

# Common littoral pycnogonids of the Mediterranean Sea

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## Abstract

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## Key Words

SEM

Pycnogonida

Sea spider

*Achelia*

*Ammothella*

*Anoplodactylus*

*Callipallene*

*Endeis*

*Pycnogonum*

*Tanystylum*

*Trygaeus*

In the present study 21 littoral pycnogonid species from 5 families are analysed: Ammotheidae (9 species), Callipallenidae (5 species), Endeidae (2 species), Phoxichilidiidae (3 species), and Pycnogonidae (2 species). The material was mainly taken from Mediterranean pycnogonid collections housed in the Bavarian State Collection of Zoology. Additional material was collected during field trips. Altogether the material was obtained from six different locations: Banyuls-sur-Mer (France), Tavolara Island (Italy), Elba Island (Italy), Giglio Island (Italy), Sicily Island (Italy), and Istria Peninsula (Croatia). The animals were studied in detail with a scanning electron microscope (SEM). Additionally series of light microscopic pictures were made to generate extended depth of field pictures of whole animals. The observed features are compared with previous literature.

## Introduction

The Pycnogonida or sea spiders are exclusively marine invertebrates, numbering more than 1330 species worldwide (Arango and Wheeler 2007, Bamber and El Nagar 2013). They were first named Pycnonides Latreille, 1810. Later they were given the names Podosomata Leach, 1815 and Pantopoda Gerstaeker, 1863. The latter name is still in use for the order which comprises all extant pycnogonids. Although largely unnoticed, due to their cryptic form, often small size, and economic insignificance, sea spiders are common benthic animals occurring from the littoral zone to the deep-sea, in all oceans from the poles to the tropics. Most species are benthic, few are in-

terstitial, some are pelagic and some are commensals or ectoparasites of other invertebrates. Pycnogonids are normally small animals; littoral species have a leg span of at most a few centimetres, while polar and deep-water species can achieve a leg span of 70 cm (Ruppert et al. 2004).

The phylogenetic position of the Pycnogonida has long been controversial and is still under debate. Today pycnogonids are placed either within the Chelicerata as sister taxon of the Euchelicerata or as sister taxon of all other Euarthropoda (Dunlop and Arango 2005, Regier et al. 2010, Giribet and Edgecombe 2012). The phylogenetic relationships within the group are discussed as well. Traditionally the Pycnogonida were divided into eight families (Hedgpeth 1947) but with uncertain relationships.

Recently studies on this point, using morphological and / or molecular characters were realized (Arango 2002, Arango 2003, Arango and Wheeler 2007, Nakamura et al. 2007). On the basis of these studies Bamber (2007) and Bamber and El Nagar (2013) suggested 11 families.

The Mediterranean Sea as we know it today developed about 5 million years ago. After the Messinian salinity crisis (5.6 to 5.3 Mya) the Mediterranean Sea was filled in a major flood approximately 5.3 million years ago, in which water poured in from the Atlantic Ocean and through the Strait of Gibraltar (Tichy et al. 2001). Consequently, the Mediterranean marine biota including the pycnogonid fauna is derived primarily from the Atlantic Ocean. The opening of the Suez Canal in 1869 created the first salt-water passage between the Mediterranean and Red Sea allowing some Red Sea species to invade the Mediterranean (lessepsian migration) (Schmidt et al. 2001). *Anoplodactylus californicus*, *A. digitatus*, and *Pigrogromitus timsanus* are regarded as being lessepsian migrants (Chimenz-Gusso and Lattanzi 2003).

In the Mediterranean Sea 56 pycnogonid species are known until now. A current species list of the Mediterranean pycnogonid fauna is found in Chimenz-Gusso and Lattanzi (2003), with the completion of *Anoplodactylus nanus*, described by Krapp, Kocak, and Katagan in 2008 (Krapp et al. 2008). The Mediterranean pycnogonid fauna consists mostly of littoral species, and deep-sea species are an exception. It is assumed that, because of the geological barrier caused by the Strait of Gibraltar (max. depth 286 m) and the temperature barrier in the deep-sea (Atlantic 1–4°C, Mediterranean 12°C), the deep water fauna in the Mediterranean is relatively species-poor (Schmidt et al. 2001). Deep-sea pycnogonid species adapted to cold water such as representatives of the Colossendeidae and Pallenopsidae are either absent or rarely occur in the Mediterranean. A similar barrier also exists between the western and eastern basin of the Mediterranean and between the Mediterranean Sea and the Black Sea.

Mediterranean pycnogonid literature is scattered (e.g. Giltay 1929, Helfer 1936, Faraggiana 1940, Bourdillon 1954, Stock 1958, Bacescu 1959, Stock 1962, Stock and Soyer 1965, Stock 1966, Zavodnik 1968, Krapp 1973, Schüller 1989, Pérez-Ruzafa and Munilla 1992, Chimenz et al. 1993, Munilla 1993, Munilla and Nieto 1999, Chimenz Gusso 2000, Montoya Bravo et al. 2006, Krapp et al. 2008, Kocak et al. 2010, Kocak and Alan 2013). Of particular significance is Dohrn's (1881) "Die Pantopoden des Golfes von Neapel und der angrenzenden Meeresabschnitte" with its excellent drawings and descriptions of 18 new species. The first detailed comprehensive taxonomic work about sea spiders in the Mediterranean was by Bouvier (1923), which also dealt with Atlantic species. Zoogeographical studies were done by Arnaud (1987) and Chimenz-Gusso and Lattanzi (2003); the deep-water species were discussed by Stock (1987). As many of the species distributed in Mediterranean are of Atlantic origin, also the survey of Bamber (2010) is of special interest.

There is a rapidly growing body of molecular studies especially on the Antarctic and Subantarctic fauna

(e.g. Mahon et al. 2008, Nielsen et al. 2009, Krabbe et al. 2010, Dietz et al. 2011, Arango et al. 2011, Weis and Melzer 2012b, Dietz et al. 2013, Carapelli et al. 2013). In contrast, there is a lack of publications with molecular studies for the Mediterranean. However, so far – as at January 2014 – 11 Mediterranean pycnogonid species are listed in BOLD (Ratnasingham and Hebert 2007) and 10 species in GenBank (Benson et al. 2010). Detailed morphological analyses of Mediterranean Sea species are required to support future molecular studies, and specimens stored in natural history collections can provide a useful basis for these studies (see also Dunlop et al. 2007, Weis et al. 2011, Weis and Melzer 2012a).

In the present study representatives of some of the major genera of Mediterranean pycnogonids were sourced from the Bavarian State Collection of Zoology. Additional material was collected during field trips. A significant objective of this study is to remove any ambiguity in species identifications by providing a pictorial atlas principally based on high resolution Scanning Electron Microscope (SEM) images. Classification follows Bamber (2007) and PycnoBase (Bamber and El Nagar 2013).

## Material and methods

**Material:** The majority of specimens were sourced from the Bavarian State Collection of Zoology. Additional material was collected during field trips to Banyuls-sur-Mer, France (June/July 2006) and Rovinj, Croatia (September 2006 and May 2007). Collecting sites are summarized in Figure 1. Details are given under material section of each species. All material was conserved and stored in 75% ethanol. Preparations were made according to methods described in Bolte (1996). Only adult animals were used for light microscopic and SEM imaging. Species determinations are based on the original descriptions and a variety of literature suitable for Mediterranean pycnogonids (e.g. Dohrn 1881, Bouvier 1923, Stock 1968, Bamber 2010). Synonyms followed PycnoBase (Bamber and El Nagar 2013) and Müller (1993). All specimens (SEM and alcohol material) used for this study are deposited at the Bavarian State Collection of Zoology.

**Light microscopy:** Light microscopic pictures were taken using an Olympus SZX stereo microscope and a Jenoptic Prog-Res C12 digital camera (2580 × 1944 px; 96 dpi; colour depth 24 bit). Larger specimens (*Endeis charybdaea*, *E. spinosa*) were photographed using a Wild-Heerbrugg M5A stereo microscope and a Canon Digital IXUS 850 IS digital camera (3072 × 2304 px; 180 dpi; colour depth 24 bit). Up to 12 pictures with different focus steps along the z-axis were combined to a single respective image with a greater field of depth using the computer software Auto Montage (Syncroscopy) or Helicon Focus (HeliconSoft).

**Scanning electron microscopy:** For SEM preparation, specimens were dehydrated in a graded acetone series (70%, 80%, 90%, 10 min. each, plus 3 × 100%, 20 min.

each) and critical-point-dried in a Baltec CPD 030. Dried specimens were mounted on SEM stubs with self-adhesive carbon stickers and coated with gold on a Polaron Sputter Coater. SEM pictures ( $2048 \times 1536$  px; 72 dpi; colour depth 8 bit) were made with a LEO 1430VP at 10–20 kV. Scales were inserted using the measurement utility of the SEM.

**Nomenclature:** The present study follows the nomenclature in Arnaud and Bamber (1987) and Bamber (2010). Hence, the trunk of a pycnogonid is divided into 4 segments, the cephalon (=segment 1) and the segments 2, 3, and 4. The cephalon carries the proboscis anteroventrally, the ocular tubercle dorsally, and four pairs of extremities: the chelifores above the proboscis, the palps laterally, the ovigers ventrally, and one pair of legs laterally. Segments 2, 3, and 4 each carry one pair of legs laterally. The fourth segment carries the abdomen posterodorsally. Some species do not possess palps or chelifores. Ovigers are present in males (with few exceptions, e.g. *Pycnogonum* subgen. *Nulloviger*). In some genera ovigers are reduced or absent in females. The number of articles of the chelifores, palps, and ovigers varies within the systematic groups. Each leg is composed of nine articles: first, second, and third coxa, femur, first and second tibiae, tarsus, propodus, and claw. The first coxa articulates with the lateral process of the trunk while the second coxa carries the genital opening ventrally. In males, the cement glands are on the femur and rarely on other articles. The claw is often flanked by two smaller auxiliary claws. All abbreviations used in the figures are provided in Table 1.

## Results

### General remarks

This study is based on 21 Mediterranean species. In all cases, the major morphological characteristics correspond with published descriptions; exceptions see remarks section of each species.

### Classification

- Order Pantopoda Gerstäcker, 1863
- Suborder Eupantopodida Fry, 1978
- Superfamily Ascorhynchoidea Pocock, 1904
- Family Ammotheidae Dohrn, 1881
  - Achelia echinata* Hodge, 1864
  - Achelia langi* (Dohrn, 1881)
  - Achelia vulgaris* (Costa, 1861)
  - Ammothella appendiculata* (Dohrn, 1881)
  - Ammothella biunguiculata* (Dohrn, 1881)
  - Ammothella longipes* (Hodge, 1864)
  - Ammothella uniunguiculata* (Dohrn, 1881)
  - Tanystylum conirostre* (Dohrn, 1881)
  - Trygaeus communis* Dohrn, 1881
- Superfamily Nymphonoidea Pocock, 1904
- Family Callipallenidae Hilton, 1942
  - Callipallene emaciata* (Dohrn, 1881)
  - Callipallene phantoma* (Dohrn, 1881)

- Callipallene producta* (Sars, 1888)
- Callipallene spectrum* (Dohrn, 1881)
- Callipallene tiberi* (Dohrn, 1881)
- Superfamily Phoxichilidoidea Sars, 1891
- Family Endeidae Norman, 1908
  - Endeis charybdaea* (Dohrn, 1881)
  - Endeis spinosa* (Montagu, 1808)
- Family Phoxichilidiidae Sars, 1891
  - Anoplodactylus angulatus* (Dohrn, 1881)
  - Anoplodactylus petiolatus* (Krøyer, 1844)
  - Anoplodactylus pygmaeus* (Hodge, 1864)
- Superfamily Pycnogonoidea Pocock, 1904
- Family Pycnogenidae Wilson, 1878
  - Pycnogonum nodulosum* Dohrn, 1881
  - Pycnogonum (Retroviger) pusillum* Dohrn, 1881

### Ammothidae Dohrn, 1881

#### *Achelia* Hodge, 1864

##### *Achelia echinata* Hodge, 1864

Figures 2, 5–8

- Synonyms: *Ammothea brevipes* Hodge, 1864  
*Ammothea echinata* Hodge, 1864  
*Ammothea fibulifera* (Dohrn, 1881)

**Material.** ZSMA20071461: male; Giglio Island, Italy; 08.04.2005; 4–8 m; brown algae. ZSMA20071462: female; Giglio Island, Italy; 11.04.2005; 20 m. ZSMA20071463: female; Rovinj, Croatia; 05.07.2005; 0–1.5 m; *Stylocaulon scoparium* (Linnaeus) Kützing, 1843.

##### *Achelia langi* (Dohrn, 1881)

Figures 2, 9, 10

- Synonyms: *Ammothea langi* Dohrn, 1881

**Material.** ZSMA20071464: male; Cape Savudrija, Croatia; 08.10.2004; 0–1 m; under stones. ZSMA20071465: male; Cape Savudrija, Croatia; 22.05.2005; 0–1 m. ZSMA20071466: female; Cape Savudrija, Croatia; 08.08.2005; 0–1 m; on stone.

**Remarks.** According to Dohrn (1881) the lateral processes 1–3 are armed with one protuberance with spine. Here, in the male, the lateral process 1 has two protuberances with spine and the lateral process 2 and 3 have one (Fig. 9D, E). The lateral processes in the female correspond with Dohrn's description.

##### *Achelia vulgaris* (Costa, 1861)

Figures 2, 11, 12

- Synonyms: *Achelia franciscana* (Dohrn, 1881)  
*Alcinous vulgaris* Costa, 1861  
*Ammothea franciscana* Dohrn, 1881

**Material.** ZSMA20071467: male; Bayuls-sur-Mer, France; 07.2004. ZSMA20071468: female; Giglio Island, Italy;

08.04.2005; 8–13 m; brown algae. ZSMA20071469: female; Giglio Island, Italy; 08.04.2005; 8–13 m; brown algae.

**Remarks.** Adult males are differentiated by the character described by Dohrn (1881) and Bouvier (1923): three protuberances with spine on each side of coxa 2. But Dohrn notes that there also exist varieties: two protuberances on each side of coxa 2 or two protuberances on one and three protuberances on the other side of coxa 2.

Here, only coxa 2 of the first leg has three protuberances with spine on the one and two on the other side; the coxa 2 of the other legs has two protuberances with spine on each side (Fig. 11C, D). The other characters of the male, like lateral process not touching each other (Fig. 11B) correspond with the descriptions of Costa (1861), Dohrn (1881) and Bouvier (1923).

### *Ammothella Verrill, 1900*

#### *Ammothella appendiculata* (Dohrn, 1881)

Figures 3, 13, 14

Synonyms: *Ammothea appendiculata* Dohrn, 1881

**Material.** ZSMA20071470: female; Cape Savudrija, Croatia; 03.09.2004; 0–1 m. ZSMA20071471: female; Cape Savudrija, Croatia; 08.10.2004; 0–1 m; on stone. ZSMA20071472: female; Cape Savudrija, Croatia; 08.08.2005; 0–1 m; under stone.

**Remarks.** Dohrn (1881) described the palp with 10 articles; here the palp, as in other *Ammothella*, has 9 articles (Fig. 13E).

#### *Ammothella biunguiculata* (Dohrn, 1881)

Figures 3, 15, 16

Synonyms: *Ammothea biunguiculata* Dohrn, 1881

**Material.** ZSMA20071473: male; Cape Savudrija, Croatia; 08.10.2004; 0–1 m; on stone.

#### *Ammothella longipes* (Hodge, 1864)

Figures 3, 17

Synonyms: *Achelia longipes* (Hodge, 1864)

*Achelia magnirostris* (Dohrn, 1881)

*Ammothea longipes* Hodge, 1864

*Ammothella magnirostris* (Dohrn, 1881)

**Material.** ZSMA20071477: female; Bayuls-sur-Mer, France; 07.2004.

#### *Ammothella uniunguiculata* (Dohrn, 1881)

Figures 4, 18

Synonyms: *Ammothea uniunguiculata* Dohrn, 1881

**Material.** ZSMA20140003: male; Sicily, Italy; 1988

### *Tanystylum* Miers, 1879

#### *Tanystylum conirostre* (Dohrn, 1881)

Figures 4, 19–21

Synonyms: *Clotenia conirostris* Dohrn, 1881

**Material.** ZSMA20071505: female; Bayuls-sur-Mer, France; 07.2004. ZSMA20071506: female; Bayuls-sur-Mer, France; 07.2004. ZSMA20071507: male; Bayuls-sur-Mer, France; 07.2004. ZSMA20071508: male; Bayuls-sur-Mer, France; 07.2004.

### *Trygaeus* Dohrn, 1881

#### *Trygaeus communis* Dohrn, 1881

Figures 4, 22–25

**Material.** ZSMA20071509: female; Giglio Island, Italy; 12.04.2005. ZSMA20071510: male; Giglio Island, Italy; 12.04.2005. ZSMA20071511: male; Giglio Island, Italy; 12.04.2005. ZSMA20071512: male; Giglio Island, Italy; 12.04.2005. ZSMA20071513: male; Cape Kamenjak, Croatia; 03.05.2007; 0–5 m; *Stylocaulon scorpiarium* (Linnaeus) Kützing, 1843.

**Remarks.** According to Dohrn (1881), Bouvier (1923) and Stock (1966) the palps vary in the number of articles from 4 to 7 and the oviger from 6 to 10. Here the palp has 7 articles (Fig. 23A) and the male and female oviger have 9 articles (Fig. 23C, D; Fig. 25D). Other specimens not depicted have four palp articles.

### *Callipallenidae* Hilton, 1942

#### *Callipallene* Flynn, 1929

#### *Callipallene emaciata* (Dohrn, 1881)

Figures 26, 28, 29

Synonyms: *Callipallene emaciata emaciata* Stock, 1954

*Callipallene emarginata* (Dohrn, 1881)

*Pallene emaciata* Dohrn, 1881

**Material.** ZSMA20071485: female; Giglio Island, Italy; 09.04.2005; 3–5 m; *Halopteris* sp.. ZSMA20071486: female; Giglio Island, Italy; 09.04.2005; 3–5 m; *Halopteris* sp.. ZSMA20071487: male; Giglio Island, Italy; 09.04.2005; 3–5 m; *Halopteris* sp..

#### *Callipallene phantoma* (Dohrn, 1881)

Figures 26, 30–33

Synonyms: *Callipallene phantoma crinita* Stock, 1952

*Callipallene phantoma phantoma* (Dohrn, 1881)

*Pallene phantoma* Dohrn, 1881

**Material.** ZSMA20071489: female; Brucoli, Sicily, Italy; 14.09.1988. ZSMA20071490: female; Banyuls-sur-mer, France; 07.2004. ZSMA20071491: female; Giglio Island, Italy; 11.04.2005; 20 m; red algae. ZSMA20071492: male; Giglio Island, Italy; 11.04.2005; 20 m; red algae.

ZSMA20071493: male; Giglio Island, Italy; 11.04.2005; 20 m; red algae. ZSMA20071494: male; Rovinj, Croatia; 05.07.2005.

**Remarks.** Dohrn (1881) describes the auxiliary claws as half as long as the claw. According to Stock (1952) the length of auxiliary claws can vary between specimens. Here all 6 specimens from 4 different locations have more or less rudimentary auxiliary claws (Fig. 31F; Fig. 33F, G).

### *Callipallene producta* (Sars, 1888)

Figures 26, 34, 35

Synonyms: *Callipallene brevirostris producta* (Sars, 1888)

*Pallene producta* Sars, 1888

**Material.** ZSMA20071495: female; Giglio Island, Italy; 08.04.2005; 13–18 m; on brown algae. ZSMA20071496: female; Giglio Island, Italy; 08.04.2005; 13–18 m; on brown algae.

### *Callipallene spectrum* (Dohrn, 1881)

Figures 27, 36

Synonyms: *Callipallene emaciata spectrum* (Dohrn, 1881)

*Pallene spectrum* Dohrn, 1881

**Material.** ZSMA20140004: male; Banjole, Rovinj, Croatia; 07.1968; 5 m; on *Cystoseira* sp..

### *Callipallene tiberi* (Dohrn, 1881)

Figures 27, 37

Synonyms: *Callipallene emaciata tiberii* (Dohrn, 1881)

*Pallene tiberi* Dohrn, 1881

**Material.** ZSMA20071488: female; Giglio Island, Italy; 12.04.2005; 1 m; *Halopteris* sp..

### Endeidae Norman, 1908

#### *Endeis* Philippi, 1843

#### *Endeis charybdaea* (Dohrn, 1881)

Figures 38–40

Synonyms: *Chilophoxus charybdaeus* (Dohrn, 1881)

*Phoxichilus charybdaeus* Dohrn, 1881

**Material.** ZSMA20071497: male; Rovinj, Croatia; 04.09.2006; 30 m.

#### *Endeis spinosa* (Montagu, 1808)

Figures 38, 41–44

Synonyms: *Chilophoxus spinosus* Montagu

*Endeis gracilis* Philippi, 1843

*Endeis laevis* (Grube, 1871)

*Endeis vulgaris* (Dohrn, 1881)

*Phallangium spinosum* Montagu, 1808

*Phoxichilus vulgaris* Dohrn, 1881

**Material.** ZSMA20071498: female; Rovinj, Croatia; 04.2004. ZSMA20071499: male; Rovinj, Croatia; 05.05.2007; 0–2 m; *Corallina elongata* J.Ellis & Solander, 1786.

**Remarks.** According to Dohrn (1881) and Bamber (2010) each lateral process and coxa 1 is armed with one protuberance. Here, in the males the lateral process 1 and the coxa 1 of the first leg has two protuberances (Fig. 42D, F), the remaining legs correspond with previous observations (e.g. Fig. 42E, G). The females are without such protuberances (Fig. 44C, D).

### Phoxichilidiidae Sars, 1891

#### *Anoplodactylus* Wilson, 1878

#### *Anoplodactylus angulatus* (Dohrn, 1881)

Figures 45–47

Synonyms: *Anoplodactylus angulirostris* (Dohrn, 1881)

*Phoxichilidium angulatum* Dohrn, 1881

**Material.** ZSMA20071478: female; Banyuls-sur-mer, France; 07.2004. ZSMA20071479: female; Giglio Island, Italy; 14.4.2005; 20 m; red algae.

#### *Anoplodactylus petiolatus* (Krøyer, 1844)

Figures 45, 48

Synonyms: *Anoplodactylus guyanensis* Child, 1977

*Anoplodactylus hedgpethi* Bacescu, 1959

*Anoplodactylus longicollis* (Dohrn, 1881)

*Anoplodactylus pygmaeus* (Hoek, 1881)

*Pallene attenuata* Hodge, 1864

*Phoxichilidium attenuatum* (Hodge, 1863)

*Phoxichilidium longicolle* Dohrn, 1881

*Phoxichilidium petiolatum* Krøyer, 1844

**Material.** ZSMA20071480: male; Banyuls-sur-mer, France; 07.2004. ZSMA20042384: male; Bayuls-sur-Mer, France; 06.2003.

**Remarks.** In literature there is diverse information about the articulation of the oviger, 7 articles in Dohrn (1881) and 6 articles in Bouvier (1923) and King (1986) are reported. Here the ovigers have 6 articles.

#### *Anoplodactylus pygmaeus* (Hodge, 1864)

Figures 45, 49–52

Synonyms: *Anoplodactylus derjugini* (Losina-Losinsky, 1929)

*Anoplodactylus exiguum* (Dohrn, 1881)

*Pallene pygmaea* Hodge, 1864

*Phoxichilidium exiguum* Dohrn, 1881

*Phoxichilidium pygmaeum* Hoek, 1881

**Material.** ZSMA20071481: female; Elba, Italy; 20.10.2004; 3–5 m. ZSMA20071482: female; Elba, Italy; 21.10.2004; 3–5 m. ZSMA20071483: male; Elba, Italy; 20.10.2004; 0.5–4 m. ZSMA20071484: male; Cape

Kamenjak, Croatia; 03.05.2007; 0–5 m; *Styptocaulon scoparium* (Linnaeus) Kützing, 1843.

**Remarks.** In the literature there is diverse information about the articulation of the oviger, 7 articles in Dohrn (1881) and 6 articles in Bouvier (1923) and King (1986) are reported. Here the ovigers have 6 articles (Fig. 50E, F).

### Pycnogonidae Wilson, 1878

#### *Pycnogonum* Bruennich, 1764

##### *Pycnogonum nodulosum* Dohrn, 1881

Figures 53, 54

**Material.** ZSMA20071503: female; Banyuls-sur-mer, France; 07.2004; 30 m; red algae. ZSMA20030112: female; Tavolara Island, Sardinia, Italy; 2002.

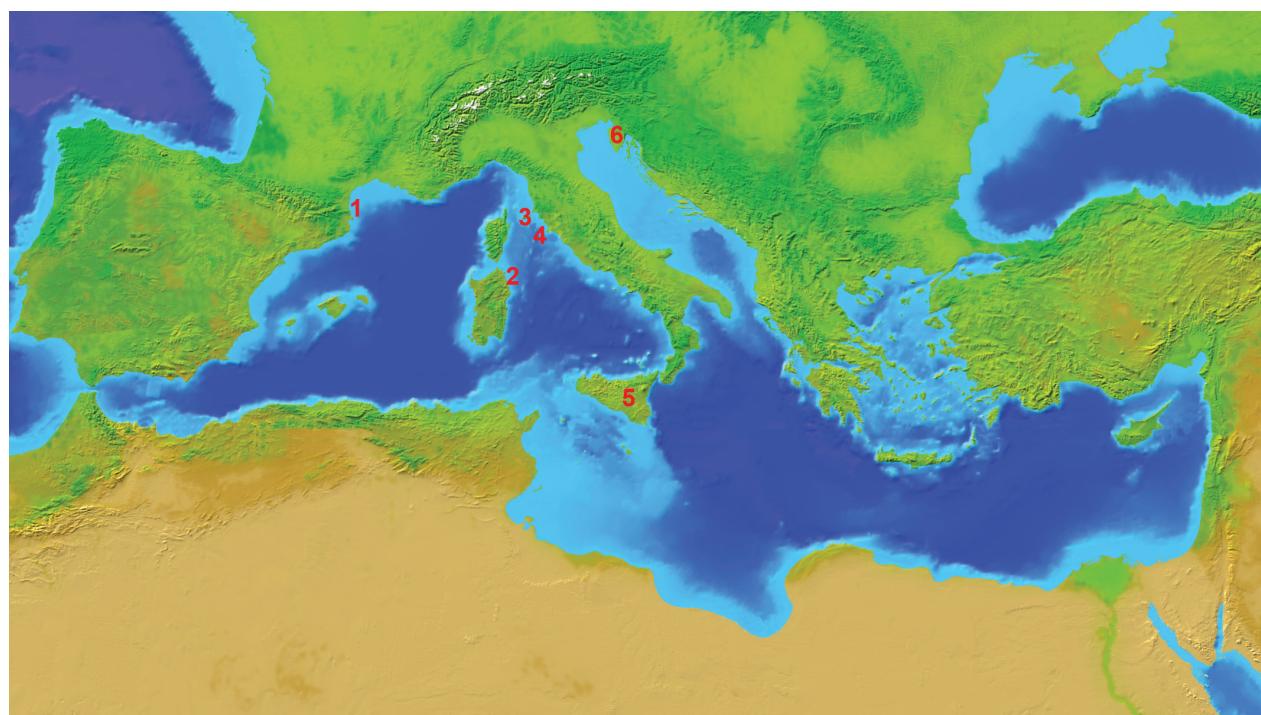
##### *Pycnogonum (Retroviger) pusillum* Dohrn, 1881

Figures 53, 55

Synonyms: *Pycnogonum pusillum* Dohrn, 1881

**Material.** ZSMA20071504: male; Brucoli, Sicily, Italy; 14.09.1988.

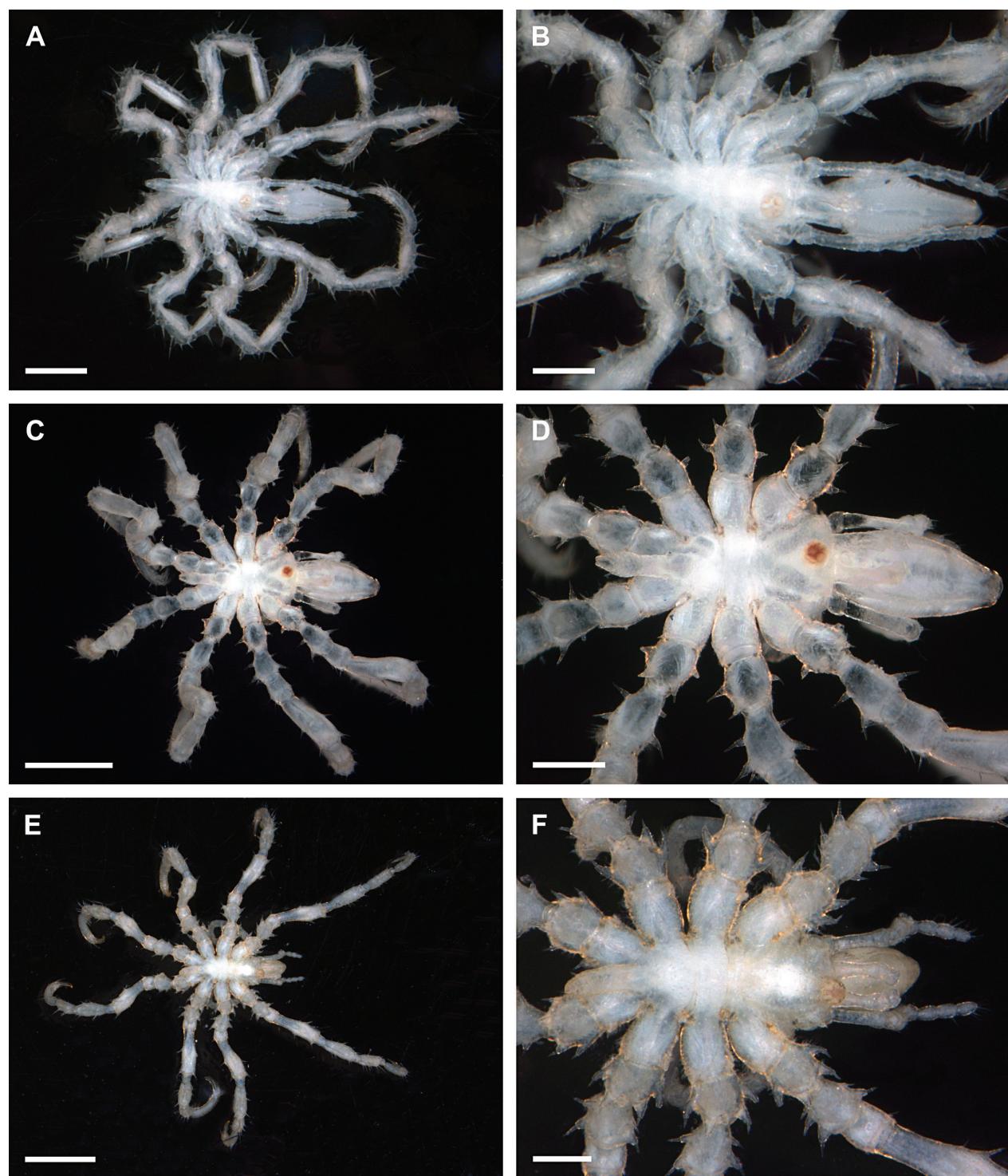
## Figures



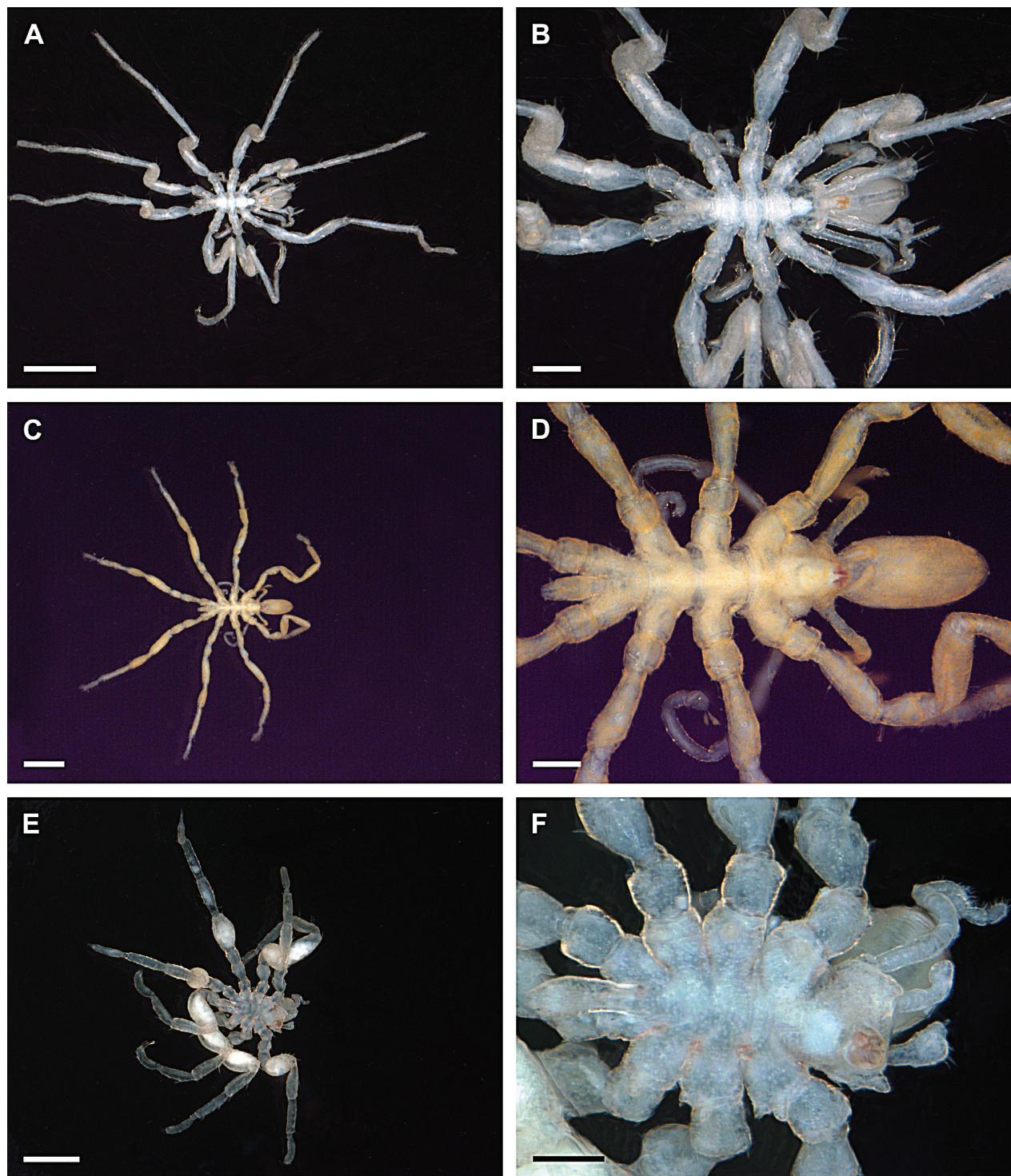
**Figure 1.** Collecting sites of pycnogonids used in this study: **1:** Banyuls-sur-Mer (France); **2:** Tavolara Island (Italy); **3:** Elba Island (Italy); **4:** Giglio Island (Italy); **5:** Brucoli, Sicily (Italy); **6:** Istria Peninsula (Croatia).

**Table 1.** Abbreviations used in the figures in alphabetical order.

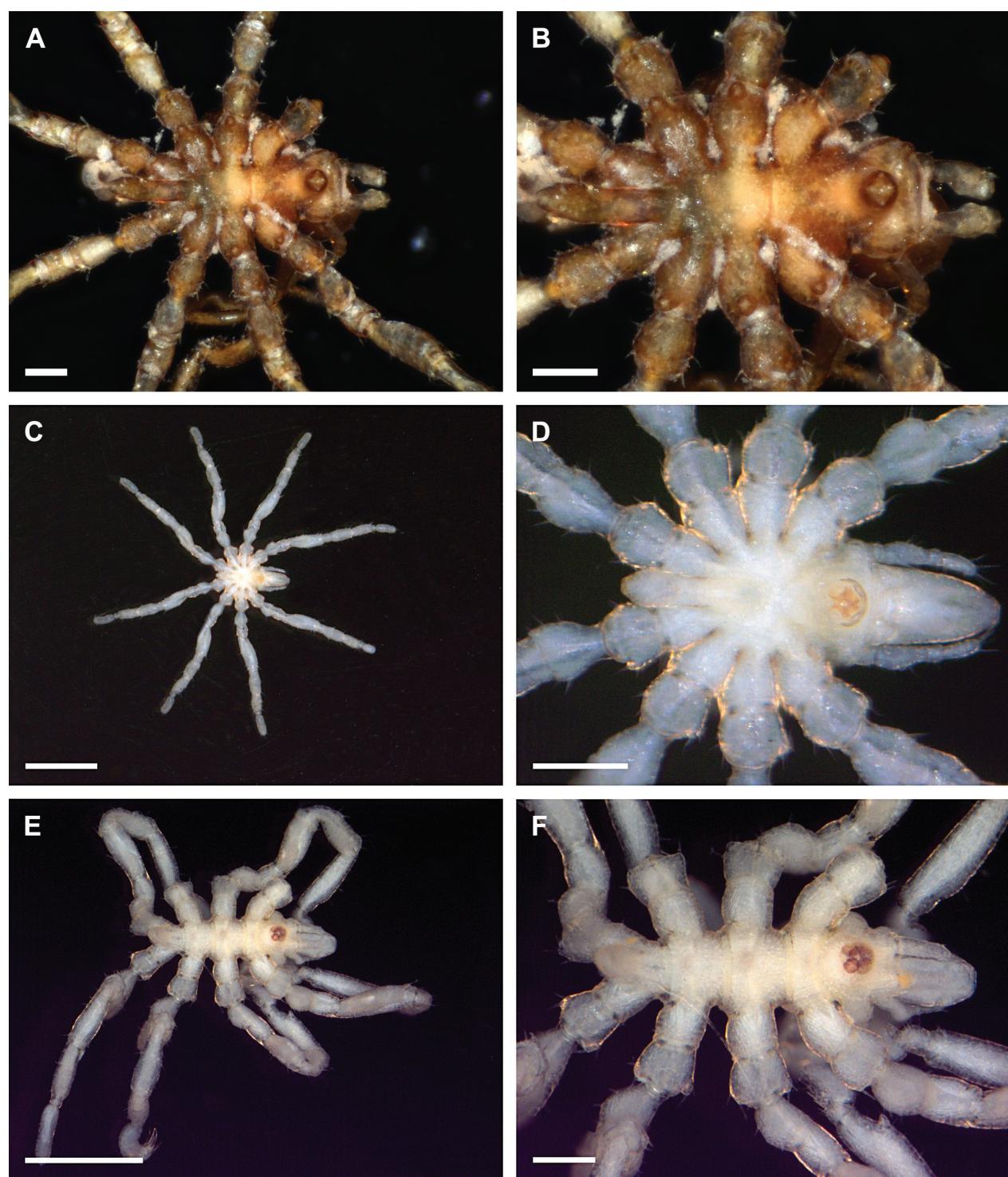
<b>ab</b>	abdomen	<b>mf</b>	movable finger
<b>ac</b>	auxiliary claw	<b>mo</b>	mouth
<b>an</b>	anus	<b>ne</b>	neck
<b>ce</b>	cephalon	<b>o</b>	oviger-article
<b>cf</b>	chelifore	<b>oc</b>	ocular tubercle
<b>cg</b>	cement gland	<b>ov</b>	oviger
<b>ch</b>	chela	<b>p</b>	palp-article
<b>cl</b>	claw	<b>pa</b>	palp
<b>cs</b>	compound spine	<b>pp</b>	propodus
<b>cu</b>	cutting lamina	<b>pr</b>	proboscis
<b>cx</b>	coxa	<b>pt</b>	protuberance
<b>ff</b>	fixed finger	<b>sb</b>	segment border
<b>fm</b>	femur	<b>se</b>	segment
<b>go</b>	genital openings	<b>so</b>	slit organ
<b>ha</b>	hair	<b>sp</b>	spine
<b>hs</b>	hollow spine	<b>tb</b>	tibia
<b>le</b>	leg	<b>te</b>	teeth
<b>lp</b>	lateral process	<b>tr</b>	trunk
<b>ls</b>	lateral sense organ	<b>ts</b>	tarsus



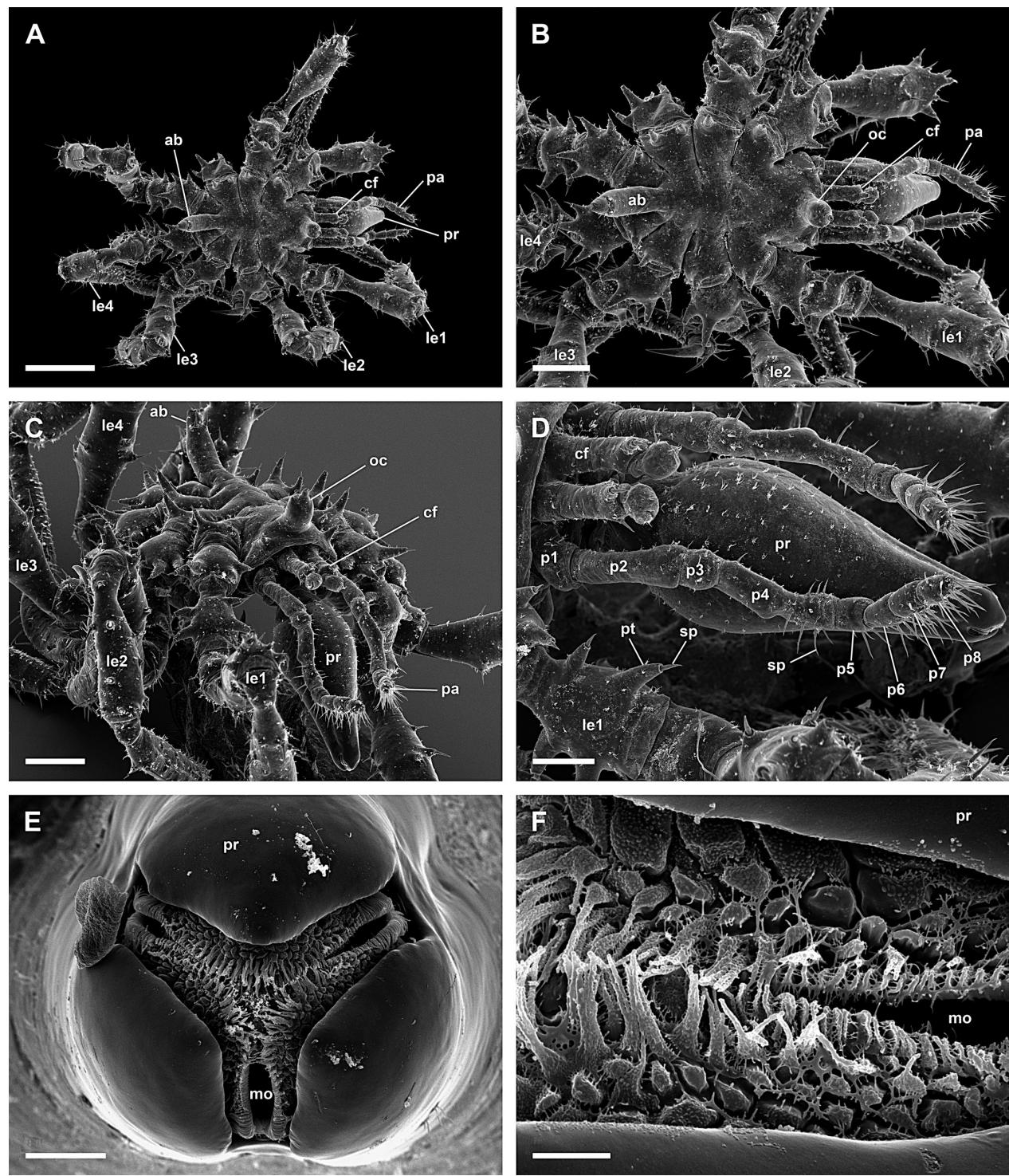
**Figure 2.** Ammoothidae 1; **A, B:** *Achelia echinata*, male, dorsal view; scales 500 µm and 250 µm, respectively; **C, D:** *Achelia langi*, male, dorsal view; scales 1 mm and 500 µm, respectively; **E, F:** *Achelia vulgaris*, male, dorsal view; scales 1 mm and 250 µm, respectively.



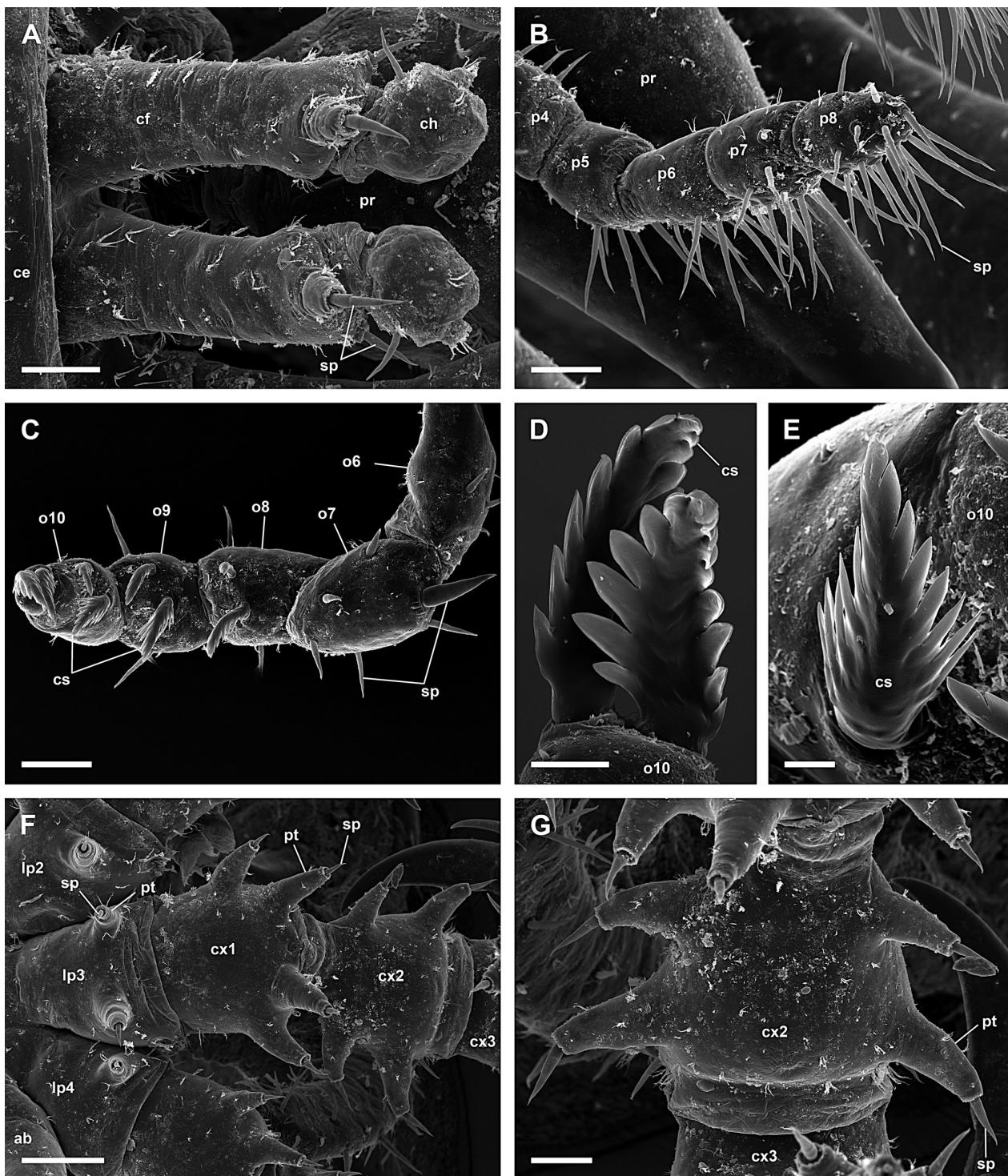
**Figure 3.** Ammotheidae 2; **A, B:** *Ammothella appendiculata*, female, dorsal view; scales 1 mm and 250 µm, respectively; **C, D:** *Ammothella biunguiculata*, male, dorsal view; scales 1 mm and 250 µm, respectively; **E, F:** *Ammothella longipes*, female, dorsal view; scales 1 mm and 250 µm, respectively.



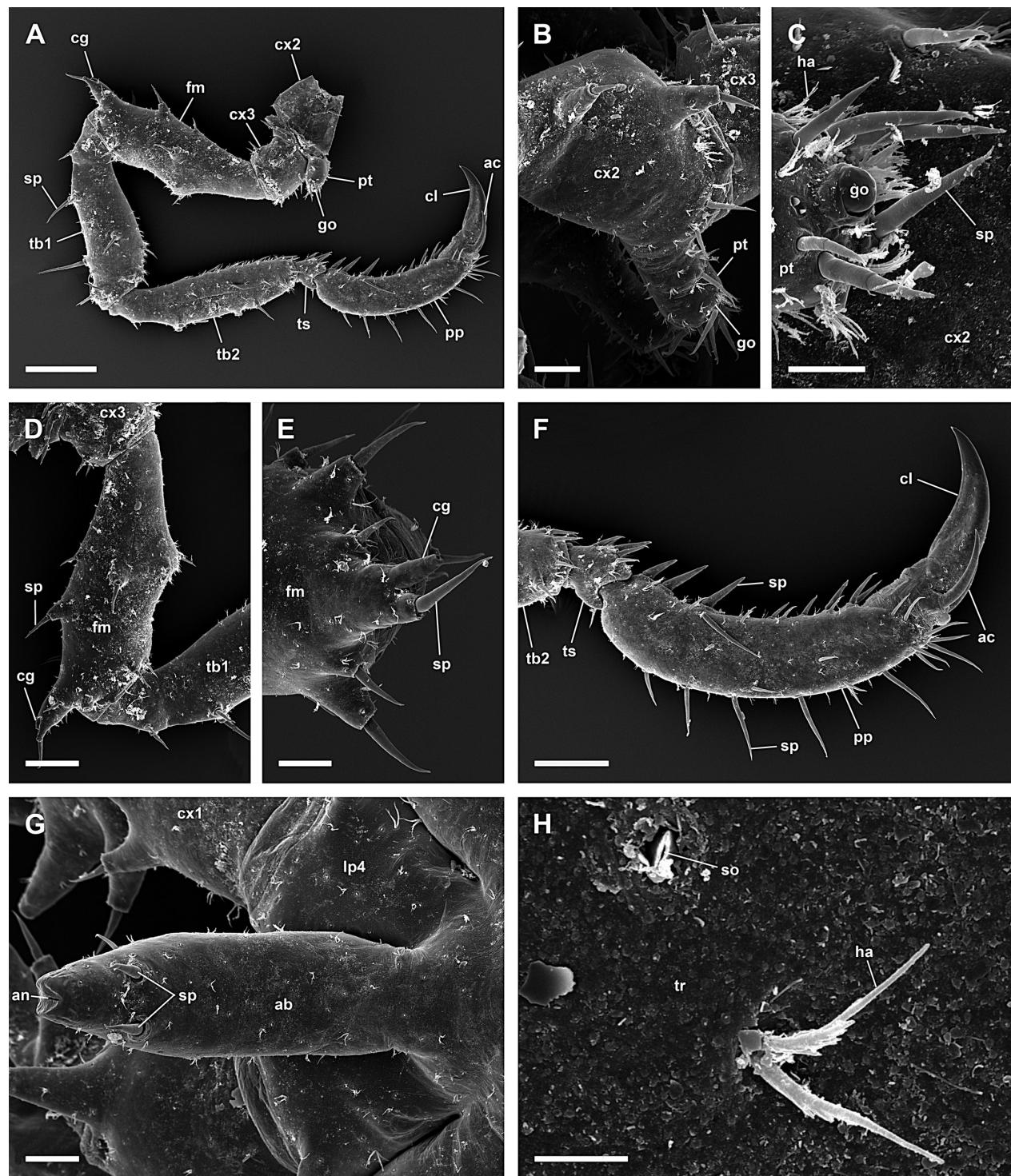
**Figure 4.** Ammotheidae 3; **A, B:** *Ammothella uniunguiculata*, male, dorsal view; scales 200 µm; **C, D:** *Tanystylum conirostre*, male, dorsal view; scales 1 mm and 250 µm, respectively; **E, F:** *Trygaeus communis*, male, dorsal view; scales 1 mm and 250 µm, respectively.



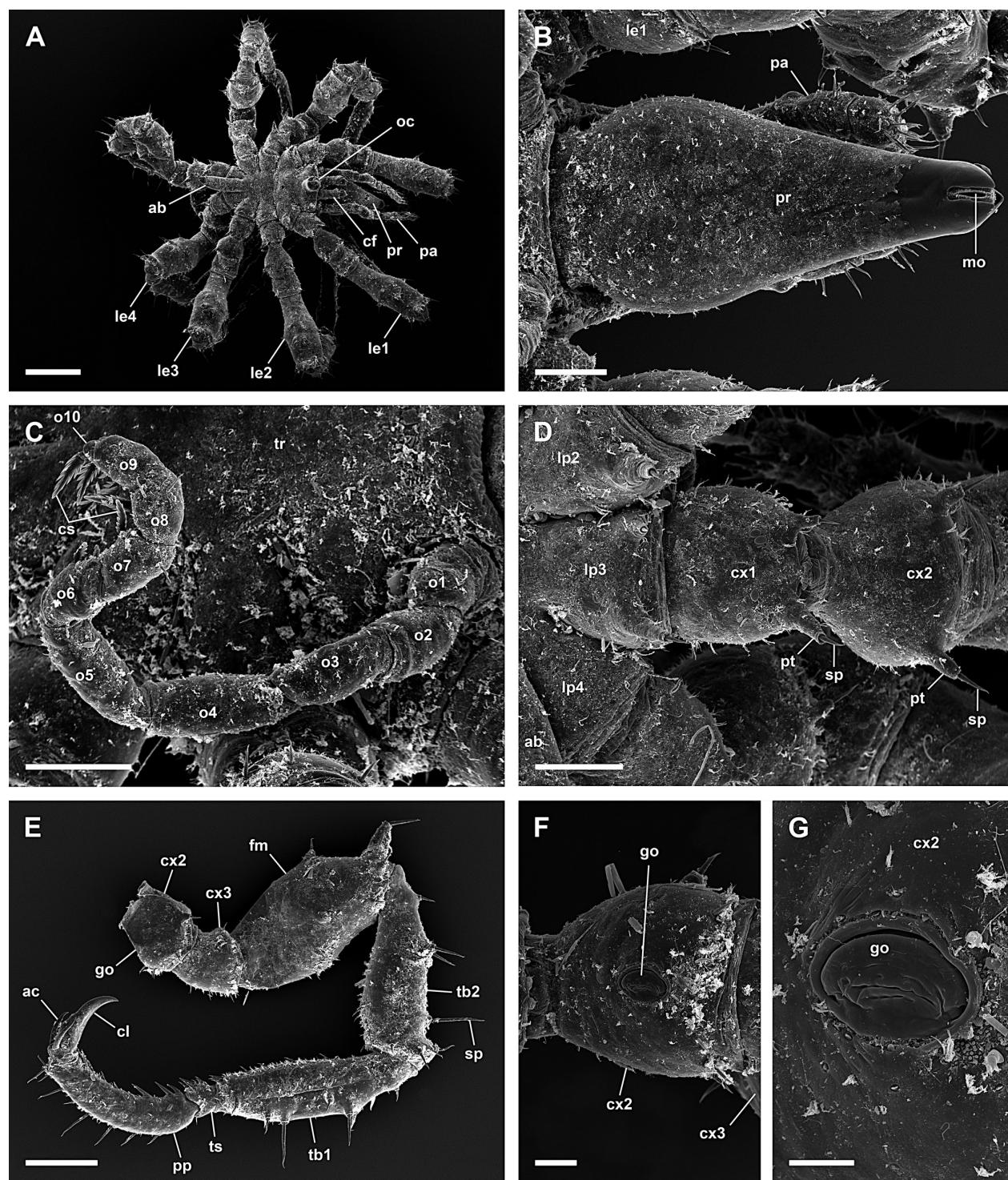
**Figure 5.** *Achelia echinata*, male; **A:** Dorsal view; scale 400 µm; **B:** Dorsal view of trunk, lateral processes touch each other; scale 200 µm; **C:** Frontal view of trunk, protuberances with spines on lateral process; scale 200 µm; **D:** Lateral view of proboscis, palp and chelipores with reduced chela; scale 100 µm; **E:** Mouth opening, dorsal is up; scale 20 µm; **F:** Mouth opening; scale 5 µm.



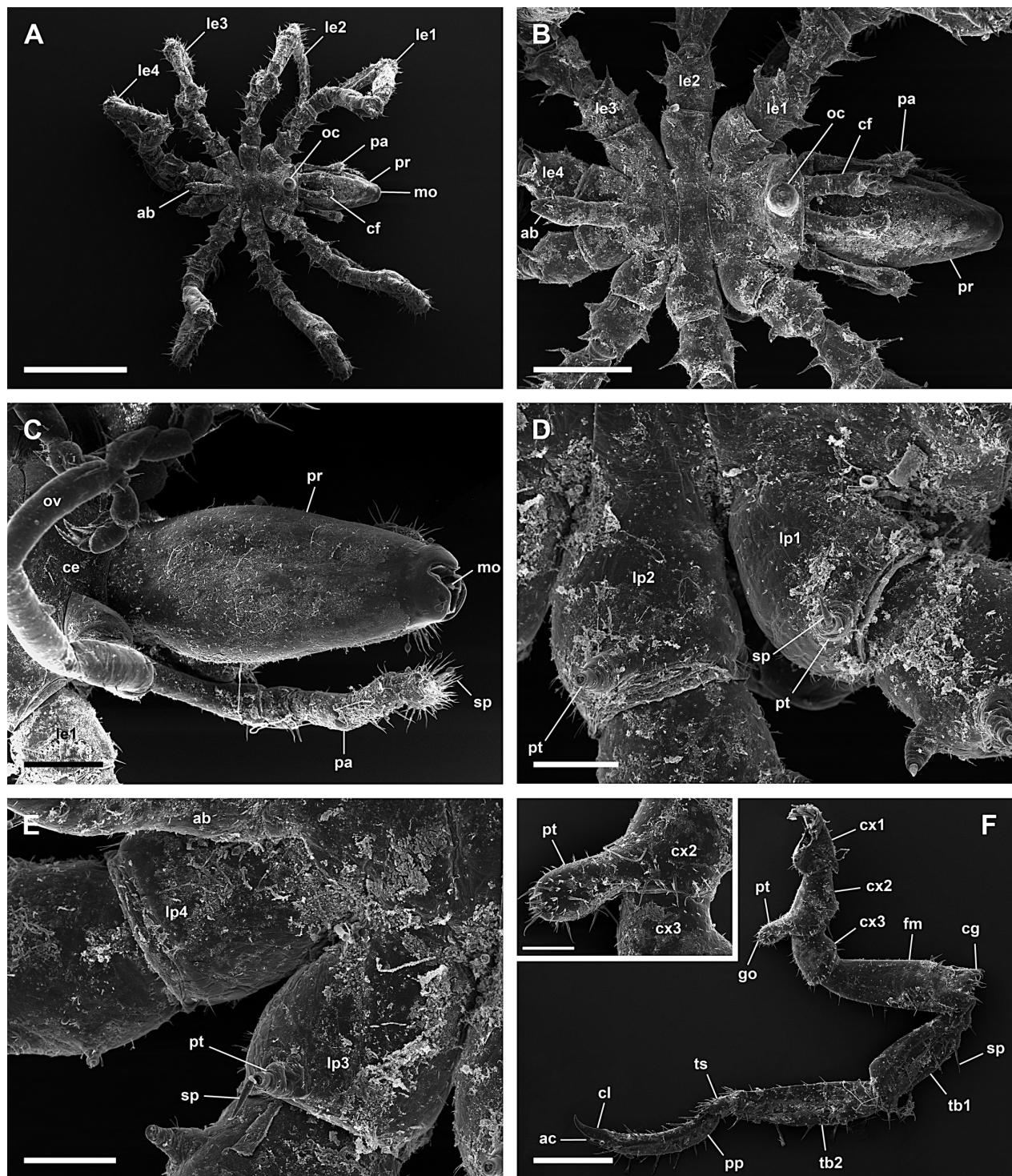
**Figure 6.** *Achelia echinata*, male; **A:** Chelifores with reduced chela; scale 40 µm; **B:** Distal articles of right 8-articled palp; scale 40 µm; **C:** Distal articles of 10-articled oviger; scale 40 µm; **D, E:** Compound spines on last oviger-article; scales 10 µm and 5 µm, respectively; **F:** Lateral process, coxa 1 and 2 of right 3rd leg, 2 protuberances with spine on each side of coxa 2; scale 100 µm; **G:** Coxa 2 with 2 protuberances with spine on each side (right 3rd leg); scale 40 µm.



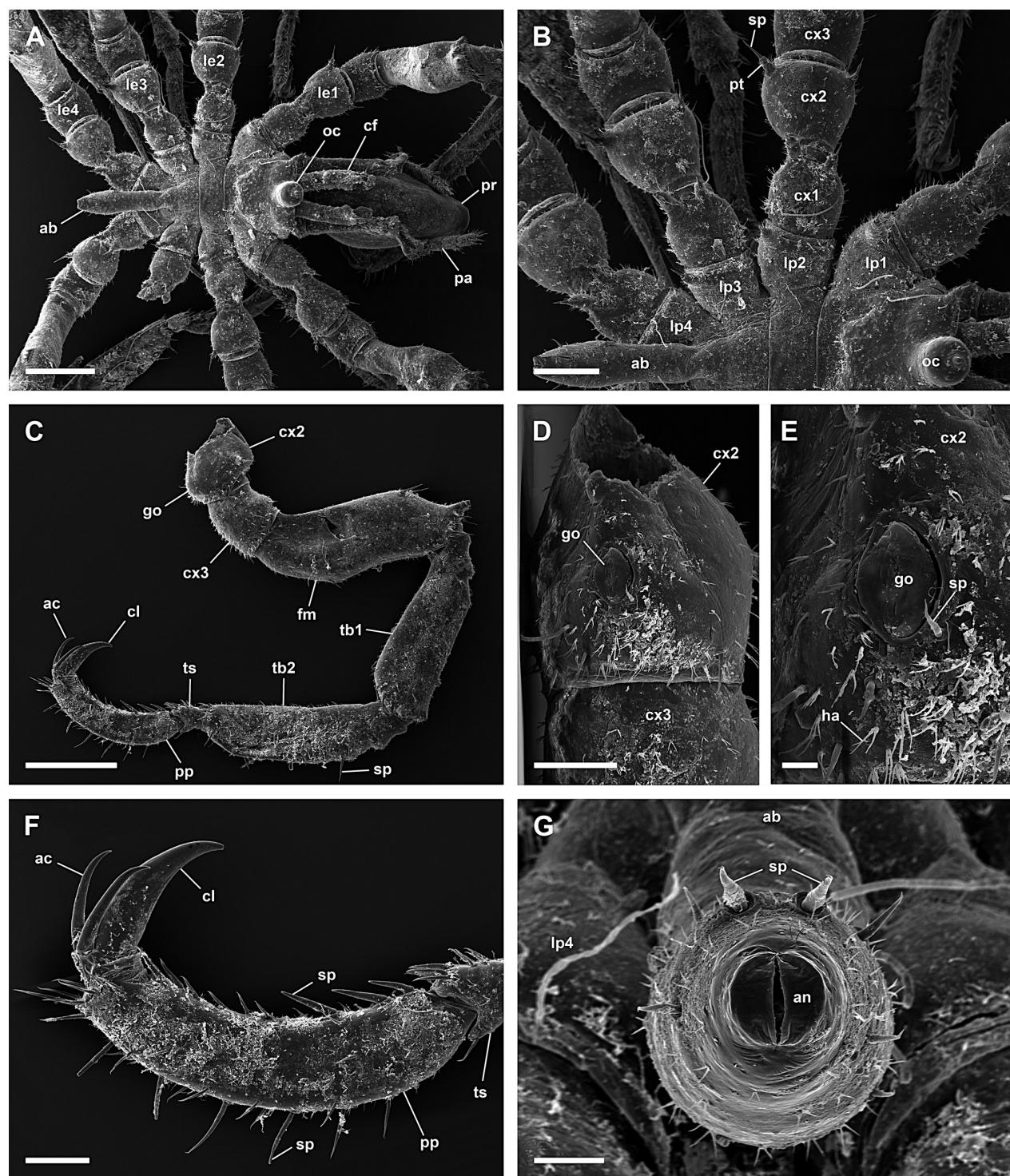
**Figure 7.** *Achelia echinata*, male; **A:** Left 3rd leg; scale 200 µm; **B:** Lateral view of coxa 2 with genital protuberance (right 4th leg); scale 40 µm; **C:** Genital opening (right 3rd leg); scale 20 µm; **D:** Lateral view of femur with cement gland on distal part (left 3rd leg); scale 100 µm; **E:** Cement gland (right 4th leg); scale 40 µm; **F:** Tarsus, propodus, and claw, auxiliary claws about half as long as claw (left 3rd leg); scale 100 µm; **G:** Abdomen; scale 40 µm; **H:** Hair and slit organ on dorsal side of trunk; scale 5 µm.



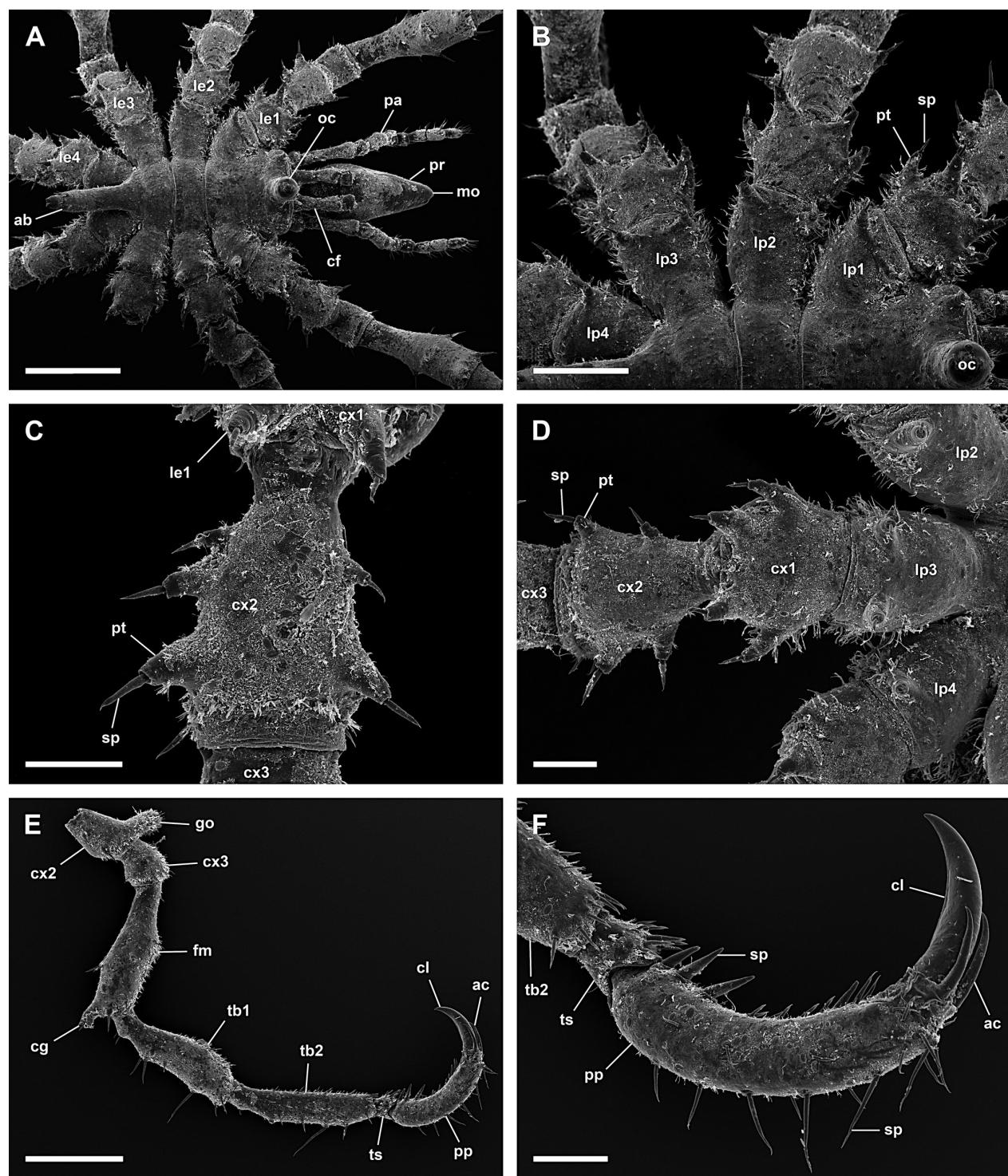
**Figure 8.** *Achelia echinata*, female; **A:** Dorsal view; scale 400 µm; **B:** Ventral view of proboscis; scale 100 µm; **C:** Left 10-articled oviger; scale 100 µm; **D:** Lateral process, coxa 1 and 2 of right 3rd leg, lateral processes touch each other; scale 100 µm; **E:** Left 3rd leg; scale 200 µm; **F:** Ventral view of coxa 2 with genital opening, distal is right (left 3rd leg); scale 40 µm; **G:** Genital opening; scale 20 µm.



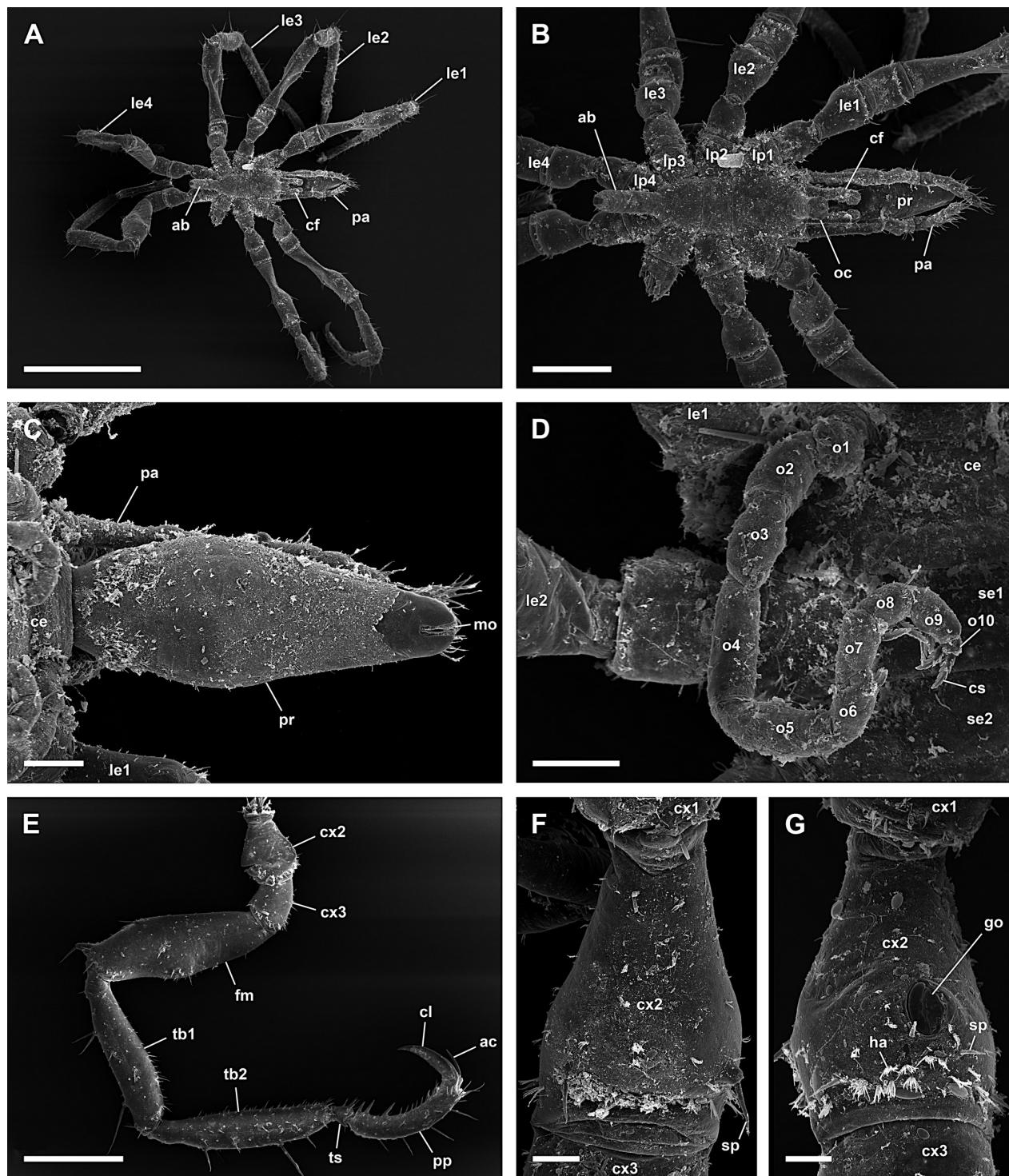
**Figure 9.** *Achelia langi*, male; **A:** Dorsal view; scale 1 mm; **B:** Dorsal view of trunk; scale 400 µm; **C:** Ventral view of proboscis; scale 200 µm; **D:** Dorsal view of right lateral processes 1 and 2, 2 protuberances with spine on lateral process 1 and 1 on lateral process 2; scale 100 µm; **E:** Dorsal view of right lateral processes 3 and 4, 1 protuberance with spine on lateral process 3 and lateral process 4 without protuberance or spine; scale 100 µm; **F:** Left 3rd leg; scale 400 µm; insert: Genital protuberance; scale 100 µm.



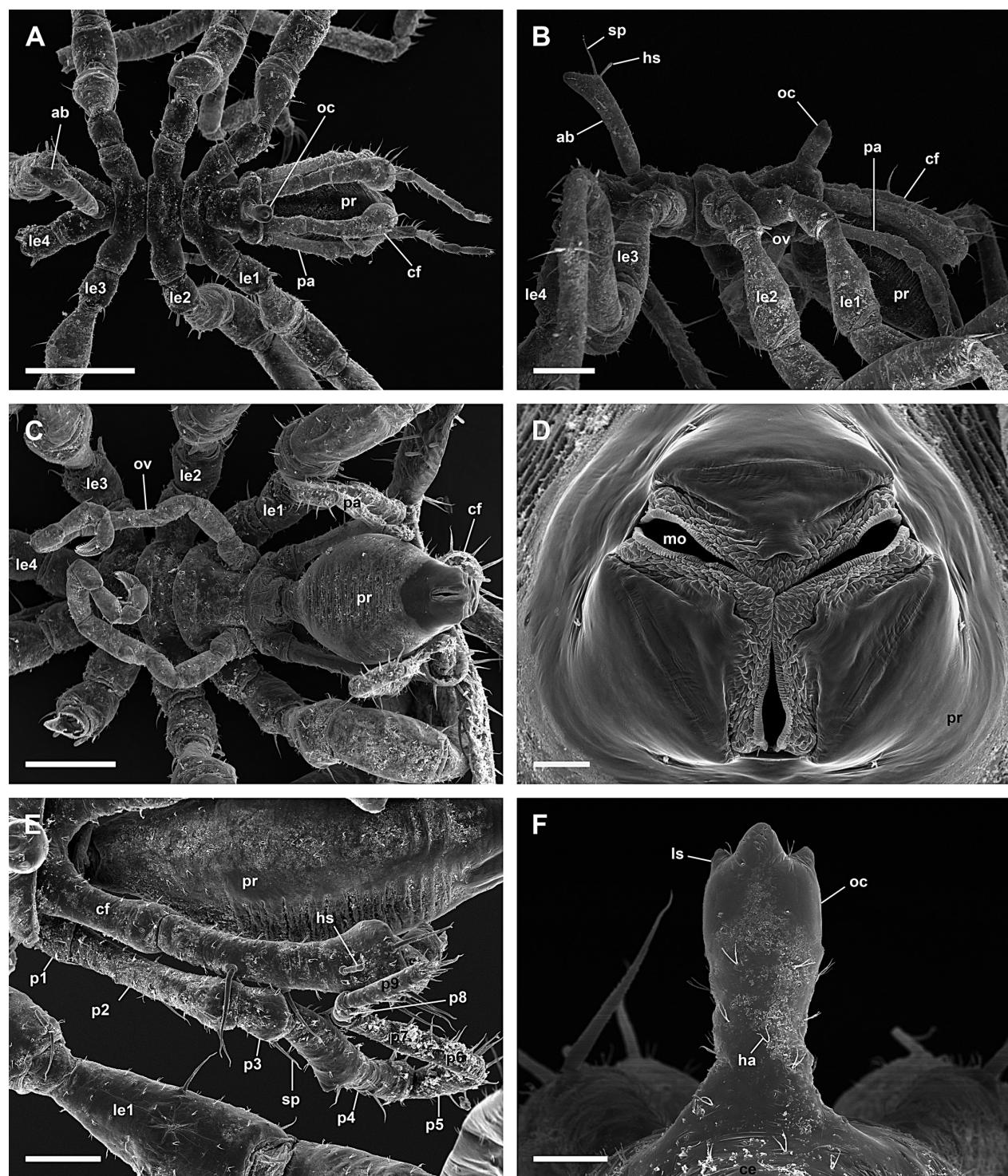
**Figure 10.** *Achelia langi*, female; **A:** Dorsal view of trunk; scale 400 µm; **B:** Dorsal view of left lateral processes, 1 protuberance with spine on lateral process 1-3, lateral process 4 without protuberance or spine; scale 200 µm; **C:** Right 3rd leg; scale 400 µm; **D:** Ventral view of coxa 2 with genital opening, distal is down (right 3rd leg); scale 100 µm; **E:** Genital opening; scale 20 µm; **F:** Tarsus, propodus, and claw, auxiliary claws about 2/3 of length of claw; scale 100 µm; **G:** Abdomen with anus; scale 40 µm.



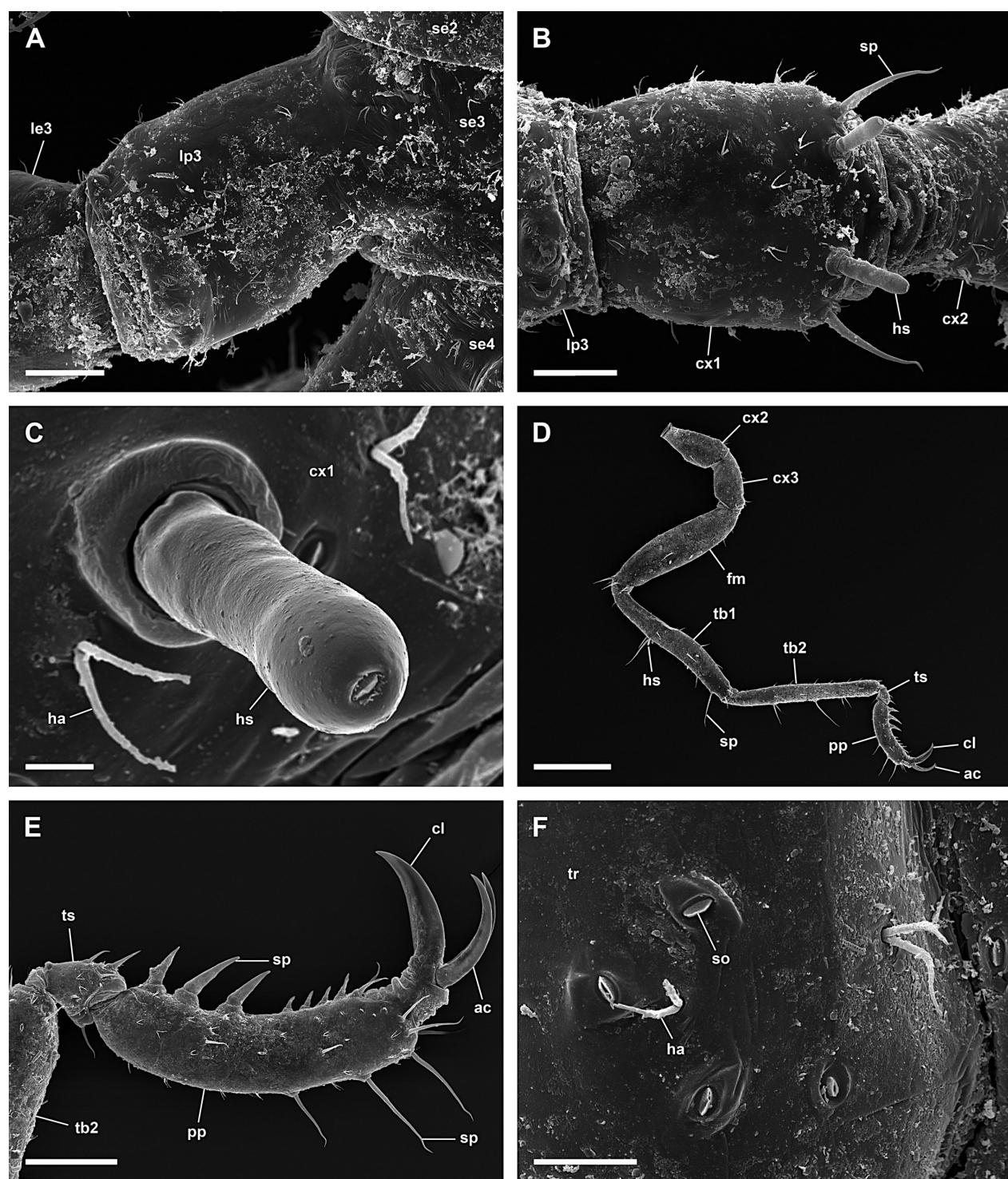
**Figure 11.** *Achelia vulgaris*, male; **A:** Dorsal view of trunk; scale 400 µm; **B:** Dorsal view of left lateral processes, lateral processes do not touch each other; scale 200 µm; **C:** 2 protuberances with spine on right side and 3 on left side of coxa 2, distal is down (right 1st leg); scale 100 µm; **D:** Lateral process, coxa 1 and 2, 2 protuberances with spine on each side of coxa 2 (left 3rd leg); scale 100 µm; **E:** Right 3rd leg; scale 400 µm; **F:** Tarsus, propodus, and claw, auxiliary claws about half as long as claw; scale 100 µm.



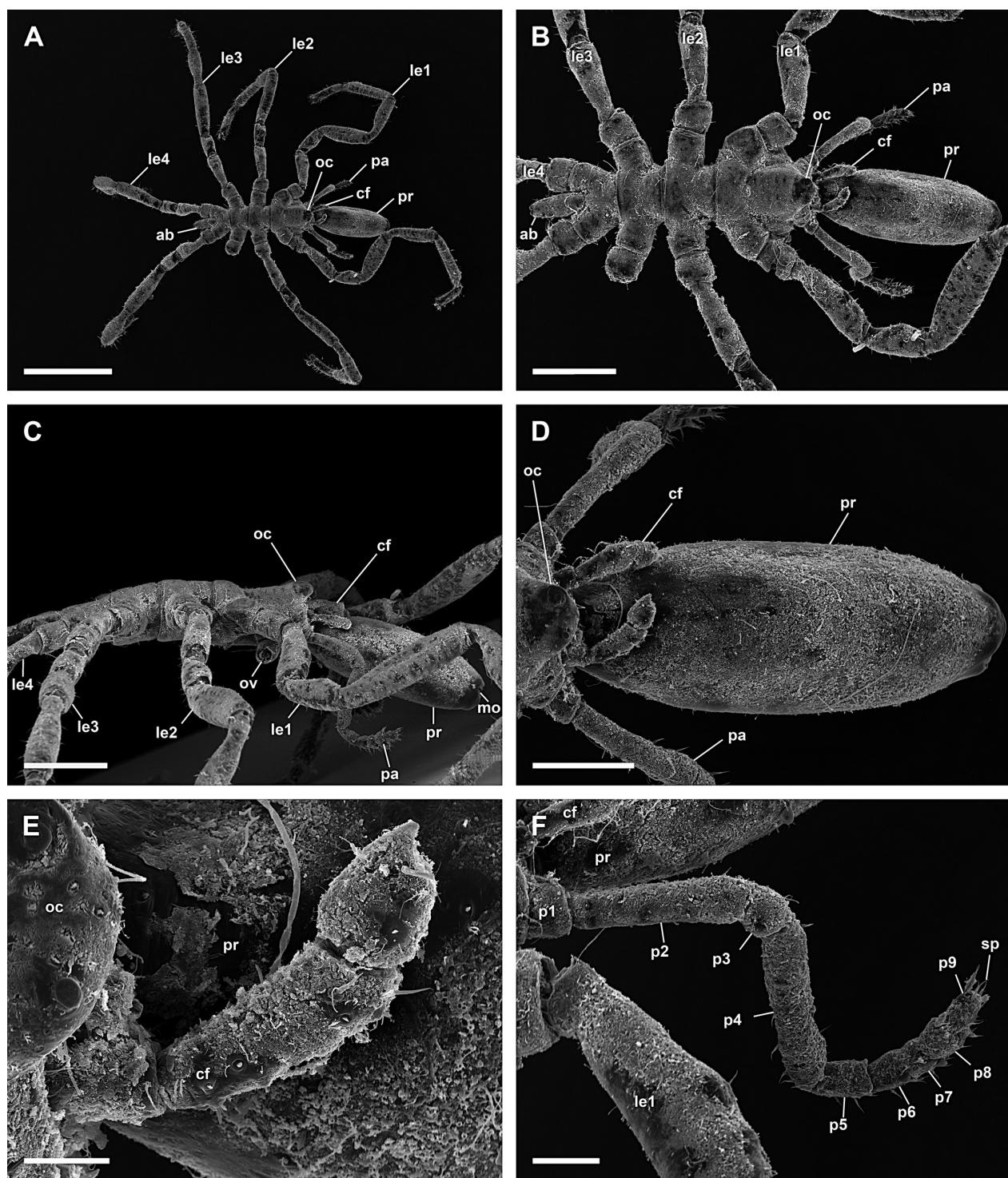
**Figure 12.** *Achelia vulgaris*, female; **A:** Dorsal view; scale 1 mm; **B:** Dorsal view of trunk, lateral processes do not touch each other; scale 300 µm; **C:** Ventral view of proboscis; scale 100 µm; **D:** Right 10-articled oviger; scale 100 µm; **E:** Right 3rd leg; scale 400 µm; **F:** Dorsal view of coxa 2 (left 3rd leg); scale 40 µm; **G:** Ventral view of coxa 2 with genital opening (left 3rd leg); scale 40 µm.



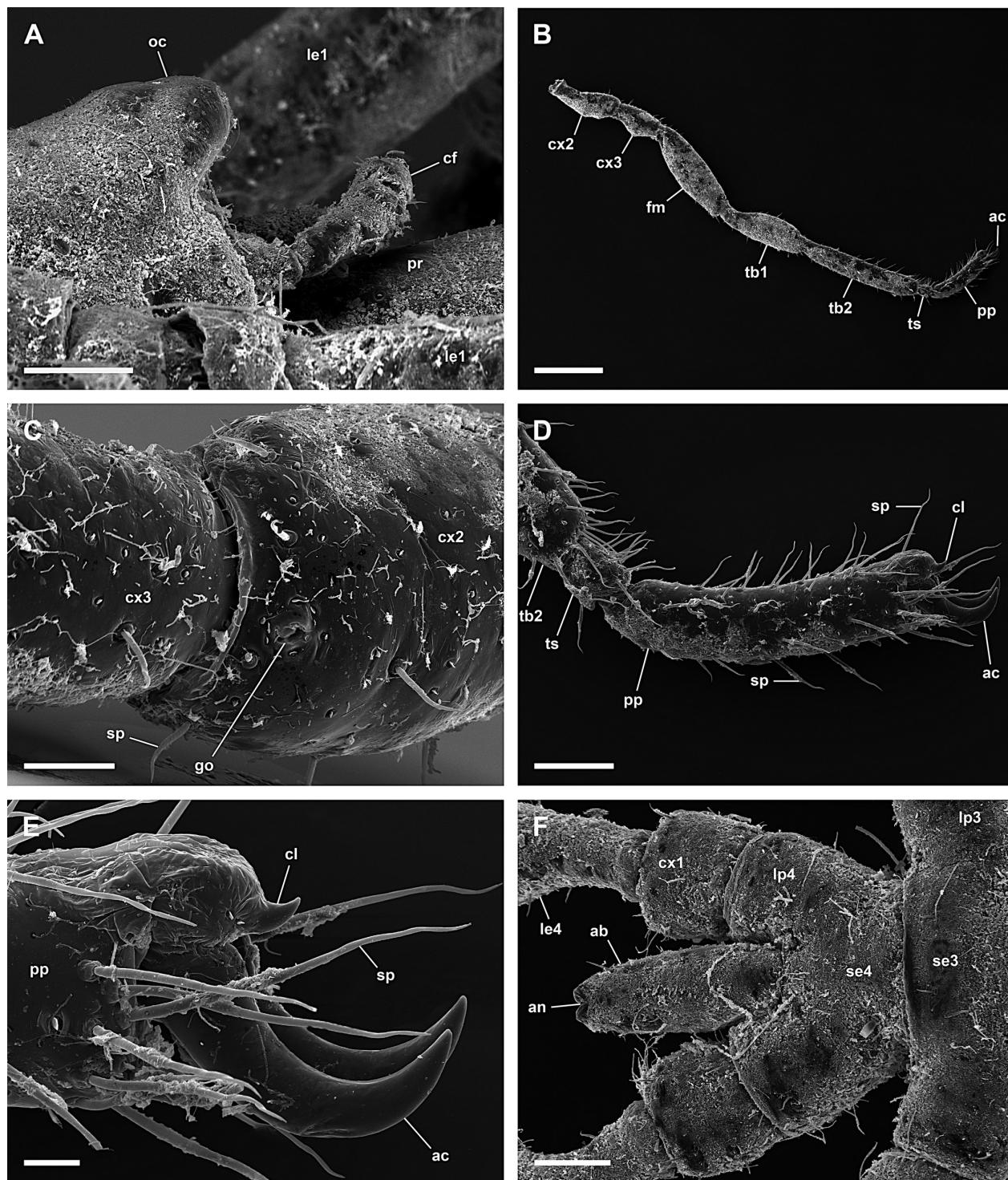
**Figure 13.** *Ammothella appendiculata*, female; **A:** Dorsal view of trunk; scale 400 µm; **B:** Lateral view of trunk; scale 200 µm; **C:** Ventral view of trunk; scale 200 µm; **D:** Mouth opening, dorsal is up; scale 20 µm; **E:** Right chelifore with reduced chela and right 9-articled palp; scale 100 µm; **F:** Ocular tubercle with lateral sense organ; scale 40 µm.



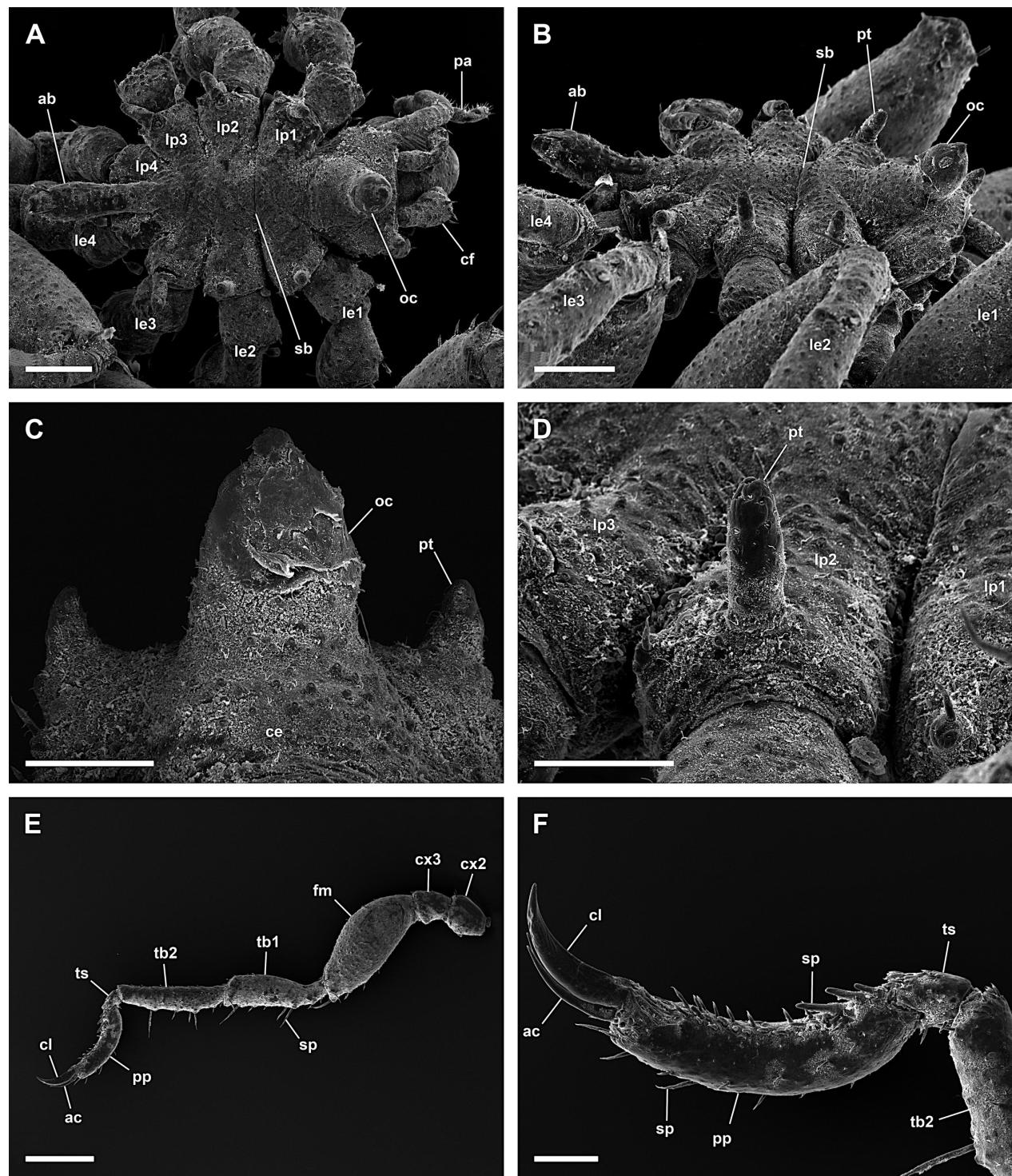
**Figure 14.** *Ammothella appendiculata*, female; **A:** Lateral process of left 3rd leg; scale 40 µm; **B:** Coxa 1 of right 3rd leg with hollow spines; scale 40 µm; **C:** Hollow spine; scale 5 µm; **D:** Right 4th leg; scale 400 µm; **E:** Tarsus, propodus, and claws (right 4th leg); scale 100 µm; **F:** Hairs and slit organs of dorsal side of trunk; scale 10 µm.



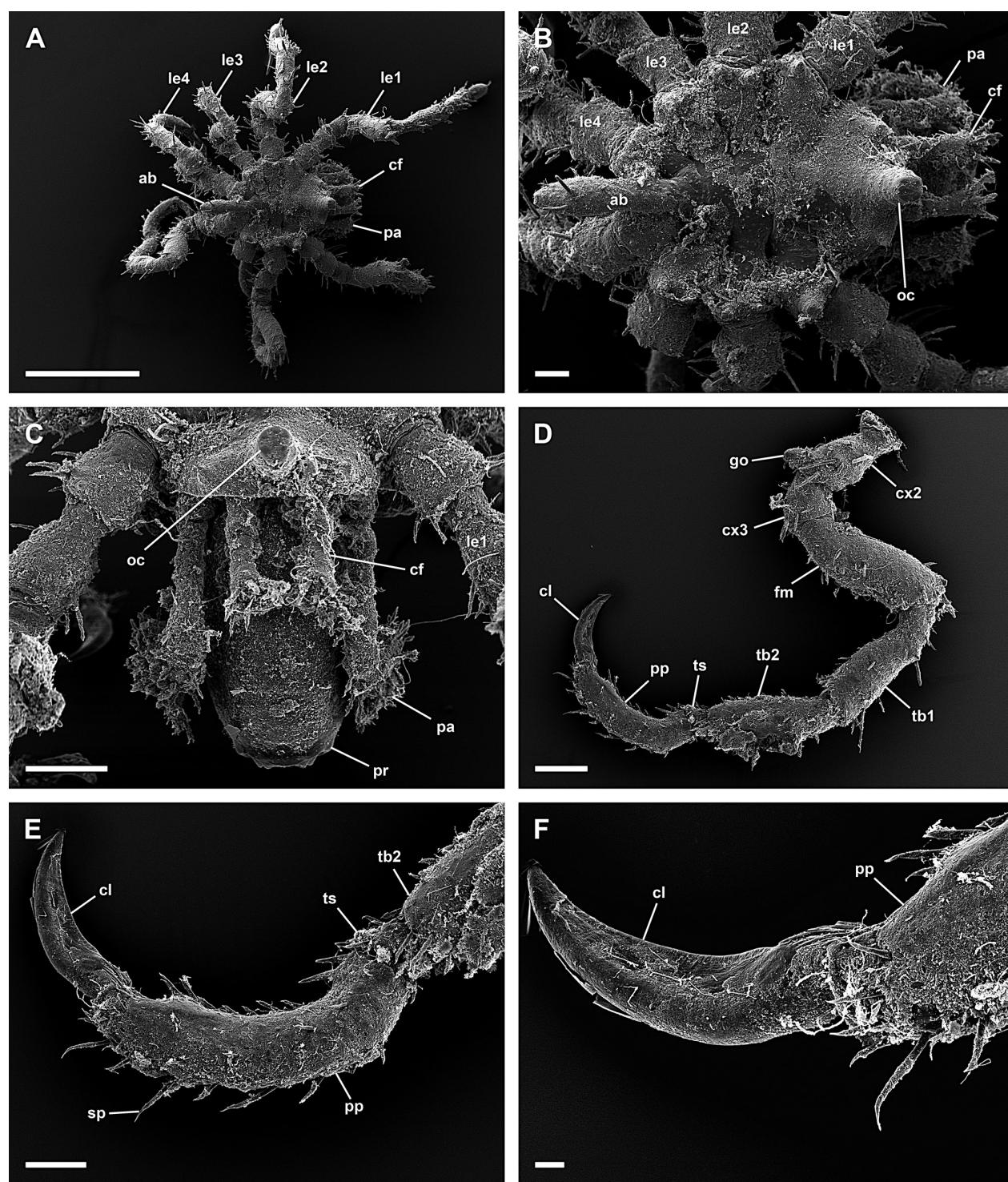
**Figure 15.** *Ammothella biunguiculata*, male; **A:** Dorsal view; scale 1 mm; **B:** Dorsal view of trunk; scale 400 µm; **C:** Lateral view of trunk, oviger dissected; scale 400 µm; **D:** Dorsal view of proboscis; scale 100 µm; **E:** Right chelifore with reduced chela; scale 40 µm; **F:** Right 9-articled palp; scale 100 µm.



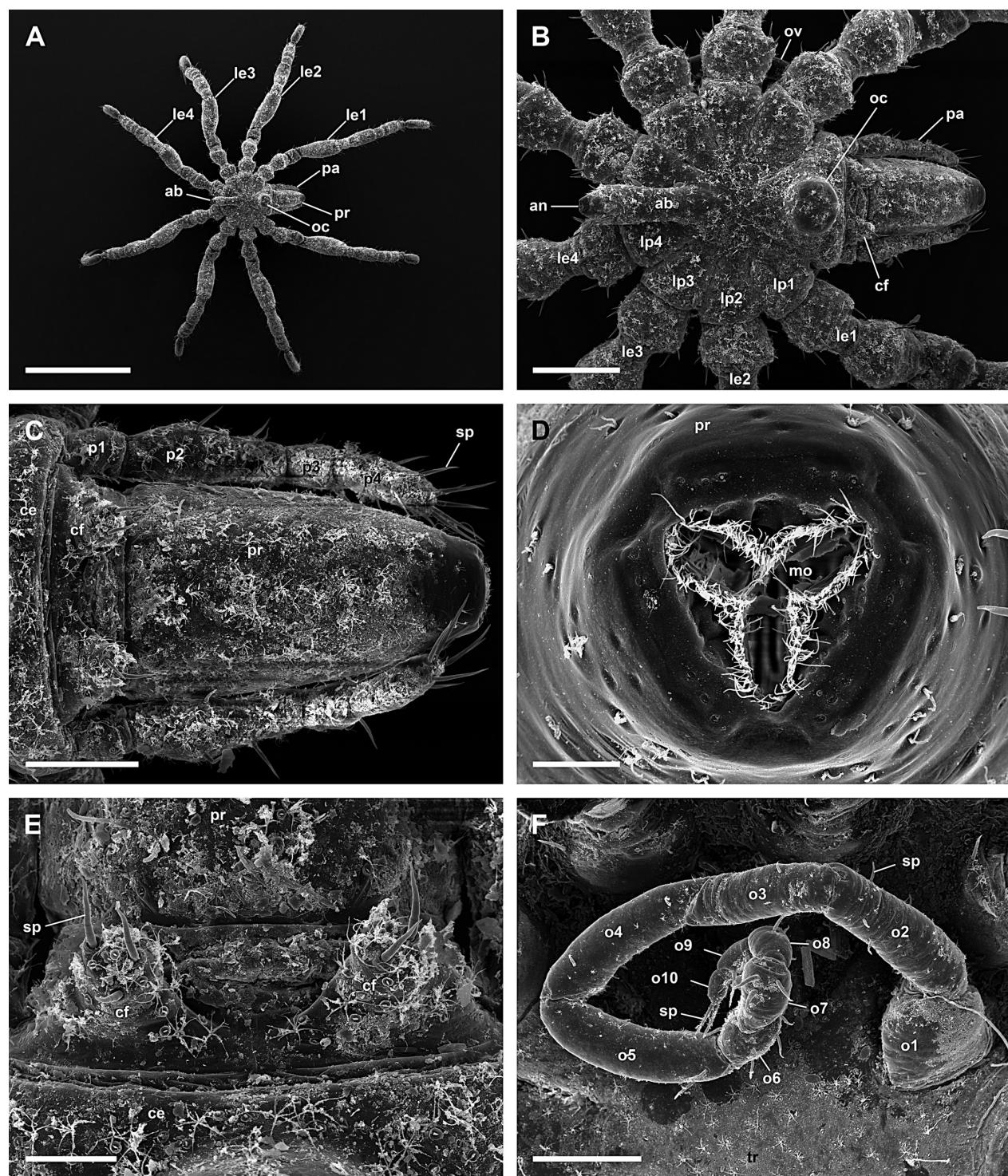
**Figure 16.** *Ammothella biunguiculata*, male; **A:** Lateral view of ocular tubercle; scale 100 µm; **B:** Right 3rd leg; scale 400 µm; **C:** Ventral view of coxa 2 with genital opening, distal is left (right 3rd leg); scale 40 µm; **D:** Tarsus and propodus with reduced claw and dominating auxiliary claws; scale 100 µm; **E:** Reduced claw and dominating auxiliary claws; scale 20 µm; **F:** Dorsal view of trunk segment 4 and abdomen; scale 100 µm.



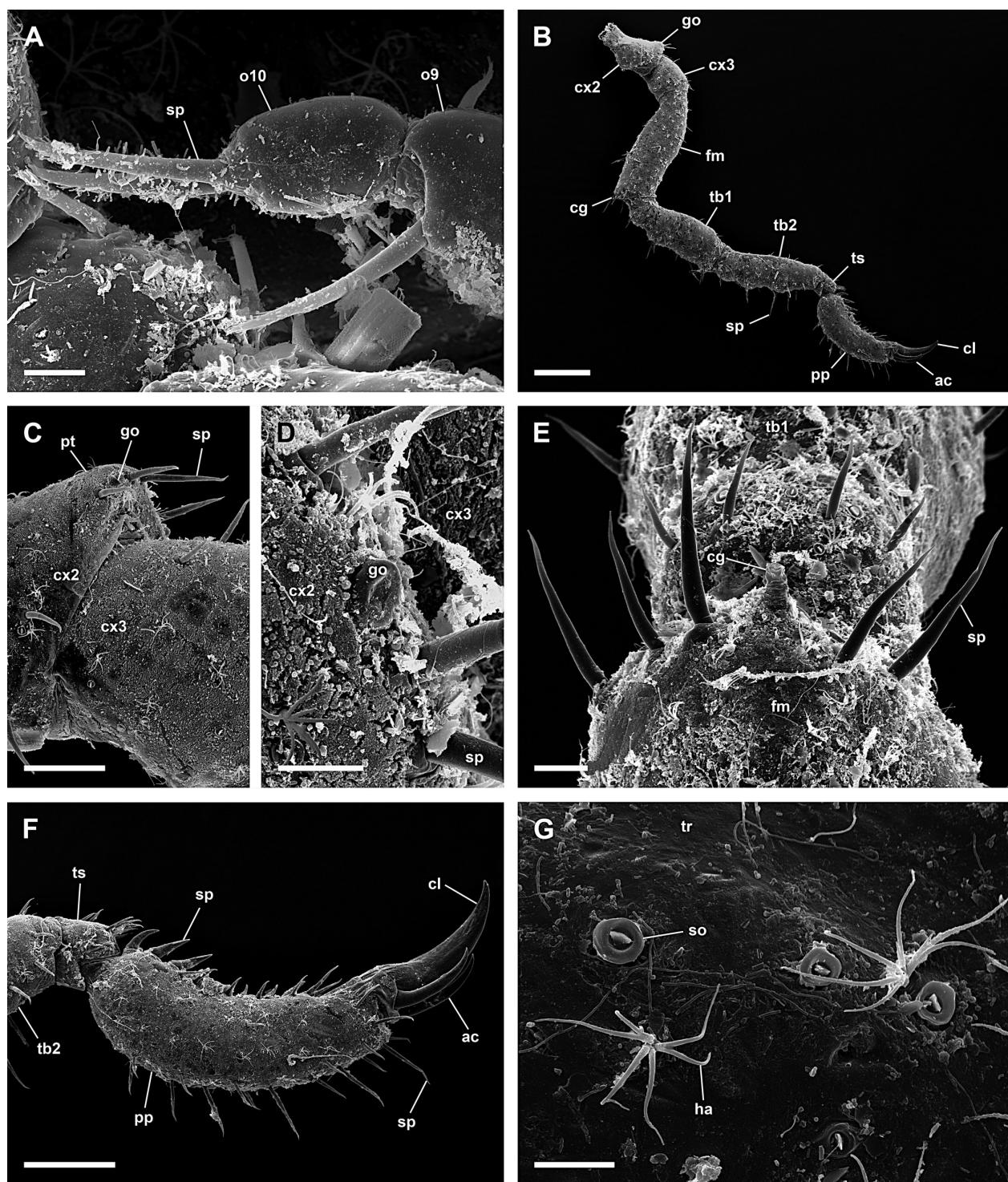
**Figure 17.** *Ammothella longipes*, female; **A:** Dorsal view of trunk; scale 200 µm; **B:** Lateral view of trunk, one protuberance without spine aside on lateral processes; scale 200 µm; **C:** Ocular tubercle; scale 100 µm; **D:** Right lateral process; scale 100 µm; **E:** Left 3rd leg; scale 400 µm; **F:** Tarsus, propodus, and claws (left 3rd leg); scale 100 µm.



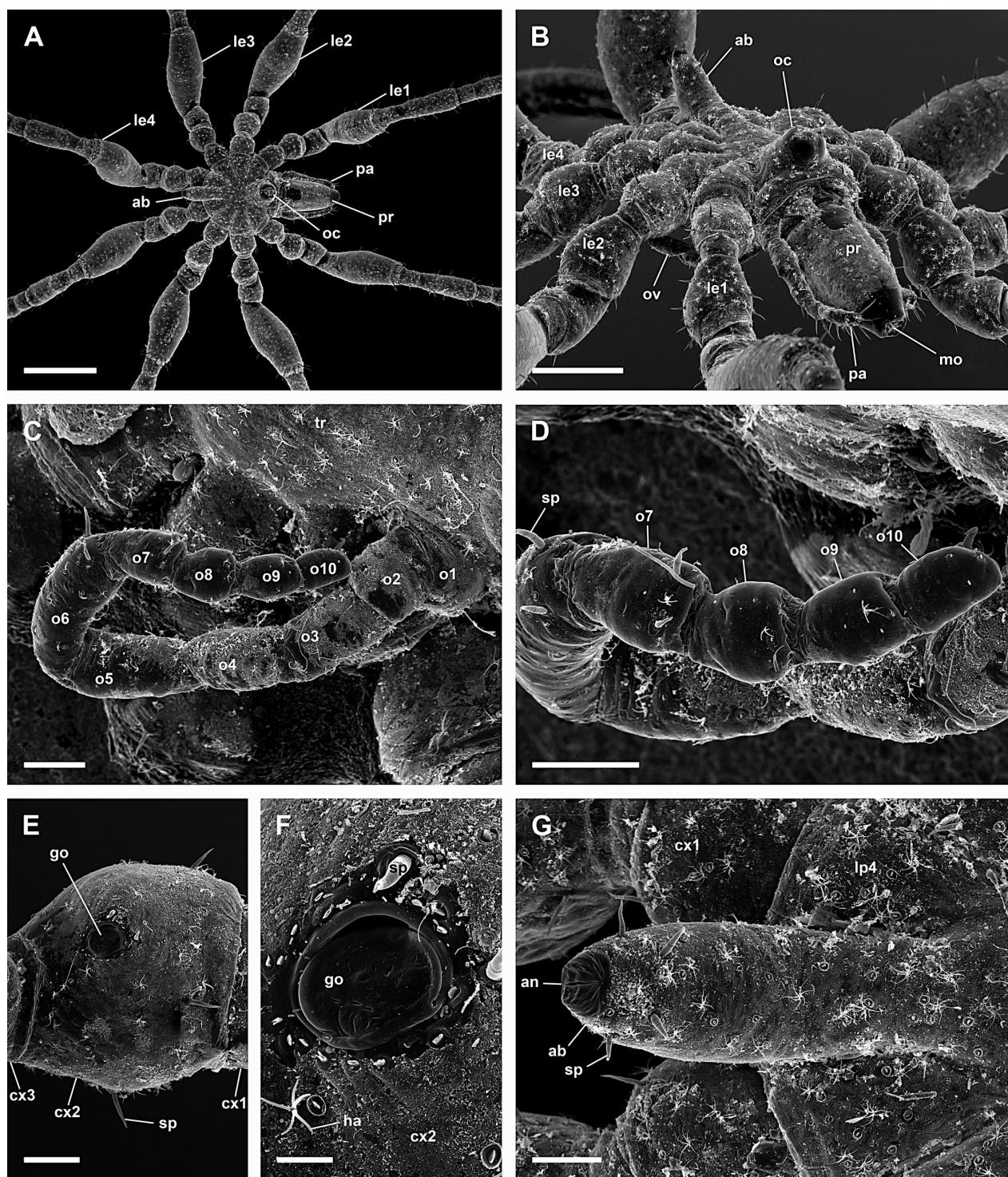
**Figure 18.** *Ammothella uniunguiculata*, male; **A:** Dorsal view; scale 1 mm; **B:** Dorsal view of trunk; scale 100 µm; **C:** Cephalon with proboscis, chelidore, and palps; scale 200 µm; **D:** Right 3rd leg; scale 200 µm; **E:** Tibia 2, tarsus, and propodus with claw (right 3rd leg); scale 100 µm; **F:** Propodus with claw; scale 20 µm.



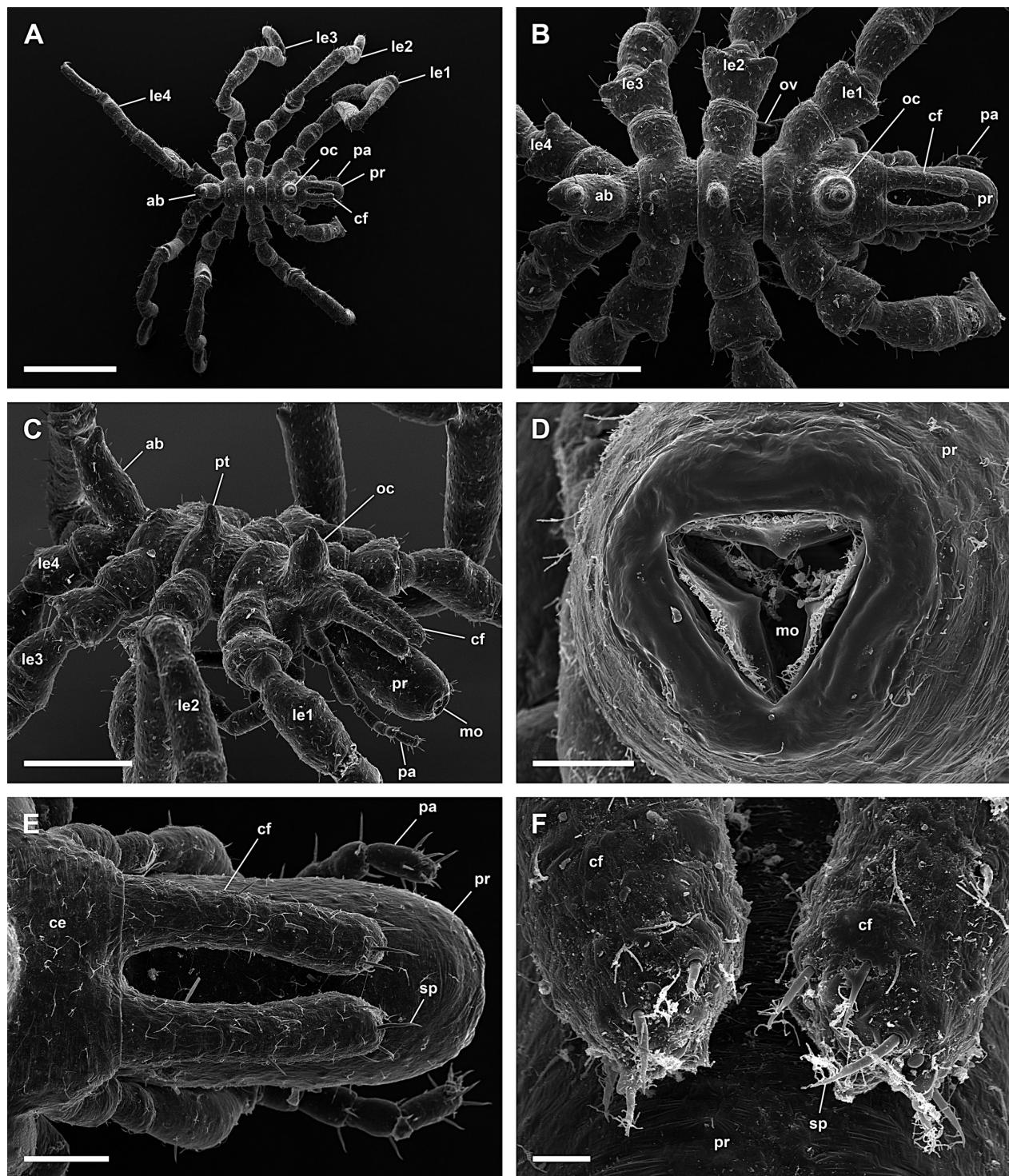
**Figure 19.** *Tanystylum conirostre*, male; **A:** Dorsal view; scale 1 mm; **B:** Dorsal view of trunk; scale 200 µm; **C:** Dorsal view of proboscis and 4-articled palp; scale 100 µm; **D:** Mouth opening; scale 20 µm; **E:** Reduced chelipores, frontal is up; scale 40 µm; **F:** Right 10-articled oviger; scale 100 µm.



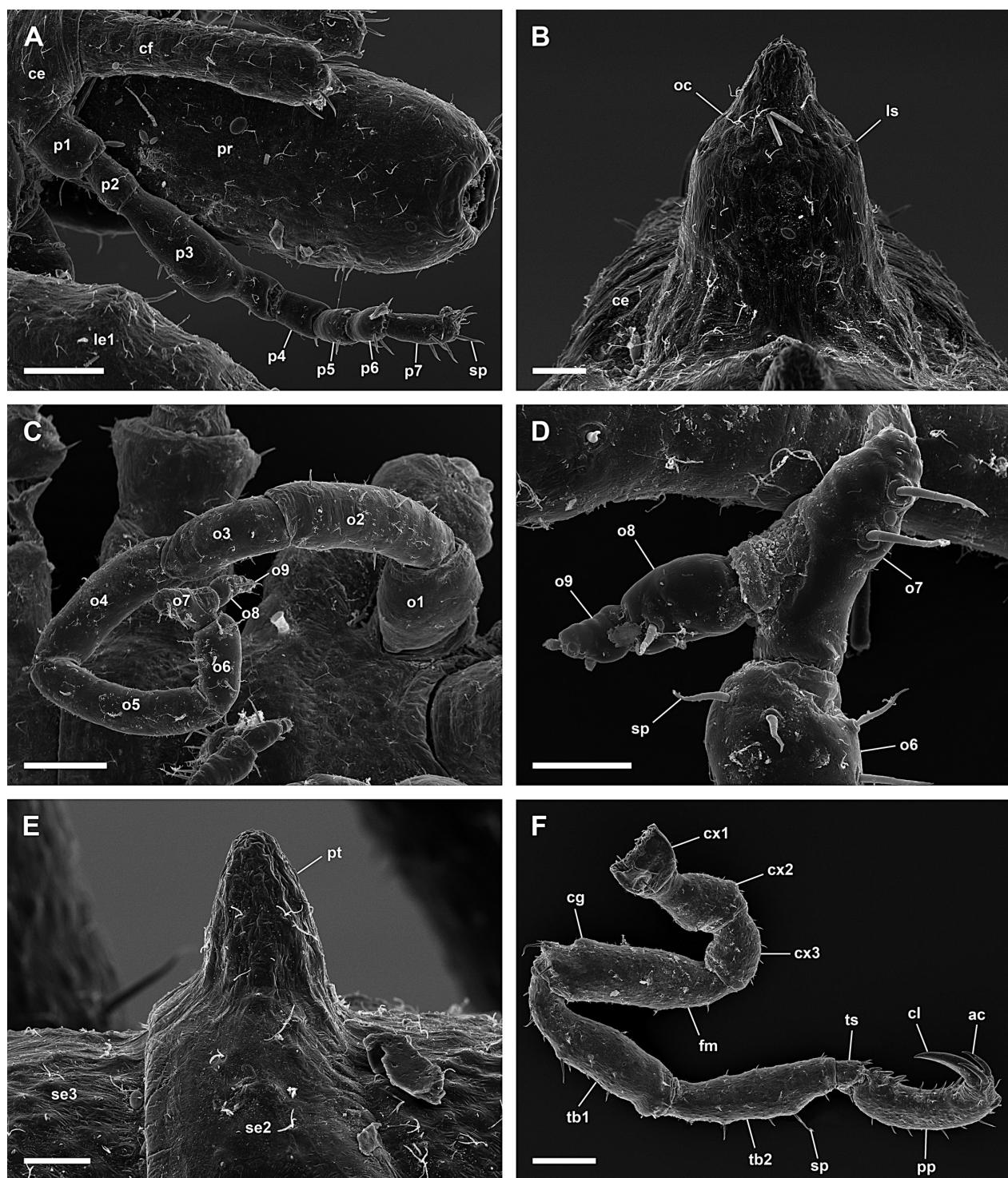
**Figure 20.** *Tanystylum conirostre*, male; **A:** Distal articles of right oviger with spines on tip; scale 10 µm; **B:** Left 3rd leg; scale 100 µm; **C:** Lateral view of coxa 2 with genital opening on a protuberance, distal is right (left 4th leg); scale 40 µm; **D:** Genital opening; scale 10 µm; **E:** Cement gland on femur, distal is up (left 3rd leg); scale 20 µm; **F:** Tarsus, propodus, and claws (left 3rd leg); scale 100 µm; **G:** Hairs and slit organs on dorsal side of trunk; scale 10 µm.



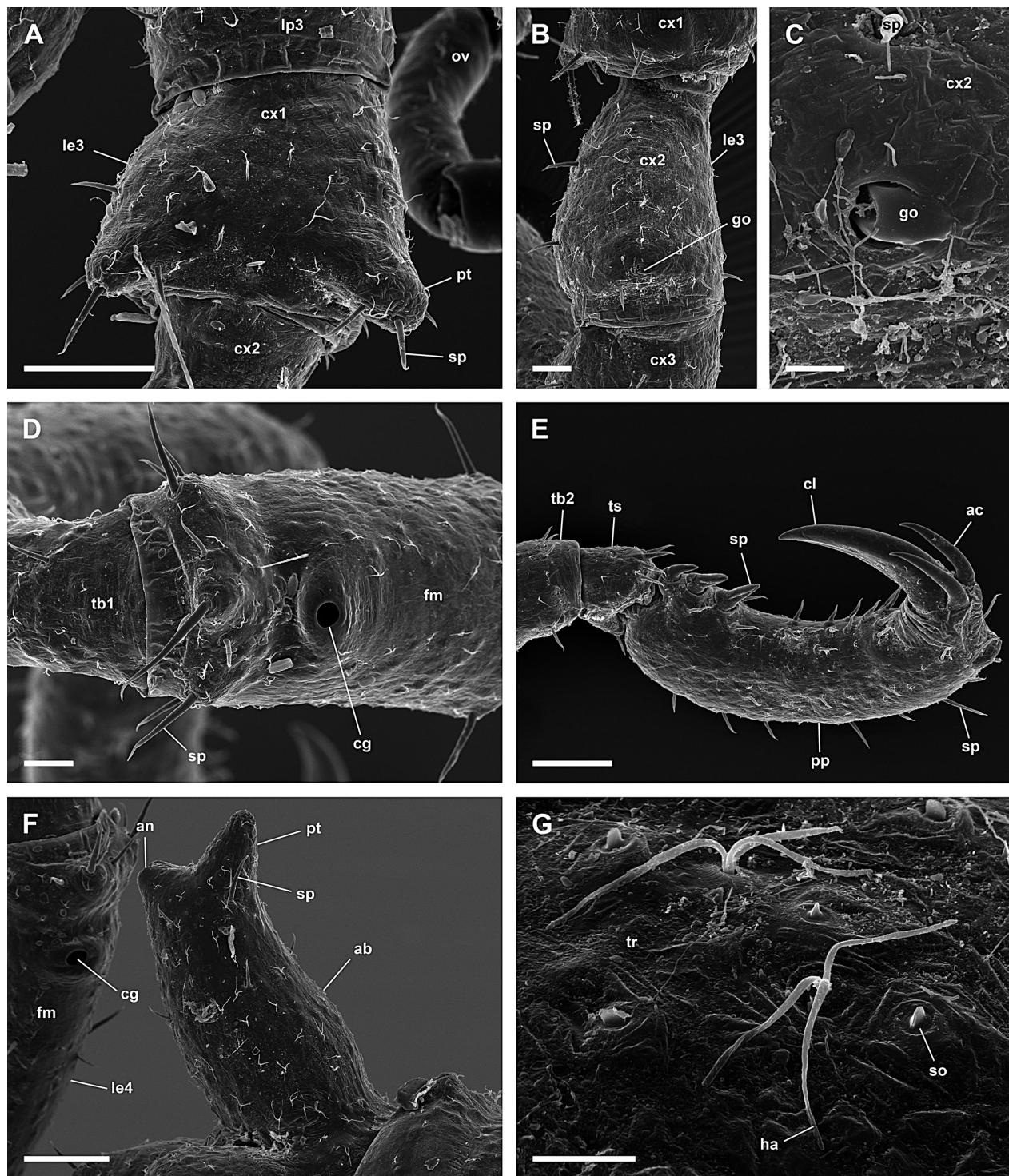
**Figure 21.** *Tanystylum conirostre*, female; **A:** Dorsal view of trunk; scale 400 µm; **B:** Frontal view of trunk; scale 200 µm; **C:** Left 10-articled oviger; scale 40 µm; **D:** Distal articles of left oviger; scale 40 µm; **E:** Ventral view of coxa 2 with genital opening, distal is right (right 4th leg); scale 40 µm; **F:** Genital opening; scale 10 µm; **G:** Abdomen; scale 40 µm.



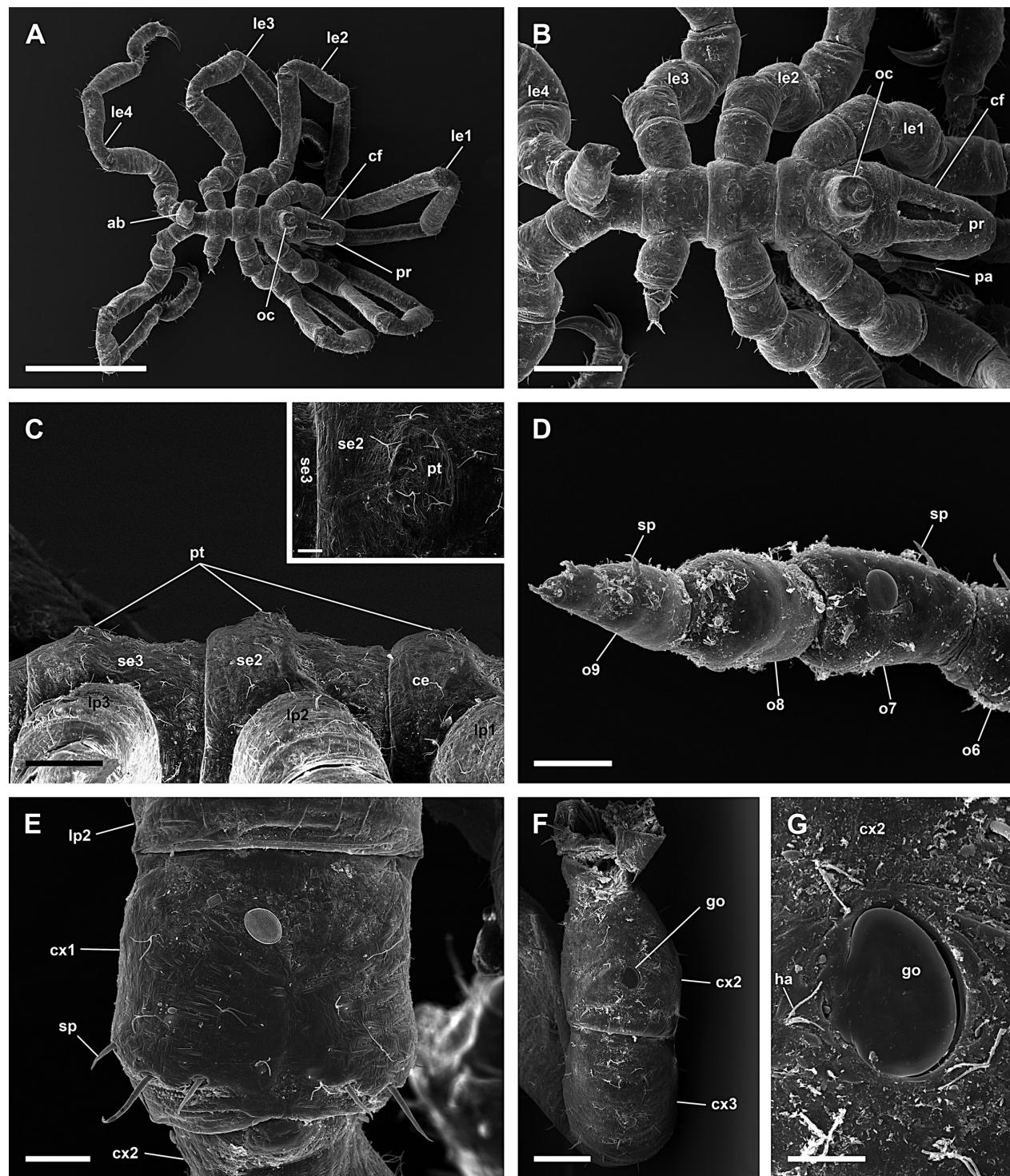
**Figure 22.** *Trygaeus communis*, male; **A:** Dorsal view; scale 1 mm; **B:** Dorsal view of trunk; scale 400 µm; **C:** Lateral view of trunk with protuberances on midline; scale 400 µm; **D:** Mouth opening; scale 40 µm; **E:** Dorsal view of proboscis and chelifore without chela; scale 100 µm; **F:** Tip of chelifore without chela; scale 20 µm.



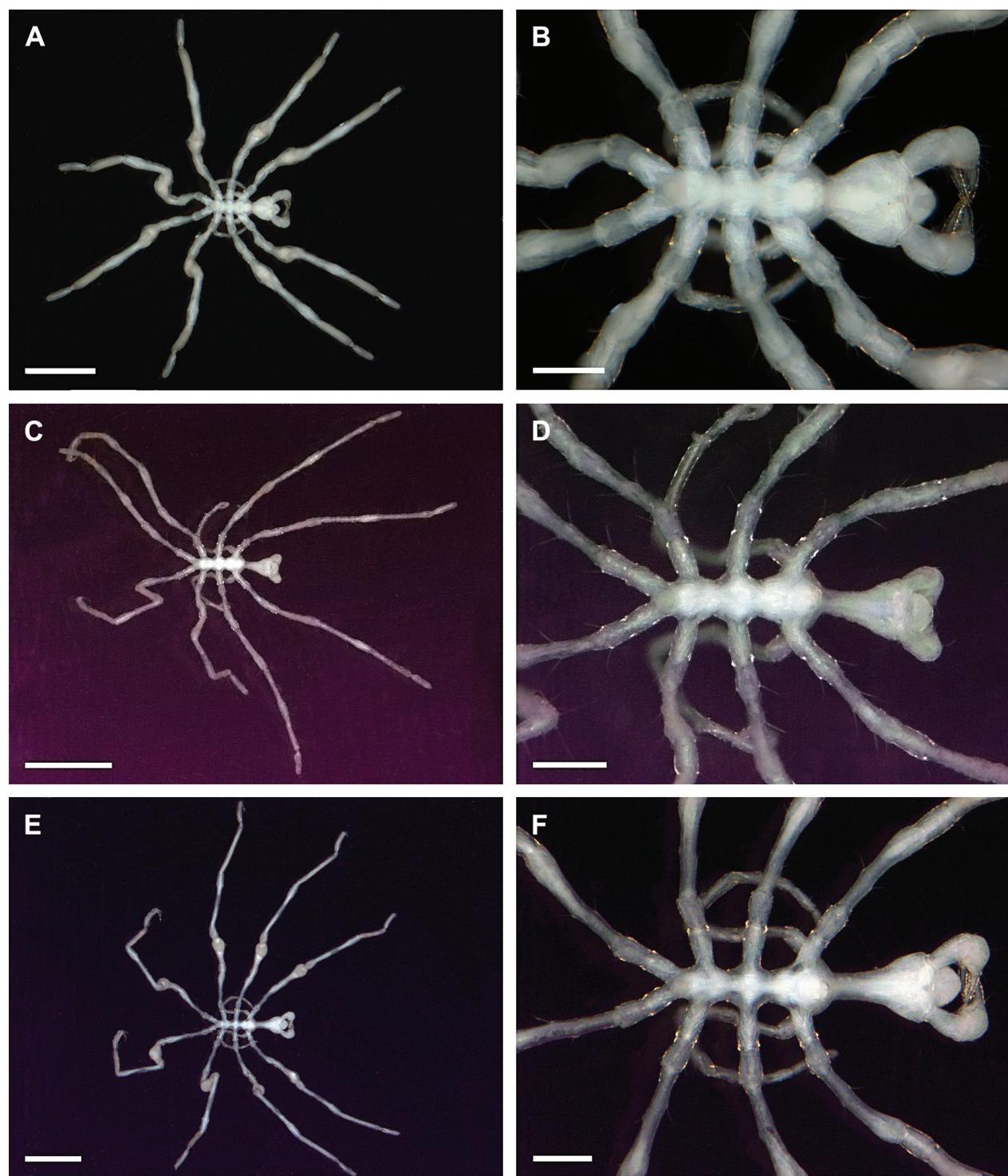
**Figure 23.** *Trygaeus communis*, male; **A:** Lateral view of proboscis and 7-articled right palp; scale 100 µm; **B:** Ocular tubercle with lateral sense organ; scale 40 µm; **C:** Right 9-articled oviger; scale 100 µm; **D:** Distal articles of right oviger; scale 40 µm; **E:** Pro-tuberance on midline of segment 2; scale 40 µm; **F:** Right 3rd leg; scale 200 µm.



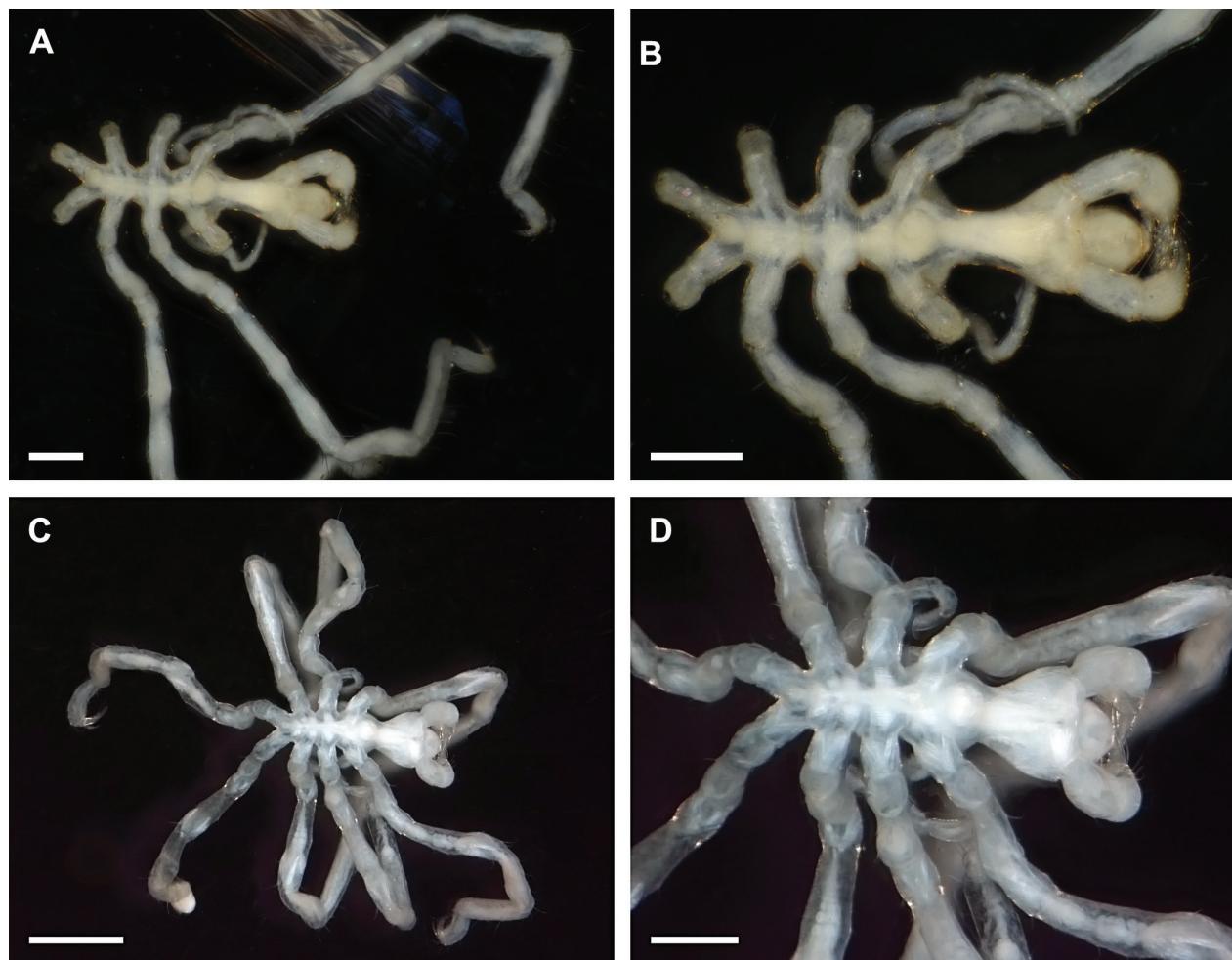
**Figure 24.** *Trygaeus communis*, male; **A:** Dorsal view of coxa 1 with protuberances on distal corners (right 3rd leg); scale 100 µm; **B:** Ventral view of coxa 2 with genital opening, distal is down (left 3rd leg); scale 40 µm; **C:** Genital opening; scale 10 µm; **D:** Cement gland on femur, distal is left (left 3rd leg); scale 40 µm; **E:** Tarsus, propodus, and claws (right 3rd leg); scale 100 µm; **F:** Abdomen with protuberance on tip; scale 100 µm; **G:** Hairs and slit organs on dorsal side of trunk; scale 10 µm.



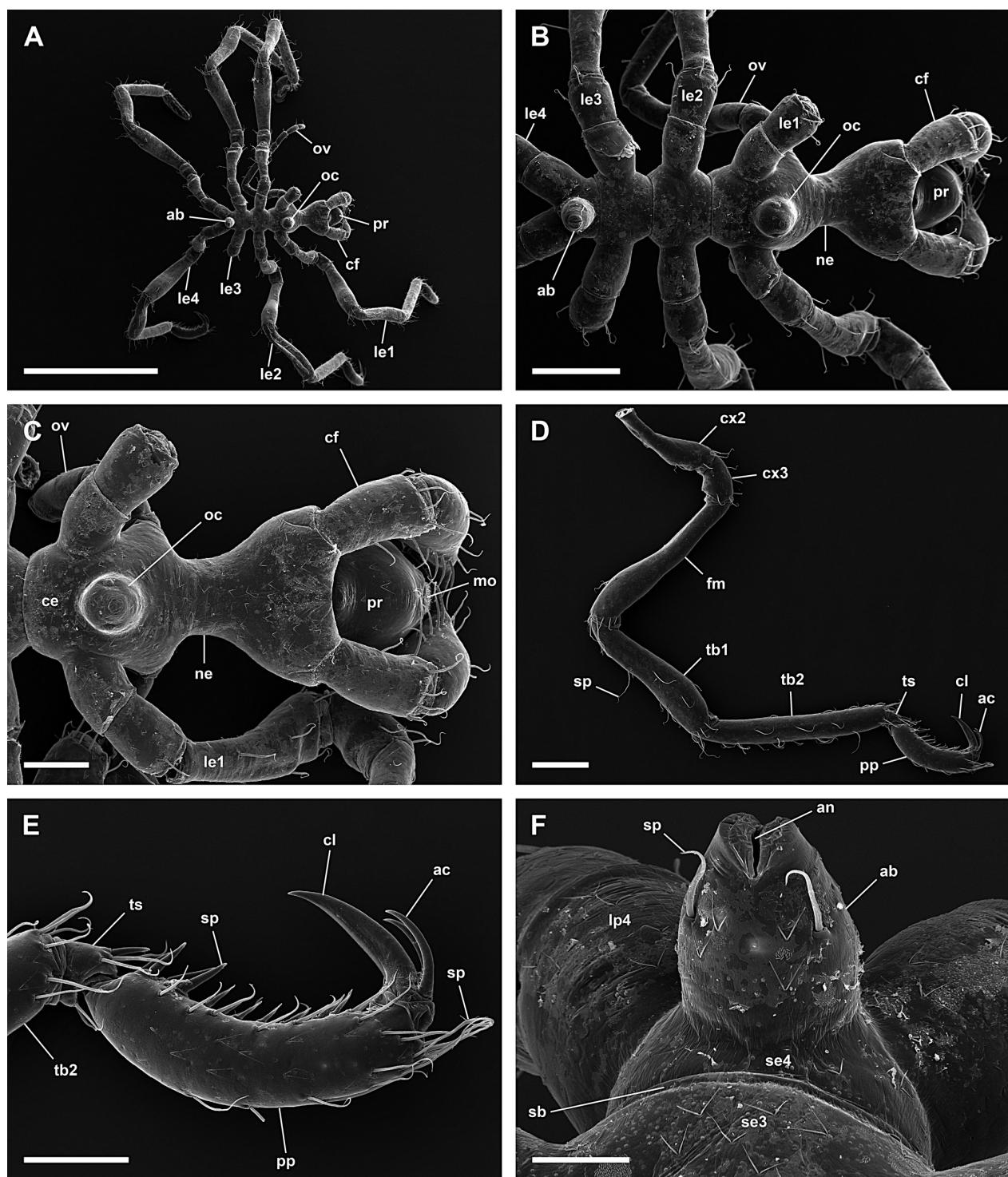
**Figure 25.** *Trygaeus communis*, female; **A:** Dorsal view; scale 1 mm; **B:** Dorsal view of trunk; scale 300 µm; **C:** Lateral view of trunk with protuberances on midline, frontal is right; scale 100 µm; insert: Protuberance on segment 2; scale 20 µm; **D:** Distal article of oviger; scale 40 µm; **E:** Dorsal view of coxa 1 without protuberances on distal corners (right 2nd leg); scale 40 µm; **F:** Ventral view of coxa 2 with genital opening, distal is down (right 3rd leg); scale 100 µm; **G:** Genital opening; scale 20 µm.



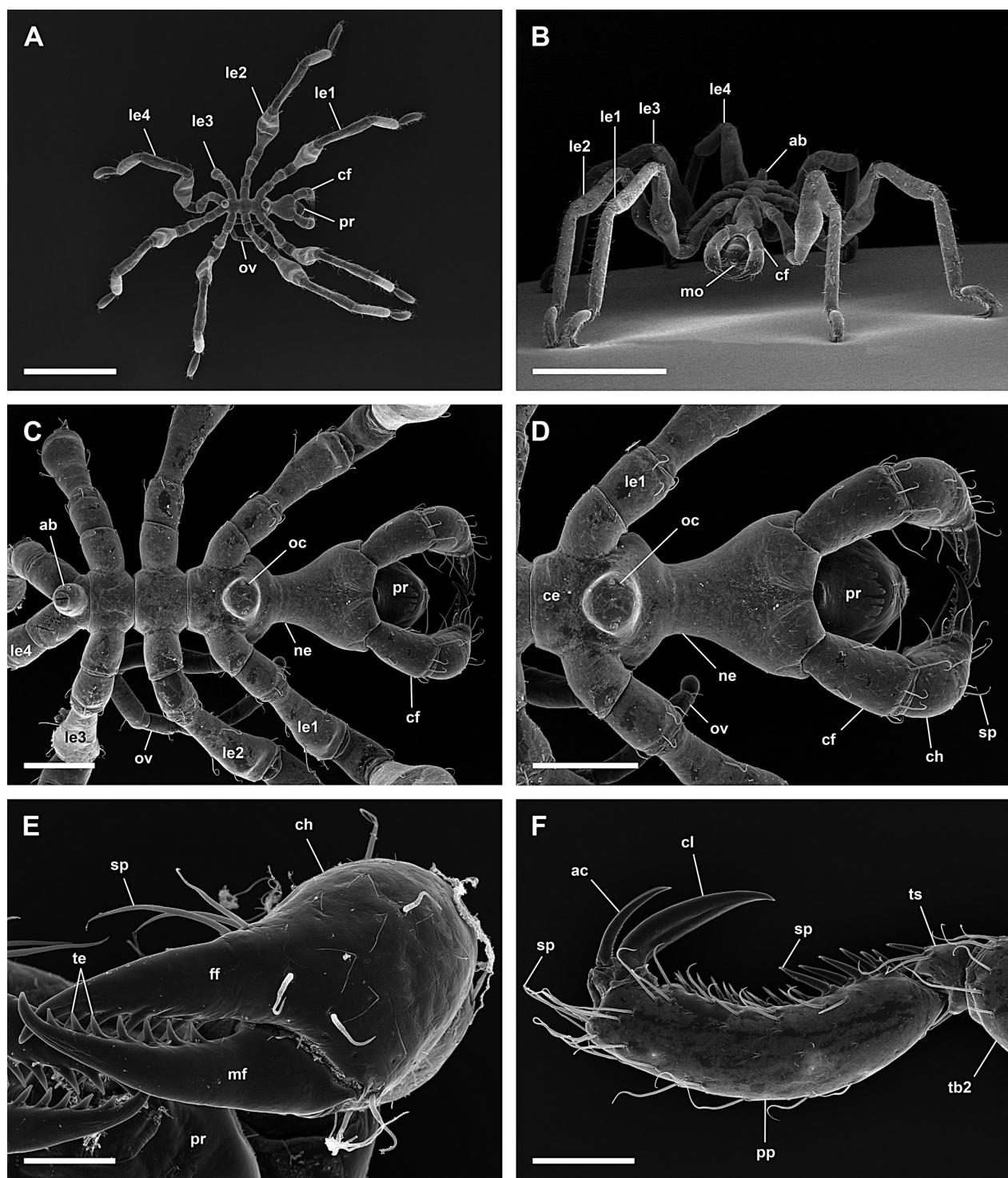
**Figure 26.** Callipallenidae 1; **A, B:** *Callipallene emaciata*, female, dorsal view; scales 1 mm and 250 µm, respectively; **C, D:** *Callipallene phantoma*, male, dorsal view; scales 1 mm and 250 µm, respectively; **E, F:** *Callipallene producta*, female, dorsal view; scales 1 mm and 250 µm, respectively.



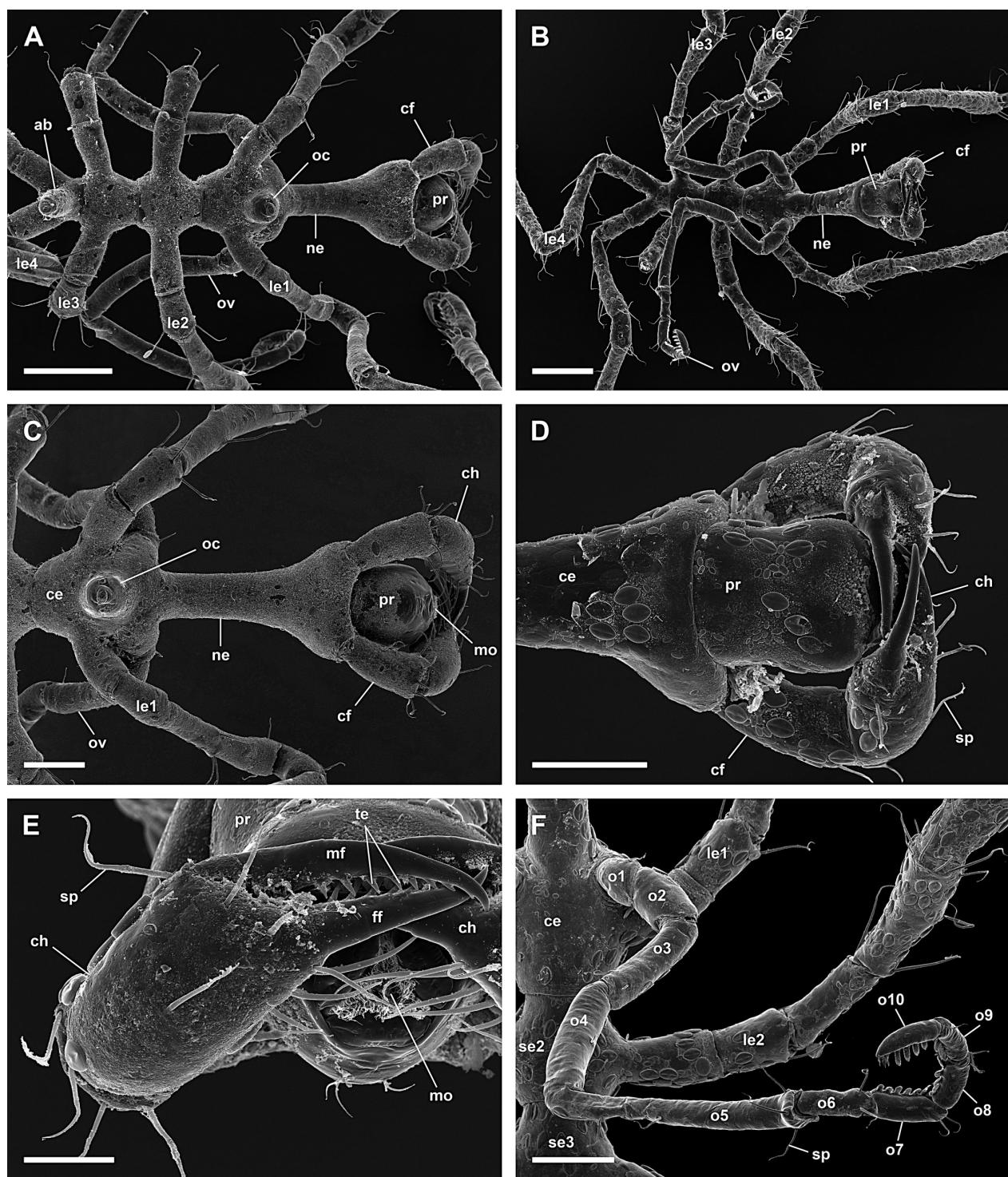
**Figure 27.** Callipallenidae 2; **A, B:** *Callipallene spectrum*, male, dorsal view; scales 200 µm; **C, D:** *Callipallene tiberi*, female, dorsal view; scales 500 µm and 250 µm, respectively.



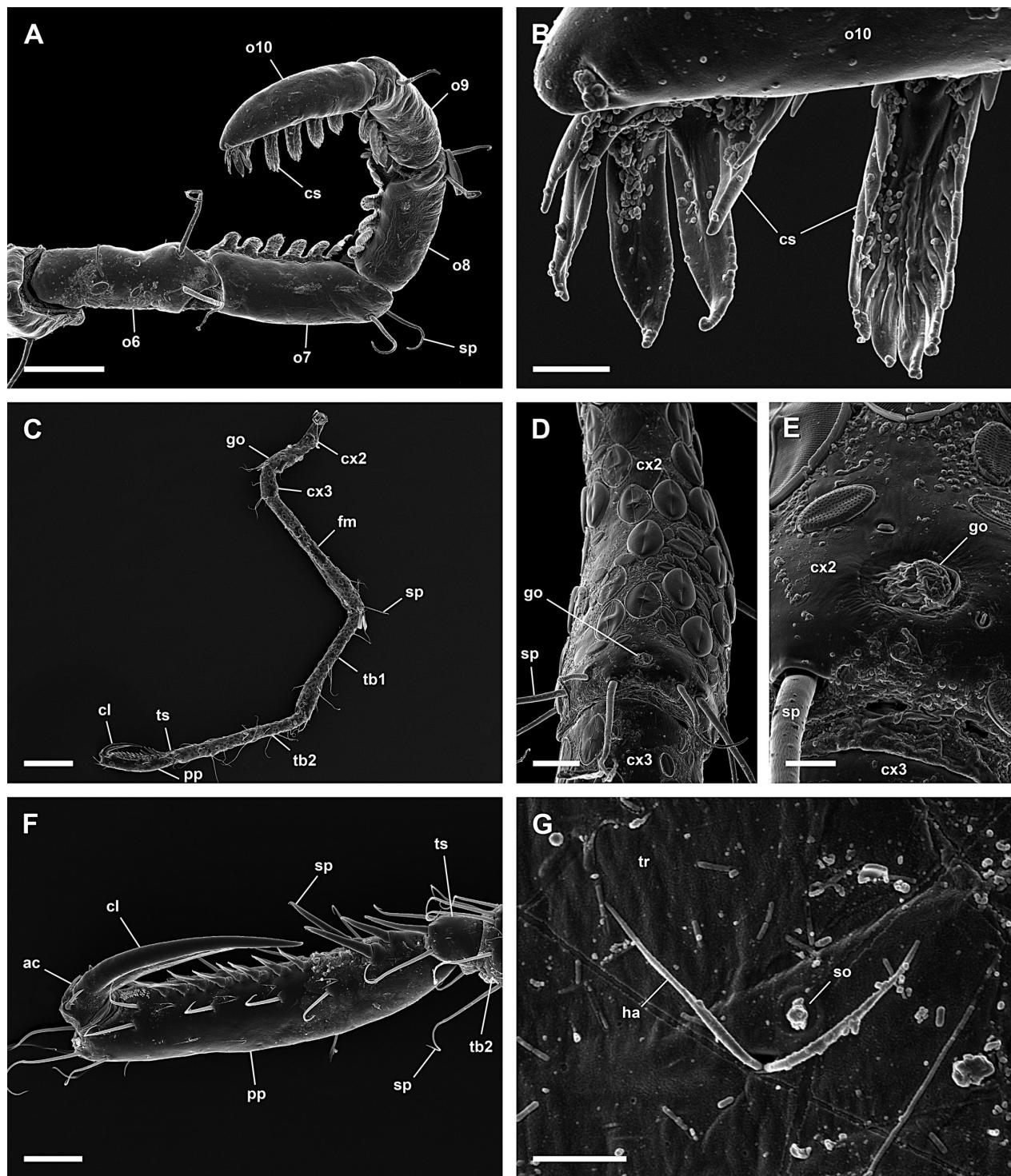
**Figure 28.** *Callipallene emaciata*, male; **A:** Dorsal view; scale 1 mm; **B:** Dorsal view of trunk; scale 200 µm; **C:** Dorsal view of cephalon with rather slender neck; scale 100 µm; **D:** Right 3rd leg; scale 100 µm; **E:** Tarsus, strongly curved propodus, and claw, auxiliary claws about half as long as claw (right 3rd leg); scale 100 µm; **F:** Segment 3, 4 and abdomen; scale 40 µm.



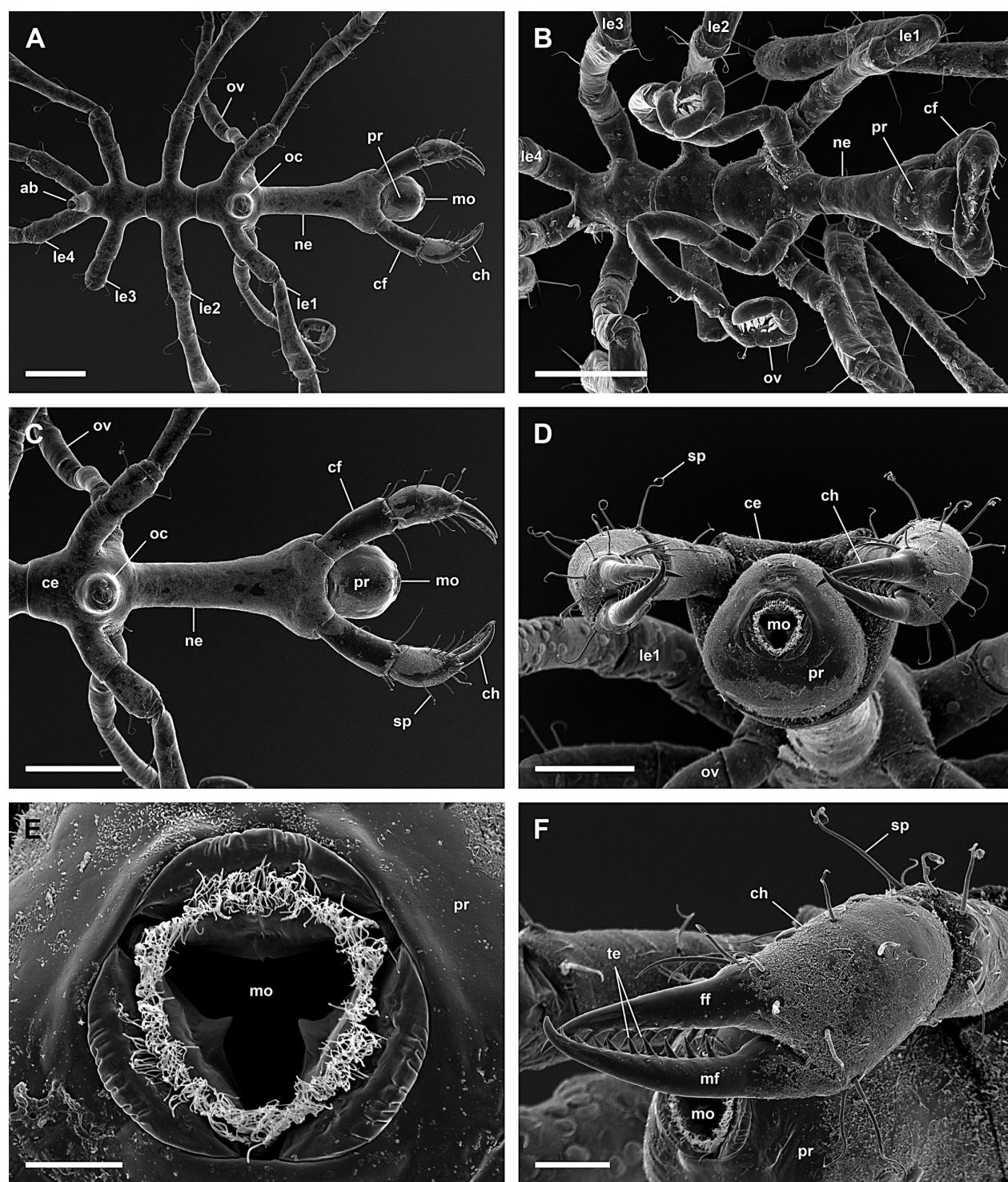
**Figure 29.** *Callipallene emaciata*, female; **A:** Dorsal view; scale 1 mm; **B:** Frontal view; scale 1 mm; **C:** Dorsal view of trunk; scale 200 µm; **D:** Dorsal view of cephalon with rather slender neck; scale 200 µm; **E:** Left chela, dorsal is up; scale 40 µm; **F:** Tarsus, strongly curved propodus, and claw, auxiliary claws about half as long as claw (left 3rd leg); scale 100 µm.



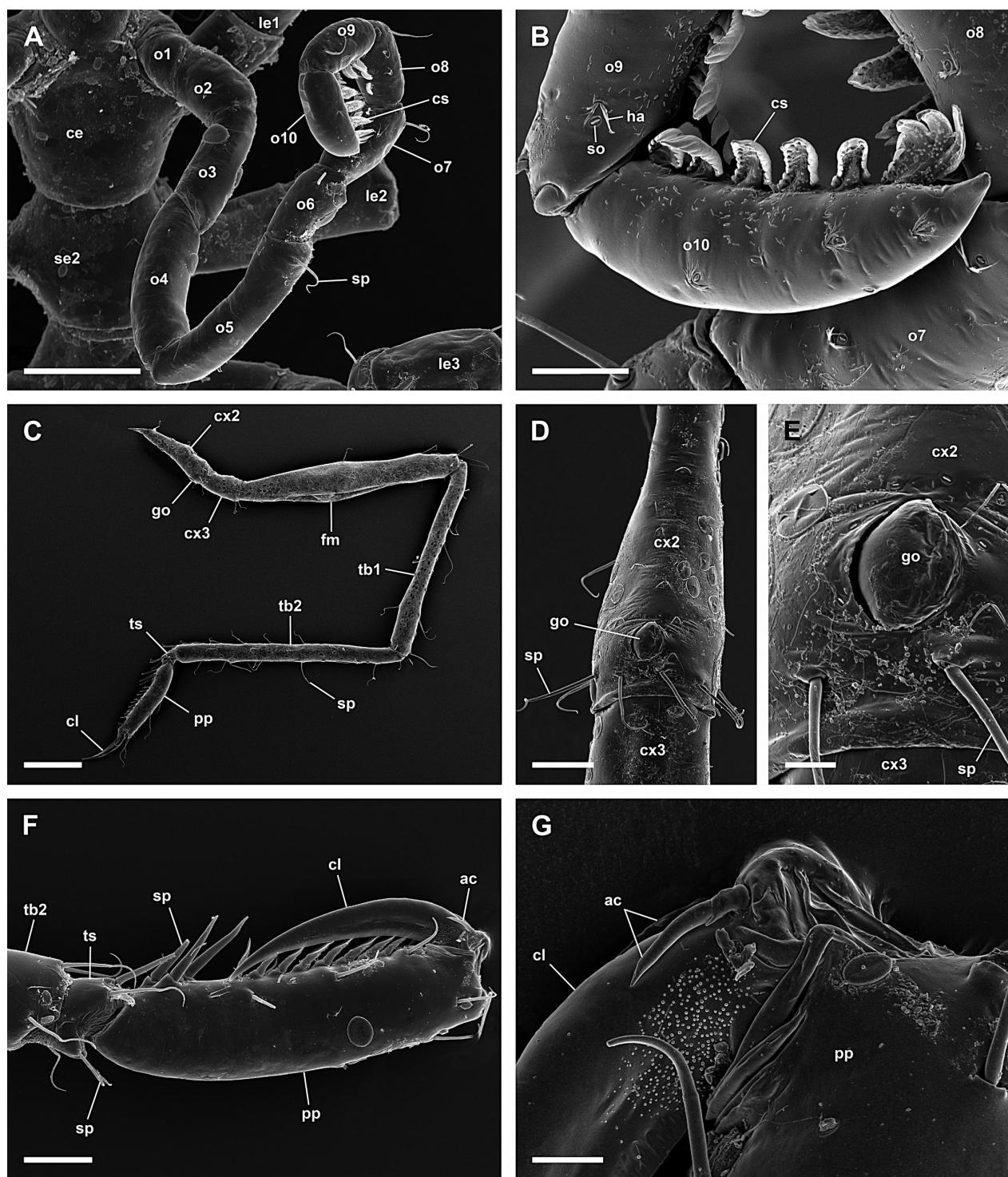
**Figure 30.** *Callipallene phantomma*, male; **A:** Dorsal view of trunk; scale 200 µm; **B:** Ventral view of trunk; scale 200 µm; **C:** Dorsal view of cephalon with very long and slender neck; scale 100 µm; **D:** Ventral view of proboscis; scale 100 µm; **E:** Left chela, dorsal is down; scale 40 µm; **F:** Left 10-articled oviger; scale 100 µm.



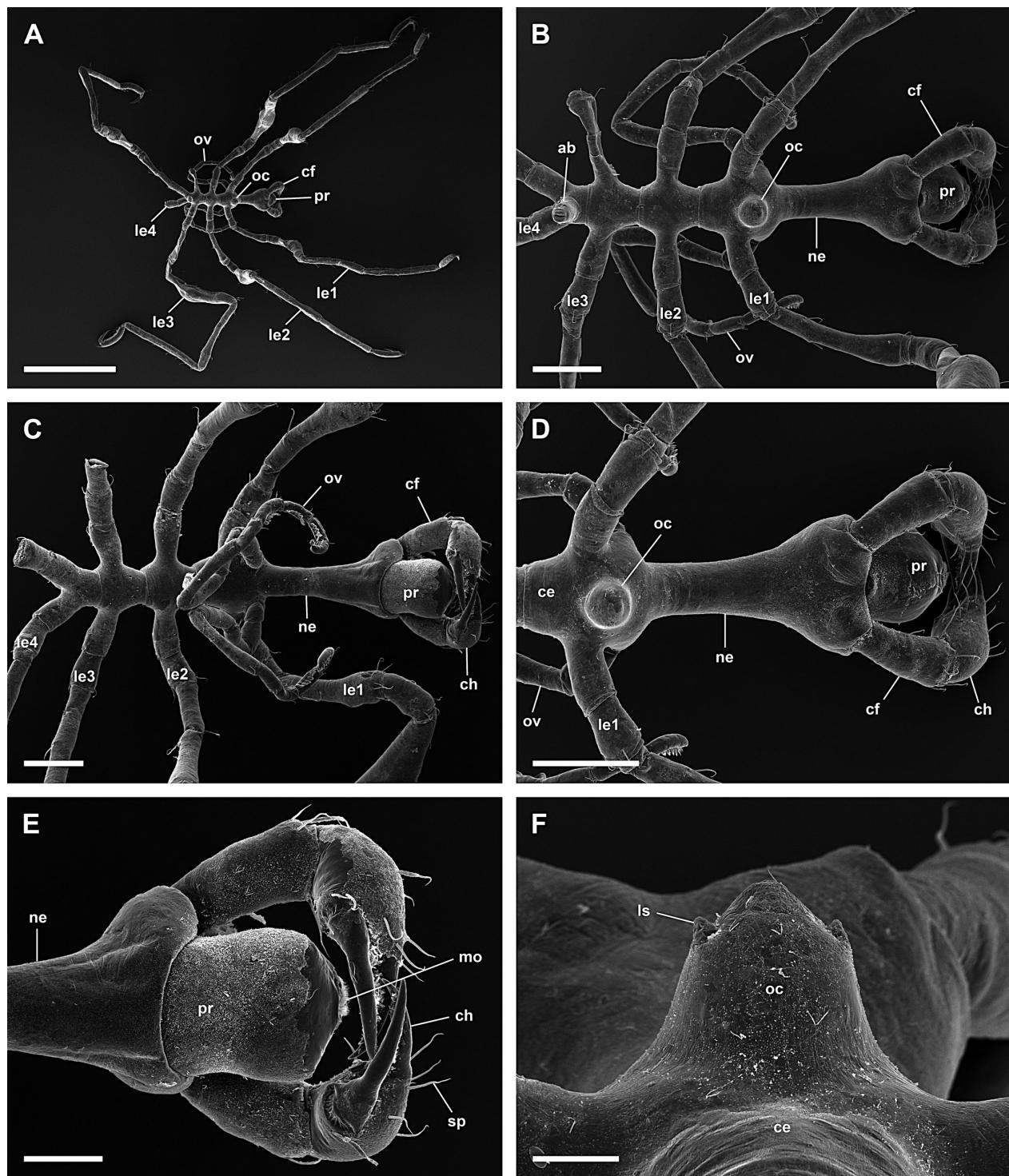
**Figure 31.** *Callipallene phantoma*, male; **A:** Distal articles of left oviger with compound spines; scale 40 µm; **B:** Compound spines on last oviger-article; scale 5 µm; **C:** Left 3rd leg; scale 200 µm; **D:** Ventral view of coxa 2 with genital opening, distal is down (right 2nd leg); scale 20 µm; **E:** Genital opening; scale 5 µm; **F:** Tarsus, straight propodus, and claw with very short auxiliary claws (right 3rd leg); scale 40 µm; **G:** Hair and slit organ on dorsal side of trunk; scale 5 µm.



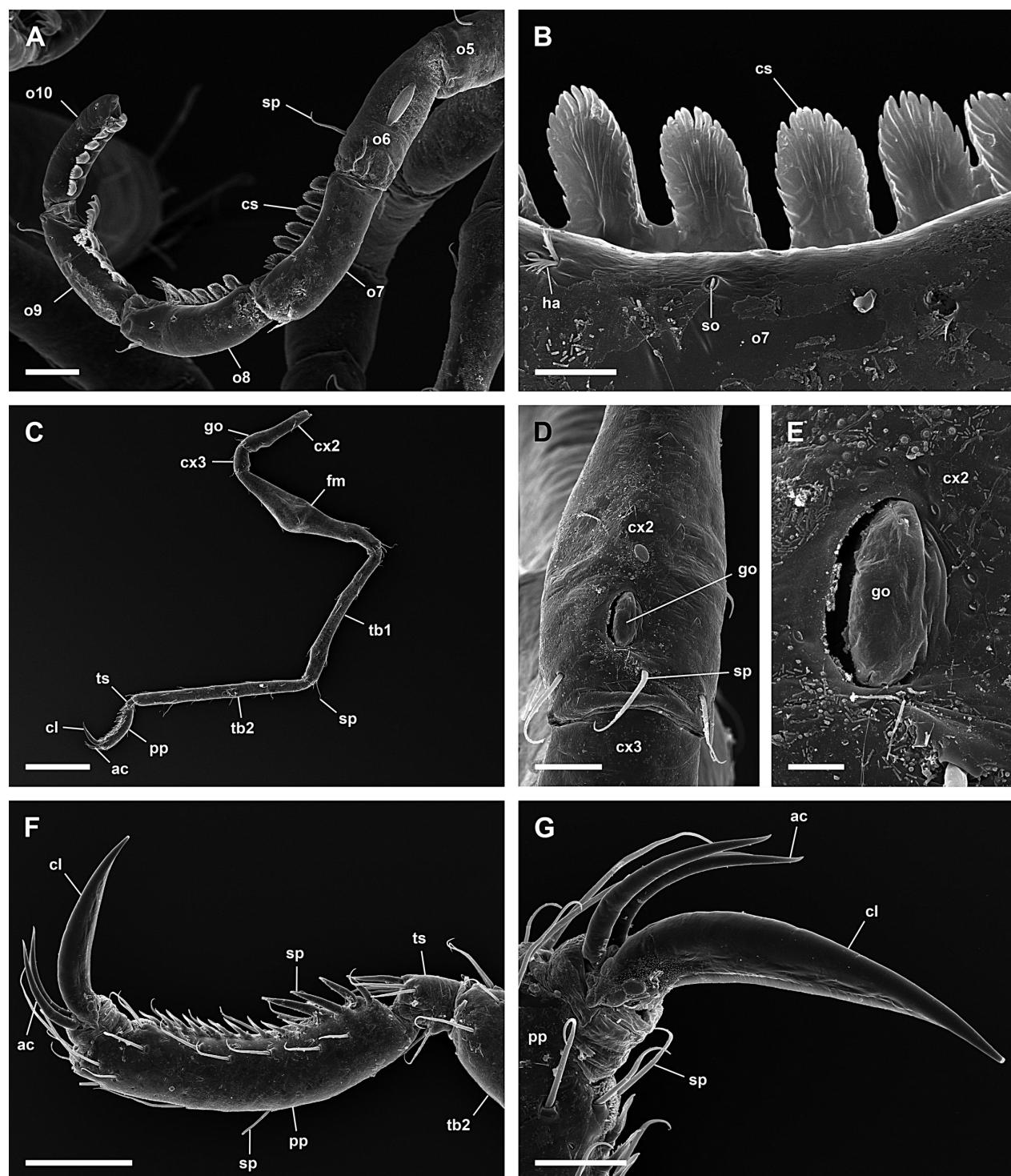
**Figure 32.** *Callipallene phantoma*, female; **A:** Dorsal view of trunk; scale 200 µm; **B:** Ventral view of trunk; scale 200 µm; **C:** Dorsal view of cephalon with very long and slender neck; scale 200 µm; **D:** Frontal view of cephalon; scale 100 µm; **E:** Mouth opening; scale 20 µm; **F:** Left chela, dorsal is up; scale 40 µm.



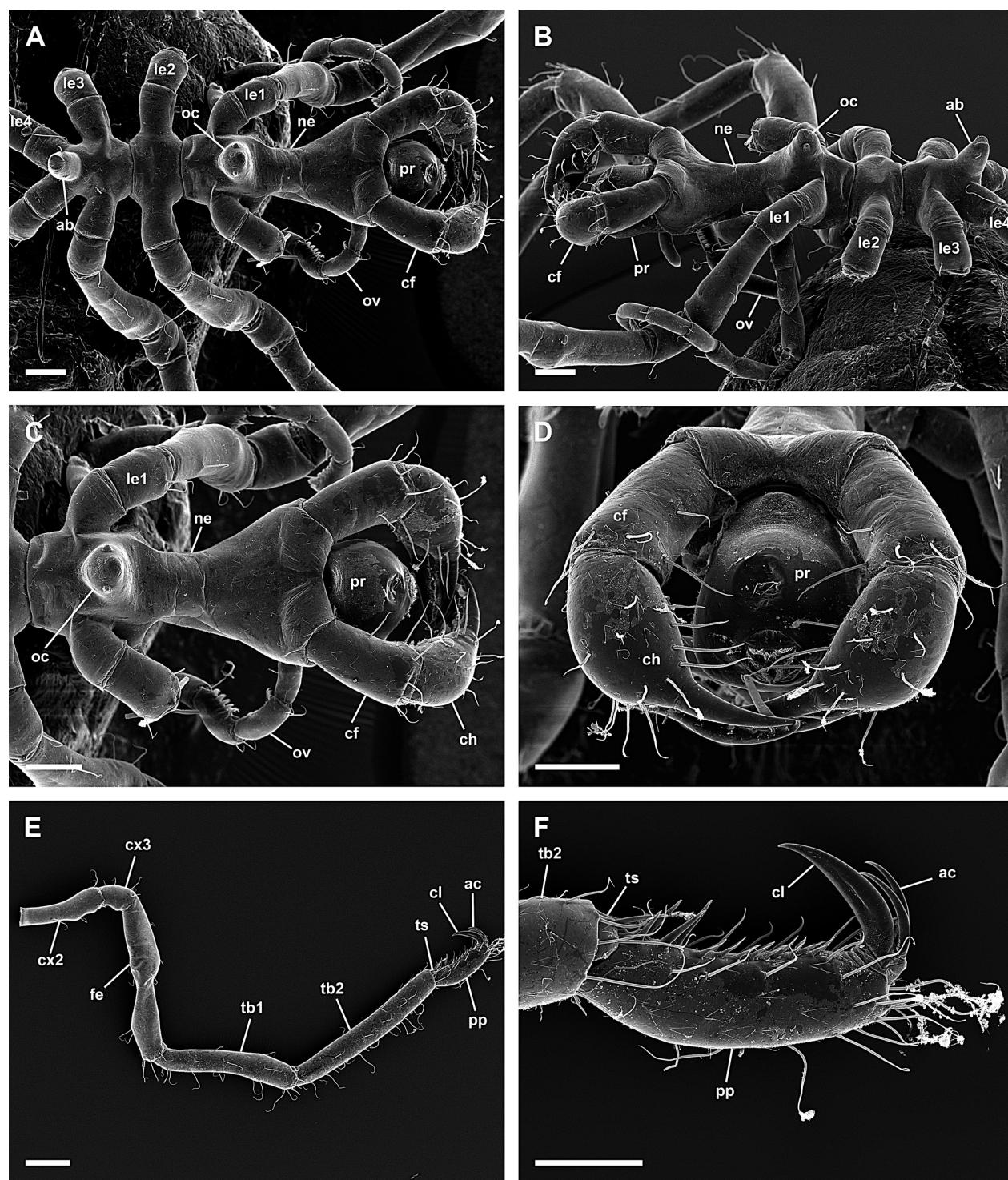
**Figure 33.** *Callipallene phantoma*, female; **A:** Right 10-articled oviger; scale 100 µm; **B:** Distalmost oviger-articles with compound spines; scale 20 µm; **C:** Right 3rd leg; scale 200 µm; **D:** Ventral view of coxa 2 with genital opening, distal is down (left 4th leg); scale 40 µm; **E:** Genital opening; scale 10 µm; **F:** Tarsus, straight propodus, and claw with very short auxiliary claws (left 3rd leg); scale 40 µm; **G:** Small auxiliary claws; scale 10 µm.



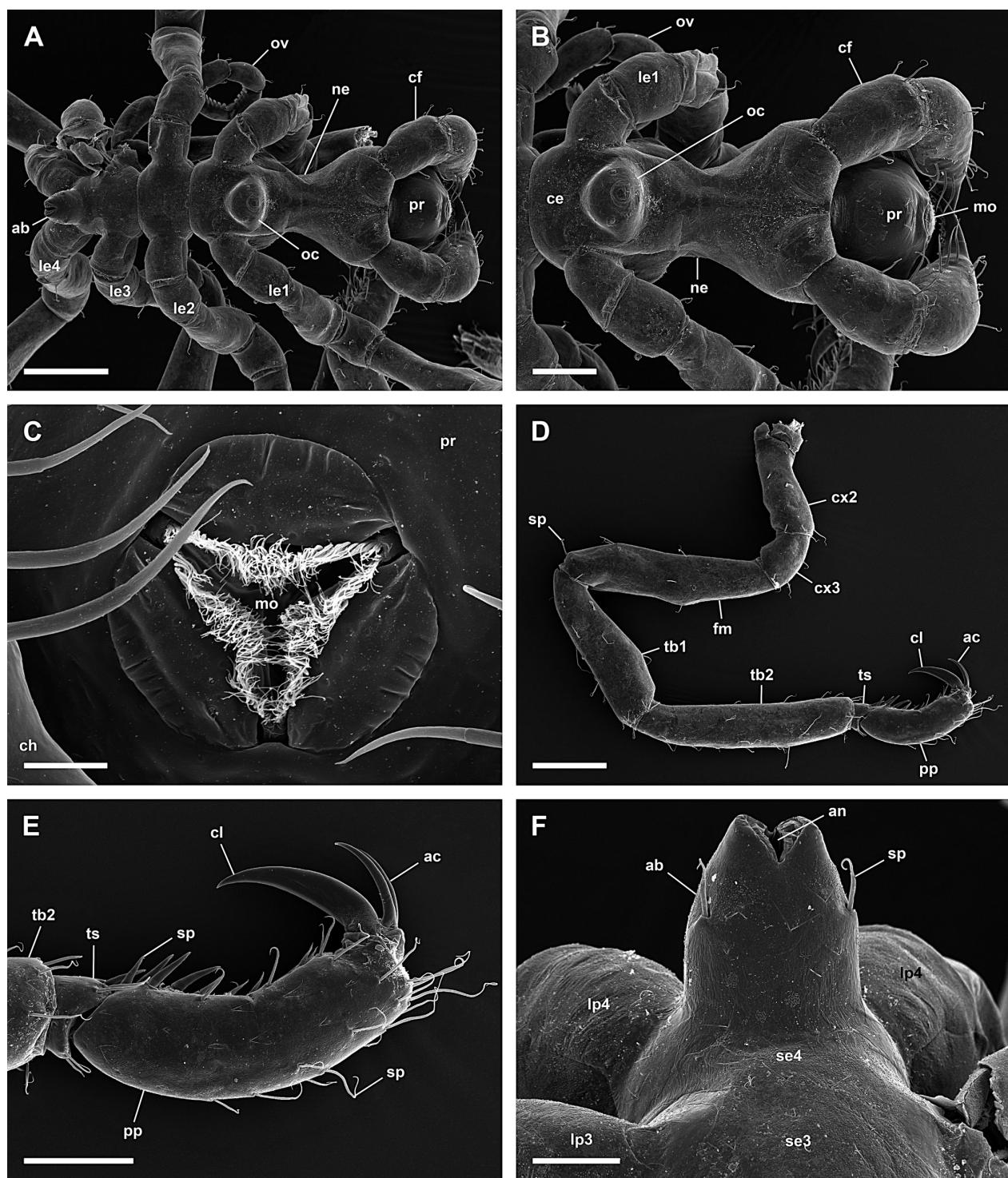
**Figure 34.** *Callipallene producta*, female; **A:** Dorsal view; scale 1 mm; **B:** Dorsal view of trunk; scale 200 µm; **C:** Ventral view of trunk; scale 200 µm; **D:** Dorsal view of cephalon with very long and slender neck; scale 200 µm; **E:** Ventral view of proboscis; scale 100 µm; **F:** Ocular tubercle with lateral sense organ; scale 40 µm.



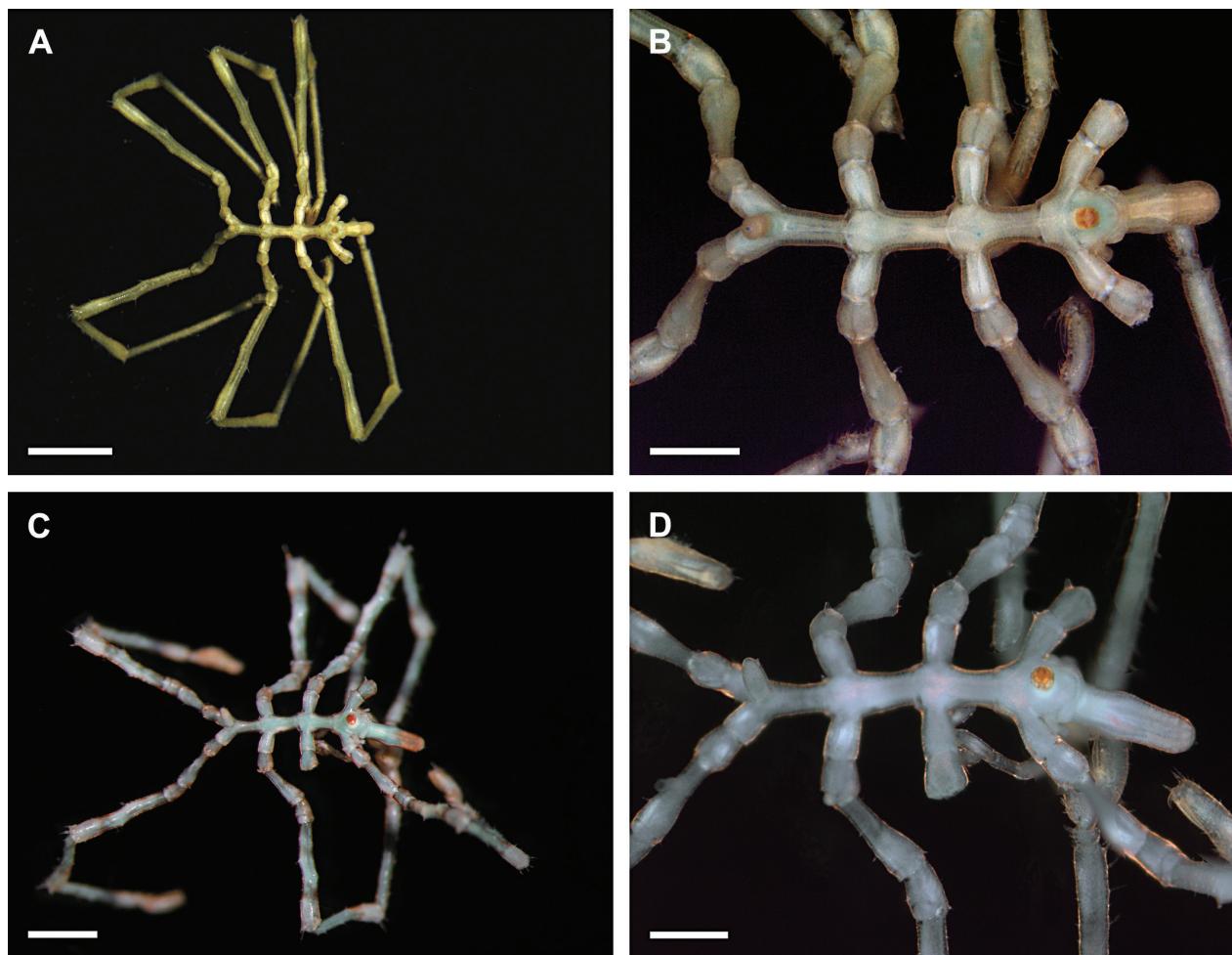
**Figure 35.** *Callipallene producta*, female; **A:** Distal article of right 10-articled oviger; scale 40 µm; **B:** Compound spines on oviger-article 7; scale 10 µm; **C:** Right 3rd leg; scale 400 µm; **D:** Ventral view of coxa 2 with genital opening, distal is down (left 3rd leg); scale 40 µm; **E:** Genital opening; scale 10 µm; **F:** Tarsus, slightly curved propodus, and claw with very long auxiliary claws (right 3rd leg); scale 100 µm; **G:** Claw and auxiliary claws; scale 40 µm.



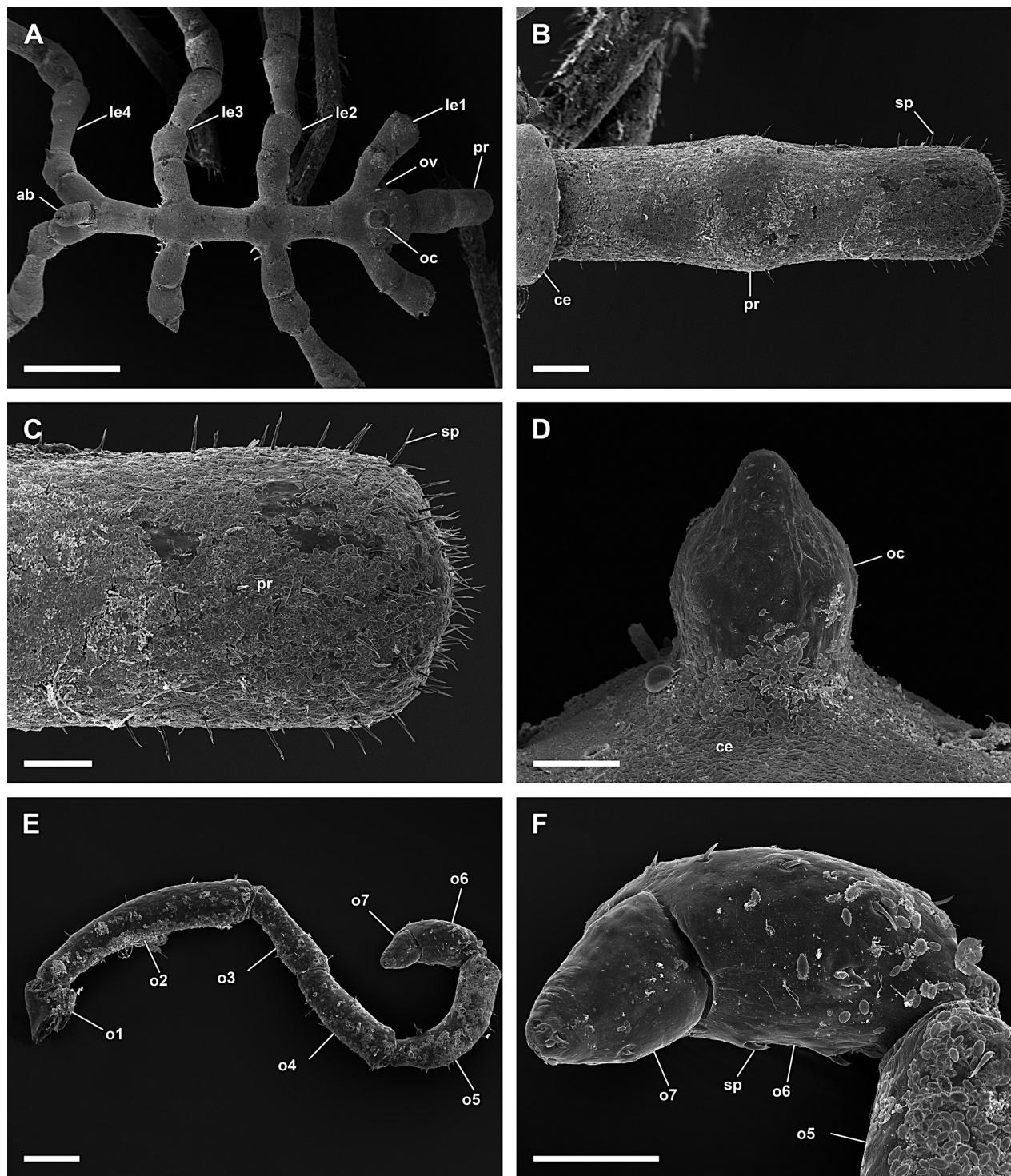
**Figure 36.** *Callipallene spectrum*, male; **A:** Dorsal view of trunk; scale 100 µm; **B:** Lateral view of trunk; scale 100 µm; **C:** Dorsal view of cephalon; scale 100 µm; **D:** Cephalon with proboscis and chelicerae; scale 100 µm; **E:** Left 3rd leg; scale 200 µm; **F:** Tibia2, tarsus, propodus, and claws (left 3rd leg); scale 100 µm.



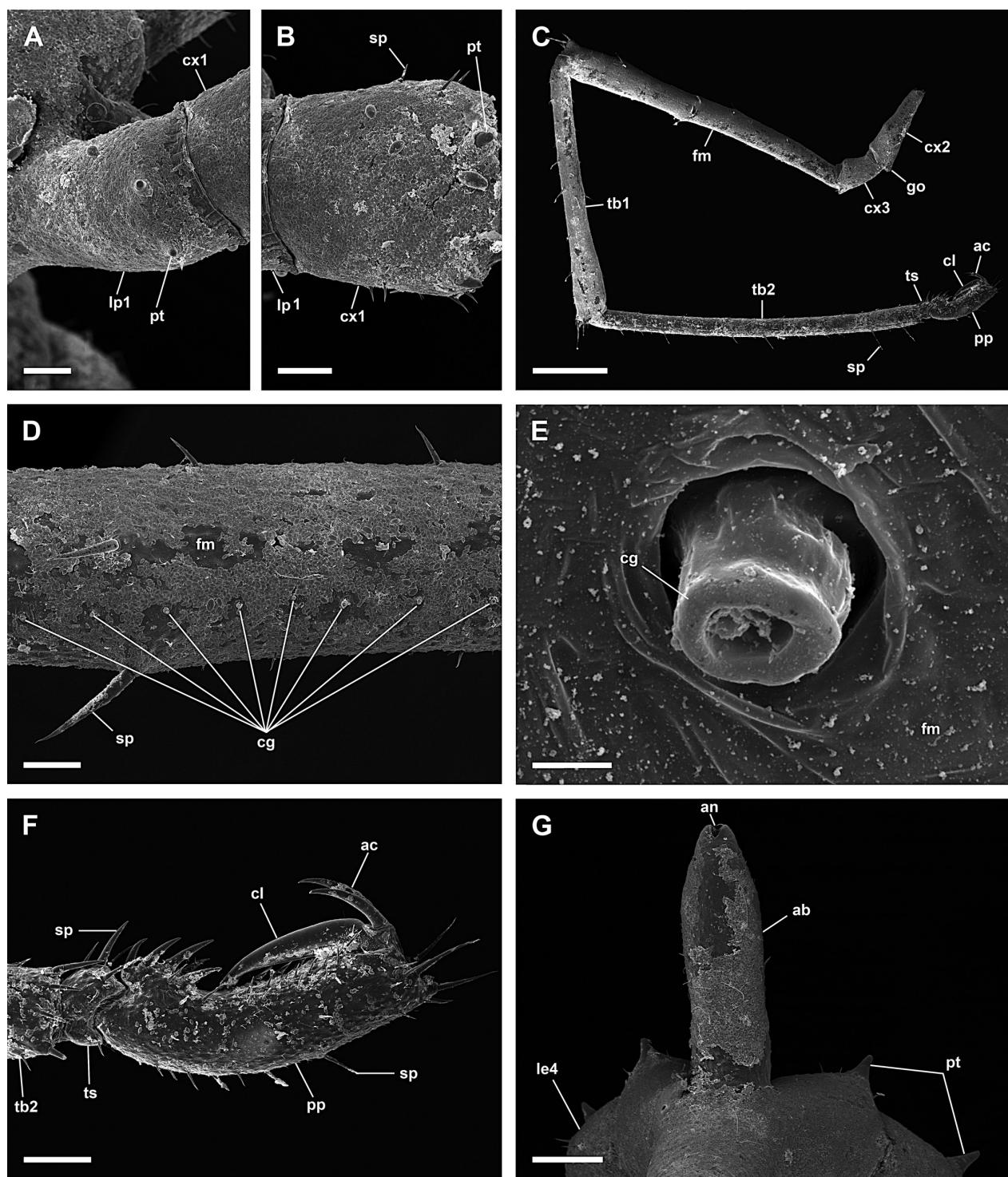
**Figure 37.** *Callipallene tiberi*, female; **A:** Dorsal view of trunk; scale 200 µm; **B:** Dorsal view of cephalon with very short neck; scale 100 µm; **C:** Mouth opening; scale 20 µm; **D:** Left 3rd leg; scale 200 µm; **E:** Tarsus, strongly curved propodus, and claw, auxiliary claws about half as long as claw (left 3rd leg); scale 100 µm; **F:** Segment 3, 4 and abdomen; scale 40 µm.



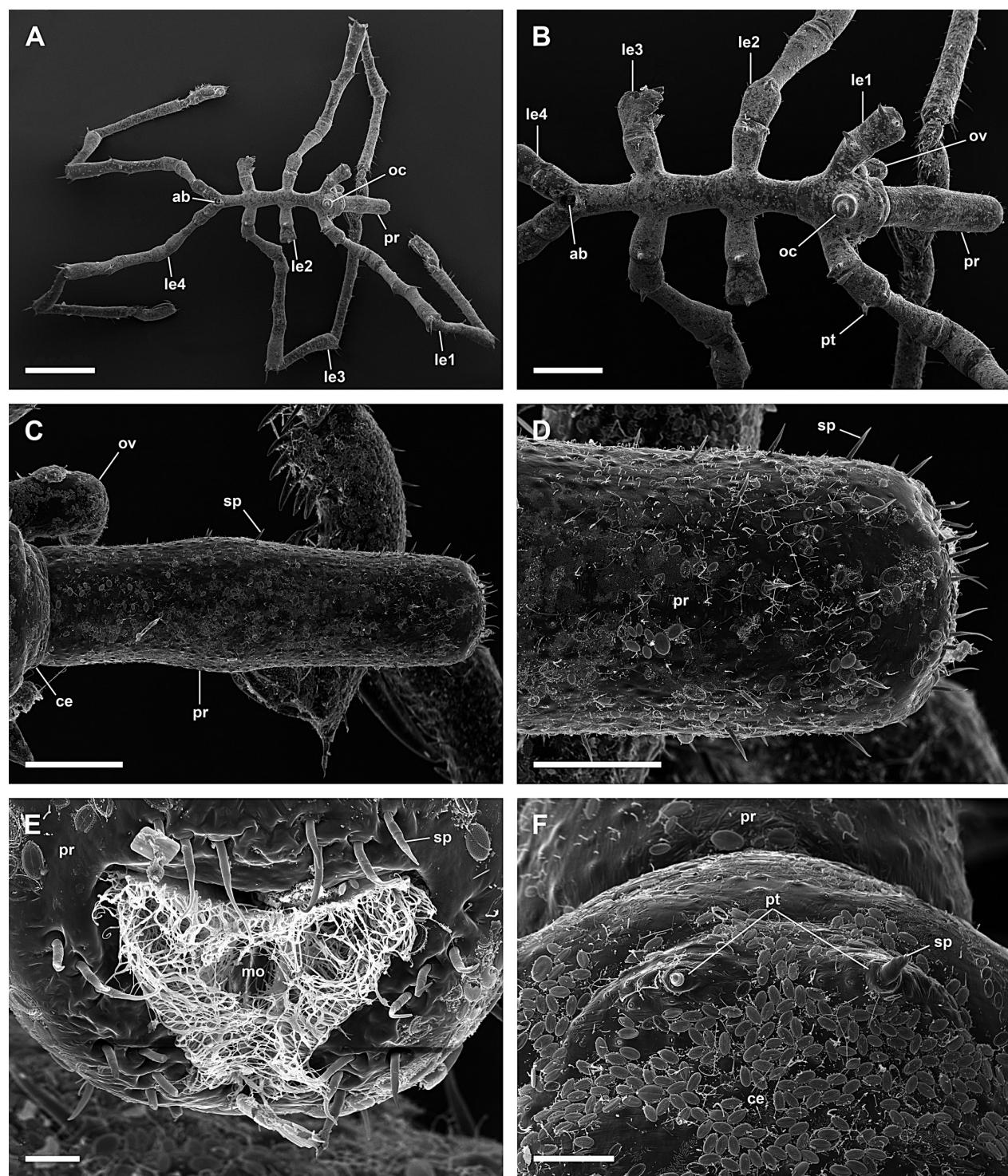
**Figure 38.** Endeidae; **A, B:** *Endeis charybdaea*, male, dorsal view; scales 3 mm and 1 mm, respectively; **C, D:** *Endeis spinosa*, male, dorsal view; scales 1 mm and 500 µm, respectively.



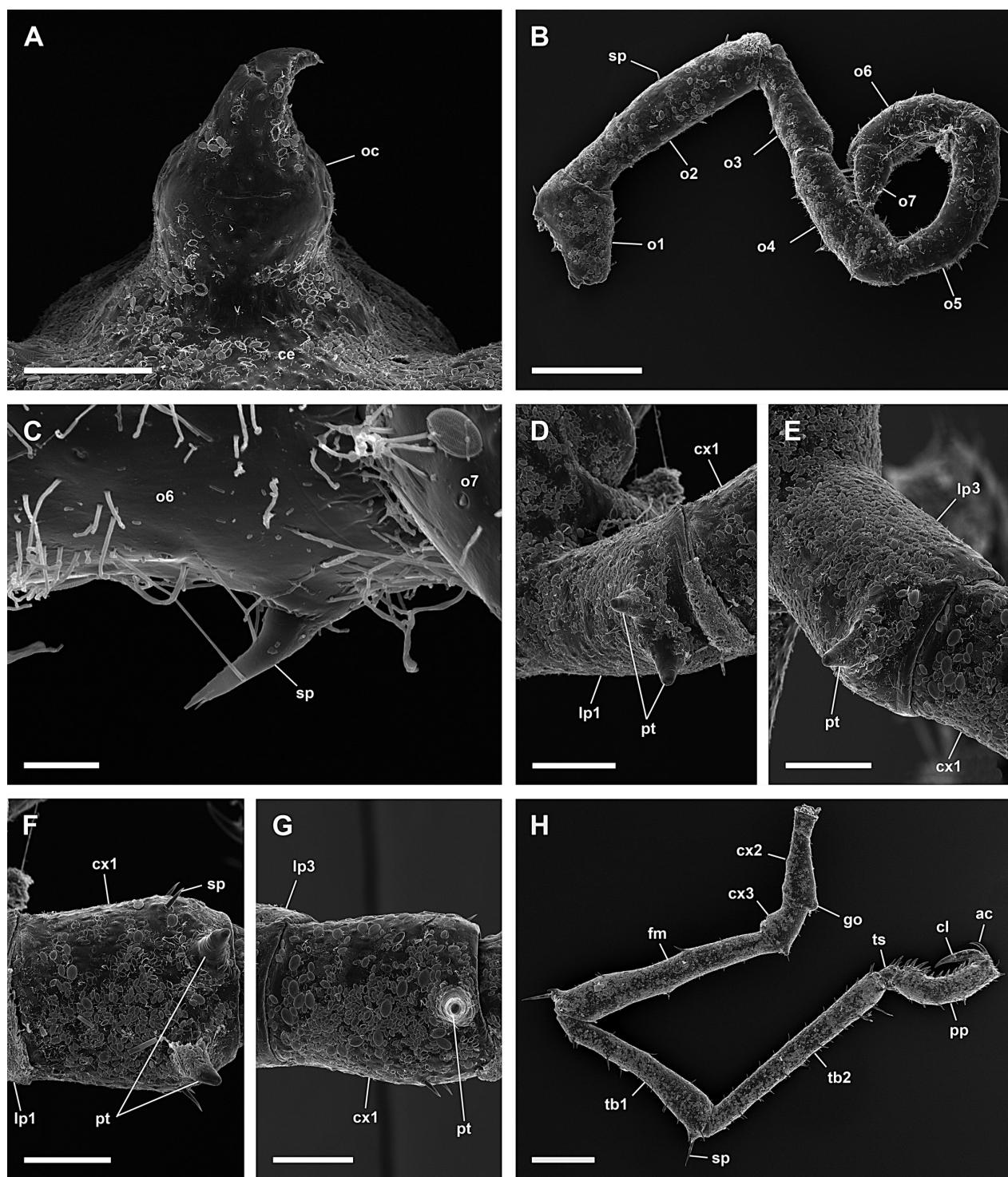
**Figure 39.** *Endeis charybdaea*, male; **A:** Dorsal view of trunk; scale 1 mm; **B:** Dorsal view of proboscis; scale 200 µm; **C:** Tip of proboscis with numerous spines around mouth; scale 100 µm; **D:** Ocular tubercle; scale 100 µm; **E:** 7-articled oviger; scale 200 µm; **F:** Distal articles of oviger; scale 100 µm.



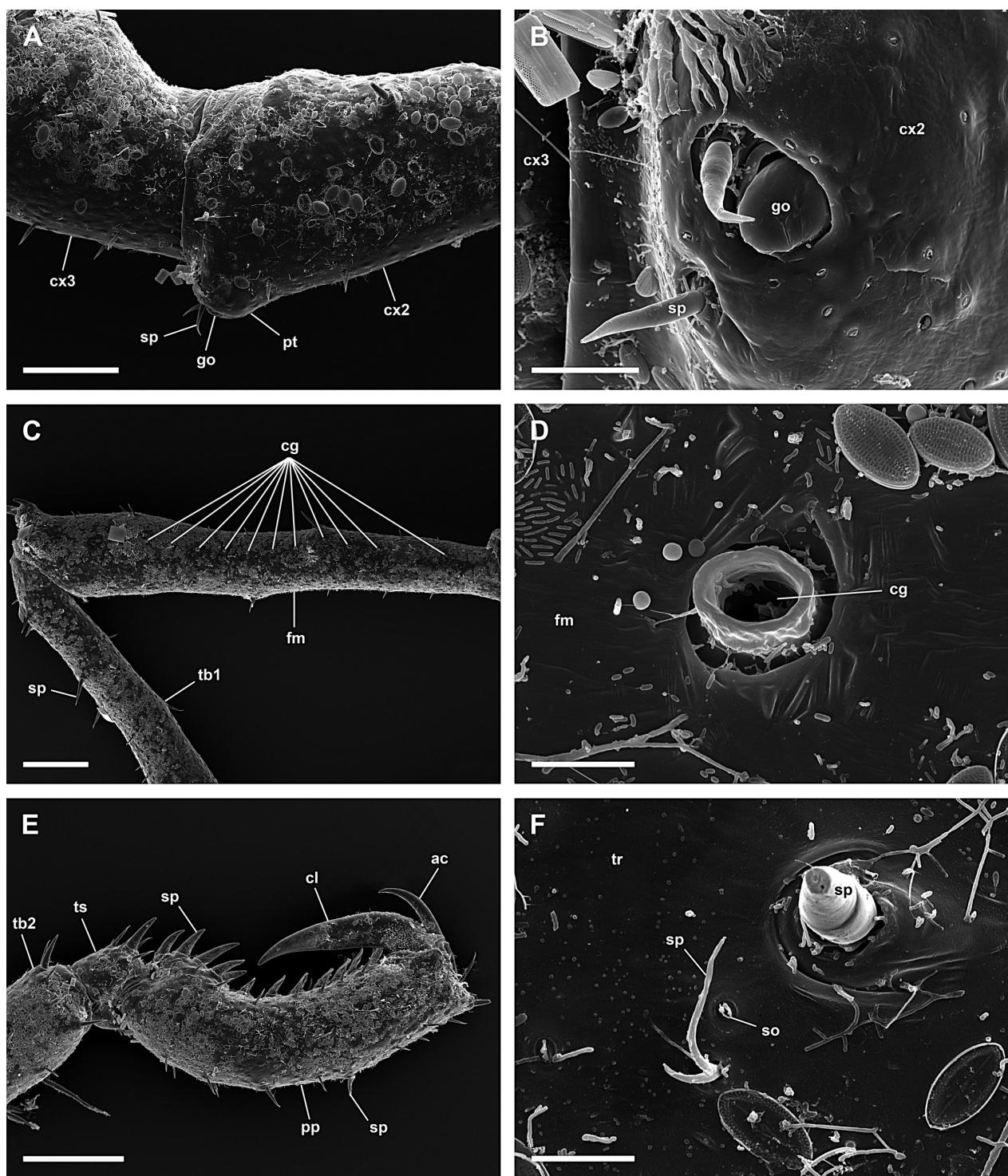
**Figure 40.** *Endeis charybdaea*, male; **A:** Right lateral process 1 with 2 protuberances; scale 100 µm; **B:** Coxa 1 of right 1st leg with 2 protuberances; scale 100 µm; **C:** Right 3rd leg; scale 1 mm; **D:** Femur with 8 of overall 24 cement glands (left 3rd leg); scale 100 µm; **E:** Single cement gland; scale 5 µm; **F:** Tarsus, propodus, and claws (right 3rd leg); scale 200 µm; **G:** Abdomen; scale 200 µm.



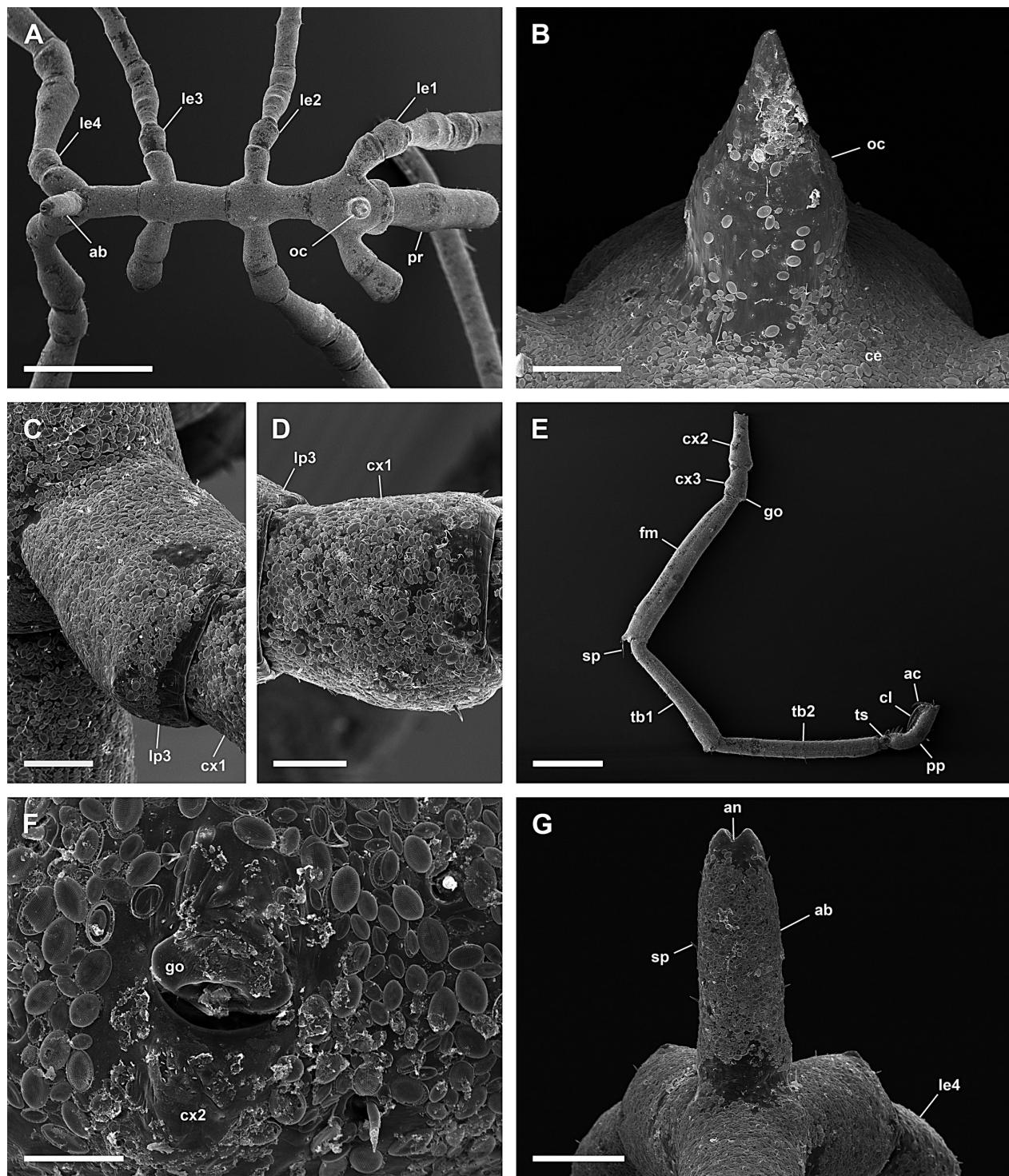
**Figure 41.** *Endeis spinosa*, male; **A:** Dorsal view, abdomen lost due to preparation; scale 1 mm; **B:** Dorsal view of trunk; scale 400 µm; **C:** Dorsal view of proboscis; scale 200 µm; **D:** Tip of proboscis with few spines around mouth; scale 100 µm; **E:** Mouth opening; scale 20 µm; **F:** Cephalon with small protuberances with spine and without chelipores; scale 40 µm.



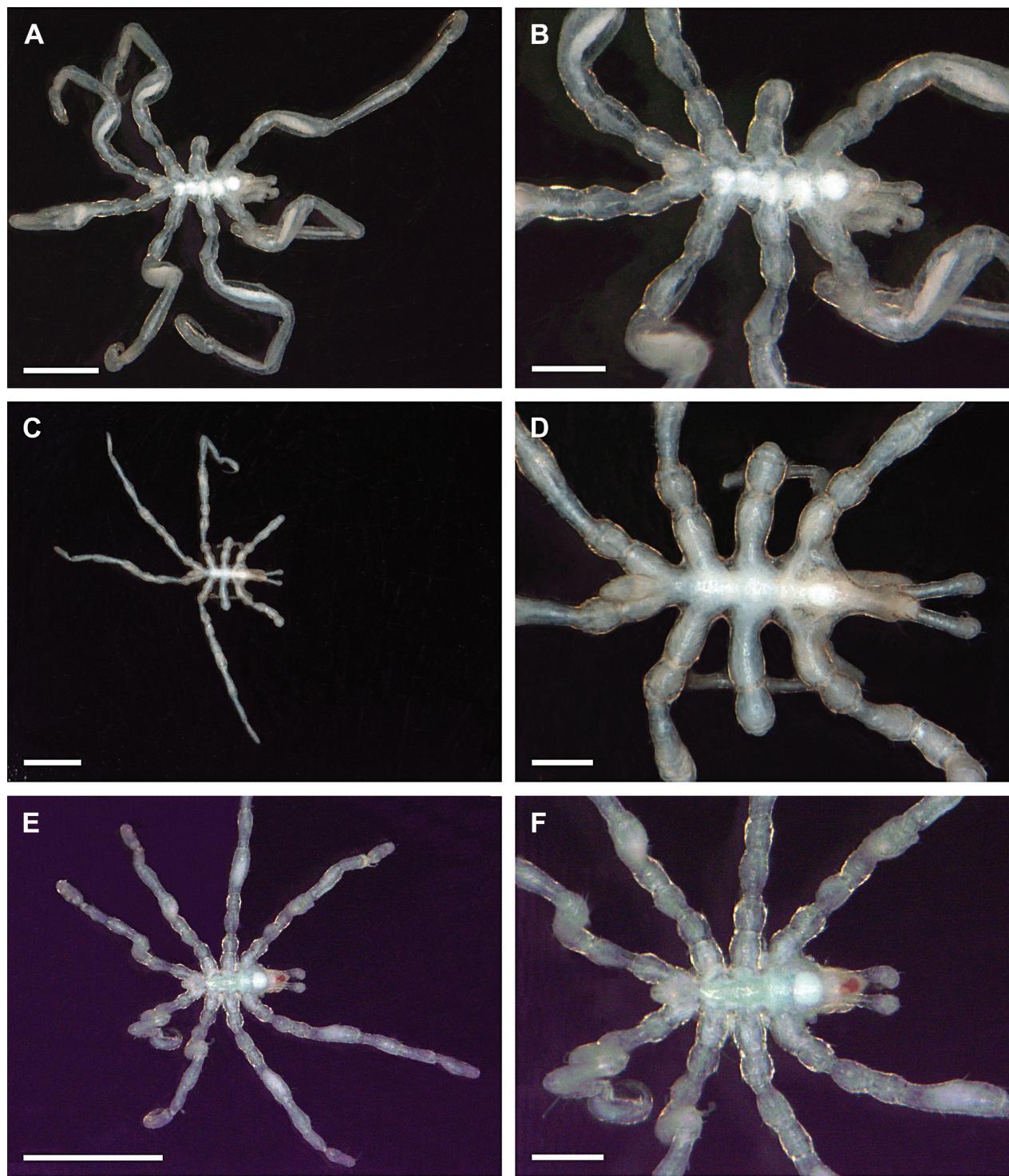
**Figure 42.** *Endeis spinosa*, male; **A:** Ocular tubercle; scale 100 µm; **B:** 7-articled oviger; scale 200 µm; **C:** Small spine on oviger-article 6; scale 10 µm; **D:** Right lateral process 1 with 2 protuberances; scale 100 µm; **E:** Right lateral process 3 with 1 protuberance; scale 100 µm; **F:** Coxa 1 of right 1st leg with 2 protuberances; scale 100 µm; **G:** Coxa 1 of right 3rd leg with 1 protuberance; scale 100 µm; **H:** Left 3rd leg; scale 400 µm.



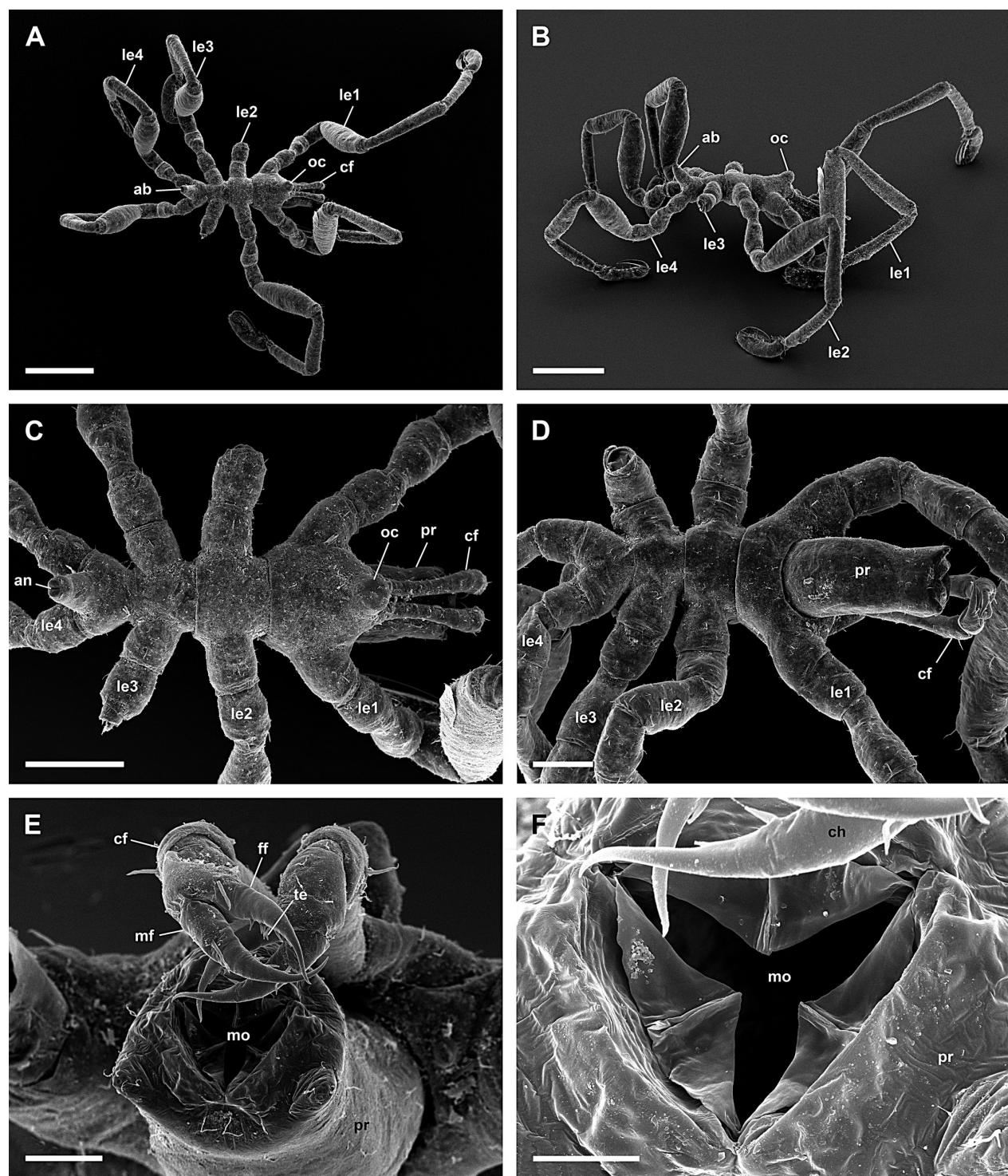
**Figure 43.** *Endeis spinosa*, male; **A:** Lateral view of coxa 2 with genital opening on a protuberance (right 3rd leg); scale 100 µm; **B:** Genital opening; scale 20 µm; **C:** Femur with overall about 11 cement glands (left 3rd leg); scale 200 µm; **D:** Single cement gland; scale 10 µm; **E:** Tarsus, propodus, and claws (left 3rd leg); scale 200 µm; **F:** Spine, hair and slit organ on dorsal side of trunk; scale 10 µm.



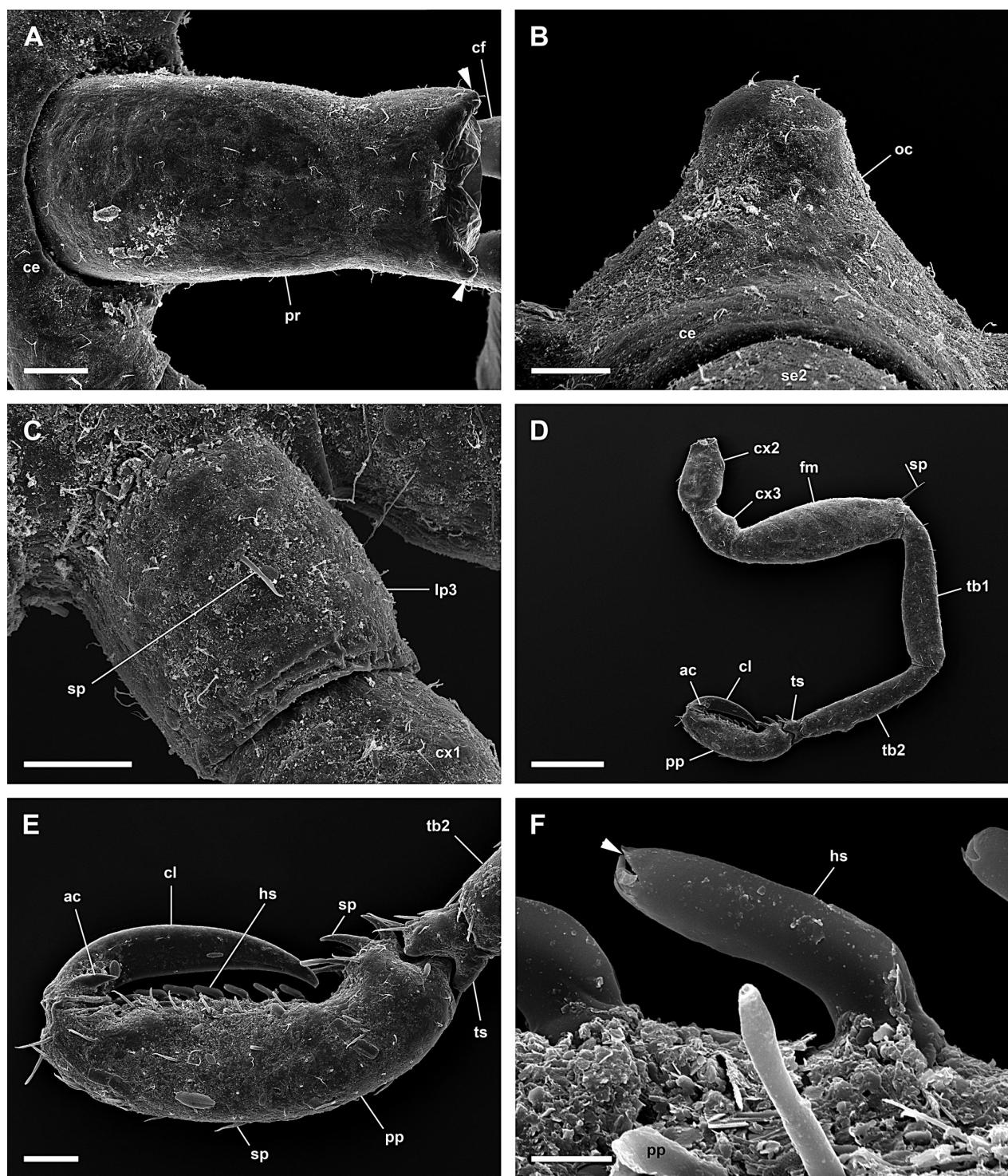
**Figure 44.** *Endeis spinosa*, female; **A:** Dorsal view of trunk; scale 1 mm; **B:** Ocular tubercle; scale 100 µm; **C:** Right lateral process 3 without protuberance; scale 100 µm; **D:** Coxa 1 of right 3rd leg without protuberance; scale 100 µm; **E:** Right 3rd leg; scale 1 mm; **F:** Genital opening on ventral side of coxa 2; scale 40 µm; **G:** Abdomen; scale 200 µm.



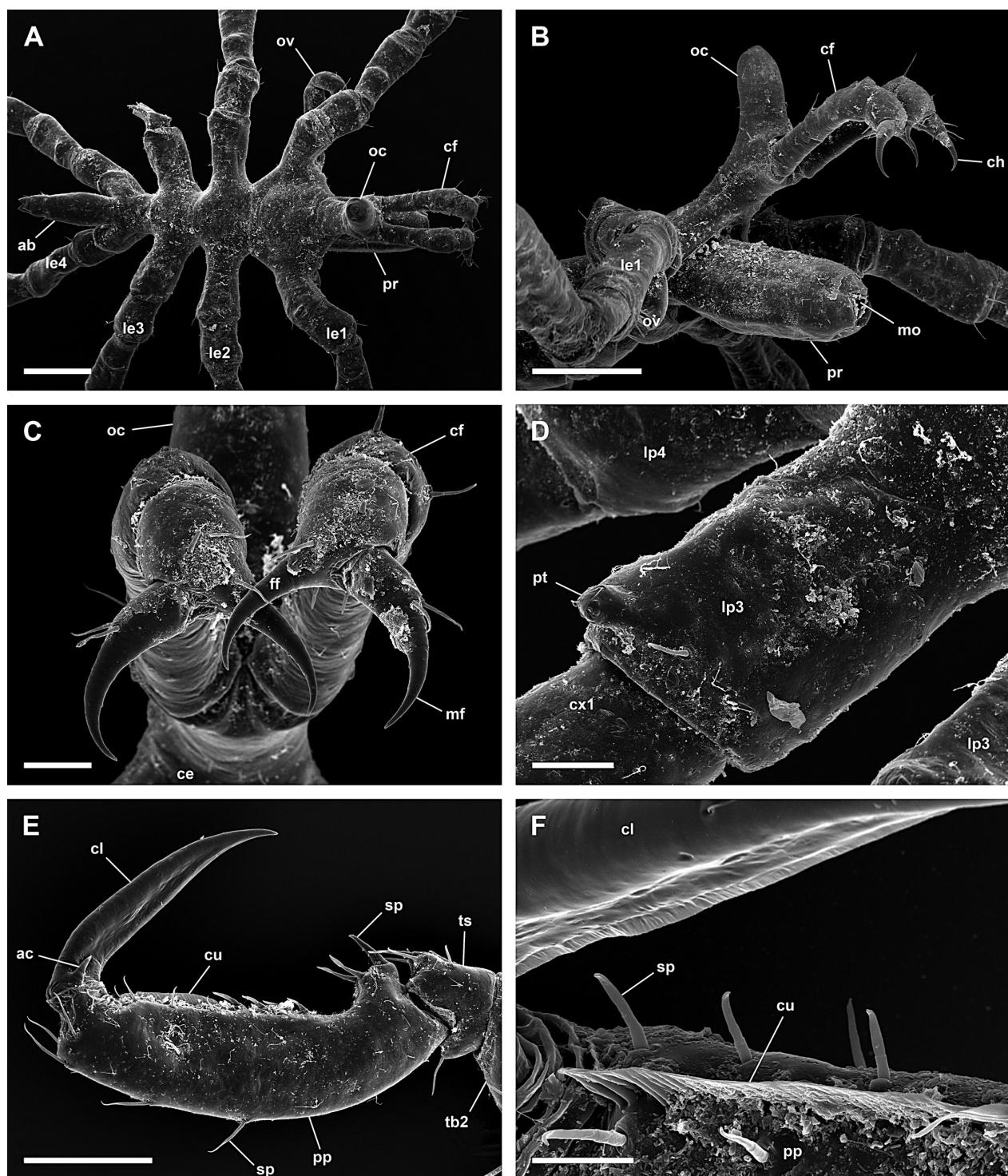
**Figure 45.** Phoxichilidiidae; **A, B:** *Anoplodactylus angulatus*, female, dorsal view; scales 500 µm and 250 µm, respectively; **C, D:** *Anoplodactylus petiolatus*, male, dorsal view; scales 1 mm and 250 µm, respectively; **E, F:** *Anoplodactylus pygmaeus*, male, dorsal view; scales 1 mm and 250 µm, respectively.



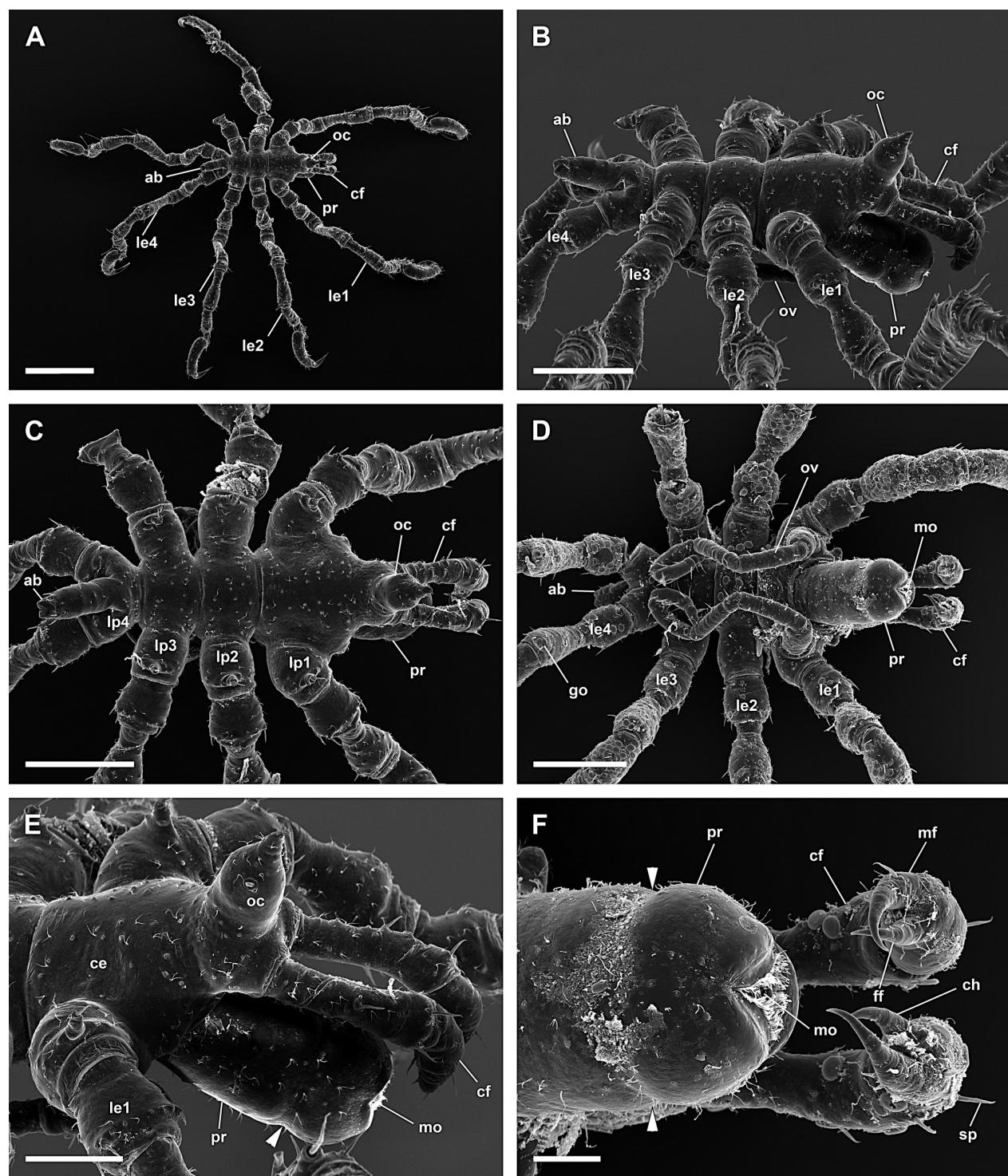
**Figure 46** *Anoplodactylus angulatus*, female; **A:** Dorsal view; scale 400 µm; **B:** Lateral view; scale 400 µm; **C:** Dorsal view of trunk; scale 200 µm; **D:** Ventral view of trunk; scale 100 µm; **E:** Frontal view with chelifores with developed chela and mouth opening; scale 40 µm; **F:** Mouth opening; scale 20 µm.



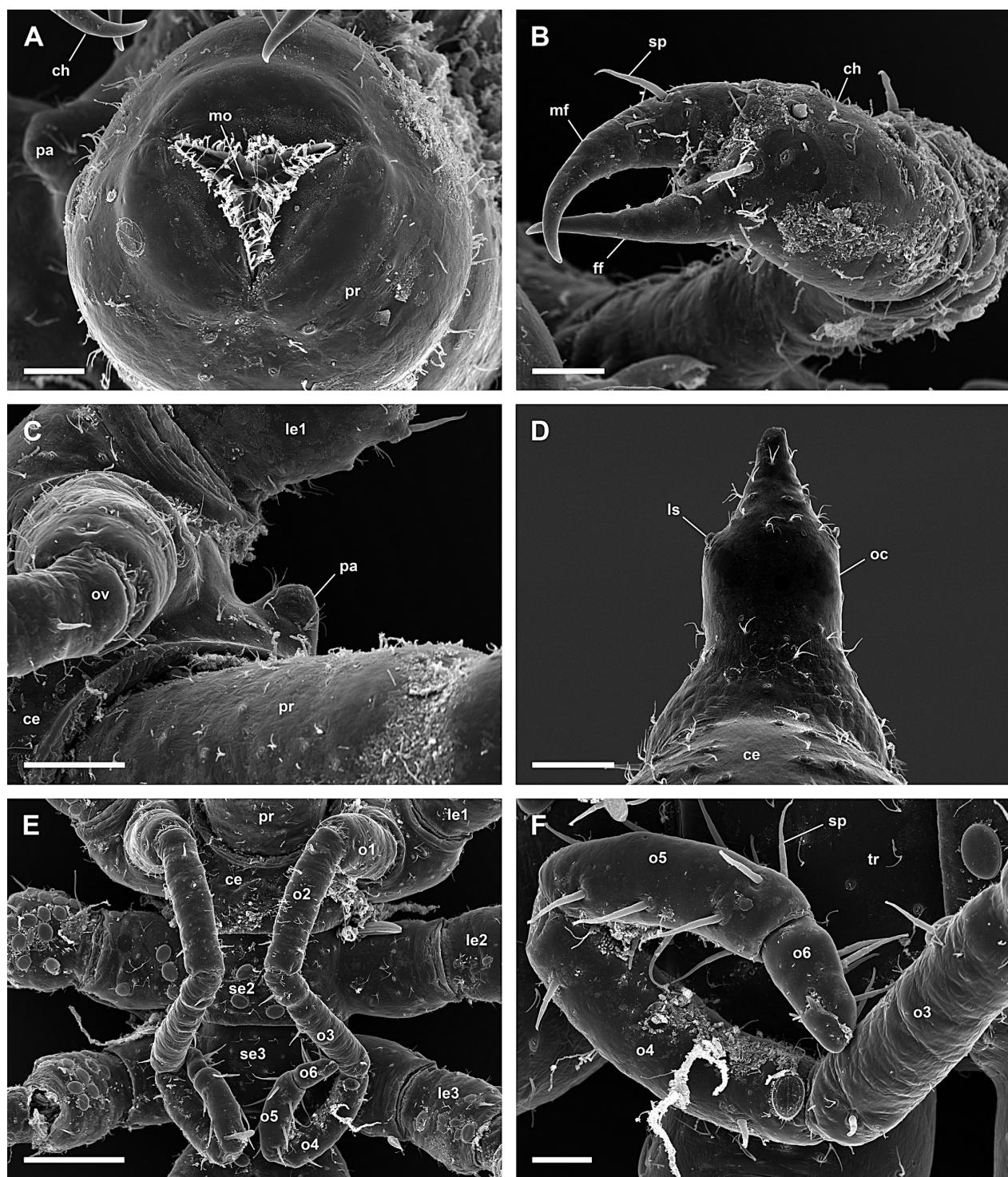
**Figure 47.** *Anoplodactylus angulatus*, female; **A:** Ventral view of proboscis with conspicuous angles at corners (arrowheads); scale 40 µm; **B:** Ocular tubercle; scale 40 µm; **C:** Right lateral process 3 with spine; scale 40 µm; **D:** Right 3rd leg; scale 200 µm; **E:** Tarsus and propodus with hollow spine on propodus (right 3rd leg); scale 40 µm; **F:** Hollow spine on propodus with slit on tip (arrowhead); scale 5 µm.



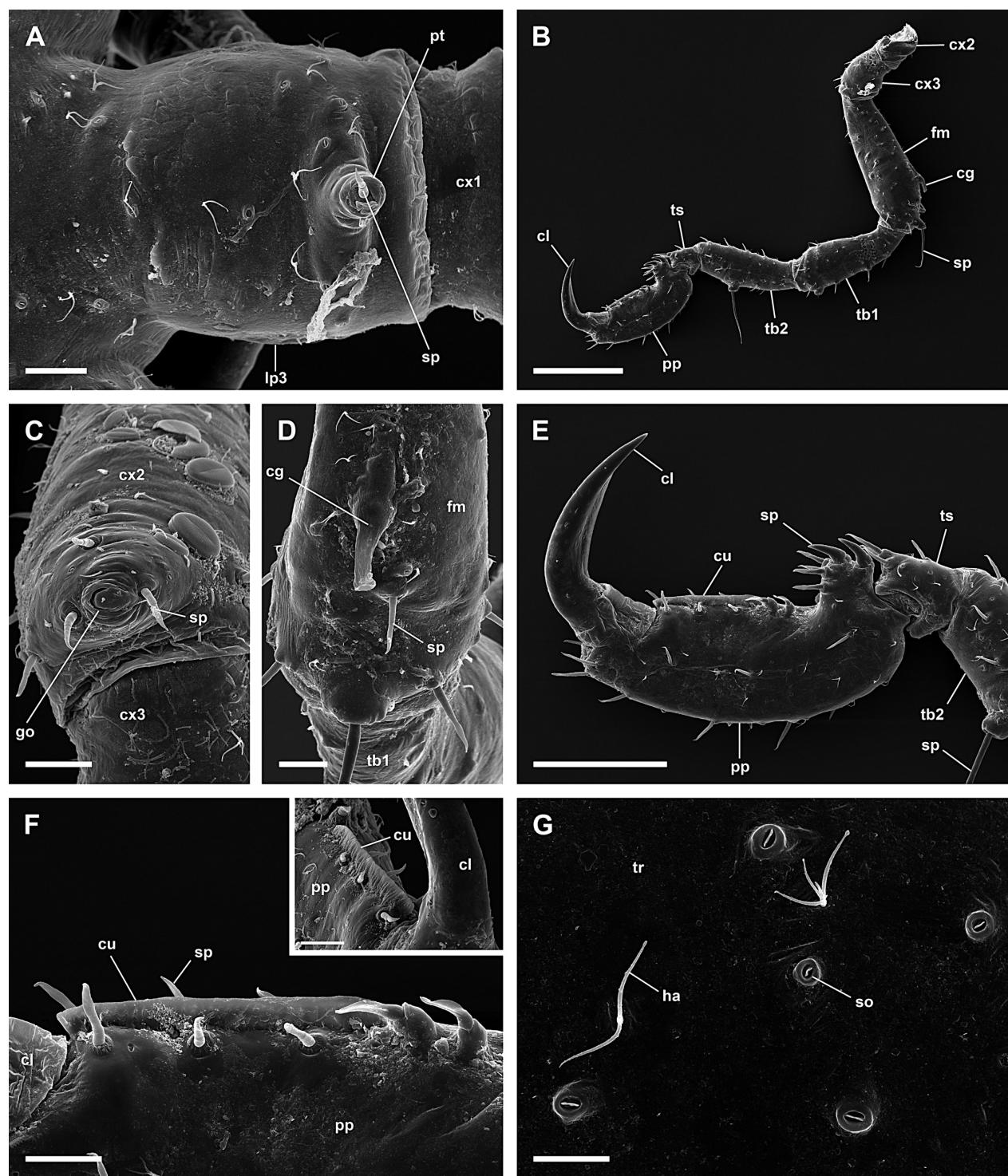
**Figure 48.** *Anoplodactylus petiolatus*, male; **A:** Dorsal view of trunk; scale 200 µm; **B:** Lateral view of cephalon overreaching posterior part of proboscis, oviger dissected; scale 200 µm; **C:** Chelipores with developed chela; scale 40 µm; **D:** Left lateral process 3 with protuberance; scale 40 µm; **E:** Tarsus, propodus with cutting lamina, and claws (left 3rd leg); scale 40 µm; **F:** Cutting lamina on propodus (right 1st leg); scale 20 µm.



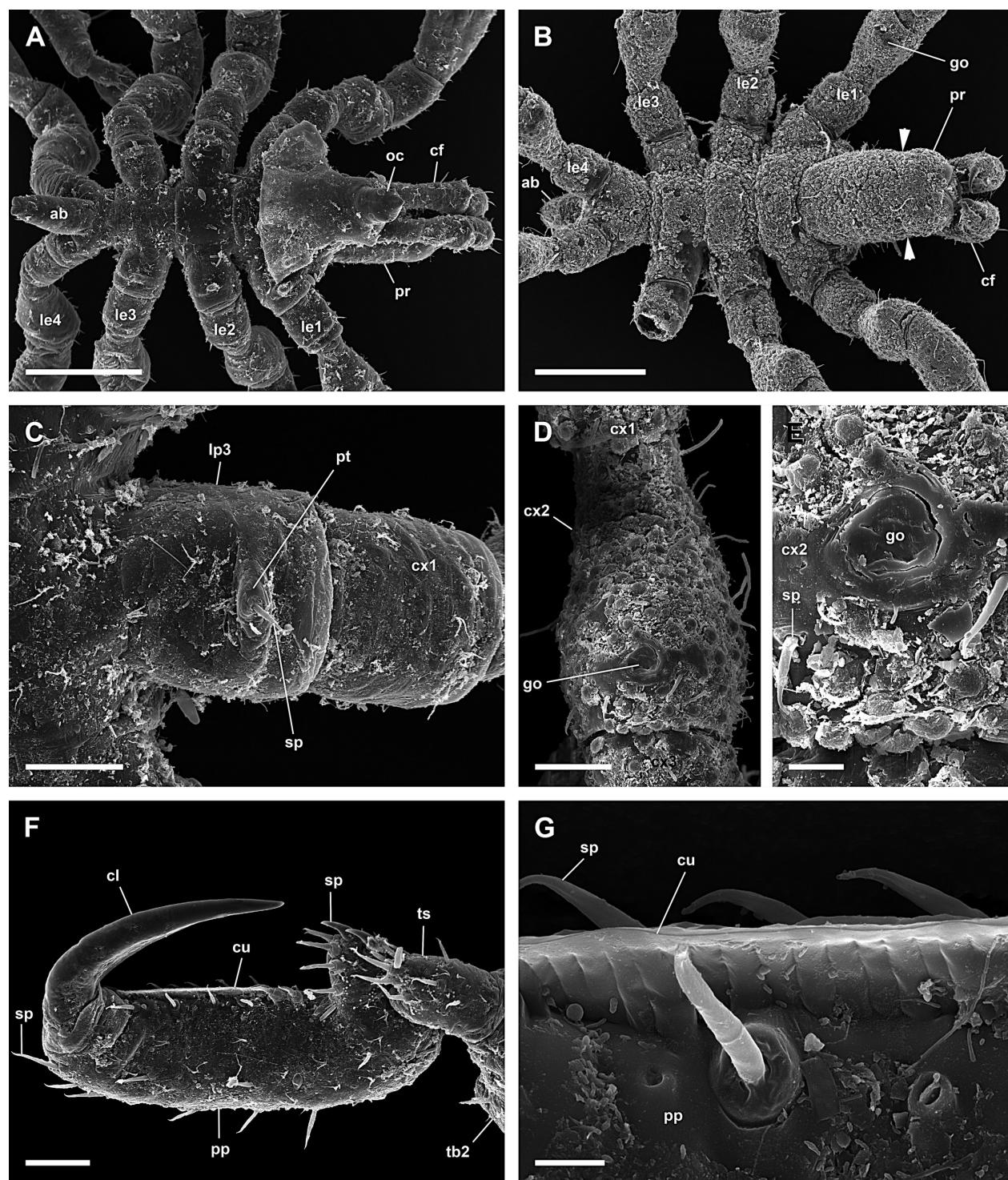
**Figure 49.** *Anoplodactylus pygmaeus*, male; **A:** Dorsal view; scale 400 µm; **B:** Lateral view of trunk; scale 200 µm; **C:** Dorsal view of trunk; scale 200 µm; **D:** Ventral view of trunk; scale 200 µm; **E:** Lateral view of cephalon overreaching posterior part of proboscis, proboscis with constriction encircling it subterminally (arrowheads); scale 100 µm; **F:** Ventral view of proboscis with constriction encircling it subterminally (arrowheads); scale 40 µm.



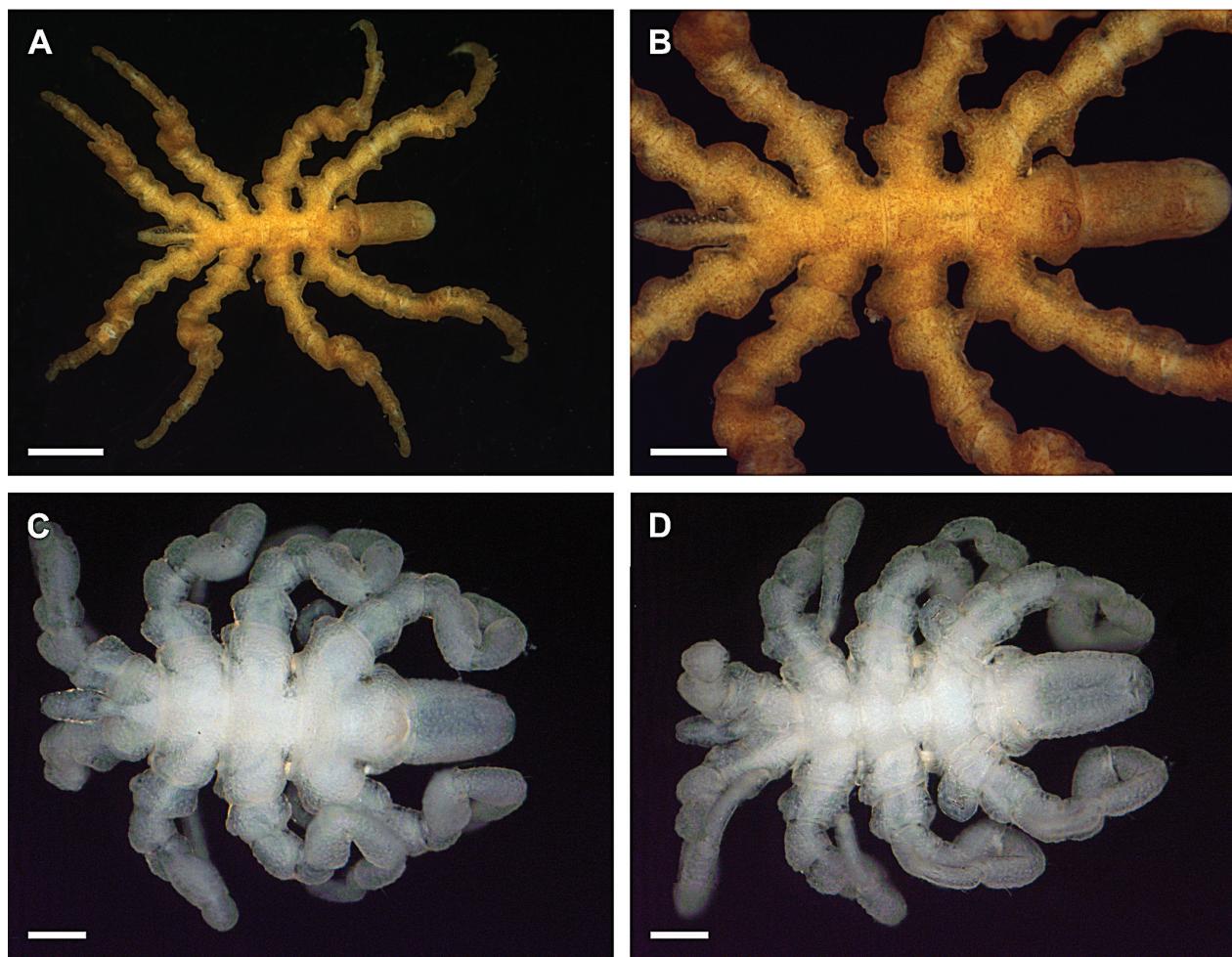
**Figure 50.** *Anoplodactylus pygmaeus*, male; **A:** Mouth opening; scale 20 µm; **B:** Left chelifore with developed chela; scale 20 µm; **C:** Ventral view of right palp, reduced to a small tubercle; scale 40 µm; **D:** Ocular tubercle with lateral sense organ; scale 40 µm; **E:** 6-articled oviger; scale 100 µm; **F:** Distal articles of left oviger; scale 20 µm.



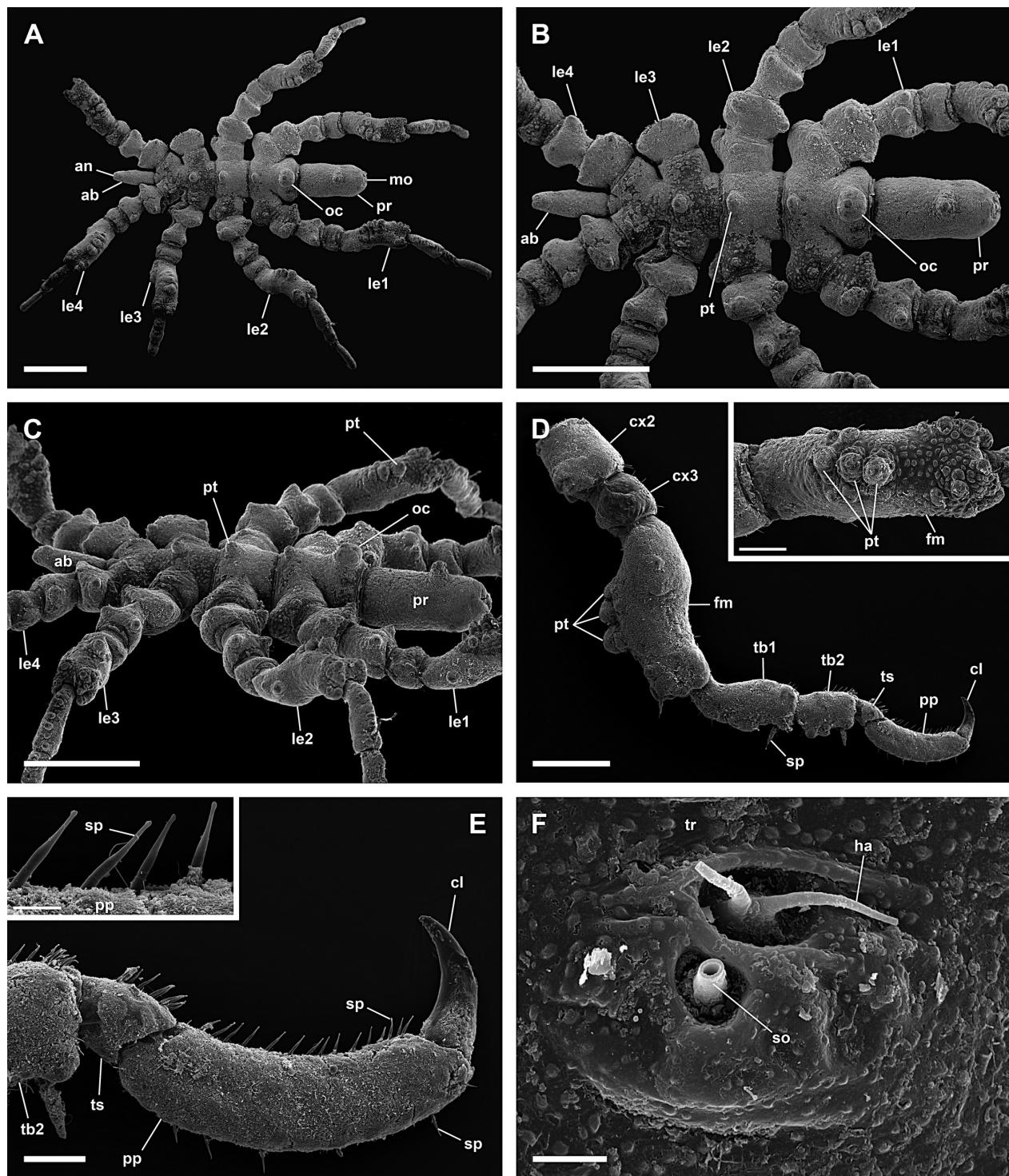
**Figure 51.** *Anoplodactylus pygmaeus*, male; **A:** Right lateral process 3 with protuberance and spine; scale 20 µm; **B:** Left 3rd leg; scale 200 µm; **C:** Ventral view of coxa 2 with genital opening, distal is down (left 4th leg); scale 20 µm; **D:** Dorsal view of femur with cement gland, distal is down (right 4th leg); scale 20 µm; **E:** Tarsus, propodus with cutting lamina, and claws (left 3rd leg); scale 100 µm; **F:** Cutting lamina on propodus; scale 100 µm; insert: Detail of cutting lamina; scale 20 µm; **G:** Hairs and slit organs on dorsal side of trunk; scale 10 µm.



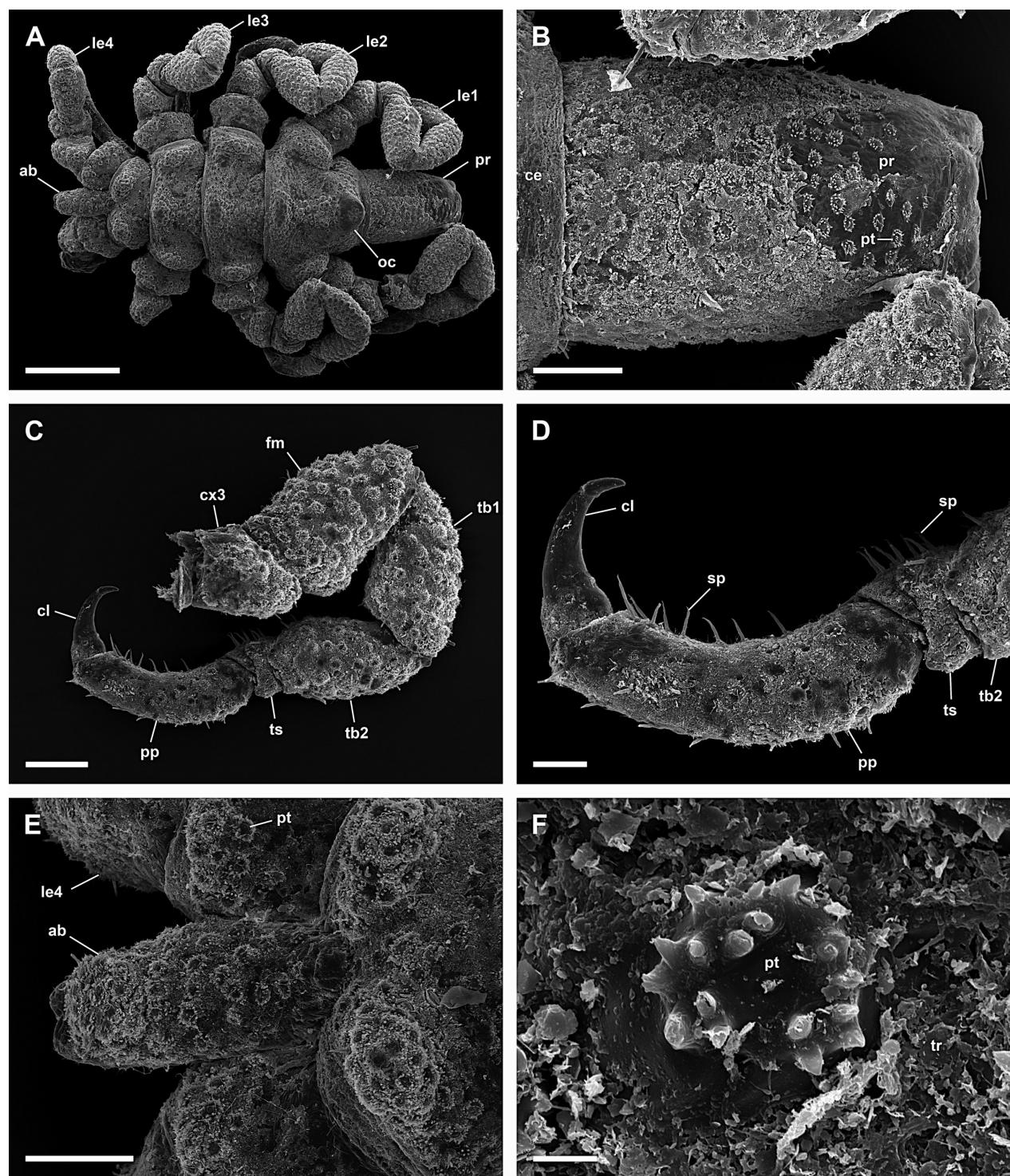
**Figure 52.** *Anoplodactylus pygmaeus*, female; **A:** Dorsal view of trunk; scale 200  $\mu$ m; **B:** Ventral view of trunk, proboscis with a constriction encircling it subterminally (arrowheads); scale 200  $\mu$ m; **C:** Right lateral process 3 with protuberance and spine; scale 40  $\mu$ m; **D:** Ventral view of coxa 2 with genital opening (right 4th leg); scale 40  $\mu$ m; **E:** Genital opening; scale 10  $\mu$ m; **F:** Tarsus, propodus with cutting lamina, and claws (left 1st leg); scale 40  $\mu$ m; **G:** Cutting lamina on propodus; scale 5  $\mu$ m.



**Figure 53.** Pycnogonidae; **A, B:** *Pycnogonum nodulosum*, female, dorsal view; scales 1 mm and 500 µm, respectively; **C, D:** *Pycnogonum (Retroviger) pusillum*, male, dorsal and ventral view, respectively; scales 250 µm.



**Figure 54.** *Pycnogonum nodulosum*, female; **A:** Dorsal view; scale 1 mm; **B:** Dorsal view of trunk with protuberances on dorsal midline; scale 1 mm; **C:** Lateral view of trunk; scale 1 mm; **D:** Left 3rd leg with protuberances on femur; scale 400 µm; insert: Dorsal view of protuberances on femur; scale 200 µm; **E:** Tarsus, propodus, and claw without auxiliary claws (left 3rd leg); scale 100 µm; insert: Spines on propodus; scale 20 µm; **F:** Hair and slit organ on dorsal side of trunk; scale 5 µm.



**Figure 55.** *Pycnogonum (Retroviger) pusillum*, male; **A:** Dorsal view; scale 400 µm; **B:** Dorsal view of proboscis; scale 100 µm; **C:** Right 3rd leg; scale 100 µm; **D:** Tarsus, propodus, and claw without auxiliary claws (right 3rd leg); scale 40 µm; **E:** Abdomen; scale 100 µm; **F:** Protuberance, scattered over trunk and legs; scale 5 µm.

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