Scientific Note

Cocoon morphology of *Bicyrtes variegatus* (Oliver, 1789) (Hymenoptera: Crabronidae), with notes on habitat and biological interactions

Morfología del capullo de *Bicyrtes variegatus* (Oliver, 1789) (Hymenoptera: Crabronidae), con notas sobre el hábitat y las interacciones biológicas

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Abstract. A morphological study on the cocoon of *Bicyrtes variegatus* (Oliver, 1789) is presented based on specimens collected in Center-West Brazil. Notes on nesting habitat is provided. *Euschistus heros* (Fabricius, 1798) (Hemiptera: Pentatomidae) is recorded as prey, and *Traumatomutilla ocellaris* (Klug, 1821) (Hymenoptera: Mutillidae) as parasitoid.

Key words: Apoidea; behavior; Bembicinae; biology; solitary wasps.

Resumen. Se presenta un estudio morfológico del capullo de *Bicyrtes variegatus* (Oliver, 1789) basado en especímenes recolectados en el centro-oeste de Brasil. Se proporcionan notas sobre el hábitat de anidación. Se registra a *Euschistus heros* (Fabricius, 1798) (Hemiptera: Pentatomidae) como presa y a *Traumatomutilla ocellaris* (Klug, 1821) (Hymenoptera: Mutillidae) como parasitoide.

Palabras clave: Apoidea; avispas solitarias; Bembicinae; biología; comportamiento.

Cocoon structure has been fruitfully used in Hymenoptera taxonomic and phylogenetic studies (*e.g.*, Sarzetti *et al*. 2019; Martynova 2020). Evans (1966) comparatively studied cocoons of sand wasp (Crabronidae: Bembecinae), showing its structural complexity and variability, and its taxonomic importance, however, his study has not been significantly revisited and even detailed cocoon descriptions of Bembecinae, or of other apoid wasps, are still rare in the literature.

Bicyrtes Lepeletier de Saint Fargeau, 1845 (Crabronidae: Bembecinae) is a New World genus of ground-nesting wasps (Evans & O'Neill 2007) with 27 described species (Bohart 1996; Pulawski 2021). Aiming to encourage further morphological studies on Bembecinae cocoon, herein the cocoon of *Bicyrtes variegatus* (Oliver, 1789), which present somewhat peculiar features, is detailed described and illustrated. Notes on nesting habitat, prey and parasitoids are also provided.

The description is based on four specimens collected at Lagoa Grande rural settlement

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(21°59'35.6" S, 55°19' 23.8" W, 430 m), Dourados municipality, Mato Grosso do Sul State, Center-West Brazil, in April 27, 2017. Photographs of the cocoons were obtained using a Leica M205C stereomicroscope coupled with a digital camera and captured using the Leica LAS imaging system. Measurements were done using an ocular micrometer. The cocoons were placed in glass tubes closed with cotton and deposited in entomological collections from Instituto Oswaldo Cruz, Rio de Janeiro, Brazil. Parasitoid emerged from cocoons are deposited in Hymenoptera collection at Museu da Biodiversidade, Universidade Federal da Grande Dourados, Dourados, MS, Brazil.

Cocoon morphological description

General aspect. Ovoid, posterior half slightly more tapered than anterior; extremities rounded. Length 9-10 mm; about 4 mm in maximum width. Constructed with soil grains firmly closely together and with oral secretions (Figs. 1-3). Consistency quite rigid. Adult emerges through anterior extremity cutting an apical cap (Fig. 4).

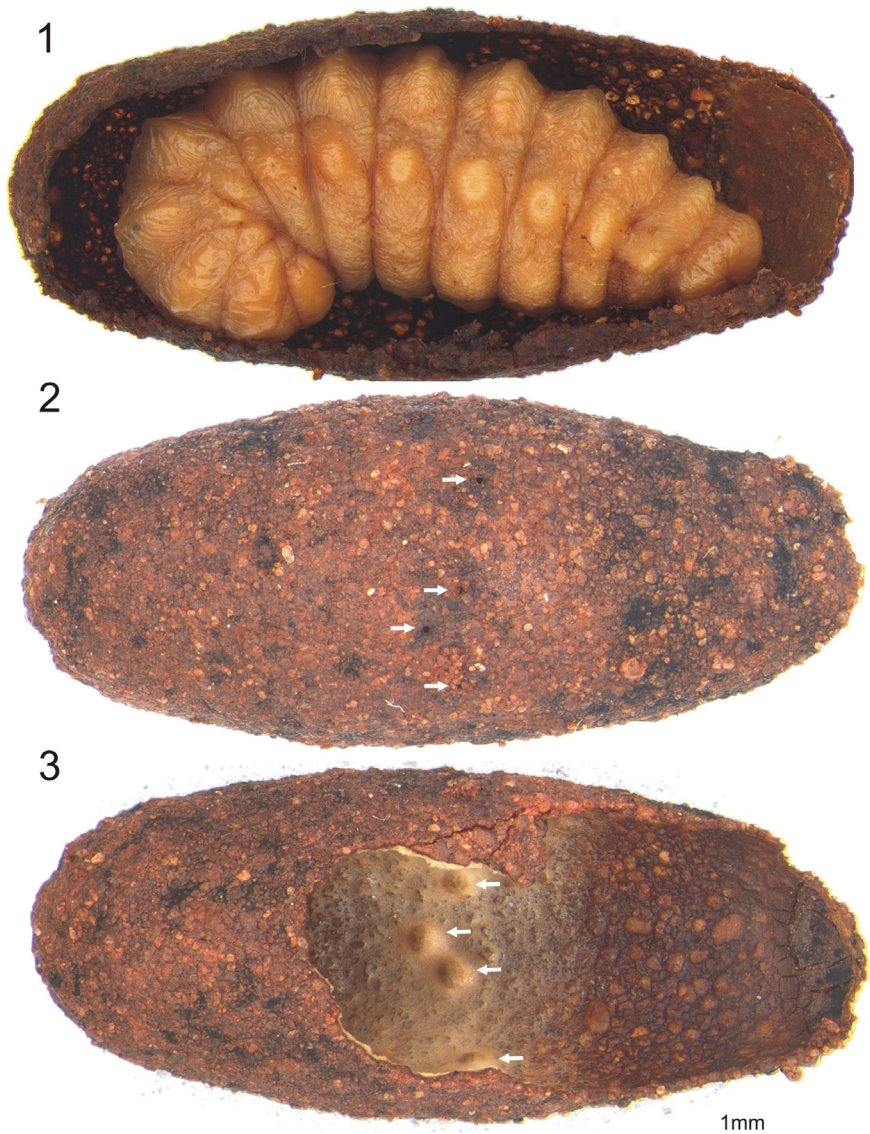
External structure. Brown in color, opaque. Texture granulose, with soil grains of variable sizes interspersed by brown substance (probably an oral secretion). Sparse silken threads visible. Ten or eleven pores distributed irregularly, not equidistant from each other, around the midline (Fig. 2); pores contour circular or oval, with protruding edges (Fig. 6), about 0.07 mm in maximum diameter (n = 40).

Internal structure. Middle third coated with a layer of light brown silken threads gradually more densely arranged towards the midline (Figs. 3, 7). A layer of silk threads is inconspicuous at basal and apical thirds. Pores internally covered with dome-shaped structures, up to about 0.3 mm in diameter (n = 26) (Figs. 3, 7), with no visible opening inward. Meconium as a black amorphous mass concentrated at posterior portion, without visible layer of silken threads isolating it of the lumen where larva develops (Fig. 5).

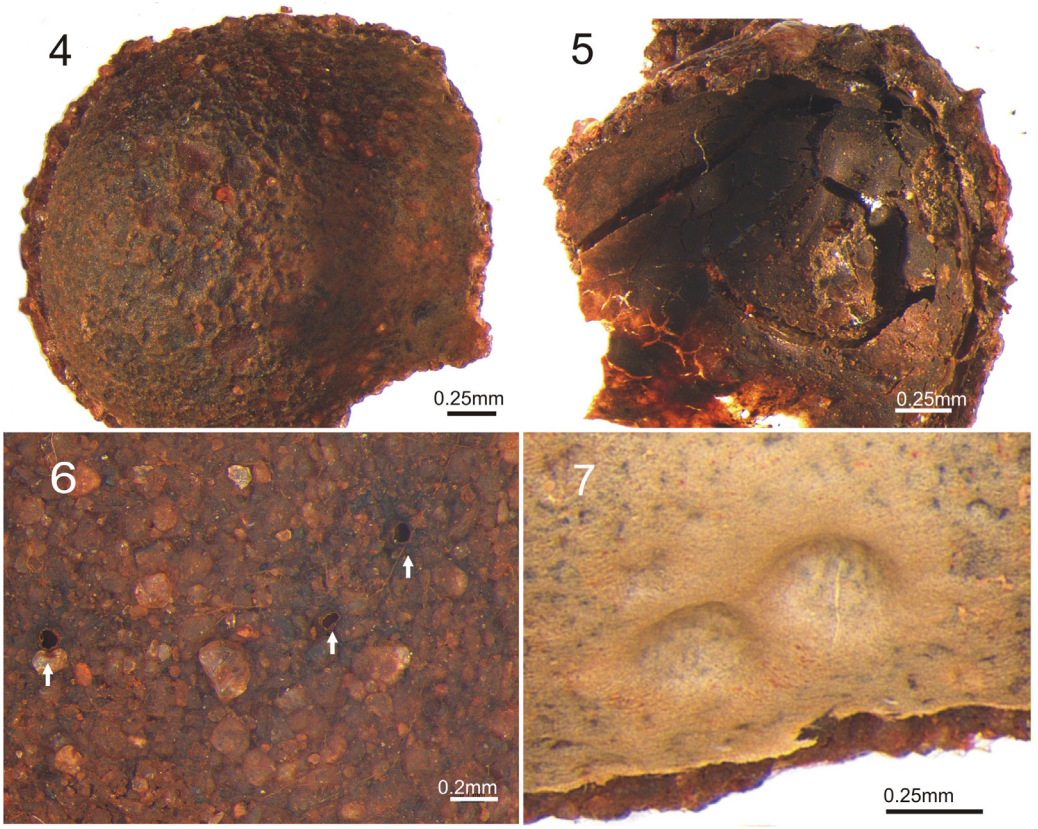
Remarks. The cocoon of *B. variegatus* is similar to those of the four *Bicyrtes* species described by Evans (1966), but markedly differs in having more pores, although it has smaller size (Table 1). Evans (1966) suggested that the number of pores of Bembicinae cocoons are roughly positively correlated with the cocoon size. Thus, on small cocoons of *Alysson* Panzer, 1806 and *Nysson* Latreille, 1796 have no pores (Evans 1966) and on the large cocoons of *Editha magnifica* (Perty, 1833) have about 40 pores (Martins 1993). Besides, the pores number tends to be constant within species of Bembecinae, but a few cases of significant intraspecific variation was reported, for example, cocoons of *Bembix niponica* F. Smith, 1873 have from 6 to 17 pores (Tsuneki 1956) and cocoons of *Bembix dentilabris* Handlirsch, 1893 have from 9 to 32 pores (Evans 1966; as *Bembix u-scripta* W. Fox, 1895). The sample of *B. variegatus* cocoons examined are quite similar morphologically, suggesting that, at least locally, there is no significant morphological variation and that the relatively high number of pores is not the result of an occasional malformation. A very striking feature of the material examined is the dome-shaped structure that covers the pores internally, this feature apparently was not described in other species of the group. Unfortunately, it was not possible to internally examine the dome-shaped structures.

Nesting habitat, preys and parasitoidism. The females *B. variegatus* were observed gregariously digging nests in a sandy area devoid of vegetation and exposed to the sun. The soil was well-drained, composed by a top layer of unconsolidated coarsely grained sand, very dry, and below a humid consolidated layer of sand mixed with clay, where the nest cells were found. A cell with a young larva and four immature Pentatomidae (Hemiptera) used

as prey was found about 13 cm deep. The prey items were deeply paralyzed (Fig. 10), but able to twitch antennae and legs. A female of *B. variegatus* was captured carrying *Euschistus heros* (Fabricius, 1798) (Hemiptera: Pentatomidae) as prey. In laboratory, a specimen of *Traumatomutilla ocellaris* (Klug, 1821) (Hymenoptera: Mutillidae) emerged from a *B. variegatus* cocoon. Several specimens of *T. ocellaris* were observed at the site during nesting activity. The cocoon from which the parasitoid hatched was opened on anterior portion, as well on *Bicyrtes* wasps. Finally, the collection site is a rural settlement where several projects involving agroecology are being developed. The predation habit of *B. variegatus*, as well the record of the brown stink bug, suggest the importance of this pentatomid-hunting sand wasp species in the agroecological context developed at this rural settlement.



Figures 1-3. Cocoon structure of *Bicyrtes variegatus* (Oliver). 1. Cocoon with the mature larva inside. 2. external view, white arrows pointing the pores. 3. Broken cocoon showing the internal surface, white arrows pointing the internal domes of the pores. / Estructura del capullo de *Bicyrtes variegatus* (Oliver). 1. Capullo con la larva madura en su interior. 2. Vista externa, flechas blancas señalan los poros. 3. Capullo roto mostrando la superficie interna, fechas blancas señalan las cúpulas internas de los poros.



Figures 4-7. Details of cocoon structures of *Bicyrtes variegatus* (Oliver). 4. Apical portion, internal view. 5. Basal portion, internal view, showing the fecal mass. 6. External surface, white arrows point the pores. 7. Internal domes of the pores, covered with light brownish silken threads. / Detalles de las estructuras del capullo de *Bicyrtes variegatus* (Oliver). 4. Porción apical, vista interna. 5. Porción basal, vista interna, que muestra la masa fecal. 6. Superficie externa, flechas señalan los poros. 7. Cúpulas internas de los poros cubiertas con hilos sedosos de color marrón claro.

Table 1. Quantitative features *Bicyrtes* cocoon: total length and number of pores. / Características cuantitativas de los capullos de *Bicyrtes*: longitud total y número de poros.

Species	Cocoon Length (mm)	Number of pores	Source
B. conopterus (Handlirsch, 1889)	16	7	Evans (1966)
B. fodiens (Handlirsch, 1889)	16	5-7	Evans (1966)
B. quadrifasciatus (Say, 1824)	19	5-7	Evans (1966)
B. variegatus (Oliver, 1789)	9-10	10-11	present paper
B. ventralis (Say, 1824)	17	5	Evans (1966)

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