

Morphological and Molecular Contribution to the Taxonomy of *Attheyella* (*Attheyella*) *crassa* (G. O. Sars, 1863) Species Complex (Harpacticoida: Canthocamptidae)

Serdar Sönmez^{1*} & Süphan Karaytuğ²

¹Department of Biology, Faculty of Science and Letters, Adıyaman University, Adıyaman, Turkey

²Department of Biology, Faculty of Arts and Science, Mersin University, Mersin, Turkey

Abstract: The aim of this study is to contribute to the taxonomy of the family Canthocamptidae and the genus *Attheyella* Brady, 1880 through a detailed morphological redescription and molecular characterisation of *A. (A.) crassa* from Turkey. In addition, we review previous descriptions. Specimens were collected from a spring located in the Tut District of Adıyaman, Turkey. We redescribe both sexes of *A. (A.) crassa* and provide illustrations and SEM images. Also, we present partial sequences of gene 28S rRNA for future studies. Comparison of the previous descriptions and illustrations with the present redescription has revealed that *A. (A.) crassa* is a species complex.

Key words: Taxonomy, 28S rRNA, Turkey, species complex, freshwater.

Introduction

The family Canthocamptidae Brady 1880 is the largest family of Harpacticoida; its representatives can be found in freshwater habitats such as ponds, wetlands, hot springs, glacial melt water and damp moss (BOXSHALL & HALSEY 2004). Some species of the genera belonging to it have been inadequately described and most are in need of urgent revision (WELLS 2007). For example, the high intraspecific variability of some of the 150 species of the six subgenera of *Attheyella* Brady, 1880 has not been documented adequately. Thus, many species, e.g. the type species *Attheyella crassa* (G. O. Sars, 1863), have a wide distribution and it is known throughout the Palaearctic Region, both in Eurasia and North Africa (DEFAYE & DUSSART 2011). However, recent morphological and molecular advances in copepod systematics have shown that many supposedly cosmopolitan freshwater species have a more restricted geographical distribution (KARANOVIC & KRAJICEK 2012, KARANOVIC et al.

2016). On the other hand, the diagnosis of the genus *Attheyella* and its subgenera need to be amended. Taxonomists working on the Harpacticoida still rely on and follow the generic diagnosis given by Lang in 1948 (CARAMUJO & BOAVIDA 2009) and have arbitrarily placed new taxa into the genus *Attheyella* (see KIM et al. 2005).

The aim of this study is to contribute to the taxonomy of the family Canthocamptidae and the genus *Attheyella* through a detailed morphological redescription and molecular data of *A. (A.) crassa* from Turkey as well as to revise the previous descriptions of this species. Since its early description by BRADY (1880), the species boundaries of *A. (A.) crassa* have been extended through subsequent records from distant localities. The differences observed between some distant populations of *A. (A.) crassa* strongly indicate that this species is composite, probably representing an amalgam of several related species.

*Corresponding author: sonmezserdar@gmail.com

Materials and Methods

Specimens were collected from a spring-fed artificial pond in the Tut District of the Adıyaman Province (37°48'43.6464" N; 37°55'7.5612" E) in February 2017. The samples were collected with a hand net (mesh size 60 µm) and fixed with 99% ethanol. Copepods were sorted with an Irwin loop under an Olympus SZX-12 stereo microscope and preserved in 99% ethanol at +4°C. Specimens for morphological analysis were prepared as described in KARAYTUĞ & SAK (2006). KAYMAK & KARAYTUĞ (2014) were followed for preparing the specimens for SEM examination. Specimens that were used in molecular analysis were placed temporarily on cavity slides with glycerol for identification and then transferred to 99% ethanol. Identification and drawings were made with an Olympus BX-53 binocular microscope. SEM observations were made with a Zeiss SUPRA 55VP (FESEM) scanning electron microscope in the Mersin University Advanced Technology Education, Research and Application Centre (MEITAM). All specimens that were used in the morphological analysis have been deposited in the collection of the Adıyaman University Zoology Museum (ZMADYU). We followed HUYS et al. (1996) for the terminology used in the text. Abbreviations used are: Pl–P6 for swimming legs 1–6; exp (endp)–1 (–2, –3) to denote the proximal (middle, distal) segment of a ramus. Armature formula is according to LANG (1948).

The method described by MONTERO PAU et al. (2008) was followed to isolate DNA from the bulk of eggs of ovigerous females. For this purpose, eggs of 6 females were dissected in 99% ethanol. After dissection of the eggs, the whole body of the adult females were stored in ethanol as vouchers. Eggs were then transferred to dH₂O and kept for 2 h at room temperature to remove the ethanol. Once the ethanol was removed, the eggs were transferred into a 0.2 mL tube containing 50 µL of alkaline lysis buffer (NaOH 25mM, disodium EDTA 0.2mM, pH 8.0) and minced with the help of a sterile pipette tip. Then, 50 µL of neutralising buffer (Tris-HCl 40mM, pH 5.0) was added to the tube. Partial sequence of 28S rRNA gene was amplified through polymerase chain reaction (PCR) using 10X HotStarTaq DNA Polymerase buffer (GeneAll), 2U HotStarTaq DNA Polymerase (GeneAll), 400 µM of each dNTP, 5 µL of the template, 10 µM of each PCR primer and dH₂O in PCR thermal cycler (PROGENE). The amplification primers used were 28S-01 (5' GAC TAC CCC CTG AAT TTA AGC AT 3') and 28SR-01 (5' GAC TCC TTG GTC CGT GTT TCA AG 3') (SØRENSEN et al. 2015).

The amplification protocol was as follows: initial denaturation for 5 min at 94°C, 35 cycles of denaturation for 45 s at 94°C, annealing for 45 s at 50°C, extension for 2 min at 72°C and final extension for 5 min at 72°C. PCR results were checked by electrophoresis of the amplification products on 1% agarose gel with ethidium bromide. The sequencing reaction was carried out by BMLabosis (Ankara/Turkey). Forward and reverse sequences were assembled to construct a contig using CAP contig assembly of the BioEdit software package (HALL 1999).

Results

A 725 bp fragment of 28S rRNA was successfully sequenced and submitted to GenBank under accession number MG020727.

Attheyella Brady, 1880

Attheyella (*Attheyella*) *crassa* (G. O. Sars, 1863)

Material examined: 2 ♀♀ (ZMADYU 2017/134–135) and 1 ♂ (ZMADYU 2017/136) dissected on 8 slides; 2 ♀♀ and 1 ♂ used for critical point dried for SEM observations; 6 ♀♀ (egg sacs dissected for DNA isolation) (ZMADYU 2017/137)

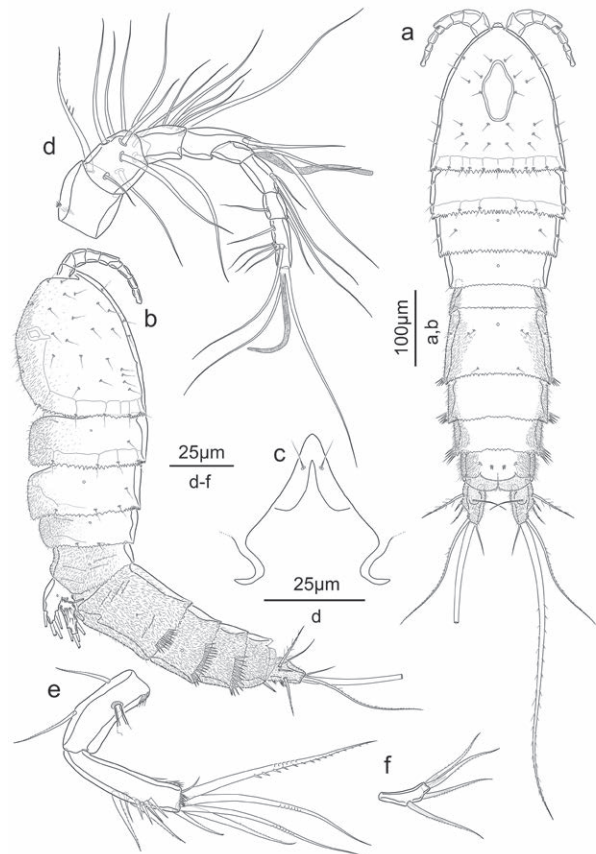


Fig. 1. *Attheyella* (*Attheyella*) *crassa*, female: a. habitus, dorsal; b. habitus, lateral; c. rostrum; d. antennule; e. antenna; f. exopod of antenna.

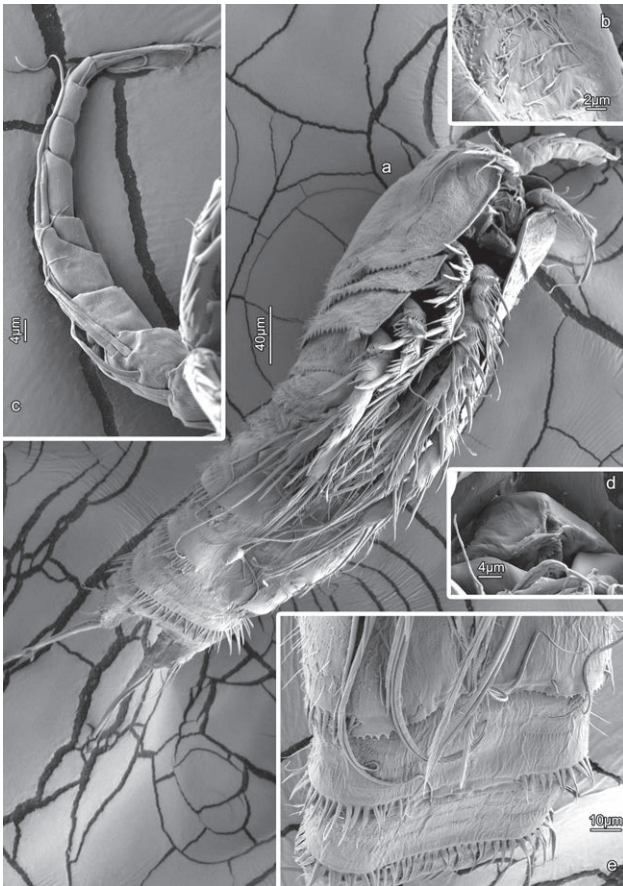


Fig. 2. *Attheyella (Attheyella) crassa*, female, SEM: a. habitus, ventral; b. ornamentation of pleural areas; c. antennule; d. labrum; e. urosome, ventral.

and 2 ♂♂ (ZMADYU 2017/138) undissected are deposited in 99% ethanol.

Description (Figs. 1–7)

Female

Total body length measured from anterior margin of rostrum to posterior margin of caudal rami, 680µm. Body slightly compressed laterally, prosome slightly wider than urosome, posterior margins of all somites serrated. Dorsal and lateral surface of body somites ornamented with sensillae (Figs. 1a, b). Dorsolateral margins of all somites with fine setules (Figs. 1a, b, 2a, b, 3a). Rostrum (Fig. 1c) very small, bent ventrally, triangular, armed with two short sensilla, fused to cephalothorax. The latter with dorsal integumental window (Fig. 1a). Pleural area of prosomites well-developed. Genital somite and first abdominal somite completely fused, genital field as shown (Fig. 3a). Anal somite with two dorsal sensilla, with two pores and three symmetric spinules ventrally (Fig. 3a); anal operculum slightly convex, with short posterior spinules.

Outer edge of caudal rami (Figs. 3a–c, 4a, b) markedly tapering from midline to posterior margin,

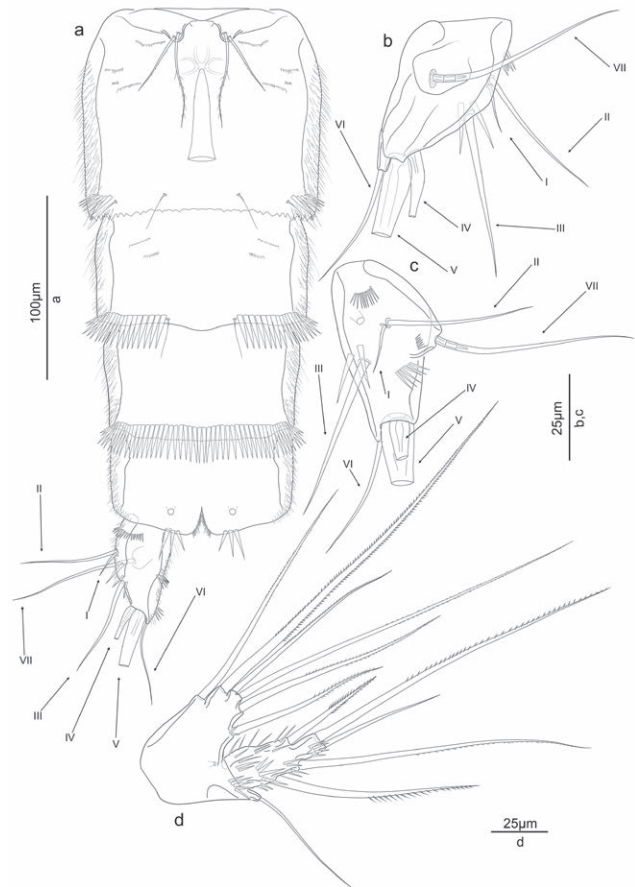


Fig. 3. *Attheyella (Attheyella) crassa*, female: a. urosome, ventral; b. caudal rami, dorsal; c. caudal rami, lateral; d. P5.

dorsal surface produced into a conic projection bearing seta VII; with 7 elements; seta I small and naked, located laterally at the ventral of seta II; seta II naked, close to seta I; seta III long and naked, about as long as seta II, with two spinules near its base; seta IV distally unipinnate, about 4 times as long as caudal ramus; seta V bipinnate, about 2.5 times as long as seta IV; seta VI issuing from short pedestal at inner distal corner, short and naked; seta VII biarticulated at base, issuing from cuticular dorsal projection, naked.

Antennule (Figs. 1d, 2c) eight-segmented, cylindrical, gradually tapering distally. First segment with short row of spinules; fourth segment with aesthetasc fused basally to a long slender seta arising from pedestal; last segment with apical acrothek, consisting of relatively short aesthetasc, fused basally to two long bare setae. Armature formula: 1– [1 spinulose], 2– [10], 3– [5], 4– [1+(1+ae)], 5[1], 6[3], 7[2], 8[5+acrothek].

Antenna (Figs. 1e, f) with allobasis and unisegmented endopod. Allobasis elongated, about 2.7 times as long as wide; with a row of inner short

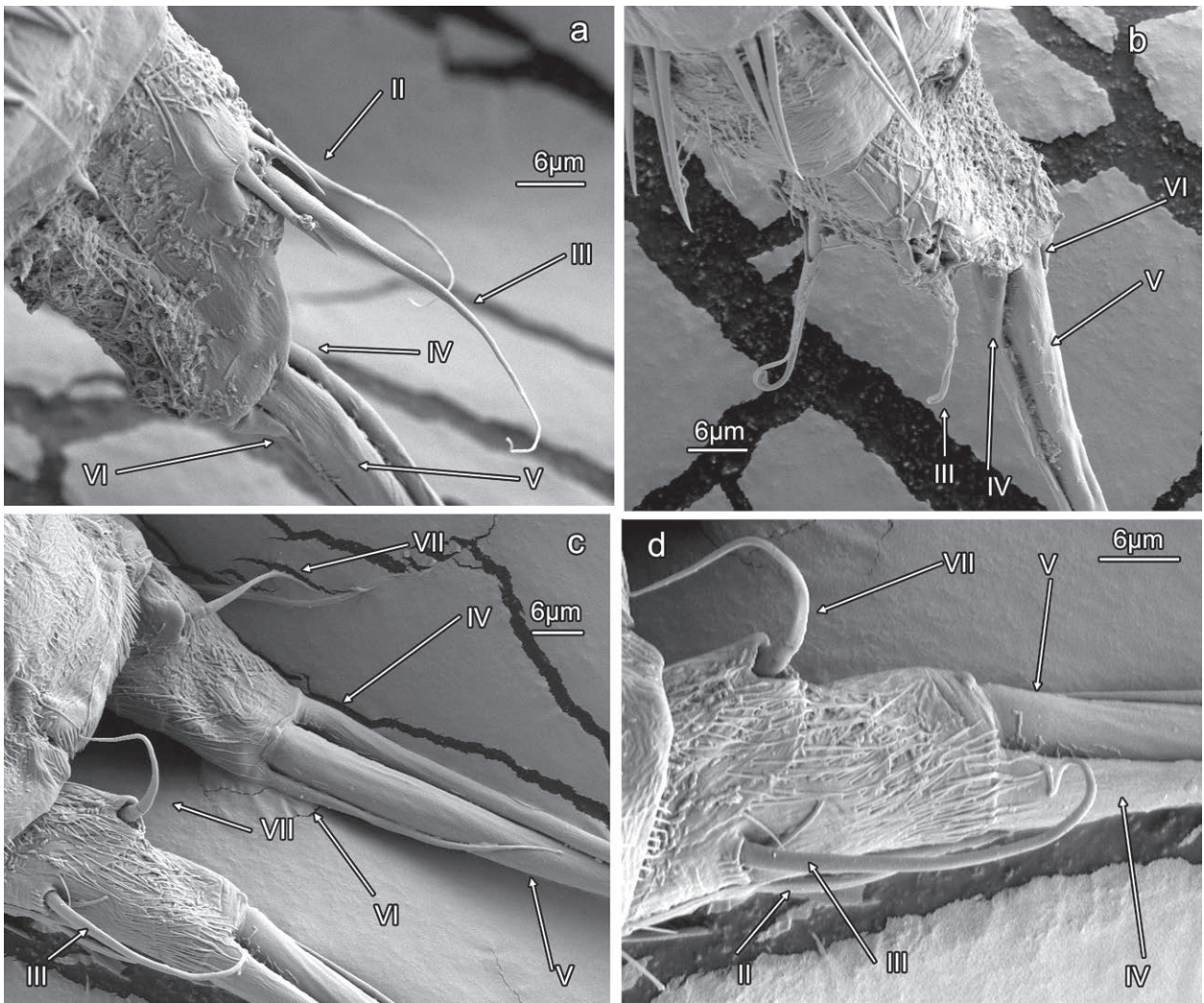


Fig. 4. *Attheyella* (*Attheyella*) *crassa*, caudal rami, SEM: a, b. female; c, d. male.

spinules proximally, with two unipinnate setae. Endopod elongated, about 4 times as long as wide, with long strong inner spinules along distal half, with rows of short spinules distally and on outer margin; lateral armature comprised of two strong unipinnate spines; apical armature of two geniculate setae basally fused, one long unipinnate geniculate seta, two unipinnate spines and one minute seta (Fig. 1e). Exopod (Fig. 1f) unisegmented, with two lateral unipinnate and two apical bipinnate setae.

Labrum (Figs. 2d, 5a) well-developed, with strong anterior spinules.

Mandible (Figs. 5b, c) with well-developed gnathobase, the latter with several strong and one multicuspitate tooth (Fig. 5b). Palp (Fig. 5c) two-segmented; first segment with one bare seta, arising from pedestal; second segment with four apical setae, two of them basally fused.

Maxillule (Fig. 5d). Arthrite of praecoxa fused basally with coxa, the former with seven strong spines and a minute plumose seta apically, the lat-

ter with short spinular row, bipinnate spine and bare seta; basis with row of spinules, with three bare seta laterally and one strong bipinnate spine apically.

Maxilla (Fig. 5e). Syncoxa with two endites; proximal endite with short row of spinules, strong bipinnate spine and one bare seta, the former fused basally to endite; distal endite with row of short spinules and two bare apical setae. Allobasis drawn out into unipinnate claw, with bare seta near base of claw. Endopod very small, squarish, with two bare setae.

Maxilliped (Fig. 5f). Syncoxa with very fine spinules near outer distal corner and with plumose seta at inner distal corner. Basis elongated, about 2.5 times as long as wide, with row of inner spinules on anterior and posterior surfaces. Endopod strong, curved, unipinnate claw with accessory seta.

P1–P4 (Figs. 6a–d) intercoxal sclerites well-developed, surface without ornamentation (P1) or ornamented with coarse spinules (P2–P4); coxa and basis well-developed, with several rows of spinules.

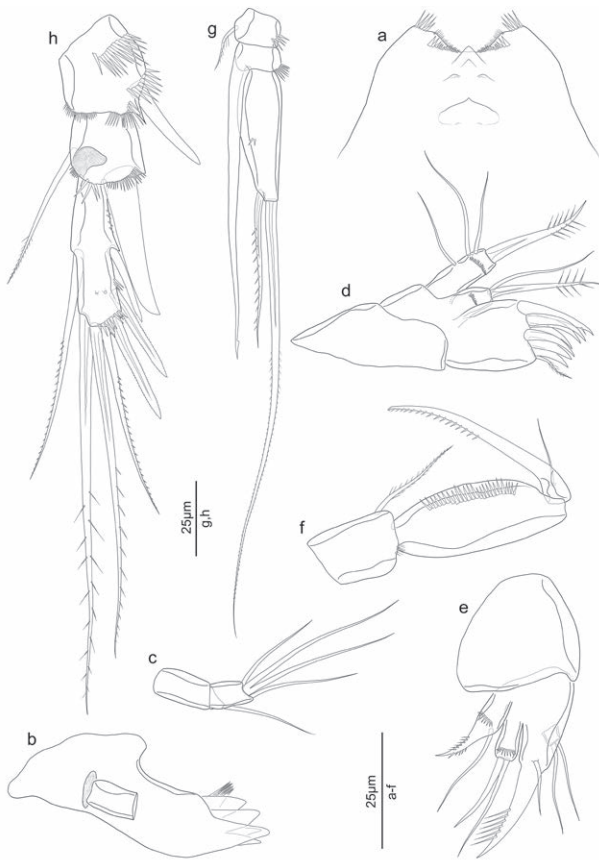


Fig. 5. *Attheyella* (*Attheyella*) *crassa*, a–f. female, h, g. male: a. labrum; b. mandible; c. mandibular palp; d. maxillule; e. maxilla; f. maxilliped; g. P3 exopod; h. P3 endopod.

Basis of P1 with naked inner spine close to endopod and strong bipinnate outer spine. P2–P4 basis without inner armature, with strong outer bipinnate spine (P2) or plumose outer seta (P3–P4); with (P3–P4) or without (P1–P2) a pore on anterior surface.

P1 (Fig. 6a) with three-segmented rami. Endopod slightly longer than exopod; endp–1 elongated, as long as half of total length of ramus, with strong spinules and bipinnate spine at inner distal corner; endp–2 with strong outer spinules, with bipinnate spine near inner distal corner; endp–3 with bare seta at inner distal corner, long geniculate seta and long bipinnate spine with tip curved apically. Exp–1 with two rows of strong outerspinules and strong unipinnate seta with a curved tip near outer distal corner. Exp–2 with strong outer spinules, strong unipinnate seta with curved tip near outer distal corner and plumose seta at inner distal corner reaching about end of last segment. Exp–3 with two long geniculate setae apically and two long strong unipinnate outer spines with curved tips.

P2–P4 (Figs. 6b–d) with two-segmented endopod and three-segmented exopod. Endp–1 very short and squarish, with strong bipinnate spine (P2) or seta at inner edge (P3 and P4). Endp–2 elongated, reaching about the distal margin of exp–2 (P2–P3) or exp–1 (P4). Exp–1 slightly longer than wide, with strong outer spinules, without inner armature, with strong bipinnate outer spine. Exp–2 about as long as exp–1,

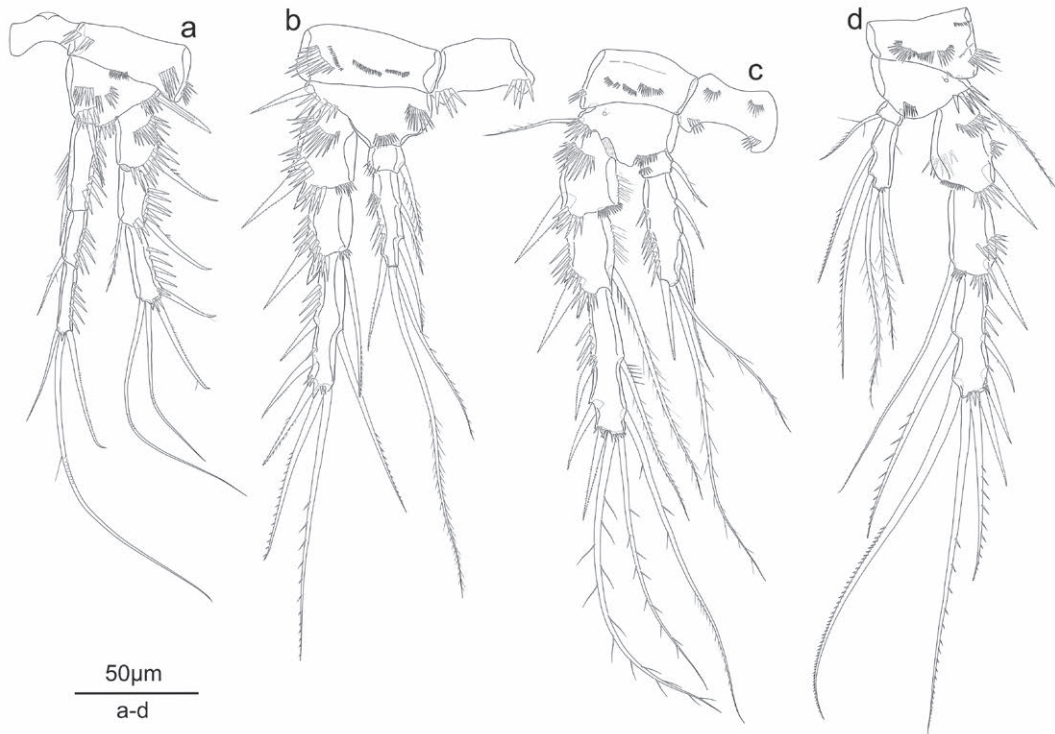


Fig. 6. *Attheyella* (*Attheyella*) *crassa*, female: a. P1; b. P2; c. P3; d. P4.

with strong outer spinules, inner spine (P2) or seta (P3–P4), with a strong bipinnate outer spine. Exp–3 elongated, about 4 (P2–P3) or 3.5 times (P4) as long as wide, with two bipinnate outer spines, relatively long bipinnate spine at outer distal corner, two unipinnate (P2–P4) or bipinnate (P3) setae at tip and one (P2) or two (P3–P4) inner setae. Setal formula of the swimming legs as follows:

P1		P2	
Exopod	Endopod	Exopod	Endopod
0.1.022	1.1.120	0.1.123	1.221
P3		P4	
Exopod	Endopod	Exopod	Endopod
0.1.223	1.321	0.1.223	1.320

P5 (Fig. 3d) baseoendopod and exopod distinct. Baseoendopod with strong spinules near articulation of exopod, outer naked basal seta arising from short and narrow pedestal with anterior pore. Endopodal lobe slightly elongated, with 6 elements. Exopod elongated, about 2.5 times as long as wide measured from the midline of anterior surface, with well-developed spinules. Exopod bears with 5 elements.

Both P6 (Fig. 3a) almost distinct, connected by very thin cuticular line at inner proximal, symmetrical, each leg carries one plumose and one bipinnate setae.

Male

Body length measured from tip of rostrum to posterior margin of caudal rami 683 μm . Posterior margin of urosomites with well-developed spinules (Figs. 7a, b). Antennule, P3 both rami, P5, P6 and caudal rami sexually dimorphic.

Caudal rami (Figs. 4c, d, 7a, b) gradually tapering posteriorly, about 1.7 times as long as wide, dorsal surface swollen proximally. Seta I relatively smaller than that of female, seta VI not arising from pedestal.

Antennule (Fig. 7c) nine-segmented, subchirocer, with geniculation between segment 6 and 7. First segment with short row of spinules; third segment very short; fourth segment swollen, with an aesthetasc and long bare seta fused basally and arising from pedestal; last segment elongated, with apical acrothek consisting of relatively short aesthetasc fused basally to two long bare seta. Armature formula as follows: 1–[1], 2–[6], 3–[4], 4–[9+(1+ae)], 5–[0], 6–[1], 7[0], 8–[1], 9–[7+acrothek].

P3 endopod (Fig. 5g) and exopod (Fig. 5h) three-segmented. Endp–1 short and squarish, with short plumose seta. Endp–2 about as long as endp–1, with apophysis, latter with hook at tip, fused to

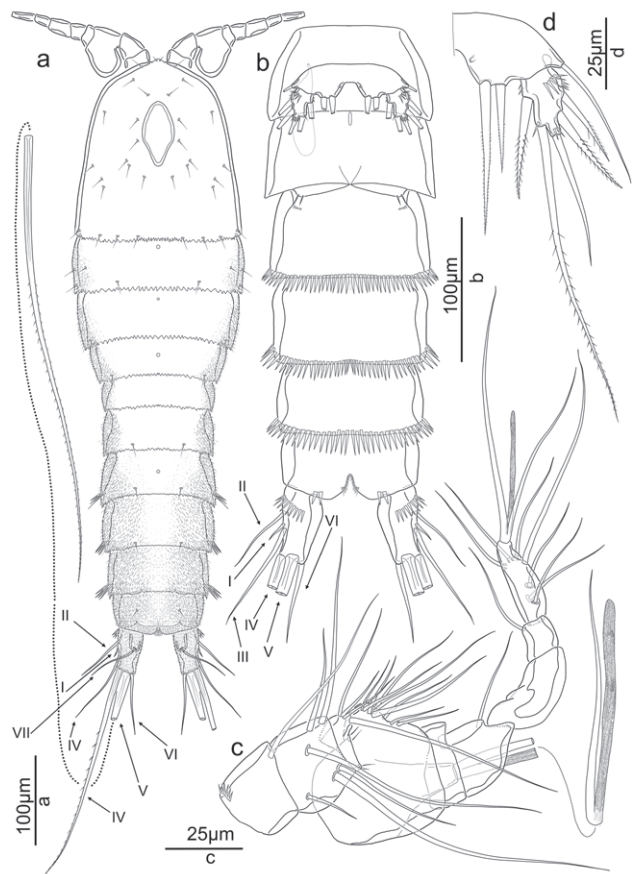


Fig. 7. *Attheyella (Attheyella) crassa*, male: a. habitus, dorsal; b. urosome, ventral; c. antennule; d. P5.

the inner anterior margin of the segment and about 1.6 times as long as endopod. Endp–3 elongated, about 3 times as long as wide, with strong unipinnate spine and very long bipinnate seta. Exp–1 with strong outer spine and ornamented as figured. Exp–2 with very long and strong modified outer spine and inner seta with plumose tip; cuticle of inner distal quarter of anterior surface very thin (shaded in Fig. 5g). Exp–3 elongated, about 3.5 times as long as wide, with two small anterior pores, three strong outer spines and four setae.

Both P5 (Figs. 7b, d) fused. Baseoendopod and exopod distinct. Baseoendopod with anterior tube pore near proximal part of inner margin, with two bipinnate spines. Exopod slightly elongated, with several strong spinules, with five elements.

P6 (Fig. 7b) strongly reduced, each with two bare setae.

Discussion

Attheyella (Attheyella) crassa was originally described (but not figured) as *Canthocamptus crassus* from Norway by Sars (1863). The species was subsequently found by Brady (1880) in samples from

Britain. He considered his material as belonging to a new species and described it as the type of the genus *Attheyella*, *A. spinosa*. The form recorded by the same author at a later date as *Paratachidius inermis* is now synonym of *Mesochra inermis* (BRADY 1902). Later on, SARS (1907) distinguished BRADY's species from *Canthocamptus crassus* and accepted *A. spinosa* as a synonym of SARS' species. However, upon comparison of the original figures of SARS (1907) and BRADY (1880), some doubts arose about the conspecificity of these two forms. Firstly, it must be noted that BRADY (1880) was dealing with two populations of *A. spinosa* – some specimens were collected from an old engine-pond at the Murton Junction, near Sunderland (England), and a single specimen was found in a sample sent by Mr. David Robertson from an old canal at Peterhead (England). Upon revision of the original drawings, it seems evident that BRADY (1880) has been dealing with two different species. For example, the fifth leg of the single specimen from Peterhead and of the specimens from the Murton Junction are different (with five setae on the baseoendopod of the material from the Murton Junction but six setae in the specimens from Peterhead). Unfortunately, BRADY (1880) showed the P5 of the specimens from the Murton Junction only and it is not possible to confirm that the variability in the armature complement of the baseoendopod of P5 in both populations is attributable to interpopulation variability. In addition, BRADY (1880) figured the last exopodal segment of P2 of the material from the Motor Junction with six setae but it was figured with five setae in subsequent descriptions from Norway (SARS 1907), Britain (GURNEY 1932), Russia (BORUTSKY 1952), China (TAI & SONG 1979), Japan (ISHIDA 1987, ISHIDA & KIKUCHI 2000), Korea (CHANG & LEE 2003) and Portugal (CARAMUJO & BOAVIDA 2009). Also, the last endopodal segment of P2 was figured with four elements in SARS' (1907) description but with five elements in all other descriptions except for the male specimens reported by ISHIDA (1987) and CHANG & LEE (2003) from Japan and Korea, respectively (see discussion below). Despite all these differences, SARS' (1907) view has been accepted and *A. (A.) crassa* became established in the literature because subsequent researchers simply followed SARS (1907), even though his descriptions were not adequate according to modern standards. The variability observed between some of these distant populations strongly indicates that *A. (A.) crassa* is a species complex composed of probably related taxa. For example, the relative length of P1 enp-1 significantly differs between specimens. Unfortunately, the surface ornamentation was shown in CHANG & LEE (2003) only and it is impossible to

evaluate the differences in ornamentation in the different redescrptions. As many species within the genus are now separated from each other by only differences in the spinular ornamentations on P5 exopod or anal operculum (WELLS 2007), variation in the armature of P2–P4 in female and male strongly indicates the presence of different species of *Attheyella* reported under the name of *A. (A.) crassa*.

As discussed above, BRADY (1880) and SARS (1907) were almost certainly dealing with different species. For example, the armature complement of P2–P4 enp-2 is 4.5.5 in BRADY (1880) but 5.5.5 in SARS (1907). Subsequent records of the species, viz. GURNEY (1932), BORUTSKY (1952), TAI & SONG (1979), ISHIDA (1987), ISHIDA & KIKUCHI (2000), CHANG & LEE (2003), CARAMUJO & BOAVIDA (2009), showed a different armature complement: 5.6.5 in P2–P4 enp-2. Also, the material reported by BORUTSKY (1952) from Russia could belong to a different species. BORUTSKY (1952) observed six setae/spines on P4 exp-3 but seven setae/spines have been observed in all other populations, including the material reported herein.

In addition, the following characters almost certainly indicate a species differing from *A. (A.) crassa*: (a) male P2–P4 armature formulas (with four setae instead of five in male P2 endp-2; with an inner seta on P3 exp-1, absence of an inner seta on P4 endp-1 and with three setae on P4 enpd-3 instead of five); (b) the proportional length of P1 enpd-1 of female; (c) the relative shortness of the setae on female P5 in East Asian specimens that were reported from East Korea (CHANG & LEE 2003) and Japan (ISHIDA 1987).

Examination with differential interference contrast and SEM revealed complex spinular ornamentation in the material presented herein. Such spinular ornamentation has been overlooked by previous authors. These minor details may be useful for future comparisons of *A. (A.) crassa* from other localities, as well as for species delineation. We believe that the present study is the first step towards a better understanding of the species and genetic diversity of the *A. (A.) crassa* species complex.

References

- BORUTSKY E. V. 1952. Fauna of USSR. Crustacea: Crustaceans freshwater harpacticoids. Moscow – Leningrad: Izdatel'stvo AN USSR.
- BOXSHALL G. A. & HALSEY S. H. 2004. An introduction to copepod diversity. London: Ray Society 166: 1–966.
- BRADY G. S. 1880. A monograph of the free and semi-parasitic Copepoda of the British Islands. Vol. 2. London: Ray Society.
- BRADY G. S. 1902. New Irish copepod crustaceans. Irish Naturalist 11: 102.

- CARAMUJO M. J. & BOAVIDA M. J. 2009. The practical identification of harpacticoids (Copepoda, Harpacticoida) in inland waters of Central Portugal for applied studies. *Crustaceana* 82 (4): 385–409.
- CHANG C.Y. & LEE J. M. 2003. Taxonomy on freshwater canthocamptid harpacticoids (Copepoda) from South Korea I. Genus *Canthocamptus*. *Korean Journal of Systematic Zoology* 19 (1): 149–159.
- CHAPPUIS P. A. 1929. Die Unterfamilie der Canthocamptinae. *Archiv für Hydrobiologie* 20: 471–516.
- DEFAYE D. & DUSSART B. 2011. World directory of Crustacea Copepoda of Inland Waters. III. Harpacticoida, Gellyelloida. Weikersheim: Backhuys Pu., Margraf Pu. GmbH.
- GURNEY R. 1932. *British Freshwater Copepoda*. Volume 2. London: Ray Society.
- HALL T. A. 1999. BioEdit: A user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium Series* 41: 95–98.
- HUYS R., GEE J. M., MOORE C. G. & HAMOND R. 1996. Synopses of the British Fauna (New Series) No. 51. Marine and Brackish Water Harpacticoids, Part 1. Shrewsbury: Field Studies Council.
- HUYS R., LLEWELLYN-HUGHES J., OLSON P. D. & NAGASAWA K. 2006. Small subunit rDNA and Bayesian inference reveal *Pectenophilus ornatus* (Copepoda incertae sedis) as highly transformed Mytilicolidae, and support assignment of Chondracanthidae and Xarifiidae to Lichomolgoidea (Cyclopoida). *Biological Journal of the Linnean Society* 87 (3): 403–425.
- ISHIDA T. (1987). Freshwater harpacticoid copepods of Hokkaido, northern Japan. *Scientific Reports of the Hokkaido Salmon Hatchery* 41: 77–119.
- ISHIDA T. & KIKUCHI Y. 2000. Illustrated fauna of the freshwater harpacticoid copepods of Japan. *Bulletin of the Biogeographical Society of Japan* 55: 7–94.
- KARANOVIC T., DJURAKIC M. & EBERHARD S. (2016). Cryptic Species or Inadequate Taxonomy? Implementation of 2D Geometric Morphometrics Based on Integumental Organs as Landmarks for Delimitation and Description of Copepod Taxa. *Systematic Biology* 65 (2): 304–327.
- KARANOVIC T. & KRAJICEK M. 2012. When anthropogenic translocation meets cryptic speciation globalised bouillon originates; molecular variability of the cosmopolitan freshwater cyclopoid *Macrocyclus albidus* (Crustacea: Copepoda). *Annales de Limnologie* 48: 63–80.
- KARAYTUĞ S. & SAK S. 2006. A contribution to the marine harpacticoid (Crustacea, Copepoda) fauna of Turkey. *Ege Journal of Fisheries and Aquatic Sciences* 23: 403–405.
- KAYMAK N. B. & KARAYTUĞ S. 2014. Systematics of the genus *Heterolaophonte* (Crustacea, Copepoda, Harpacticoida) with redescription of *H. uncinata* and *H. curvata*. *Zootaxa* 3780 (3): 503–533.
- KIM B. W., SOH H. Y. & LEE W. 2005. A new species of the genus *Attheyella* (Copepoda: Harpacticoida: Canthocamptidae) from Gosu cave in Korea. *Zoological Science* 22 (11): 1279–1293.
- MONTERO-PAU J., GÓMEZ A. & MUÑOZ J. 2008. Application of an inexpensive and high-throughput genomic DNA extraction method for the molecular ecology of zooplanktonic diapausing eggs. *Limnology and Oceanography: Methods* 6 (6): 218–222.
- SARS G. O. 1907. *An Account of the Crustacea of Norway*. Volume 5. Copepoda Harpacticoida. Bergen: Bergen Museum.
- SARS G. O. 1863. Oversigt af de indenlandske Ferskvandscopepoder. *Forhandlingeri Videnskabs – Selskabeti Christiana* 1862: 212–262.
- SØRENSEN M. V., DAL ZOTTO M., RHO H. S., HERRANZ M., SÁNCHEZ N., PARDOS F. & YAMASAKI H. 2015. Phylogeny of Kinorhyncha Based on Morphology and Two Molecular Loci. *Plos One* 10 (7): 1–33.
- TAI A. Y. & SONG Y. Z. 1979. Harpacticoida Sars, 1903. In: SHEN C. J. & Fauna Editorial Committee (Eds.). *Freshwater Copepoda*. Fauna Sinica, Crustacea. Beijing: Science Press.
- WELLS J. B. J. 2007. An annotated checklist and keys to the species of Copepoda Harpacticoida (Crustacea). *Zootaxa* 1568: 1–872.

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