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ORIGINAL PAPER

Pseudoneotachidius sinuspersici gen. et sp. nov., a new member of the family Tachidiidae Boeck, 1865 (Copepoda: Harpacticoida) from Iran

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Abstract

A new member of the harpacticoid copepod family Tachidiidae Boeck, 1865 was found in sediment samples of meiobenthic harpacticoids taken during a study on the diversity of meiobenthic harpacticoids along the northern coast of the Persian Gulf. The taxonomic analysis of this material revealed that it contained an undescribed species. A new genus is herein proposed to accommodate the new species. The new genus, *Pseudoneotachidius* gen. nov., displays superficial similarities with *Neotachidius* Shen & Tai, 1963 and *Cithadius* Bowman, 1972, and a closer relationship is hypothesized with the former. The lack of a midventral copulatory pore, the female P5 endopodal lobe with two inner spines, and P1 with one inner seta on enp-3 are regarded here as synapomorphies for both *Neothachidius* and *Pseudoneotachidius* gen. nov. These two genera can be separated by several characters, including the structure and shape of the male fourth antennulary segment, segmentation of the antennary exopod, ornamentation of the male P2 enp-3, sexual dimorphism of the male P2 enp-2, structure and shape of the male P5, morphology of the male P2 and P3, male and female P5 armature complement and ornamentation, male P6, ventral spinulation pattern of the female genital-double somite, and in the mouthparts armature of among others. An updated key to the genera of the family Tachidiidae is presented.

Keywords Intertidal · Marine · New genus · New species · Persian Gulf · Taxonomy

Abbreviations

A1	antennule
A2	antenna
ae	aesthetasc
P1–P6	first to sixth swimming legs
enp	endopod
exp	exopod
enp-1,2,3	proximal, middle, distal segments of endopod
exp-1, 2, 3	proximal, middle, distal segments of exopod

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Introduction

Our knowledge on the diversity of benthic copepods from the Persian Gulf and the Gulf of Oman is still lagging. The first comprehensive taxonomic studies on the diversity of benthic copepods from the Persian Gulf and the Gulf of Oman started in year 2016, and only five species of benthic copepods (*Brianola haliensis* Nazari, Mirshamsi, Sari, Aliabadian & Martínez Arbizu, 2018b; *Canuella persica* Nazari, Mirshamsi, Sari, Aliabadian & Martínez Arbizu, 2018b; *Canuellina insignis* Gurney, 1927; *Delavalia longifurca* (Sewell, 1934); and *Scottolana gomezi* Nazari, Mirshamsi, Sari, Aliabadian & Martínez Arbizu, 2018b) are known so far from this area (Mohammed 2018; Nazari et al. 2018a, b).

Recent studies on the diversity and community structure of meiobenthic harpacticoid copepods from the northern coast of the Persian Gulf and the Gulf of Oman resulted in the discovery of a new species of the family Tachidiidae Boeck, 1865. The new species, however, could not be accommodated in any of the known genera; thus, a new genus is proposed herein to accommodate this species.

The present paper deals with the erection of a new genus, *Pseudoneotachidius* gen. nov. (Harpacticoida: Tachidiidae), to accommodate a new species found in sediment samples of Iran tide pools. This is the third contribution on the diversity of marine meiobenthic copepods from Iranian waters.

Materials and methods

Meiofauna samples were collected during low tide in several tide pools along the Iranian coast of the Persian Gulf and the Gulf of Oman using a 60 cc syringe. Sediment samples were sieved using 200 and 35 μm sieves to separate macro- and meiofauna. The material retained in the 35 μm sieve (meiofauna) was preserved in 96% ethanol.

Fig. 1 *Pseudoneotachidius sinuspersici* gen. et sp. nov., female, confocal laser microphotograph. **a** Habitus, dorsal; **b** habitus, ventral; **c** habitus, lateral

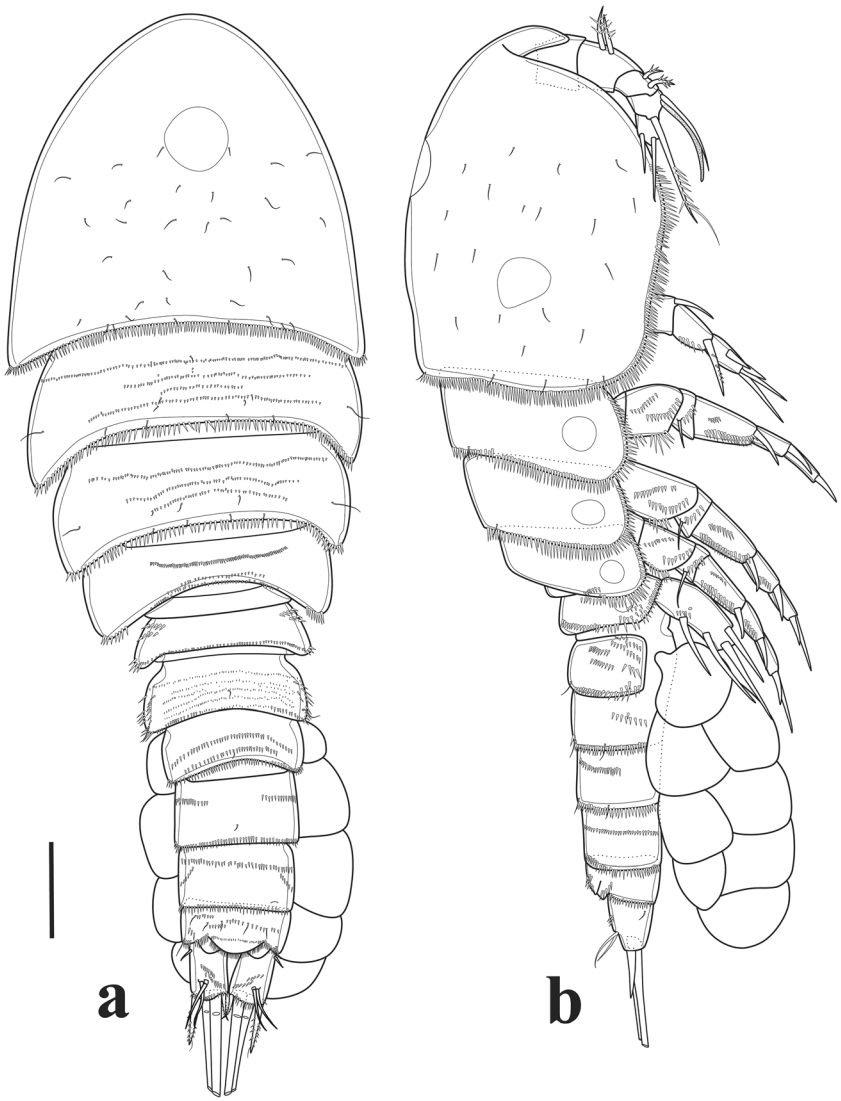

Fig. 2 *Pseudoneotachidius sinuspersici* gen. et sp. nov., female. **a** Habitus, dorsal view; **b** habitus, lateral view. Scale bar: 50 μm

Harpacticoid copepods were separated through repeated decantation, sorted manually using an Olympus SZH stereomicroscope, and preserved in 96% ethanol for further investigations. One male and female were stained in 1:1 solution of Congo Red and Acid Fuchsin overnight (Michels and Büntzow 2010). Microphotographs of whole specimens were taken with a Leica TCS SP5 equipped with a Leica DM5000 B upright microscope and three visible-light lasers (DPSS 10 mW 561 nm; HeNe 10 mW 633 nm; Ar 100 mW 458, 476, 488, and 514 nm), combined with the software LAS AF 2.2.1.—Leica Application Suite Advanced Fluorescence. Dissected parts of the specimens were mounted in glycerin and slides were sealed with a mixture of wax and paraffin, and in the end, with insulating transparent nail varnish. Observation and drawings were made using a Leica DMR differential interference contrast microscope at a magnification of ×1000.

The type material was deposited in the collection of the German Centre for Marine Biodiversity Research (DZMB), Senckenberg am Meer in Wilhelmshaven, Germany.

Results

Order **Harpacticoida** Sars, 1903

Family **Tachidiidae** Boeck, 1865

***Pseudoneotachidius* gen. nov.**

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Etymology. The prefix "pseudo" from the Ancient Greek ψευδής, false, makes reference to its close and deceptive resemblance to the genus *Neotachidius* Shen & Tai, 1963. Gender masculine.

Diagnosis. Body cyclopoid. P1-bearing somite fused to cephalosome. Antennule short, five-segmented in female,

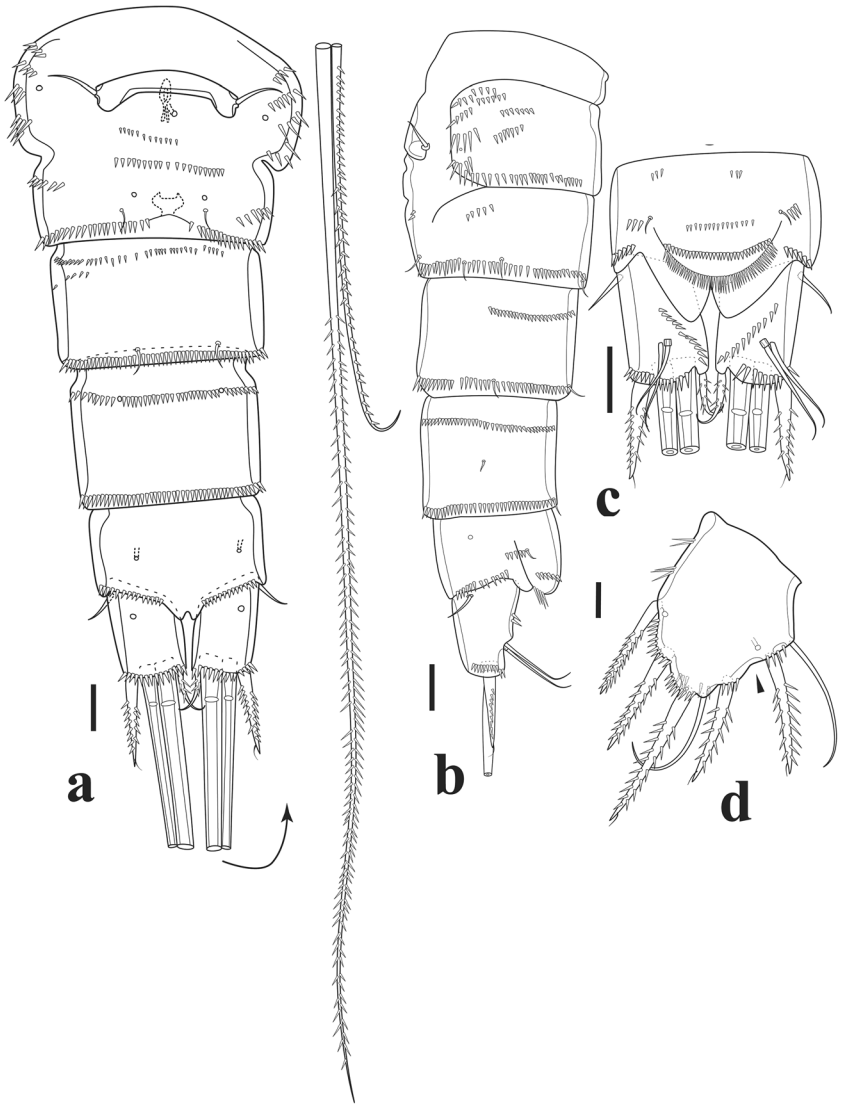

Fig. 3 *Pseudoneotachidius sinuspersici* gen. et sp. nov., female. **a**, Urosome, ventral (P5-bearing somite omitted); **b**, urosome, lateral (P5-bearing somite omitted); **c**, anal somite and furcal rami, dorsal; **d**, P5, anterior. Scale bars: 10 μm

seven-segmented and chirocer in male. Antenna with basis and two-segmented endopod; exopod one-segmented. Mandible with two setae on basis; endopod with nine, exopod with five setae. Maxillule with 12 elements on praecoxal arthrite; coxa with five, basis with six setae; exopod with one, endopod with three setae. Maxilla with three syncoxal endites; proximal endite with four, middle endite with three, distal endite with three setae; endopod one-segmented, with six setae. Maxilliped subchelate, prehensile; endopod one-segmented, with pinnate claw and accompanying seta. P1–P4 with three-segmented rami.

Armature formula of female and male:

	P1	P2	P3	P4
Exp	0.1.122	1.1.222	1.1.222	1.1.122
Enp	1.1.121	1.2.221	1.2.221	1.1.221

Male P2 and P3 sexually dimorphic. Pair of P5 distinct in both sexes, with exopod and baeoendopod fused; with seven elements in female and six elements in male. Female P6 a single transverse plate closing off genital slit, with one seta on each side; male P6 symmetrical, each leg with one inner pinnate spine and one outer naked seta.

Dimorphism expressed in the segmentation of the urosome (P6-bearing somite and third urosomite separated), antennule, P2 and P3 enp (enp-2 elongated, distal and inner armature complements of enp-3 visibly stronger), P5, and P6.

***Pseudoneotachidius sinuspersici* sp. nov., by monotypy.** http://zoobank.org/B08195B1-7D74-4A55-B7CF-7A32CAFD12BF

Type material. One dissected female holotype (SMF37213/1–15), one dissected male allotype (SMF37214/1–7), and 25 paratypes (15 females and 10 males) preserved in alcohol (SMF37215).

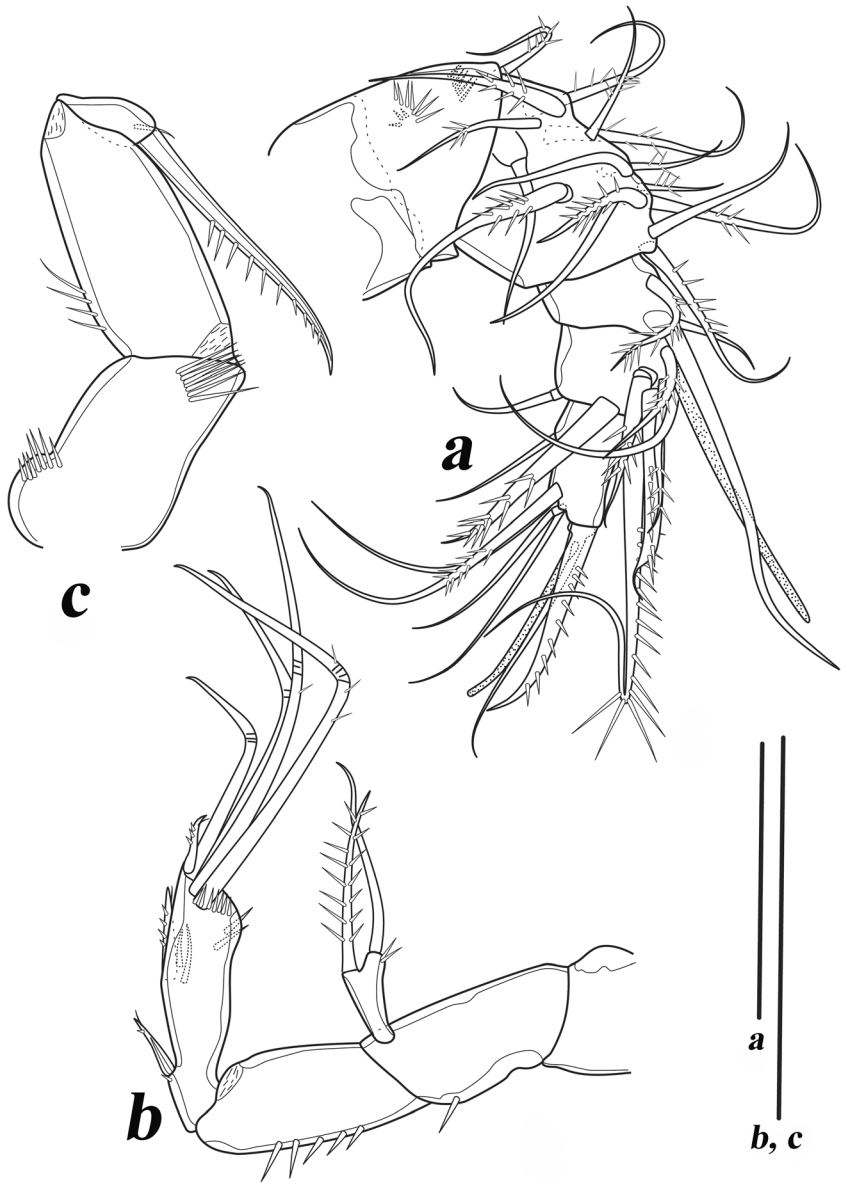

Fig. 4 *Pseudoneotachidius sinuspersici* gen. et sp. nov., female. **a** antennule; **b** antenna; **c** maxilliped. Scale bars: 50 μm

Type locality: Intertidal zone at Bushehr, Iran (50°48′ 36.86″E, 28°56′44.25″N).

Etymology. The specific epithet is derived from the Latin toponymy *Sinus Persica*, found in translations of Ptolemy and Strabo when referring to the Persian Gulf, where the new species was found. It is to be treated as a noun in apposition.

Description

Female (holotype). Body (Figs. 1a–c and 2a, b) cyclopiform, boundary between prosome and urosome distinct. Total body length from tip of rostrum to distal margin of furcal rami 520 μm.

Cephalothorax and prosomites covered with spinules along posterior and lateral margins except for denticulate margin of tergite of P4 pedigerous somite; sensilla scattered on cephalothorax dorsally.

Urosomites with dorsal rows of small spinules and sensilla. Posterior margin of P5-bearing somite denticulate, with lateral and ventral spinules as shown (Figs. 2a and 3a, b).

Genital-double somite fused ventrally (Figs. 2b and 3a), original segmentation discernible dorsally (Figs. 1a and 2a) and laterally (Figs. 1c, 2b, and 3b); genital area (Fig. 3a) located on anterior part (second urosomite) of genital-double somite; genital apertures fused medially to form genital slit, covered by extension derived from unisetose P6 (Fig. 3a) on each side; copulatory pore not recognizable, probably covered by P6 extension or located inside genital slit; single seminal receptacle positioned medially; with medial spinular rows; with rows of spinules and one pore posterior to genital silt (Fig. 3a); genital segment covered with denticles dorsally, with long spinules on along posterior margin.

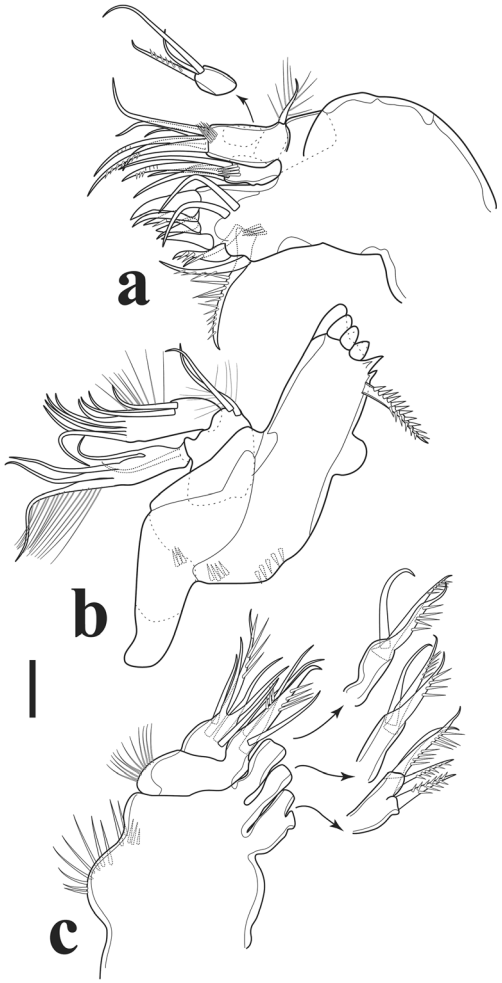

Fig. 5 *Pseudoneotachidius sinuspersici* gen. et sp. nov., female. **a** Maxillule; **b** mandible; **c** maxilla. Scale bar: 10 μm

Fourth to fifth urosomites with dorsolateral and ventral spinules as shown, with sensilla except for penultimate somite (Figs. 2a, b and 3a, b).

Anal somite with two dorsal spinular rows as figured, with two sensilla flanking semicircular anal operculum, the latter with two rows of transverse spinules (Fig. 3c); ventrally with two pores (Fig. 3a), with spinules close to joint with furcal rami ventrally (Fig. 3a) and laterally (Fig. 3b).

Furcal rami slightly convergent, slightly longer than wide (Fig. 3c), with dorsal, lateral, and ventral spinules distally (Fig. 3a–c), with oblique spinular row dorsally (Fig. 3c), with ventral pore proximally (Fig. 3a); with seven setae; lateral seta I issuing proximally, small, naked; seta II naked, located dorsally close to seta VII; seta III spiniform, bipinnate, flagellate subapically; setae IV and V bipinnate, setae V longest, two times as long as seta IV; seta VI bipinnate, bent outwards; seta VII bi-articulated, naked.

Rostrum (Fig. 2b). triangular, partly fused to cephalothorax, with two sensilla at tip, bent downwards.

Antennule (Fig. 4a). Five-segmented, with numerous pinnate setae/spines; segments smooth except for two rows of spinules on first segment. Armature formula: 1—[1 pinnate], 2—[4 naked+11 pinnate], 3—[1 pinnate+1 naked+(1 naked+ae)], 4—[2 naked+6 pinnate], 5—[4 naked+2 pinnate+(1 naked+ae)].

Antenna (Fig. 4b). Basis with one spinule on abexopodal margin. Exopod one-segmented, with one naked and one pinnate seta, with spinules at base of naked seta. Endopod two-segmented; Enp-1 with longitudinal spinular row on abexopodal margin; Enp-2 with subdistal spinules as shown, with two medial setae, and two pinnate lateral spines (one proximal, one subdistal) with subapical tubular extension; apical armature consisting of one pinnate spine with subapical tubular extension, and four geniculate setae, two of them unipinnate.

Mandible (Fig. 5b). Gnathobase with ventral spinular rows, distally with several blunt teeth, with one strongly spinulose dorsal element. Basis with two pinnate setae. Endopod one-segmented, with three lateral, and six apical naked elements; all setae fused to supporting segment. Exopod one-segmented, with one naked proximal seta, one naked lateral seta, and two naked and one pinnate apical seta; all setae fused to exopod.

Maxillule (Fig. 5a). Praecoxal arthrite with seven strong spines and one pinnate seta distally, with two surface setae, two pinnate posterior setae of which outermost longest, typically curved, and with some spinules at its base. Coxa with long anterior spinules, with four naked and one geniculate pinnate seta. Basis with long spinules distally, with two pinnate and four naked setae of which one geniculate. Endopod one-segmented, with two naked and one pinnate seta. Exopod represented by one pinnate seta.

Maxilla (Fig. 5c). Syncoxa with long outer spinules, with three endites; proximal endite slightly bi-lobed, proximal lobe with one, distal lobe with three pinnate setae; middle and distal endites cylindrical, with one naked and two pinnate setae each. Allobasis drawn out into pinnate claw, accompanied by two naked and one pinnate seta, with long outer setules. Endopod one-segmented, with three naked and one pinnate proximal seta, and two apical naked setae fused basally to endopod.

Maxilliped (Fig. 4c). Subchelate; three-segmented. Syncoxa with small outer spinules proximally, with long spinules close to inner distal corner. Basis with some proximal spinules on outer margin. Endopod one-segmented, with curved pinnate claw, and one minute seta.

P1–P4 (Figs. 6a, b and 7a, b) with three-segmented rami; intercoxal sclerite of all swimming legs with distal strong spinules on surface posterior margin.

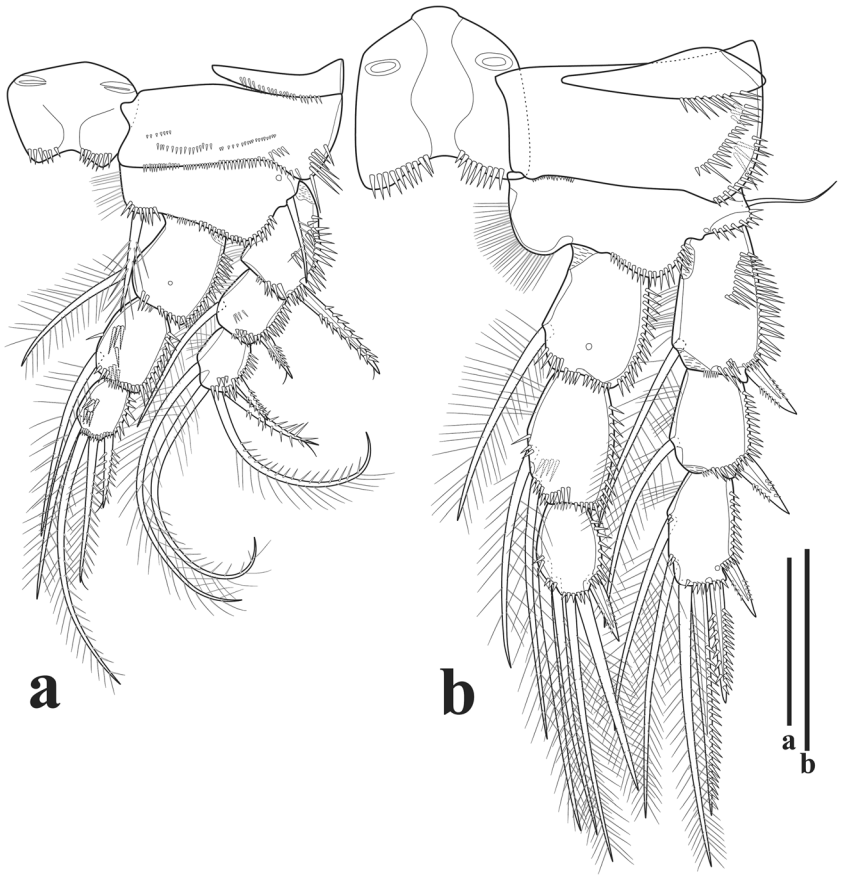

Fig. 6 *Pseudoneotachidius sinuspersici* gen. et sp. nov., female. **a** P1, anterior; **b** P2, anterior. Scale bars: 50 μm

P1 (Fig. 6a). Praecoxa small, triangular, with anterior distal spinules. Coxa with long outer spinules, and transverse rows of smaller spinules. Basis with inner and outer bipinnate seta; with row of spinules between rami and at base of inner element; with proximal outer pore. Exopod and endopod subequal in absolute length, exopod reaching middle of second endopodal segment. All exopod segments furnished with outer spinular rows, and with long inner setules; exp-1 longest; outer spine coarsely spinulose, long and strong, with subapical flagellate extension; exp-2 with pinnate inner seta, outer pinnate spine with subapical flagellate extension; exp-3 with three pinnate setae and two pinnate outer spines, the latter with subapical flagellate extension. Endopodal segments with distal and outer spinules; enp-1 largest, with one inner pinnate seta and one medial pore; enp-2 with medial spinular patch, with one inner pinnate seta; enp-3 with medial spinular patch, with three pinnate setae and one pinnate spine, the latter with subapical flagellate extension.

P2–P4 (Figs. 6b and 7a, b). Praecoxa triangular, with distal spinules. Coxa with outer spinular rows. Basis with spinules between rami and at base of outer element; inner margin of basis produced into lobate setulose expansion; outer seta naked (P2) or pinnate (P3–P4). Exopod and endopod subequal in length (P2), or exopod slightly longer than endopod (P3–P4). Exopodal segments with outer and distal spinules, with long inner setules; exp-1 and exp-2 with outer pinnate spine and inner pinnate seta; exp-3 of P2–P4 with 6, 6, 5 setae/spines, respectively. Enp-1 with spinular row on outer and distal margins, with inner pinnate seta, with subdistal anterior pore; enp-2 with spinules on outer and distal margins, with short (P2) or long inner spinules (P3–P4), with two inner pinnate setae in P2–P3 and one in P4; enp-3 with spinules along outer and distal margin, P2–P4 enp each with 5 setae/spines.

P5 (Fig. 3d). Exopod fused to baseoendopod; with two lobes indicated by slight outer concavity (arrowed in Fig. 3d); outer lobe with basal naked seta and one pinnate spine with subapical flagellate extension; inner lobe with one pinnate spine with subapical flagellate extension, one bare slender seta, one apical spine with subapical flagellate extension, and two inner spinulose spines; with spinular row along distal margin; with three anterior pores.

Male (allotype). Habitus (Fig. 8a–c) as in female except for genital somite distinct from third urosomite. Surface ornamentation of urosome as in female except for first abdominal somite with more elaborate spinular pattern ventrally (Fig. 9). Total body length 500 μm. Sexual dimorphism expressed in

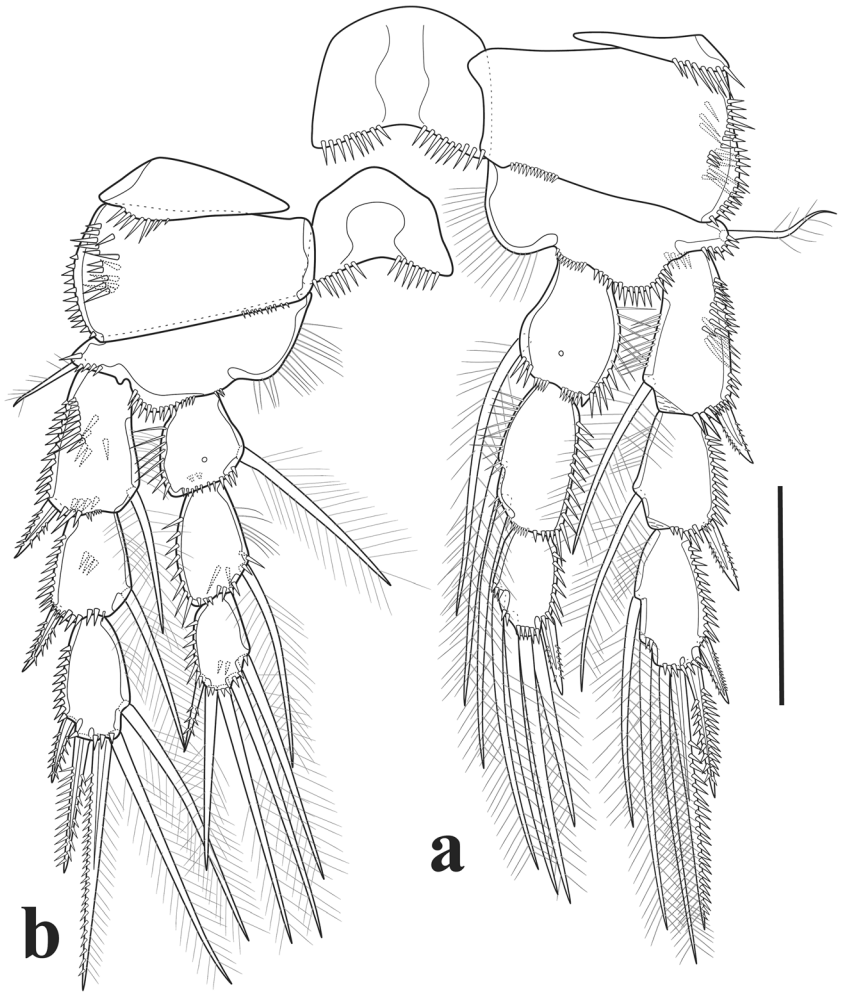

Fig. 7 *Pseudoneotachidius sinuspersici* gen. et sp. nov., female. **a** P3, anterior; **b** P4 anterior. Scale bar: 50 μm

the antennule, P2, P3, P5, and P6. Spermatophore located between fifth pedigerous somite and first abdominal somite, about 29 μm long.

Antennule (Fig. 10a, b). Seven-segmented, chirocer, with numerous pinnate setae/spines. All segments smooth except for first segment with several spinular rows; first segment with one pinnate seta arising from short pedestal; second segment small; fifth segment minute; sixth segment swollen and very large, with modified longitudinally striated element on anterior surface (indicated by an asterisk in Fig. 10b), with two multicuspidate elements (arrowed in Fig. 10b); seventh segment narrow, with chitinized apical process. Armature formula: 1—[1 pinnate], 2—[1 pinnate], 3—[7 naked+4 pinnate], 4—[6 naked+1 pinnate+2 ae], 5—[1 pinnate], 6—[8 naked+4 pinnate+1 membranous element+ (1+ae)], 7—[1 pinnate+10 naked+(1+ae)].

P2 (Fig. 11a). Endopodal segments longer than in female. Exopod reaching tip of enp-2. Inner seta of enp-2 shorter than in female, endopod without apophysis. Armature of enp-3 stronger than in female.

P3 (Fig. 11b). Distinctly longer than in female. Endopod with elongate segments, reaching beyond exopod. Armature of enp-3 stronger than in female.

P5 (Fig. 9). Both legs not fused medially; with spinular row along distal margin; with outer basal seta, one outer spinulose spine, one slender seta, and one apical and two inner spinulose spines; with three anterior pores.

P6 (Fig. 9). Symmetrical, fused medially; with coarse spinules along distal margin; with one outer naked seta and a strong inner pinnate spine.

Discussion

Lang (1948) recognized five genera of Tachidiidae distributed in three subfamilies, Euterpininae, Thompsonulinae, and Microarthridioninae. Subsequently, Huys et al. (1996) raised the subfamily Euterpininae to family rank and distinguished four genera within the family Tachidiidae, *Cithadius* Bowman, 1972, *Microarthridion* Lang, 1944, *Geeopsis* Huys, 1996 in Huys et al. (1996), and *Tachidius* Lilljeborg, 1853, the

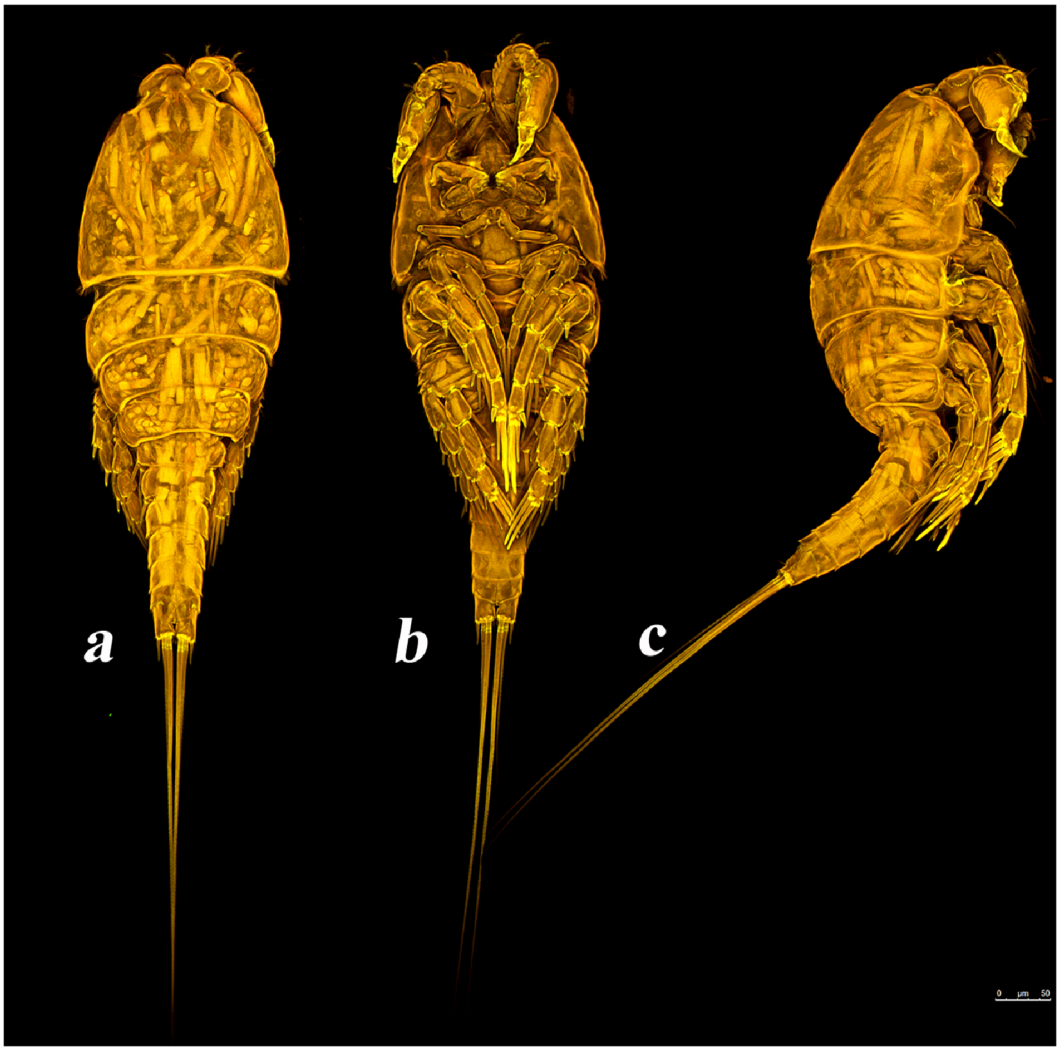

Fig. 8 *Pseudoneotachidius sinuspersici* gen. et sp. nov., male, confocal laser microphotograph. **a** Habitus, dorsal; **b** habitus, ventral; **c** habitus, lateral

latter with two subgenera, *Tachidius* (*Tachidius*) Lilljeborg, 1853 and *Tachidius* (*Neotachidius*) Shen & Tai, 1963. In her revision of Lang's (1948) Exanechentera, Seifried (2003) excluded the family Thompsonulidae Lang, 1944 from Lang's (1948) Exanechentera and reallocated it into Lang's (1948) Podogennonta, thus relegating the Euterpinidae as a synonym of the Tachidiidae and reinstating the genus *Euterpina* as a member of the latter, because *E. acutifrons* shares the autapomorphies of the family Tachidiidae (Seifried 2003: 108, 112). Boxshall and Halsey (2004) did not follow Seifried's (2003) view, accepted Euterpinidae as a separate monotypic family and recognized four genera in Huys et al. (1996) as the only members of the family Tachidiidae. Some years later, Huys et al. (2005) gave *Tachidius* (*Tachidius*) and *T.* (*Neotachidius*) full generic rank and proposed a new genus, *Sinotachidius* Huys, Ohtsuka, Conroy-Dalton & Kikuchi, 2005 for *T.* (*T.*) *vicinospinalis* Shen & Tai, 1964. Huys et al.'s (1996) view has been followed more recently by Kihara and Rocha (2007) and Tran and Chang (2012). Huys et al.'s (1996) scheme is adopted here.

In their revision of the genus *Tachidius*, Huys et al. (2005) detected several apomorphies supporting the full generic rank of *T.* (*Tachidius*) and *T.* (*Neotachidius*). Following Huys et al. (2005), the apomorphies for *Neotachidius* are (1) the location of the spinous process on the fourth segment of the male antennule at ventral anterior corner, (2) absence of a midventral copulatory pore, (3) reduction of the inner armature complement of P1 enp-3 to one seta, (4) male P2 enp-3 with anterior surface spinular comb, (5) reduction of the armature complement of the female P5 endopodal lobe to two spines, and (6) both male P5 fused medially forming a single plate. On the other hand, the apomorphies detected for *Tachidius* are (1) the elongation of the male P2 enp-3 with distinct concavity in the proximal inner margin, (2) loss of the inner seta on male P2 enp-3, and (3) elongation of the outer spine on the male P2 enp-3.

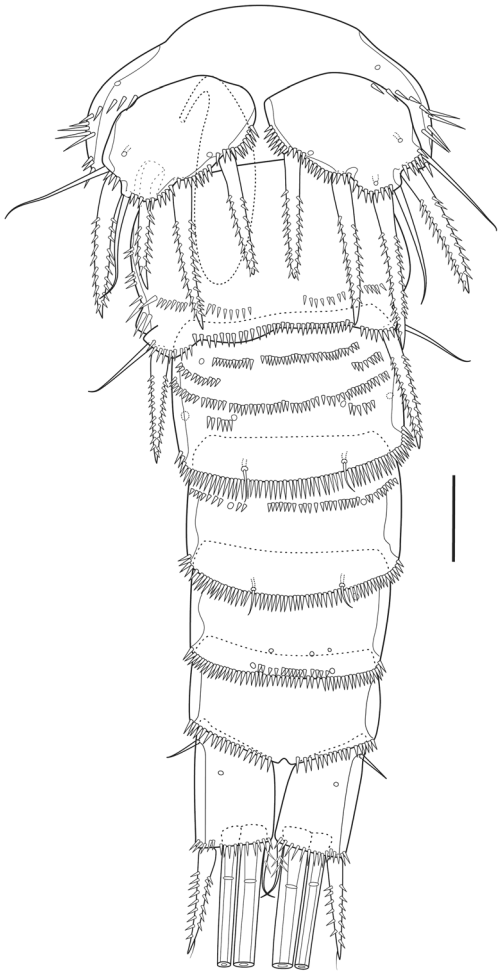

Fig. 9 *Pseudoneotachidius sinuspersici* gen. et sp. nov., male. Urosome, ventral. Scale bar: 10 μm

Pseudoneotachidius gen. nov. is placed in the family Tachidiidae on account of the combination of the following character states: (1) body slightly dorsoventrally flattened, (2) presence of a dorsal nuchal organ on cephalothorax and paired accessory nuchal organs on cephalothorax and first to fourth pedigerous somites laterally, (3) endopod of maxilliped one-segmented bearing a large distal claw with seta on anterior surface, (4) P5 a single plate in both sexes, (5) presence of two outer spines on P2–P4 exp-3, (6) male antennule chirocer, and (7) sexual dimorphism expressed in P2 and P3.

The new species could not be attributed to any genus of Tachidiidae. Although the new species could not be attributed neither to *Tachidius*, *Neotachidius*, *Sinotachidius* (see Huys et al. 2005: 157; from now on referred to as the *TNS*-group), nor to *Cithadius* (see Bowman 1972: 249), the new species seems to be related either to the *TNS*-group or to *Cithadius*, and the proposal of the new genus, *Pseudoneotachidius* gen. nov., for the new Iranian species is justified (see below).

Huys et al. (2005) recognized a monophyletic group composed of *Neotachidius*, *Tachidius*, and *Sinotachidius* (*TNS*-group above) defined by the synapomorphic P1 exp-3 with two outer spines, P3 enp-3 with two inner setae, and male P2 enp-2 with spinous apophysis. On the other hand, Bowman (1972) defined the so far monotypic genus *Cithadius* by the combination of a seven-segmented female antennule, one-segmented antennary exopod with four setae, P1 endopod no longer than exopod, rami of P2 and P3 subequal in length, P2 and P3 exp-1 and enp-1 not reduced and with one inner seta, P4 with two-segmented rami, P5 a broad undivided plate in both sexes, and P2 and P3 not sexually dimorphic. Among all these, the one-segmented antennary exopod, the two-segmented rami of P4, and both P5 fused medially in both sexes are potential apomorphies for *Cithadius* (the seven-segmented female antennule, and the normal—not reduced—P2 and P3 exp-1 and enp-1 with one inner seta are present also in the *TNS*-group). *Pseudoneotachidius* gen. nov. shares some character states with the *TNS*-group and *Cithadius*. For example, the reduced armature complement of P1 exp-3 (with two outer spines only) is common to *Pseudoneotachidius* gen. nov. and the *TNS*-group, but *Cithadius* and *Pseudoneotachidius* gen. nov. share the one-segmented antennary exopod. The nature of the reduced armature on P3 enp-3 with two inner setae only, and the lack of sexual dimorphism in the male P2 enp-2 is not clear. The P3 enp-3 with two inner setae regarded as synapomorphic for the *TNS*-group in Huys et al. (2005) is shared also with *Cithadius*, and the non-dimorphic male P2 enp-2—without apophysis—in *Cithadius* and *Pseudoneotachidius* gen. nov. is present also in *Microarthridion* and *Geeopsis*, and are likely to have evolved independently.

Pseudoneotachidius gen. nov. is more similar to *Neotachidius* than to the other two genera of the *TNS*-group. The lack of midventral copulatory pore, the female P5 endopodal lobe with two inner spines, and P1 with one inner seta on enp-3 are regarded here as synapomorphies for *Neothachidius* and *Pseudoneotachidius*. However, these two genera can be readily distinguished by (1) the lack of a spinous process on the fourth segment of the male antennule (absent in the new genus, but present in *Neotachidius*), (2) the antennary exopod (one-segmented in the new genus, but two-segmented in *Neotachidius*), (3) absence of a spinular comb on the male P2 enp-3 of *Pseudoneotachidius* gen. nov, but present in *Neotachidius*, (4) sexual dimorphism in the male P2 enp-2 (without apophysis in the new genus, but an apophysis is present in *Neotachidius*), (5) structure and shape of the male P5 (both limbs not fused medially and with two inner spines in the Iranian genus, but both P5 fused medially in the male and with one inner spine only in *Neotachidius*), (6) the morphology of the male P2 (endopodal segments elongated

Fig. 10 *Pseudoneotachidius sinuspersici* gen. et sp. nov., male. **a** Antennule, dorsal; **b** same, anterior (modified elements arrowed). Scale bar: 50 μm

and with robust spins on enp-3 in *Pseudoneotachidius* gen. nov), (7) number of setae/spines on the male P5 (six in *Pseudoneotachidius* gen. nov., but five in *Neotachidius*), (8) male P6 (with one spinulose spine and one naked seta in *Pseudoneotachidius* gen. nov., but with two spinulose spines and one naked seta in *Neotachidius*). Additional differences between these genera are summarized in Table 1.

Pseudoneotachidius gen. nov. and *Cithadius* share the one-segmented antennary exopod, the lack of a sexually dimorphic apophysis on the male P2 enp-2, and the lack of anterior long setules on P2 enp-3. As noted above, *Cithadius*, *Pseudoneotachidius*, *Microarthridion*, and *Geeopsis* share the lack of a sexually dimorphic apophysis on the male P2 enp-2, and the loss of such apophysis could have had occurred several times within the family.

Pseudoneotachidius gen. nov. and *Cithadius* can be easily separated by (1) the three-segmented rami of P4 in the new genus, but two-segmented in *Cithadius*; (2) the presence of two setae on the antennary exopod of *Pseudoneotachidius* gen. nov., but four setae in *Cithadius*; (3) the absence of a nuchal organ on the P5-bearing somite in *Cithadius*, but present in the new genus; and (4) female genital somite and third urosomite not fused in *Cithadius*, but fused in *Pseudoneotachidius* gen. nov. Also, Bowman (1972) did not observe any sexual dimorphism in the swimming legs of the male of *C. cyathurae*. Sexual dimorphism is obvious in P2 and P3 of *Pseudoneotachidius* gen. nov.

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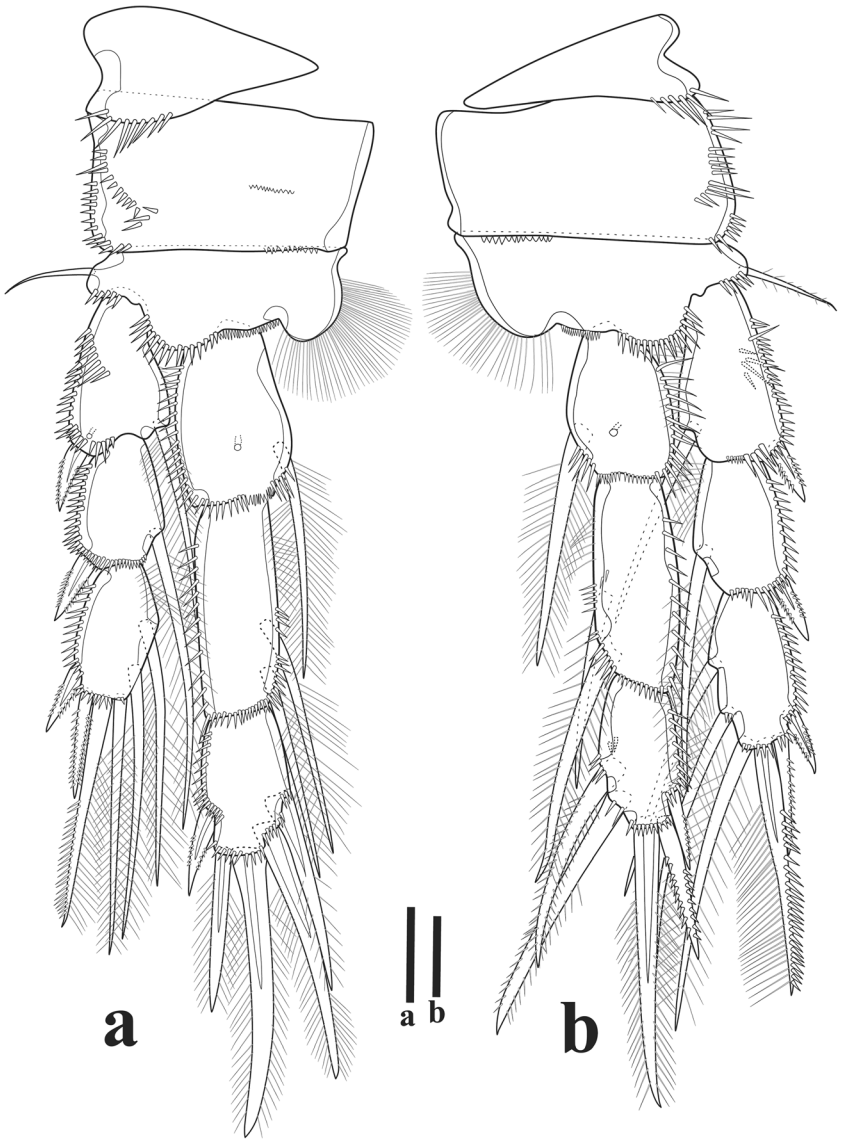

Fig. 11 *Pseudoneotachidius sinuspersici* gen. et sp. nov., male. **a** P2, anterior; **b** P3, anterior. Scale bars: 50 μm

Table 1 Diagnostic features in *Pseudoneotachidius* gen. nov., *Cithadius*, *Neothachidius*, and *Tachidius*

	Pseudoneotachidius gen. nov.	*Cithadius*	*Neotachidius*	*Tachidius*
Nuchal organ on P5-bearing somite	Present	Absent	Present	Present
Genital and third urosomite ♀	Fused	Free	Fused	Fused
Antennary exopod segmentation	1	1	2	2
Antennule segmentation ♀	5	7	7	7
P1 exp-3 number of setae	5	6	5	5
P1 exp-3 number of outer spines	2	3	2	2
P1 enp-3 size	Small	Normal	Small	Normal
P1 enp-3 number of inner setae	1	2	1	2
P1 enp-3 number of setae	4	5	4	5
P4 rami segmentations	3	2	3	3
P2 ♂ enp-2	Without apophysis	Without apophysis	With apophysis	With apophysis
P6 ♂ armatures	1 basal naked seta + 1 pinnate spine	1 basal naked seta + 2 pinnate spines	1 basal naked seta + 2 pinnate spines	1 basal naked seta + 2 pinnate spines

Data for *Cithadius* taken from Bowman (1972). Data for *Neotachidius* taken from Huys et al. (2005). Data for *Tachidius* taken from Shen and Tai (1963), Huys et al. (2005), and Chang (2008)

Key to genera of the family Tachidiidae

1. P1 rami 2-segmented ..... ***Euterpina***
   P1 rami 3-segmented **2**
2. Antennary exopod one-segmented **3**
   Antennary exopod two-segmented **4**
3. P4 with two-segmented rami..... ***Cithadius***
   P4 with three-segmented rami ..... ***Pseudoneotachidius* gen. nov.**
4. P1 exp-3 with five setae/spines; male P2 enp-2 with inner apophysis **5**
   P1 enp-3 with six setae/spines; male P2 enp-2 without inner apophysis **7**
5. P1 enp-3 with five setae/spines; female P5 with nine setae/spines **6**
   P1 enp-3 with four setae/spines; female P5 with seven setae/spines ..... ***Neotachidius***
6. Male P5 with six setae/spines; P2 enp-3 small and with minute outer spine in male ..... ***Sinotachidius***
   Male P5 with seven setae/spine; P2 enp-3 of normal size and without outer spine in male ..... ***Tachidius***
7. Female with genital somite and first abdominal somite fused; P1–P4 enp-1 a small segment without inner seta; accessory nuchal organ on P5-bearing somite absent ..... ***Microarthridion***
   Female with separate genital and first abdominal somites; P1–P4 enp-1 of normal size and with inner seta; accessory nuchal organ on P5-bearing somite present ..... ***Geeopsis***

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All applicable international, national, and/or institutional guidelines for the care and use of animals were followed by the authors.

Sampling and field studies All necessary permits for sampling and observational field studies have been obtained by the authors from the competent authorities.

Data availability All data generated or analysed during this study are included in this published article.

Author contribution F.N. and O.M. conceived and designed research. F.N. conducted samplings and experiments. A.S., S.G., and M.A. contributed analytical tools. F.N. and O.M. wrote the manuscript. All authors read and approved the manuscript.

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