

# Descriptions of three new species of jumping-spiders, genus *Arnoliseus* (Araneae, Salticidae), from Rio de Janeiro state, Brazil, with comments on their genital morphology and a key to species

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<http://zoobank.org/112F19F9-A191-49D8-9663-9A30B25746F0>

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Academic editor: Danilo Harms ♦ Received 12 September 2019 ♦ Accepted 28 January 2020 ♦ Published 24 February 2020

## Abstract

New data on the jumping-spider genus *Arnoliseus* are presented. Three new species from the Atlantic Forest in Rio de Janeiro state are described, based on both sexes: *Arnoliseus carioca* **sp. nov.** from the city of Rio de Janeiro, and *Arnoliseus hastatus* **sp. nov.** and *Arnoliseus falcatus* **sp. nov.** from the municipality of Cachoeiras de Macacu. The genus' genital morphology is discussed in detail and new English terminology for their structures is created. An identification key for all *Arnoliseus* species is given.

## Key Words

Amycinae, Atlantic Forest, Neotropical Region, Taxonomy

## Introduction

The jumping-spider genus *Arnoliseus* Bräul, 2002 was proposed in a work by Bräul and Lise (2002) and included two species from southern and southeastern Brazil: *A. calcarifer* (Simon, 1902) from Teresópolis, Rio de Janeiro state, and also recorded from Paraná, Santa Catarina, and Rio Grande do Sul states, and originally placed in the genus *Vinnius* Simon, 1902; and a new species, *A. graciosa* Bräul & Lise, 2002, from São Paulo and Paraná states.

Bräul and Lise (2002) originally distinguished the genus from other salticid genera by the following set of characters: wide embolus overlying the tegulum, with an apical apophysis (or keel), basal article of the chelicerae of males with a large ectal apophysis (or mastidia), two retrolateral tibial apophyses on male palps, small tubercle on the ectal margin of the chelicerae of females, and two copulatory openings.

Bräul and Lise (2002) revised *Vinnius* and established the new genera *Arnoliseus* and *Frespera* Bräul & Lise,

2002 for species formerly included in *Vinnius*. They pointed out that the three genera were related to each other and similar to some genera included in the group Amyciae, which was proposed by Simon (1903), except that they are unidentate, instead of pluridentate. Maddison (2015) placed *Arnoliseus* in the tribe Amycini of the clade Amycoidea, based on his comprehensive molecular phylogeny of Salticidae. Later the same year, Ruiz and Maddison (2015) placed *Arnoliseus* in the subfamily Amycinae, also in the Amycoidea. In Ruiz and Maddison's paper, a detailed molecular phylogeny of the Amycoidea was presented, and several putative morphological synapomorphies for some of the included clades were proposed. Amycinae was characterized morphologically by some shared characters (high carapace, high clypeus in males, mastidia, pluridentate retrolateral cheliceral furrow, leg III longer than IV), some of which may be absent, in part, in some included genera. Ruiz and Maddison (2015) also indicated that the only possible morphological synapomorphy shared by Amycinae genera is that leg

III is longer than leg IV. *Arnoliseus* was considered to be related to the two other unidentate genera of Amycinae, *Vinnius* and *Frespera*, “based on the remaining common features” (Ruiz and Maddison (2015: 277), although only *Frespera* had been included in the molecular phylogeny. In that phylogeny, *Frespera* was placed in a smaller clade together with *Acragas* Simon, 1900, *Amycus* C.L. Koch, 1846, and *Letoia* Simon, 1900.

In this paper, we describe from Rio de Janeiro state three new species of *Arnoliseus* based on both sexes. One species was collected during the taxonomic survey by Castanheira et al. (2016) in Parque Estadual da Pedra Branca (PEPB), an urban forest in the western region of the city of Rio de Janeiro. The other two new species were collected in the NGO Reserva Ecológica de Guapiaçu (REGUA), in Cachoeiras de Macacu, a municipality from central Rio de Janeiro state, in the hydrographic basin of the Guapi–Macacu rivers.

## Material and methods

Morphological terminology is generally an English translation of Bräul and Lise (2002) and follows Ruiz and Maddison (2015). Colour patterns were described from specimens preserved in 75% ethanol. Type material for new species is deposited at the collections of Laboratório de Aracnologia, Museu Nacional (MNRJ; curator: A. Kury) and Laboratório de Diversidade de Aracnídeos, Instituto de Biologia (UFRJ; R. Baptista), both at Universidade do Brasil/Universidade Federal do Rio de Janeiro (UFRJ).

Specimens and structures were cleaned with Cristofoli Ultrasonic Cleaner and positioned in Veja sanitizer alcohol gel 70% for multifocal images and measurements. Live specimens photographs were taken with a Sony Alpha A6000 with Sony E 30 mm f/3.5 macro lens, while multifocal images were taken with a Leica DFC450 camera mounted on a Leica M205C stereoscope microscope (Leica Camera AG, Wetzlar, Germany) at Laboratório de Entomologia, Universidade do Brasil/Universidade Federal do Rio de Janeiro (UFRJ). All photos were edited in the software Adobe Photoshop CS 5.1 and plates were edited with Adobe Illustrator CS 5.1 (Adobe Inc., San Jose, California, USA). Measurements are given in millimetres. Carapace length was measured from the anterior margin of the anterior median eye socket (not including the eye lens), to the posterior border of carapace. Total length was measured from the anterior margin of the clypeus to the posterior border of abdomen, including the spinnerets. Males were matched with their respective females by the general resemblance in their colour pattern and distance of their collection sites.

For scanning electron microscope (SEM), preparations were submitted to critical point drying and mounted on adhesive copper tape (Electron Microscopy Sciences, EMS 77802), affixed to a stub for examination under high vacuum with a JEOL JSM-6510 microscope at Laboratório de Imagens (Labim), Instituto de Biologia,

UFRJ. The structures in all samples were sputter-coated using a Leica, EM SCD050 Au-Pd coater. To clear female genitalia, a pancreatic enzyme solution was prepared using a borax solution following Álvarez-Padilla and Hormiga (2008) and digestive enzyme tablets of “Orthoplex D.E.F” (Bioconcepts Pty Ltd, Banyo, Queensland, Australia) consisting of Pancreatin (200 mg), Bromelain (100 mg), and Trypsin (30 mg).

For map construction, we used QGIS 2.14. Geographic coordinates were extracted from original labels. When no coordinate information was available, the closest nearby area coordinates were extracted from Google Earth (version 9.1.39.1) or Global Gazetteer (version 2.3, <http://www.fallingrain.com/world/index.html>).

## Abbreviations used in the text and images

**Eyes:** ALE = anterior lateral eyes; AME = anterior median eyes; PLE = posterior lateral eyes; PME = posterior median eyes.

**Legs:** Fe = femur; Pa = patella; Ti = tibia; Mt = metatarsus; Ta = tarsus.

**Genitalia:** CD = copulatory ducts; CO = copulatory openings; E = embolus; FD = fertilization ducts; GH = glandular head (new terminology); N = epigynal notch; RK = retrolateral keel of embolus (new terminology); RTA = retrolateral tibial apophysis; RTAd = dorsal branch of RTA (new terminology); RTAv = ventral branch of RTA (new terminology); Sp = spermathecae.

## Results

### Comments on morphology and terminology of structures

Bräul and Lise (2002) considered the two projections at the retrolateral side of each palp tibia in males of *Arnoliseus* and *Vinnius* as two separate retrolateral tibial apophysis (RTA anterior and posterior). They also considered the two apophysis in *Frespera* as separate structures, and called them the retrolateral tibial apophysis, placed near the apex of the article, and the retroventral tibial apophysis, placed at the middle or near the basis. In a similar way, Ruiz and Maddison (2015) also pointed out the presence of two different apophyses in other Amycoida (*Uruguayu* Ruiz & Maddison, 2015 and *huriines*) and also referred to them as the retrolateral tibial apophysis (RTA) and the retroventral tibial apophysis (RvTA). However, Ruiz and Maddison (2015) had not studied the possible homology of the RTA and RvTA in *Uruguayu*, *Frespera*, and *Vinnius*.

The RvTA may actually be a different structure than the RTA. Both RTA and RvTA are present and have a similar position on palp tibia in all genera cited above, except in *Arnoliseus*. The larger and more median and apical

tibial apophysis (RTA) in *Vinnius* and *Frespera* species is clearly separated from the other smaller and more lateral and ventral apophysis (RvTA, e.g. Braul and Lise 2002: figs 3, 4, 10, 11, 17, 18, 24, 25), which indicates that these structures are really separate. Besides, RTA and RvTA are also found in several other Amycinae genera, such as *Mago* O. Pickard-Cambridge, 1882 (see Ruiz et al. 2019: figs 7, 9, 29) and in some huriines (Ruiz and Maddison 2015). A possible homology of these structures throughout those genera can be assessed only through a comprehensive phylogeny including all them.

On the other hand, we consider the anterior and posterior RTA in *Arnoliseus* as just two separate branches of the usual RTA found in other Salticidae. The larger median RTA in *Frespera* and, especially, *Vinnius* seems rather similar to the bifurcated RTA in *Arnoliseus* males, whose common basis is wide, large, and clearly separated from the tibia proper, with both apical corners projected in acuminate tips (Figs 1F, G, 3C, E, 4F, G, 7C, E, 8F, G). A comparison with the large median RTA of *V. buzium* Braul & Lise, 2002, which is apically truncated and with a projected dorsal apical corner (Braul and Lise 2002: figs 17, 18), highlights its similarities with the RTA in *Arnoliseus*. In this way, we consider that the RTA in *Arnoliseus* is a single structure with a bifid apex, with both branches being apart by a large gap. Thus, the apical projections of the RTA are called the dorsal and ventral branches (Figs 1G, 3C, E, 4G, 7C, E, 8G). An additional projection connected to the RTA is found in the three species of *Arnoliseus* described in this paper. It is an inner hook also connected to the common basis of the two branches of the RTA. This RTA hook is a very sclerotized, curved projection; it is variable in size and ends in an acute tip. It is difficult to find, as it is hidden by the other parts of RTA, though it is clearly seen in some species (Figs 1G, 4G, 7C, E, 8G). This hook was not described or illustrated by Braul and Lise (2002).

Following Braul and Lise (2002: figs 30–37), the embolic complex in *Arnoliseus* is considered to consist of two parts: the embolus itself and an embolic apical apophysis. In *Uruguayu*, Ruiz and Maddison (2015: 256) used the term “projection on embolus” to identify a structure somewhat similar to the embolic apical apophysis of Braul and Lise (2002). There is doubt whether the embolic structures of *Arnoliseus* and *Uruguayu* are homologous, as they differ in position and shape, and Ruiz and Maddison (2015) thought these genera to be related to other genera. The original designation of the embolic apophysis by Braul and Lise (2002) suggests a structure clearly delimited from the embolus. However, the embolic complex is composed of two connected parts without a clear separation between them (Figs 3D, 7D). The embolus itself is placed at the prolateral side of the complex, including the copulatory duct and its opening; which sets it apart from a large, flattened, retrolateral keel or flap (Figs 1F, 3B, D, 4F, 7B, D, 8F; Braul and Lise 2002: figs 30, 37) originating near the base of the sclerotized embolic complex. So, we call this structure the retrolateral keel (RK) of the embolus, to imply it is not a separate structure, but just a

flattened expansion of the flat embolus, which originates near the base of the embolic complex.

The female genitalia in *Arnoliseus* have a series of characteristics that were not highlighted by Braul and Lise (2002). The epigynal plate is wider than long, usually with a posterior median notch (N) and two rounded lateral lobes overlying the epigastric furrow (Figs 2E, 6E, 10E; Braul and Lise 2002: figs 34, 41). The plate also bears two semicircular and slit-like copulatory openings (CO) placed far posteriorly in the epigynal plate, near the epigastric furrow. The CO are nearly parallel or slightly transverse to the epigastric furrow, with their extremities directed anteriorly. Internally, the entire structure is transversally placed, covering an area much wider than long, divided by a pair of copulatory ducts and spermathecae. The long and laterally placed copulatory duct (CD) is composed of two parts: a mesal branch, where the CO ventrally opens and whose anterior end fuses with the spermathecae, and an ectal branch, which is more or less elongated and sinuous in some species (Figs 2F, 3F, 6F, 7F, 10F, 11A–C), with an anterior distal area with possible glandular pores (maybe an accessory spermatheca or a glandular head? = GH). It is not easy to determine the rough transition between the mesal and ectal branches, which are demarcated by the end of CO. The rounded or two-lobed central spermathecae (Sp) bear slender, ragged fertilization ducts (FD) in their anterior ends (Figs 2F, 3F, 6F, 7F, 10F, 11A–C; Braul and Lise 2002: figs 33, 42).

## Taxonomy

### *Arnoliseus* Braul, 2002

*Arnoliseus* Braul in Braul and Lise 2002: 100.

**Type species.** *Vinnius calcarifer* Simon, 1902, by original designation.

**Diagnosis.** *Arnoliseus* can be recognized by the following set of characters: bulb with a thick embolus, overlying the tegulum, bearing a wide retrolateral keel, basal article of male chelicerae with a large curved or straight ectal apophysis (or mastidia), male palp with a bifid RTA (dorsal and ventral branches), separated by a notch of variable depth, and an inner hook, epigyne with two semicircular slit-like copulatory openings placed posteriorly in the poorly defined epigynal plate, close to epigastric furrow; female internal genitalia in a transversal position, with all structures at a similar level, much wider than long (Figs 1F, G, 2E, F, 3A–F, 4F, G, 5B, 6E, F, 7A–F, 8F, G, 9A–D, 10E, F).

### *Arnoliseus carioca* sp. nov.

<http://zoobank.org/2AADB9F9-3A57-4443-9047-C64488F50583>

Figs 1–3, 11, 12

**Type material.** Holotype ♂. BRAZIL: Rio de Janeiro: Rio de Janeiro, Parque Estadual da Pedra Branca, Pau-da-

Fome, Trilha da Padaria, 22°56'12.8"S, 043°26'29.1"W, 133 m, 16.iii.2014, looking down, R. Baptista coll. (MNRJ 60024). Paratypes: same locality as holotype, 6 ♂ 4 juveniles, 13.vi.2013, sweeping, R. Baptista coll. (UFRJ 1575); 1 ♂ 2 juveniles, 22.ix.2013, sweeping, P. Castanheira coll. (UFRJ 1576); 1 ♀ 1 juvenile, 22.ix.2013, looking down, P. Castanheira coll. (UFRJ 1578); 1 ♀, 17.xii.2013, looking up, R. Baptista coll. (MNRJ 60025); 1 ♂ 1 ♀ 2 juveniles, 17.xii.2013, sweeping, R. Baptista coll. (UFRJ 1579); 2 ♂ 1 ♀, 17.xii.2013, beating, R. Baptista coll. (MNRJ 60026); 1 ♀, 16.iii.2014, looking up, R. Baptista coll. (UFRJ 1580); 1 ♀, Parque Estadual da Pedra Branca, Pau-da-Fome, Trilha da Figueira, 22°54'39.3"S, 043°30'24.8"W, 162 m, 13.vi.2013, looking down, R. Baptista coll. (UFRJ 1581); 1 ♀, same locality as preceding, 09.xii.2013, looking down, R. Baptista coll. (UFRJ 1582); 1 ♀, same locality as preceding, 12.vi.2013, looking down, R. Baptista coll. (UFRJ 1583).

**Additional material examined.** BRAZIL: 1 ♀ 1 juvenile, Rio de Janeiro: Rio de Janeiro, Parque Estadual da Pedra Branca, Pau-da-Fome, Trilha da Figueira, 22°54'39.3"S, 043°30'24.8"W, 162 m, 12.vi.2013, sweeping, R. Baptista coll. (UFRJ 1589); 1 ♂, same locality as previous, 10.xii.2013, sweeping, R. Baptista coll. (UFRJ 1590); 1 ♀, same locality as preceding, 15.iii.2014, looking down, P. Castanheira coll. (UFRJ 1592); 1 ♂, Parque Estadual da Pedra Branca, Pau-da-Fome, Trilha da Padaria, 22°56'12.8"S, 043°26'29.1"W, 133 m, 22.ix.2013, sweeping, P. Castanheira coll. (UFRJ 1577); 3 ♂ 1 juvenile, Parque Estadual da Pedra Branca, Camorim, Sede, 22°58'12.0"S, 043°26'16.4"W, 160 m, 02.vi.2013, sweeping, R. Baptista coll. (UFRJ 1593); Parque Estadual da Pedra Branca, Camorim, Açude, 22°58'08.3"S, 043°26'38.5"W, 342 m, 01.vi.2013, looking up, R. Baptista coll. (UFRJ 1594); 1 ♀, same locality as preceding, 02.vi.2013, beating, P. Castanheira coll. (UFRJ 1595); 1 ♀, same locality as preceding, 01–09.vi.2013, pitfall traps, P. Castanheira & R. Baptista coll. (UFRJ 1596); 1 ♀, same locality as preceding, 15.ix.2013, looking down, R. Baptista coll. (UFRJ 1597); 1 ♂ 2j, same locality as preceding, 08.i.2014, sweeping, R. Baptista coll. (UFRJ 1598); 1 ♂, same locality and as preceding, 31.iii.2014, sweeping, P. Castanheira coll. (UFRJ 1600); 1 ♂, same locality as preceding, 15–24.iii.2014, pitfall traps, P. Castanheira & R. Baptista coll. (UFRJ 1601).

**Etymology.** The species epithet “*carioca*” is a Tupi noun used in apposition to designate inhabitants of or anything related to Rio de Janeiro city.

**Diagnosis.** In *A. carioca* sp. nov., palps resemble those of *A. falcatus* sp. nov. as both bear wide embolic complexes with truncated semiquadrate embolic retrolateral keels (Figs 1F, 3B, D, 8F). However, they differ as in *A. carioca* sp. nov. RTAd and RTAv are in about the same level, forming a “U” (Figs 1G, 3E) and the embolic keel is smaller, with its tip retrolaterally projected, being more

proximal than the embolus (Figs 1F, 3D). Females have epigyne similar to *A. calcarifer*, with two large and pronounced semicircular, slit-like openings (Fig. 2E; Braul and Lise 2002: fig. 34) and U-shaped copulatory ducts, with glandular heads that do not touch the mesal branch of CD (Figs 2F, 3F, 11A; Braul and Lise 2002: fig. 33). They differ as the spermathecae are much larger and the copulatory ducts uniformly taper to the glandular head in *A. carioca* sp. nov., with no enlarged terminal expansions as observed in *A. calcarifer* (Figs 2F, 3F, 11A; Braul and Lise 2002: fig. 33).

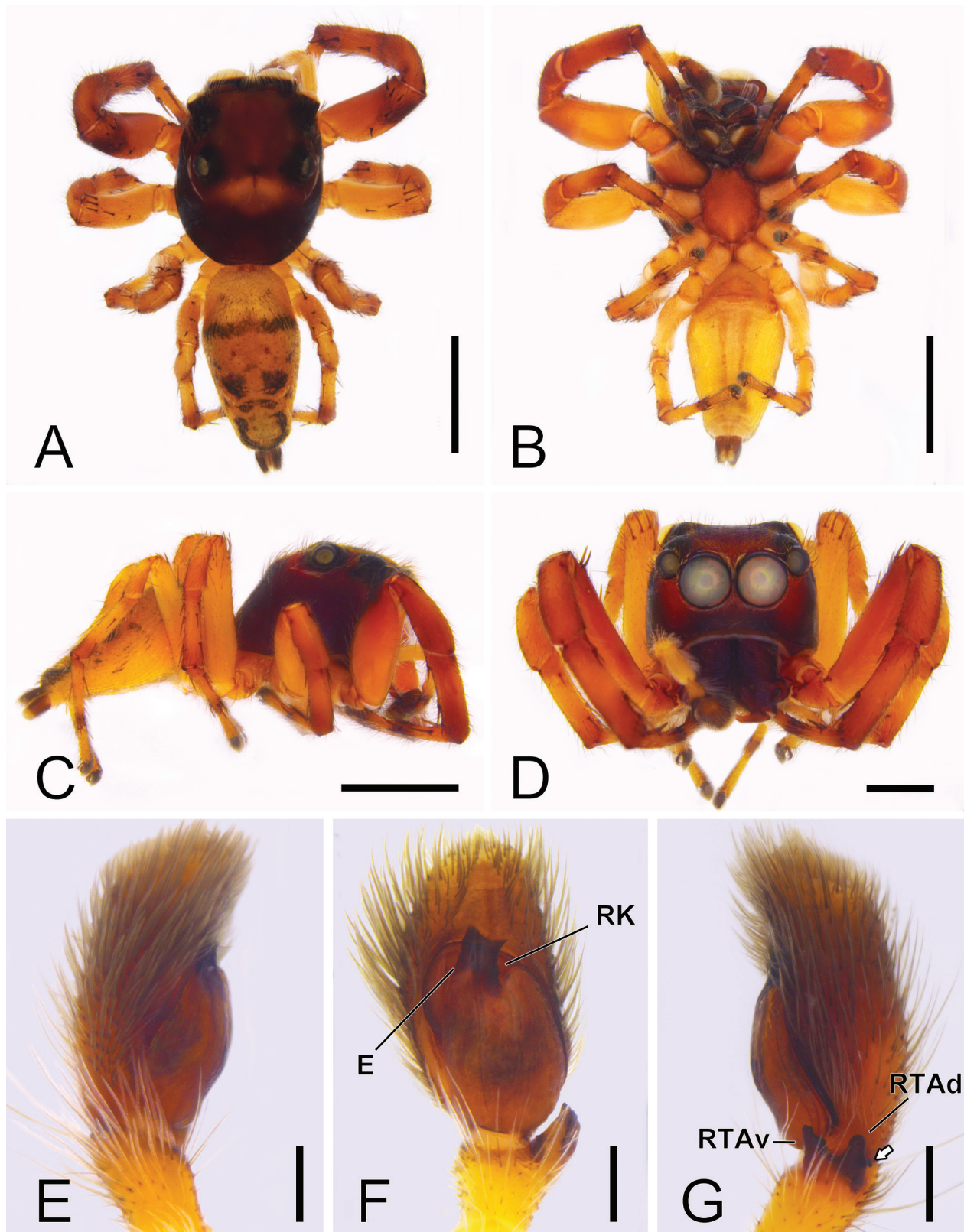
**Description.** **Male** (holotype MNRJ 60024): carapace reddish brown and very elevated from fovea to the anterior rim (Fig. 1A, B). Fovea dusky with smooth strikes after the eyes (Fig. 1A). Labium long and brown (Fig. 1B). Endites short and dark brown, anteriorly lighter (Fig. 1B). Sternum orange-brown with darker contour (Fig. 1B). PLE evenly separate by almost the carapace length; PME reduced; AME centrally placed, almost touching and occupying most of the clypeus height; ALE located on edge of carapace (Fig. 1A, C, D). Legs orange-brown with dusky patches on femur, tibia, metatarsus, and tarsus of leg I (Fig. 1A–D). Chelicerae paturon reddish brown, bearing thick, bulky, curved, C-shaped apophyses (Fig. 3A). Abdomen oval and tapering to slightly more elongated posterior part towards the dark spinnerets (Figs 1A–C). Dorsum pale beige, with one black transversal line after folium, two black patches followed by one small arched black patch on middle third and U-shaped black patch on posterior edge (Fig. 1A). Lateral portion of abdomen yellow with no patches or lines (Fig. 1C). Venter orange on area of book-lungs and light yellow towards posterior edge, longitudinally divided midway by two orange lines (Fig. 1B). Palps with short tubular tibiae with RTAd and RTAv of almost the same size and apart by a small U-shaped notch; RTAv with carved tip on ectal side (Figs 1G, 3C, E). RTA hook small, almost completely hidden by remaining parts of RTA (Fig. 1G). Cymbium elongated and oval, completely covered by setae (Figs 1E–G, 3B, C). Tegulum ovoid and laterally grooved; embolic complex wide midway, ending in a sclerotized large tip, composed of a more elevated prolateral embolus, bearing the pore opening, and wide, subquadrate and slightly truncated retrolateral keel, with small, triangular and pointed laterally projected apex, located in a lower position to the embolus itself (Figs 1F, 3B, D).

Total length 6.39. Carapace 3.08 long, 0.92 wide, 2.05 high. Left chelicera 1.27 long, 0.67 wide. Clypeus 0.63 high. Endites 0.74 long, 0.47 wide. Labium 0.42 long, 0.38 wide. Sternum 1.30 long, 0.92 wide. Abdomen 3.17 long, 1.57 wide, 1.08 high.

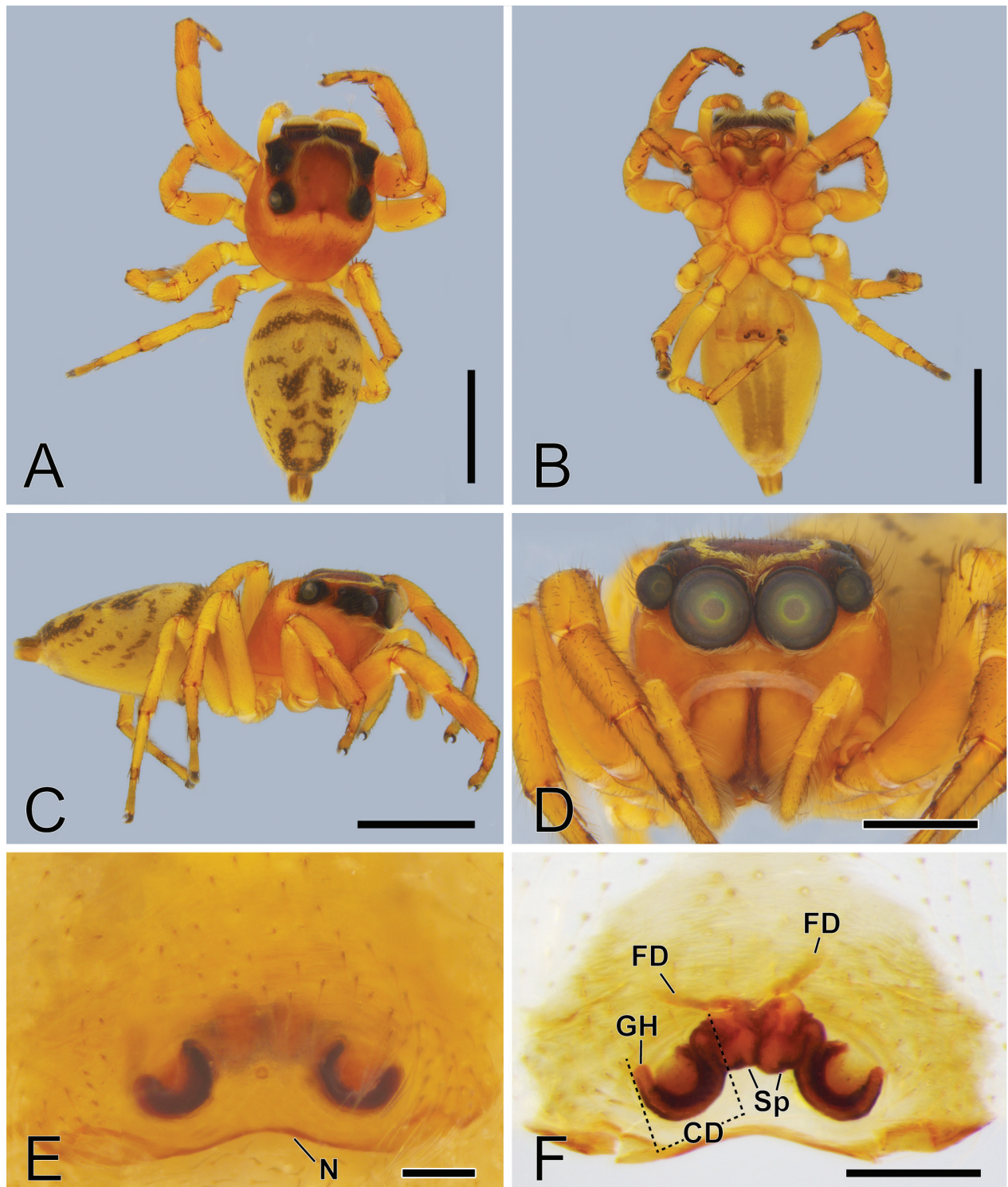
Diameter of eyes and interdistances: AME 0.72; ALE 0.40; PME 0.11; PLE 0.37. ALE–PME 0.36; PME–PLE 0.37. Ocular area (dorsal view): 1.43 long, 1.48 anterior width, 1.45 posterior width.

Leg articles length: Leg I: Fe 2.38; Pa 1.41; Ti 1.82; Mt 1.22; Ta 0.73; Total 7.56. Leg II: Fe 1.70; Pa 0.98;





**Figure 1.** *Arnoliseus carioca* sp. nov., male holotype (MNRJ 60024). **A.** Dorsal habitus; **B.** Ventral habitus; **C.** Lateral habitus; **D.** Frontal habitus; **E–G.** Left palp: **E.** Prolateral view; **F.** Ventral view; **G.** Retrolateral view, exposing the RTA. Scale bars: 2 mm (A–C); 1 mm (D); 0.2 mm (E–G). Arrow points to RTA hook.



**Figure 2.** *Arnoliseus carioca* sp. nov., female paratypes. **A.** Dorsal habitus (UFRJ 1583); **B.** Ventral habitus (UFRJ 1583); **C.** Lateral habitus (UFRJ 1583); **D.** Frontal habitus (UFRJ 1583); **E.** Epigyne, ventral view (UFRJ 1583); **F.** Internal genitalia, dorsal view (UFRJ 1581). Scale bars: 2 mm (A–C); 1 mm (D); 0.1 mm (E); 0.2 mm (F).

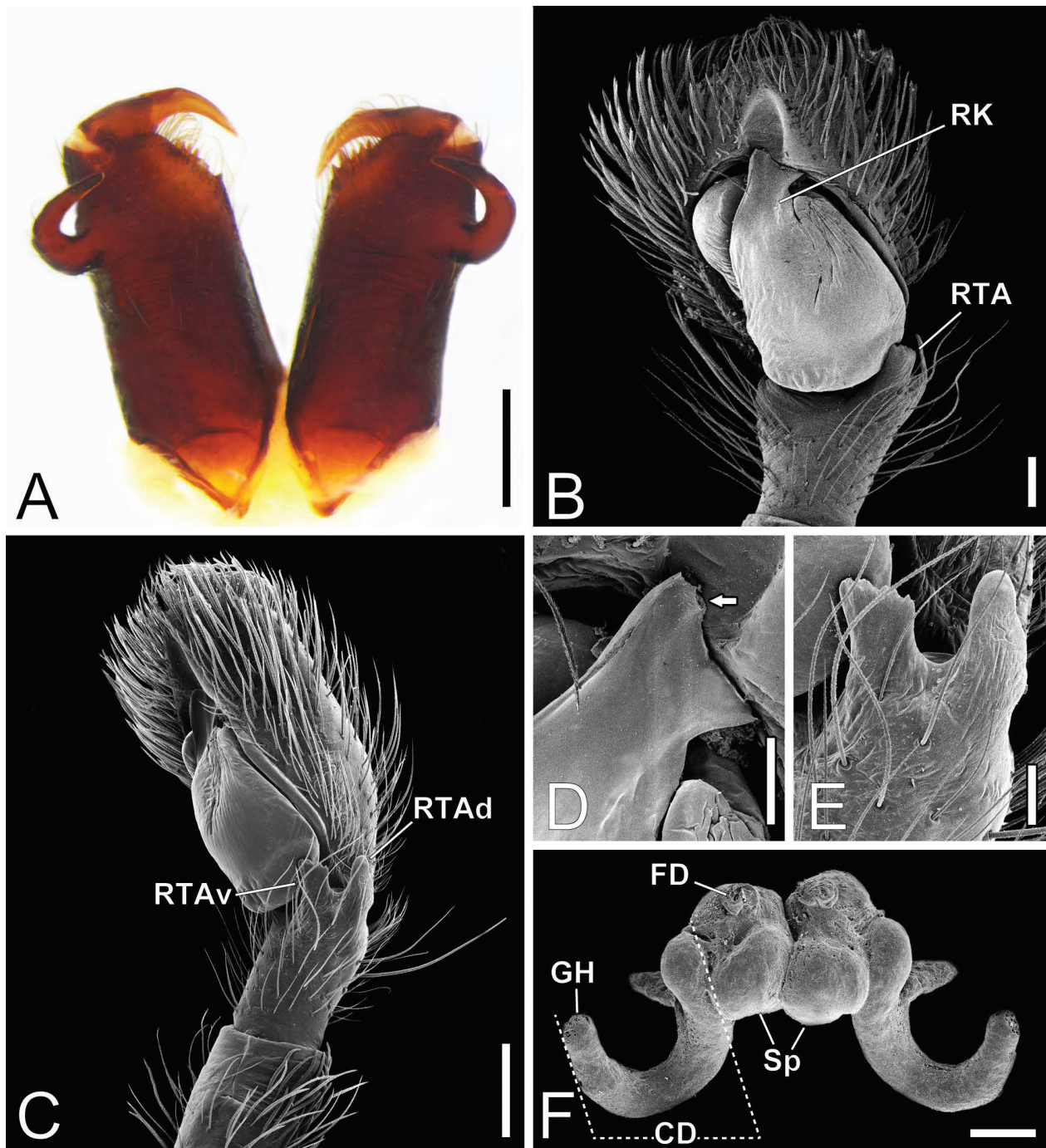
Ti 1.17; Mt 1.09; Ta 0.61; Total 5.55. Leg III: Fe 2.42; Pa 1.00; Ti 1.40; Mt 0.93; Ta 0.54; Total 6.29. Leg IV: Fe 2.12; Pa 0.75; Ti 1.36; Mt 1.15; Ta 0.61; Total 5.99.

Leg formula I-III-IV-II.

**Female** (paratype UFRJ 1583): carapace orange brown, with lighter contour after fovea and light brown

on ocular area (Fig. 2A). Fovea orange (Fig. 2A). Labium elongated and orange-brown (Fig. 2B). Endites short and orange brown, anteriorly lighter (Fig. 2B). Sternum yellowish brown with orange contour (Fig. 2B). Eyes as in male, outlined by yellow setae (Fig. 2A–D). Legs yellowish brown (Fig. 2A–D). Abdomen beige, with same shape





**Figure 3.** *Arnoliseus carioca* sp. nov. **A.** Male holotype chelicerae, ectal view exposing the apophyses (MNRJ 60024). **B–F.** SEM images: **B.** Left male palp, ventral view (UFRJ 1577); **C.** Left male palp, retrolateral view (UFRJ 1577); **D.** left male palp, embolus detail (UFRJ 1577); **E.** Left male palp, RTA detail (UFRJ 1577); **F.** Female internal genitalia, dorsal view (UFRJ 1581). Scale bars: 0.5 mm (**A**); 0.1 mm (**B**); 0.2 mm (**C**); 0.05 mm (**D–F**). White arrow points to the embolus pore.

and dorsal patches pattern as male (Fig. 2A–C). Epigyne with epigynal plate orange, poorly defined, sclerotized at the posterior half, with two semicircular slit-like copulatory openings just anteriorly to posterior rim, which has a shallow posterior median notch (Fig. 2E). Internal genitalia composed of two slender fertilization ducts anteriorly connected to the ventral portion of the massive rounded spermathecae and two thick U-shaped copulatory ducts

formed of thicker mesal branches and regularly curved ectal branches ending in rounded glandular heads, placed far from the spermathecae (Figs 2F, 3F, 11A).

Total length 6.09. Carapace 2.63 long, 1.87 wide, 1.30 high. Left chelicera 0.78 long, 0.52 wide. Clypeus 0.32 high. Endites 0.70 long, 0.54 wide. Labium 0.49 long, 0.43 wide. Sternum 1.10 long, 0.85 wide. Abdomen 3.32 long, 1.09 wide, 1.16 high.

Diameter of eyes and interdistances: AME 0.74; ALE 0.42; PME 0.11; PLE 0.36. ALE-PME 0.35; PME-PLE 0.25. Ocular area (dorsal view): 1.29 long, 1.41 anterior width, 1.43 posterior width.

Leg articles length: Leg I: Fe 1.63; Pa 0.71; Ti 1.11; Mt 0.85; Ta 0.52; Total 4.82. Leg II: Fe 1.15; Pa 0.81; Ti 0.78; Mt 0.41; Ta 0.38; Total 3.53. Leg III: Fe 1.01; Pa 0.81; Ti 1.12; Mt 0.63; Ta 0.47; Total 4.04. Leg IV: Fe 0.89; Pa 0.64; Ti 0.97; Mt 1.02; Ta 0.50; Total 4.02.

Leg formula I-III-IV-II.

**Variation.** Males ( $n = 6$ ): total length, 5.58–7.80; females ( $n = 9$ ): total length, 5.87–7.21.

**Distribution.** Only known from type locality (Fig. 12).

**Preservation status.** Well preserved in 75% ethanol. Male holotype with left chelicera dissected. Female paratype UFRJ 1581 with genitalia dissected.

### *Arnoliseus hastatus* sp. nov.

<http://zoobank.org/8AB053F2-9421-4762-8EDD-79C52BB8C959>

Figs 4–7, 11, 12

**Type material.** Holotype ♂. BRAZIL: Rio de Janeiro: Cachoeiras de Macacu, Reserva Ecológica de Guapiaçu, Trilha do Fragmento, 22°28'6.20"S, 042°45'38.70"W, 41m, 17.v.2017, beating, R. Baptista coll. (MNRJ 60027). Paratypes: BRAZIL: Rio de Janeiro: Cachoeiras de Macacu, Reserva Ecológica de Guapiaçu, Trilha Verde, 22°24'28.30"S, 042°44'16.10"W, 296 m, 18.v.2017, sweeping, H. Schinelli coll., 1 ♂, 1 juvenile (UFRJ 1584); same locality and date as preceding, R. Baptista coll., 1 ♂ (UFRJ 1585); Reserva Ecológica de Guapiaçu, São José, 22°26'15.60"S, 042°46'26.20"W, 71 m, 01.ix.2017, looking down, R. Baptista coll., 1 ♀ (UFRJ 1586); 1 ♀ (MNRJ 60028); same locality as preceding, 16.xii.2017, sweeping, R. Baptista coll., 1 ♂, 2 immatures (UFRJ 1587); same locality as preceding, 31.viii.2019, looking down, G. Oliveira coll. (UFRJ 1599).

**Additional material examined.** None.

**Etymology.** The specific epithet "*hastatus*" is a Latin adjective, from the Latin root "*hasta*", meaning spear and referring to the projection on basal article of male chelicerae.

**Diagnosis.** Males of *A. hastatus* sp. nov. are easily diagnosed from all other species within the genus by straight and extremely elongate, spear-like apophyses on the ectal side of the chelicerae; these apophyses project well beyond the clypeus and are clearly visible in dorsal view (Figs 4A, 5A, 7A). Females of *A. hastatus* sp. nov. bear a epigynum with a deep notch at the posterior rim and a curved U-shaped CO. Internal genitalia of *A. hastatus* sp. nov. is set apart from all species within the genus by the extremely thick copulatory ducts with the ectal branch

bent over and curved outwards, touching the mesal branches forming wide ventral glandular heads, placed near the spermathecae (Figs 6F, 7F, 11B).

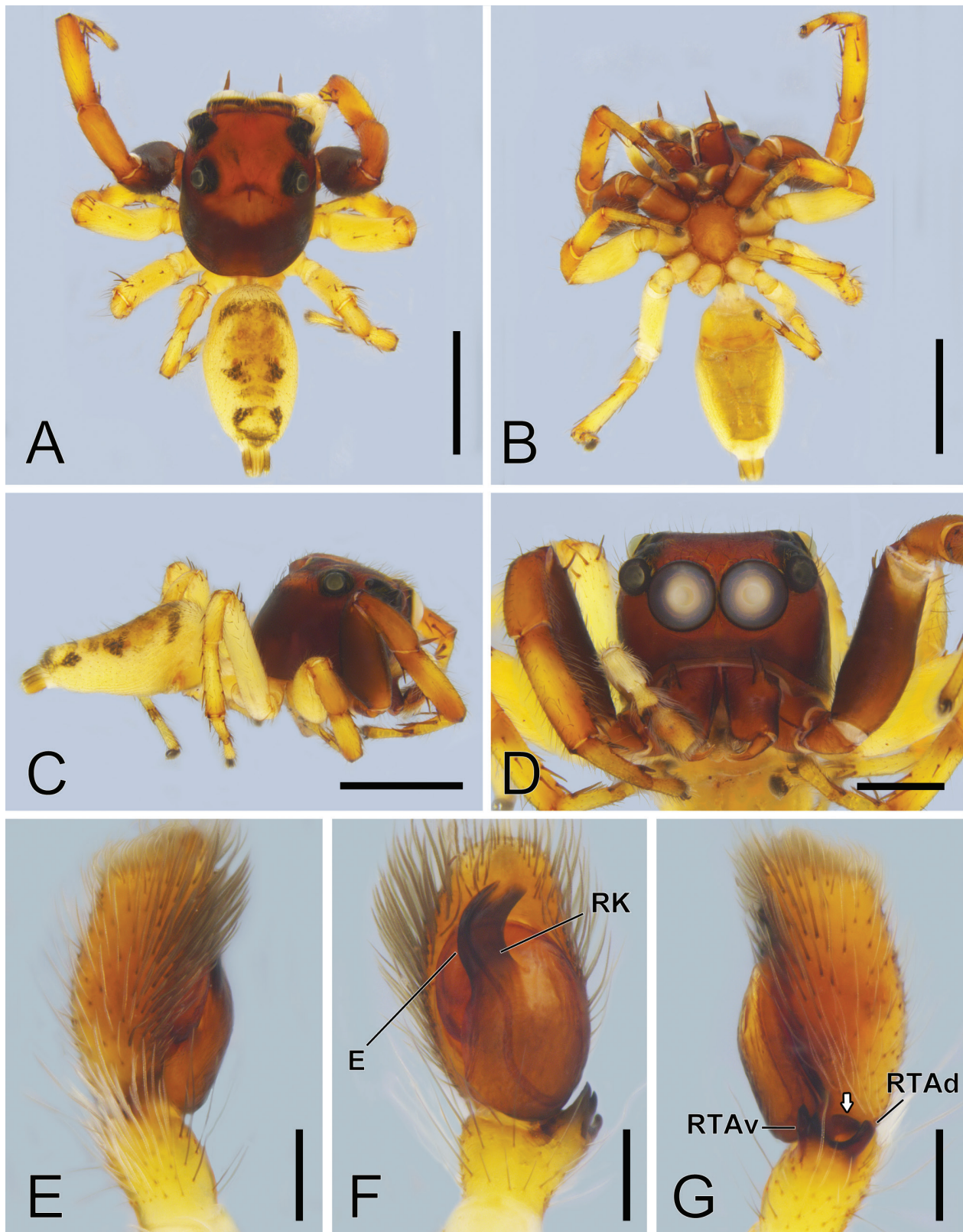
**Description.** **Male** (holotype MNRJ 60027): carapace reddish brown, lighter from behind the fovea towards anterior elevated part (Figs 4A, 5A, B). Labium reddish brown and very elongated (Fig. 4B). Endites short, basally reddish brown, orange-brown midway, and distally beige (Fig. 4B). Sternum orange-brown with a smooth darker contour (Fig. 4B). AME centrally placed, almost touching and occupying most of clypeus height; ALE reduced and almost adjoined to AME and PME, located on the edge of carapace, with contour of yellow setae, and PLE evenly separate by almost carapace length (Figs 4A, C, D, 5A, B). Leg I with reddish brown femur and orange-brown patella, tibia, metatarsus, and tarsus, with dusky patches from tibia to tarsus; Legs II–IV yellow, with Leg II bearing dusky patches from patella to tarsus (Fig. 4A–D). Chelicerae with orange-brown paturon, bearing extremely elongated spear-like apophyses on their ectal side (Fig. 4A, B, 5A, B, 7A). Abdomen oval and tapering to the elongated, yellow median and brown lateral spinnerets (Figs 4A–C, 5A). Dorsum yellow, with black transversal line after folium, followed by a brown region towards two medially placed black patches and a small dusky black patch on middle third and rounded black patch on posterior edge (Figs 4A, 5A). Lateral portion of abdomen yellow with no patches or lines (Fig. 4C). Venter yellow on area of book-lungs, greyish towards posterior edge, with two longitudinal, yellow lines midway and lighter contour near spinnerets (Fig. 4B). Palps with short tubular tibias bearing RTAv more developed than RTAd and set apart by a wide, U-shaped notch; RTAv clearly divided midway, forming two pointed projections and RTAd finger-like with a rounded tip (Figs 4G, 7C, E). RTA hook large, visible behind the deep notch separating both branches of RTA (Figs 4G, 7C, E). Cymbium elongated and oval, completely covered by long setae (Figs 4E–G, 7B, C). Embolic complex long, regularly arched, relatively narrow with a poorly sclerotized fringe: embolus itself thick, more elevated, followed by the boomerang-shaped embolic retrolateral keel that bears a straight and undivided tip (Figs 4F, 7B, D).

Total length 5.34. Carapace 2.56 long, 1.85 wide, 1.35 high. Left chelicera 1.03 long, 0.54 wide. Clypeus 0.23 high. Endites 0.70 long, 0.45 wide. Labium 0.46 long, 0.36 wide. Sternum 1.17 long, 0.86 wide. Abdomen 2.6 long, 1.32 wide, 1.45 high.

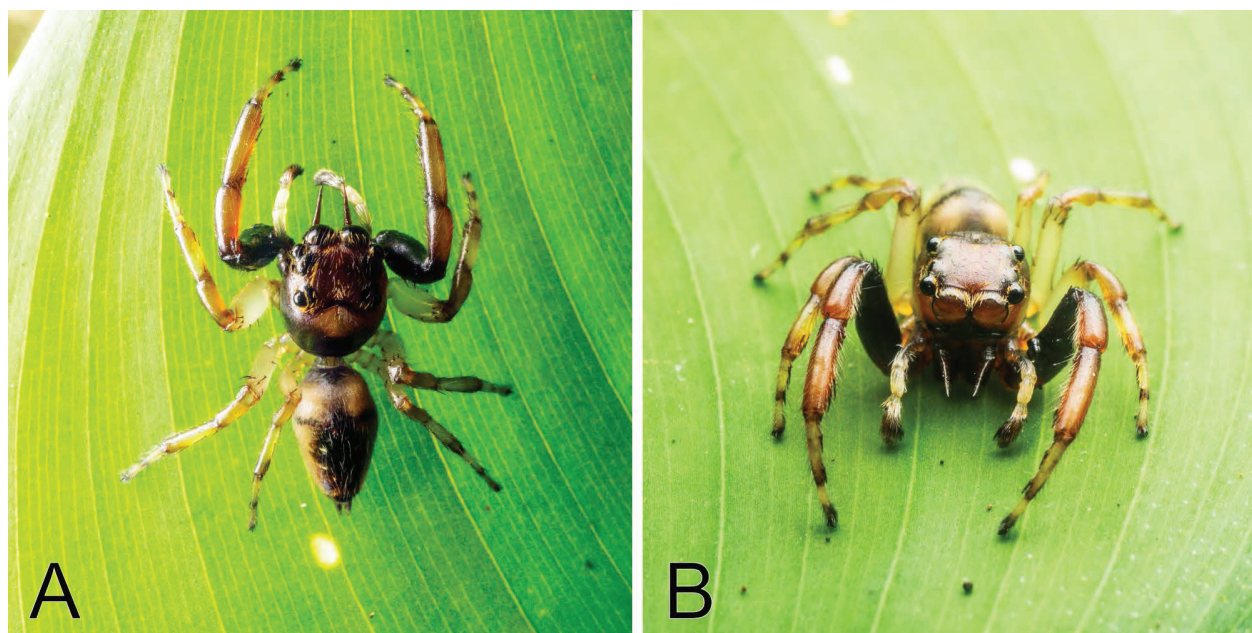
Diameter of eyes and interdistances: AME 0.71; ALE 0.34; PME 0.10; PLE 0.33. ALE-PME 0.40; PME-PLE 0.37. Ocular area (dorsal view): 1.28 long, 1.50 anterior width, 1.22 posterior width.

Leg articles length: Leg I: Fe 1.59; Pa 1.07; Ti 1.63; Mt 1.02; Ta 0.61; Total 5.92. Leg II: Fe 1.33; Pa 0.56; Ti 0.98; Mt 0.82; Ta 0.58; Total 4.27. Leg III: Fe 1.91; Pa 0.53; Ti 0.98; Mt 0.97; Ta 0.58; Total 4.97. Leg IV: Fe 1.62; Pa 0.78; Ti 0.80; Mt 1.01; Ta 0.65; Total 4.86.





**Figure 4.** *Arnoliseus hastatus* sp. nov., male holotype (MNRJ 60027). **A.** Dorsal habitus. **B.** Ventral habitus; **C.** Lateral habitus; **D.** Frontal habitus; **E–G.** Left palp: **E.** Prolateral view; **F.** Ventral view; **G.** Retrolateral view, exposing the RTA. Scale bars: 2 mm (A–C); 1 mm (D); 0.2 mm (E–G). Arrow points to RTA hook.



**Figure 5.** *Arnoliseus hastatus* sp. nov., male paratype (UFRJ 1599) in vivo. **A.** Dorsal habitus; **B.** Frontal-dorsal habitus. Photos: André Almeida Alves

Leg formula I-III-IV-II.

**Female:** (paratype UFRJ 1586): carapace orange-brown, darker on ocular area (Fig. 6A). Fovea orange (Fig. 6A). Labium elongated and orange-brown (Fig. 6B). Endites short and reddish brown, anteriorly lighter (Fig. 6B). Sternum orange-brown (Fig. 6B). Eyes as male, contoured by yellow setae (Fig. 6A–D). Leg I orange-brown, Legs II–IV yellowish brown (Fig. 6A–D). Abdomen beige, with same shape as male (Fig. 6A, C). Dorsum with darker patches, first two on the folium, followed by a transversal patch almost in the middle portion, and remaining ones as in male (Fig. 6A, C). Venter as male (Fig. 6B). Epigynal plate sclerotized, orange, short, and with a deep notch in the posterior rim, with two basal, anteriorly curved, U-shaped slit openings (Fig. 6E). Internal genitalia composed of slender, ribbon-like fertilization ducts on the anterior portion of the spermathecae, which are extremely thick, rounded, and connected to two rounded, uniformly thick and bulky copulatory ducts, with a thicker ectal branch that bend over to a curved tip, in a ventrally placed glandular head that touches the thinner mesal branch of CD (Figs 6F, 7F, 11B).

Total length 6.66. Carapace 3.05 long, 1.99 wide, 1.54 high. Left chelicera 0.91 long, 0.61 wide. Clypeus 0.36 high. Endites 0.53 long, 0.41 wide. Labium 0.61 long, 0.25 wide. Sternum 1.19 long, 0.88 wide. Abdomen 3.37 long, 1.93 wide, 1.33 high.

Diameter of eyes and interdistances: AME 0.76; ALE 0.32; PME 0.11; PLE 0.31. ALE–PME 0.28; PME–PLE 0.28. Ocular area (dorsal view): 1.52 long, 1.67 anterior width, 1.61 posterior width.

Leg articles length: Leg I: Fe 1.75; Pa 0.73; Ti 1.40; Mt 0.83; Ta 0.56; Total 5.27. Leg II: Fe 1.46; Pa 0.69; Ti 0.98; Mt 0.75; Ta 0.54; Total 4.42. Leg III: Fe 1.97;

Pa 0.77; Ti 1.01; Mt 1.02; Ta 0.64; Total 5.41. Leg IV: Fe 1.44; Pa 0.69; Ti 1.03; Mt 1.08; Ta 0.69; Total 4.93.

Leg formula I-III-IV-II.

**Variation.** Males ( $n = 3$ ): total length, 5.18–7.09. Females ( $n = 2$ ): total length, 5.23–6.66.

**Distribution.** Only known from type locality (Fig. 12).

**Preservation status.** Well preserved in 75% ethanol. Male holotype with left chelicera and palp dissected. Female paratype UFRJ 1586 with genitalia dissected.

#### *Arnoliseus falcatus* sp. nov.

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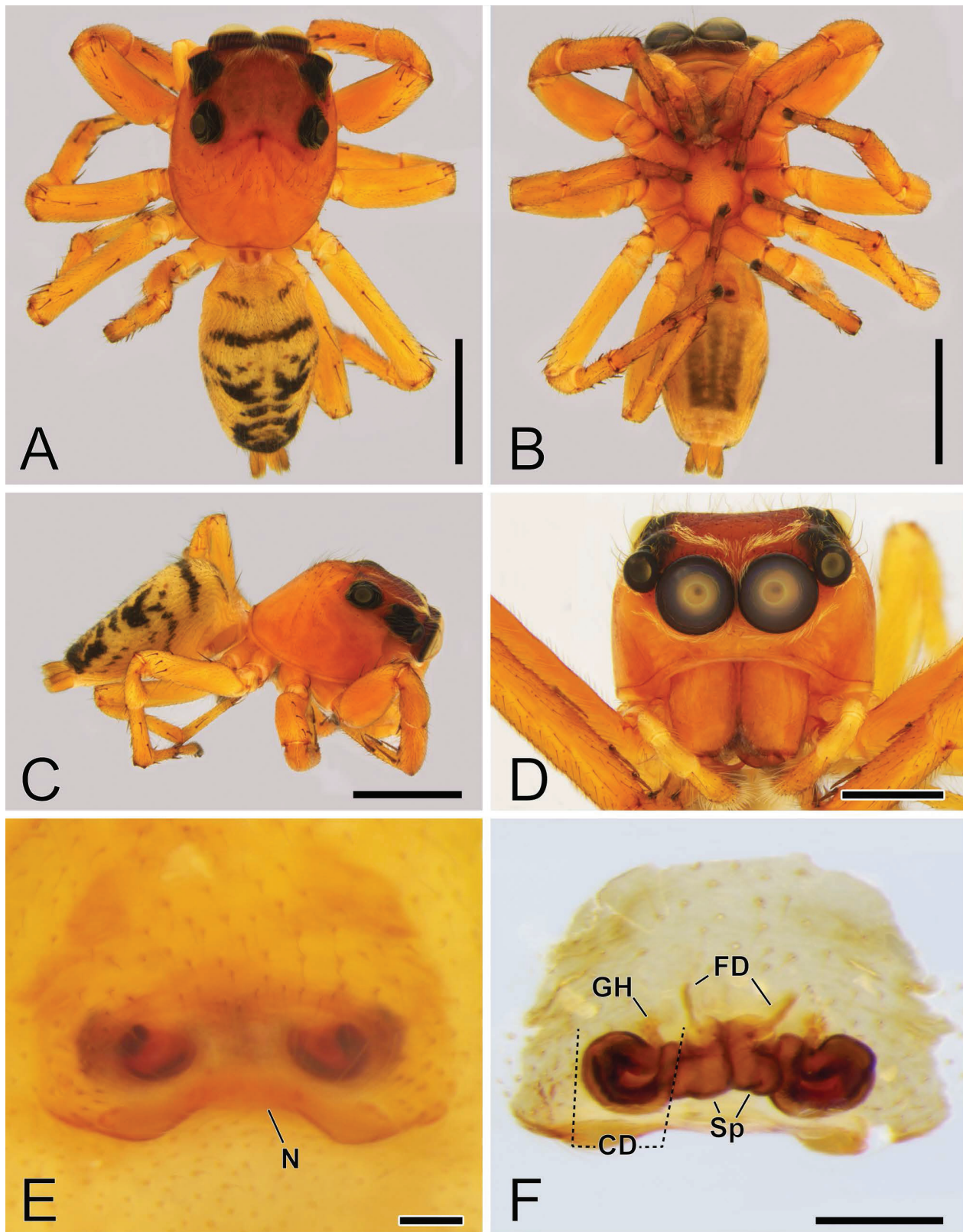
Figs 8–12

**Type material.** Holotype ♂. BRAZIL: Rio de Janeiro: Cachoeiras de Macacu, Reserva Ecológica de Guapiaçu, Trilha da Lagoa, 22°26'47.90"S, 42°46'20.70"W, 58 m, 11.v.2019, sweeping, R. Baptista coll. (MNRJ 60029). Paratype: BRAZIL: Rio de Janeiro: Cachoeiras de Macacu, Reserva Ecológica de Guapiaçu, São José, 22°26'15.60"S, 42°46'26.20"W, 71 m, 12.vii.2018, cryptic, G. Oliveira coll., 1 ♀ (UFRJ 1588).

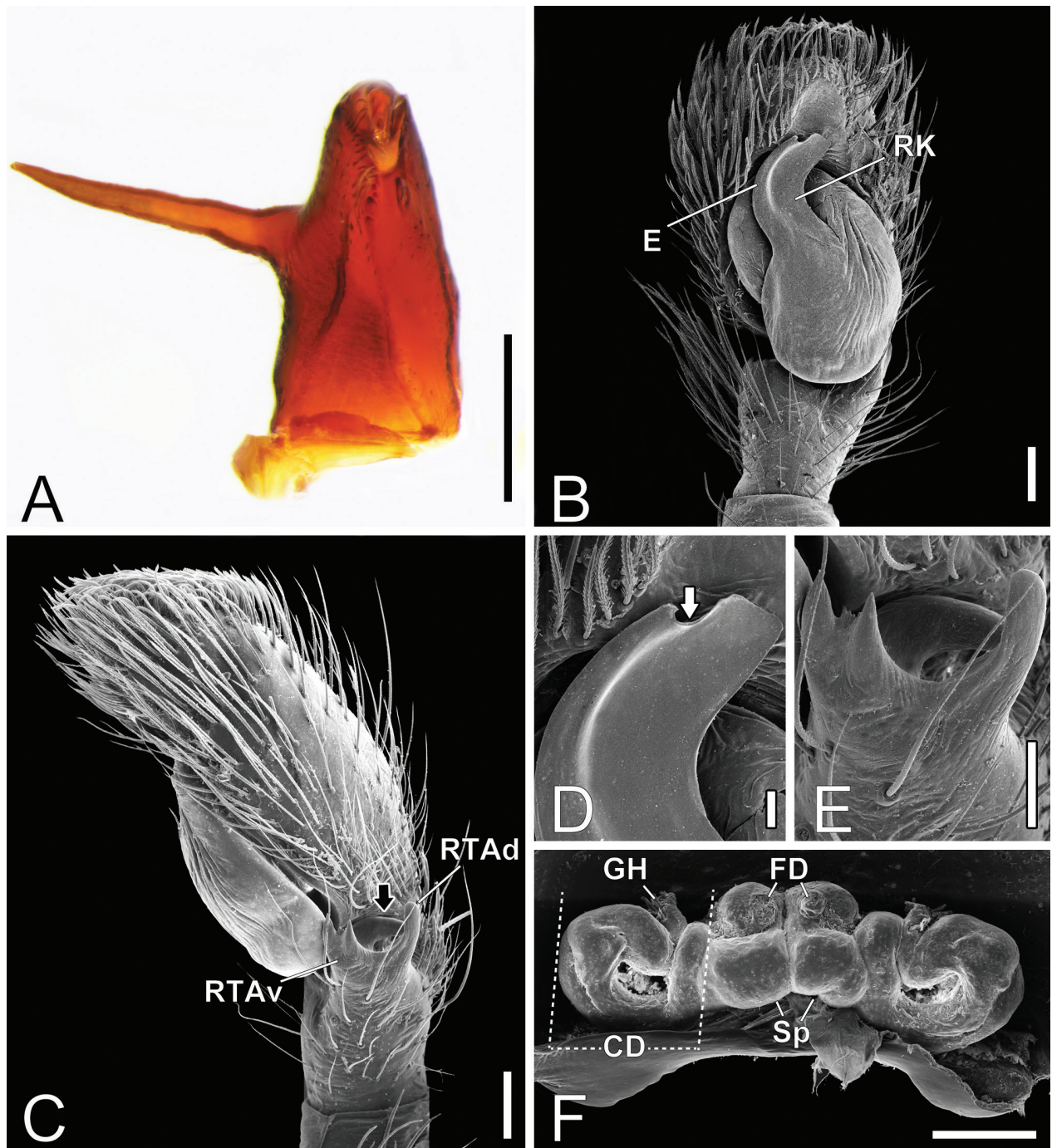
**Etymology.** The specific epithet “*falcatus*”, considered as an adjective, derives from “*falx*”, a Latin word meaning scythe or sickle, which refers to the scythe-like projection at the apex of the male cheliceral apophysis.

**Diagnosis.** *Arnoliseus falcatus* sp. nov. males have palps with retrolateral embolic keels bearing a tip directed ret-





**Figure 6.** *Arnoliseus hastatus* sp. nov., female paratype (UFRJ 1586). **A.** Dorsal habitus; **B.** Ventral habitus; **C.** Lateral habitus; **D.** Frontal habitus; **E.** Epigyne, ventral view; **F.** Internal genitalia, dorsal view. Scale bars: 2 mm (**A–C**); 1 mm (**D**); 0.1 mm (**E**); 0.2 mm (**F**).

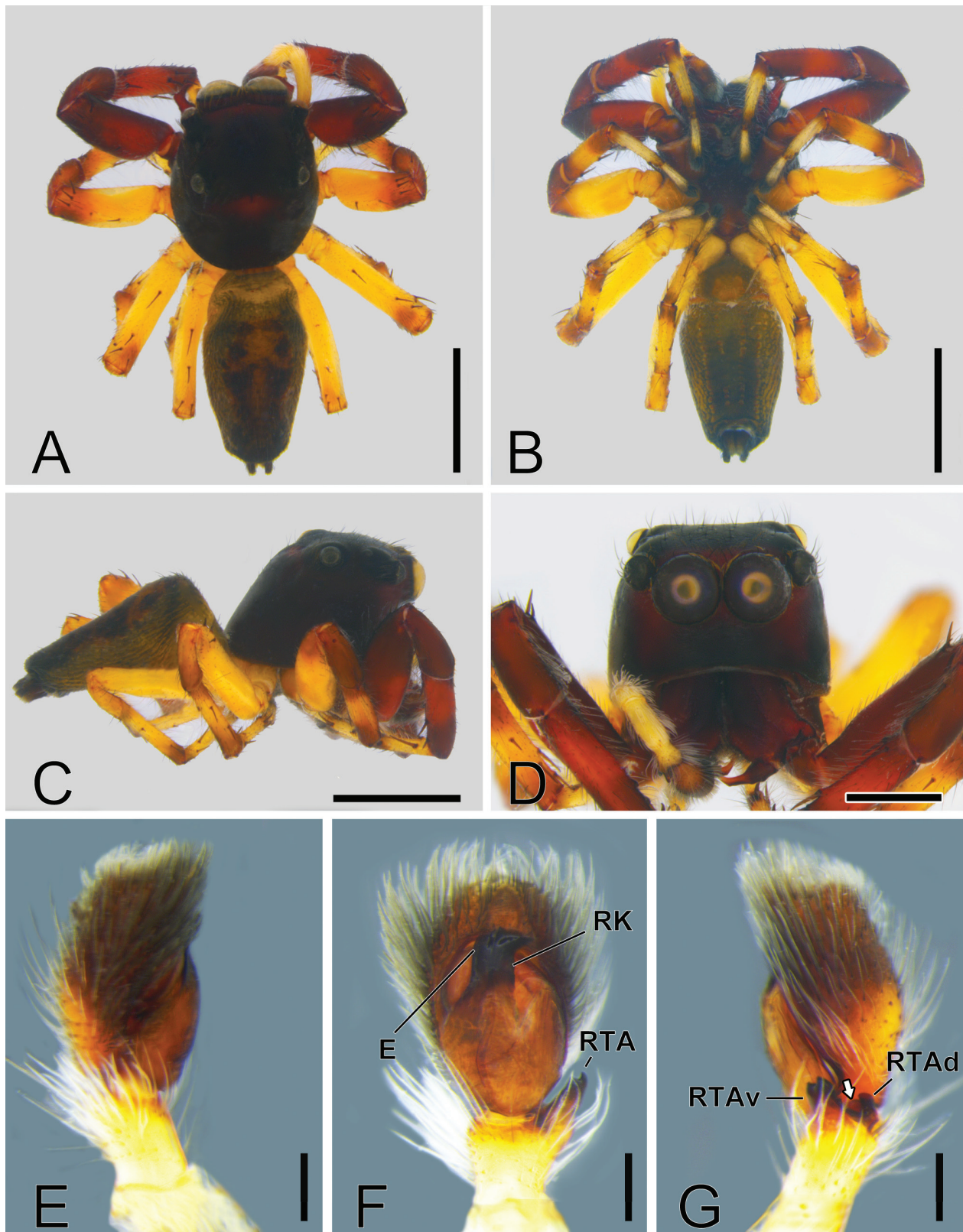


**Figure 7.** *Arnoliseus hastatus* sp. nov. **A.** Male holotype left chelicera, ventral view exposing the apophysis (MNRJ 60027). **B–F.** SEM images: **B.** Left male palp, ventral view (UFRJ 1585); **C.** Left male palp, retrolateral view (UFRJ 1585); **D.** left male palp, embolus detail (UFRJ 1585); **E.** Left male palp, RTA detail (UFRJ 1585); **F.** Female internal genitalia, dorsal view (UFRJ 1586). Scale bars: 0.5 mm (**A**); 0.1 mm (**B, C, F**); 0.02 mm (**D**); 0.05 mm (**E**). White arrow points to the embolus pore. Black arrow points to RTA hook.

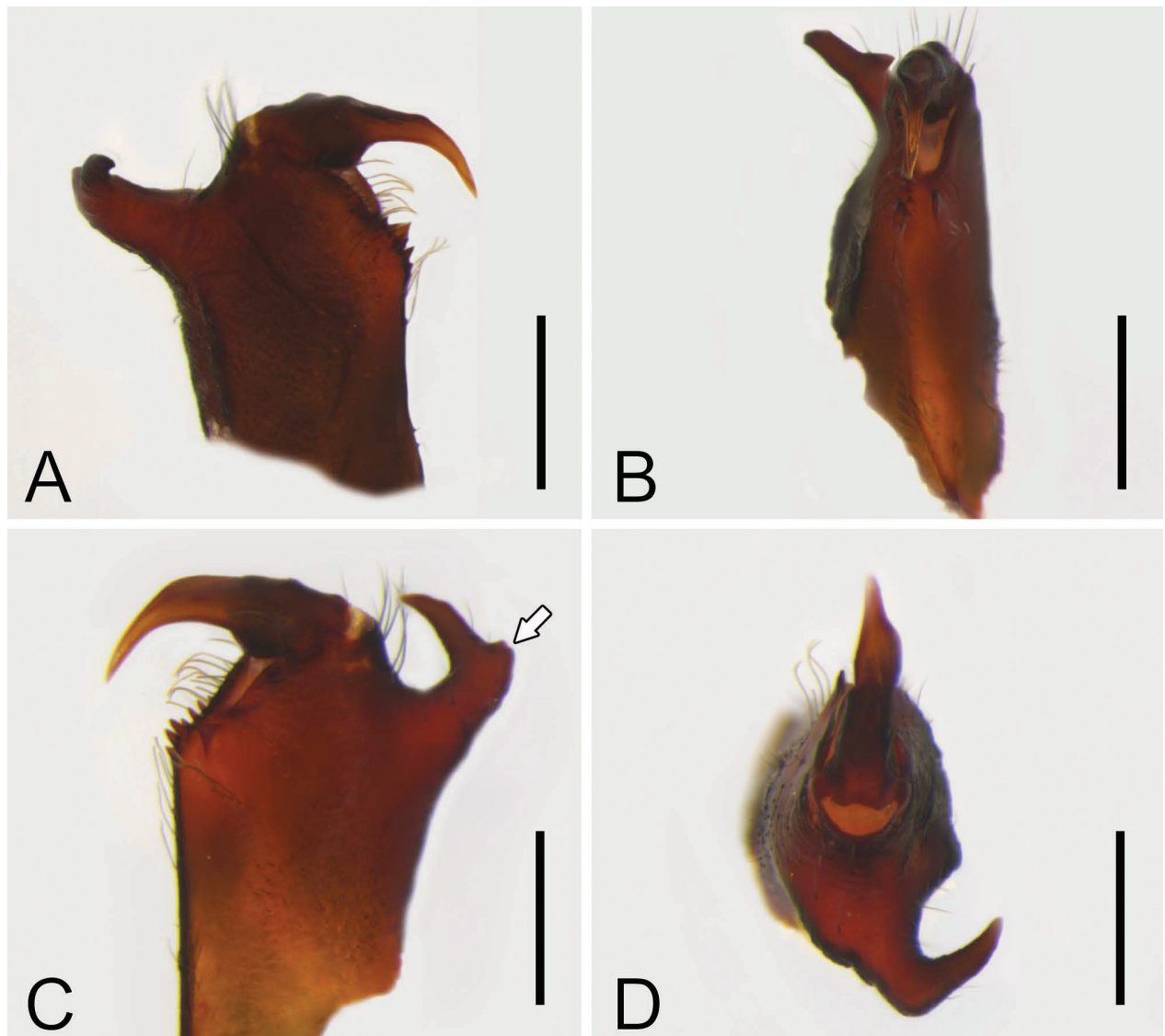
rolaterally as in *A. carioca* sp. nov. (Figs 1E, F, 3B, D, 8F), but the RTAv is bifid and larger than RTAd, as in *A. hastatus* sp. nov. (Figs 4F, G, 7C, E, 8F, G). However, *A. falcatus* sp. nov. has the RK long and with a thicker retrolateral projection, at the same level of the embolus tip (Fig. 8F), and the RTAd is much lower in position in comparison to the clearly divided RTAv (Figs 8F, G). Cheliceral apophysis (or mastidia) are similar to *A. cario-*

*ca* sp. nov. and *A. graciosa*, as in all three species they are curved into a C-shape (Figs 3A, 9A–D; Braul and Lise 2002: fig. 40). In *A. graciosa* and *A. falcatus* sp. nov., there is a clear elbow midway, with a distal curved hook. *A. falcatus* sp. nov. differs by its small cap over a wider and shorter basal part and a thinner distal hook (Fig. 9A–D). Females differ from all described species by the transversally placed CO, which is situated below the tips of the





**Figure 8.** *Arnoliseus falcatus* sp. nov., male holotype (MNRJ 60027). **A.** Dorsal habitus. **B.** Ventral habitus. **C.** Lateral habitus; **D.** Frontal habitus; **E–G.** Left palp: **E.** Prolateral view; **F.** Ventral view; **G.** Retrolateral view, exposing the RTA. Scale bars: 2 mm (**A–C**); 1 mm (**D**); 0.2 mm (**E–G**). Arrow points to RTA hook.



**Figure 9.** *Arnoliseus falcatus* sp. nov., male holotype left chelicera, exposing the apophysis (MNRJ 60027). **A.** Ectal view; **B.** Ventral view; **C.** Mesal view; **D.** Distal view. White arrow points to the tip of the knob.

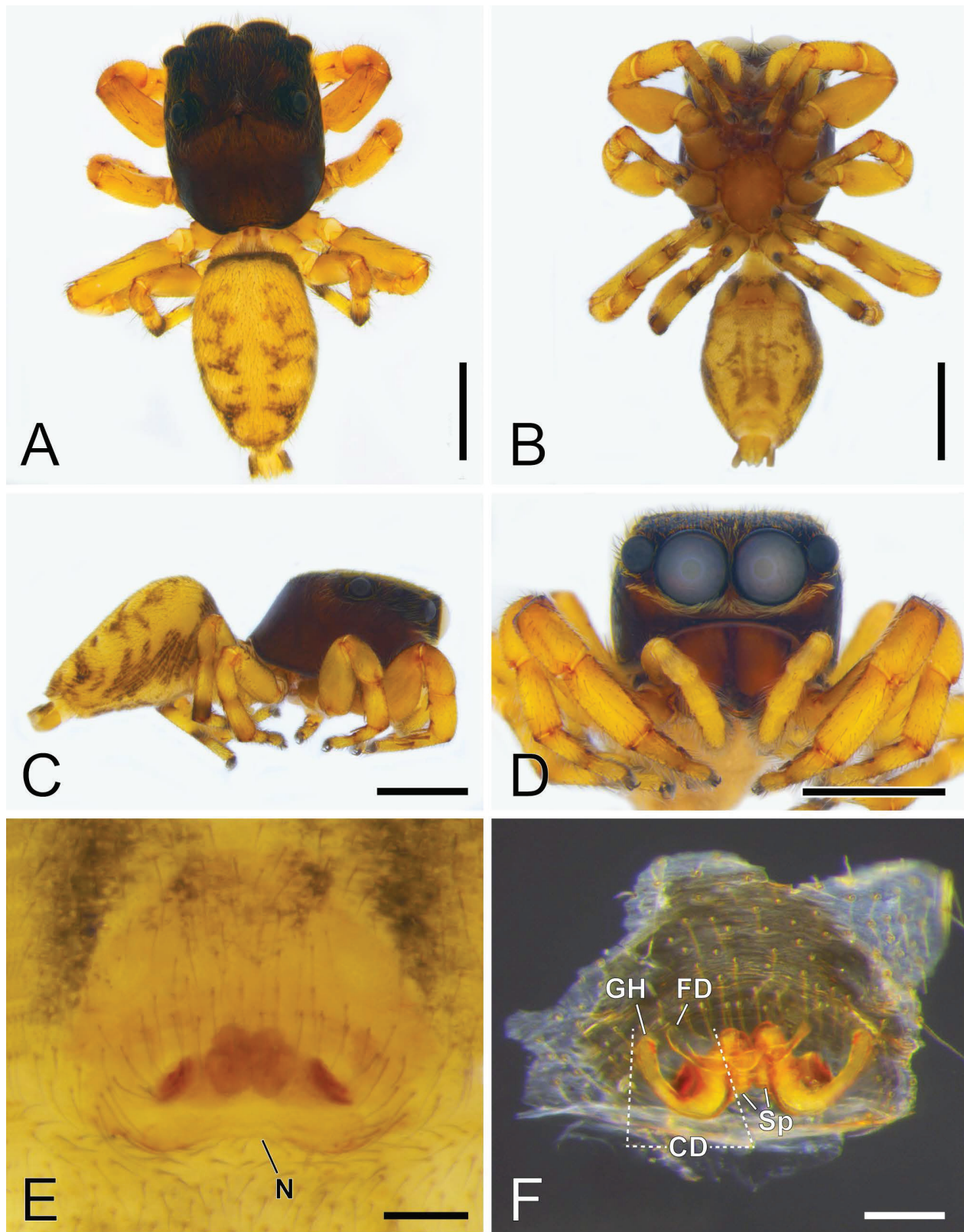
spermathecae, and by the medially constricted, extremely elongated, and laterally projected, tubular ectal branch of the copulatory duct (Figs 10F, 11C).

**Description. Male** (Holotype MNRJ 60029): carapace dark brown, reddish brown on fovea (Fig. 8A). Labium and endites dark brown (Fig. 8B). Sternum dark brown, lighter posteriorly (Fig. 8B). AME centrally placed, almost touching and occupying half of clypeus height, bearing yellow setae; ALE small, with black tapetum and almost adjoined to AME, located on edge of carapace; PME reduced and located midway between PME and PLE, which is evenly separate by almost carapace length (Fig. 8A, C, D). Leg I reddish brown; Leg II–IV yellow, Leg II with darker patella and joints (Fig. 8A–D). Chelicerae with paturon reddish brown, bearing curved C-shaped apophyses with small knobs midway (Fig. 9A–D). Abdomen oval and tapering to the elongated, dark brown spinnerets (Fig. 8A–C). Dorsum dark

brown, with two opposite black patches after the folium, followed by two thick parallel black lines towards the posterior rim (Fig. 8A). Lateral portion of abdomen dark brown, with no patches or lines (Fig. 8C). Venter dark brown, with big black region towards spinnerets (Fig. 8B). Palps with short tubular tibias bearing the small RTA branches separated by a small irregular sclerotized gap; RTAv much larger, clearly carved midway, and apically placed in relation to the rounded RTAd (Fig. 8G). RTA hook medium-sized, scarcely visible behind the notch separating both branches of RTA (Figs 8G). Cymbium elongated, oval, completely covered by long setae (Fig. 8E–G). Embolic complex long, relatively thin; RK bearing a large, elongated, triangular retrolateral tip, in the same level of the sclerotized and almost undistinguishable embolus itself (Fig. 8F).

Total length 5.76. Carapace 2.72 long, 2.35 wide, 2.04 high. Left chelicera 0.79 long, 0.71 wide. Clypeus 0.47 high. Endites 0.74 long, 0.47 wide. Labium 0.54





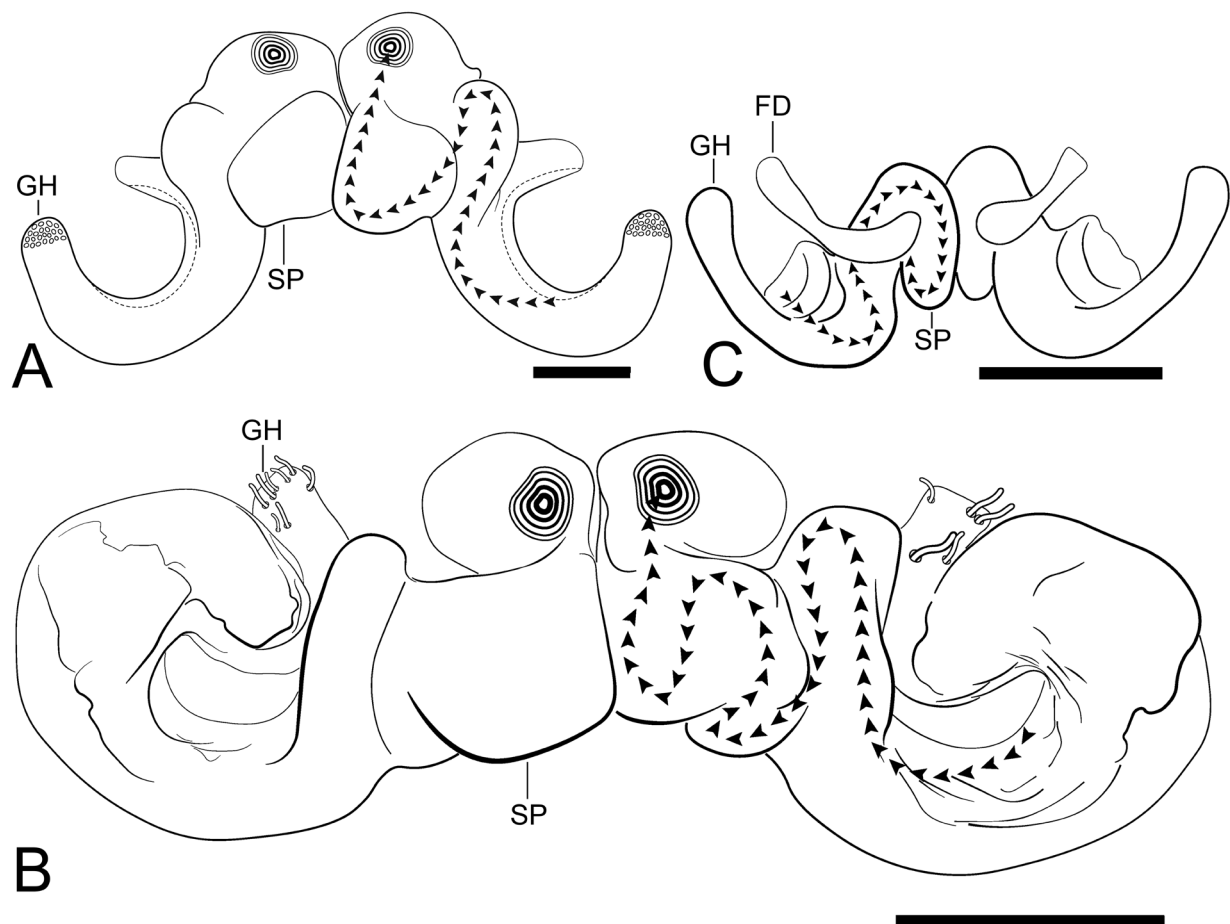
**Figure 10.** *Arnoliseus falcatus* sp. nov., female paratype (UFRJ 1588). **A.** Dorsal habitus; **B.** Ventral habitus; **C.** Lateral habitus; **D.** Frontal habitus; **E.** Epigyne, ventral view; **F.** Internal genitalia, dorsal view. Scale bars: 1 mm (**A–D**); 0.1 mm (**E, F**).

long, 0.19 wide. Sternum 1.26 long, 0.98 wide. Abdomen 3.04 long, 1.66 wide, 1.96 high.

Diameter of eyes and interdistances: AME 0.67; ALE 0.34; PME 0.15; PLE 0.33. ALE-PME 0.41; PME-PLE

0.38. Ocular area (dorsal view): 1.24 long, 1.50 anterior width, 1.60 posterior width.

Leg articles length: Leg I: Fe 2.31; Pa 1.26; Ti 1.88; Mt 1.01; Ta 0.61; Total 7.07. Leg II: Fe 2.06; Pa 0.88;



**Figure 11.** Schematic illustrations of female internal genitalia, dorsal view. **A.** *Arnoliseus carioca* sp. nov. **B.** *Arnoliseus hastatus* sp. nov. **C.** *Arnoliseus falcatus* sp. nov. Scale bars: 0.1 mm (A–C). Arrows illustrate the flow direction in internal ducts.

Ti 1.29; Mt 0.77; Ta 0.39; Total 5.39. Leg III: Fe 2.44; Pa 0.78; Ti 1.30; Mt 0.98; Ta 0.52; Total 6.02. Leg IV: Fe 1.98; Pa 0.64; Ti 1.13; Mt 1.10; Ta 0.41; Total 5.26.

Leg formula I-III-II-IV.

**Female:** (Paratype UFRJ 1588): carapace and fovea as male, completely covered of yellow setae (Fig. 10A, C). Labium subquadrate and brown (Fig. 10B). Endites short and brown (Fig. 10B). Sternum brown, with dusky, narrow contour (Fig. 10B). Eyes as male (Fig. 10A, C, D). Clypeus with thick row of yellow setae in the gap between AME and chelicerae (Fig. 10D). Legs yellowish brown (Fig. 10A–D). Abdomen beige, with same shape as male (Fig. 10A, C). Dorsum with black contour on the anterior part, followed by parallel black dusky patches towards posterior rim (Fig. 10A, C). Lateral portion of abdomen with black scratchy patch (Fig. 10C). Venter beige (Fig. 10B). Epigyne with a small, ill-defined yellow epigynal plate, with slight notch on posterior rim, bearing two small slanted slit openings, placed at a level posterior to the anterior half of the spermathecae (Fig. 10E, F). Internal genitalia composed of two central, curved tubular spermathecae, with the fertilization ducts connected to its ventral end, where the copulatory ducts, also tubular U-shaped, are connected. Copulatory ducts composed

of a wider mesal branch, that taper to long tubular ectal branch, ending in rounded glandular heads, placed far away of the spermathecae (Figs 10F, 11C).

Total length 4.09. Carapace 1.97 long, 1.36 wide, 1.02 high. Left chelicera 0.43 long, 0.38 wide. Clypeus 0.17 high. Endites 0.43 long, 0.36 wide. Labium 0.32 long, 0.24 wide. Sternum 0.78 long, 0.61 wide. Abdomen 1.97 long, 1.26 wide, 1.03 high.

Diameter of eyes and interdistances: AME 0.48; ALE 0.25; PME 0.09; PLE 0.20. ALE–PME 0.27; PME–PLE 0.27. Ocular area (dorsal view): 0.87 long, 0.97 anterior width, 1.09 posterior width.

Leg articles length: Leg I: Fe 0.97; Pa 0.59; Ti 0.73; Mt 0.42; Ta 0.34; Total 3.05. Leg II: Fe 0.91; Pa 0.44; Ti 0.47; Mt 0.43; Ta 0.28; Total 3.02. Leg III: Fe 1.11; Pa 0.52; Ti 0.57; Mt 0.40; Ta 0.42; Total 3.02. Leg IV: Fe 1.02; Pa 0.32; Ti 0.59; Mt 0.62; Ta 0.43; Total 2.98.

Leg formula I-III-IV-II.

**Distribution.** Only known from type locality (Fig. 12).

**Preservation status.** Well preserved in 75% ethanol. Male holotype with left chelicera and palp dissected. Female paratype with genitalia dissected.



## Key to species

- 1 Male ..... 2
- Female ..... 6
- 2 Chelicerae with very elongated, narrow, straight and pointed apophyses, visible in dorsal view ..... *A. hastatus* sp. nov. (Figs 4A, B, D, 5A, B, 7A)
- Chelicerae with apophyses moderately elongated, curved inwards and not visible in dorsal view ..... 3
- 3 Tip of embolic complex rounded, not diverging from the retrolateral keel ..... *A. graciosa* (Braul and Lise 2002: fig. 37)
- Tip of embolic complex diverging in a truncated retrolateral keel ..... 4
- 4 RTAv not pointed and apart from posterior RTAd by a smaller gap ..... 5
- RTAv pointed and apart from RTAd by a very large gap ..... *A. calcarifer* (Braul and Lise 2002: figs 30, 32)
- 5 Embolic keel in a lower position in comparison with the tip of the embolus itself and with a small retrolateral tip ..... *A. carioca* sp. nov. (Figs 1F, 3B–D)
- Dark brown abdomen; embolic keel in the same level of the embolus itself and with retrolateral tip longer and wider... *A. falcatus* sp. nov. (Fig. 8A, F)
- 6 Epigyne with two thick, slit-like copulatory openings ..... 7
- Epigyne with slender, slit-like copulatory openings ..... *A. graciosa* (Braul and Lise 2002: fig. 41).
- 7 CD with slender ectal branches overreaching the spermathecae apices ..... 8
- CD with thick ectal branches in lower position from the spermathecae apices ..... 9
- 8 Glandular heads thick, enlarged, and not twisted ..... *A. calcarifer* (Braul and Lise 2002: fig. 33)
- CD with tubular and elongated ectal branches, laterally projected ..... *A. falcatus* sp. nov. (Figs 10F, 11C)
- 9 CD with U-shaped ectal branches with pointed glandular heads ..... *A. carioca* sp. nov. (Figs 2F, 3F, 11A)
- CD bending over, with ectal branches bearing thick, enlarged, and twisted glandular heads which touch the mesal branches ..... *A. hastatus* sp. nov. (Figs 6F, 7F, 11B).

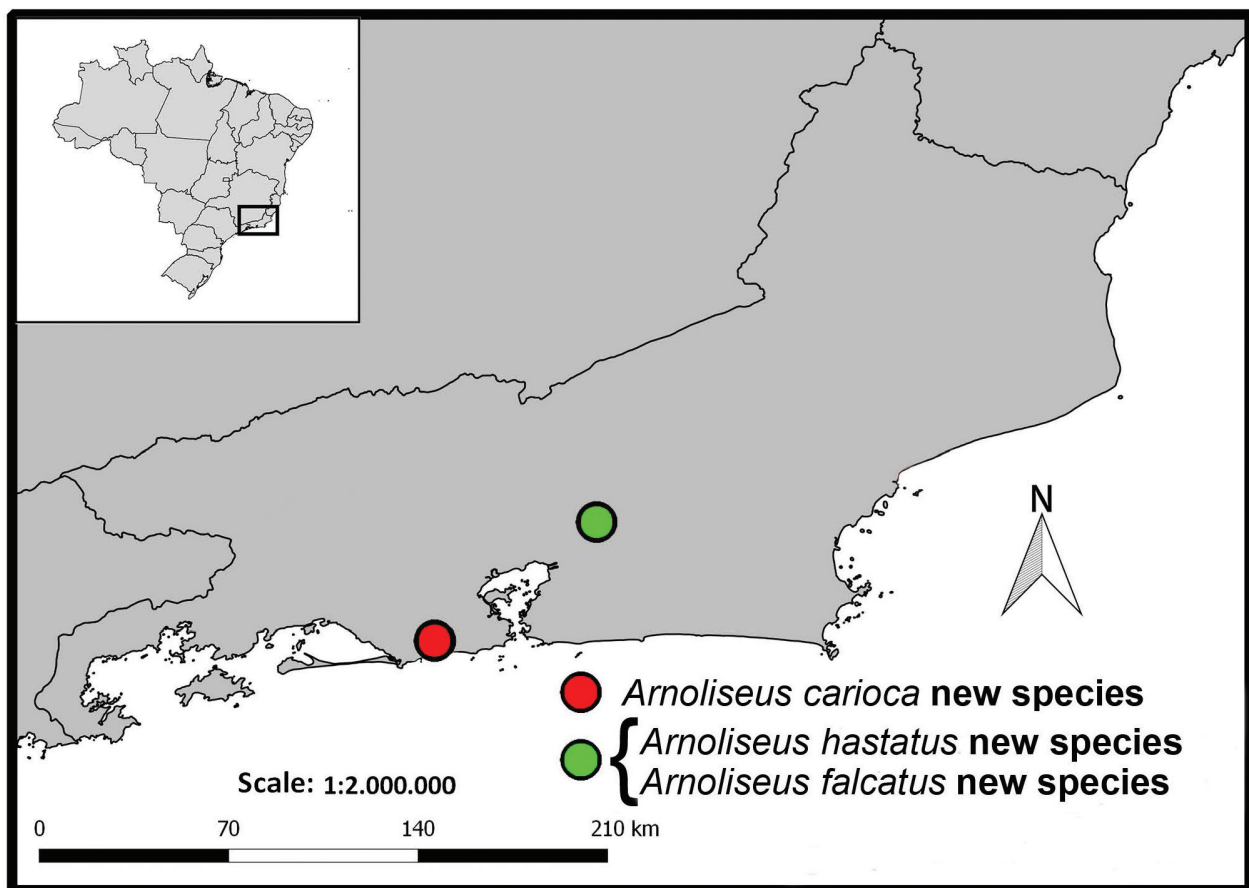


Figure 12. Map with the type localities of the three new species.

## Acknowledgments

We thank A. Kury and Carla Barros for depositing the new species holotypes and some of the paratypes in the MNRJ. We also thank the staff of the Parque Estadual da Pedra Branca and Reserva Ecológica de Guapiaçu for which fieldwork would otherwise be impossible. We are also indebted to Dr José Ricardo M. Mermudes for the use of automontage microscope at Laboratório de Entomologia (UFRJ), to André Almeida Alves for the live specimen photos and to Marcelo Henrique de Oliveira Sales for the assistance with taking SEM photos at Laboratório de Imagem (UFRJ). Finally, we thank the editor, Danilo Harms, and the reviewers, Tamás Szűts, Gustavo Ruiz, and Marek Żabka, for their enriching comments that improved our manuscript, and we acknowledge the support of the Museum für Naturkunde Berlin in publishing our research. This study was only possible due to a Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) PhD scholarship (88882.183274/2018-01) to the second author.

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