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RESEARCH ARTICLE

Biology and reproductive traits of *Drymoea veliterna* (Druce, 1885) (Lepidoptera: Geometridae)

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Abstract: Despite the urban and landscape impact caused by *Drymoea veliterna* (Druce, 1885) (Lepidoptera: Geometridae) larvae on trees of the genus *Croton* L. (Euphorbiaceae) in the Neotropics, there is no information about its biology and reproductive traits. In this study, we describe the life cycle and reproductive traits of this species. Its life cycle lasts approximately 56 days, the larvae develop during 24 days on average and the longevity of the females is 7 days on average. Females have an average fecundity of 207 eggs. Regarding their reproductive system, the presence of previtellogenic eggs in the reproductive tract of the females is emphasized. The bursa copulatrix and a highly sclerotized signum is depicted. The number of spermatophores found in the reproductive tract of the females was quantified. Male and female genitalia were schematized.

Key words: Immature stages, life history, fitness components, genital dimorphism, *Croton*.

Introduction

The family Geometridae is distributed worldwide and one of the three most species-rich families of the order Lepidoptera, with approximately 21000 known species (Scoble 1995, 1999). A distinctive autapomorphy is the presence of the ansa, a unique structure to Geometridae, located in the tympanal organ, near to the base of the abdomen (Cook & Scoble 1992; Scoble 1999). Furthermore, maybe the best-known character is the peculiar movement exhibited by the larvae, also called inchworms, as they seem to measure the ground by curving their bodies into loops (Scoble 1999). This behaviour is complemented by lack or

reduction of three pairs of prolegs, A3 to A5 (Sugiura & Yamazaki 2006; Sihvonen *et al.* 2011).

The forty-five percent of the species of this family belong to the largest subfamily Ennominae, which comprises several species that can cause extensive damage to forest and ornamental plants (Scoble 1992, 1999). One third of the moths of this subfamily occurs in the Neotropics (Pitkin 2002) and at least six defoliator species were recently reported from Colombia: *Cargolia arana* (Dognin, 1895); *Chrysomima semilutearia* (Felder & Rogenhofer, 1875); *Drymoea veliterna* (Druce, 1885); *Glena bisulca* Rindge, 1967; *Melanolophia commotaria* (Maassen, 1890) and *Oxydia trychiata* Guenée, 1858 (Vélez Ángel 1974; Bustillo 1976; Scoble 1992; Rodas & Madrigal 1996; Hernández Duran *et al.* 2014).

Drymoea veliterna is a pest of *Croton* L. (Euphorbiaceae), one the most diverse genera of plants in the tropics, with more than 1200 species known worldwide (Govaerts *et al.* 2000). Ornamental native species such as *C. bogotanus* Cuatrec. and *C. funckianus* Müll. Arg. are widely used to restore wildlife corridors and protect watersheds, and are also involved in the restoration of secondary forests, which are considered an important carbon sink (Mahecha Vega *et al.* 2004; Rojas Rodríguez *et al.* 2006; Infante-Betancour *et al.* 2008). These two *Croton* species are especially affected by larvae of *D. veliterna* in Colombia.

Based on literature records and label data, the species is known to occur in Colombia and Ecuador. Druce (1885) described *Nelo veliterna* based on specimens collected by Clarence Buckley and William Chapman Hewitson. Specimens' labels accounted for the following collecting locations: Chiguinda, Morona Santiago province, Ecuador; Intag, Imbabura prov., Ec.; Sarayaku, Pastava prov., Ec.; Fusagasugá, Cundinamarca department, Colombia; Pacho, Cundinamarca dept., Col. and Tolima dept., Col. The male syntypes from Ecuador, deposited in the Natural History Museum, London, U.K., have been revised by Scoble (1999), who established a new combination, *Melanoptilon veliterna*. Pitkin (2002) synonymized the former genera *Melanoptilon* Herrich-Schäffer, 1855; *Nelo* Walker, 1854; *Nelopsis* Warren, 1895 and *Sangala* Walker, 1854 with *Drymoea* Walker, 1854, and so transferring this species to the latter genus.

Little is known about the biology and reproductive aspects of *D. veliterna*. Recently, Hernández Duran *et al.* (2014) indicated that the females of this species present polyandry, a mating system in which they mate with more than one male per breeding season. Taking into account that this species is considered a forest pest, a polyandrous mating system can have significant effects on population ecological factors. In addition to the previously established ecological and behavioural variables that determine the fitness of *D. veliterna* (Hernandez Duran *et al.* 2014), this research provides valuable information about the biology and population control of this species.

In this study, the life cycle of *D. veliterna* and the internal and external genitalia of males and females are illustrated, along with some population attributes related to reproduction aspects such as: male and female longevity, fecundity and female fertility.

Material and methods

Rearing

Pupae and adults (30 males and 30 females) of *D. veliterna* were collected on heavily infested *Croton* spp. trees in Bogotá, Colombia. The breeding was performed in the entomology laboratory at the Centro de Bio-Sistemas of the Jorge Tadeo Lozano University, Chia, Colombia. The larvae were reared at average room temperature of 23.5 ± 2.0°C and

relative humidity of 60%. Leaves of *Croton* species were provided both as food for the larvae and oviposition substrates for the caged imagines, which were fed with pollen and a 10% honey mixture.

A sample of 40 larvae was selected from the present rearing to determinate the duration of the larval instars. The larvae were transferred to net sleeves, approximately 30 cm long and 15 cm wide, each containing four larvae and a branch of the food plant. The different stages were distinguished by counting the number of exuviae and cephalic capsules collected in the rearing sleeves. Daily observations were made in order to record the cephalic capsule width and larvae length.

Longevity

The longevity of the adults was assessed by recording the survival time of each individual imago. The collected data allowed to obtain a total mean longevity, calculated as the timespan from egg hatching to imago's death.

Fecundity and fertility

Fecundity, defined as the average number of eggs laid by a female in its reproductive life span, was determined by counts of the eggs laid on *Croton* spp. by the female imagines. Fertility was determined by counting the number of hatched eggs. In either case, 30 females served as a sample for this study.

Preparation of genitalia

Dissections of newly emerged females were performed to describe their reproductive system, following the method proposed by Chapman (2013). Male genitalia was prepared, adhering to the technique described by Leston (1953), by clearing the abdomen with KOH (10%), then dehydrated in glacial acetic acid and dissected. The genitalia were then stored in microvials of alcohol. Dissections and slide preparations were achieved using a Nikon AW100 camera and a KOZO Stereo Microscope.

Results

Descriptions

Eggs (Figs 1A–B). Average 0.8 mm long and 0.6 mm wide, ovoid-shaped. Size corresponds to that of individual females, and is found within the range observed by Peterson (1962) for other species of Geometridae. Deposited in single-layered clusters of 50 to 70 eggs. Freshly deposited eggs are greenish and turn brown a few days after oviposition. The unfertilized eggs can be easily recognized as they remain greenish with a reddish brown patch and soon begin flattening. It was possible to see through the eggshell during the last 48 hours before the hatching of the larvae. Eggs hatched in 8 to 12 days (Table 1).

First instar (Fig. 1C). Head: black. Body: bright green with white setae. The freshly hatched larvae start feeding on their own egg shell. Length: average 7.3 mm. Duration: average 8 days (Table 1).

Second instar (Fig. 1D). Head: black. Body: green with a dorsal black line, edged with white spots; white spiracular line, paralleled by a brown lateral line dorsally and a bright yellow line beneath. Length: average: 10.5 mm. Duration: average 3 days (Table 1).

Table 1. *Drymoea veliterna*: duration of life stages, cephalic capsules width and length of larvae at different instars. *N* = number of observations, *SD* = standard deviation.

Stage	*N*	Duration Mean (days) ± *SD*	Cephalic capsule width Mean (mm) ± *SD*	Larva length Mean (mm) ± *SD*
Egg	40	10 ± 2.0		
Instar				
L1	29	8 ± 1.3	0.50 ± 0.01	7.3 ± 0.92
L2	23	3 ± 1.0	0.80 ± 0.03	10.5 ± 0.83
L3	21	1.9 ± 0.55	1.00 ± 0.09	15 ± 1.2
L4	20	5 ± 2.1	1.20 ± 0.04	20 ± 2.6
L5	20	4 ± 1.8	1.50 ± 0.06	26 ± 2.9
Prepupa	20	2.2 ± 0.92		
Pupa	19	17 ± 1.2		
Imago	19	5 ± 1.4		
Total mean longevity:		56.1		

Third instar (Fig. 1D). Head: black with several dark spots. Body: green, similar to the previous instar and with a broader yellow lateral line. Length: average 15 mm. Duration: average 1.9 days (Table 1).

Fourth instar (Fig. 1D). Head: black with several dark spots, with a bluish spot in the centre. Body: brown with a dorsal black line, black spiracles, white subspiracular line and a subtle dark brown lateral superspiracular line. Length: average 20 mm. Duration: average 5 days (Table 1).

Fifth instar (Fig. 1D). Head: turquoise, with scattered black spots and distinct white spots on the fronto-clypeus. Body: green without dorsal lines, black spiracles surrounded by yellow spots and a white subspiracular line with a black lateral line above and a brown line beneath. Length: average 26 mm. Duration: average 4 days (Table 1). Prepupae (Fig. 1F) last average 2 days before pupating.

Pupae (Fig. 1G). The obtecta pupa (Johnson & Triplehorn, 2005) is green when recently formed and turns brown as soon as the sclerotization of the cuticle is complete. This process occurs within a few days. Clusters of wild pupae can be found on the tree trunks. The average pupa is 1.1 cm long and the cremaster is strongly sclerotized and bifurcated posterad. Duration: average 17 days (Table 1).

Adult sexual dimorphism (Figs 1H–I). Both sexes show the same wing pattern, with an orange triangular spot on the forewings. The male can be distinguished by the bipectinate antennae, while the female's antennae are filiform (Forbes, 1925). Females have a larger abdomen than males, but both sexes have the same wingspans measuring 1.2 cm on avarage. The abdomen is bigger in females, accommodating the eggs.

Behaviour

Gregarious at all instars, the larvae have typical appearance and movement of inchworms (Fig. 1E). Both larvae and adults are active during the day. We have not observed the adults in the wild know which flowers they take nectar from.

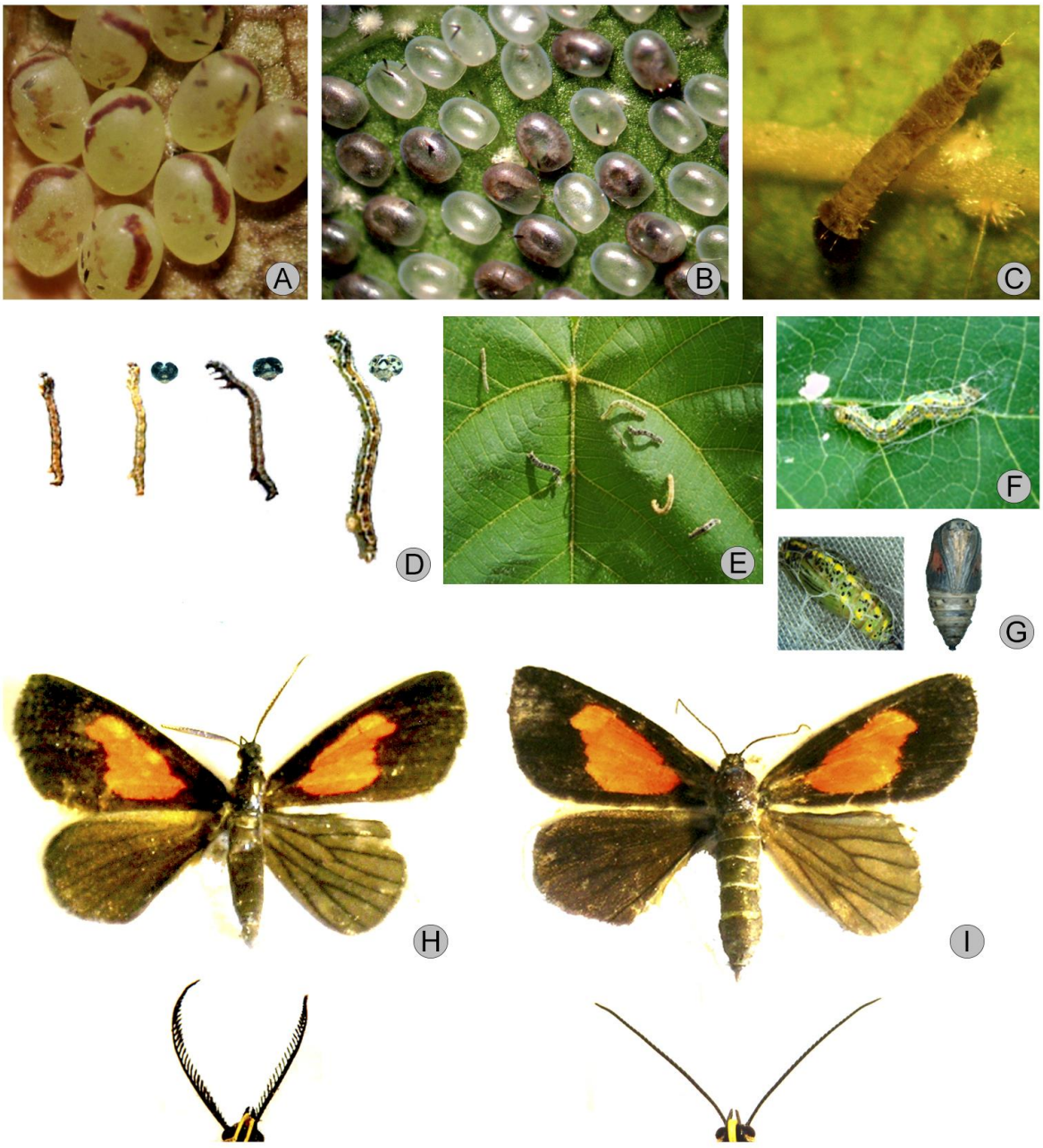

Figure 1. *Drymoea veliterna* life cycle. **A,** freshly deposited eggs; **B,** eggs hatching; **C,** first instar larva (L1); **D,** second through fifth instar larvae, left to right L2, L3, L4, L5; **E,** larvae of various instars on host leaf; **F,** pre-pupa; **G,** left, dorsolateral view of fresh pupa; right ventral view of pupa just before emergence; **H,** adult male with enlargement below showing bipectinate antennae; **I,** adult female with enlargement below showing filiform antennae.

Longevity

The females live longer than males. The average life of a female can last as much as 7 days while the males one last 5 days. The pairing last three hours on average and then the females start the oviposition process within a few hours on the underside of leaves of *Croton* spp. The

sex proportion for the laboratory-reared population of *D. veliterna* was of 2 females for every male (2:1). The total mean longevity was of 56.1 days from egg hatching to imago's death.

Fecundity

The estimated number of eggs laid per female of *D. veliterna*, in laboratory conditions, was between 200 and 320 eggs on average. Wild females can lay between 180 and 250 eggs on average, over the course of several oviposition events. In the present study, the average number of eggs laid, calculated from a population of 30 females, was 207 eggs and the number of eggs laid per oviposition event was between 15 and 120 eggs.

Fertility

On average, 40.4% of the larvae hatched from the oviposition of 15 females from the experimental group, with an average of 95.5 eggs laid.

Female genitalia

The female external and internal genitalia were examined (Figs 2D–E). The number of ovarioles per ovary is approximately 150-200 and occupy most of the abdominal cavity. The oocites are previtellogenic. The bursa copulatrix was examined and the spermatophores transferred by the male were observed. Up to five spermatophores per bursa could be observed. Located on the inner wall of the bursa, the signum (Fig. 2F) with five sclerotized tips, is an important structure that helps break the spermatophores. According to Cordero (1995) signa act during and after the copula, and can affect the male sperm selection.

Male genitalia

The male external and internal genitalia were examined (Figs 2A–C). The structure of the claspers (or valvae) are characteristic of Ennominae moths. The aedeagus doesn't show any structure for the sperm removal from the female reproductive system: cornuti are absent so the spermatorphore is broken only by the signum and perhaps contractions of the abdomen. The spermatophores transferred to the bursa copulatrix were depicted (Fig. 2G).

Discussion

Infested trees yielded up to about five *D. veliterna* larvae. Larvae were usually observed on the underside of *C. bogotanus* leaves. Similar to other larvae of geometrids pest species, such as *Perixera illepidaria* (Guenée 1858) (Kumar *et al.* 2014), *D. veliterna* larvae are voracious as they feed, leaving behind only the midribs and veins of the leaves. The duration of larval development on such trees is 24 days on average (Table 1).

The colour variation between larvae of different instars (Fig. 1D) is common among geometrids. The behaviour is peculiar, as both larvae and adults are active during the day, compared to most other geometrid species that are mostly active at night (Scoble 1992).

Although *D. veliterna* larvae can defoliate an entire tree, they do not cause the *Croton* spp. trees to die. In contrast, *Pinus patula* Schiede ex Schltdl. & Cham., which is attacked by *C. semilutearia* larvae, eventually dies after the foliage dries (Rodas & Madriñan 1996).

Regarding the adults, the estimated population sex ratio is three females per two males (Hernandez *et al.* 2014). Furthermore, this population is characterized by a polyandrous mating pattern: females mate with more than one male during their lifespan. Female longevity can be affected by the number of matings, and increases when a female mates multiple times. Mating frequency depends on ecological and behavioural variables such as male availability (Wedell *et al.* 2002; Valimaki & Kaitala 2006).

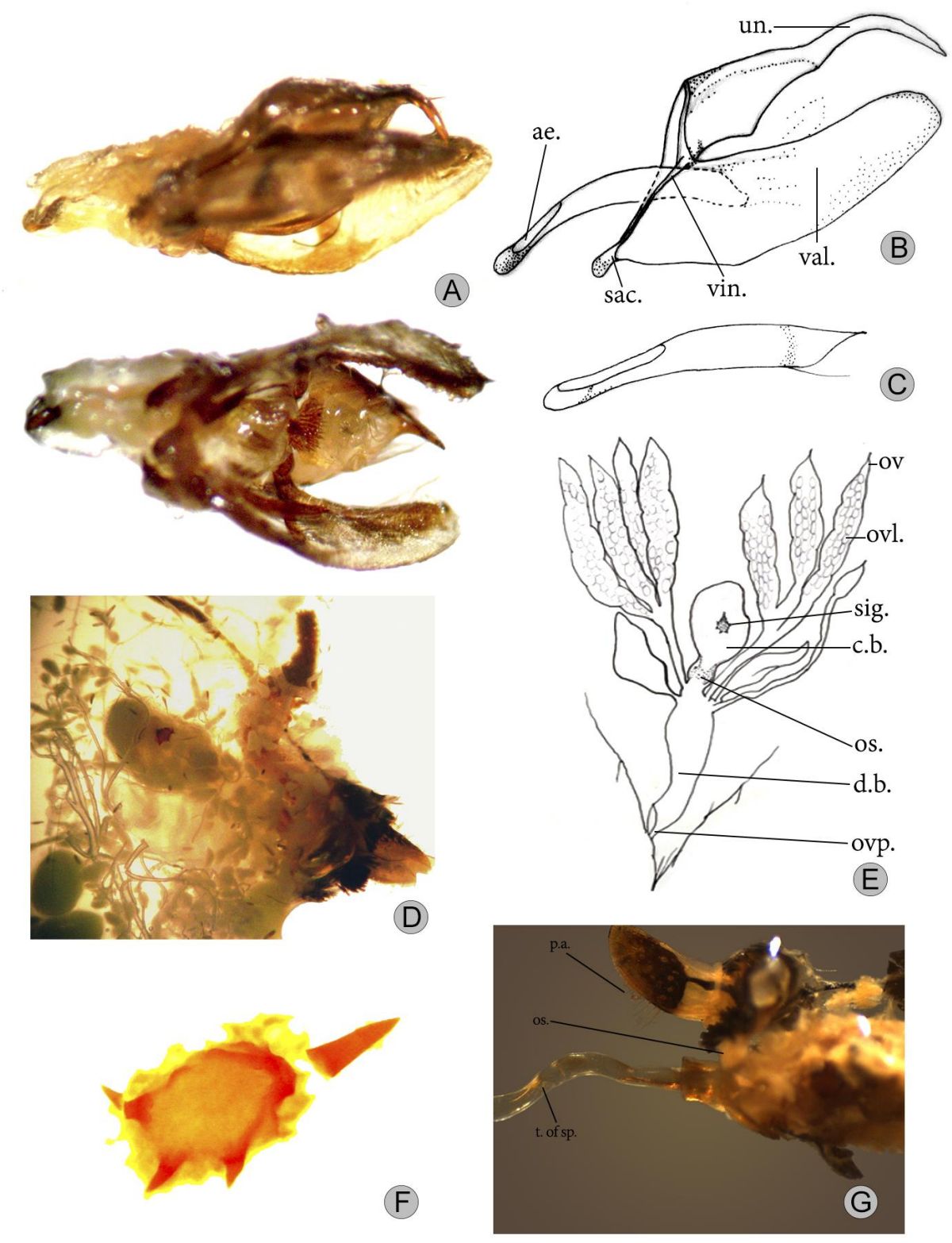

Figure 2. Male and female genitalia of *D. veliterna*. **A,** lateral (above) and dorsal (below) views of male genitalia; **B,** schematic lateral view of male genitalia showing aedeagus (ae.), saccus (sac.), uncus (un.), valva (val.), vinculum (vin.); **C,** ae. drawing of the same specimen; **D,** female genitalia; **E,** schematic representation of female genitalia showing ovaries (ov.), ovarioles (ovl.), corpus bursae (c.b.), and ductus bursae (d.b.); **F,** signum (sig.); **G,** lateral view of female genitalia showing ovipositor (ovp.), papillae anales (p.a.), ostium (os.) and tail of spermatophore (t. of sp.) protruding from d.b.

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References

Bustillo A. E. 1976. Estudio biológico del medidor gigante, *Oxydia trychiata*, plaga de coníferas en Colombia. *Revista Colombiana de Entomología* 2(2): 41–61. (in Spanish)

Chapman R. F. 2013. *The insects: structure and function*. Cambridge University Press, Cambridge, U.K., 929 pp.

Cook M. A. & Scoble M. J. 1992. Tympanal organs of geometrid moths: a review of their morphology, function, and systematic importance. *Systematic Entomology* 17(3): 219–232. DOI: 10.1111/j.1365-3113.1992.tb00334.x

Cordero C. 1995. Ejaculate substances that affect female insect physiology and behavior: honest or arbitrary traits? *Journal of Theoretical Biology* 174: 453–461.

Druce H. 1885. Descriptions of new species of Lepidoptera Heterocera chiefly from South America. *Proceedings of the Zoological Society of London* 1885: 518–536. DOI: 10.1111/j.1469-7998.1885.tb07859.x

Forbes WM. T. M. 1925. Pectinate antennae in the Geometridae. *Psyche* 32:106-112.

Govaerts R., Frodin D. G. & Radcliffe-Smith A. 2000. *World checklist and bibliography of Euphorbiaceae (with Pandaceae)*. Royal Botanic Gardens, Kew, U.K, 4189 pp.

Hernández Duran L. C., Fajardo Medina G. E. & Fuentes Quintero L. S. 2014. Mating opportunities in *Sangalopsis veliterna* females: costs and benefits. *Journal of Insect Science* 14(112): 1–9. DOI: 10.1673/031.014.112

Infante-Betancour J., Jara-Muñoz A. & Rivera-Díaz O. 2008. *Árboles y arbustos más frecuentes de la Universidad Nacional de Colombia sede Bogotá*. Universidad Nacional de Colombia, Bogotá, Colombia, 31 pp. (in Spanish) http://www.docentes.unal.edu.co/oriverad/docs/Arboles_arbustos_UN.pdf

Johnson N. F. & Triplehorn C. A. 2005. *Borror and DeLong's Introduction to the Study of Insects*. Brooks/Cole, Belmont, CA, U.S.A., 888 pp.

Leston D. 1953. A simple method for making stained mounts. *Entomologist* 86(10): 254.

Kumar V., Reddy P. V. R., Anal A. K. D. & Nath V. 2014. Outbreak of the Looper, *Perixera illepidaria* (Lepidoptera: Geometridae) on Litchi, *Litchi chinensis* (Sapindales: Sapindaceae) - A new pest record from India. *Florida Entomologist* 97(1): 22–29. DOI: 10.1653/024.097.0103

Mahecha Vega G. E., Ovalle-Escobar A., Camelo-Salamanca D., Rozo-Fernández A. & Barrero-Barrero D. 2004. *Vegetación del territorio CAR, 450 especies de sus llanuras y montañas*. Corporación Autónoma Regional de Cundinamarca, Bogotá, Colombia, 871 pp. (in Spanish)

Peterson A. 1962. Some eggs of moths among the Geometridae-Lepidoptera. *The Florida Entomologist* 45(3): 109–119. DOI: 10.2307/3492561

Pitkin L. M. 2002. Neotropical ennomine moths: a review of the genera (Lepidoptera: Geometridae). *Zoological Journal of the Linnean Society* 135: 121–401. DOI: 10.1046/j.1096-3642.2002.01200.x

Rodas C. & Madrigal A. 1996. *Chrysomima semilutearia* (Felder y Rohenhofer) (Lep: Geometridae) nuevo defoliador de importancia forestal en Colombia. *Crónica forestal y del medio ambiente* 11(1): 1–7. (in Spanish)

Rojas Rodríguez F., Bermúdez Cruz G. & Quírico Jiménez M. 2006. *Plantas ornamentales del trópico*. Editorial Tecnológica de Costa Rica, Cartago, Costa Rica, 704 pp. (in Spanish)

Scoble M. J. 1992. *The Lepidoptera: form, function and diversity*. Oxford University Press, Oxford, U.K., 404 pp.

Scoble M. J. 1999. *Geometrid moths of the world: A catalogue (Lepidoptera, Geometridae)*. CSIRO Publishing, Collingwood, Australia, 2 vols, 1016 pp + 129 pp.

Scoble M. J., Gaston K. J. & Crook A. 1995. Using taxonomic data to estimate species richness in Geometridae. *Journal of the Lepidopterists' Society* 49(2): 136–147. http://images.peabody.yale.edu/lepsoc/jls/1990s/1995/1995-49(2)136-Scoble.pdf

Sihvonen P., Mutanen M., Kaila L., Brehm G., Hausmann A. & Staude H. S. 2011. Comprehensive molecular sampling yields a robust phylogeny for geometrid moths (Lepidoptera: Geometridae). *PLOS ONE* 6(6): e20356. DOI: 10.1371/journal.pone.0020356

Sugiura S. & Yamazaki K. 2006. The role of silk threads as lifelines for caterpillars: pattern and significance of lifeline-climbing behaviour. *Ecological Entomology* 31(1): 52–57. DOI: 10.1111/j.0307-6946.2006.00755.x

Valimaki P. & Kaitala A. 2006. Does a lack of mating opportunities explain monandry in the green-veined white butterfly (*Pieris napi*)? *Oikos* 115: 110–116.

Vélez Ángel R. 1974. El defoliador del ciprés, *Glena bisulca* Rindge: 1972-73. *Revista Facultad Nacional de Agronomía, Universidad Nacional de Colombia* XXIX(3): 4–63. http://www.revistas.unal.edu.co/index.php/refame/article/download/30272/30432 (in Spanish)

Wedell N., Wiklund C. & Cook P. A. 2002. Monandry and polyandry as alternative lifestyles in a butterfly. *Behavioral Ecology* 13: 450–455.

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