Aspisoma lineatum (Gyllenhal) (Coleoptera: Lampyridae) Firefly: Description of the Immatures, Biological, and Ecological Aspects
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Abstract

Aspisoma lineatum (Gyllenhal) is a common firefly in the Southeastern region of Brazil. Adults and larvae were collected in the municipality of Campinas, state of São Paulo, Brazil, and the immature stages were described and reared in the laboratory. Four generations were reproduced in the laboratory, and a method for its rearing was established. The life cycle usually lasts 6 months, but under optimal laboratory conditions, it lasted from 2 to 4 months. Larvae were fed with Bradybaena similaris and Bulimulus tenuissimus snails since the beginning of the larval stage. This species was found to be easily adapted to environments under anthropic influence, such as urban areas and farms.

Introduction

The family Lampyridae includes about 100 genera and 2,000 species which are distributed throughout the world. The richest biodiversity is found in the Neotropical region. In Brazil, there are 350 described species, which represent about 20% of the world biodiversity (Costa et al 1988, Viviani 2001). The subfamily Lampyrinae comprises the tribes Lampyriini, Pleotomini, Photinini, Cratomorphini, Lampicrocerini, and Amydetini, with the last three occurring only in the Neotropical region (McDermott 1964).

Despite the richness, very few recent studies were done on the biology and description of the Neotropical species of Lampyridae, but the immature stages of Aspisoma spp., Cratomorphus sp., Bicellonycha sp. (Costa et al 1988, Viviani 1989), and Photuris fulvipes Blanchard (Rosa 2007) have been described. Aspects of the biology and ecology of several species occurring in the Southeastern region, including the common species Aspisoma lineatum (Gyllenhal) and an undescribed species of Aspisoma (Viviani 1989, 2001) have also been recorded.

Material and Methods

Collecting sites and field observations

Adults and larvae of Aspisoma lineatum were collected during the late evening and first hours during the night in the following localities: (1) Fazenda Santana (22°53′38.67″ S; 46°58′15.87″ W; 650 m asl; Sousas, Campinas, Sao Paulo); (2) Campus Bela Vista of the Universidade Estadual de São Paulo (22°23′40.68″ S; 47°32′34.23″ W; UNESP, Rio Claro, Sao Paulo); (3) Rodovia Washington Luis (22°29′32.50″ S; 47°25′54.06″ W; Limeira, Sao Paulo); (4) Campus...
Sorocaba of the Universidade Federal de São Carlos (23°34'53" S 47°31'28" W, 666 m asl, Sorocaba, Sao Paulo). Larvae and adults were collected on the grass, in flight or over the grass, respectively.

Laboratory rearing

Field-collected larvae were reared in small glass terraria (10×20×12 cm) constituted by the original soil from their habitat and some grasses. They were periodically fed with the land snails Bradybaena similaris and Bulimus tenuissimus. Adults were reared in small plastic boxes with wet absorbing paper and fed with saturated sugar juice or honey juice. After oviposition, the eggs laid on the absorbing paper were transferred to Petri dishes and incubated at room temperature (20–24°C) until their hatching. Newly hatched larvae were kept on wet paper during 14 days and fed with dead snails or newly born B. similaris live snails. Then, larvae were transferred to small plastic jars containing soil and some grass, and fed with young snails and reared. Some of the larvae obtained were isolated into Petri dishes and fed B. similaris snails until they reached the adult stage. Newly emerged adults were then transferred to small plastic jars lined with paper towel, fed with honey solution, and allowed to mate.

Results and Discussion

Morphological description

Eggs and the first four instars

Eggs: 0.7–1.0 mm, spherical and pale yellow, with smooth surface in light microscopy, but with microscopic circular depressions visible in SEM images (Fig 1a). The first instar is similar to the mature larva, but differs by the apical region of antennae, in which the sensorial appendix and the antennomere III appear to be fused to the antennomere II (Fig 1c); a nasale is present (Fig 1b) but is narrower than that of the mature larva. The channel opening of mandibleus is long, the segment I of the labial palpi lacks the lateral process, and the galea possesses one or two long setae (Fig 1d). The lateral setae of tergum IX are relatively longer and wider than those of mature larva (Fig 1e). Larvae of the instars 2–4 are more similar to the mature larva. Their antennal sensilla and lateral process of the labial palpi are as developed as those of the mature larva when compared at light microscopy.

Fifth instar: Total length (without head) is 21–24 mm, ca. 4.3 times longer than wide; fusiform, flattened dorsoventrally (Figs 2b, 3a), prognathous head, completely retractile within prothorax. Thoracic and abdominal tergites 1–8 divided longitudinally by the white exuvial line. Dorsal integument densely punctate in a reticulated pattern, each puncture with a microscopic scale (Fig 5a); with four pairs of longitudinal strips (Figs 2b, c), one outer pair of yellow lateral strip followed inwards by: a brown sublateral strip, a submedian yellow strip, and a thinner median brown strip. Ventral surface yellowish, glabrous, thoracic sternites with several lateral brown sclerotizations; one to five abdominal sternites with a sublateral pair of elongate and narrow brown sclerotization; one to seven abdominal epipleura with a longitudinal brown strip.

Head (Figs 4a, 5b): ca. 1.3 times longer than wide (measured from base to nasale), dorsal surface scarcely pilose, one stemma situated basally to the antennifer; membranous cervical area 1.7 times longer than head with two elongate and punctate sclerotized areas dorsally. Frontal arms short, epicranial stem reaching half of the head length; frons with lateral anterior lobes rounded; nasale partially membranous with anterior margin densely pilose. Antennifer large, membranous. Antennae (Figs 4b, c) elongate, with three segments—segment I weakly sclerotized with fine short setae posteriorly and stout long setae anteriorly; segment II sclerotized, with one stout long seta apically, apex of segment II (Figs 5c, d) with a ventral, large, and globular sensorial appendix; segment III minute, dorsally situated on the apex of the segment II, bearing short and long spiniform setae. Hypopharynx (Figs 4e, 5e) with anterior lobe triangular, well sclerotized, densely hairy, rectangular base, with two lateral anterior arms and three or four asymmetrical minute depressions (Fig 5f). Epipharynx (Figs 4e, 5g, h) formed by two triangular plates anteriorly clothed with fine and long setae, with parallel ascending mediadly rows of microscopic pores and two orifices on each lateroposterior margin. Mandibles (Figs 4g, h) symmetrical, falcate, with a channel opening near to the apex, with a row of long setae laterally and several shorter setae lateroventrally; mesal margin with retinaculum rectangular and laminate steeply declivous to the curved apex, densely pilose ventrally; penicillum well developed. Maxillae and labium (Fig 4d) with reduced articulation; cardo rounded anteriorly, but acute posteriorly; elongate stipes partially sclerotized with one lateral and one ventral stout long setae, several fine short setae on lateral margins and a dense dorsal tuft of setae anteromedially; maxillary palpi four-segmented, tapering to apex; galea palpiform two-segmented (Fig 5i), with two short spiniform setae, one medium-size seta, and one long stout seta at apex. Labium with prementum sclerotized at base, glabrous; postmentum with apical lobes sclerotized each one bearing one stout seta; labial palpi two-segmented (Fig 5i), palpomere I with a lateral process longer than segment II.

Thorax (Fig 3a): Pronotum subtrapezoidal with posterior and anterior angles rounded. Mesonotum ca. 1.5 times wider than long. Metanotum ca. two times wider than long. Both
Aspisoma lineatum firefly

Fig 1 Aspisoma lineatum, egg, and first instar larva. a Egg—detail of the chorion surface; b anterior head and antenna; c antennomere III and sensorial appendix (dorsal); d apical region of hypostoma and mandible; e abdominal segment X.

Fig 2 Aspisoma lineatum firefly. a Pupa; b larva; c–d, pre-pupae; e mating adults.

Fig 3 Aspisoma lineatum. a Fifth instar larva (dorsal), b dorsal, and c ventral views of a pupa.

rectangular, with lateral margins rounded. Mesepipleuron with a functional biforous spiracle (Fig 4f). Ventral surface glabrous, pale yellowish, with small lateral sclerotized areas. Legs (Fig 4i) cylindrical, densely pilose, dorsal, and lateral surfaces with fine and short setae, trochanter, and femur with a few stout setae ventrally, tibia with two parallel rows of stout setae ventrally; tarsungulus with one stout setae (Fig 5l) in each side longer than the tarsungulus.

Abdomen (Fig 3a): tapering to apex, with nine dorsally visible segments. Epipleura I–VIII with functional biforous spiracles situated in a circular sclerotized area (Figs 2d and 5k) and adjacent to a small black spot corresponding to the ecdysial scar (Fig 5j). Terga subrectangular, I–VI about 3.0 times wider than long, VII–VIII 1.5–1.8 times wider than long, IX 2.6–3.0 times wider than long. Posterior angles rounded on terga I–VI and acute on VII–IX, with one stout, short seta on posterior angles of tergum IX (Fig 4j). Bioluminescent organs indistinct. Segment X (Fig 4j) ventrally directed with several tubular and protractible filaments (Fig 2b), partially sclerotized dorsal and ventrally, with three pairs of stout setae ventrally.

Pupae (Figs 2a, 3b, c): Total length 15.0 mm, adecticous, exarate, pigmented in a pattern similar to the larvae. Ventral and dorsal surfaces glabrous. Pronotum subtriangular with posterior angles strongly produced laterally and acute. Metanotum ca. 1.4 times longer than mesonotum. Abdominal terga I–III with posterior angles rounded; IV–VI with hind angles acute and short; VII and IX with hind angles acute and produced.

Material examined
Brazil, São Paulo: Campinas, Fazenda Santana, Distrito de Sousas, Ill. 1989, V. Viviani col., three fifth instars, one first instar, one pupa, six first instars exuviae, six instars exuviae, six third instars exuviae, and six fourth instars exuviae (MZSP).

Taxonomic remarks
The mature larvae of Aspisoma lineatum differ from the
larva of *Aspisoma* sp. described by Costa et al. (1988) mainly in the coloration pattern of the body; the shape of the prothoracic tergum, shorter and not abruptly narrowed anteriorly in *A. lineatum*; in the rounded hind angles of the abdominal terga in *A. lineatum*, while in *Aspisoma* sp., they are acute. The mandibular retinaculum is rectangular in *A. lineatum* and acute in *Aspisoma* sp.

The mature larva of *Aspisoma* sp. described by Viviani (1989) is more similar to the larva of Costa et al. (1988). *Aspisoma lineatum* differs from *Aspisoma* sp. (Viviani 1989) in the coloration pattern of the body, in the shape of the mandibular retinaculum, chaetotaxy, and in the hind angles of abdominal pleurae, which are more rounded in *A. lineatum*.

*Aspisoma lineatum* was compared with lampyrind larvae described by Costa et al. (1988), LaBella and Lloyd (1991), and Rosa (2007). The elongate, fusiform shape of the body is also characteristic of other Cratomorphini species, as those belonging to *Pyraustroma* Melsheimer, *Cratomorphus* Most- schulsky, and *Micronaspis* Green, as well as the Lampyridinae *Lasiochilus caeruleus* Kirsch. These species also share the globular sensorial appendix of antennae (Figs 5c, d), the triangular lobe of the hypopharynx (Figs 4e, 5e), and the pair of stout setae on tarsungulus (Fig 5e). In Photurinae, the sensorial appendix is conical, the hypopharyngeal lobe is bilobed and the tarsungulus setae are thin. The species of *Aspisoma* differ from other species in the first segment of labial palpi with a lateral process longer than segment II (Fig 5i). The epipharynx of *A. lineatum* and *Photuris fulvipes* (Blanchard) seems like a trabecular net, with trabeculae largely fused and small circular holes in *A. lineatum* (Figs 5g, h), while in *P. fulvipes*, the trabeculae are more distinct and the holes are elongate (Fig 21 in Rosa 2007).

**Field observations and laboratory rearing**

**Habitat**

This species of firefly was shown to be very common and abundant in open fields and in a wide variety of habitats including pastures, marshy areas, gardens, and near secondary growths (Viviani 2001). The larvae require arborescent environments where they can find their favorite preys, snails of the exotic species *Bradybaena similis* and *Bulimulus tenuissimus*, although other species of snails and slugs were found to be preyed in laboratory conditions. Several graminaceae (*Brachiaria* spp., *Axonopus* spp., *Cenchrus* spp., *Eragrostis* spp.) and weeds (*Ricinus communis*, *Cyperus*, *Vernonia*, *Solidago chilensis*, *Pterocaule lanatum*) are among the plant species in habitats exploited by *A. lineatum*.

**Larvae** (Fig 2b, c)

Larvae are arboreal and they were found in a variety of plants. Larvae were often found by their luminosity in the rainy period from November through April. Mature larvae were especially abundant in the period from February through April. They were found in medium height plants and during humid and rainy nights on the top of the grass and also over dry bushes. They were found to prey a variety of snails in the field, some of them still unidentified.

**Pupae** (Fig 2a)

Before pupation, larvae fix with the anal papilla to substrates such as leaves, cauli, the plastic walls or the absorbing paper of their containers, and become swollen and inactive. The prepupa lasts in average 6 days and the pupa lasts in average 13 days.

**Adults** (Fig 2e)

The adults were fed with saturated honey solution lived between 30 and 45 days, whereas adults fed with saturated sugar lived for a shorter time.

**Seasonality**

Extensive observation of this species in the region of Campinas shows that the adults appear from August throughout April,
with two major yearly peaks, one usually in March–April and another between August and October, depending on the year. Yearly seasonal variations were observed, and during some years, active adults were found at the end of July and early August. Mature larvae are found between February and April and between September–October.

**Life cycle**

Previously, Viviani (2001) showed that the full cycle of *A. lineatum* in the field can take as long as 6 months. However, since 2003, we started to rear this species in the laboratory and to improve our rearing technique. We successfully reproduced four consecutive generations in the laboratory. The full cycle starting from eggs to adults varied from only 2–6 months under optimal feeding conditions, depending on the period. Below, we describe the life cycle from the independent ovipositions of females I and II, and from four consecutive generations originating from female III.

**Female I**

Female I, which was copulating in the field, was collected on October 26, 2003 (Fig 2e) and laid 48 isolated eggs after 10 days in captivity (Table 1). The first group of eggs hatched after 54 days, the second group after 56 days, and the last one after 61 days, at the end of December.

**Table 1** Life cycle parameters of different springs of *Aspisoma lineatum* firefly reared from egg to adult in the laboratory.

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$^a$Not counted

$^b$Sex proportion—males/females

$^c$N-survival; Females III, IV, and V are from consecutive generations originated from female III oviposition.

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Fig 5 *Aspisoma lineatum* fifth instar larva. a Prothoracic tegument, b nasale, c dorsal, and d ventral view of the antennomere III and sensorial appendix (dorsal, ventral), e–f hypopharynx, g–h epipharynx, i galea and labial palpi, j ecdysial scar, k abdominal spiracle, l tarsungulus.
Among the 48 eggs, only 33 of them hatched (68% viability). The newly hatched larvae grew quickly. However, mortality reached 82% 14 days after. After 3 months, only three larvae survived to maturity. Two of them reached the pupal stage; however, in contrast to field collected larvae that often reach the adult stage, they died after 4 days. We suspect that the larvae got infested with some parasite.

**Female II**

Female II was reared from a larva collected in the field, and copulated in the laboratory. This female laid 33 eggs, from which 22 larvae hatched. The incubation of eggs lasted 23 days, the average of larval stage was 116 days, the pupal stage 13 days, and the adult 56 days, averaging a full life cycle of 234 days.

**Consecutive generations (Female III)**

Four generations could be obtained from a female (female III) that was collected in the field on 06/04/2009. Female III laid 43 eggs, 32 of them hatched (74% viability). Viviani (2001) reported 50% of viability for the same species and an incubation period varying from 32 to 43 days. The incubation of the eggs for this last female lasted 16 days in April. Newly hatched larvae are whitish, but soon after 1 day, they acquire a brownish pigmentation. There were four to six instars. Late instars acquire a characteristic creamy-brownish pigmentation, as described above. Initially, the newly hatched larvae could be fed with dead snails; however, we soon realized that these larvae readily attacked live newly born *B. similis* snails. Several newly hatched larvae were seen preying on a single larger young snail in laboratory conditions. The full life cycle in this period lasted in average 161 days; the larval cycle lasted in average 140 days; the pupal stage lasted 14 days, and the adult stage 49 days (Table 1).

Adults that emerged from this batch of eggs copulated, and a female (IV) laid a second generation of eggs in December of 2009. Noteworthy, the full life cycle during this period was much shorter, lasting only 61 days in average (Table 1). All life stages were shorter in average, with the larval cycle lasting 48 days, the pre-pupa lasting 4 days and the pupal stage 8 days.

The third generation of eggs was obtained in 05/10/2010 from female IV of the previous generation. Although the number of eggs was not counted, 28 larvae were born, and only 5 adults from this generation emerged in November of 2010, taking 6 months to complete their entire development cycle and a fourth generation of eggs was obtained in November of 2010.

Since the life cycle of insects obtained from eggs laid by female I, which were also laid in December, was quite short (120 days), we attribute such short life cycle to the season, with higher average temperature (summer time), which were between 25°C and 26°C, besides the optimal feeding. Fireflies of temperate regions such as *Photuris* spp. have life cycles lasting 1–2 years (McLean et al 1972), whereas tropical species from 6 to 9 months (Kaufmann 1965, Viviani 1989, Rosa 2007). Thus, to our knowledge, this is the shortest reported life cycle under laboratory conditions for a firefly.

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**References**


McDermott FA (1964) The taxonomy of the Lampyridae. Trans Am Entomol Soc (Phila) 90:1–72

McLean M, Buck J, Hanson FE (1972) Culture and larval behavior of photurid fireflies. Am Nat 87:133–145

Rosa SP (2007) Description of *Photuris fulvipes* (Blanchard) immatures (Coleoptera, Lampyridae, Photurinae) and bionomic aspects under laboratory conditions. Rev Bras Entomol 51:125–130
