Morphological comparison and description of five new species of *Hyalella* (Crustacea: Amphipoda) from Veracruz and Mexico City

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**ABSTRACT**

In this work we describe five new species of *Hyalella*: *Hyalella sarukhani* sp. nov. from Mexico City, Mexico; *H. alvarezi* sp. nov., *H. garyi* sp. nov., *H. villalobosi* sp. nov., and *H. viviannae* sp. nov. from Veracruz, Mexico. Since the four species from Veracruz belong to the *H. azteca* complex due to the form of the telson, here we present a morphological comparison using scanning electron microscopy images to address the variations within the species.

http://www.zoobank.org/urn:lsid:zoobank.org:pub:9DF27EA5-DSDD-4010-9092-CB6B8358E6B7

**Introduction**

Inland water ecosystems provide us with fresh water and a variety of ecosystem services. However, although there are several studies focused on freshwater macroinvertebrates, these are scarce compared to studies of those in marine or terrestrial environments in Mexico. Studies in these habitats are necessary due to increases in the loss of biodiversity in these ecosystems. Human activities produce habitat degradation due to climate change, overexploitation of resources, deterioration of freshwater quality as consequence of pollution, fragmentation of the habitat, land-use change, overfishing and/or introduction of alien species (Dudgeon 2019; Reid et al. 2019; Albert et al. 2021). The biodiversity crisis is more acute in this environment due to the small area (2% of the Earth’s surface) and high levels of endemism (Lehner and Döll 2004; Collen et al. 2014; Reid et al. 2019).

Additionally, the invertebrate diversity, habitat and distribution within inland freshwater ecosystems is poorly known because of the presence of complexes of cryptic species, which are morphologically similar but can be distinguished at a genetic level (Cook et al. 2008; Brito et al. 2014; Poulin and Pérez-Ponce de León 2017). As a consequence of misidentification, some species were considered to be generalists with a wide distribution (Bickford et al. 2006). Nevertheless, several supposedly cryptic species are, in fact, pseudo-cryptic species with subtle differences in morphological traits sufficient to delimit and
identify species after a carefully detailed morphological examination, or using integrative taxonomy (Knowlton 1993; Lajus et al. 2015; Korshunova et al. 2019).

In Mexico there have been few studies of inland/freshwater amphipods with a taxonomic approach, and most of them are referred to stygobionts adapted to subterranean freshwater environments. *Hyalella azteca* (De Saussure, 1858) was the only epigean species registered in Mexico, with its type locality in the state of Veracruz; however, it is part of a phenotypical cryptic species complex in North America, so it is challenging to uncover the biodiversity that lies hidden within. Hence, the diversity of the genus is underestimated in Mexico. However, in recent years, three species of the genus were described, two from the Yucatan peninsula (*Hyalella cenotensis* Marrón-Becerra, Hermoso-Salazar and Solís-Weiss, 2014, and *Hyalella maya* Marrón-Becerra, Hermoso-Salazar and Solís-Weiss, 2018) and one from the state of Durango, in Northern Mexico (*Hyalella tepehuana* Marrón-Becerra, Hermoso-Salazar and Rivas, 2020).

*Hyalella azteca* was first described by De Saussure (1858) as *Amphitoe aztecus* from material collected in a ‘cistern’ in the city of Veracruz, Mexico; however, the type locality is currently unknown (Gonzalez and Watling 2002). De Saussure also examined material from streams of Chapultepec Park in Mexico City, and concluded that the two populations belonged to the

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Table 1. Morphological comparison of five new species of genus *Hyalella* from Veracruz and Mexico City (main characters).

| Locality                  | *Hyalella azteca* | *Hyalella sarukhani* sp. nov. | *Hyalella alvarezi* sp. nov. | *Hyalella viviannae* sp. nov. | *Hyalella villalobosi* sp. nov. | *Hyalella garyi* sp. nov. |
|---------------------------|-------------------|-------------------------------|-----------------------------|-------------------------------|-------------------------------|-------------------------|
| Mean total body length (mm) | 7                 | 7.7                           | 4.4                         | 4.9                           | 5.4                           | 4.7                     |
| Micronations              | Present (2)       | Present (2)                   | Present (2)                 | Present (2)                   | Present (2)                   | Present (2)             |
| Maxilla 1 palp distal margin | Rounded          | Present short                 | Present short               | Present with a cylindrical base | Present short                 | Absent Rounded         |
| Maxilla 1 distal setae    | Absent            | Present short                 | Present with a cylindrical base | Present short     | Present short                 | Absent                  |
| Maxilla 1 palp distal margin | Rounded          | Present short                 | Present short               | Present with a cylindrical base | Present short                 | Absent Rounded         |
| Maxilla 1 distal setae    | Absent            | Present short                 | Present with a cylindrical base | Present short     | Present short                 | Absent                  |
| Gnathopod 2 propodus length vs width | 1.5×   | 1.3×                          | 1.3×                        | 1.6×                         | 1.5×                         | 1.5×                    |
| Gnathopod 2 palm excavation | Present wide     | Present wide                  | Present narrow              | Absent (angle step)           | Present wide                  | Present wide           |
| Gnathopod 2 basis polygon pattern | Absent | Absent                      | Present                     | Absent                        | Absent                        | Absent                 |
| Pereopod 7 basis posterior margin setae | 19     | 15                           | 10–12                       | 15                           | 13                            | 8–12                   |
| Pereopod 7 basis lobe, distal margin stout setae | 4      | 2                            | 2–4                         | 2                            | 0                             | 0                      |
| Telson proportion/distal setae | W > L/   | L = W/                       | L = W/                      | L > W/                       | L > W/                       | L > W/                 |
|                           | separated        | separated                    | separated                  | separated                    | separated                    | separated              |

Abbreviations: W = width; L = length.
same species, distinguished by the presence of two dorsal mucronations over the pleon (De Saussure 1858). Unfortunately, the type material from Chapultepec was poorly preserved, and probably lost (Gonzalez and Watling 2002). Later, Pearse (1911) described a species from material collected from Lake Catemaco in the state of Veracruz; this species is differentiated by the presence of four distal setae over the inner plate in maxilla 1, instead of two as in H. azteca. On the other hand, Shoemaker (1933) recognised this characteristic as an intraspecific variation and synonymised the two species (among others) under the name H. azteca. Afterwards, Gonzalez and Watling (2002) also considered the species described by Pearse (1911) to be a valid synonym of H. azteca. The taxonomic history of H. azteca is complex because several authors described numerous species in the genus that were synonymised later under the same nominal species H. azteca (Gonzalez and Watling, 2002).

In this study, we compare the populations of Hyalella from Veracruz and Mexico City, to observe the morphological differences in these locations, the species richness, and attempt to find the type locality of H. azteca. We analysed populations of three localities in Mexico City: Chapultepec (centre), Xochimilco (South) and Chalco (Southwest) (Figure 1a); these are now artificial lakes but, in the past, they were all part of the former Lake Texcoco. We also collected samples from three lakes in the state of Veracruz: Lake San Julian (near the former Veracruz City), Lake Catemaco (one of the larger lakes in the country and the biggest in Veracruz), and Lake La Encantada (due to its proximity to Lake Catemaco) (Figure 1b–c).

**Materials and methods**

The material was collected with a fine mesh net (250 µm) on aquatic vegetation, fixed with ethanol 99%, and storage with ice for future molecular studies. The collections in Veracruz
localities occurred during the summer of 2015 and the collections in Mexico City were made during the spring and summer of 2016.

The anatomical pieces were dissected under a stereo microscope using fine needles; semi-permanent slides were mounted in glycerol and permanent slides were sealed with Entellan®, a synthetic resin. Specialised keys and literature were used for identification at the genus level (Bousfield 1996; LeCroy 2000; Soucek et al. 2015), and compared with original descriptions of species in the genus and the lectotype of Hyalella azteca. The terminology used for the setae follows Zimmer et al. (2009). The characters that differ within descriptions are highlighted in bold. Drawings were made with digital methods following Coleman (2003), using digital photos, and then traced in Adobe Illustrator (version 24.0) with a digital drawing tablet (Wacom Intuos). Measurements were taken using digital images from the stereoscope and optical microscope with ImageJ software; total body length was taken from the head to base of telson following Gonzalez and Watling (2002). Morphological description includes the intraspecific variations.

Type material was deposited in the Colección Nacional de Crustáceos, Instituto de Biología, Universidad Nacional Autónoma de Mexico (UNAM).

Scanning electron microscopy (SEM) images were taken from paratypes (one female and one male) with a Hitachi SU1510 scanning electron microscope from the Laboratory of Microscopy and Photography of Biodiversity I, at the Instituto de Biología, UNAM.

**Taxonomy**

Order **AMPHIPODA** Latreille, 1816

Family **HYALELLIDAE** Bulycheva, 1957

Genus **Hyalella** Smith, 1874

**Hyalella sarukhani** sp. nov.

http://www.zoobank.org/urn:lsid:zoobank.org:act:7B0E06D1-9F55-4345-9055-9054F8B9B450

(Figures 2–4)

**Etymology.** The new species is named in honour of Dr José Sarukhán in recognition of his outstanding contribution to the study of the biodiversity of Mexico.

**Material examined.** Holotype male, size 7.7 mm (Cat. No. CNCR 35726), from Lake Chapultepec (19.424°N, 99.187°W), 10 August 2016, 2253 m a.s.l. collector: A. Marrón-Becerra. Paratypes (n = 10 males, n = 10 females): males – mean size 6.4 ± 0.5 mm, mean head length: 0.6 ± 0.03 mm (n = 10), females – mean size 6.2 ± 0.4 mm, mean head length 0.5 ± 0.04 (n = 10) (permanent slides Cat. No. CNCR 35731, paratypes and SEM preparations Cat. No. CNCR 35732), locality same as holotype. Other material revised Xochimilco (19.264°N, 99.094°W), 10 August 2016, 2240 m a.s.l., collector A. Marrón-Becerra (Cat. No. CNCR 35733). Lake Chalco, Mexico City (19.264°N,
98.974°W), 29 March 2016, 2231 m a.s.l., temp. 24°C, pH 8.7, conductivity 1793 µS/cm, dissolved oxygen 2.8 mg/L, collectors: A. Marrón-Becerra and F. Charqueño-Celis (Cat. No. CNCR 35734).

**Type locality (Figure 1a).** Lake Chapultepec, Mexico City, Mexico (19.424°N, 99.187°W).

**Diagnosis.** Pleonite 1 and 2 with dorsoposterior carina. Coxa 4 excavated posteriorly. Eyes pigmented. Antenna 1 shorter than antenna 2. Antenna 2 less than half body length. Maxilla 1 palp short, reaching less than half of length between base of palp and tip of setae in outer plate, with 1 short stout distal seta and setules; inner plate slender with 2–3 strong pappose distal setae. Maxilla 2 inner plate with 2 strong pappose setae on inner margin. Gnathopod 1, propodus hammer shaped, palm slope transverse, inner face with 5–6 serrate setae, comb scales on distoposterior and distoanterior border, carpus inner face lobe with 5 serrate setae. Gnathopod 2, basis hind margin with 3–5 setae, merus with 1 medial seta, excavation of palm wide. Uropods without curved setae. Uropod 3, peduncle and ramus subequal in length, styliform. Telson slightly wider than long, distal margin rounded with 2 long simple setae widely separated. Coxal gills on segments 2–6. Sternal gills on segments 3–7.

**Description of male**

**Body** (Figures 2a, and 17a), tergites of pleon 1 and 2 with dorsoposterior carina. Epimeral plates 1–3 acuminate. Coxae 1–3 (Figures 2a, and 17a) subequal in shape, subrectangular, longer than wide; coxa 4 wider than coxae 1–3, with deep posterior excavation; acumination absent; coxa 5 with two subequal lobes, anterior lobe slightly shorter than posterior, coxa 6 anterior lobe reduced.

**Head** typically gammaridean (Figures 2a, and 17a), shorter than first two thoracic segments, reaching to middle of second pereonite, rostrum absent. Eyes pigmented, black, medium, rounded, located between insertions of antennae 1 and 2.

**Antenna 1** (Figure 2a–b) less than half the body length, shorter than antenna 2, but longer than peduncle of antenna 2, almost reaching to middle of third pereonite; peduncle as long as head; article 1 and 2 subequal in length, article 1 wider than articles 2–3, article 2 longer and wider than article 3, (proportions 1.8:1.6:1), article 1 with 2 short cuspitate setae ventrally, 1 smaller, and one cluster with 3 cuspitate setae at distal end; flagellum longer than peduncle with 9–10 articles gradually shorter towards distal portion; aesthetascs present on articles 4–7 (one pair), and 8–9 (one aesthetasc).

**Antenna 2** (Figure 2a, c) almost 1.3 times longer than antenna 1, slightly shorter than one-third body length, reaching fourth pereonite; peduncle almost reaching to middle of first pereonite, peduncle articles increase gradually in length and decrease in width; article 3 shorter but wider than 4 and 5, article 4 slightly longer than article 3, article 5 longer than article 4 (almost 1.5 times); flagellum with 11–12 articles, longer than peduncle (almost 1.5 times); without aesthetascs.

**Buccal parts:** upper lip (Figure 2f) distal margin rounded, with numerous setules.
Lower lip (Figure 2g), subquadrate, outer lobes without notches or excavations; mandibular projection of outer lobes rounded.

Mandibles (Figure 2h–i) without palp, asymmetric. Incisor toothed, 6 teeth present. Left lacinia mobilis with 5 teeth; setal row on left mandible with 3 main pappose setae plus accessory setae. Right mandible with 6 teeth, right lacinia mobilis reduced, with 2 pairs of asymmetric L-shaped teeth; setal row on right mandible with 2 main pappose setae plus accessory setae and with setulæ near molar process. Both molar processes large, cylindrical and triturative, with accessory pappose setae.

Maxilla 1 (Figures 2d, and 19b), palp short, uniarticulate, longer than wide, distally pointed with 1 short and stout distal seta, setules present; palp length almost half of distance between base of palp and base of seta on outer plate, but less than half distance between base of palp and tip of seta on outer plate (Figures 2d, and 19b); inner plate slender, shorter than outer plate, with 2–3 pappose distal setae; outer plate with 9 stout serrate setae and with setules.

Maxilla 2 (Figure 2e) plates subequal; inner plate shorter and slender, with 2 pappose setae on mid-distal margin, and with 7 shorter serrulate setae on distal margin; outer and inner plates with large simple distal setae (type A2) and abundant setules on both distal surfaces and margins.

Maxilliped (Figures 2j, and 20b) inner plate lobe longer than outer plate lobe; distal margin slightly convex, on both plates; inner plate distal margin with 3 cuspidate setae of equal size and with plumose setae, inner margin with several pappose setae; outer plate, inner and distal margins with numerous simple setae. Palp composed of four articles subequal in maximum length; first article with 3 simple setae at inner distal end and 1 seta at outer distal end; second article with numerous simple setae on inner margin and 3 on outer distal end; third article with several setae on distal margin, distal end of outer margin with 3 simple setae and comb scales, inner margin with at least 12 setae and 6 at distal end; fourth article ungualiform, longer than nail, with comb scales; nail almost reaching 2/3 of fourth article, with serration at distal half.

Gnathopod 1 (Figure 3a) subchelate, hammer shaped. Basis elongated, maximum length almost 3.5 times longer than maximum width; posterior margin with 1 seta, distal end with one cluster of 2 setae. Ischium short, subquadrate, distal posterior end with 2 clusters of 2 setae. Merus longer than wide, almost distal half of length of ventral surface with comb scales; distal margin with 5–6 setae. Carpus longer than wide, longer and slightly wider than propodus; with strong, short, and wide posterior lobe forming one scoop-like structure open to inside; inner surface with 5–6 serrate setae, Propodus 1.5 times longer than wide; inner surface near distal margin with 5–6 serrate setae in one row; distal anterior end with two clusters of approximately 5 setae; distal anterior and posterior surfaces with comb scales; palm transverse, posterior distal end with 1 robust seta and cup for dactylus. Dactylus claw-like; nail present; with 1 plumose seta, and comb scales.

Gnathopod 2 (Figures 3b, and 21b) subchelate; palm slightly oblique. Basis elongate, more than 3 times longer than wide; posterior margin with 3–5 long setae. Ischium short, subquadrate, shorter than merus. Merus short; posterior margin with 1 seta and distal end of posterior margin with 8 simple setae; posterior inner and outer surfaces with comb
scales. Carpus shorter than propodus; anterodistal end with 3 setae; posterior lobe scooped-like, elongate, with several submarginal pappose setae and comb scales. Propodus robust, length **slightly less than 1.5 times** maximum wide, subrectangular; palm slightly shorter than posterior margin; slope slightly irregular, with several long simple setae, and few short and medium setae; distal margin of palm with one truncated process near insertion.
of dactylus and with one wide posterior excavation at base (Figure 22b); palm posterior distal end with 2 strong setae, comb scales and cup for dactylus. Dactylus claw-like, congruent with palm, without comb scales; outer margin with 1 plumose seta; inner margin crenulate with separated setules.

**Pereopods 3–7 (Figure 3e–i)** simple, gradually longer posteriorly. Pereopod 5 shorter than 4 and 6.

**Pereopod 3 (Figure 3e)**, basis elongate; mid-posterior margin with 1–2 simple setae. Merus longer than ischium (almost 3 times the maximum length); anterior margin with 2 setae; posterior margin with 6 setae; anterodistal and posterodistal ends each with one cluster of 4–5 setae, lobe less than one-fourth length of carpus. Carpus shorter and slenderer than merus; posterior margin with 5 stout setae plus accessory setae; posterodistal end with at least 5 slender setae; anterodistal end with at least 2 setae. Propodus shorter than anterior margin of merus, slenderer than carpus; posterior margin with 7 stout setae; anterodistal end with 5 simple setae. Dactylus claw-like, length slightly overreaching half of propodus; nail present.

**Pereopod 4 (Figure 3f)** similar in shape to pereopod 3 but slightly longer; coxa 4 wider than coxa 3 with posterior excavation; basis posterior margin with 1–2 simple setae; merus mid-anterior margin without setae; propodus posterior margin with 6 setae.

**Pereopods 5–7 (Figure 3g–i)** similar in shape; basis posterior lobe rounded and denticulated. Pereopod 7 (Figure 3i) basis lobe widely expanded, almost reaching ischium distal margin; wider than lobes of pereopods 5 and 6; basis lobe, width almost 1.5 times as wide as basis (measured at cleft between basis and basis lobe); posterior margin with 19 serrations, each with 1 setule (17) but 2 serrations with 1 stout seta on distal margin; anterior margin with two clusters of 2 stout setae on distal half and 1 at distal end. Dactylus length almost half of propodus length.

**Pleopods 1–3 (Figure 4e)** not modified, biramous, elongated, rami multi-annulated, with numerous plumose setae; pleopod 1, inner margin of peduncle at distal end with 2 short retinacula (coupling hooks).

**Uropod 1 (Figure 4a)** longer than uropod 2 (Figure 4b); peduncle longer than rami, with 3 dorsal setae, inner and outer distal ends each with 1 seta; rami subequal, inner ramus slightly shorter, with 2 dorsal and 4 distal setae, outer ramus with 3 dorsal and 4 distal setae; male without curved setae on inner ramus.

**Uropod 2 (Figure 4b)** longer than peduncle of uropod 1; peduncle as long as rami, with 2 dorsal setae and 2 additional distal setae; rami subequal, inner ramus slightly longer, with 2–3 dorsal and 4 distal setae, outer ramus with 3 dorsal and 5 distal setae.

**Uropod 3 (Figures 4c, and 23b)** slightly shorter than peduncle of uropod 2; peduncle rectangular, wider than ramus with 5 strong distal setae of variable length; inner ramus absent; outer ramus uniarticulate, slender, slightly shorter than peduncle, 2 times the length of larger seta of peduncle, basal width near 2 times width of apex of ramus, with 3 slender apical setae and 1 connate seta.
Figure 3. *Hyalella sarukhani* sp. nov. male holotype, 7.7 mm, female paratype 6.2 mm. (a) Male gnathopod 1; (b) male gnathopod 2; (c) female gnathopod 1; (d) female gnathopod 2. Male pereiopods: (e) pereiopod 3; (f) pereiopod 4; (g) pereiopod 5; (h) pereiopod 6; (i) pereiopod 7. Scale bars: 100 µm.
Telson (Figures 4d, and 24b) entire, as long as wide, distal margin rounded with 2 long simple setae widely separated by almost one-third of maximum width of telson; and two lateral clusters of 3 plumose setae symmetrically distributed.

Coxal gills sac-like, present on segments 2–6. Sternal gills tubular, present on segments 3–7.

Female (Figure 17b) similar to male. Gnathopod 1 (Figure 3c), ischium distal half of posterior surface with comb scales; carpus with 3 serrate setae on inner face lobe; propodus with 4–5 serrate setae in row over the inner face. Gnathopod 2 (Figure 3d) smaller than male gnathopod 2, parachelated, palm reverse oblique; basis posterior margin with 2–3 setae; ischium distal half of posterior surface with comb scales; propodus slightly longer than twice maximum width, outer face with 3 serrate setae in one row and 3 large setae near palm, anterior and posterior distal half with comb scales. Pereonite 2 with one anterior excavation or notch for amplexus. Pereopod 7 lobe with 13 serrations and setules, and 2 stout setae on distal margin. Oostegites subtriangular with curled setae on margins.

Intraspecific variation. Gnathopod 2 of male, basis hind margin up to 5 setae (some organisms from Chalco). Pereopod 3 merus posterior margin up to 4 setae (organisms from Chalco).
**Habitat.** freshwater, epigean, littoral, found associated with roots of *Lemna* sp.

**Distribution.** Mexico City, Mexico.

**Remarks**
*Hyalella sarukhani* sp. nov. (from Mexico City) can be easily distinguished from species in the *Hyalella azteca* complex by the telson with rounded distal margin and the presence of 2 long setae wide apart (almost one-third of maximum width of telson). This species has more serrations in the posterior margin of the lobe of pereopod 7 but less stout setae on the distal margin than *H. azteca*. This species bears setules on the palp of maxilla 1, in contrast with *Hyalella wakulla* (Drumm and Knight, 2019). The morphological differences from the other *Hyalella* species described in this work are summarised in Tables S1 and S2 (Table 1).

*Hyalella alvarezi* sp. nov.  
http://www.zoobank.org/urn:lsid:zoobank.org:act:14E267AE-A7D5-4E38-A00A-1CA79136C1FF  
(Figures 5–7)

**Etymology.** The new species is named in honour of Dr Fernando Alvarez Noguera for his important contribution to carcinological study in Mexico.

**Material examined.** Holotype male, size 4.4 mm (Cat. No. CNCR 35727), from Lake La Encantada in state of Veracruz, Mexico (18.458°N, 95.185°W), 24 July 2015, 332 m a.s.l., temp. 30°C, pH 7. Collectors: A. Marrón-Becerra, E. Lemus-Santana and M. Hermoso-Salazar. Paratypes (n = 30 males, n = 30 females): males – mean size 4.4 ± 0.5 mm, mean head length 0.6 ± 0.03 mm (n = 27), females – mean size 4.5 ± 0.5 mm, mean head length 0.5 ± 0.04 (n = 25) (permanent slides Cat. No. CNCR 35735, paratypes and SEM preparations CNCR 35736), locality same as holotype.

**Type locality (Figure 1c).** Lake La Encantada, state of Veracruz, Mexico (18.458°N, 95.185°W).

**Diagnosis.** Pleonite 1 and 2 with **dorsoposterior carina**. Coxa 4 excavated posteriorly. Eyes pigmented. Antenna 1 shorter than antenna 2. Antenna 2 less than half body length. Maxilla 1 palp short, **overreaching** half of length between base of palp and base of setae in outer plate, with 1 **stout distal** seta; base of the seta covered by a **cylindrical structure**, setules present; inner plate slender with 3 strong pappose distal setae. Maxilla 2 inner plate with 2 strong pappose setae on inner margin. Gnathopod 1, propodus hammer shaped, palm slope transverse, inner face with 4 serrate setae, comb scales on distoposterior and distoanterior border, carpus inner lobe with 3–4 serrate setae. Gnathopod 2, basis hind margin with 2 setae and denticles in **polygonal pattern**. Uropods without curved setae. Uropod 3, peduncle and ramus subequal in length, styliform. Telson as long as wide, distal margin **truncated**, with 2 long simple **apposed** setae. Coxal gills on segments 2–6. Sternal gills on segments 3–7.
**Description of male**

**Body** (Figures 5a, and 17c), tergites of pleon 1 and 2 with dorsoposterior carina. **Epimeral plates** 1–3 slightly acuminate. **Coxae** 1–3 (Figures 5a, and 17c) subequal in shape, subrectangular, longer than wide, coxa 4 wider than coxae 1–3 with deep posterior excavation, acumination absent. Coxa 5 with two subequal lobes. Coxa 6 anterior lobe reduced, coxa 7 anterior lobe absent.

**Head** typically gammaridean (Figures 5a, and 17c), smaller than first two thoracic segments, rostrum absent. Eyes pigmented, medium, rounded, located between insertions of antennae 1 and 2.

**Antenna 1** (Figure 5a–b) less than half body length, shorter than antenna 2 (80% length of antenna 2), but longer than peduncle of antenna 2, almost reaching to middle of **third** pereonite; peduncle longer than head, reaching to middle of length of **first** pereonite; article 1 and 2 subequal in length, article 1 wider than articles 2–3, article 2 longer and wider than article 3, proportions (1.3:1.26:1), article 1 with 3 short setae ventrally, 1 smaller, and one cluster with 3 cuspidate setae at distal end, **articles 1–3 mid-ventral margin with slender setae**; flagellum longer than peduncle with 9 articles becoming gradually shorter towards distal portion; aesthetascos on flagellum, present on articles 2–6 (one pair), 7–8 (one).

**Antenna 2** (Figure 5a, c) almost 1.27 times longer than antenna 1, reaching one-third body length, reaching **fourth** pereonite; peduncle reaching **second** pereonite, peduncle articles increase gradually in length and decrease in width; article 3 shorter but wider than 4 and 5, article 4 longer than article 3, article 5 slightly longer than article 4 (almost 1.3 times); flagellum with 8–10 articles, **slightly longer** than peduncle, without aesthetascos.

**Buccal parts**: upper lip (Figure 5f), distal margin rounded with numerous setules.

**Lower lip** (Figure 5g) subquadrate, outer lobes without notches or excavations, mandibular projection of outer lobes rounded.

**Mandibles** (Figure 5h–i), without palp, asymmetric; incisor toothed, 6 teeth present. Left lacinia mobilis with 5 teeth; setal row on left mandible with 3 main pappose setae plus accessory setae. Right mandible with 5 teeth, right lacinia mobilis reduced, with 2 pairs of asymmetric L-shape teeth; setal row on right mandible with 2 main pappose setae plus accessory setae and with setulae near molar process. Molar process large, cylindrical and triturative, with accessory pappose seta in both molars.

**Maxilla 1** (Figures 5d, and 19c), palp short, uniarticulate, longer than wide, distally pointed with 1 short distal stout distal seta (A5 type), with a cylindrical structure near the base that covers almost one-third of distal seta, setules present; palp length slightly exceeds one-half of distance between base of palp and base of seta on outer plate (Figures 5d, and 19c); inner plate slender, shorter than outer plate, with 3 pappose distal setae; outer plate with 9 distal stout serrate setae and with setules.

**Maxilla 2** (Figure 5e) plates subequal; inner plate shorter and slender with 2 pappose setae on mid-distal inner margin, distal margin with abundant setae and 6 serrulate setae; outer plate without serrate setae but with 2 long pappose setae; outer and inner plates
Figure 5. *Hyalella alvarezi* sp. nov. lateral habitus. (a) Male holotype 4.4 mm. (b) Antenna 1; (c) antenna 2. Buccal parts: (d) maxilla 1; (e) maxilla 2; (f) upper lip; (g) lower lip; (h) left mandible; (i) right mandible; (j) maxilliped. Scale bars: 100 µm.
with large simple distal setae (type A2) and abundant setules on both distal surfaces and margins.

Figure 6. *Hyalella alvarezi* sp. nov. male holotype, 4.4 mm; female paratype, 5 mm. (a) Male gnathopod 1; (b) male gnathopod 2; (c) female gnathopod 1; (d) female gnathopod 2. Male pereiopods: (e) pereiopod 3; (f) pereiopod 4; (g) pereiopod 5; (h) pereiopod 6; (i) pereiopod 7. Scale bars: 100 µm.
Maxilliped (Figures 5j, and 20c) inner plate lobe longer than outer plate lobe, distal margin slightly convex, in both plates, inner plate distal margin with 3 cuspidate setae of equal size and with plumose setae, inner margin with several pappose setae; outer plate, inner and distal margins with numerous simple setae. Palp composed of four articles subequal in maximum length, first article with 3 simple setae at inner distal end and without seta on outer distal end; second article with numerous simple setae on inner margin and 3 on the outer distal end; third article with several setae on distal margin, distal end of outer margin with 4 simple setae and comb scales, inner margin with at least 8 setae and at least 5 at distal end; fourth article unguiform slightly longer than nail, with
comb scales, inner margin near distal half with 2 setae, and 1 seta near nail base on outer margin; nail exceeds 2/3 of fourth article, with serration at distal half.

**Gnathopod 1** (Figure 6a) subchelate, hammer shaped. Basis elongated, maximum length almost 3 times longer than maximum width; posterior margin with 1 seta, distal end with one cluster of 2 setae. Ischium short, subquadrate, slightly longer than wide, length almost same as maximum width of basis and maximum length of merus, distal posterior end with one cluster of 4 setae. Merus longer than wide, ventral surface with comb scales, distal margin with 7 setae. Carpus longer than wide, longer than propodus; with strong, short, and wide posterior lobe and forming one scoop-like structure, open to inside; lobe, inner surface with 2–3 serrate setae. Propodus 1.5 times longer than wide, inner surface near distal margin with 3–4 serrate setae (3 in a row), outer surface near half of margin with 1 seta; distal anterior end with two clusters of approximately 8 setae; distal anterior and posterior surfaces with comb scales; palm transverse, posterior distal end with 1 robust seta and cup for dactylus. Dactylus claw-like; nail present; with 1 plumose seta, and comb scales.

**Gnathopod 2** (Figures 6b, and 21c) subchelate; palm slightly oblique. Basis elongate, more than 3 times longer than wide; posterior margin with 1–2 long setae and denticles in polygonal pattern. Ischium short, subquadrate, shorter than merus. Merus short; posterior margin with 1 seta and distal end of posterior margin with 5 simple setae; posterior inner and outer surfaces with comb scales. Carpus shorter than propodus; anterodistal end with 5 setae; posterior lobe scoop-like, elongate, almost 1.5 times width of merus, with several submarginal pappose setae and comb scales. Propodus robust, almost 1.3 times as long as wide, subrectangular, palm slightly shorter than posterior margin; slope slightly irregular, with several long simple setae, and some short and medium setae; distal margin of palm with one truncated process near insertion of dactylus and with narrow posterior excavation at base (Figure 22c); palm posterior distal end with 2 strong setae, comb scales, and cup for the dactylus. Dactylus claw-like, congruent with palm, without comb scales; outer margin with 1 plumose seta; inner margin with setules widely separated, crenulation absent.

**Pereopods 3–7** (Figure 6e–i) simple, gradually longer posteriorly; pereopod 5 shorter than 4 and 6.

**Pereopod 3** (Figure 6e), basis elongate; mid-posterior margin with 1 simple seta. Merus anterior margin with 1 long simple seta; posterior margin with 3 setae; anterodistal and posterodistal end with one cluster of 4 setae. Carpus slightly shorter and slenderer than merus; posterior margin with 4 stout setae plus accessory seta; anterodistal end with at least 5 slender setae, posterodistal end with at least 2 setae. Propodus slenderer than carpus; posterior margin with 4 setae; anterodistal end with 6 simple setae. Dactylus claw-like, length less than half of propodus; nail present.

**Pereopod 4** (Figure 6f) similar in shape to pereopod 3 but slightly longer, coxa 4 wider than coxa 3 with posterior excavation; basis posterior margin with 1 simple seta; merus mid anterior margin with 1 stout setae; propodus posterior margin with 3–5 setae.

**Pereopods 5–7** (Figure 6g–i) similar in shape, basis posterior lobe rounded and denticulated; pereopod 7 (Figure 6i) basis lobe widely expanded, almost reaching ischium distal
margin; wider than lobes in pereopods 5 and 6; basis lobe width as wide as **1.5 times** the basis (measured at cleft between basis and basis lobe); posterior margin with **10–12** serrations, each with 1 setule but **2–4 serrations with 1 stout seta** on distal margin; anterior margin with three clusters of 2 stout setae and one cluster of 2 setae at distal end. Dactylus length **less than half** of propodus length.

**Pleopods** 1–3 (**Figure 7e**) not modified, biramous, elongated, rami multi-annulated, with numerous plumose setae; pleopod 1, inner margin of peduncle at distal end with 2 short retinacula (coupling hooks).

**Uropod 1** (**Figure 7a**) longer than uropod 2 (**Figure 7b**); peduncle longer than rami, dorsal margin with 2 setae; inner and outer distal ends each with 1 seta; rami subequal, inner ramus slightly **longer**, with 2 dorsal and 4 distal setae, outer ramus with 2 dorsal and 4 distal setae; male without curved setae on inner ramus.

**Uropod 2** (**Figure 7b**) **as long as** peduncle of uropod 1; **peduncle slightly longer than outer rami**, with 1 dorsal seta, inner and outer distal ends each with 1 seta; rami subequal; inner ramus slightly longer with 2 dorsal and 3 distal setae; outer ramus with 2 dorsal and 4 distal setae.

**Uropod 3** (**Figures 7c, and 23c**) peduncle rectangular, wider than ramus, with 5 strong distal setae of variable length; inner ramus absent; outer ramus uniarticulate, slender, slightly shorter than peduncle, with 4 slender apical setae and 1 connate seta.

**Telson** (**Figures 7d, and 24c**) entire, as long as wide, distal margin pointed, with **2 long simple setae apposed**; two clusters of **3 plumose setae** symmetrically distributed.

**Coxal gills** sac-like, present on segments 2–6 (**Figure 6h**, dotted line). Sternal gills tubular, present on segments 3–7 (**Figure 6h**, dotted line).

**Female** (**Figure 17d**) similar to male. Gnathopod 1 (**Figure 6c**), carpus with 3 serrate setae on the inner face lobe. Propodus with 4 serrate setae in a row over the inner face, and 3 long setae on a row on the outer face. Gnathopod 2 (**Figure 6d**) smaller than male gnathopod 2, parachelated, palm reverse oblique, basis posterior margin with 1 seta; propodus longer than twice maximum width, outer face with **3–4** serrate setae in a row and 1 large seta near the palm, anterior and posterior distal half with comb scales. Pereonite 2 with one anterior excavation or notch for amplexus. Pereopod 7 lobes with 9 serrations and setules, and with 2 stout setae on the distal margin. Oostegites sub-triangular, almost reaching one-half length of merus, with setae curled on the margins.

**Intraspecific variation.** The palp of maxilla 1 is short and varies in length and form in the same organism or if is molting; can reach a maximum length of almost **2 times** width and presents constricted margin in the middle.

**Habitat.** Freshwater, epigean, littoral, associated with *Eichhornia crassipes* (Mart.) Solms.

**Distribution.** Lake La Encantada, state of Veracruz, Mexico (18.458°N, 95.185°W).
Remarks

*Hyalella alvarezi* sp. nov. (La Encantada, Veracruz) shares morphological traits with the other species from Veracruz and with *H. wakulla* from Florida, such as the dorsal micro- nations (except in *H. garyi* sp. nov.), and the telson with 2 distal setae apposed, similar to *H. azteca* s.s. (except in *H. sarukhani* sp. nov., and *H. garyi* sp. nov.). This species can be distinguished primarily by the presence of one cylindrical base covering almost one-third of the distal setae in palp of maxilla 1, the polygonal pattern (denticles) over the surface of basis in male gnathopod 2 (similar to *H. gauchensis* Streck and Castiglioni, 2017, *H. georginae* Streck and Castiglioni, 2017 and *H. rioantensis* Penoni and Bueno, 2020 – i.e. the three from southern Brazil), and one slender excavation in the palm of male gnathopod 2. On the other hand, this species shares morphological characters with *H. sarukhani* sp. nov. (Tables 1, S1–S2).

*Hyalella viviannae* sp. nov.

http://www.zoobank.org/urn:lsid:zoobank.org:act:340959E3-C21D-4170-A8A2-85E21305C032

(Figures 8–10)

**Etymology.** The new species is named in honour of Dra Vivianne Solís-Weiss, in recognition of her studies of marine and estuarine invertebrates in Mexico.

**Material examined.** Holotype male, size 4.9 mm (Cat. No. CNCR 35728) from Lake San Julian, state of Veracruz, Mexico (19.256°N, 96.265°W), 24 July 2015, 5 m.a.s.l., temp. 37°C, pH 7.8. Collectors: A. Marrón-Becerra, E. Lemus-Santana and M. Hermoso-Salazar. Paratypes (n = 30 males, n = 30 females): males – mean size 4.5 ± 0.6 mm (n = 27), mean head length 0.6 ± 0.03 mm (n = 10), females – mean size 4.3 ± 0.4 mm, mean head length 0.6 ± 0.03 (n = 30) (permanent slides Cat. No. CNCR 35737, paratypes and SEM preparations CNCR 35738), locality same as holotype.

**Type locality (Figure 1b).** Lake San Julian, state of Veracruz, Mexico (19.256°N, 96.265°W).

**Diagnosis.** Pleonite 1 and 2 with dorsoposterior carina. Coxa 4 excavated posteriorly. Eyes pigmented. Antenna 1 shorter than antenna 2. Antenna 2 less than half body length. Maxilla 1 palp short, overreaching half of length between base of palp and tip of setae in outer plate, with 1 large stout distal seta and setules; inner plate slender with 3 strong pappose distal setae. Maxilla 2 inner plate with 2 strong pappose setae on inner margin. Gnathopod 1, propodus hammer shaped, palm slope transverse, inner face with 4 serrate setae, comb scales on distoposterior and distoanterior border, carpus inner face lobe with 3 serrate setae. Gnathopod 2, basis hind margin with 2 serrate setae. Uropods without curved setae. Uropod 3, peduncle slightly shorter than ramus, ramus styliform. Telson slightly longer than width, distal margin rounded with 2 long simple apposed setae. Coxal gills on segments 2–6. Sternal gills on segments 3–7.
Description of male

Body (Figures 8a, and 17e), tergites of pleon 1 and 2 with dorsoposterior carina. Epimeral plates 1–3 slightly acuminate. Coxae 1–3 (Figures 8a, and 17e) subequal in shape, subrectangular, longer than wide; coxa 4 wider than coxae 1–3 with deep posterior...
excavation; acumination absent. coxa 5 anterior lobe slightly shorter than posterior; coxa 6 anterior lobe reduced; coxa 7 anterior lobe absent.

Figure 9. *Hyalella vivianna* sp. nov. male holotype, 4.9 mm; female paratype, 4 mm. (a) male gnathopod 1; (b) male gnathopod 2; (c) female gnathopod 1; (d) female gnathopod 2. Male pereiopods: (e) pereiopod 3; (f) pereiopod 4; (g) pereiopod 5; (h) pereiopod 6; (i) pereiopod 7. Scale bars: 100 µm.
Head typically gammaridean (Figures 8a, and 17e), shorter than first two thoracic segments, rostrum absent. Eyes pigmented, medium, rounded, located between insertions of antennae 1 and 2.

Antenna 1 (Figure 8a–b) less than half body length, shorter than antenna 2, but longer than peduncle of antenna 2; peduncle longer than head, almost reaching second pereonite; articles 1 and 2 subequal in length, article 1 wider than articles 2–3, article 2 longer and wider than article 3 (proportions 1.6:1.3:1), article 1 almost reaching half ventral surface with 1 short cuspidate seta and with one cluster with 3 cuspidate setae at ventral-distal end, articles 2–3 without mid-ventral margin setae; flagellum longer than peduncle with 6 articles gradually shorter towards distal portion; aesthetascs present on articles 3–5 (one).

Antenna 2 (Figure 8a, c) almost 1.2 times longer than antenna 1, reaching one-third body length, almost reaching fifth pereonite; peduncle almost reaching the second pereonite, peduncle articles increase gradually in length and decrease in width; article 3

Figure 10. *Hyalella viviannae* sp. nov. male holotype, 4.9 mm: (a) uropod 1; (b) uropod 2; (c) uropod 3; (d) telson; (e) pleopod 1. Scale bars: 100 µm.
shorter but wider than 4 and 5, article 4 slightly longer than article 3, article 5 longer than article 4 (**less than 1.5 times**); flagellum with **7–9** articles, slightly longer than peduncle (almost 1.5 times); without aesthetascs.

**Buccal parts**: upper lip (Figure 8f) distal margin rounded with numerous setules.

**Lower lip (Figure 8g)**, subquadrate, outer lobes without notches or excavations, mandibular projection of outer lobes rounded.

**Mandibles** (Figure 8h–i), without palp, asymmetric. Incisor toothed, **6** teeth present. Left lacinia mobilis with **5** teeth; setal row on left mandible with **3** main pappose setae plus accessory seta. Right mandible with **6** teeth, right lacinia mobilis reduced, with **2** pairs of asymmetric L-shape teeth; setal row on right mandible with **2** main pappose setae plus accessory setae and with setulae near molar process. Both molar processes large, cylindrical and triturative, with accessory pappose setae.

**Maxilla 1** (Figure 8d and 19d), palp uniarticulate, longer than wide, distally pointed with **1** stout distal seta, **seta length reaching one-third** of palp length, **setules present**; palp length almost reach **2/3** of distance between base of palp and base of seta on outer plate, almost half distance between base of palp and tip of seta on outer plate (Figure 8d); inner plate slender, shorter than outer plate with **2–3** pappose distal setae; outer plate with **9** stout distal serrate setae and with setules (Figure 8d).

**Maxilla 2** (Figure 8e) plates subequal; inner plate shorter and slender, with **2** pappose setae on mid-distal margin, and with **7** shorter paposerrate setae; outer and inner plates with large simple distal setae (A2 type) and abundant setules on both distal surfaces and margins.

**Maxilliped** (Figures 8j, and 20d) inner plate lobe longer than outer plate lobe; distal margin slightly convex; inner plate distal margin with **3** cuspidate setae of equal size and with plumose setae, inner margin with several pappose setae; outer plate, inner and distal margins with numerous simple setae. Palp composed of **4** articles subequal in maximum length; first article with **3** simple setae at inner distal end and **1** seta at outer distal end; second article with numerous simple setae on inner margin and **3** on outer distal end; third article with several setae on distal margin, outer margin with **4** simple setae and comb scales, inner margin with **5–6** setae and at least **9** at distal end; fourth article unguiform, longer than nail, with comb scales, inner margin near distal half with **3** setae and **1** near nail base on outer margin; nail **exceeds 2/3** of fourth article, with serration at distal half.

**Gnathopod 1** (Figure 9a) subchelate, hammer shaped. Basis elongated, maximum length almost **3.5 times** longer than maximum width; posterior margin with **1** seta, distal end with **one** cluster of **4** setae. Ischium short, subquadrate; distal posterior end with **two** clusters of **2** setae. Merus longer than wide, ventral surface with comb scales; distal margin with **5** setae. Carpus longer than wide, longer and slightly wider than propodus, with strong, short, and wide posterior lobe, forming one scoop-like structure, open to inside; lobe inner surface with **3** serrate setae. Propodus maximum length **less than 1.5 times** longer than wide; inner surface near distal margin with **4** serrate setae in one row, distal anterior end with **one** cluster of approximately **7** setae, **distal anterior and posterior**
surfaces with comb scales; palm transverse, posterior distal end with 1 robust seta and cup for dactylus. Dactylus claw-like; nail present with 1 plumose seta, and comb scales.

Gnathopod 2 (Figures 9b, and 21d) subchelated; palm slightly oblique. Basis elongate, more than 3 times longer than wide; posterior margin with 1–2 setae. Ischium short, subquadrate, shorter than merus. Merus short, posterior margin with 8 simple setae; distal third of posterior inner and outer surfaces with comb scales. Carpus shorter than propodus; anterodistal end with 3 setae; posterior lobe scoop-like, elongate, with several submarginal pappose setae and comb scales. Propodus robust, length slightly exceeds 1.5 times as long as wide (1.6 times), subrectangular; palm slightly shorter than posterior margin; slope slightly irregular, with several long simple setae, and few and médium setae; inner face with 4 submarginal thinner simple setae; palm, distal margin, with one truncated process near insertion of dactylus, and without posterior excavation at base, angle stepped (Figure 22d); palm, posterior distal end with 2 strong setae, comb scales and cup for the dactylus. Dactylus claw-like, congruent with palm, without comb scales, outer margin proximal third with one plumose seta, inner margin crenulate with separated setae.

Pereopods 3–7 (Figure 9e–i) simple, gradually longer posteriorly. Pereopod 5 shorter than 4 and 6.

Pereopod 3 (Figure 9e), basis elongate, mid-posterior margin with 1 simple seta. Merus; anterior margin with 2 setae; posterior margin with 4 setae, anterodistal end with one cluster of 2 setae and posterodistal end with one cluster of 4–5 setae. Carpus shorter and slenderer than merus; posterior margin with 4 stout setae plus accessory setae; posterodistal end with at least 4 slender setae; anterodistal end with at least 2 setae. Propodus shorter than posterior margin of merus; posterior margin with 4 setae; anterodistal end with 5 simple setae. Dactylus claw-like, length almost half of length of propodus; nail present.

Pereopod 4 (Figure 9f) similar in shape to pereopod 3 but slightly longer; coxa 4 wider than coxa 3 with posterior excavation; basis posterior margin with 1 simple seta; merus mid-anterior margin with 1 seta; propodus posterior margin with 5 stout setae.

Pereopods 5–7 (Figure 9g–i) similar in shape, basis posterior lobe rounded and denticulated. Pereopod 7 (Figure 9i) basis lobe widely expanded, almost reaching ischium distal margin; wider than lobes of pereopods 5 and 6; basis lobe, width almost 1.5 times as width as basis (measured at cleft between basis and basis lobe); posterior margin with 15 serrations, each with 1 setule (13) but 2 serrations with 1 stout seta on distal margin; anterior margin, distal end with three clusters of stout setae on distal half and one cluster of 3 stout setae at distal end. Dactylus length almost half of propodus length.

Pleopods 1–3 (Figure 10e) not modified, biramous, elongated, rami multi-annulated, with numerous plumose setae; pleopod 1, inner margin of peduncle at distal end with 2 short retinacula (coupling hooks).

Uropod 1 (Figure 10a) longer than uropod 2; peduncle longer than rami, dorsal margin with 3 dorsal setae, inner and outer distal ends each with 1 seta; rami subequal, inner
ramus slightly longer, with 2 dorsal and 3 distal setae, outer ramus with 2 dorsal and 4 distal setae; male without curved setae on inner ramus.

Uropod 2 (Figure 10b) slightly longer than peduncle of uropod 1; peduncle as long as outer ramus, with 1 dorsal seta and inner and outer distal ends each with 1 seta; rami subequal, inner ramus slightly longer with 2 dorsal and 3 distal setae, outer ramus with 2 dorsal and 4 distal setae.

Uropod 3 (Figures 10c, and 23d) length similar to peduncle of uropod 2; peduncle rectangular, wider than ramus, with 4 strong distal setae of variable length; inner ramus absent; outer ramus uniarticulate, slender, slightly longer than peduncle, more than 2 times (almost 3 times) length of larger setae of peduncle, basal width near 3 times width of apex of ramus, with 3 slender apical setae and 1 connate seta.

Telson (Figures 10d, and 24d) entire, longer than wide, narrowing posteriorly, with 2 long simple apposed setae; outer surface with two clusters of 3 plumose setae near middle distal portion, near margin, symmetrically distributed.

Coxal gills sac-like, present on segments 2–6. Sternal gills tubular, present on segments 3–7.

Female (Figure 17f) similar to male. Gnathopod 1 (Figure 9c), carpus with 2 serrate setae on inner face lobe; propodus with 3 serrate setae in a row over the inner face. Gnathopod 2 (Figure 9d) smaller than male gnathopod 2, parachelated; palm reverse oblique; basis posterior margin with 1 seta; propodus slightly longer than twice maximum width, outer face with 2 serrate setae in a row and 1 large seta near the palm; anterior and posterior distal half with comb scales. Pereonite 2 with an anterior excava-
tion or notch for amplexus. Pereopod 7 lobes with 10 serrations and setules, and with 3 stout setae on the distal margin. Oostegites subtriangular with setae curled on the margins.

Intraspecific variation. The palp of maxilla 1 is short but presents differences in length and form; especially if the organism is moultling, it could reach almost 2 times its length and present a constricted margin in the middle.

Habitat. Freshwater, epigean, littoral, associated with roots of Typha dominguensis Pers, found in the sediment.

Distribution. Lake San Julian, state of Veracruz, Mexico (19.256°N, 96.265°W).

Remarks

Hyalella viviannae sp. nov. is similar to H. azteca and the other species from state of Veracruz; however, this species can be recognised by the relatively long distal seta in the palp of maxilla 1, the absence of one notch in the palm of gnathopod 2 in males (angle step), the relative length of the ramus in uropod 3 (longer than peduncle), and the form of the telson – longer than wide with 2 apposed setae and the distal margin rounded.)
Hyalella villalobosi sp. nov.

http://www.zoobank.org/urn:lsid:zoobank.org:act:E4237141-1948-4D18-A6F3-7AFB6F5592F8
(Figures 11–13)

Etymology. The new species is named in honour of Dr José Luis Villalobos Hiriart, in recognition of his valuable and outstanding contributions to the marine and freshwater carcinology of Mexico.

Material examined. Holotype male, size 5.4 mm (Cat. No. CNCR 35729), from Lake Catemaco in state of Veracruz, Mexico (18.366°N, 95.084°W), 24 July 2015, 337 m a.s.l., temp. 34°C, pH 7. Collectors: A. Marrón-Becerra, E. Lemus-Santana and M. Hermos-Salazar. Paratypes (n = 30 males, n = 30 females): males – mean body total length 5.1 ± 0.5 mm, mean head length 0.6 ± 0.03 mm (n = 27), females – mean body total length 4.5 ± 0.5 mm, mean head length 0.5 ± 0.04 (n = 30) (permanent slides Cat. No. CNCR 35739, paratypes and SEM preparations CNCR 35740), locality same as holotype.

Type locality (Figure 1). Lake Catemaco, state of Veracruz, Mexico (18.366°N, 95.084°W).

Diagnosis. Pleonite 1 and 2 with dorsoposterior carina. Coxa 4 excavated posteriorly. Eyes pigmented. Antenna 1 shorter than antenna 2. Antenna 2 less than half body length. Maxilla 1 palp short, overreaching half of length between base of palp and base of setae in outer plate, with 1 short stout distal seta and setules; inner plate slender with 3 strong pappose distal setae. Maxilla 2 inner plate with 2 strong pappose setae on inner margin. Gnathopod 1, propodus hammer shaped, palm slope transverse, inner face with 2 pappose setae, comb scales on distosteposterior and distoanterior border, carpus inner face lobe with 5 pappose setae. Gnathopod 2, basis hind margin with 1 medial seta, excavation of palm wide. Uropods without curved setae. Uropod 3, peduncle longer than ramus, styliform. Telson as long as wide, distal margin acute, with 2 long simple apposed setae. Coxal gills on segments 2–6. Sternal gills on segments 3–7.

Description

Body (Figures 11a, and 18a), tergites of pleon 1 and 2 with dorsoposterior carina. Epimeral plates 1–3 slightly acuminate. Coxae 1–3 (Figures 11a, and 18a) subequal in shape, subrectangular, longer than wide; coxa 1 shorter than coxae 2–3; coxa 4 wider than coxae 1–3 with deep posterior excavation, acumination absent; coxa 5 with two subequal lobes, anterior lobe slightly shorter than posterior; coxa 6 anterior lobe reduced; coxa 7 anterior lobe absent.

Head typically gammaridean (Figures 11a, and 18a), shorter than first two thoracic segments, rostrum absent. Eyes pigmented, medium, rounded, located between insertions of antennae 1 and 2.

Antenna 1 (Figure 11a–b) less than half the body length, shorter than antenna 2, but longer than peduncle of antenna 2, almost reaching to middle of third pereonite;
peduncle longer than head, reaching to middle of length of first pereonite; article 1 and 2 subequal in length, article 1 wider than articles 2–3, article 2 longer and wider than article 3, proportions (1.3:1.26:1), article 1 with 3 short setae, 1 smaller, and one cluster with 3 cuspidate setae ventrally at distal end, articles 1–3 mid-ventral margin with slender setae; flagellum longer than peduncle with 9 articles gradually shorter towards distal portion; aesthetascs on flagellum, present on articles 2–6 (one pair), 7–8 (one).

**Antenna 2** (Figure 11a, c) almost 1.27 times longer than antenna 1, reaching one-third body length, reaching fourth pereonite; peduncle reaching second pereonite, peduncle articles increase gradually in length and decrease in width; article 3 shorter but wider than 4 and 5, article 4 longer than article 3, article 5 slightly longer than article 4; flagellum with 8–10 articles slightly longer than peduncle (subequal), without aesthetascs.

**Buccal parts:** upper lip (Figure 11f), distal margin rounded with numerous setules.

**Lower lip** (Figure 11g) subquadrate, outer lobes without notches or excavations; mandibular projection of outer lobes rounded.

**Mandibles** (Figure 11h–i) without palp, asymmetric. Incisor toothed, 6 teeth present. Left lacinia mobilis, with 5 teeth; setal row on left mandible with 3 main pappose setae plus accessory setae. Right mandible with 6 teeth, right lacinia mobilis reduced than left, with 2 pairs of asymmetric L-shape teeth; setal row on right mandible with 2 main pappose setae plus accessory setae and with setulae near molar process. Both molar processes large, cylindrical and triturative, with accessory pappose setae.

**Maxilla 1** (Figures 11d, and 19e), palp vestigial, uniarticulate, longer than wide, distally pointed and with 1 distal stout distal seta (A5 type), setules present; palp length over-reaches half of the distance between base of palp and base of seta on outer plate, or reaching to middle; inner plate slender, shorter than outer plate, with 3–4 pappose distal setae (2 distal and 2 subdistal); outer plate with 9 distal stout serrate setae and with setules.

**Maxilla 2** (Figure 11e) plates subequal; inner plate shorter and slender with 2 pappose setae on mid-distal inner margin, and with 6 serrulate setae on distal margin; outer plate without serrate setae but with 2 long pappose setae; outer and inner plates with abundant large simple setae (type A2) and setules on both distal surfaces and margins.

**Maxilliped** (Figures 11j, and 20e) inner plate lobe longer than outer plate lobe; distal margin slightly convex; inner plate distal margin with 3 cuspidate setae of equal size and with plumose setae, inner margin with several pappose setae; outer plate, inner and distal margins with numerous simple setae. Palp composed of four articles subequal in maximum length; first article with 2 simple setae at the inner distal end and 1 seta at outer distal end; second article with numerous simple setae on inner margin and 1 on outer distal end; third article with several long setae on distal margin, outer margin with 1 simple seta and comb scales, inner margin with 5 setae and 5 at distal end; fourth article unguiform slightly longer than nail, with comb scales, inner margin near distal half with 3 setae, and 2 setae near nail base on outer margin; nail exceeds two-thirds of fourth article, with serration at distal half.
Gnathopod 1 (Figure 12a) subchelate, hammer shaped. Basis elongated, maximum length almost 3 times longer than maximum width posterior margin with 2 setae, distal end without cluster of setae. Ischium short, subquadrate; distal posterior end with one cluster of 2 setae. Merus longer than wide, ventral surface with comb scales; distal margin
with 8 setae. Carpus longer than wide, longer than propodus; with strong, short, and wide posterior lobe forming one scoop-like structure open to inside; inner surface with 5 serrate setae. Propodus less than 1.5 times longer than wide (1.36 times); inner surface near distal margin with 2 serrate setae in one row, distal anterior end with 2 clusters of approximately 8 setae; distal anterior and posterior surfaces with comb scales; palm transverse, posterior distal end with 1 robust seta and cup for dactylus. Dactylus claw-like; nail present; with 1 plumose seta, with comb scales.

Gnathopod 2 (Figures 12b, and 21e) subchelated; palm slightly oblique. Basis elongate, more than 3 times longer than wide; posterior margin with 0–1 medial seta. Ischium short, subquadrate, shorter than merus. Merus short, posterior margin with 8 simple setae, posterior inner and outer surfaces with comb scales. Carpus shorter than propodus; anterodistal end with 6 setae; posterior lobe scoop-like, elongate, length similar to merus maximum length, almost 1.5 times width of merus, with several submarginal pappose setae and comb scales. Propodus robust, almost 1.5 times as long as wide, subrectangular; palm similar length to or slightly longer than posterior margin; slope slightly irregular, with several long simple setae, and some short and medium setae; distal margin of palm with one truncated process near insertion of dactylus, and with wide posterior excavation at base (Figure 22e); palm posterior distal end with 2 strong setae, comb scales and cup for the dactylus. Dactylus claw-like, congruent with palm without comb scales; outer margin with 1 plumose seta; inner margin crenulated, with setules.

Pereopods 3–7 (Figure 12e–i) simple, gradually longer posteriorly. Pereopod 5 slightly shorter than 4 and 6.

Pereopod 3 (Figure 12e) basis elongate; mid-posterior margin without simple seta. Merus anterior margin almost at half with 1 seta; posterior margin with 3 long simple setae; anterodistal and posterodistal ends with one cluster of 4 and 7 setae, respectively. Carpus slightly shorter and slenderer than merus; posterior margin with 2 stout setae plus accessory setae; posterodistal end with at least 7 slender setae, anterodistal end with at least 6 setae. Propodus, slenderer than carpus; posterior margin with 3 stout setae; anterodistal end with 5 simple setae. Dactylus claw-like; length less than half of propodus; nail present.

Pereopod 4 (Figure 12f) similar in shape to pereopod 3 but slightly longer; coxa 4 wider than coxa 3 with posterior excavation; basis posterior margin without simple seta; merus mid-anterior margin without setae; propodus posterior margin with 3 stout setae.

Pereopods 5–7 (Figure 12g–i) similar in shape; basis posterior lobe rounded and denticulated. Pereopod 7 (Figure 12i) basis lobe widely expanded, overreaching ischium distal margin; basis lobe width 1.7 times as wide as basis (measured at cleft between basis and basis lobe); posterior margin with 13 serrations with setules and without stout seta on distal margin; anterior margin with 2 stout setae and one cluster of 2 setae at distal end. Dactylus length almost one-third of propodus length.

Pleopods 1–3 (Figure 13e) not modified, biramous, elongated, rami multi-annulated, with numerous plumose setae; pleopod 1, inner margin of peduncle at distal end with 2 short retinacula (coupling hooks).
Figure 12. *Hyalella villalobosi* sp. nov. male holotype, 5.4 mm; female paratype, 5.5 mm. (a) male gnathopod 1; (b) male gnathopod 2; (c) female gnathopod 1; (d) female gnathopod 2. Male pereiopods: (e) pereiopod 3; (f) pereiopod 4; (g) pereiopod 5; (h) pereiopod 6; (i) pereiopod 7. Scale bars: 100 μm.
Uropod 1 (Figure 13a) longer than uropod 2; peduncle longer than rami, dorsal margin with 2 dorsal setae, inner and outer distal ends each with 1 seta; rami subequal, inner ramus slightly longer, with 2 dorsal and 5 distal setae; outer ramus with 2 dorsal and 3 distal setae; male without curved setae on inner ramus.

Uropod 2 (Figure 13b) as long as peduncle of uropod 1; peduncle shorter than outer rami, with 1 dorsal seta and 1 seta at distal end; rami subequal, inner ramus slightly longer with 2 dorsal and 6 distal setae, outer ramus with 2 dorsal and 4 distal setae.

Uropod 3 (Figures 13c, and 23e) slightly longer than or as long as peduncle of uropod 2; peduncle rectangular, wider than ramus, with 5 strong distal setae of variable length; inner ramus absent; outer ramus uniarticulate, slender, slightly shorter than peduncle; basal width

**Figure 13.** *Hyalella villalobosi* sp. nov. male holotype, 5.4 mm. (a) Uropod 1; (b) uropod 2; (c) uropod 3; (d) telson; (e) pleopod 1. Scale bars: 100 µm.
almost 3 times width of apex of ramus, with 3 slender apical setae (one longer) and 1 connate seta.

**Telson** (Figures 13d, and 24e) entire, longer than wide, distal margin pointed or truncated, with 2 long simple apposed setae; outer surface bearing two clusters of 3 plumose setae, near margin, symmetrically distributed.

**Coxal gills** sac-like, present on segments 2–6. Sternal gills tubular, present on segments 3–7.

**Female** (Figure 18b) similar to male. Gnathopod 1 (Figure 12c), carpus with 7 serrate setae on inner face lobe; propodus with 4 serrate setae in row over inner face. Gnathopod 2 (Figure 12d) smaller than male gnathopod 2, parachelated, palm reverse oblique, basis posterior margin without seta; propodus longer than twice maximum width, inner face with 4 serrate setae in a row and 1 simple seta, outer face with 4 setae in one row and 3 large setae near palm, anterior and posterior distal half with comb scales. Pereonite 2 with anterior excavation or notch for amplexus. Pereopod 7 lobes with 11 serrations and setules, and without stout setae on distal margin. Oostegites subtriangular with curled setae on margins.

**Habitat.** Freshwater, epigean, littoral, associated with sediment and *Eichhornia crassipes* (Mart.) Solms.

**Distribution.** Lake Catemaco, state of Veracruz, Mexico (18.366°N, 95.084°W).

**Remarks**
This species has parasites of the genus *Lagenophrys*, possibly *Lagenophrys patina* (Stokes, 1887); they are abundant in the coxae and the basis of pereopods; the protozoos are even attached to the setae.

This species is morphologically similar to *H. azteca*, with two dorsal mucronations on the pleon and the telson with the distal margin acute with 2 distal apposed setae. But this species differs in the following: telson is longer than wider, isquium is longer than its width, uropod 2 is similar in length to peduncle of uropod 1, peduncle is shorter than ramus in uropod 2, and this species has more articles in the antennae despite its shorter size (Tables 1, S1).

**Hyalella garyi** sp. nov.

http://www.zoobank.org/urn:lsid:zoobank.org:act:3B63AA3A-852D-4852-92C0-4829136EEE1E

(Figures 14–16)

**Etymology.** The new species is named in honour of Dr Gary A. Wellbon for his valuable contributions to the knowledge of the *Hyalella* genus.

**Material examined.** Holotype male, size 4.7 mm (Cat. No. CNCR 35730), from Lake Catemaco, state of Veracruz, Mexico (18.366°N, 95.084°W), 24 July 2015, 335 m a.s.l.,
temp. 34°C, pH 7. Collectors: A. Marrón-Becerra, E. Lemus-Santana and M. Hermoso-Salazar. Paratypes (n = 30 males, n = 30 females): males – mean size 4.8 ± 0.6 mm, mean head length 0.5 ± 0.1 mm (n = 27), females – mean size 4.5 ± 0.2 mm, mean head length 0.5 ± 0.06 (n = 27) (permanent slides Cat. No. CNCR 35741, paratypes and SEM preparations CNCR 35742), locality same as holotype.

**Type locality (Figure 1).** Lake Catemaco, state of Veracruz, Mexico (18.366°N, 95.084°W).

**Diagnosis.** Pleonite 1 and 2 without dorsoposterior carina. Coxa 4 excavated posteriorly. Eyes pigmented. Antenna 1 shorter than antenna 2. Antenna 2 less than half body length. Maxilla 1 palp short, reaching less than half of length between base of palp and base of setae in outer plate, without distal seta, setules present; inner plate slender with 3 strong pappose distal setae. Maxilla 2 inner plate with 2 strong pappose setae on inner margin. Gnathopod 1, propodus hammer shaped, palm slope transverse, inner face with 3 serrate setae, comb scales distoposterior and distoanterior border, carpus inner face lobe with 3 serrate setae. Gnathopod 2, basis hind margin without setae. Uropods without curved setae. Uropod 3, peduncle and ramus subequal in length, styliform. Telson as long as wide, distal margin pointed or truncated, with 2 long simple apposed setae. Coxal gills on segments 2–6. Sternal gills on segments 3–7.

**Description of male**

**Body** (Figures 14a, and 18c, e), tergites of pleon 1 and 2 without dorsoposterior carina. **Epimeral plates** 1–3 slightly acuminate. **Coxae** 1–3 (Figures 14a, and 18c) subequal in shape, subrectangular, longer than wide; coxa 4 wider than coxae 1–3 with deep posterior excavation; acumination absent. Coxa 5 with two subequal lobes, anterior lobe slightly shorter than posterior, anterior lobe reduced; coxa 7 anterior lobe absent.

**Head** typically gammaridean (Figures 14a, and 18c), shorter than length of first two thoracic segments, rostrum absent. Eyes pigmented, medium, rounded, located between insertions of antennae 1 and 2.

**Antenna 1** (Figure 14a–b) less than half body length, shorter than antennae 2, but longer than peduncle of antenna 2, almost reaching to middle of third pleonite; peduncle longer than head, reaching half the length of first pleonite; articles 1 and 2 subequal in length, article 1 wider than articles 2–3, article 2 longer and wider than article 3 (1.1:1.2:1), article 1 with 3 short setae ventrally, 1 smaller, and one cluster with 3 cuspidate setae at distal end, articles 1–3 mid-ventral margin with slender setae; flagellum slightly longer than peduncle with 8–9 articles gradually shorter towards distal portion; aesthetascs present on articles 2–6 (one pair), 7–8 (one).

**Antenna 2** (Figure 14a, c) almost 1.27 times longer than antenna 1, reaching one-third body length, reaching the fourth pleonite; peduncle articles increase gradually in length and decrease in width; article 3 shorter but wider than 4 and 5, article 4 longer than article 3, article 5 slightly longer than article 4; flagellum with 8–10 articles, slightly longer than peduncle; without aesthetascs.

**Buccal parts:** upper lip (Figure 14f), distal margin rounded with numerous setules.
Lower lip (Figure 14g) subquadrate, outer lobes without notches or excavations, mandibular projection of outer lobes rounded.

Mandibles (Figure 14h–i) without palp, asymmetric. Incisor toothed, 6 teeth present. Left lacinia mobilis with 5 teeth; setal row on left mandible with 3 main pappose setae plus accessory setae. Right mandible with 6 teeth, right lacinia mobilis more reduced than left, with 2 pairs of asymmetric L-shaped teeth; setal row on right mandible with 2 main pappose setae plus accessory setae and with setulae near the molar process. Both molar processes large, cylindrical and triturative, with accessory pappose setae.

Maxilla 1 (Figures 14d, and 19f), palp short, vestigial, uniarticulate, longer than wide, distally rounded, setules present, without stout distal seta (A5 type); palp length no more than one-third of distance between base of palp and base of setae on outer plate; inner plate slender, shorter than outer plate, with 3 pappose distal setae (2 distal and 1–2 subdistal); outer plate with 9 distal stout serrate setae and with setules.

Maxilla 2 (Figure 14e) plates subequal; inner plate shorter and slender, with 2 pappose setae on mid-distal inner margin, without serrulate setae on distal margin; outer plate without serrulate setae but with 2 long pappose setae; outer and inner plates with large simple setae (A2 type), and setules on both distal surfaces and margins.

Maxilliped (Figures 14j, and 20f) inner plate lobe longer than outer plate lobe; distal margin slightly convex; inner plate distal margin with 3 cuspidate setae of equal size and with plumose setae; inner margin with several pappose setae; outer plate, inner and distal margins with numerous simple setae. Palp composed of four articles subequal in maximum length; first article with 6 simple setae at inner distal end and 1 seta at outer distal end; second article with numerous simple setae on inner margin and 1 on outer distal end; third article with several long simple setae, distal end of outer margin with 1 simple seta and comb scales, inner margin with 5 setae and 5 at distal end; fourth article unguiform, slightly longer than the nail, with comb scales, inner margin near distal half with 4 setae and 2 near nail base on outer margin; nail exceeds 2/3 of fourth article, with serration at distal half.

Gnathopod 1 (Figure 15a) subchelate, hammer shaped. Basis elongated, maximum length almost 3 times longer than maximum width; posterior margin without seta, distal end without cluster of setae. Ischium short, subquadrate; distal posterior end with one cluster of 2 setae. Merus longer than wide, ventral surface with comb scales; distal margin with 8 setae. Carpus longer than wide, longer than propodus; with strong, short, and wide posterior lobe forming one scoop-like structure open to inside; inner surface with 3 serrate setae. Propodus less than 1.5 times longer than wide, anterior margin distal third with 1 medial seta; inner surface with 3 serrate setae in one row, outer surface with 1 seta on margin near halfway point; distal anterior end with two clusters of approximately 8 setae; distal anterior and posterior surfaces with comb scales; palm transverse, posterior distal end with 1 robust seta and cup for dactylus. Dactylus claw-like; nail present; anterior surface near proximal third with 1 plumose seta, with comb scales over anterior surface.

Gnathopod 2 (Figures 15b, and 21f) subchelated; palm slightly oblique. Basis elongate, more than 3 times longer than wide; posterior margin without seta. Ischium short,
subquadrate, shorter than merus. Merus short; posterior margin with 8 simple setae, posterior inner and outer surfaces with comb scales. Carpus shorter than propodus; anterodistal end with 6 setae; posterior lobe scoop-like, elongate, length similar to merus maximum length, almost 1.5 times width of merus, with several submarginal pappose
Figure 15. *Hyalella garyi* sp. nov. male holotype, 4.7 mm; female paratype, 4.8 mm. (a) male gnathopod 1; (b) male gnathopod 2; (c) female gnathopod 1; (d) female gnathopod 2. Male pereiopods: (e) pereiopod 3; (f) pereiopod 4; (g) pereiopod 5; (h) pereiopod 6; (i) pereiopod 7. Scale bars: 100 µm.
setae and comb scales. Propodus robust, length almost 1.5 times as long as wide, subrectangular; palm similar in length to slightly longer than posterior margin; slope slightly irregular, with several long simple setae, and some short and medium setae; distal margin of palm with one truncated process near insertion of dactylus, and with wide posterior excavation (Figure 22f); palm posterior distal end with 2 strong setae, comb scales and cup for the dactylus. Dactylus claw-like, congruent with palm, without comb scales; outer margin with 1 plumose seta; inner margin crenulate with setules.

**Pereopods** 3–7 (Figure 15e–i) simple, gradually longer posteriorly, pereopod 5 slightly shorter than 4 and 6.

**Pereopod 3** (Figure 15e), basis elongate; mid-posterior margin without simple seta. Merus anterior margin with 1 stout seta, posterior margin with 2 long simple setae respectively and 1 medial shorter seta; anterodistal and posterodistal ends with one cluster of 4 and 7 setae, respectively. Carpus slightly shorter and slenderer than merus; posterior margin with 2 stout setae plus accessory seta; posterodistal end with at least 7 slender setae; anterodistal end with at least 6 setae. Propodus slenderer than carpus; posterior margin with 3 setae; anterodistal end with 5 simple setae. Dactylus claw-like, length almost half of propodus; nail present.

**Pereopod 4** (Figure 15f) similar in shape to pereopod 3 but slightly longer; coxa 4 wider than 3 with posterior excavation; basis posterior margin without simple seta; merus mid-anterior margin without setae; propodus posterior margin with 4 stout setae.

**Pereopods 5–7** (Figure 15g–i) similar in shape; basis posterior lobe rounded and denticulated. Pereopod 7 (Figure 15i) basis lobe widely expanded, almost reaching ischium distal margin; basis lobe, width 1.6 times as width as basis (measured at cleft between basis and basis lobe); posterior margin with 8 serrations, each with 1 setule without stout seta on distal margin; anterior margin with 2 stout setae and one cluster of 2 setae at distal end. Dactylus length less than half of propodus length.

**Pleon 1–3** (Figure 16e) not modified, biramous, elongated, rami multi-annulated, with numerous plumose setae; pleopod 1, inner margin of peduncle at distal end with 2 short retinacula (coupling hooks) at distal end.

**Uropod 1** (Figure 16a) longer than uropod 2; peduncle longer than rami, with 2 dorsal setae, inner and outer distal ends each with 1 seta; rami subequal, inner ramus slightly longer, with 2 dorsal and 4 distal setae, outer ramus with 2 dorsal and 4 distal setae; male without curved setae on inner ramus.

**Uropod 2** (Figure 16b) as long as peduncle of uropod 1; peduncle shorter than outer rami, with 1 dorsal seta and 1 seta at distal end; rami subequal, inner ramus slightly longer with 2 dorsal and 4 distal setae, outer ramus with 2 dorsal and 3 distal setae.

**Uropod 3** (Figures 16c, and 23f) slightly shorter than peduncle of uropod 2; peduncle rectangular, wider than ramus with 3 strong distal setae of variable length; inner ramus absent; outer ramus uniarticulate, slender, slightly shorter than peduncle, 2 times length of larger seta of peduncle, basal width almost 2 times width of apex of ramus, with 3 slender apical setae (1 longer) and 1 connate seta.
Telson (Figures 16d, and 24f) entire, longer than wide, distal margin rounded, with 2 long simple apposed or separated setae; with two clusters of 3 plumose setae near middle distal portion, near margin, symmetrically distributed.

Coxal gills sac-like, present on segments 2–6. Sternal gills tubular, present on segments 3–7.

Female (Figure 18d) similar to male. Gnathopod 1 (Figure 15c), carpus with 7 serrate setae on the inner face lobe. Gnathopod 2 (Figure 15d) smaller than male gnathopod 2, parachelated, palm reverse oblique, basis posterior margin without seta; propodus longer than twice maximum width, inner face with 3 serrate setae in a row, outer face with 3 setae in a row and 3 large setae near the palm, anterior and posterior distal half with comb scales. Pereonite 2 with one anterior excavation or notch for amplexus. Pereopod 7 lobes with 10–13 serrations and setules, and without stout setae on the distal margin. Oostegites subtriangular with setae curled on the margins.

Habitat. Freshwater, epigean, littoral, associated with sediment and Eichhornia crassipes (Mart.) Solms.
**Hyalella sarukhani** sp. nov.

**Hyalella alvarezi** sp. nov.

**Hyalella viviannae** sp. nov.

*Figure 17.* Scanning electron microscopy images. Lateral habitus. *Hyalella sarukhani* sp. nov. paratypes: (a) male; (b) female, arrow shows the notch for amplexus. *Hyalella alvarezi* sp. nov. paratypes: (c) male; (d) female, arrow shows the notch for amplexus. *Hyalella viviannae* sp. nov. paratypes: (e) male; (f) female, arrow shows the notch for amplexus.

*Distribution.* Lake Catemaco, state of Veracruz, Mexico (18.366°N, 95.084°W).
**Remarks**

This species is similar to *H. villalobosi* sp. nov.; however, *H. garyi* sp. nov. can be distinguished by the absence of dorsal mucronations on the pleon, the shape of the upper lip.
Figure 19. Scanning electron microscopy images, comparison, paratypes. Maxilla 1 with amplification of plap. (a) Hyalella azteca (De Saussure, 1858); (b) Hyalella sarukhani sp. nov.; (c) Hyalella alvarezi sp. nov., arrow shows the cylindrical structure in the base of distal seta; (d) Hyalella vivianae sp. nov.; (e) Hyalella villalobosi sp. nov. Arrows show the number of setae on the distal margin of inner plate; (f) Hyalella garyi sp. nov.

(subquadrate), the shape of the lower lip (subtriangular in H. villalobosi sp. nov.), the absence of 1 distal seta in the palp of maxilla 1 (similar to H. azteca s.s.) but with setules (absent in H. wakulla Drumm and Knight-Gray, 2019), the inner plate of maxilla 2 wider, the absence of setae in the hind margin of male gnathopod 2, the length of the merus vs
isquium in the pereiopod 3 (close to 2 times), the relative width of the base of uropod 3 (less than 2 times), and the distal margin of telson rounded, in contrast to the other species from Veracruz with the margin acute (similar to *H. azteca* s.s.). In the species from lake Catemaco (*H. villalobosi* sp. nov. and *H. garyi* sp. nov.) the articles of the palp in maxilliped are apparently longer than articles in *H. azteca* and the other species described herein.

Figure 20. Scanning electron microscopy images, comparison, paratypes. Maxilliped with amplification of fourth article. (a) *Hyalella azteca* (De Saussure, 1858); (b) *Hyalella sarukhani* sp. nov.; (c) *Hyalella alvarezi* sp. nov.; (d) *Hyalella viviannae* sp. nov.; (e) *Hyalella villalobosi* sp. nov.; (f) *Hyalella garyi* sp. nov.
Remarks on ecology and distribution

*Hyalella azteca* complex is restricted to North America, Central America and the Caribbean region. An important traditional character to identify species in the *H. azteca* complex is the presence of two mucronations over the pleon, a character that has led to significant taxonomic confusion; this character is common in the species described here, except for *H. garyi* sp. nov.

**Figure 21.** Scanning electron microscopy images, comparison, paratypes. Gnathopod 2 of male. (a) *Hyalella azteca* (De Saussure, 1858), view of the outer face; (b) *Hyalella sarukhani* sp. nov., view of the inner face; (c) *Hyalella alvarezi* sp. nov., view of the outer face with deail of comb scales on basis; (d) *Hyalella vivianname* sp. nov., view of the outer face; (e) *Hyalella villalobosi* sp. nov., view of the inner face; (f) *Hyalella garyi* sp. nov. view of the outer face.
Several authors described new species with these mucronations; however, later these species were synonymised with *H. azteca*. In this study, we analysed other characters to identify species based on their morphology, as other authors have suggested (e.g. Stevenson and Peden 1973; Cole and Watkins 1977; Gonzalez and Watling 2002; Soucek et al. 2015; Bueno et al. 2019; Drumm and Knight-Gray 2019). According to Holsinger (1972), Bousfield (1996) and Gonzalez and Watling (2002), the morphological characters

![Figure 22](image_url)

*Figure 22.* Scanning electron microscopy images, comparison, paratypes. Palm, gnathopod 2 of male; arrows show presence or absence of excavation near truncated process in the palm. (a) *Hyalella azteca* (De Saussure, 1858); (b) *Hyalella sarukhani* sp. nov.; (c) *Hyalella alvarezi* sp. nov.; (d) *Hyalella viviannae* sp. nov.; (e) *Hyalella villalobosi* sp. nov.; (f) *Hyalella garyi* sp. nov.
should not be used in isolation, and it is necessary to analyse several characters at the same time for an accurate identification of amphipod species. It is also important to consider the total body length, since some characters change proportionally with the growth of the organism (Stevenson and Peden 1973; Bousfield 1996; Gonzalez and Watling 2002; Garcia-Schoeder and Araujo 2009).

According to Gonzalez and Watling (2002) and Drumm and Knight-Gray (2019), the shape and setation of the palp in maxilla 1 are useful to identify species (Tables 1, S1). In this study, the palp is mostly distally pointed with one distal seta, except in *H. garyi* sp.
Figure 24. Scanning electron microscopy images, comparison, paratypes. Telson, dorsal view. (a) *Hyalella azteca* (De Saussure, 1858); (b) *Hyalella sarukhani* sp. nov.; (c) *Hyalella alvarezi* sp. nov.; (d) *Hyalella viviannae* sp. nov.; (e) *Hyalella villalobosi* sp. nov.; (f) *Hyalella garyi* sp. nov.
nov., which has a distal rounded margin without distal setae, similar to *H. azteca* s.s. In the organisms from Veracruz the distal seta helps in identifying species: in *H. vivianna* sp. nov. the seta is long and robust, and in *H. villalobosi* sp. nov. and *H. alvarezi* sp. nov. it is short and robust, but *H. alvarezi* sp. nov. has a cylindrical structure that covers one-third of the base of the distal seta (Figure 19c).

We corroborate the importance of the shape of the excavation in the palm of the male gnathopod 2 as a diagnostic character, as suggested by Soucek et al. (2015); we add as essential characters the proportion of the cup of the dactylus vs the palm, as well as the space filled with the nail in the cup of the dactylus in the gnathopod 2 of males. These two characters can be useful for future geometric morphometric studies.

According to Garm and Watling (2014), the development of the setae is not a trivial event, as it is carried out by an ontogenetic signal, and it is associated to the nervous system. We conclude that setae in antennae, gnathopods, basis of pereopod 7, uropods and telson are important to distinguish between species, regardless the sex (Tables 1, S2).

**Figure 25.** Atypical maxilla 1, long palp with 3–4 distal setae, and up to five distal setae on inner plate: *Hyalella* sp., male 6.8 mm, Lake Catemaco, Veracruz. Scale bar: 100 µm.
However, the setae are fragile structures and break easily, so these characters should be considered with caution. Of the five species described in this study, two were found in Lake Catemaco, Veracruz (H. villalobosi sp. nov. and H. garyi sp. nov.); we hypothesise that it is very probable that Lake Catemaco harbours more than two co-existing species due its extension (72.54 km²), as we collected an organism with atypical maxilla 1, with palp longer and with more distal setae (Figure 25). Also, this is one of the most highly polluted lakes in the region (Calderón-Villagómez et al. 2001); therefore, it is a priority issue to implement strategies for the conservation of these ecosystems. Definitively, more studies focused on discovering the diversity of freshwater amphipods are needed before the loss of these endangered habitats and the clear diversity in these ecosystems.

Acknowledgements

The first author is grateful to the Posgrado en Ciencias del Mar y Limnología, UNAM, and CONACYT for a scholarship granted by Consejo Nacional de Ciencia y Tecnología, Programa Nacional de Posgrados de Calidad (CONACYT-PNCP, no. 579646), Mexico. We thank Dr Peter Schwendinger and the Muséum d’Histoire Naturelle, Geneva, Switzerland, for their important role in preserving the type material of several arthropods and for loaning us the lectotype of H. azteca. We thank the Laboratorio de Microscopía y Fotografía de la Biodiversidad I, in the Instituto de Biología, UNAM, and Berenit Mendoza-Garfias for technical assistance with SEM images, as well as Pablo Hernandez Alcántara, Carlos Illescas Monterroso and Alicia Rojas, for their technical help and support with equipment for mounting permanent and semi-permanent slides and taking measurements. We thank Fernanda Charqueño, Elia Lemus, Alejandro Estradas, Karina Arvizu and Liseth Pérez for their assistance in the collection of specimens.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The authors reported there is no funding associated with the work featured in this article.

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