

Amphipod diversity in South American high-altitude peatlands: two novel *Hyaella* species supported by morphological and molecular evidence (Amphipoda, Hyaellidae)

Águeda Verónica Isa-Miranda^{1*}, Marcela A. Peralta¹, Carolina Nieto²

¹ Instituto de Invertebrados, Fundación Miguel Lillo, Miguel Lillo 251, T4000JFE-San Miguel de Tucumán, Tucumán, Argentina

² Instituto de Biodiversidad Neotropical (CONICET), Universidad Nacional de Tucumán, Facultad de Ciencias Naturales, Ciudad Universitaria, Horco Molle, 4107, Yerba Buena, Tucumán, Argentina

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Corresponding author: Águeda Verónica Isa-Miranda (aisamiranda@lillo.org.ar)

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Abstract

The peatlands of the Puna and High Andes of northwestern Argentina harbor a poorly known diversity of freshwater amphipods of the genus *Hyaella*. Using an integrative taxonomic approach combining morphological and molecular evidence, we describe two new species, *Hyaella portaesolis* **sp. nov.** and *Hyaella rodriguezi* **sp. nov.** Molecular analyses based on the mitochondrial COI gene support the distinctiveness of both taxa and confirm the usefulness of this marker for species delimitation within South American Hyaellidae. We also provide ecological and distributional information for the new species, including habitat characteristics and the presence of epibionts. Additionally, we report other *Hyaella* species occurring in the study area, contributing to a better understanding of amphipod diversity in Andean peatlands. Our results highlight the high and still underestimated biodiversity of these unique wetlands and reinforce the importance of integrative studies for documenting and conserving freshwater fauna in a region increasingly affected by human activities.

Key Words

COI, Crustacea, freshwater, new species, taxonomy

Introduction

One of the major current challenges in biodiversity research is the lack of knowledge regarding the true number of species inhabiting the planet. This phenomenon, known as the Linnean shortfall, refers to the discrepancy between the total number of existing species and those that have been formally discovered, described, and named by science (Lomolino 2004). This knowledge gap represents a major obstacle for ecological, evolutionary, and conservation studies, particularly in freshwater invertebrates, where cryptic diversity and taxonomic

impediments frequently hinder species discovery and description, making it difficult to effectively understand and protect biodiversity.

Hyaellidae Bulyčeva, 1957 is a family found exclusively in the Nearctic and Neotropical regions, from southern Patagonia to Alaska, and only includes the genus *Hyaella* S.I. Smith, 1874. During the last decade, the taxonomic knowledge of the genus *Hyaella* in South America has increased considerably mainly due to contributions from specialists in southern Brazil and the high Andean region of Argentina and Chile (González 2003; Isa-Miranda et al. 2025a; Penoni et al. 2025).

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Currently, approximately 130 species have been described, of which 104 occur in South America. Brazil harbors the highest number of described species, with a total of 59 species recorded to date (Jaume et al. 2021; WoRMS 2026), followed by Argentina with 18 species (Isa-Miranda et al. 2025b), whereas Chile has a lower recorded diversity, with seven species reported so far (Pérez-Schultheiss et al. 2022).

Despite these recent advances, the diversity of *Hyaella* inhabiting the high-altitude peatlands of the Central Andes remains poorly known. These ecosystems provide key ecological and socio-economic services, including water supply, grazing resources, and the maintenance of cultural landscapes for local communities (Anderson et al. 2011; Izquierdo et al. 2015). *Hyaella* species are among the dominant amphipods in these peatlands and constitute an important energy resource for aquatic birds due to their high relative biomass (Nieto et al. 2017). However, the amphipod fauna of these environments has only begun to be investigated in recent years (Peralta and Isa-Miranda 2019; Isa-Miranda and Peralta 2022; Isa-Miranda et al. 2025a, 2025b).

Although *Hyaella* exhibits considerable morphological diversity (Jurado-Rivera et al. 2020), marked similarities among species have complicated species delimitation (González 2003), leading to the recognition of several “species complexes” (González 2003; Bueno et al. 2014; Jurado-Rivera et al. 2020; Cannizzaro et al. 2025b; Isa-Miranda et al. 2025b). Consequently, morphological identification in *Hyaella* requires a detailed examination of appendages and cuticular structures, including setae (Zimmer et al. 2009). However, no single character unequivocally distinguishes species within the genus (Bueno et al. 2014). Analyses based on traditionally diagnostic characters have often proven insufficient, suggesting that some traits may have been overemphasized, whereas other potentially informative characters have been underestimated (Cannizzaro et al. 2025a).

In response to these limitations, molecular approaches have provided new perspectives for phylogenetic and taxonomic studies of the group, becoming essential tools for understanding species relationships (Jurado-Rivera et al. 2020; Zapelloni et al. 2021a, 2021b). For example, recent studies on morphospecies from Lake Titicaca demonstrated that species identification based solely on diagnostic morphological characters is less reliable than previously assumed (Jurado-Rivera et al. 2020). Accurately assessing the magnitude of this diversity requires detailed morphological redescrptions combined with the incorporation of molecular reference sequences (Jaume et al. 2021).

In this context, the aim of this study is to assess the taxonomic status of two *Hyaella* morphospecies previously identified as *Hyaella* sp. 4 and *Hyaella* sp. 5 by Hankel et al. (2023) using an integrative approach that combines morphology, molecular data, and species delimitation analyses. The results support the recognition of both taxa as distinct evolutionary lineages, which are herein described as new species from the high-altitude peatlands of northwestern Argentina.

Materials and methods

Sampling and morphological description

The samples of *Hyaella* studied were collected during a limnological research campaign between 2015 and 2017 in the Puna and High Andean ecoregions, Argentina. The sampling sites cover approximately 14,210,000 hectares in peatlands that retain surface or groundwater throughout the year (Navarro 2018), and are located between 3,400 and 4,000 m a.s.l., across an approximate latitudinal range of 24°S and 29°S (Fig. 1) in the framework of the Puna Project (CONICET-UNT), whose dataset is available through the CONICET Digital Repository (<https://ri.conicet.gov.ar/handle/11336/231218>). At each sampling site, physicochemical parameters were measured using a Horiba U-52 multiparameter water quality meter. The regional climate is characterized by extreme aridity, with mean annual precipitation varying from less than 100 mm in the southwest to 400 mm in the northeast of the region. The average annual temperature ranges from 9°C to −4°C (Cabrera 1976).

A geographic distribution map of the sampled peatlands was produced in QGIS version 3.34 (QGIS Development Team 2024). Topographic relief was represented using a hillshade model derived from digital elevation data obtained from the U.S. Geological Survey (USGS; <https://www.usgs.gov/>). National and international boundary shapefiles were obtained from the National Geographic Institute of Argentina (IGN; <https://www.ign.gob.ar/>) and incorporated into the GIS environment. Sampling localities were georeferenced using field coordinates, and species richness at each peatland was represented by proportional symbols.

In sampling peatlands, the specimens of *Hyaella* were collected using a net (mesh of 300 µm) and immediately fixed in the field in 96% ethanol for molecular studies, after which the samples were kept refrigerated to preserve DNA quality. Upon arrival at the laboratory, several specimens were transferred to 80% ethanol. Body measurements were performed from the tip of the head to the tip of the telson. The largest male and female specimens were dissected in Brunson solution (2 parts distilled water, 1 part glycerin, and 1 part alcohol at 96%) under a stereomicroscope (Nikon 84978). The appendages were examined and illustrated using a Leitz Dialux camera lucida. The drawings were digitized with CorelDRAW® Graphics Suite 2020. Photographs of the habitus were taken using a stereomicroscope LEICA M165 C coupled with a LEICA DMC 2900 digital camera.

The description of the new species was made based on previous taxonomic works and identification keys on *Hyaella* species (Peralta and Isa-Miranda 2019; González et al. 2020; Isa-Miranda et al. 2025a). The terminology for setae and other cuticular structures follows Zimmer et al. (2009) and Isa-Miranda and Peralta (2022). Specimens are deposited in the Crustaceans Collection of Fundación Miguel Lillo (FML-CRUST) and Instituto de Biodiversidad Neotropical (IBN, CONICET-UNT), Tucumán, Argentina.

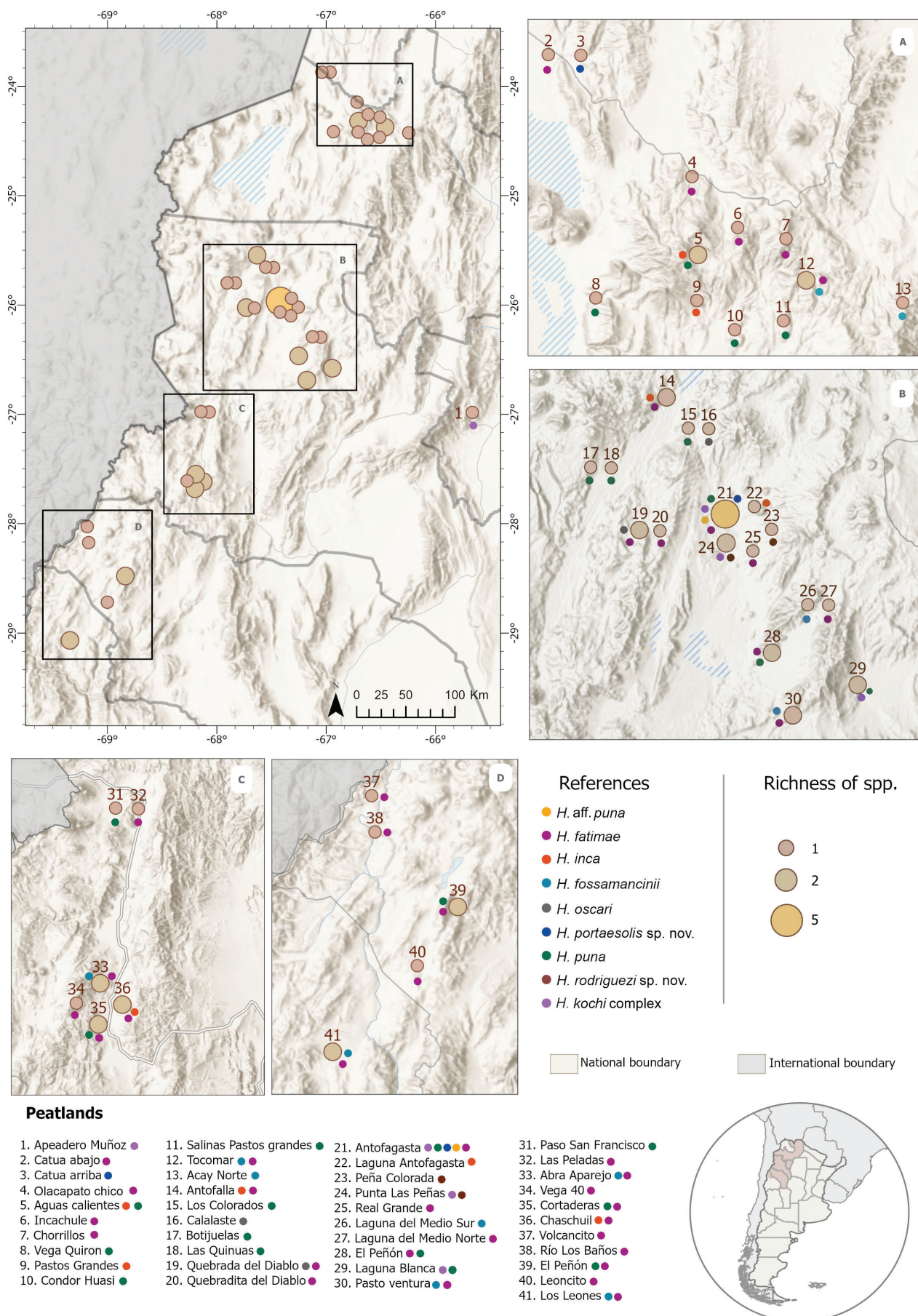


Figure 1. Distribution map of sampled peatlands in the Puna and High Andes of northwestern Argentina. Colors indicate *Hyaella* species and morphospecies, numbers denote peatland sites, and circle size represents species richness.

Unilocus species delimitation

All molecular procedures, including extraction, amplification, purification, and sequencing, followed the protocols described by Isa-Miranda et al. (2025a).

We conducted species delimitation analyses with COI sequences to support our morphological descriptions of new members of *Hyaella*, using GMYC bPTP and ASAP. The analyses were conducted using a COI alignment comprising 22 mitochondrial COI sequences of *Hyaella* obtained in the present study, together with 19 additional sequences of nominal species retrieved from GenBank, and two sequences of *Platorchestia* Bousfield, 1982 used as outgroup taxa (Suppl. material 1: table S1).

We performed maximum likelihood phylogenetic analyses for the gene using the software IQ-TREE 2 (Minh et al. 2020); branch support was assessed using ultrafast bootstrap analyses (Hoang et al. 2018) with 1000 replicates. Final tree visualisation and figure editing were performed in iTOL v6 (<https://itol.embl.de/>). Additionally, three species delimitation approaches were applied to evaluate putative new species: Generalised Mixed Yule Coalescent (GMYC), Assemble Species by Automatic Partitioning (ASAP), and Bayesian Poisson Tree Processes (bPTP).

For the GMYC (Pons et al. 2006; Fujisawa and Barraclough 2013) analysis, an ultrametric tree was reconstructed through Bayesian inference in BEAST v2.6.2 (Bouckaert et al. 2019) under a strict molecular clock and a birth–death speciation model (Heled and Drummond 2010). The dataset was analysed as a single partition using the HKY+G+I substitution model previously selected in jModelTest2 (Darriba et al. 2012). Markov chain Monte Carlo (MCMC) analyses were run for 10 million generations, sampling one tree every 1000 generations. Convergence and parameter performance were evaluated in Tracer v1.5 by verifying effective sample sizes (ESS > 200), applying a burn-in of 25%. Trees were summarised with TreeAnnotator and visualised in FigTree (Drummond and Rambaut 2007; Rambaut 2009). GMYC analyses were conducted using the online GMYC web server (<https://species.h-its.org/gmyc/>).

ASAP (Puillandre et al. 2021) analyses were performed using the online platform ASAP in iTaxoTool 0.1 (Vences et al. 2021), with Kimura two-parameter (K80) distance matrices, while all remaining parameters were kept at their default settings. Bayesian Poisson Tree Processes (Zhang et al. 2013) analyses were carried out using the online bPTP web server (<http://species.h-its.org/ptp/>), an updated implementation of the original maximum likelihood PTP method that incorporates Bayesian support (BS) values into species delimitation analyses. Higher BS values at a given node indicate greater support for all descendant lineages belonging to the same species.

Results

Unilocus species delimitation

Species delimitation analyses based on the COI dataset were highly congruent across methods (Fig. 2). ASAP, bPTP, and GMYC consistently recovered 27 MOTUs throughout the phylogeny, with no major discrepancies among delimitation approaches. One of the partitions proposed by ASAP (score = 9.5) was largely congruent with the currently recognized nominal species. Most MOTUs corresponded to morphologically recognized taxa; however, some species, particularly *Hyaella kochi* González & Watling, 2001, as well as *H. fatimae* Isa-Miranda & Peralta, 2022 and *H. krolli* Jaume, 2021, were subdivided into multiple distinct MOTUs by all delimitation methods. In contrast, *H. nefrens* González & Watling, 2003 and *H. longipalma* (Faxon, 1876) were consistently grouped within a single MOTU. Additionally, *H. portaesolis* sp. nov. and *H. rodriguezi* sp. nov. were consistently recovered as independent MOTUs by all delimitation methods and showed high bPTP support values, supporting their recognition as putative new species. The Bayesian implementation of PTP (bPTP) recovered high support values for most delimited lineages, with the majority of MOTUs showing posterior probabilities equal or close to 1.00. The lower support values were observed for the lineages corresponding to *Hyaella montforti* Chevreux, 1907 (PP = 0.655) and *H. inca* Isa-Miranda, Peralta, González & Nieto, 2025 (PP = 0.650).

In addition, most nodes in the ML phylogeny showed high ultrafast bootstrap support (UFBoot ≥ 95), indicating a robust phylogenetic structure overall and strong concordance with the species delimitation analyses.

Species description

Order Amphipoda Latreille, 1816
Suborder Senticaudata Lowry & Myers, 2013
Infraorder Talitrida Rafinesque, 1815
Parvorder Talitridira Rafinesque, 1815
Superfamily Hyaloidea Bulyčeva, 1957
Family Hyaellidae Bulyčeva, 1957
Genus *Hyaella* S.I. Smith, 1874

Hyaella portaesolis sp. nov.

<https://zoobank.org/58BA3A1F-38B6-4BEB-909B-80F393F0BCB8>

Figs 3–8

Synonymy. *Hyaella* sp. 4—Hankel et al. 2023.

Type material. *Holotype*. ARGENTINA • 1 ♂ (9.75 mm); Catamarca Province, Antofagasta de la Sierra Department, Antofagasta peatlands; 26.02461°S, 67.40756°W; 3417 m a.s.l.; 7 Mar. 2017; J. Rodríguez leg.; FML-CRUST 01443.

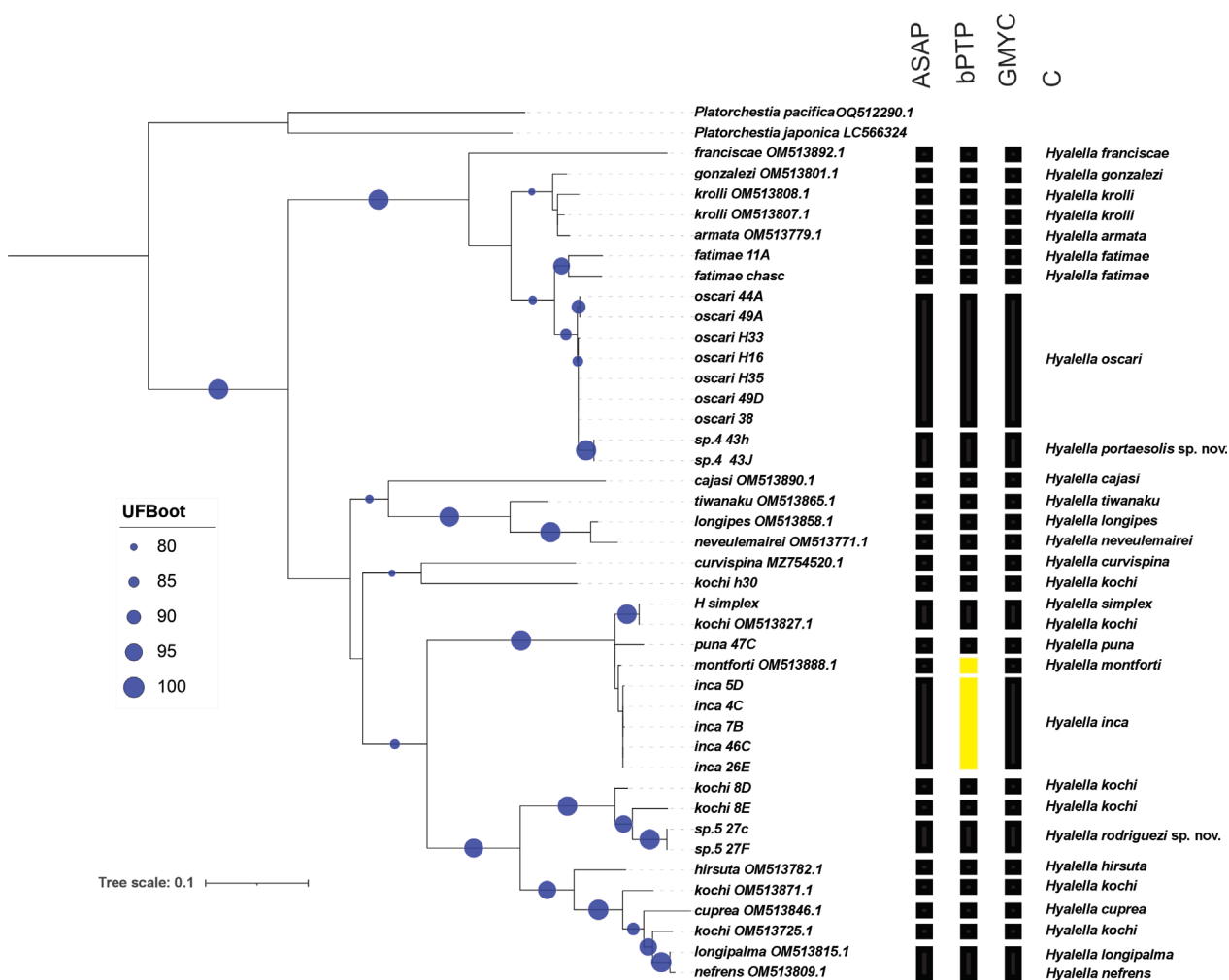


Figure 2. Maximum likelihood tree of *Hyalella*. Circles indicate UFBboot support values greater than 80. Vertical bars show species hypotheses recovered by different species delimitation analyses. In the bPTP results, yellow bars denote low support values for species partitions. The letter “C” identifies nominal species or lineages recognized through morphological taxonomy.

Paratypes. ARGENTINA • 1 ovigerous ♀ (7.02 mm); same data as holotype; FML-CRUST 01444. • 4 ♂♂, 2 ♀♀; same data as holotype; FML-CRUST 01445. • 4 ♂♂, 2 ♀♀; same data as holotype; IBN-EcoPP-43F.

Type locality. Argentina, Catamarca Province, Antofagasta peatland, 26.02461°S, 67.40756°W, 3417 m a.s.l.

Other material examined. Argentina, Catamarca Province: Antofagasta de la Sierra Department, Antofagasta peatlands, 25.65969°S, 67.62964°W, 3531 m a.s.l.; 25 Nov 2017; coll. C. Nieto & J. Rodríguez (IBN-EcoPP-46-C).—Antofagasta peatlands, 25.97219°S, 67.38636°W, 3485 m a.s.l.; 8 Mar 2017; coll. J. Rodríguez (IBN-EcoPP-43-H). — Antofagasta peatlands, 25.98900°S, 67.39756°W, 3459 m a.s.l.; 8 Mar 2017; coll. J. Rodríguez (IBN-EcoPP-43-J). — Catua Arriba peatlands, 23.85847°S, 67.00339°W, 4008 m a.s.l.; 30 Mar 2015; coll. C. Nieto & J. Rodríguez (IBN-EcoPP-18-B).

Diagnosis. Body smooth. Antenna 1 short, much shorter than antenna 2. Maxilla 1 palp long and slender, reaching approximately 3/4 of the distance between its base

and the base of the setae of the outer plate, with a single distal papposerrate seta. Coxa of gnathopod 2 notably smaller than that of gnathopod 1 in males. Propodus of gnathopod 1 hammer-shaped; palmar angle bearing four cuspidate setae with distal setule, one longer and more robust. Coxa of pereopod 4 subtriangular, with posterior cavity poorly developed, broad and shallow. Basis of pereopod 7 with two short subdistal setae on the external surface. Uropod 1 without sexual dimorphism, lacking modified curved seta in males. Sternal gills present on pereonites 3–7. Uropod 3 short and compact, ramus stout shorter than peduncle; peduncle bearing a row of 10 robust distal cuspidate setae. Telson subquadrangular, wider than long, with two groups of 4–5 thin simple setae on apical margin; dorsal surface densely covered with microtrichs.

Etymology. The specific epithet *portaeolis* is derived from the Latin *porta* (gate) and *solis* (of the sun), meaning “gate of the sun”, in reference to the village of Antofagasta de la Sierra, whose name is traditionally interpreted as “Puerta del Sol”.



Figure 3. *Hyaletella portaesolis* sp. nov., habitus, holotype male (FML-CRUST 01443).

Description of male. Body: stout, smooth; maximum body length observed 9.75 mm.

Head: Eye rounded, pigmented (Fig. 3).

Antenna 1: Shorter than antenna 2, but slightly longer than its peduncle. Peduncular segments 1–3 with few simple setae, numerous plumose C2 setae, and microtrichs (type Ib); segment 1 additionally bearing hair-like microtrichs. Flagellum composed of nine articles, each with groups of simple A1 setae and few C2 setae; aesthetascs present distally on articles 1–8 (Fig. 4A).

Antenna 2: Longer than antenna 1; peduncle approximately as long as head. Peduncular segment 4 much shorter than segment 5. Segment 3 bearing plumose C2 setae and a row of simple setae near base of gland cone; segments 3–5 with distal and medial simple A1 or plumose C2 setae. Flagellum with 16 articles, each bearing groups of simple setae and microtrichs of type Ib (Fig. 4B).

Upper lip: Ordinary, distal margin with minute setae (Fig. 4C).

Mandibles: Left mandible with 5-denticulate incisor (three distal long, two proximal short), 4-denticulate lacinia mobilis, and setal row of three pappose setae (Fig. 4E). Right mandible with 6-denticulate incisor (three distal long, three proximal short), complex bifurcate lacinia mobilis, and setal row of three pappose setae

(Fig. 4F). Molar triturative and accessory seta well developed in both mandibles.

Lower lip: Ordinary; outer and inner margins apically covered with minute setae; mandibular processes acute (Fig. 4D).

Maxilla 1: Palp unsegmented, long and slender, reaching approximately 3/4 of the distance between its base and the base of the setae of the outer plate, with a single distal papposerrate seta. Outer plate with nine serrate F4 setae, some enlarged and spatulate. Inner plate shorter than outer plate, with two apical papposerrate setae and several marginal setules (Fig. 5B).

Maxilla 2: Inner plate subequal in length to outer plate, with one strong pappose seta on inner margin. Both plates with serrate, simple, pappose and sparse hair-like setae (Fig. 5C, D).

Maxilliped: Inner plate longer than wide, rectangular, transversally truncate, apex well armed with three long cuspidate setae B1, one more robust, accompanied by pappose setae and setules on apex and margins. Outer plate with simple setae on inner and distal margins. Palp four-segmented; segment 2 as long as wide; segments 1–3 with simple setae distally on outer margin, additionally segment 3 externally ornamented with a row of 6 serrate setae; segment 4 short and unguiform (Fig. 5E).

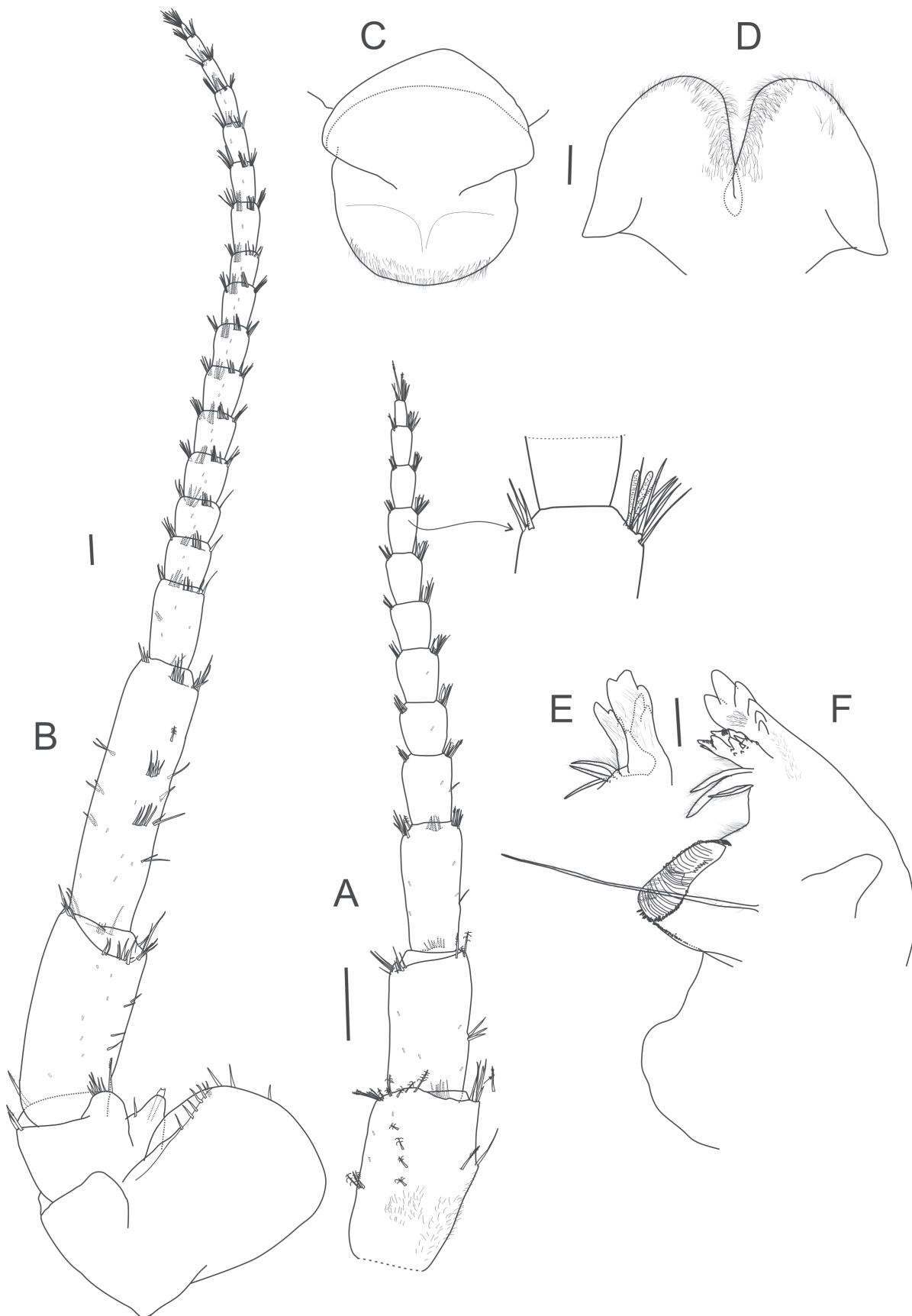


Figure 4. *Hyalella portaesolis* sp. nov., holotype male (FML-CRUST 01443). **A.** Antenna 1 (arrow indicating the apex of article 6); **B.** Antenna 2; **C.** Upper lip; **D.** Lower lip; **E.** Left mandible, showing incisor and lacinia mobilis; **F.** Right mandible. Scale bars: 0.1 mm.

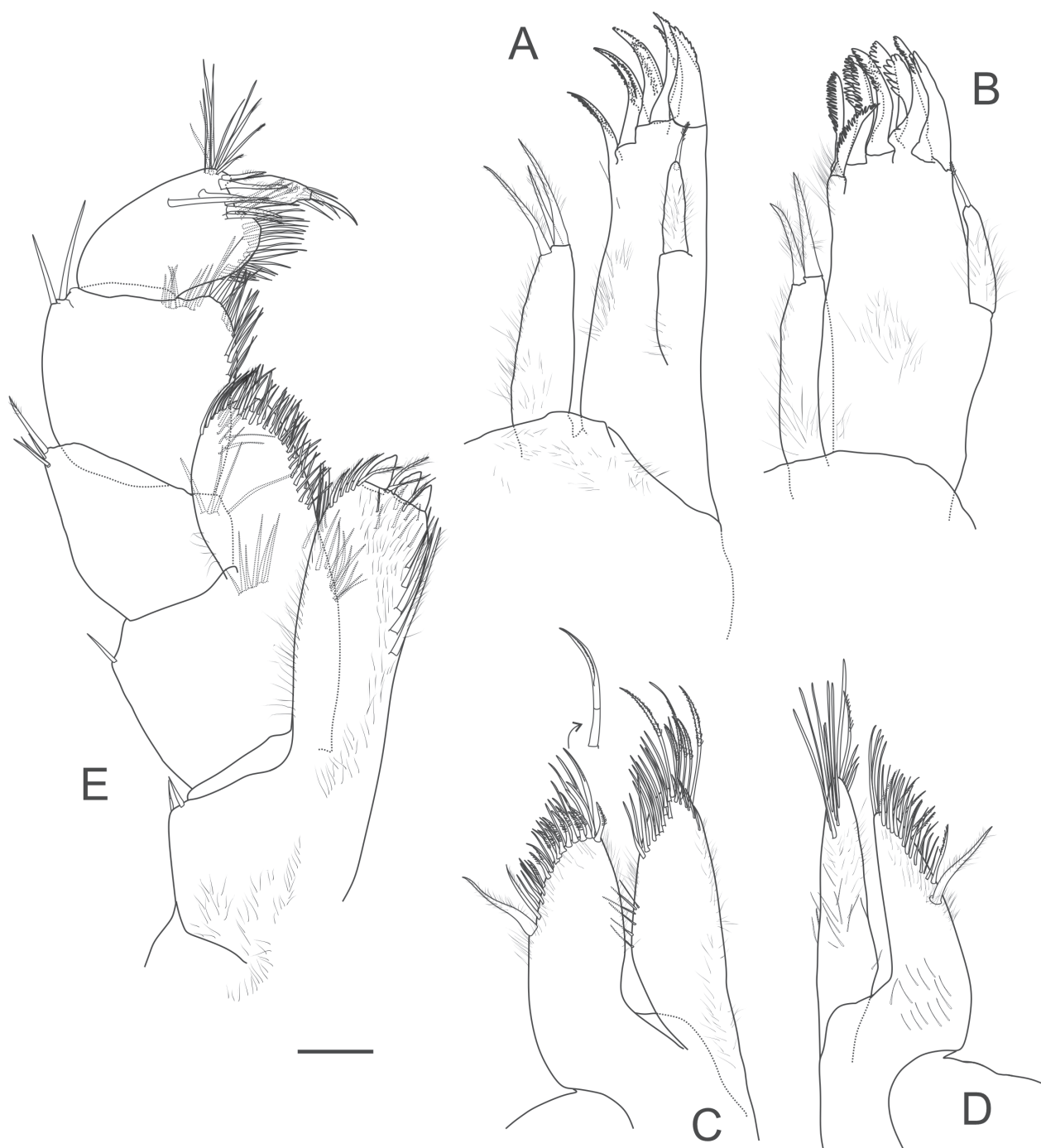


Figure 5. *Hyaella portaeolis* sp. nov. **A.** Maxilla 1 of male paratype (FML-CRUST 01445); **B–D.** Holotype male (FML-CRUST 01443): **B.** Maxilla 1; **C.** Maxilla 2, arrow indicating the detail of a seta; **D.** Maxilla 2, lateral view; **E.** Maxilliped. Scale bars: 0.1 mm.

Gnathopod 1: Subchelate. Coxal plate longer than wide, margins with microtrichs type Ia. Basis with four simple setae on posterior margin. Propodus hammer-shaped, longer than maximum width, with a group of slender simple setae on anterodistal corner; inner face with oblique row of nine serrate F3 setae; palmar margin with simple setae. Palm angle with four cuspidate setae with distal setule, one markedly larger and positioned opposite the others, accompanied by one plumose seta, simple setae, and comb/setose scales. Dactylus claw-like, with microtrichs type Ib, inner margin denticulate. Palmar Index (*sensu* Ruffo 1973) = 0.38 (Fig. 6B).

Gnathopod 2: Subchelate. Coxa smaller than that of gnathopod 1. Basis approximately four times longer than maximum width, posterior margin bearing 10 serrate setae. Basis, ischium, and merus each with a group of setae on posterodistal angle. Posterior lobe of carpus short with pectinate border lined by row of serrate setae. Propodus ovate; palm oblique, longer than posterior margin, bearing several strong short to medium-length setae. Palm angle with two cuspidate B5 setae, each with accessory seta and comb/setose scales. Microtrichs type Ib present on palm and dactylus. Dactylus claw-like, congruent with palm, with one thin plumose dorsal seta. Palmar Index (*sensu* Ruffo 1973) = 0.42 (Fig. 6A).

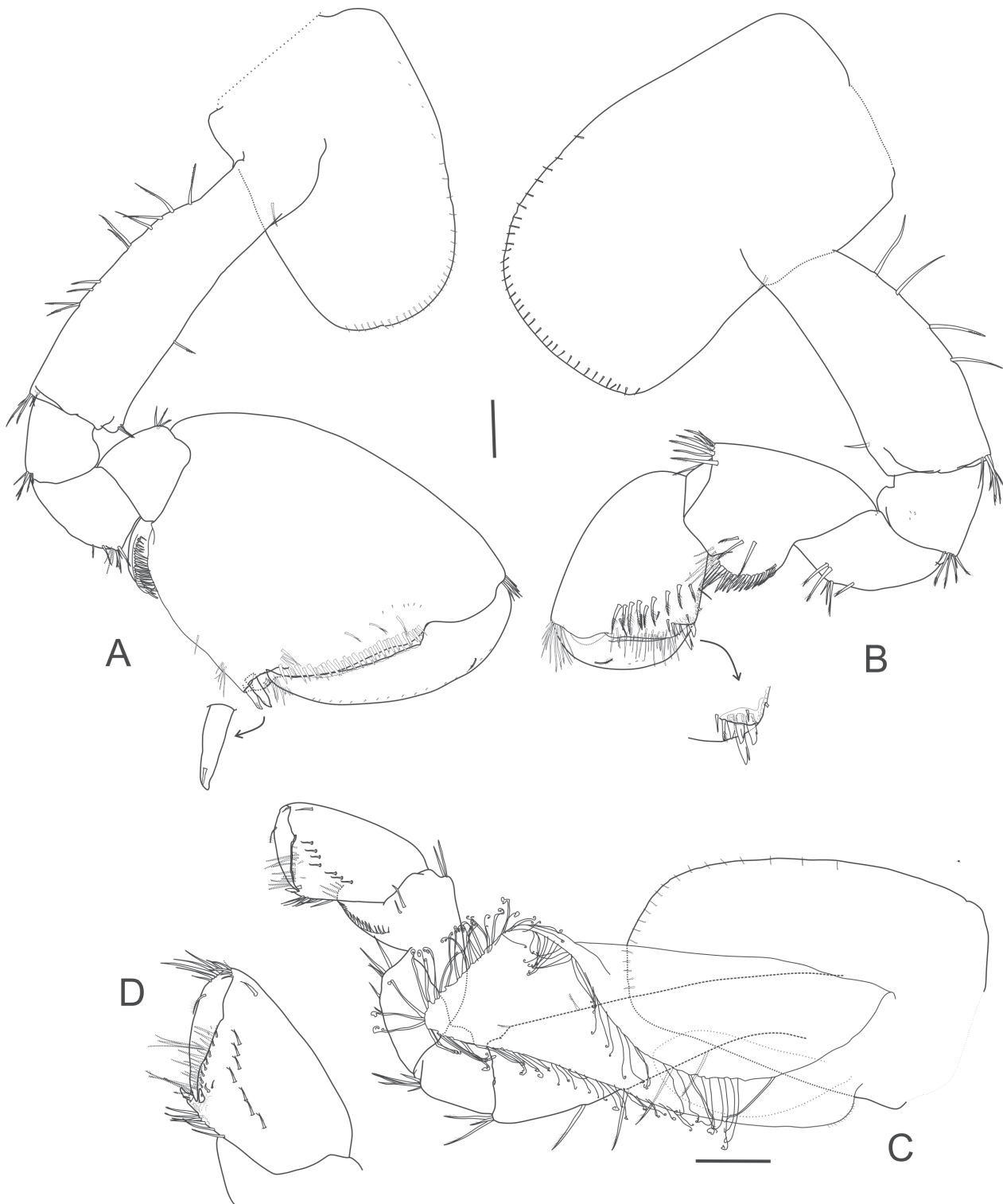


Figure 6. *Hyalella portaesolis* sp. nov. Holotype male (FML-CRUST 01443) and paratype female (FML-CRUST 01444). **A.** Male gnathopod 2, arrow indicating cuspidate seta; **B.** Male gnathopod 1, arrow indicating palmar angle; **C.** Female gnathopod 2; **D.** Propodus and dactylus of gnathopod 2 female. Scale bars: 0.1 mm.

Pereiopods 3–4: Similar in size and shape. Coxal plate of pereiopod 3 longer than wide; coxal plate of pereiopod 4 subtriangular, posterior cavity broad, shallow, and poorly developed, slightly longer than maximum width. Margins of both coxal plates lined with thin simple setae (type 1a); microtrichs type 1b also present. Posterior margins of basis, merus, carpus, and propodus with simple or

cuspidate setae. Dactylus short, less than half length of propodus (Fig. 7A, B).

Pereiopods 5–7: Pereiopod 5 distinctly shorter than pereiopods 6 and 7, the latter subequal in length. Coxal plates: pereiopod 5 wider than long, posterior lobe deeper than anterior; pereiopod 6 as long as maximum width, with strongly reduced anterior lobe; pereiopod 7

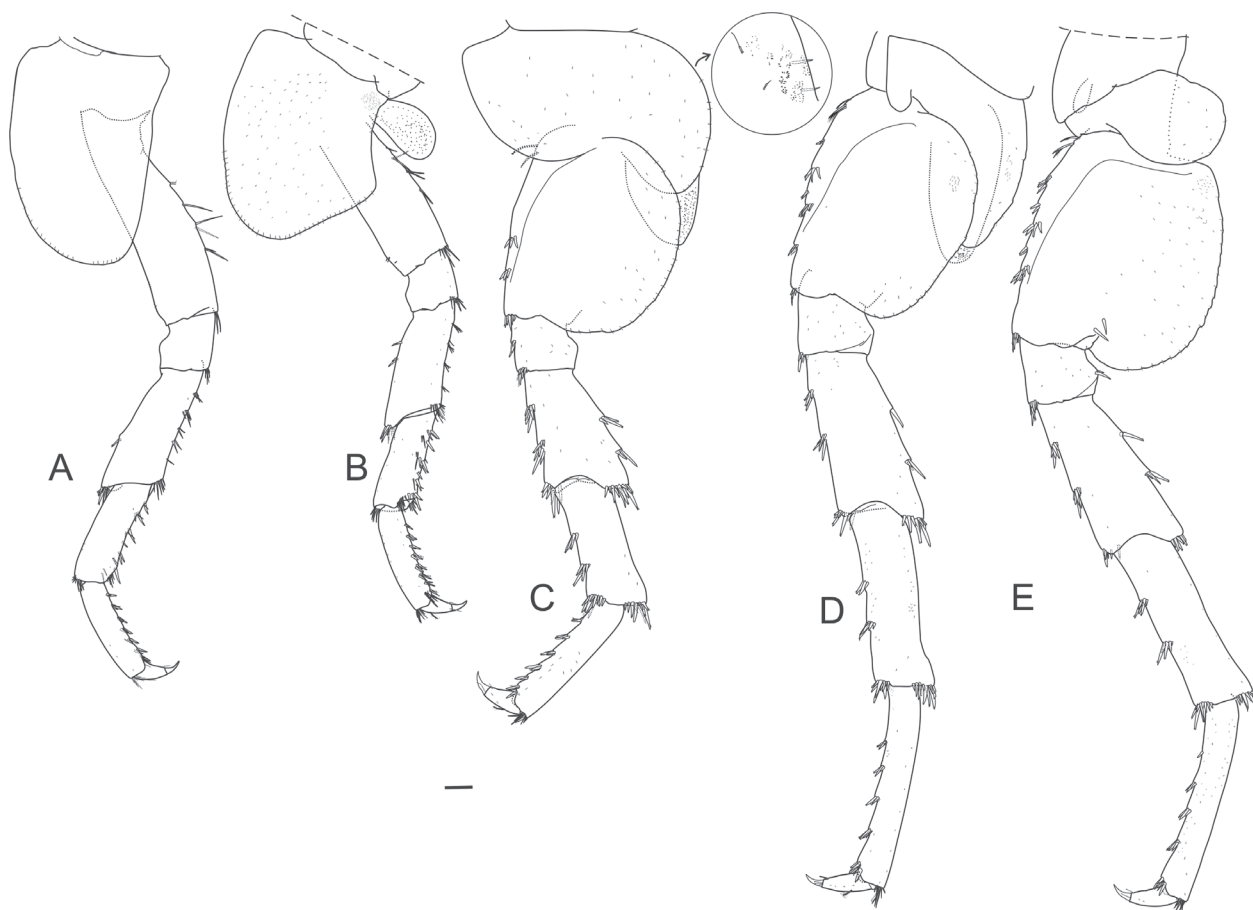


Figure 7. *Hyaella portaesolis* sp. nov. Holotype male (FML-CRUST 01443). **A.** Pereiopod 3; **B.** Pereiopod 4; **C.** Pereiopod 5, arrow indicating coxal detail; **D.** Pereiopod 6; **E.** Pereiopod 7. Scale bars: 0.2 mm.

slightly wider than long; margins of all plates lined with thin simple setae (type Ia) and microtrichs type Ib (see details in Fig. 7C). Basis posteriorly expanded, especially on pereiopod 7, with finely serrated margin; pereiopod 7 additionally with two subdistal cuspidate setae on outer surface. Anterior margin of basis of pereiopods 5–7 with groups of two or three plumose setae. Ischium, merus, carpus, and propodus with simple or cuspidate setae on anterior and posterior margins. Dactylus short, similar to those of pereiopods 3 and 4 (Fig. 7C–E).

Coxal gills: Sacciform (Fig. 7B–D), present from gnathopod 2 to pereiopod 6.

Sternal gills: Sacciform (Fig. 7E), present on pereionites 3–7.

Pleopods: Biramous and similar; peduncle shorter than rami, with retinacula. Rami multiarticulate, bearing long plumose setae (Fig. 8A).

Uropod 1: Peduncle longer than rami, with three proximal dorsal cuspidate setae aligned longitudinally and two distal cuspidate setae. Rami subequal in length. Outer ramus with two dorsal and four distal cuspidate setae, one shorter than remaining setae; inner ramus with one dorsal and five distal cuspidate setae (one much shorter), without modified curved seta on inner margin. Microtrichs type Ib present on peduncle and rami (Fig. 8B).

Uropod 2: Shorter than uropod 1. Peduncle with four dorsal cuspidate setae aligned longitudinally and one dorsomedial distal cuspidate seta. Outer ramus with three dorsal cuspidate setae, two arising as a group, and five distal cuspidate setae, one distinctly longer and another much shorter and thinner than the remaining setae. Inner ramus with two dorsal and four distal cuspidate setae, one of them longer than rest and another much shorter and thin. Microtrichs type Ib present on peduncle and rami (Fig. 8C).

Uropod 3: Shorter than peduncle of uropod 2. Peduncle much wider than ramus, as long as maximum width, with 10 strong distolateral cuspidate setae. Ramus stout, shorter than peduncle, apex bearing one thin simple seta and another six strong cuspidate setae, one markedly larger than rest. Microtrichs type Ib present on peduncle and ramus; grouped scale-like structures present laterally on peduncle which gives it a rough appearance (Fig. 8D).

Telson: Wider than long, entire, subquadrangular, distal margin with four or five thin simple setae on each side; lateral margins with three plumose setae (Fig. 8E). Dorsal surface with microtrichs type Ib and scale-like pattern (Fig. 8F).

Epimeral plates: Plate 1 posterodistally rounded (Fig. 8A); plate 2 with broadly rounded posterodistal corner; plate 3 subrectangular posterodistally.

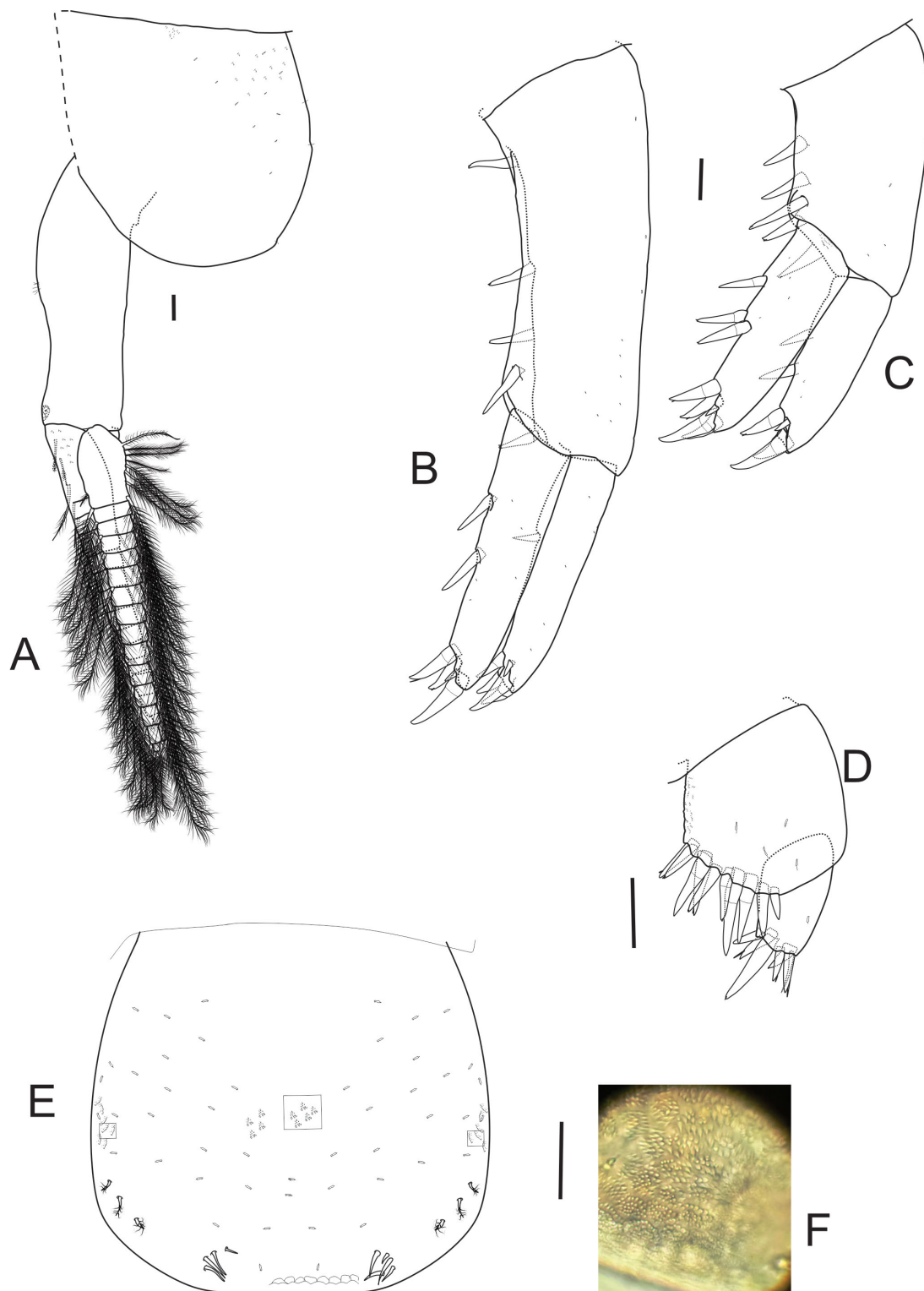


Figure 8. *Hyalella portaesolis* sp. nov. Holotype male (FML-CRUST 01443). **A.** Epimeral plate 1 and pleopod 1; **B.** Uropod 1; **C.** Uropod 2; **D.** Uropod 3; **E.** Telson; **F.** Detail of telson surface ornamentation. Scale bars: 0.1 mm.

Intraspecific variation (males): In one male paratype, inner plate of maxilla 1 bears three apical pappose setae instead of two (Fig. 5A).

Female (paratypes): Maximum body length observed 7.02 mm. Habitus generally similar to male except for following characters: gnathopods 1 and 2 similar in size

and shape; inner face of propodus of gnathopods 1 and 2 with seven serrate setae. Gnathopod 2 differs from male in relatively smaller and more elongate propodus (Fig. 6C, D). Oostegites broad, subtriangular, margins bearing large curled setae (Fig. 6C).

Habitat. Freshwater, epigeal, peatlands.

Ecological notes. The species was found at water temperatures ranging from 12.59 to 14.08°C, with pH values between 6.74 and 8.07. Conductivity varied from 430 to 1,210 µS/cm, while oxygen saturation ranged from 106% to 113%.

Taxonomic remarks. The coxa of pereopod 4 in the new species, with a broad and shallow cavity, is a diagnostic character shared with *Hyaella yashmara* Tomikawa, Kawasaki, Leiva & Arroyo, 2023 (Cajamarca, Perú) and *Hyaella pauperocavae* González & Watling, 2002 (Huancayo, Perú). However, *Hyaella portaesolis* sp. nov. differs from *H. yashmara* mainly in the male gnathopod 2 (Fig. 6A), which has a regular palmar margin and a weakly developed palmar angle (vs. irregular palmar margin and well-developed palmar angle in *H. yashmara*).

Additional diagnostic characters of *Hyaella portaesolis* sp. nov. include the maxilla 1 palp, which is long and slender, reaching approximately 3/4 of the distance between its base and the base of the setae of the outer plate, with a single distal papposerrate seta (vs. reduced, uniarticulate, slender, distally acute, and lacking setae in *H. yashmara*).

The differentiation between *Hyaella portaesolis* sp. nov. and *H. pauperocavae* is based on the following characters (characters of *H. pauperocavae* in parentheses): antenna 1 shorter than antenna 2 (antennae 1 and 2 equal in length); propodus of gnathopod 1 lacking setae on the anterior margin (four setae present); basis of pereopod 7 with two robust subdistal setae (without setae); uropod 3 with globose peduncle, wider than ramus, bearing 10 robust distal setae (peduncle longer than wide, with 5 robust setae), and short ramus with a total of 6 robust setae (ramus with a single robust seta); telson with a total of 9 short, slender apical setae (6–8 robust setae).

Hyaella rodriguezi sp. nov.

<https://zoobank.org/02799106-EE75-48F4-A0F2-5D1CD3AAF4E0>

Figs 9–14

Synonymy. *Hyaella* sp. 5 — Hankel et al. 2023.

Type material. Holotype. ARGENTINA • 1 ♂ (7.78 mm); Catamarca Province, Antofagasta de la Sierra Department, Punta Las Peñas peatlands; 26.01281°S, 67.31742°W; 3679 m a.s.l.; 16 Dec. 2015; J. Rodríguez leg.; FML-CRUST 01446.

Paratypes. ARGENTINA • 1 ovigerous ♀ (5.02 mm); same data as holotype; FML-CRUST 01447. • 4 ♂♂, 2 ♀♀; same data as holotype; FML-CRUST 01448. • 4 ♂♂, 2 ♀♀; same data as holotype; IBN-EcoPP-27C.

Type locality. Argentina, Catamarca Province, Punta Las Peñas peatlands, 26.01281°S, 67.31742°W, 3679 m a.s.l.

Other material examined. Argentina, Catamarca Province: Antofagasta de la Sierra Department, Punta Las Peñas peatlands, 26.01281°S, 67.31742°W, 3679 m a.s.l.; 16 Dec 2015; coll. J. Rodríguez (IBN-EcoPP-27-C). — Punta Las Peñas peatlands, 26.00961°S, 67.30656°W,

3721 m a.s.l.; 16 Dec 2015; coll. J. Rodríguez (IBN-EcoPP-27-F). — Peña Colorada peatlands, 26.04731°S, 67.37853°W, 3464 m a.s.l.; 12 Dec 2015; coll. J. Rodríguez (IBN-EcoPP-22-E). — Peña Colorada peatlands, 26.04933°S, 67.38019°W, 3456 m a.s.l.; 12 Dec 2015; coll. J. Rodríguez (IBN-EcoPP-22-F).

Diagnosis. Body smooth. Maxilla 1 palp asymmetric: much shorter on left maxilla, bearing a very reduced seta; on right maxilla, palp longer than wide, reaching approximately half of the distance between its base and the base of the setae of the outer plate, bearing one peg-like apical seta. Male gnathopod 1 with hammer-shaped propodus, bearing on inner face five bifurcate serrate setae arranged obliquely and two additional bifurcate setae on the anterior margin. Uropod 1 sexually dimorphic: inner ramus of male bearing a distinctive modified curved seta (“copulatory spine” *sensu* Bousfield, 1996). Uropod 3 long and slender, with ramus slightly longer than peduncle; ramus styliform, longer than wide, gradually tapering distally. Sternal gills present on pereonites 3–7.

Etymology. The specific epithet *rodriguezi* refers to José Rodríguez, who carried out extensive fieldwork and collected a large part of the macroinvertebrates from the study area.

Description of male. Body: Smooth. Maximum body length observed 7.78 mm.

Head: Eye oval to slightly elliptical, pigmented (Fig. 9).

Antenna 1: Shorter than antenna 2 but longer than its peduncle. Peduncular segment 1 longer than segments 2 and 3, which are subequal in length; all bearing numerous simple and plumose setae, together with microtrichs type Ib; segment 1 with a row of six plumose setae on the medial surface. Flagellum composed of 11 articles, each bearing groups of simple A1 setae; aesthetascs present distally on articles 2–10 (Fig. 10A).

Antenna 2: Approximately equal to half the body length. Peduncular segments 3–5 with groups of simple and plumose setae. Flagellum composed of 14 articles, each bearing distal and subdistal simple A1 setae. Peduncle and flagellum with microtrichs type Ib (Fig. 10B).

Upper lip: Ordinary, distal margin with minute setae; surface with dense medial patch of minute setae (Fig. 10C).

Mandibles: Left mandible (Fig. 10E) with 6-denticulate incisor (three strong distal ones and the three tiny proximal ones); lacinia mobilis 4-denticulate, with one long and three short teeth; setal row with six pappose setae, three longer than the others. Right mandible (Fig. 10F) with 7-denticulate incisor, bearing three long and four short teeth; lacinia mobilis complex, multidenticulate and with tiny setae; setal row with four pappose setae. Molar triturative and accessory seta well developed in both mandibles.

Lower lip: Ordinary; outer lobes densely covered with minute setae near inner margin (Fig. 10D).

Maxilla 1: Outer plate with nine robust serrate F4 setae and setules on inner surface; inner plate shorter than

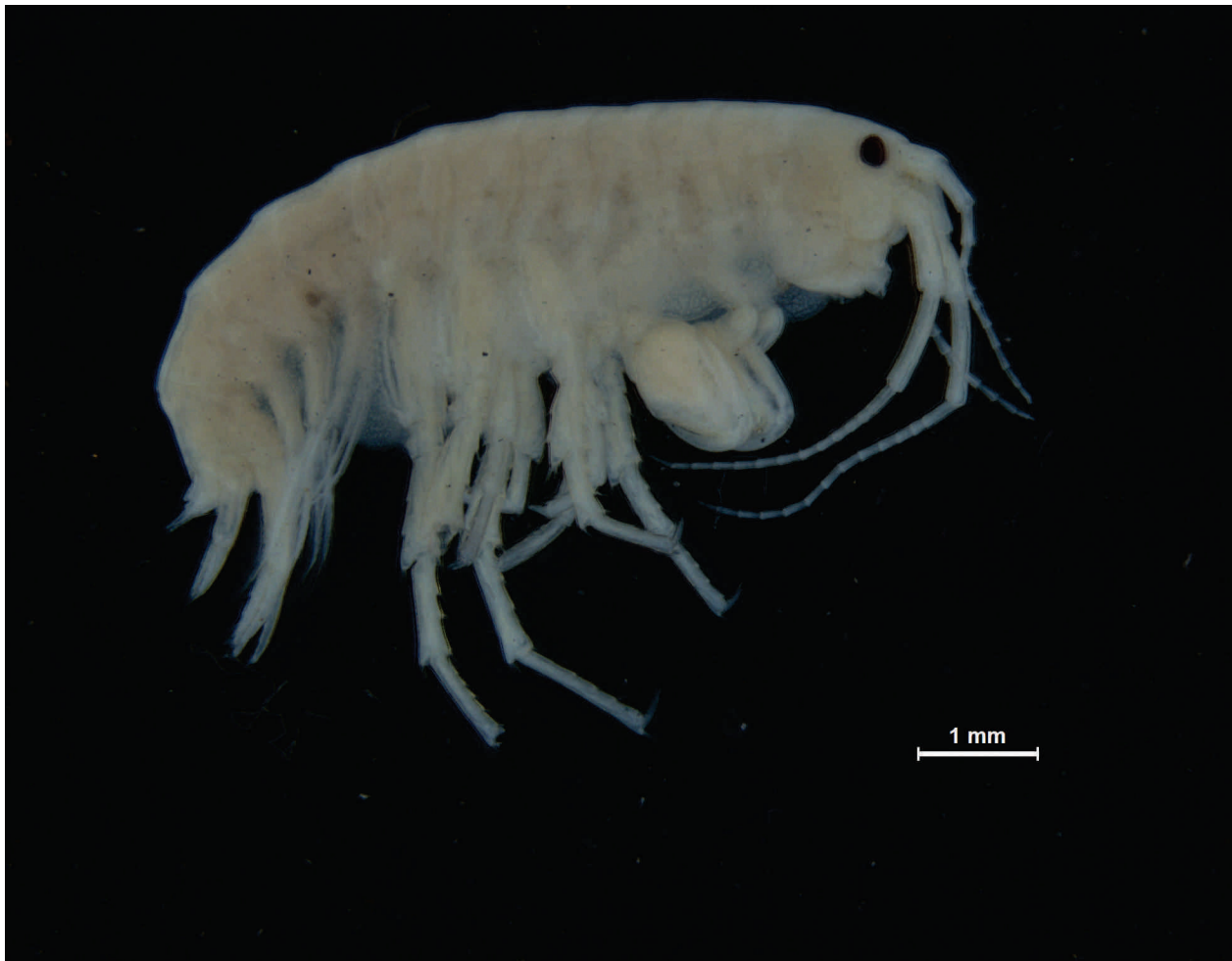


Figure 9. *Hyalella rodriguezi* sp. nov., habitus, holotype male (FML-CRUST 01446).

outer plate, with two apical papposerrate setae and several marginal setules. Palp asymmetrical, in the right maxilla is longer than wide, reaching approximately half of the distance between its base and the base of the setae of the outer plate, bearing one peg-like apical seta (Fig. 11A). Palp of left maxilla 1 much shorter than right counterpart, with one stout reduced distal seta (Fig. 11B).

Maxilla 2: Inner plate slightly shorter than the outer, with one strong pappose seta on inner margin; both plates distally bearing simple and serrate setae, with few surface setules (Fig. 11C).

Maxilliped: Inner plate truncated with three apical robust cuspidate setae; distal and medial margins with plumose setae. Outer plate ovate, longer than palp segment 1; distal and medial margins with simple setae and few serrate setae on surface. Palp four-segmented; segment 3 longer than wide; segments 1–3 bearing simple and serrate setae on medial and lateral margins; segment 4 unguiform, shorter than segment 3, with a group of simple distal setae shorter than the nail; nail finely setulose along inner margin. Segments 3 and 4 with comb-scales on lateral margins. Microtrichs type Ib present on inner and outer plates and on palp segments 1–2 (Fig. 11D).

Gnathopod 1: Subchelate. Coxal plate longer than wide, with microtrichs type Ib and marginal simple setae

type Ia. Basis posterior margin with two serrate setae and distal groups of serrate setae; ischium and merus margins with T1 denticles and posterior margins with groups of serrate setae. Carpus longer than maximum width, with group of setae on posterodistal corner; posterior pectinate lobe bordered by serrate setae (Fig. 12A). Propodus (Fig. 12B) longer than broad, hammer-shaped; anterodistal margin with two bifurcate serrate setae, anterodistal corner and palm angle with comb-scales. Inner face with five bifurcate serrate setae (Fig. 12C) arranged obliquely, accompanied by smaller supplementary setae. Palm margin lined with simple A1 setae near dactylus. Palm angle with two cuspidate setae with accessory seta. Dactylus with comb-scales and one accessory seta. Palmar Index (*sensu* Ruffo 1973) = 0.33.

Gnathopod 2: Subchelate. Coxal plate longer than wide, smaller than gnathopod 1; with microtrichs type Ib on surface and simple setae type Ia along margin. Basis with one serrate seta on posterior margin; posterodistal corners of basis, ischium and merus with groups of serrate setae. Carpus subtriangular, with two serrate setae on posterodistal corner; posterior pectinate lobe bordered by serrate setae. Propodus subovate, anterior margin with two small serrate setae; palm oblique, bordered by several rows of simple setae. Palm angle with two very short

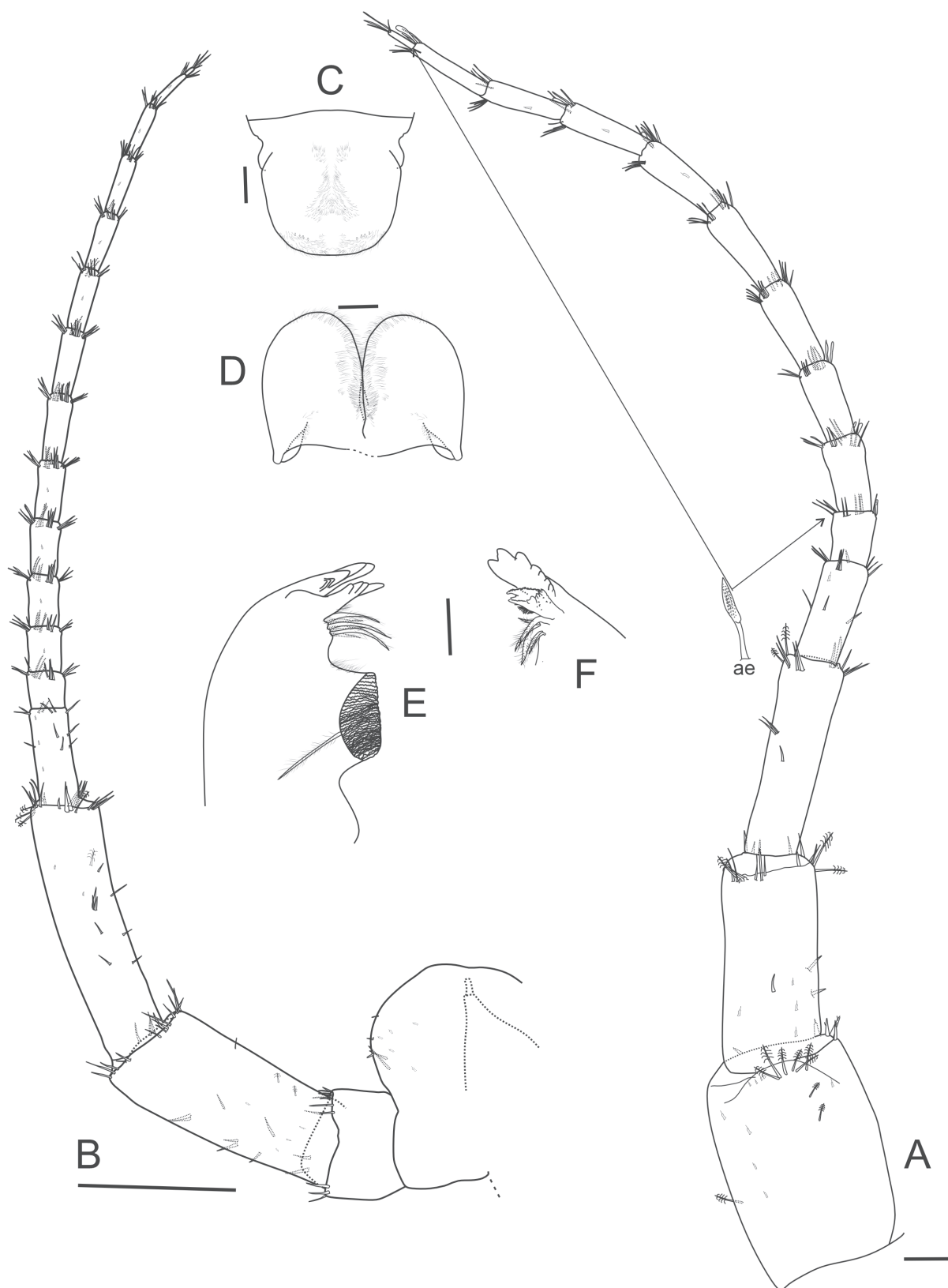


Figure 10. *Hyaella rodriguezi* sp. nov. Holotype male (FML-CRUST 01446). **A.** Antenna 1, arrows indicating distribution of aesthetascs (ae); **B.** Antenna 2; **C.** Upper lip; **D.** Lower lip; **E.** Left mandible; **F.** Incisor and lacinia mobilis of right mandible. Scale bars: 0.5 mm (**B**); 0.1 mm (**A, C–F**).

cuspidate setae and comb-scales. Dactylus claw-like, congruent with palm. Palmar Index (*sensu* Ruffo 1973) = 0.53 (Fig. 12D).

Pereiopods 3–4: Similar in size. Coxal plate of pereopod 3 subrectangular, longer than wide (Fig. 13A); coxal plate of pereopod 4 broad, deeply excavated posteriorly,

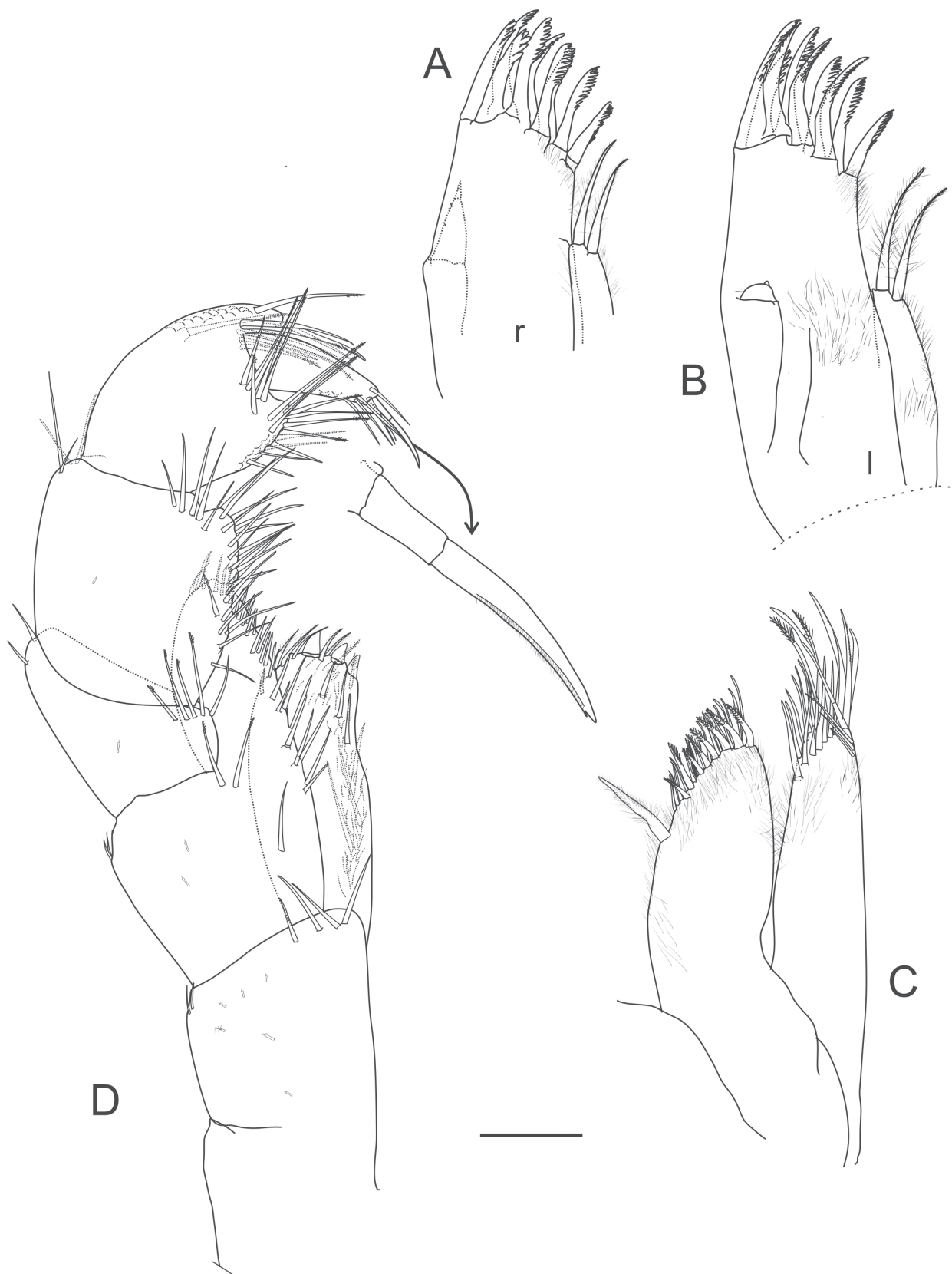


Figure 11. *Hyalella rodriguezi* sp. nov. Holotype male (FML-CRUST 01446). **A.** Right maxilla 1; **B.** Left maxilla 1; **C.** Maxilla 2; **D.** Maxilliped, arrow indicating detail of nail. Scale bars: 0.1 mm.

as long as maximum width (Fig. 13C). Margins of both plates lined with thin simple type Ia setae; surface with microtrichs type Ib. Posterior margins of basis, ischium,

merus, carpus, and propodus with groups of bifurcate serrate (Fig. 13B) and cuspidate setae. Dactylus, approximately one-third length of propodus.

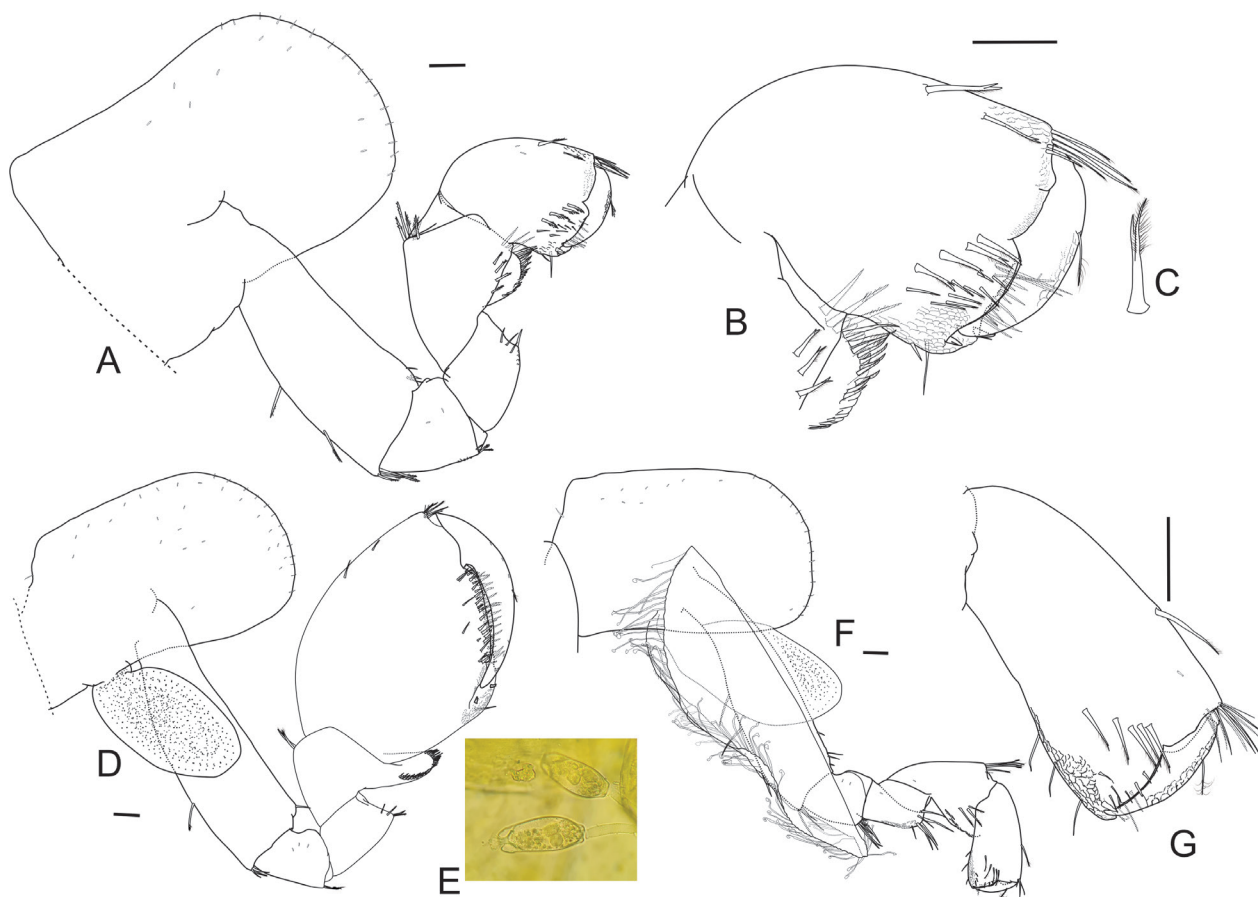


Figure 12. *Hyaella rodriguezi* sp. nov. Holotype male (FML-CRUST 01446) and paratype female (FML-CRUST 01447). **A.** Male gnathopod 1; **B.** Detail of propodus and dactylus of male gnathopod 1; **C.** Bifurcate serrate seta; **D.** Male gnathopod 2; **E.** Epibiotic protozoans on male gnathopod 2; **F.** Female gnathopod 2; **G.** Detail of propodus and dactylus of female gnathopod 2. Scale bars: 0.1 mm.

Pereiopods 5–7: Pereiopod 5 shorter than pereopods 6 and 7, the latter subequal in length. Coxal plates: pereiopod 5 bilobed, wider than long, posterior lobe deeper than anterior; pereiopod 6 as long as wide, with strongly reduced anterior lobe; pereiopod 7 wider than long. Margins of all coxal plates lined with thin simple setae (type Ia), and surfaces with microtrichs type Ib. Basis of pereopods 5–7 expanded with finely serrated margin; anterior and posterior margins of ischium, merus, carpus, and propodus with simple or cuspidate setae. Numerous microtrichs type Ib distributed on surface from basis to propodus. Dactylus similar to those of pereopods 3–4 (Fig. 13D–F).

Coxal gills: Sacciform, present from gnathopod 2 to pereiopod 6 (Figs 12D–F, 13A, C, D).

Sternal gills: Sacciform, present on pereionites 3–7 (Fig. 13F).

Pleopods: Biramous. Peduncle with a pair of retinacula. Rami multiarticulate, bearing long plumose setae (Fig. 14A).

Uropod 1: Peduncle longer than rami, with six dorsal cuspidate setae: four aligned longitudinally, plus two distal ones. Rami subequal in length. Inner ramus with three dorsal cuspidate setae and nine distal setae, one markedly elongate, slender, and curved, extending beyond apex of

ramus (“copulatory spine”, *sensu* Bousfield, 1996), with serrated edges and end partially covered by distal cuticular expansion forming apical hood. Outer ramus with four dorsal cuspidate setae and four distal setae, one distinctly longer than rest (Fig. 14B).

Uropod 2: Slightly longer than peduncle of uropod 1. Peduncle is slightly longer than rami, with five dorsal cuspidate setae: two aligned longitudinally and other three apically. Both rami are each with three dorsal cuspidate setae. Outer ramus with four distal cuspidate setae, the one at the end notably long and robust; inner ramus with eight distal cuspidate setae, the most distal one longer and stouter than remaining setae. Microtrichs type Ib present on peduncle and rami (Fig. 14C).

Uropod 3: Subequal in length to peduncle of uropod 2. Peduncle rectangular, slightly shorter than ramus, distal margin with four robust distal cuspidate setae with accessory setules (one of them longer and stouter than remaining setae), and others two or three slender setae; with three thin setae medially and scattered scale-like structures on surface. Ramus styliform, longer than wide, gradually tapering distally, surface with microtrichs type Ib and few scattered scales; apex bearing six to eight long simple setae and one short distal cuspidate seta (Fig. 14D, E).

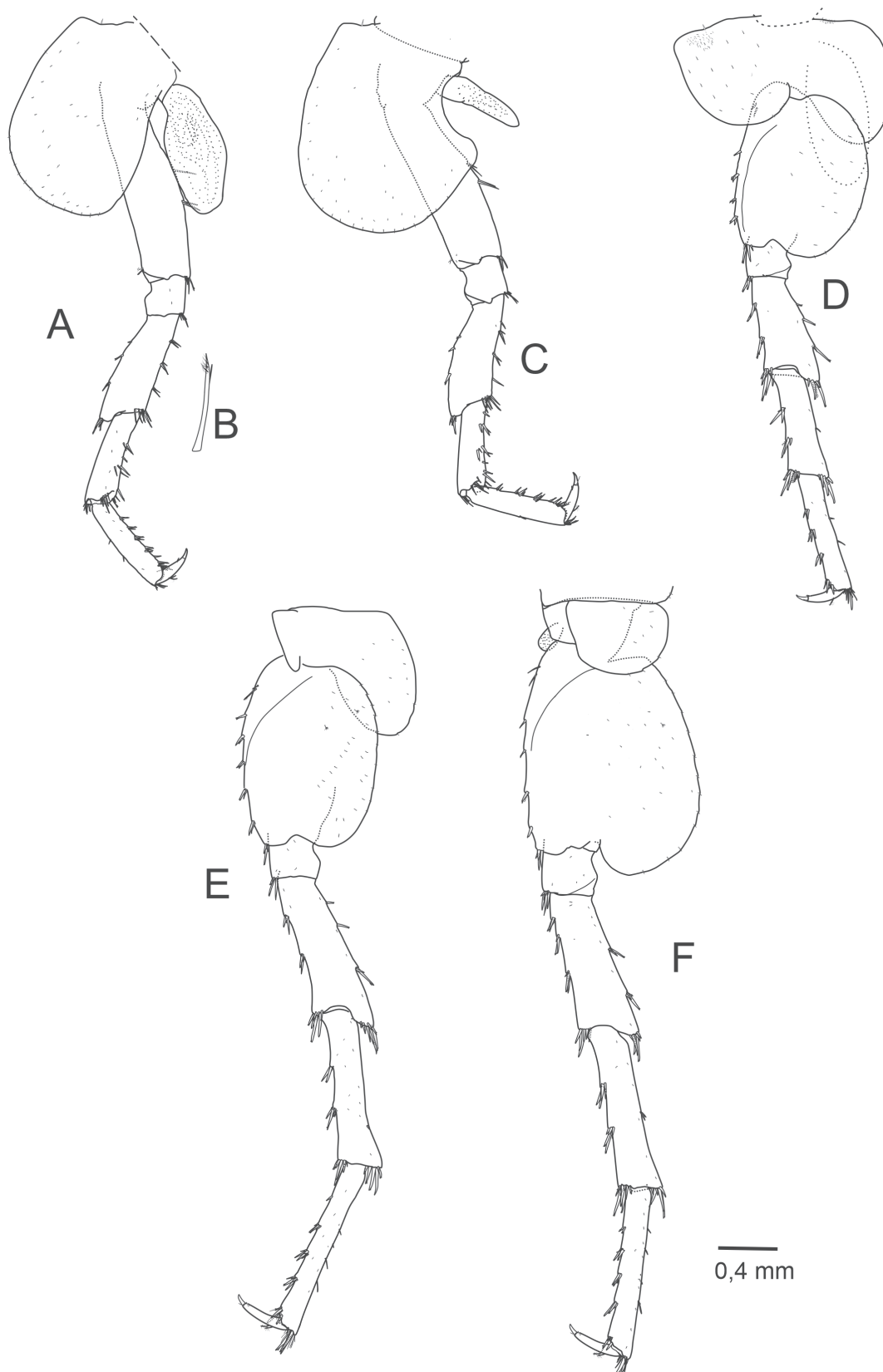


Figure 13. *Hyalella rodriguezi* sp. nov. Holotype male (FML-CRUST 01446). **A.** Pereiopod 3; **B.** Detail of bifurcate seta on pereiopod 3; **C.** Pereiopod 4; **D.** Pereiopod 5; **E.** Pereiopod 6; **F.** Pereiopod 7.

Telson: Subrectangular, distal margin with two long serrate setae; additionally, three short plumose setae present subdistally on each side of dorsal surface (Fig. 14F).

Epimeral plates: Plates 1 (Fig. 14A) and 3 rounded posterodistally, posterodistal corner not produced; plate 2 acuminate posterodistally, angle strongly produced.

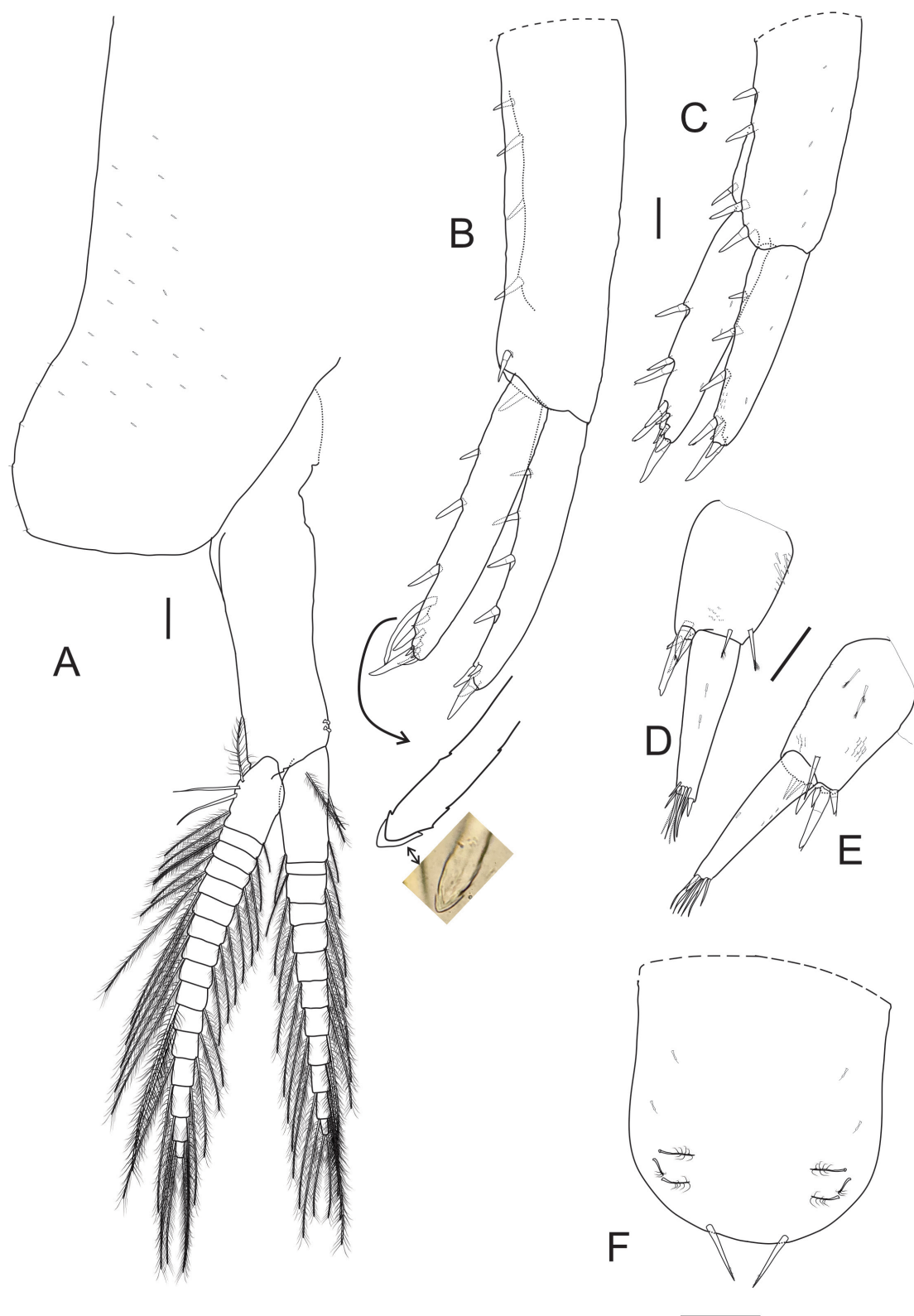


Figure 14. *Hyaella rodriguezi* sp. nov. Holotype male (FML-CRUST 01446). **A.** Epimeral plate 1 and pleopod 1; **B.** Uropod 1, arrow indicating ornamentation at the apex of curved seta (shown in drawing and photomicrograph); **C.** Uropod 2; **D.** Right uropod 3; **E.** Left uropod 3; **F.** Telson. Scale bars: 0.1 mm.

Intraspecific variation (males): Variation observed in number and arrangement of setae on peduncle of right and left uropod 3 (Fig. 14D, E).

Female (paratypes): Maximum body length observed 5.02 mm. Gnathopod 2 propodus (Fig. 12G) smaller and

more slender than in male, with five bifurcate serrate setae on the inner face and one similar seta on the anterior margin. Oostegites subtriangular, bearing curled setae along margins (Fig. 12F).

Habitat. Freshwater, epigeal, peatlands.

Ecological notes. The species was found at an average water temperature of 16.87°C and a pH of 9.25. Conductivity was 100 µS/cm, and oxygen saturation reached 76%.

Record of epibiotic protozoans. Peritrich ciliates, similar to *Vorticella* Linnaeus, 1767 (Fig. 12E), were observed on the male holotype gnathopod 2, specifically on the ischium and merus (pers. comm. Carlos Rauque).

Taxonomic remarks. *Hyaella rodriguezi* sp. nov. is similar to *Hyaella inca* in the asymmetry between the left and right maxilla 1 palps, the morphology of gnathopods 1 and 2, the presence of a curved seta on the inner ramus of male uropod 1, and telson ornamentation. However, the new species differs from *H. inca* mainly in the following characters: the male gnathopod 1 propodus bears five principal bifurcate serrate setae arranged obliquely on the inner face (vs. more than 10 serrate, non-bifurcate setae in *H. inca*); the male gnathopod 2 propodus bears two serrate setae on the anterior margin (vs. anterior margin lacking setae); and uropod 3 has a peduncle longer than wide and a styliform ramus slightly longer than the peduncle, approximately 3.7 times longer than wide and lacking subdistal setae (vs. peduncle rectangular, wider and longer than ramus, and ramus less elongate approximately 2.5 times longer than wide, bearing one to four subdistal setae in *H. inca*). In addition, sternal gills are present on pereionites 3–7 in *H. rodriguezi* sp. nov. (vs. pereionites 2–7 in *H. inca*).

Additionally, *H. rodriguezi* sp. nov. shows affinity with *Hyaella kochi* González & Watling, 2001 in the presence of a curved seta on the inner ramus of uropod 1, the hammer-shaped propodus of gnathopod 1 with fewer than 10 setae on the inner face, and the distribution of sternal gills. Nevertheless, the new species differs from *H. kochi* mainly in the morphology of the telson, uropod 3, and male gnathopod 2. In *H. rodriguezi* sp. nov., the propodus of male gnathopod 2 bears two serrate setae on the anterior margin (vs. absent in *H. kochi*); the propodus is subovate, with a more oblique palmar margin (vs. propodus more quadrangular and palm less oblique in *H. kochi*); the palmar angle bears two cuspidate setae inserted on the same side of the angle (vs. one cuspidate seta on palmar angle in *H. kochi*). Uropod 3 bears a longer and more styliform ramus than that of *H. kochi*, and the telson is apically rounded with two serrate apical setae (vs. telson quadrangular, apically truncate, bearing two to four simple apical setae in *H. kochi*).

Distributional comments

From the material examined, 9 species of *Hyaella* have been identified in 41 sites of the study area, with records from Puna and High Andean ecoregions: *H. fatimae*; *H. inca*; *H. fossamancinii* Cavalieri, 1959; *H. oscar* Isa-Miranda, Peralta, González & Nieto, 2025; *H. puna* Peralta & Isa-Miranda, 2019; *H. kochi* species complex (*sensu* Jurado-Rivera et al. 2020); *H. aff. puna* and the two new species. The new species *H. rodriguezi* sp. nov. is known from Punta Las Peñas peatlands in sympatry with *H. kochi*

complex. These records are in the vicinity of the Antofagasta peatland where the highest concentration of sympatric species in the region is recorded: *H. fatimae*; *H. puna*; *H. kochi* complex; *H. portaesolis* sp. nov. and *H. aff. puna*.

Hyaella portaesolis sp. nov. shows the widest distribution of the two newly described species, extending from Catua Arriba peatlands, the northernmost locality recorded in the study area (23.85847°S), to Antofagasta peatland (25.98900°S). The species was recorded across an altitudinal range of 3,417–4,008 m a.s.l., with records from Antofalla, Antofagasta, and Catua Arriba peatlands. In contrast, *H. rodriguezi* sp. nov. has a more restricted distribution, currently known only from Punta Las Peñas and Peña Colorada peatlands, between 3,456 and 3,721 m a.s.l. Both species occur in high-altitude peatlands characterized by heterogeneous hydrological conditions, including central areas with flowing water and zones with slower water movement and water accumulation, which are mainly determined by local topography and slope.

With these new records, *H. fatimae* is the most widely distributed species, found at 23 of the 41 sites sampled. Regarding *H. fossamancinii*, its known distribution, San Juan Province, Argentina, and northern Chile (Cavalieri 1959; González and Watling 2001) is expanding towards 24°S in northern Argentina (Fig. 1).

Discussion

Diversity and species delimitation within the genus *Hyaella*

The results indicate that COI provides useful information for species delimitation within South American Hyalellidae (Jurado-Rivera et al. 2020; Waller et al. 2022; Penoni et al. 2025) and strongly supports the recognition of *Hyaella portaesolis* sp. nov. and *Hyaella rodriguezi* sp. nov., increasing the number of described species in the genus to 132. The congruence among ASAP, GMYC, and bPTP analyses, together with the diagnostic morphological differences observed in both taxa, provides robust evidence for their recognition as independent evolutionary lineages. However, several nominal species exhibited complex delimitation patterns, highlighting both the utility and limitations of mitochondrial markers for resolving species boundaries in the genus.

All methods consistently recovered *H. nefrens* and *H. longipalma* as a single MOTU, suggesting a complex evolutionary history of Andean freshwater systems. Previous studies have suggested that the rapid hydrological fluctuations that affected the Titicaca-Desaguadero-Poopó-Salar de Coipasa basin during the last three million years (Servant and Fontes 1978; Dejoux and Iltis 1992; Zapelloni et al. 2021a) may have played a major role in the diversification of *Hyaella* lineages by repeatedly creating and disrupting ecological niches. Such environmental dynamics could have promoted recent divergence processes that are not yet fully reflected in mitochondrial markers such as COI. Additionally, the lack

of congruence between morphological and molecular evidence may also be explained by incomplete lineage sorting or historical hybridization events among closely related lineages. These processes may obscure species boundaries and contribute to the difficulty of resolving taxonomic limits within *Hyaella*, particularly in high-altitude Andean systems characterized by complex geological and hydrological histories.

A similar pattern was observed in *H. kochi* (OM513827) and *H. simplex* Schellenberg, 1943, which were consistently recovered as a single MOTU, indicating low genetic divergence among these taxa. Such patterns may reflect recent divergence processes or incomplete lineage sorting. In particular, *H. kochi* and *H. simplex* are morphologically very similar species, differing mainly in subtle characters such as the shape and setation of the telson, the relatively longer palp of maxilla 1, and the presence of several connate setae on the inner plate together with a broader second palp article of the maxilliped in *H. simplex* (González 2003). Given the subtle nature of these diagnostic traits, the possibility of voucher misidentification cannot be excluded. Overall, the absence of clear molecular separation among these taxa highlights the challenges associated with species delimitation in *Hyaella*, a genus characterized by conservative morphology and high morphological similarity among closely related species.

These results also suggest that the phylogenetic significance of several morphological characters traditionally used in *Hyaella* taxonomy remains poorly understood. For example, *H. portaesolis* sp. nov. shares a poorly excavated coxa 4 with *H. pauperocavae* and *H. yashmara*, a feature that may indicate morphological affinity among these taxa. However, the limited molecular information currently available prevents a robust assessment of whether this character represents a shared ancestral condition, convergent evolution, or a phylogenetically informative trait. Broader phylogenetic analyses incorporating additional taxa and molecular markers will be necessary to evaluate the evolutionary history of characters such as coxa 4 morphology and to determine their usefulness for inferring species-group relationships within the genus.

In contrast, *H. kochi*, *H. krolli* and *H. fatimae* were each recovered as multiple MOTUs, suggesting considerable intraspecific genetic divergence and the possible existence of additional cryptic lineages within these nominal species (Jurado-Rivera et al. 2020; Waller et al. 2022; Isa-Miranda et al. 2025a). In the case of *H. kochi*, the marked geographic structuring observed among lineages may be associated with historical isolation processes and the fragmented nature of high-altitude freshwater ecosystems, which can restrict gene flow and promote diversification among populations. These findings reinforce the hypothesis that the diversity of Andean *Hyaella* remains underestimated and emphasize the importance of integrative taxonomic approaches (Hankel et al. 2023) combining molecular, morphological, ecological, and biogeographic evidence to clarify species boundaries within the genus.

Overall, the results reveal both unresolved taxonomic relationships and substantial hidden diversity in South American *Hyaella*, particularly in high-altitude Andean ecosystems. Studies on this genus in other regions of South America also suggest that its real biodiversity is underestimated (Limberger et al. 2021; Marrón-Becerra et al. 2023).

Remarks on ecology and geographical distribution

The contrasting distribution of *H. portaesolis* sp. nov. and *H. rodriguezi* sp. nov. across different conductivity thresholds suggests that hydrochemical gradients act as critical drivers of ecological speciation in Andean peatlands. While the broad tolerance of *H. portaesolis* sp. nov. (430–1,210 $\mu\text{S}/\text{cm}$) aligns with the well-documented plasticity of the genus in the Puna region (Rodríguez Capítulo et al. 2014; Scott et al. 2015; Nieto et al. 2016; Peralta and Isa-Miranda 2019; Hankel et al. 2023), the restriction of *H. rodriguezi* sp. nov. to hyperfresh environments (100 $\mu\text{S}/\text{cm}$) points to a narrower ecological niche. Rather than a simple lack of tolerance, this restricted distribution could reflect an evolutionary trade-off, where adaptation to low-mineralization waters grants a competitive advantage in specific habitats. These findings emphasize that high-altitude *Hyaella* are not a homogeneous ecological group, but rather a complex radiation driven by habitat specialization across the diverse gradient described for these peatlands (Reynaga et al. 2020; Hankel et al. 2023). Therefore, additional studies will not only contribute to resolving the taxonomy of the genus—helping to reduce the significant Linnean shortfall—but will also improve our understanding of the unique and diverse ecosystems inhabited by *Hyaella* (Cannizzaro et al. 2025b). This information is especially relevant given the ongoing expansion of mining activities in the region, which may pose significant threats to freshwater biodiversity and ecosystem integrity (Barbarossa et al. 2026).

The presence of epibionts associated with *Hyaella rodriguezi* sp. nov. represents an interesting ecological observation for Andean freshwater amphipods. Epibiotic ciliates have previously been reported on South American inland water amphipods by Rauque (2013), Rauque et al. (2024), De los Ríos-Escalante et al. (2024), who documented the occurrence of unidentified Peritrichia Stein, 1859 and Folliculinidae Dons, 1914 on specimens of *Hyaella*, although without detailed taxonomic identification of the epibionts. The occurrence of epibionts on *H. rodriguezi* sp. nov. expands the ecological information currently available for the genus and suggests that these associations may occur in high-altitude freshwater environments of the Andes. As highlighted by De los Ríos-Escalante et al. (2026), documenting these interactions is important to better understand the ecological and biogeographical relationships between amphipods and their environments, as well as the environmental factors influencing these species and ecosystems over time.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Artificial Intelligence (AI) use

The authors accept full responsibility for the content of the manuscript, including the disclosure of any use of AI.

Regarding the use of AI in the preparation of this manuscript, the authors declare the following: GPT

Used for: Language, style and writing

The authors used ChatGPT (OpenAI) for language editing and improvement of writing style.

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Author contributions

All authors have contributed equally.

Author ORCIDs

Á.V. Isa-Miranda  <https://orcid.org/0000-0002-3300-7490>

M.A. Peralta  <https://orcid.org/0000-0001-7661-3223>

C. Nieto  <https://orcid.org/0000-0003-1909-1750>

Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

Supplementary material 1

List of specimens used in the molecular analyses, including sampling localities, geographic coordinates, GenBank accession numbers, and museum voucher numbers.

Authors: Águeda Verónica Isa-Miranda, Marcela A. Peralta, Carolina Nieto

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