootheca (Fig. 1A) that was elaborated using earth from the substratum and material originating from the anal valves. A second oviposition was observed 15 (±2) days after the first, with about 40 eggs. From this oviposition, most of the eggs did not develop. Many of them were observed hardened and covered by fungus inside the ootheca (arrow Fig. 2A); others were placed on the substratum without an ootheca or any protection, and these dried up quickly. Oothecae were not observed without eggs.

During the period of copulation and laying of eggs, the female remained most of the time buried in the substratum.

The development was observed in eggs from the first oviposition.

After 15 (±2) days, rudiments of the antennae (arrow in Fig. 1B) and of the pairs of legs (arrow heads in Fig. 1B) were observed. After 21 (±2) days the head was already better defined, presenting the pair of antennae, covered by little bristles, and also, the formation of an ocellar spot. In this phase of development the definition of the posterior region and a better visualization of the segments occurs (Fig. 1C). Most of the individuals died during this period (Fig. 2B).

The individuals continued their development inside the ootheca (Fig. 3A) reaching the juvenile I stage (Figs. 3B, C). These are pale, and only acquire some pigmentation in the anterior region, as their development proceeds (Fig. 3C). This stage presents three pairs of legs, one defined ocellus and seven well-defined segments (arrows, Fig. 3C). The antennae show six articles no covered with bristles (Fig. 8).

The first molt (Fig. 3D) was fast; a period of 9(±2) days was observed between juvenile I and the appearance of juvenile II.

Juvenile II presents 22 segments, of which the colum and the first 14 segments are well-defined (Fig. 4A). The articles of antennae during development become thiner and very similar to those of the adults, covered by several bristles.

Three pairs of repugnatory glands were observed at this stage (Fig. 4C), as well 3 ocelli, that is, a new row with 2 ocelli had been added.

Juvenile II possesses one pair of legs in the first three segments, which adds up to three pairs. From the fifth to the seventh segments, there are two pairs of legs per segment. The fourth segment, and those following the seventh segment are apodous (Fig. 4B).

After 23 (±2) days the second molt occurred. We verified that the animal left the exuviae by its ventral portion (Fig. 5A). Juvenile III (arrows Fig. 5B)is very similar to the adult (Fig. 5B), even in coloration. It presents 6 ocelli, that is to say, another row with 3 ocelli had been added.

Juvenile III presents 21 well-defined segments and a growth zone in the posterior region, where the segments are less evident (arrows, Fig. 5B). All the newly added segments present two pairs of legs each, except for the growth zone. At this stage, 17 new repugnatory glands are added (arrows Fig. 5B); they are pale in coloration and several have an undefined morphology.

After 10 (±2) days the third molt, occurred (Fig. 6A) juvenile IV, it has 35 (±1) segments, of which 28 are very characteristic and the remaining ones, make up a growth zone in the posterior area. The latter do not possess legs nor repugnatory glands. Soon after the molt, 17 pairs of darker repugnatory glands and 5 paler ones were observed (arrows in Fig. 6B). By the end of this stage, 2 more glands were added, totaling 24 at the end of juvenile IV (Fig. 6A). A new row of 4 ocelli was added.

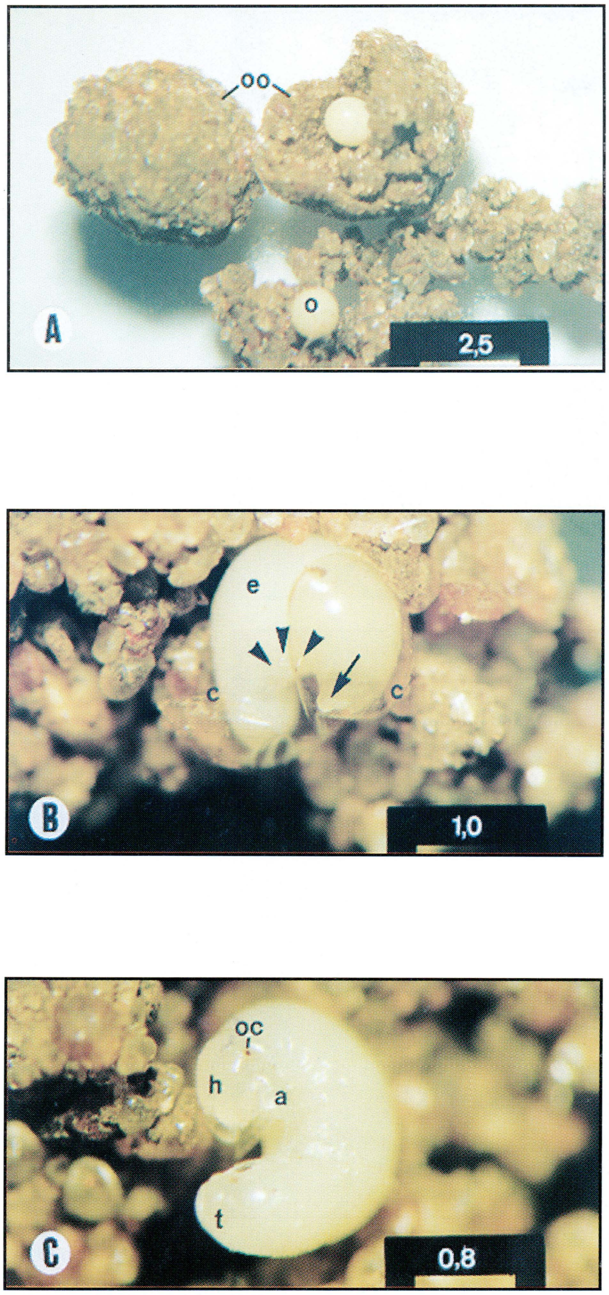


Fig. 1 - Initial development of *Plusioporus setiger*. A. eggs; B. specimen emerging; C. specimen outside of the corium. a=antenna; c=chorion; h=head; e=embryo; o=egg; oc=ocellus oo=ootheca; t=telson; arrow=rudiment of antenna; arrow heads=rudiments of legs. Scales in mm.

In juvenile V (Fig. 7A) 6 new pairs of repugnatory glands were observed (arrows in Fig. 7B) and a new row with 5 ocelli. Soon after the molt, 34 (±1) segments could be counted, besides the telson and the growth zone, which is very evident in recently molted individuals.

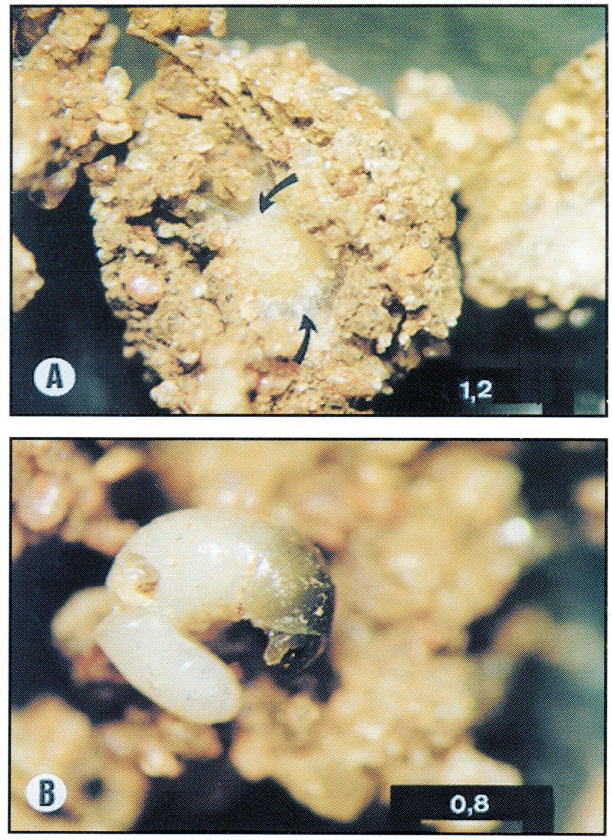


Fig. 2 - Initial development of *Plusioporus setiger*. A. unviable egg, covered by fungus (arrows); B. dead individual. Scales in mm.

The sequence of emergence of the rows of ocelli is shown in Figure 8.

DISCUSSION

The construction of oothecae has been observed in several species of millipedes by various authors (NGUYEN DUY-JACQUEMIN, 1992; BERCOVITZ & WARBURG, 1985; CRAWFORD et al., 1987; AOUTI, 1980; JUBERTHIE-JUPEAU, 1967).

AOUTI (1980) described the construction of oothecae in *Pachybolus laminatus* COOK and JUBERTHIE-JUPEAU (1967) observed the same in several species of *Glomeris*. The description of the way in which the oothecae are built is very similar in both studies. According to the authors, the oothecae are formed by agglutinated earth, most of which comes from the animal's own digestion.

DEMANGE (1972) described the ootheca of *Pachybolus ligulatus* (Voges) as being formed by plant remains that travel through the digestive system and are cemented by intestinal mucus.

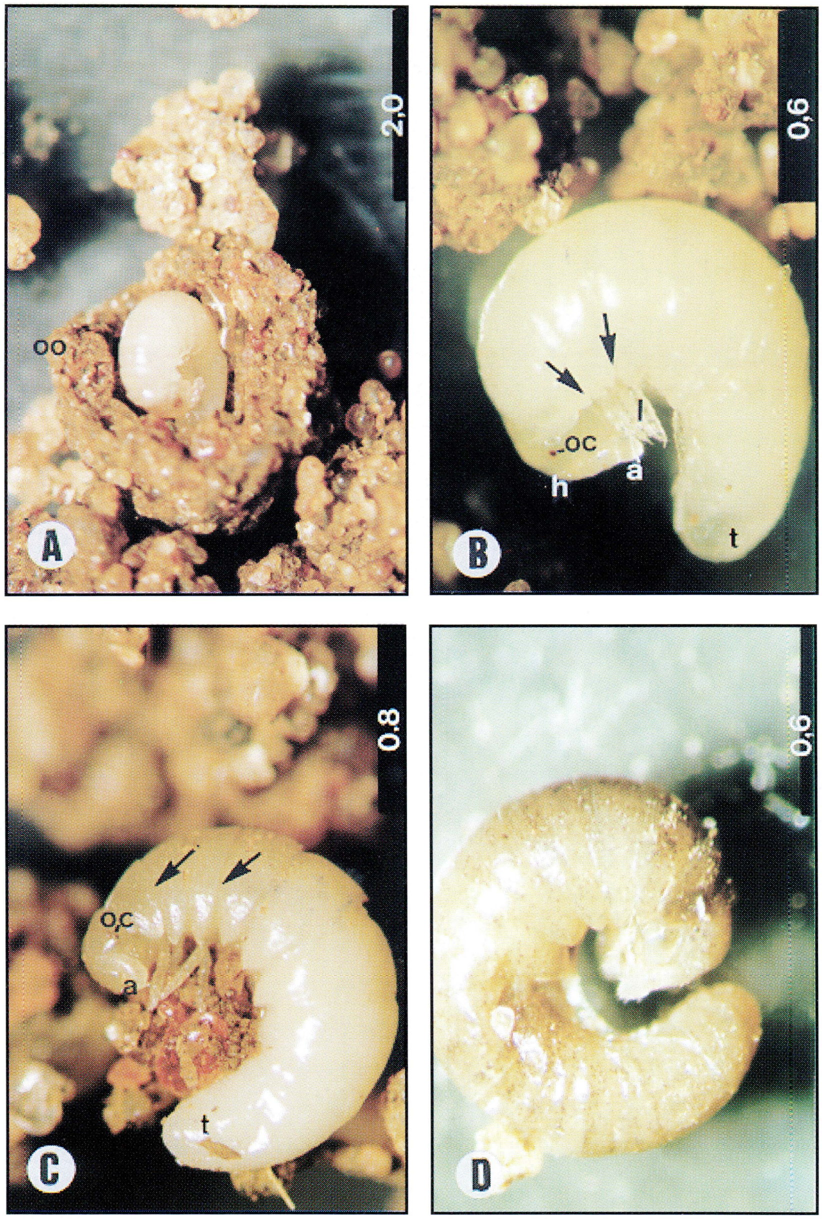


Fig. 3A-D - Juvenile I of *Plusioporus setiger*. A. in the ootheca; B and C. specimens outside ootheca; D. specimen in molting process. a=antenna; h=head; oc=ocellus; oo=ootheca; l=legs; t=telson; arrows=limits among segments. Scales in mm.

In the present study, we observed that the ootheca contained the same characteristics as the substratum in which the animals were kept, with no indication of plant remains although the female had eaten leaves; however, no further analysis was accomplished to discover the true composition of the ootheca, besides the observed earth particles.

In the species *Plusioporus setiger*, the laying of eggs, that is, the construction of a nest, occurred twice. David & Celerier (1993) verified an average of 3 to 4 ovipositions for *Polydesmus angustus* Latzel (Polydesmidae) and Snider (1981), studying *Polydesmus inconstans* Latzel, found an average of 10 nests. Contrary to these authors' findings, others have described polidesmid millipedes as laying eggs in only one nest or, exceptionally two (David, 1992; Banerjee, 1973; Stephenson, 1961). In the spirostreptids, no speculation can be made since no other species belonging to this group has been studied under this aspect.

The first active stage of *P. setiger*, that is, the one

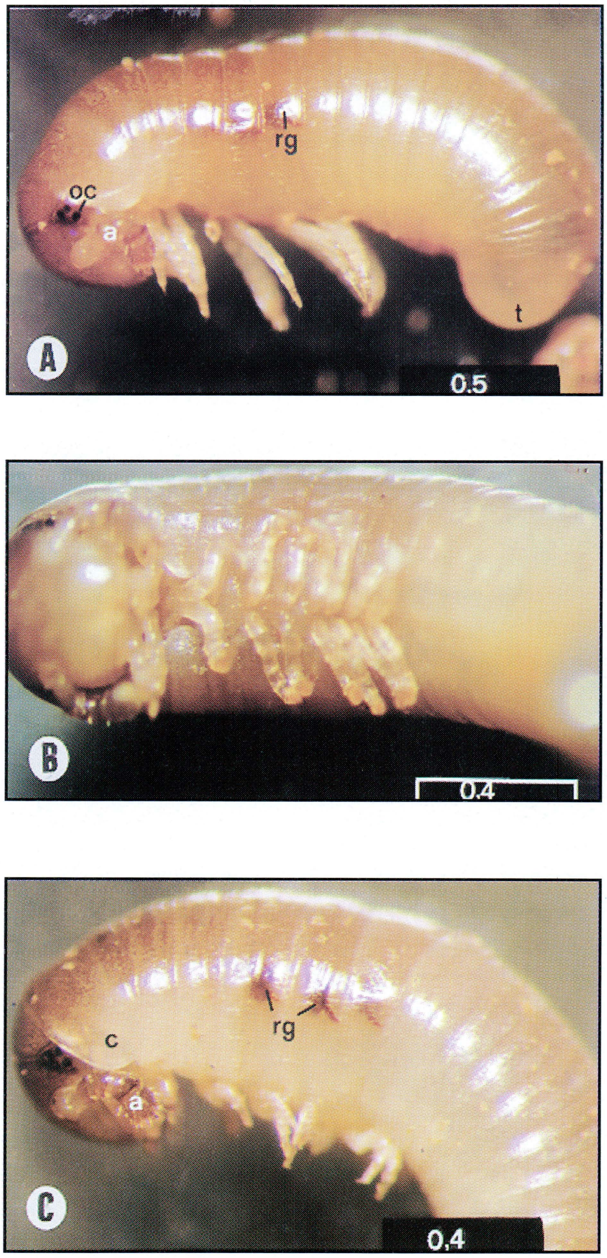


Fig. 4A-C - Juvenile II of *Plusioporus setiger*.
a=antenna; c=colo; rg=repugnatory glands; oc=ocelli. Scales in mm.

that breaks the ootheca and continues its development in the terrarium, was juvenile II. According to data in the literature, the identification of the first active stage depends on the species. In *Polydesmus inconstans* (Polydesmidae) it is the first stage (SNIDER, 1981), while in the spirobolids *Pachybolus ligulatus* (Voges) and *Narceus annulares* (Keeton), it is stage III (SHAW, 1966; DEMANGE & GASC, 1972). Independently from the stage at which the individuals leave the nest, a general principle seems to be that the young millipedes only begin to eat after they molt to stage III. Stages I and II therefore only feed on vitellus during the beginning of development (HOPKIN & READ, 1992).

Millipedes pass through several molts during their life. Molting time is frequently synchronized with

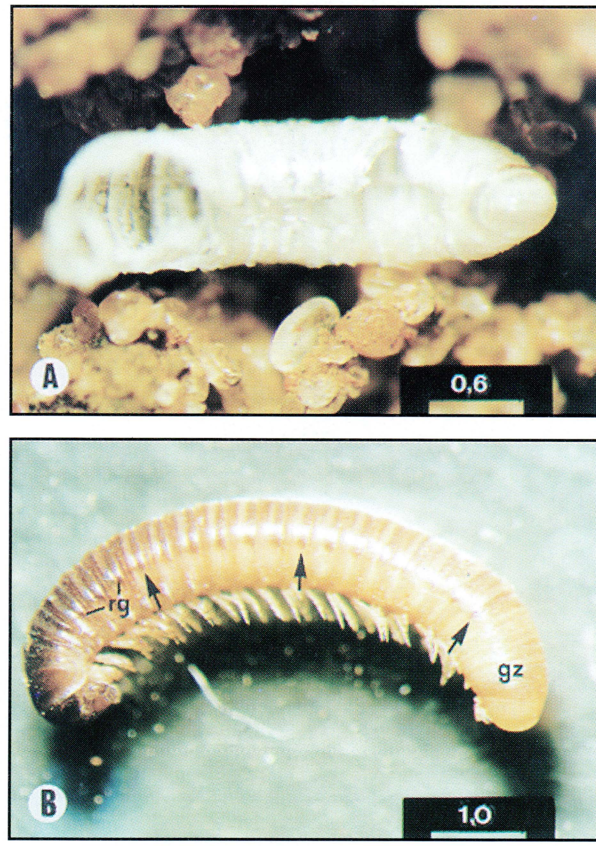
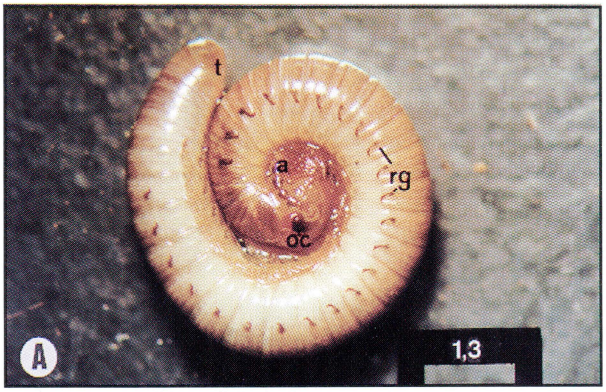


Fig. 5 - Exuviae of juvenile II (A) and specimen of juvenile III (B) of *Plusioporus setiger*.
rg=repugnatory glands; gz=growth zone; arrows in B=repugnatory glands added during the molt. Scales in mm.

climatic conditions, especially in older animals. Individually, the control is hormonal but the identification of such hormones and the site of their production has not yet been determined (HOPKIN & READ, 1992).

Like other arthropods, the millipedes become vulnerable during molting. Some build molting chambers (MILEY, 1927; CRAWFORD et al., 1987; FONTANETTI, 1989), others make a depression in the soil or even use existent structures, for example capsules of seeds (SNIDER, 1981). During the initial stages of development, *P. setiger* does not use any type of shelter for molting; some individuals were observed buried, others on the substratum without any protection and several were found beneath leaves.

The acquisition of the segments in *P. setiger* coincides with the number of acquisitions of



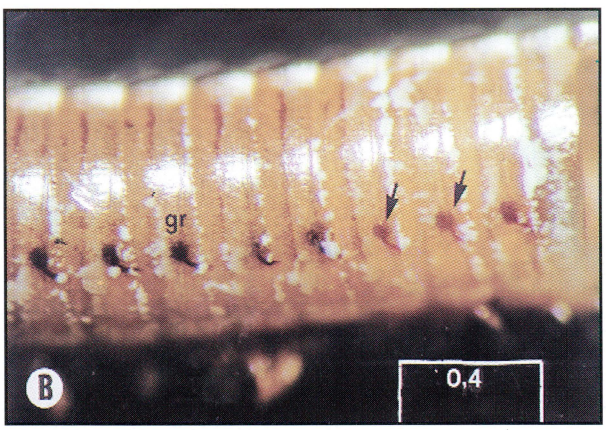


Fig. 6A-B - Juveniles IV of *Plusioporus setiger*. a=antenna; rg=repugnatory glands; oc=ocellus; t=telson; arrows=glands added during this stage. Scales in mm.

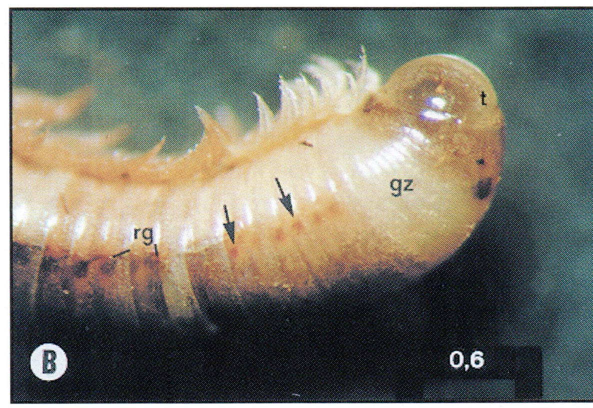


Fig. 7A-B - Juvenile V of *Plusioporus setiger*. rg=repugnatory glands; t=telson; gz=growth zone; arrows=repugnatory glands added during this stage.

repugnatory gland pairs, the segments endowed with two pairs of legs each. The segments that constitute the growth zone do not possess legs and are not always well defined. The arrangement of the segments of *P. setiger* follows, since the beginning of development, the formula found in the adult spirostreptids, that is, the first segment or column longer than the others and possessing a pair of legs, the second and third segments with one pair of legs and the fourth segment, apodous (Demange, 1967). The emergence of the repugnatory glands also follows the same pattern, beginning in the fifth segment as observed in the adult.

The number of ocelli additions in *P. setiger* coincides with the stage at which it occurs, that is, juvenile I contains one ocellus, juvenile II acquires another two, and so forth until V, which was the last stage observed in the present study. This sequence was also observed in the spirobolid *Anadenobolus leucostigma martinicensis* (Chamberlin) (Nguyen Duy-Jacquemin, 1992), but in another analyzed species the emergence of the ocelli can be very varied (Hopkin & Read, 1992).

The millipedes present an anamorphic development, that is, at every molt, new segments and pairs of legs are added to the animal (Demange, 1981; Enghoff et al., 1993). They present a region composed of apodous segments in the posterior portion, before the telson, called the growth zone, which develops new segments and new pairs of legs at every molt.

According to Enghoff et al. (1993), in some groups the maximum number of segments is reached

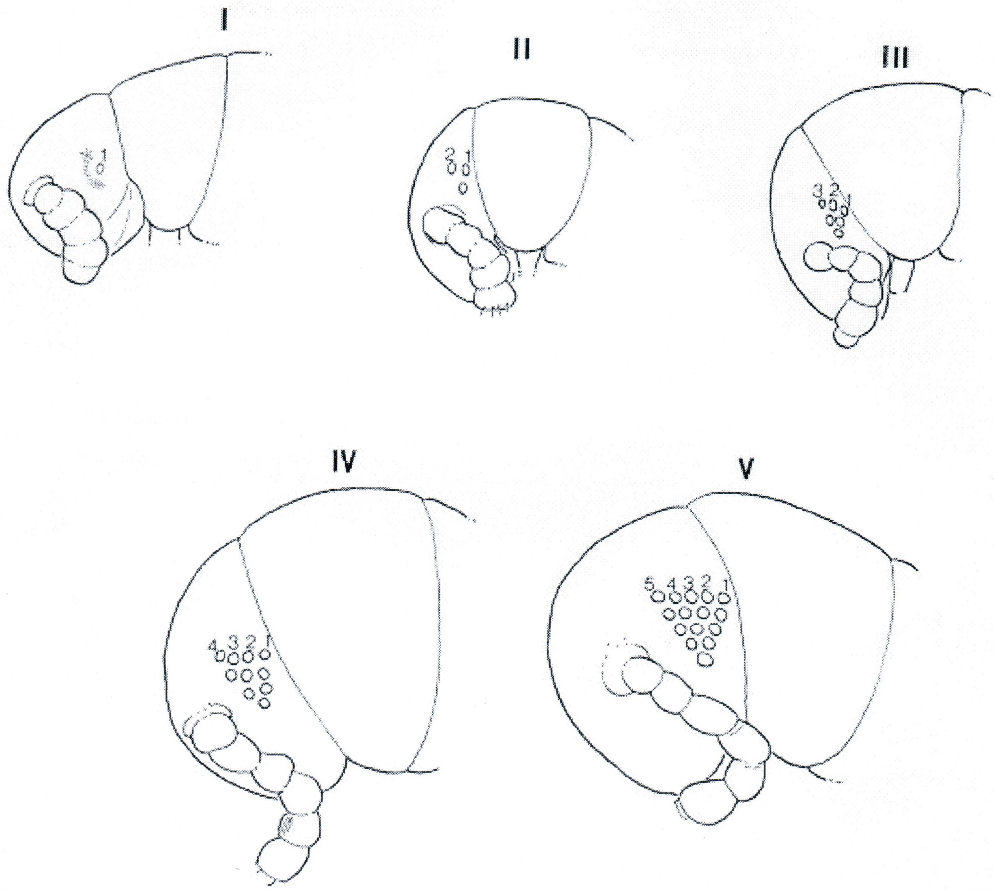


Fig. 8 - Outline of the ocelli addition at the different stages.
I, II, III, IV, V = stages; 1, 2, 3, 4, 5 = sequence of emergence of the rows of ocelli.

According to Enghoff et al. (1993), in some groups the maximum number of segments is reached at a certain stage. At later stages, although they increase in size, new segments are not added; this type of development is called hemianamorphosis and it can be found in some Juliformia. The suborder Spirostreptidea, to which *Plusioporus setiger* belongs, is included among these.

Further observations should be accomplished in subsequent stages of this species, since the knowledge of its biology can aid in the control of its populational expansion observed in coffee plantations of the state of Minas Gerais.

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