A new Ostracoda (Crustacea) genus, *Comalcandona* gen. nov., from Texas, USA

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**Abstract:** A new freshwater ostracod genus, *Comalcandona* gen. nov., and its type species (*Comalcandona tressleri* sp. nov.) are described from John Knox Ranch, Comal County, Texas, USA. The new genus differs from the related genera in the presence of the shallow pits on the trapezoidal shape of the carapace and presence of one well-developed anterior claw (posterior claw and both anterior and posterior setae are absent) on the uropod, a diagnostic character. Differences in the structure of the hemipenes, length and numbers of setae on the extremities, and shape of some other soft body parts also separate this genus from the other related genera. The taxonomic status of the new genus and species are compared and discussed with other related groups.

**Key words:** Candonidae, new genus, freshwater, taxonomy, spring

**1. Introduction**

The family *Candonidae* includes three subfamilies: Paracypridinae Sars 1923, Cyclocypridinae Kaufmann 1900a, and Candoninae Kaufmann 1900a. While the first one includes mostly brackish and marine ostracods, the last two subfamilies have mostly freshwater species. According to Karanovic (2013), *Candoninae* is divided into eight tribes with 41 genera. Although Karanovic (2013) did not mention about it, Külköylüoğlu et al. (2011) reported another new genus (and a species) of this subfamily as *Bicornucandona*, increasing the number to 42 genera. Regarding the North American *Candoninae* (see Karanovic, 2006; Külköylüoğlu et al., 2011), to date, there are about 41 species within at least eight genera: *Candona* Baird 1845, *Typhlocypris* Vejdovský 1882, *Pseudocandona* Kaufmann 1900 (also see, e.g., Gidó, 2010), *Eucandona* Daday 1900, *Nannocandona* Ekman 1914, *Paracandona* Hartwig 1899, *Fabaeformiscandona* Krstić 1972, and *Bicornucandona* Külköylüoğlu et al. 2011. Of the 41 species, 16 are already known from other continents, while 27 (including a new species *Bicornucandona fineganensis*) are endemic to North America (Karanovic, 2006; Külköylüoğlu et al., 2011) (but also see Külköylüoğlu et al. 2017). Since the description of the first ostracod (*Chlamydotheca texasiensis* (Baird 1862)) from Texas, there are about 75 living ostracods reported from the state (Külköylüoğlu, unpublished data). Nevertheless, *Candonidae* is a large family with a cosmopolitan distribution worldwide and these numbers are thought to be underestimated. The aim of the present study was to describe a new genus (*Comalcandona* gen. nov.) and a new species (*Comalcandona tressleri* sp. nov.) of candonid Ostracoda from Texas, North America.

**2. Materials and methods**

**2.1. Site description**

John Knox Spring (29°57.849′N, 98°11.739′W), located on John Knox Ranch on the border of Comal and Hays counties, Texas (Figure 1), emerges from a ca. 0.3-m vertical crevice-like orifice, 1 m below the water surface and along the bank of the scenic limestone grotto pool called Blue Hole. Blue Hole (ca. 16 m wide) reaches depths of 5 m and flows for ca. 25 m where it narrows and forms a shallow (ca. 1 m deep) channel that flows for 0.23 km where it pours over a 3-m-tall dam. From this point, the creek meanders for 1.4 km and empties into the Blanco River. Blue Hole is the perennial headwaters of Carper's Creek. Discharge of this creek was measured at 0.05 cfs by Texas Parks and Wildlife Department (TPWD) on 24 September 1988 (Gordon Linam, pers. comm.). After sufficient rain events, Carper's Creek flows down the normally dry creek bed upstream of Blue Hole, forming a waterfall that empties directly into the pool where John Knox Spring emerges. Water quality of the spring sampled using a DataSonde 5 multiprobe (Hydrotech ZS Consulting, Round Rock, TX, USA) on 1 September 2014.

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was as follows: temperature = 20 °C, pH = 6.9, dissolved oxygen = 6.1 mg/L, and specific conductivity = 534 µS/cm. This spring emerges from Lower Glenn Rose Limestone associated with the Middle Trinity Aquifer (Wierman et al., 2010). A portion of the flow might arise from hyporheic origin through alluvial deposits within the streambed of Carper’s Creek as suggested by the collection of surface fauna (e.g., early instar stonefly larvae and a small riffle beetle larva *Microclyloepus pusillus*) drifting out of the spring orifice.

Collections were performed using an 250-µm aquatic drift net (BioQuip Products, Rancho Dominguez, CA, USA) modified with a flexible copper tubing frame inserted into the crevice and then expanded outward, resulting in the net being firmly lodged in the spring orifice while capturing most of the flow. The collection bucket was also modified with 5.1-cm PVC threaded fittings allowing for removal and replacement under water without the need to dislodge the net. Additionally, an outflow area was fitted on this bucket with 200-µm nylon mesh for capture of smaller fauna, and a backwater area of reduced flow was provided for capture of invertebrates, decreasing potential damage to the specimens. Using a dive mask and snorkel, collection buckets were exchanged underwater and the sample capped and swum to shore. Invertebrates were picked from the samples with soft forceps or disposable plastic pipettes and preserved in 95% ethanol. The remaining bulk sample was preserved in jars with 95% ethanol and transported, stored, and later sorted in the laboratory at San Marcos Aquatic Resources Center (SMARC). Notable fauna collected from these drift samples include spring salamander *Eurycea pterophyla* (Bendik et al., 2013), hydrobiid spring snail *Marstonia comalensis* (Hershler and Liu, 2011; Robert Hershler, pers. comm.), subterranean flatworm, subterranean hyporheic amphipod *Stygobromus russelli* and isopod *Lirceolus* sp., and undescribed subterranean species of *Arrenurus* mite and *Stygobromus* amphipod (Randy Gibson, pers. comm.).

The individuals of the new genus, *Comalcandona* nov. gen., were collected from the type locality, John Knox Spring, John Knox Ranch, Comal County, TX, USA on 21 May 2010 by one of us (RG). After, they were fixed in plastic containers in 70% ethanol in situ.
In the laboratory, individuals were sorted from the sediments and kept in the 70% ethanol. Soft body parts separated from the carapaces were dissected in lactophenol solution and the carapaces were stored in micropaleontological slides. Each slide was given a catalogue number and covered with nail polish for future use. A scanning electron microscope (SEM) located at CBA, Faculty of Sciences, University of Lisbon, Portugal, was used to obtain detailed images of the carapaces. Soft body parts of the holotype and allotype were drawn under a camera lucida (Olympus U-DA) attached to an Olympus BX-51 microscope by the first author. Afterwards, all drawings were digitized using an Intuos 5 tablet (Wacom) and Illustrator CS5 software (Adobe). Broodbakker and Danielopol (1982), Martens (1987), Meisch (1996, 2000), and Karanovic (2004, 2005, 2006, 2007, 2012, 2013) were used to describe the chaetotaxy of the limbs and taxonomic status of the genus. All materials described here with catalogue numbers (OK-TX-20100521: 01-09) were located in the Limnology Laboratory of the Biology Department, Abant İzzet Baysal University, Bolu, Turkey. Additional materials are also available upon request from the corresponding author.

2.2. Abbreviations used in text and figures

A1, first antenna (antennula); A2, second antenna (antenna); cp, carapace; D, distal; d1–3 and dp, setae on the protopodite of the second (T2) and third (T3) thoracopods; G1–G3, Gm, GM, terminal claws of A2; H, height; L, length; LV, left valve; Mx1, maxillula; Md, mandibula; Pr, protopodite; RV, right valve; T1, first thoracopod; Ua, uropodal attachment; Ur (uropod); W, width; Y, ya, y1–y3, aesthetasc; z1–3, setae of the third (or second) segment of A2.

3. Results

Systematic description

Class: Ostracoda Latreille, 1802
Order: Podocopida Sars, 1866
Superfamily: Cypridoidea Baird, 1845
Family: Candonidae Kaufmann, 1900
Subfamily: Candoninae Kaufmann, 1900
Genus: Comalcandona gen. nov.
Type-species: Comalcandona tressleri sp. nov. (Figures 2–6)

Other species: The genus is presently monospecific.

Etymology: The name of the county, Comal, is combined with the genus Candona as Comalcandona, referring to the type locality of the new genus.

Figure 2. Comalcandona tressleri gen. nov. sp. nov. A, C, D (Female); B (Male). (A) left valve, (B) right valve, external view. (C) right valve, internal view. (D) dorsal view. Scale bar: 105 µm.
Diagnosis

In lateral view, carapace trapezoidal, medium in size with normal pore openings. Dorsal margin straight with a sharp slope posteriorly. Anterior margin wide, rounded and more tapering than the posterior in dorsal view. Posterior margin like “bairdioid forms”, anterior margin slightly dropped to the ventral. Right valve slightly concave antero-dorsally. In dorsal view, carapace laterally compressed, left valve covers the right valve from all margins. Greatest point of height and width placed almost in the middle of the valves. Valve surface ornamented with relatively shallow pits. Five big muscle scars located in the middle of the valves. Marginal areas of the right valve smooth or with tiny tubercules. These areas of the left valve smooth. Hinge adont. Calcareous inner lamella broad at both ends. A1 7-segmented. A2 4-segmented in both sexes. Natatory setae absent on A2. Exopodite of A2 with one long and 2 short setae. Second segment of Md-palp with 3 + 1 setae interiorly, and one short seta exteriorly. Terminal segment of Mxl palp short and slightly trapezoidal with 5 smooth setae. T1 with one short a seta. T2 5-segmented with one d1 seta. T3 5-segmented and with 3 setae (d1, d2, dp) on the first segment (protopodite). Uropod with well developed, smooth anterior claw; posterior claw and both anterior and posterior setae absent. Hemipenis with a “duck-bill” shape of lateral lobe and inner lobe flat dorsally. 

Comalcandona tressleri sp. nov. (Figures 2–6)

Material examined

Holotype: One dissected male with soft parts sealed in slide and valves stored in a micropaleontological slide (no: OK-TX-20100521: 01).

Allotype: One dissected female stored as the holotype (no: OK-TX-20100521: 02).

All soft body parts dissected in lactophenol; empty valves of holotype and allotype kept in micropaleontological slides (no: OK-TX-20100521: 03-04).

Dissected paratypes: Two males and two females from the type locality (no: OK-TX-20100521: 05-08).
Figure 4. *Comalcandona tressleri* gen. nov. sp. nov. (Male): (A) A1. (B) A2. (C) (Md). (D) Close view of coxal end. (E) Mxl. (F) Rake-like organ. Scale bar: 100 µm.
Figure 5. Comalcaniona tressleri gen. nov. sp. nov. A, C–E (Male); B (Female). (A) T1. (B) T1 (right and left clasping organs). (C) T2. (D) T3. (E) Ur (with U-shaped Ua). Scale bar: 100 µm.
Figure 6. *Comalcandona tressleri* gen. nov. sp. nov. A, B (Male); C, D, E (Female). (A) Zenker's organ. (B) hemipenis. (C) genital organ. (D) hypostome. (E) Close view of A2. Scale bar: 100 µm.
**Nondissected paratypes:** 386 individuals (males, females, juveniles) from the type locality kept in 70% ethanol (no: OK-TX-20100521: 09) deposited at Abant Izzet Baysal University, Department of Biology, Bolu, Turkey.

**Description**

**Male:**

Measurements (holotype): L = 0.80 mm, H = 0.50. Average: L = 0.793 mm (n = 4), H = 0.497 mm (n = 4), W = 0.355 mm (n = 2). LV overlapping RV along the entire valve margin.

Carapace in lateral view trapezoidal with normal pore canals. Dorsal margin straight with a sharp slope in posterior end and a slightly concave antero-dorsally. Anterior margin more rounded than posterior. Greatest point of height placed almost in the middle of valves. Valve surface pitted, with setae and five to six muscle scars located in the median part of the valves.

Internal view of both valves: inner calcified lamella wide both anteriorly and posteriorly. Color of the carapace translucent to opaque white. Hinge adont.

In dorsal view: carapace laterally compressed.

A1: (Figure 4A). Seven-segmented. First segment with one short antero-proximal seta and two long postero-distal setae. The longest reaching the terminal segment. Second segment with one short antero-distal seta. Third segment without any setae. Fourth segment with long seta anteriorly. Fifth segment with two long anterior setae. Penultimate (sixth) segment with three setae anteriorly and one medium sized postero-distal seta. Terminal segment with two long setae and one well-developed aesthetasc (ya). Rome and Wouter’s organs not seen.

A2: (Figure 4B). Four-segmented, penultimate segment undivided. Exopod with one long and two short setae; long seta extending to the end of the first endopodal segment, one of the two short setae strongly curved. First segment of endopod with one short seta and one long seta, interno-distally. Aesthetasc Y well developed with two subequally long segments, about the size of the first endopodal segment (or even slightly longer). Penultimate segment with one medium-sized externo-distal seta. One long t-seta present, extending to the end of terminal segment, not transformed into sensory bristles. One small z seta (z1) seen, reaching to the end of the terminal segment. z2 seta well developed claw-like. G1 and G3 claws absent, G2 claw conspicuously long, reaching about the combined length of the three distal segments of A2. GM claw slightly shorter than G2 (compare with female). Gm slender seta reaching ca. 3/4 of GM seta. All the distal part of the claws smooth or weekly serrated. Aesthetasc y1 and y2 not seen but seta y3 slender, long about the size of Gm. Rake-like organ with ten to eleven teeth (Figure 4F).

Md: (Figures 4C, 4D). Md palp four-segmented. Coxa well developed with five cusperate and one bicuspid sharp teeth. Interiorly, first segment bearing two almost equally long setae two plumose S1 and S2 and two equally long short setae (one plumose a seta and one smooth seta). Vibratory plate with about eight to ten setae.

Second segment with a group (3 + 1) of setae interiorly. Three setae plumose, one s-shaped seta smooth in equal size. β seta present, small. One seta seen on the outer edge reaching about the midpoint of the penultimate segment.

Third (penultimate) segment externo-distally with two long setae (both barely reaching the end of the terminal claws) and one medium-sized smooth seta. Distally, two setae (both gamma (γ) seta and other seta smooth) present in equal size. Interno-distally, one short and two medium smooth seta reaching the midpoint of the terminal segment.

Terminal segment with a fused terminal plumose claw, one plumose seta externo-distally and one smooth seta interno-distally. Mxl (Figure 4E). Mxl-palp two segmented. First segment with three smooth subequale setae, dorsally, second segment (palp) distally slightly enlarged with two claw-like setae and three shorter setae (all setae smooth). Vibratory plate with ca. 14 plumosed setae.

T1: (Figure 5A). Prehensile palps on endopod slightly asymmetrical, both curved. Left palp smaller, ending with a short apical part. Right palp longer and slightly robust with a pointing apical part. One a, b, and d setae present in both sexes, but c seta not well seen in female (Figure 5A). Masticatory process distally with seven setae, laterally with a bundle of 3 setae.

T2: (Figure 5C). Five-segmented. Basal segment with one short d1 seta. Second and third segments with one smooth (sub-)apical seta. Fourth (penultimate) segment with two setae, one long seta slightly longer than the terminal segment, and one short about the length of the terminal segment. Fifth (terminal) segment with one short seta, and a smooth claw, about the length of the three segments combined distally.

T3: (Figure 5D). Five-segmented with three setae (dp, d1, d2) on basal segment. d1 seta slightly longer than dp and d2, extending slightly to the middle of second segment. All setae smooth or slightly plumosed. Three setae (e, f, and g setae) of about equal size present in second, third, and penultimate segments, respectively. Terminal segment with three setae arranged in length of h3 > h2 > h1. Seta h1 slightly curved and about twice as long as the terminal segment. Seta h2 medium sized, about 2/3 of h3. Seta h3 reaching about the second segment.

Ur: (Figure 5E). With one anterior claw, smooth, and almost the length of dorsal uropodal margin. Posterior claw, anterior and posterior setae missing. Ua with a short base, continuing with almost U-shaped branching, ending with bifurcate dorsal branch.
Zenker’s organ: (Figure 6A). Elongate, with 5(+2) internal spinous whorls ending with a sperm canal.

Hemipenis: (Figure 6B). Lateral lobe ‘lobe a’ long ‘duck-bill’ shape pointed distally (diagnostic character). Inner lobe ‘lobe b’ distally enlarged and flattened. Medial lobe ‘lobe h’ flattened dorsally. M process large with a distal part ‘g2’ elongated.

Etymology: The new genus is named after the late Dr Willis L. Tressler for his important contribution to ostracod studies.

Female:
Carapace similar in shape, smaller than male in size. Female. L = 0.723 mm, H = 0.391 mm. Average: L = 0.766 mm (n = 4), H = 0.448 mm (n = 4), W = 0.245 mm (n = 2). G1, G2, and G3 claws conspicuously and equally long, reaching about the combined length of the three distal segments of A2. GM claw slightly shorter than G3. z1–3 setae minute about the size of terminal segment. T1 normally developed not transformed into clasping organs (Figure 5B). Endopod terminally with three long setae (h1–3) almost equal in size, h3 slightly shorter than the others. Three antero-dorsal setae of masticatory process about 2x longer than the four short setae. Hypostome rounded (Figure 6C). Genital lobe rounded with well developed, long, copulatory hooks (Figure 6D). Eggs medium in size. All other soft parts similar to those of the male.

Ecology
The species of the new genus Comalcandona tressleri gen. nov. sp. nov. were collected from the type locality with relatively warm, less to medium oxygenated, almost saline, and close to neutral waters (also see Site Description above). Since this is the first report of the species, there is no detailed information about its habitat preferences and ecology.

4. Discussion
The new genus Comalcandona shows several different morphological characteristics (e.g., presence of shallow pits on the trapezoidal carapace, a “duck bill” shape of the lobe a on the hemipenis, numbers of setae and segments on A1, relatively smooth claws on A2, shape of clasping organs, absence of posterior claw and both anterior and posterior setae on uropod, etc.) than the other candonids such as Meischcandona, Latinopsis, Areacandona, and Candonopsis. Moreover, the new genus shares similar morphological characteristics with some of them. According to the taxonomic key given by Karanovic (2012), the new genus can be placed into the tribe Candonopsini by having rows of spines in Zenker’s organ (and not having posterior seta on the uropod). Among the six genera (Candonopsis, Caribecandona, Cubacandona, Marocandona, Pioneercandona, Latinopsis) of this tribe, the genus Candonopsis along with two subgenera (Candonopsis, Abcandonopsis) shares a few similar but more distinctly different characteristics. For example, Candonopsis kimberleyi Karanovic and Marmonier (2002) shows similarity in the carapace shape and ornamentation with the new species Comalcandona tressleri sp. nov. proposed here. Both species more or less trapezoidal in lateral view have shallow pits on the valves, which are similar size. However, the marginal zone and line of concrescence are much broader in the new species than in Candonopsis kimberleyi. Although such similarity exists, the differences in the soft body parts are distinct and separate these two species into different groups.

Comparing the soft body parts, for example, seta d1 of the basal segment of T2 (walking leg) is absent in Abcandonopsis but present in the new genus. In addition, t1–4 setae of A2 of the males are transformed into bristle type in Abcandonopsis (and Indocandona), but not in the new genus. The new genus proposed here has 7 segments on A1. Among the genera, numbers of segments along with the numbers of setae on it, for instance, A1 is 7 segmented in four of them (Candonopsis, Candonona, Cubacandona, Latinopsis) but 6- and 4-segmented in Caribecandona and Pioneercandona, respectively. Moreover, Karanovic (2001) pointed out the presence of 5 segments on A1 in two genera (Meischcandona and Nannocandona), which may be used to understand taxonomic relationships among the genera of Candonopsini.

A similar comparison can be made for the antennae. There are no swimming setae on A2 for those species and genera in this tribe. However, some other parts of A2 can be compared among the genera. Comalcandona gen. nov. is of 1 long and 2 very tiny setae on the exopod, similar to Namibcypris and Meischcandona but the exopod has only 1 and 3 setae in Danielocandona and Trajancandona, respectively (Karanovic 2001, 2012). Furthermore, the new genus also differs from the genera mentioned above by having the same numbers of segments on A2 in both sexes. On the other hand, differences in G claws and z-setae are clear between the sexes.

When one compares the uropod among the genera (see the key in Karanovic 2001 for the genera of the subfamily Candoninae), Comalcandona gen. nov. shows very different characteristics, having only one smooth anterior claw on the uropod where posterior claw and both anterior and posterior setae are absent. It should be noted that we observed a tiny (reduced) posterior claw in only one female individual. Except this, all other individuals of the new genus described herein do not carry this seta.

The mandibula of the new species has some differences (Figures 4D and 4E); for example, the L:W ratio of its terminal segment is about 2–2.5:1, but it is never less than 3:1 in Candonopsis (e.g., the ratio is about 3.5:1 in...
C. mareza) (Karanovic and Petkovski, 1999; Karanovic, 2004). In contrast, there are some other genera (e.g., see Meridiscandona, Deminutiocandona) with a ratio less than 2:1 (Karanovic, 2003a) or even 1:1 as is the case for Acandona (e.g., see A. admiratio in Karanovic (2003b)). The ratio apparently differs in the new genus proposed here. Besides the ratio, as described above, the mandibula has differences in the numbers, position, and size of the setae even at the subgeneric level. For example, the terminal claw of the mandibular palp is distally plumed in one of the subgenera of Candonopsis (Abcandonopsis aula and A. indoles) while it has an oval plumosed one in Comalcandona tressleri sp. nov., in which the penultimate segment carries 3 medium and 3 long smooth setae internally and externally, and two setae (both gamma (γ) seta and other seta smooth) present in equal size distally. Unlike the new species, there are 2 and 1 setae in this segment of A. aula, 3 well developed and 2 medium sized setae in Candonopsis (C. sumatrana), and 4 distally and 2 setae found extero-distally in C. kimberleyi (Karanovic and Marmonier (2002). Abcandonopsis aula has only one smooth (γ) seta present distally. The second segment of the mandibular palp has 4 weakly plumosed setae and a small β seta interiorly. In contrast, there are 3 + 2 well-developed setae in the second segment of A. aula and C. kimberleyi. The first segment of Md shows similarities, except that S1 seta is weakly plumosed in the new species.

The caudal ramus with one claw is known in some other genera of the family (e.g., see Meischcandona, Indocandona, Candonopsis, Danieloocandona) but most (if not all) of them bear either posterior or anterior setae and/or posterior or anterior claws reduced. None shows a single anterior claw on the uropod, except in Abcandonopsis aula, which has similar shape of uropod without a posterior claw and both the anterior and posterior setae are missing. Moreover, the new genus possesses another interesting diagnostic character in the CR attachment, which is U-shaped in both sexes. Such a rare characteristic is so far not known in other Candoninae genera. According to Karanovic (2001), four genera (Namibcypris, Danielocandona, Trajancandona, and Meischcandona) bear 3 setae on the terminal segment of Mxl palp. In contrast, the terminal segment of Mxl palp is quadrate with five setae when the first segment bears three long setae. Other setae on the other three endites of maxillula are smooth.

Comalcandona tressleri sp. nov. has a different type of hemipenis compared with the other candonids known. The most distinguished characteristics of the big hemipenis is the “duck bill” shape of lateral (a) lobe. Both inner and medial lobes are wide and dorsally flat. All these characteristics discussed so far support that Comalcandona is a new genus with its type species C. tressleri sp. nov.

Remarks: It may be important to underline that oval pits on the left half of the carapace are well rounded and of the same size but pits on the right side are smaller and seem to be divided in two parts. This may help one to distinguish the species from others.

Although it is easy to recognize Comalcandona gen. nov. sp. nov. from other candonid relatives, the family Candonidae needs more taxonomic and systematic work due to the presence of taxonomic problems.

Conclusions
As described in detail above, Comalcandona tressleri sp. nov. gen. nov. sp. proposed here as a new genus along with its type species differs in the shape and structure of the valves, hemipenis, uropod, and numbers of setae and their location on the soft body parts.

Nomenclatural acts: This work and the nomenclatural acts it contains have been registered in ZooBank. The ZooBank Life Science Identifier (LSID) for this publication is: http://zoobank.org/urn:lsid:zoobank.org:pub:E3F37A90-67CB-43CE-847A-C8D202696AB0.

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References


