

First record of egg sac predation on a wall crab spider Selenopidae (Araneae) by the wasp *Camera lunavenatrix* sp. n. (Ichneumonidae, Cryptinae)

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Academic editor: M. Shaw | Received 21 January 2016 | Accepted 24 March 2016 | Published 28 April 2016

<http://zoobank.org/D41127B1-BA23-482A-BCCD-AB0D2DA1F147>

Citation: Villanueva-Bonilla GA, Onody HC, Santos BF, Vasconcellos-Neto J (2016) First record of egg sac predation on a wall crab spider Selenopidae (Araneae) by the wasp *Camera lunavenatrix* sp. n. (Ichneumonidae, Cryptinae). Journal of Hymenoptera Research 49: 65–79. doi: 10.3897/JHR.49.7862

Abstract

We report the first record of egg sac predation on the wall crab spider *Selenops cocheleti* by wasps of the genus *Camera* (Ichneumonidae: Cryptinae) with the description of a new species, as well as biological information on the wasp and the spider host. The rearing record and information presented herein are the first biological data for the genus.

Keywords

Egg sac structure, egg predation, Hymenoptera, neotropical

Introduction

Interactions between adult spiders and predatory or parasitoid wasps are a well-known phenomenon. Wasps from the families Crabronidae, Sphecidae and Pompilidae paralyze adult or sub-adult spiders, which are taken as food for the larvae (Hanson and Gauld 2006). The transport of prey items to pre-made nests was hypothesized to be a pre-adaptation for the evolution of social behavior (Evans 1957, Evans and Shimizu 1996); as a consequence, such interactions have sparked much attention. Ichneumonid wasps from the *Polysphincta* group (Wahl and Gauld 1998) are koinobiont ectoparasitoids of various groups of spiders (Sobczak et al. 2012a, 2014, Gonzaga et al. 2015). Likewise, this has drawn much interest due to the phenomenon of host behavioral manipulation (Gonzaga and Sobczak 2011, Takasuka et al. 2015).

On the other hand, predators of spider eggs have received much less attention, particularly in regard to their host-seeking behavior and their influence on the fitness of spiders.

Some groups of wasps are egg parasitoids, including members of the families Encyrtidae, Eulophidae (Hieber 1984, Austin 1985, Schoener et al. 2015) and Platygasteridae (Fitton et al. 1987, Godfray 1994, Stevens and Austin 2007, Bowden and Buddle 2012). In this case, each of these wasp larvae consumes only one egg of the spider host (LaSalle 1990). Other wasp lineages, including members of Eupelmidae, Eulophidae, Eurytomidae, Pteromalidae and Ichneumonidae (e.g. *Gelis festinans*), are known to act as predators in attacking and consuming successive eggs in the sacs (Fitton et al. 1987, Baarlen et al. 1994, 1996, Quicke 2015). In the temperate zone, several genera of Cryptinae (Ichneumonidae) are recorded preying on egg sacs of various groups of spiders, including *Agasthenes*, *Gelis*, *Hidryta*, *Idiolispa*, *Thaumatogelis* and *Trychosis* (Townes 1970, Schwarz and Shaw 1998, 1999, 2000). In the Neotropics, however, relatively few studies are aimed at spider egg predators (e.g. Sobczak et al. 2012b).

Spiders of the species *Selenops cocheleti* Simon 1880 (Araneae: Selenopidae) are sit-and-wait predators occurring on tree trunks, under bark or in crevices of rocks (Corronca 1998, Alayón-García 2005, Valdez-Mondragón 2007). They are skilled hunters with nocturnal habits and fast movements to capture prey and escape from predators. When disturbed, individuals promptly hide in inaccessible places (Crews et al. 2008, Alayón-García 2005), making observational studies rather difficult. As a result, knowledge of the ecological interactions involving these spiders is still sparse. In fact, there are no records of egg predation by wasps upon spiders of the family Selenopidae.

In this study we present information on the egg sac structure of *Selenops cocheleti*, as well as the first record of egg predation by wasps of the genus *Camera* (Ichneumonidae: Cryptinae), with the description of a new species. We also present biological information on the wasp and the spider host.

Methods

Study site

The *Serra do Japi* highlands area is a small mountainous region in southeastern Brazil, located in the west of the Atlantic Plateau in the state of *São Paulo*. This area has an altitudinal variation between 700 m and 1300 m above sea level. Average annual temperatures oscillate between 15.7 °C and 19.2 °C in the higher and lower parts of the highlands. A mesophyll seasonal forest covers most of the forest area of *Serra do Japi* (Morellato 1992). The material was collected in a farm near to the Base Ecológica at Serra do Japi (23°13'53.60"S, 46°52'47.01"W) in two sites denominated "Chácara do Lima" (23°13'53.60"S, 46°55'47.01"W) and "Monte Horebe" (23°14'01.17"S, 46°55'47.01"W).

Collection of *Selenops cocheleti* egg sacs

On September 28th and October 3rd of 2014, we searched at night (18:00 to 21:00) for egg sacs and for gravid adult females of *Selenops cocheleti* in trunks of *Plinia cauliflora* (Myrtaceae; commonly known as jaboticaba) and *Pinus elliottii* (Pinaceae) where these spiders are frequently seen.

The egg sacs and gravid adult females obtained in the field were photographed and taken to the laboratory where they were kept in plastic pots to inspect for potential larvae or pupae of parasitoids or predators. The attacked egg sacs were isolated and the emerging adult wasps collected. All egg sacs (attacked or not) were opened for structural analysis and description. Gravid adult females of *S. cocheleti* collected in the field were also taken and maintained under laboratory conditions. Then we collected the egg sacs laid by the females to estimate the number of eggs per sac and the development time of the early instars of this species of spider.

Taxonomic treatment

All methods and conventions, including morphological terminology and biometrics, follow Santos and Aguiar (2013), except that the cell 1+2Rs is called "areolet" for simplicity.

The studied specimens are deposited at DCBU (Departamento de Ecologia e Biologia Evolutiva da Universidade Federal de São Carlos, São Carlos, SP, Brazil) and MZUSP (Museu de Zoologia da Universidade de São Paulo, São Paulo, São Paulo, Brazil). The numbers that follow the depository acronyms refer to the registration of each specimen in the institutions.

Results

Egg sac structure and number of eggs of *Selenops cocheleti*

Selenops cocheleti builds an egg sac consisting of three steps, with layers of web giving protection to the eggs: (1) The female at first produces a concave dish that is adhered to the bark of the tree where the eggs are laid; (2) later it builds a layer that will close the egg sac; and (3) when the egg sac is complete, a dense layer of silk threads is added. The egg sac can be found attached on the inner surface of loose bark on *Plinia* and *Pinus* tree trunks (Figure 1A). The two inner layers serve as a wrap for the eggs and the outermost layer is thicker and more resistant (Figure 1B). Adult females rest on the egg sac during the day, and leave their shelter at night to feed. The egg sac can contain up to 287 eggs (Figure 1C) when it is not attacked (average = 181.75; SD = 82.13; n = 4). The eggs hatched within 16 ± 2 days (n = 2) inside the egg sac (Figure 1D). During this period (approximately two weeks) adult females take care of the egg sac standing over it. About three days later, the spiderlings moulted for the first time (into their second instar) whilst still within the egg sac; they remain within the egg sac for on average 18 days, after which they perform a second moult and become more active. Two days after the second molt, spiderlings left the egg sac and scattered. Thus, development time from egg laying to the spiderlings leaving the egg sac was about 40 days. In the egg sacs (n=2) laid by females maintained in the laboratory and in two of the egg sacs collected in the field that were not attacked by *Camera lunavenatrix* sp. n. about 10% of the eggs remained without embryonic development, even after 18 days.

Egg predation

We collected five egg sacs in the field, of which three had *Camera lunavenatrix* sp. n. larva feeding on the eggs, in each case gregariously (Table 1). The wasps pupated inside

Table 1. Number of pupae of *Camera lunavenatrix* sp. n. (Ichneumonidae: Cryptinae) per egg sac of *S. cocheleti* recorded in the trees trunks of jaboticaba (*Plinia cauliflora*, Myrtaceae) and pine (*Pinus elliottii*, Pinaceae) during September (Sep.) and October (Oct.) of 2014 in the Ecological Station Serra do Japi, SP-Brazil.

	Month	Pupae	Males	Females	Survival rate of spiders
Egg sac 1	Sep.	3	1	-	0%
Egg sac 2	Sep.	4	2	2	0%
Egg sac 3	Sep.	0	0	0	88%
Egg sac 4	Oct.	2	0	2	0%
Egg sac 5	Oct.	0	0	0	91%
Total		9	3	4	



Figure 1. Egg sac of *Selenops cocheleti*. **A** In a tree trunk **B** Egg sac structure in layers **C** Eggs **D** Newly emerged spiderlings from the egg inside the egg sac (1st instar) and detail of one of the embryos **E** Second instar spiders **F** Spiderling (3rd instar) on tree trunk **G** Adult female on *Plinia cauliflora* (Myrtaceae) tree trunk in Serra do Japi, SP, Brazil.

the egg sac (Figure 2A). The adult wasps emerged 5–7 days after collection of the egg sacs. In one of the collected egg sacs, two wasp pupae did not emerge as adults.

After the emergence of the adult wasps, we dissected all attacked egg sacs and did not find spiderlings or exuviae inside, indicating that all of the eggs had been consumed. The wasp pupae were arranged next to each other in all the egg sacs attacked (Figure 2C). To leave the egg sac, the adult wasps cut a hole in the walls with their mandibles (Figure 2D).

Wasp behavior

Adult females of the wasp *Camera lunavenatrix* were observed in the field from 19:50 PM to 20:25 PM inspecting cracks in the trunk as well as spaces under bark on *Plinia* trees trunks, possibly looking for egg sacs of *Selenops cocheleti*. On the trunks, the female wasps performed a “hammering” movement with the antennae on the trunk surface for about 15 minutes before flying to another trunk to continue searching.

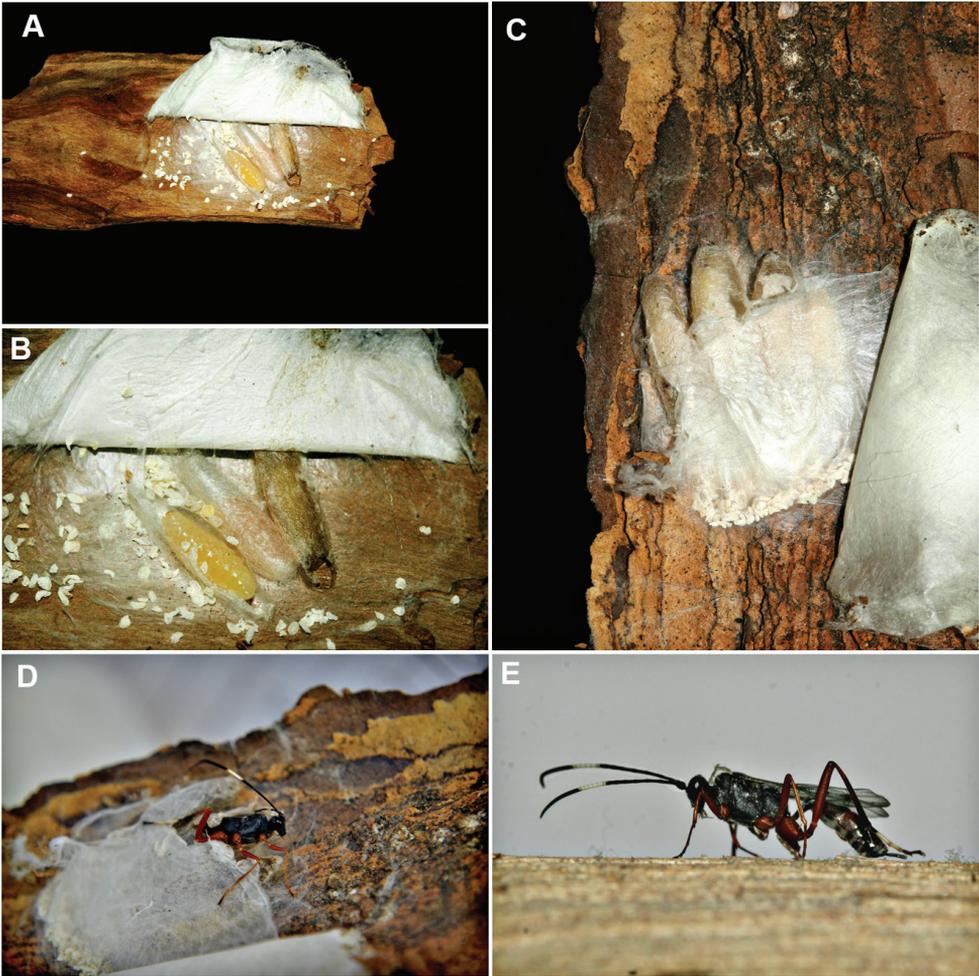


Figure 2. Pupae of *Camera lunavenatrix* sp. n. in egg sac of *Selenops cocheleti* (Selenopidae). **A, B** Egg sac collected under bark of jaboticaba (*Plinia cauliflora*, Myrtaceae) with wasp larvae developing; the white fragments correspond to consumed eggs **C** Egg sac collected under bark of pine (*Pinus elliottii*) **D, E** Adult female of *Camera lunavenatrix* emerging from the egg sac of *Selenops cocheleti*.

Taxonomy

Camera Townes 1962

Camera: Townes 1962: 432. Type species: *Mesostenus euryapsis* (Cameron, 1885), by original designation.

Diagnosis. Clypeus distinctly convex, subpyramidal in profile; malar space 0.80–1.00 as long as basal width of mandible. Mesoscutum only slightly convex; hind margin

of metanotum with distinct tooth-like projection. Propodeum short, about as long as maximum length of mesopleuron; anterior and posterior transverse carinae usually complete, posterior carina sometimes medially indistinct. Areolet moderately small, longer than wide, crossveins 2r-m and 3r-m subparallel or weakly convergent. First metasomal tergite with anterolateral tooth, its spiracle placed at posterior 0.4–0.3; ovipositor sheath 0.25–0.42 as long as hind tibia.

Comments. The new species *C. lunavenatrix* is the fifth species for the genus. There are three other Neotropical species, from Brazil, Mexico and Cuba, in addition to the type species, *Camera euryapsis*, which occurs from Texas to Mexico and also in Cuba. Species of *Camera* seem to be rarely collected by Malaise and yellow pan traps (e.g., none collected by the extensive sampling of Aguiar and Santos 2010), and examination of tens of thousands of specimens Neotropical Cryptini does not indicate a large number of undescribed species (unpublished data). *Camera* shares a number of features with Holarctic genera of Cryptini that attack spider eggs – such as *Trychosis*, *Idiolispa* and *Hidryta* – including a short ovipositor, relatively flat mesoscutum, strongly convex clypeus and a simple, unmodified tip of the apical flagellomere. The rearing record and information presented herein are the first biological data for the genus.

***Camera lunavenatrix* Santos & Onody, sp. n.**

<http://zoobank.org/4394F1C7-E421-437D-8FF6-C75DE28527F5>

Type material. Holotype ♀ (DCBU# 91323): BRAZIL, São Paulo, Jundiaí, Serra do Japi, 23°11'S, 46°52'W. Emerged on 24.x.2014 from egg sac of *Selenops cocheleti* (Araneae: Selenopidae) collected on 17.x.2014. G. Villanueva. Paratypes: 1 ♀ (MZUSP# 54697), same data as holotype; 2 ♀, 3 ♂ (DCBU# 91324-91326; MZUSP# 54698, 54699), same data as holotype, except egg sacs collected on 18.ix.2014 and emergences on 23–25.ix.2014.

Diagnosis. Head, mesosoma and metasoma almost entirely black except legs ferruginous; occipital carina incomplete ventrally; tergite 1 relatively short, almost as long as tergite 2; body covered with moderately dense white pilosity; ovipositor short, 0.25× as long as hind tibia; clypeus convex, in lateral view almost pyramidal; posterior transverse carina of propodeum medially arched forwards, raised laterally; crossveins 2r-m and 3r-m of areolet subparallel; vein 2m-cu almost straight, reclivous; forewing vein 1cu-a arising distinctly basad of 1M+Rs.

Female. Forewing 9.0 mm. **Head.** Densely pilose; mandible stout, apex 0.6× as wide as base; malar space 0.8× as long as basal width of mandible. Clypeus densely punctate, 2.0× as wide as high, in front view more or less trapezoidal, width at apex 1.4× of basal width, distinctly convex, apically abruptly truncate, in lateral view almost pyramidal; apical margin medially straight, laterally not projecting. Antenna with 33 flagellomeres; first flagellomere 6.5× as long as wide; apex of apical flagellomere uniformly tapered; area between antennae with small rounded tubercle. Supra-clypeal



Figures 3–4. *Camera lunavenatrix* sp. n. **3** Holotype habitus **4** Male paratype habitus. Scale bar: 0.5 mm.

area convex, distinctly rugose-punctate. Supra-antennal area distinctly rugose-punctate, medially with a distinct longitudinal depression. Vertex finely punctate. Occipital carina sharp, laterally sinuous, incomplete ventrally, not meeting hypostomal carina or base of mandible.

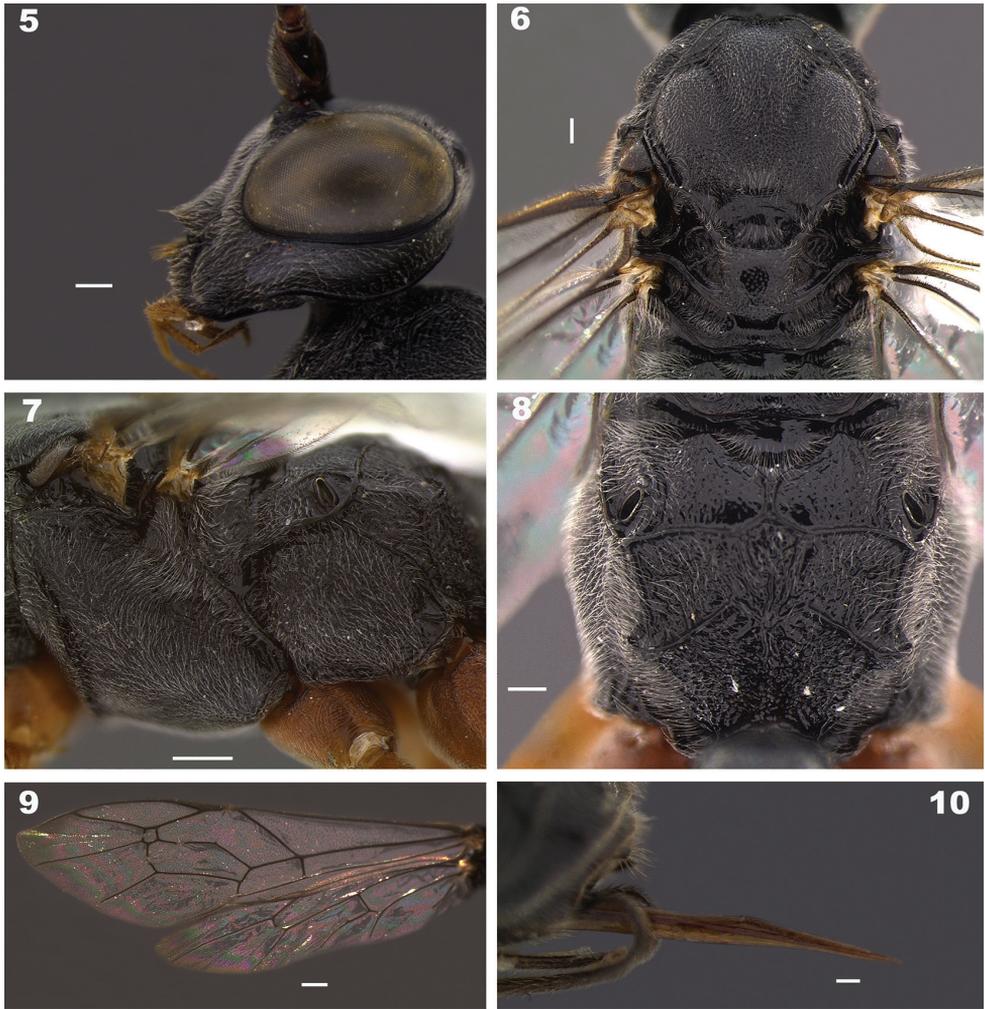
Thorax. Mostly mat, uniformly and densely pilose. Pronotum densely punctate, ventrally striate; epomia distinct, diverging from pronotal collar, dorsally straight, almost reaching dorsal margin of pronotum. Mesoscutum almost flattened, subcircular, 1.1× as long as wide, shiny, densely punctate; notaulus distinct over more than 0.5 of mesoscutum length, with transverse striae, strongly impressed anteriorly, weaker posteriorly; scutellum shiny, punctate; scuto-scutellar groove deep, anteriorly mostly smooth, posteriorly with longitudinal striae. Mesopleuron ranging from densely punctate to rugose-punctate; subalar ridge distinctly projecting, narrow; epicnemial carina reaching about 0.7 of distance to subalar ridge; sternaulus incomplete and weak, reaching 0.6 of distance to mid coxa. Transverse sulcus at base of propodeum deep, about 0.4× as long as anterior area of propodeum, medially smooth; metapleuron densely punctate, juxtacoxal carina absent. Fourth tarsomere not bilobed.

Propodeum. 1.1× as long as wide; anterior margin medially concave, with distinct anterolateral projections; anterior area moderately punctate, shiny and smooth between punctures and slightly rugose on first lateral area, medially with distinct longitudinal carina; spiracle elliptic, spiracle 2.0× as wide as long; anterior transverse carina medially slightly arched forwards. Posterior area of propodeum rugulose; posterior transverse carina complete, medially distinctly arched forwards, raised laterally; median longitudinal carina of propodeum present between anterior and posterior transverse carinae.

Wings. Forewing vein 1-Rs+M and crossvein 1m-cu both almost straight; bulla of 1-Rs+M placed almost on its midlength; forewing crossvein 1cu-a arising distinctly basad of 1M+Rs; vein 2Cua 1.1× as long as crossvein 2cu-a; crossvein 2m-cu almost straight, reclivous, bulla placed on midlength; areolet of moderate size, 1.30 as long as pterostigma, pentagonal, 1.1× as long as wide; crossveins 2r-m and 3r-m subparallel, about same length; vein 3-M distinctly shorter than 2-M. Hind wing vein 1-M forming right angle with vein Cua; vein Cub weakly convex, forming right angle with vein Cua.

Metasoma. First tergite moderately short, almost as long as tergite 2, about 2.0× as long as maximum width; in cross section approximately depressed, mostly striate, sparsely pilose; apex 2.5× as wide as base; spiracle at posterior 0.4 of its length, distinctly prominent; ventrolateral and median dorsal carinae absent; dorsolateral carinae present, reaching 0.5 of tergite 1 length. Tergite 2 short, 1.1× as long as maximum width, in dorsal view trapezoidal, posterior width 1.7× anterior width, mostly strongly punctate, apically finely punctate; thyridium slightly longer than wide; tergites 3–8 finely pilose and punctate. Ovipositor very short, 0.25× as long as hind tibia, slender, straight, distinctly compressed, nodus slight but distinct; lower valve without conspicuous teeth.

Color. Black with ferruginous legs. Head: black; palpi ferruginous; antenna black, flagellomeres 6 apically and 7–13 entirely white. Mesosoma: black; legs mostly ferruginous; fore and mid legs basally slightly dark ferruginous, generally lighter towards



Figures 5–10. *Camera lunavenatrix* sp. n. (♀ holotype). **5** Head in lateral view **6** Mesoscutum in dorsal view **7** Mesopleuron and metapleuron in lateral view **8** Propodeum in dorsal view **9** Fore and hind wings **10** Ovipositor in lateral view. Scale bars: 0.25 mm (**5**); 0.2 mm (**6**); 0.5 mm (**7**); 0.25 mm (**8**); 0.5 mm (**9**); 0.1 mm (**10**).

apex except tarsomere 5 of foreleg and tarsomeres 3–5 of mid leg dark brown; hind leg with coxa, trochanters and femur dark ferruginous; hind tibia ferruginous on basal 0.65, apical 0.35 blackish; hind tarsomeres 1 basally, 3 apically and 4–5 dark brown to blackish, tarsomeres 1 apically and 2 entirely white. Metasoma: black, except very base of tergite 1 marked with ferruginous; ovipositor ferruginous and ovipositor sheath black; wings hyaline, apically infumate.

Male. Forewing 6.0–8.0 mm long. Generally similar to female except: vertex more sparsely punctate; first flagellomere shorter, about 3.5× as long as wide; tergite 1 apically

narrower, its maximum width about 1.3–1.5× minimum width; hind leg with tibia more extensively blackish and basal 0.25 of tarsomere 1 and tarsomere 5 entirely black.

Variation. Forewing 9–9.5 mm long. Two females have metasoma with tergites 2–8 having some dark ferruginous areas.

Comments. *Camera lunavenatrix* sp. n. is similar in general morphology to the North American species *C. euryopsis* Cameron and *C. californica* Kasparyan and Ruíz-Cancino. The three species have the body approximately cylindrical, with the propodeum about as tall dorso-ventrally as the anterior part of the thorax, and a relatively short tergite 1. However, *C. lunavenatrix* can be readily distinguished from the other two species by the body almost entirely black (versus with extensive yellow marks); clypeus almost pyramidal in lateral view (versus only moderately convex, with rounded profile); posterior transverse carina of propodeum medially distinctly arched, bell-shaped (versus slightly and uniformly arched); and ovipositor quite short, only 0.25× as long as hind tibia (versus 0.42).

The Brazilian species *C. thoracica* Szépligeti is quite different from the other species of the genus in having the anterior part of the thorax rather stout, with the propodeum distinctly shorter in lateral view; furthermore, tergite 1 is distinctly longer than tergite 2, very different from the short tergite 1 of the other species. Additionally, *C. lunavenatrix* can be separated from *C. thoracica* by the black metasoma (versus bright orange); and forewing vein 1cu-a arising based to crossvein 1M+Rs (versus opposite).

Etymology. From the Latin *luna* (“moon”) and *venatrix* (“huntress”). The name of the spider genus *Selenops* derives from *Selene*, the moon goddess, and the suffix *-ops*, Greek for “eye”. Therefore the new species is deemed a “moon huntress” as it parasitizes egg sacs of *Selenops*.

Discussion

It is known that the egg sac works as a physical barrier isolating the eggs from the outside environment. In addition, maternal care provides additional protection by guarding of the eggs (Austin 1985). These protections do not provide absolute defense against predators such as *C. lunavenatrix* but can provide protection against a broad spectrum of opportunistic predators, e.g. ants and other spiders (Austin and Anderson 1978, Austin 1982, 1985).

The observation of adult females of *C. lunavenatrix* inspecting tree trunks between 19:50 PM and 20:25 PM seems to suggest some degree of nocturnal activity for the species. This is somewhat inconsistent with the general tendency of nocturnal ichneumonids to have pale body color and enlarged ocelli (Gauld 2006). It is unclear whether *C. lunavenatrix* may be also (or mostly) active during the day. Diurnal activity has been observed in other cryptine egg predators such as some European species of the genus *Trychosis*, *Hidryta* and *Gnyptomorpha* (M. Schwarz pers. comm.).

Females of *C. lunavenatrix* may search for egg sacs of *S. cocheleti* during the night because during this period the adult spider female leaves its shelter to feed, leaving the

egg sac vulnerable. On the other hand, while the (rather rapid) development of the wasp takes place, the female spider continues to guard the egg sac. This suggests that the spider may be unable to perceive any wasp activity or change inside the egg sac.

The larvae of *C. lunavenatrix* observed in this study consumed 100% of spider eggs. This is not unusual, as recorded for *Tromatobia* sp. (Ichneumonidae: Pimplinae) and *Aprostocetus* sp. (Ichneumonidae: Eulophidae) attacking *Araneus omnicolor* (Araneidae) (Sobczak et al. 2012b, 2015). However, other records show that egg consumption is not always complete; if the number of parasitoids in the egg sac is low (Cobb and Cobb 2004) some spiderlings may emerge (Fitton et al. 1988, Schwarz and Shaw 1999). Similar results were recorded for *Nephila edulis* (Nephilidae) when attacked by larvae of the moth *Anatrachyntis terminella* (Lepidoptera: Cosmopterigidae); in that case, even with low infestation (six larvae per egg sac), only up to 20% of the eggs hatched (Austin 1977).

Acknowledgements

This research was supported by Fundação de Amparo à Pesquisa do Estado de São Paulo (Processes: 2013/16469-8; 2012/15875-0) and the Instituto Nacional de Ciência e Tecnologia dos Hymenoptera Parasitoides da Região Sudeste (INCT-HYMPAR/SUDESTE) (CNPq, FAPESP, CAPES). The third author was supported by a fellowship from the Richard Gilder Graduate School; a “mini-ARTS” award by the Society of Systematic Biologists; a Doctoral Dissertation Improvement Grant by the National Science Foundation (Award # 1501802) and an Annette Kade Graduate Student Exchange Fellowship Program by the American Museum of Natural History. We are grateful to the editor and the two reviewers for their appropriate and constructive suggestions to improve the paper.

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