Redescription of *Parastenocaris brevipes* Kessler and description of a new species of *Parastenocaris* (Copepoda: Harpacticoida: Parastenocarididae) from the U.S.A.

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Abstract: *Parastenocaris brevipes* Kessler is redescribed and its presence in North America is established through comparison of specimens from the U.S.A., Finland, and Germany. *Parastenocaris wilsoni* Borutskii, *Parastenocaris starretti* Pennak, *Parastenocaris biwae* Miura, and *Parastenocaris* sp. 2 Strayer (Strayer, D.L. 1988. Stygologia, 4: 279–291.) are assigned to the synonymy of *P. brevipes*. *Biwaecaris* Jakobi is a synonym of *Parastenocaris* Kessler. Some North American records of *P. brevipes* or *P. starretti* refer in fact to *P. brevipes*, other records to a presently undescribed species. Newly verified records of *P. brevipes* include Massachusetts, Michigan, New Hampshire, New York, Virginia, and Wisconsin in the U.S.A., and Lake Biwa, Japan. ***Parastenocaris trichelata***, new species, is described from Virginia, U.S.A. The taxon is distinguished in both sexes by the combination of the long slender caudal ramus with all setae inserted in the distal half and by the medial spine of the leg 1 basipodite, and in the male by the leg 4 with slender hyaline endopodite and 3 spines on the basipodite medial to the endopodite. The new species little resembles any known North American parastenocaridid, nor is it assignable to any presently defined species-group in the genus.

Résumé : *Parastenocaris brevipes* Kessler est décrit de nouveau et sa présence en Amérique du Nord est confirmée après examen de spécimens provenant des États-Unis, de la Finlande et de l'Allemagne. *Parastenocaris wilsoni* Borutskii, *Parastenocaris starretti* Pennak, *Parastenocaris biwae* Miura et *Parastenocaris* sp. 2 Strayer (Strayer, D.L. 1988. Stygologia 4: 279–291) sont déclarés synonymes de *P. brevipes*. *Biwaecaris* Jakobi est un synonyme de *Parastenocaris* Kessler. Des spécimens nord-américains de *P. brevipes* ou de *P. starretti* sont en fait des *P. brevipes* et d'autres spécimens appartiennent à une espèce encore inédite. Un nouvel examen des *P. brevipes* de diverses collections confirme la présence de l'espèce au Massachusetts, au Michigan, au New-Hampshire, au New-York, en Virginie et au Wisconsin aux États-Unis, et dans le lac Biwa, au Japon. ***Parastenocaris trichelata*** n.sp., également décrite ici, provient de Virginie, États-Unis. Le taxon se distingue des autres par les caractères suivants : la longue rame caudale étroite aux soies toutes insérées sur la moitié distale et l'épine médiale du basipodite de la patte 1 chez les deux sexes, et, chez le mâle, l'endopodite mince et transparent de la patte 4 et la présence de trois épines sur le basipodite médial par rapport à l'endopodite. La nouvelle espèce est très distincte de tous les autres paraténocaridiidés nord-américains et elle ne peut encore être assingée à aucun groupe d'espèces déjà existant du genre.
[Traduit par la Rédaction]

Introduction

Continuing investigations of the meiofauna of Goose Creek, Virginia, by Margaret Palmer and associates have yielded several new locality records and new species of copepods (Reid 1991, 1992, 1993). Two species of parastenocaridid harpacticoids were recently collected from the creek. One species resembled published descriptions of *Parastenocaris brevipes* Kessler, 1913*a*, which was originally described from Germany. *Parastenocaris brevipes* has been reported several times from North America (Chappuis 1957; Pennak 1939*a*, 1939*b*, 1940; Strayer 1985; C.B. Wilson 1932; M.S. Wilson and Yeatman 1959). The presence of *P. brevipes* in North America has been accepted by these and other limnologists (e.g., Chappuis 1937*a*, 1955; Damian-Georgescu 1970; Kiefer 1967; Michailova-Neikova 1973; Pennak 1951, 1953; Thienemann 1950; Wells 1964), but some have considered this distribution improbable (Borutskii 1952, 1954; Dussart and Defaye 1990; Lang 1948; Reid 1991; Rouch 1986; Whitman 1984).

The question of the distribution of *P. brevipes* is biogeographically interesting, because the known ranges of all other species of the primarily hypogean parastenocaridids are con-

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fined to a single continent. To determine the distribution of *P. brevipes*, the specimens from Goose Creek and available material of the *P. brevipes*-group from other locations in North America were compared with specimens obtained from Europe and Japan. A detailed redescription was desirable, both because present descriptions are incomplete and because *P. brevipes* is the type species of the genus.

The other species from Goose Creek is described herein as a new taxon.

Materials and methods

Most specimens examined were initially fixed in formalin and stored in 70% ethanol. Unless otherwise noted, specimens were measured in glycerin and drawn in lactic acid, and some were dissected and permanently mounted in commercial polyvinyl lactophenol (PVL) with a little Chlorazol Black E added. Initial drawings were made at 600× or 1000× (using an oil-immersion lens) from the whole animal in a temporary mount in lactic acid, with the cover slip supported by tiny pieces of glass. Details were confirmed from permanent mounts in PVL. A Wild M20 microscope fitted with a drawing tube was used. Some specimens were deposited in the collections of the National Museum of Natural History, Smithsonian Institution (USNM).

Taxonomic account

Family Parastenocarididae Chappuis, 1940
Genus *Parastenocaris* Kessler, 1913*a*

Synonymy:

Biwaecaris Jakobi, 1972: 140–141; Dussart and Defaye 1990: 225. NEW SYNONYMY.

Parastenocaris brevipes Kessler, 1913*a* Figs. 1–4

Synonymy:

Parastenocaris brevipes Kessler. C.B. Wilson 1932: xiii, 289–290, Fig. 178. Chappuis 1937*a*: 197 (partim). Lang 1948: 1223–1224 (partim). Brehm 1950: 112 (partim). Thienemann 1950: 256 (partim). Pennak 1951: 465, 480 (partim). Pennak 1953: 405–406 (partim). Chappuis 1955: 68 (partim). Chappuis 1957: 423, 424, 430, 431 (partim). Chappuis and Delamare Deboutteville 1957: 370. M.S. Wilson and Yeatman 1959: 823. Wells 1964: 193 (partim). Kiefer 1967: 183 (partim). Damian-Georgescu 1970: 220 (partim). Kikuchi 1970: 173 (partim). Jakobi 1972: 130, 131, 136, Table 1 (partim). Michailova-Neikova 1973: 39, 41, 42, 52–54, Fig. 27 (partim). Strayer 1985: 358, 360, Table 21. Rouch 1986: 355 (partim). Dussart and Defaye 1990: 226 (partim). For North America.

Parastenocaris wilsoni Borutskii, 1952: 11, 388, 400–401. Chappuis 1957: 424. Wilson and Yeatman 1959: 823. Borutskii 1964: xii, 361, 372–373. Whitman 1984: 695, 698. Rouch 1986: 351, 355. Dussart and Defaye 1990: 237, 383. Reid 1992: 2901. Rouch 1992: 156. NEW SYNONYMY.

Parastenocaris starretti Pennak, 1939*a*: 224–227, Figs. 1–10. Pennak 1939*b*: 103. Pennak 1940: 580–581, 613. Pennak 1951: 465. Pennak 1953: 405, 406, Fig. 255A. Chappuis 1957: 425, Fig. 15. Chappuis and Delamare Deboutteville 1957: 370. M.S. Wilson and Yeatman 1959: 823–824, Fig. 29.156. Miura 1969: 43. Jakobi 1972: 131, 136, Table 1. Kikuchi 1970: 173. Whitman 1984: 695, 698. Rouch 1986: 350. Dussart and Defaye 1990: 236. Reid 1992: 2901. NEW SYNONYMY.

Parastenocaris s. restr. *starretti*. Jakobi 1972: 131, 136, Table I. NEW SYNONYMY.

Parastenocaris Starretti. Chappuis 1957: 430. NEW SYNONYMY.

Parastenocaris Staretti. Chappuis 1957: 431. NEW SYNONYMY.

Parastenocaris staretti. Borutskii 1952: 12, 387, 408. Noodt 1952: 342. Borutskii 1964: xii, 360, 380. NEW SYNONYMY.

Parastenocaris Starreti. Brehm 1950: 112. NEW SYNONYMY.

Parastenocaris starreti. Rouch 1992: 156. NEW SYNONYMY.

Parastenocaris sp. 2 Strayer 1988: 287–288, Figs. 6*b*, 6*e*. NEW SYNONYMY.

?*Parastenocaris starretti*. Williams and Hynes 1974: 246.

Parastenocaris biwae Miura 1969: 40–44, Figs. 1–15. Kikuchi 1970: 170, 173; Jakobi 1972: 131, 140–141, Table I. Shen and Tai 1973: 382. Shen 1979: 297–298. Imamura and Kikuchi 1986: 319, 329, Fig. 2C. Rouch 1986: 343. Dussart and Defaye 1990: 254. NEW SYNONYMY.

Biwaecaris biwae, n.comb., Jakobi 1972: 140–141. NEW SYNONYMY.

Non *Parastenocaris brevipes*. Pennak 1939*a*: 226. Pennak 1939*b*: 103. Pennak 1940: 580, 585, 613. Pennak 1951: 464–466, 480, Tables III, IV (partim). Pennak 1953: 405, 406 (partim).

Non *Parastenocaris starretti*. Shiozawa 1991: 289, 297.

Material

Massachusetts: 1 ♂, partly dissected and mounted on slide in PVL by author, and 2 ♂♂, 2 ♀♀, and 1 copepodid, ethanol-preserved, Waquoit Pond, Falmouth, 11 July 1927, coll. C.B. Wilson, USNM 63880. Original label lists 15 ethanol-preserved specimens; however, a note by Clarence R. Shoemaker on the catalog card states that only 7 specimens were found in February 1934; only 6 specimens were found by the author.

Michigan: 3 ♀♀ (1 damaged) and 1 ♂, mounted whole together on slide in glycerin jelly, Bryant's Bog Mat, 6 August 1947, coll. P.S. Welch, prep. H.C. Yeatman, USNM 259886. 1 ♀ and 1 ♂, each mounted whole on separate slide, USNM 259887, and 1 ♂ on slide together with 1 ♀ identifed as *Parastenocaris delamarei*, USNM 259888, all from Mud Lake near East Lansing, 22 October 1961, coll. and prep. H.C. Yeatman.

New Hampshire: 1 ♂ and 1 ♀, partly dissected on slide in CMC, Mirror Lake, Grafton Co., 2 August 1981, coll. and prep. D.L. Strayer, USNM 259704. 2 ♂♂ and 1 ♀, 10 July 1981; 1 ♀, 2 August 1981; and 1 ♂, 17 October 1981; most partly dissected and mounted on slides in CMC, Mirror Lake, Grafton Co., collection of D.L. Strayer.

New York: 2 ♂♂, partly dissected and mounted on slide

in CMC, Sample No. 110, East Branch of Wappinger Creek at Cary Arboretum, town of Washington, Dutchess Co., 2 December 1985, coll. and prep. D.L. Strayer; originally determined as "*Parastenocaris* sp. 2," USNM 259703. 1 ♂, Sample No. 59, Coxing Kill at Split Rock, town of Gardiner, Ulster Co., no date; 1 ♂ (part), Sample No. 133, 25 March 1986, East Branch of Wappinger Creek at Cary Arboretum, town of Washington, Dutchess Co., both partly dissected and mounted on slides in CMC, coll. and prep. D.L. Strayer; originally determined as "*Parastenocaris* sp. 2"; collection of D.L. Strayer.

Virginia: 1 ♂ and 1 ♀, each partly dissected on slide in PVL, and 7 ♂♂ and 3 ♀♀, ethanol-preserved, Sample Dam 32 Time 1 coarse sediment, Goose Creek, June 1992, coll. M.A. Palmer, USNM 264750.

Wisconsin: 1 ♂ and 1 ♀, each mounted whole on slide in glycerin, Starrett Lake, no date, coll. and prep. R.W. Pennak, USNM 81979; deposited as cotypes of *P. starretti*.

Finland: 1 ♂ and 1 ♀, each semi-dissected and mounted on slide in PVL, and 33 ♂♂♀♀, ethanol-preserved, natural province South Häme, municipality of Koski, Kurjala village, Kallilampi Lake, north shore, 61°01′53″N, 25°05′17″E, among *Sphagnum* sp. in a wide floating moss belt on the lake shore, 19 August 1972, coll. and det. J. Sarvala, USNM 259763. 3 ♂♂ and 1 ♀, each dissected and mounted on slide in PVL, and 57 ♂♂♀♀, ethanol-preserved, natural province South Häme, municipality of Tammi, Evo village, Onkimanjärvi Lake, east shore, 61°11′33″N, 25°05′36″E, among *Sphagnum riparium* in a narrow floating moss belt along the lake shore, 24 August 1972, coll. and det. J. Sarvala, USNM 259764.

Germany: 2 ♂♂ and 4 ♀♀, ethanol-preserved, Serrahn-Moor, Neustrelitz, northern Germany, 22 April 1965, coll. and det. D. Flössner, USNM 259759.

Japan: 1 ♂ and 1 ♀, each mounted whole on slide, prep. Y. Kikuchi; and 5 ♂♂ and 5 ♀♀, ethanol-preserved, all from interstitial water of Lake Biwa, Honshu, 6 November 1992, collection of Y. Kikuchi.

The following redescription is based on specimens from all populations examined; variations seen in some specimens of some populations are noted. Because it proved impossible to obtain specimens from the type locality in Germany, no neotypes are designated.

Male

Lengths (μm), not including caudal setae, of specimens from Massachusetts (USNM 63880) 400–435, median = 420, n = 3; Virginia (USNM 264750) 355–375, median = 366, n = 8; Wisconsin (USNM 81979) 508; Germany (USNM 259759) 392 and 400; Finland (Kallilampi, USNM 259763) 448–496, median = 476, n = 10; Finland (Onkimanjärvi, USNM 259764) 452–516, median = 492, n = 10; Japan 324–404, median = 400, n = 5.

Habitus vermiform (Fig. 1*a*); cephalothorax with ringform dorsal integumental window, urosomites 2–5, each with saddle-shaped dorsal window as described by Kessler (1913*b*). Anal somite (Figs. 1*a*–1*c*) with 2 dorsal sensilla, 2 diagonal rows of small proctodeal spines and with small duct terminating in papilla on posterior margin ventrally above each caudal ramus, otherwise without ornamentation; anal operculum medially concave. Caudal rami (Figs. 1*a*–1*c*) set broadly apart and slightly divergent, slender and smoothly tapering except for slight expansion at midlength, with small dorsal knob at midlength bearing basally articulated dorsal seta; 3 lateral caudal setae inserted at level slightly posterior to dorsal seta; medial terminal seta inserted partly ventrally to long middle terminal seta; lateral terminal seta inserted far from and slightly dorsal to middle terminal seta. Middle of 3 lateral caudal setae large and obvious in all specimens examined, but 2 remaining lateral caudal setae slender, sometimes short and difficult to see. Caudal ramus otherwise ornamented with ventral row of 2–4 tiny spines at base of large middle terminal seta.

Antennule (Fig. 1*d*) geniculate, of 7 articles, article 3 deeply incised, article 1 with row of small ventromedial spines, articles 4 and 7 each with long slender esthetasc. Antenna (Fig. 1*e*) with allobasis, coxa–basipodite anterior margin with proximal group of 1–3 slender, hairlike spines and more distal diagonal row of several short stout spines; uniarticulate exopodite bearing 1 terminal seta; endopodite with 5 terminal spiniform setae and 2 spiniform setae on anterior margin. Mandible (Fig. 1*f*) with uniarticulate palp bearing 2 slender terminal setae; coxal gnathobase with 4 teeth and 1 seta. A suitable mount of the maxillule was not obtained; its structure is like that of *Parastenocaris ahaggarica* Bozic, 1978. Maxilla (Fig. 1*g*), precoxa with 1 lobe bearing 2 setae; coxa–basis with 1 lobe bearing 1 slender and 1 spiniform setae; basal part attenuated in strong claw; exopod represented by tiny article bearing 2 slender setae. Maxilliped (Fig. 1*h*) slender, prehensile, coxa and basis unornamented.

Legs 1–4 (Figs. 2, 3*a*–3*f*) with segmentation and major armament as is usual in family. Leg 1 basipodite, medial surface with 1 or several tiny spines; endopodite articles 1 and 2 each with several groups of spines, number of spines in each group varying between individuals. Leg 2, endopodite cylindrical, shorter than exopodite article 1, usually with 3 (sometimes with 4 or 6) short terminal and subterminal spines, always with 1 long thin terminal seta inserted posterior to spines. Leg 3, coxopodite with row of 3–5 spines on anterior surface; basipodite with curved row of large spines along lateral half of distal margin; endopodite represented by short, usually slender seta; exopodite massive, tapering distally, strongly sclerotized except for longitudinal median hyaline membrane, ornamented only with transverse row of few tiny spines on lateral surface near base of distal "thumb," exopodite also bearing 3 or 4 (usually 4) knobs on proximal part of medial surface, these best seen in medial view (Fig. 2*i*); anteriormost knob always sclerotized, tiny, and appearing acute or rounded in different views, middle 1 or 2 knobs usually larger, hyaline, rounded or quadrate; distalmost, most posterior knob sclerotized, usually invisible in anterior view. Leg 3 exopodite terminating in lateral "thumb" and blunt medial extension, each with thin hyaline tip, medial extension with small knob medial to hyaline tip. Apparent proportions and thickness of leg 3 somewhat dependent on degree of flattening and angle of view. Leg 4 endopodite complex consisting of these structures (numbered in Fig. 3*c*): 2 medial sclerotized claws, (1) claw with narrow base inserted anterior to (2) claw with broad hyaline base, apparent shapes of claws and bases differing according to angle of view, from effects of preservation, and

Fig. 1. *Parastenocaris brevipes* Kessler, 1913, male; *a*–*c* show a specimen from Massachusetts (USNM 63880) and *d*–*h* a specimen from Onkimanjärvi Lake, Finland (USNM 259764). (*a*) Urosome, dorsal. (*b*) Posterior part of anal somite and caudal rami, dorsal. (*c*) Posterior part of anal somite, ventral. (*d*) Rostrum (arrow) and left antennule. (*e*) Antenna. (*f*) Mandible. (*g*) Maxilla. (*h*) Maxilliped.

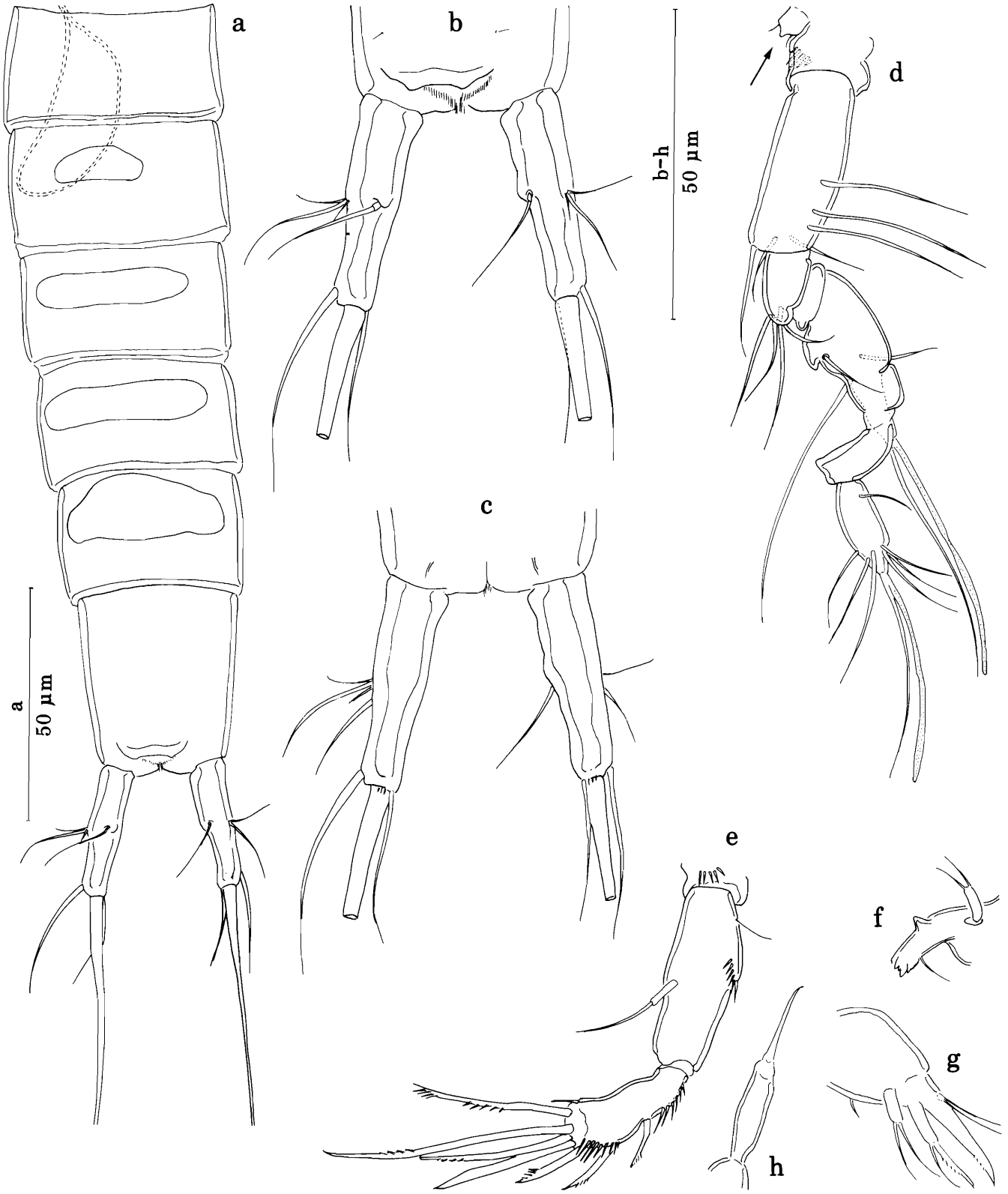


Fig. 2. *Parastenocaris brevipes* Kessler, 1913, male; *a*, *d*, and *f* show a specimen from Onkimanjärvi Lake, Finland (USNM 259764), *b*, *e*, and *h* a specimen from Massachusetts (USNM 63880), *c* and *g* a specimen from Wisconsin (male cotype of *P. starretti*, USNM 81979), *i* a specimen from Japan (Y. Kikuchi coll.), and *j* a specimen from New Hampshire (USNM 259704): (*a*–*c*) Leg 1. (*d* and *e*) Leg 2. (*f*–*h*) Leg 3, anterior. (*i*) Left leg 3, medial view (the arrow indicates the endopodite). (*j*) Basipodite and part of exopodite of leg 3, anterior. All figures are drawn to the same scale.

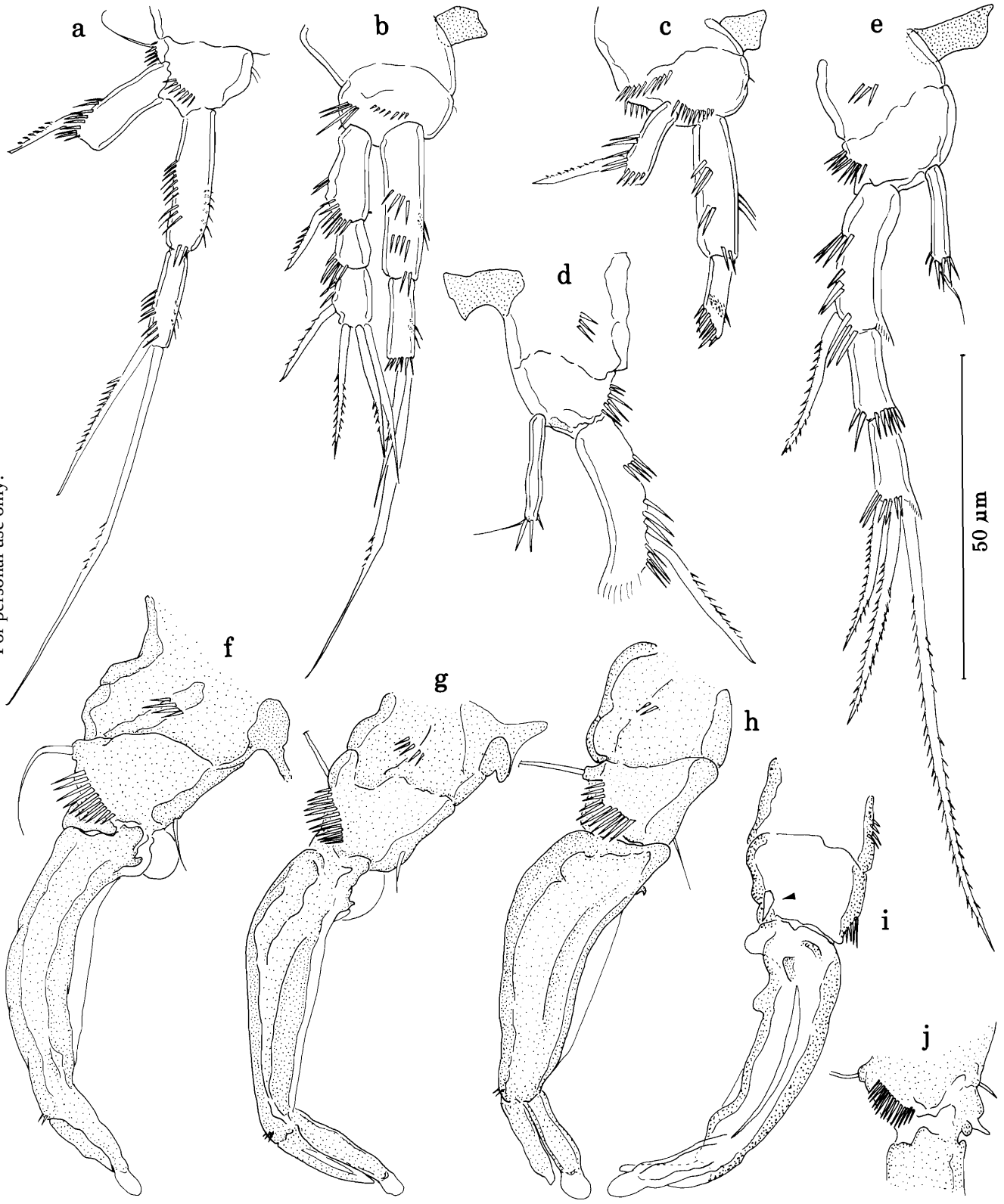
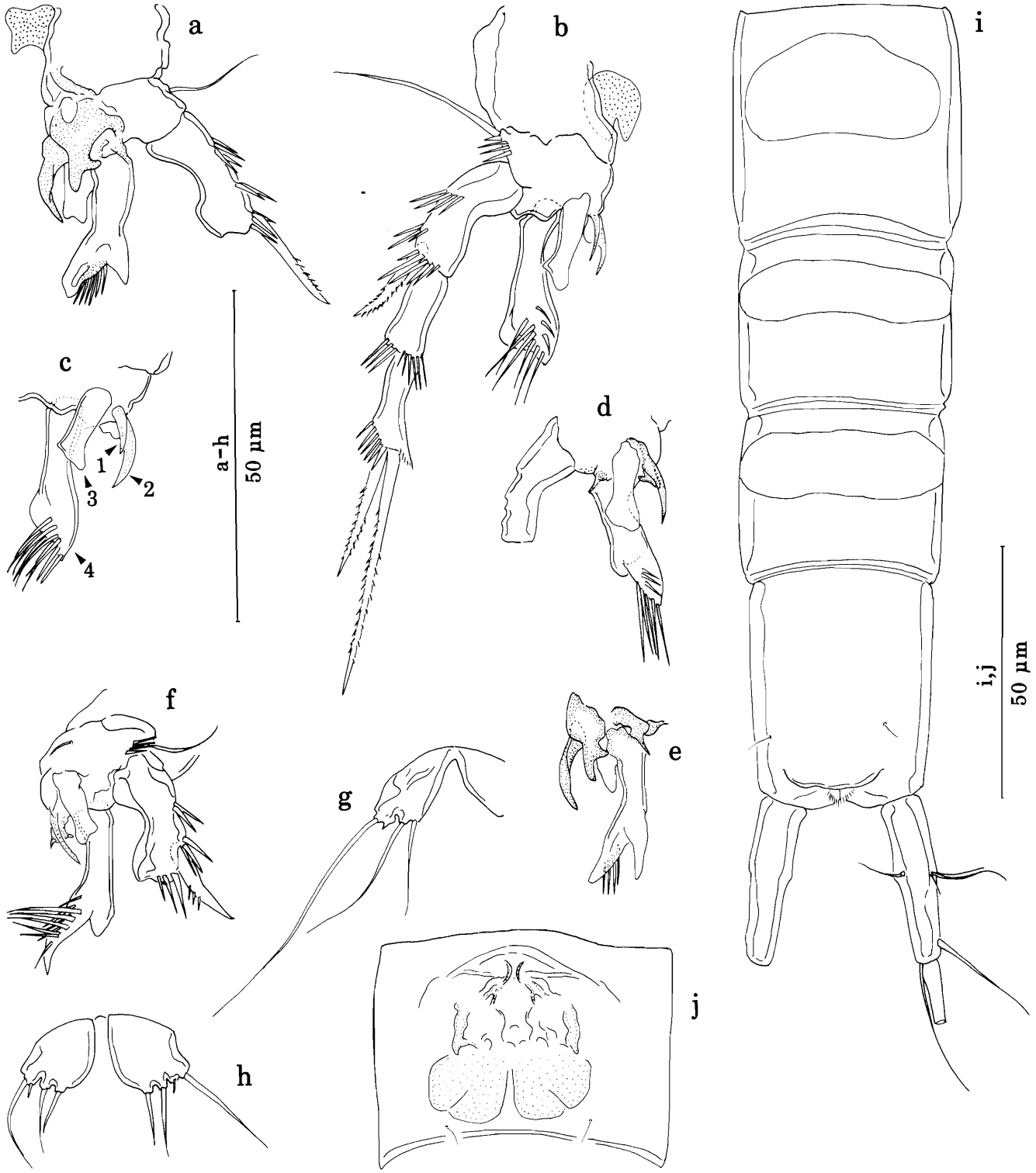


Fig. 3. *Parastenocaris brevipes* Kessler, 1913 (*a*–*h*, male, *i* and *j*, female); *a*, *i*, and *j* show a specimen from Onkimanjärvi Lake, Finland (USNM 259764), *b*, *c*, and *h* a specimen from Massachusetts (USNM 63880), *d* a specimen from New Hampshire (USNM 259704), *e* a specimen from New York (USNM 259703), and *f* and *g* a specimen from Wisconsin (male cotype of *P. starretti*, USNM 81979). (*a*–*f*) Leg 4: *a*, endopodite complex, posterior; *b*, entire leg, anterior; *c*, endopodite complex of same specimen after compression in permanent mount; *d* and *f*, endopodite complexes, anterior; *e*, endopodite complex, posterior. See text for description of structures 1–4 in *c*. (*g* and *h*) Leg 5. (*i*) Urosome, dorsal. (*j*) Genital segment.



between some populations; (3) broad hyaline claw with sock-shaped, nearly invisible hyaline tip, inserted on anterior surface laterally to medial claws; (4) endopodite inserted on posterior surface, consisting of single hyaline article with posterior, short or long expansion at about midlength, and diagonal double row of long spines on distal 1/3. Sclerotized proximolateral surface of endopodite might be interpreted as separate claw (Figs. 3*d*, 3*e*). Leg 4 exopodite article 1 strongly curved, distomedial corner without ornament.

Legs 5 (Figs. 3*g*, 3*h*) usually distinct at base, each with rounded medial margin, 3 setae along incised terminal margin, and tiny spine or denticle medial to insertion of lateralmost seta. Lengths of setae varying in different populations, medialmost seta always shortest.

Female

Lengths (μm) of specimens from Massachusetts (USNM 63880) 436, 485; Virginia (USNM 264750) 372–438, median = 381, n = 4; Germany (USNM 259759) 380–400, median 388, n = 4; Finland (Kallilampi, USNM 259763) 420–476, median = 462, n = 10; Finland (Onkimanjärvi, USNM 259764) 450–497, median = 475, n = 10; Japan 360–380, median = 360, n = 5.

Habitus vermiform (Fig. 3*i*); cephalosome with ring-form dorsal integumental window, genital double somite and succeeding 2 urosomites each with dorsal saddle-shaped window. Main genital field (Fig. 3*j*) about as long as broad, with paired rounded bilobed posterior sections. Anal somite (Fig. 3*i*) and form and setation of caudal ramus (Fig. 3*i*) as in male.

Antennule (Fig. 4*a*) of 7 articles, article 1 with ventromedial row of small spines, articles 4 and 7 each with slender esthetasc. Antenna and mouthparts as in male.

Legs 1–4 (Figs. 4*b*–4*e*) with segmentation and major setation as in family. Leg 1 as in male. Leg 2, endopodite nearly cylindrical, with 3 terminal spines and 1 slender terminal seta. Leg 3, endopodite of 1 slender, acute, terminally serrate article, slightly shorter than exopodite article 1. Leg 4, endopodite reaching about midlength of exopodite article 3, a little longer or shorter in some specimens, usually with diagonal row of spines at about distal 1/3, and densely serrate acute tip.

Legs 5 (Figs. 4*f*, 4*g*) separate or fused medially near base, heavily sclerotized, medial margin produced in long acute extension (length varying slightly), 3 terminal setae, and tiny spine medial to insertion of lateralmost seta.

Variation

Variations were noted in some specimens, as described in the following paragraphs. Few variations appeared consistently in all specimens of any population.

The number of spines in the spine groups on the swimming legs varied between individuals, as is best seen in the leg 1 endopodite (Figs. 2*a*–2*c*). However, no consistent pattern of variation between populations was observed.

One male from Germany and several males from Onkimanjärvi Lake (but no males from Kallilampi Lake) had 4 rather than the usual 3 spines on the leg 2 endopodite. All males from Massachusetts had 6 spines on the leg 2 endopodite. No corresponding variation was observed in females.

The proximomedial knobs of leg 3 of the male usually appeared as in Figs. 2*f*, 2*g*, or 2*i*. There was some variation in the shapes of all the knobs, but it was impossible to determine whether this was real or an artifact of angle and mounting technique. In a few individuals, no middle hyaline knobs were visible (Fig. 2*h*), or (in a single individual from New Hampshire) all the knobs were small and displaced to the extreme proximal end of the exopodite (Fig. 2*j*).

In the male cotype of *P. starretti* from Wisconsin and in a female from Massachusetts, the fifth legs were basally fused (Figs. 3*g*, 4*f*); the fifth legs were separate in most specimens examined.

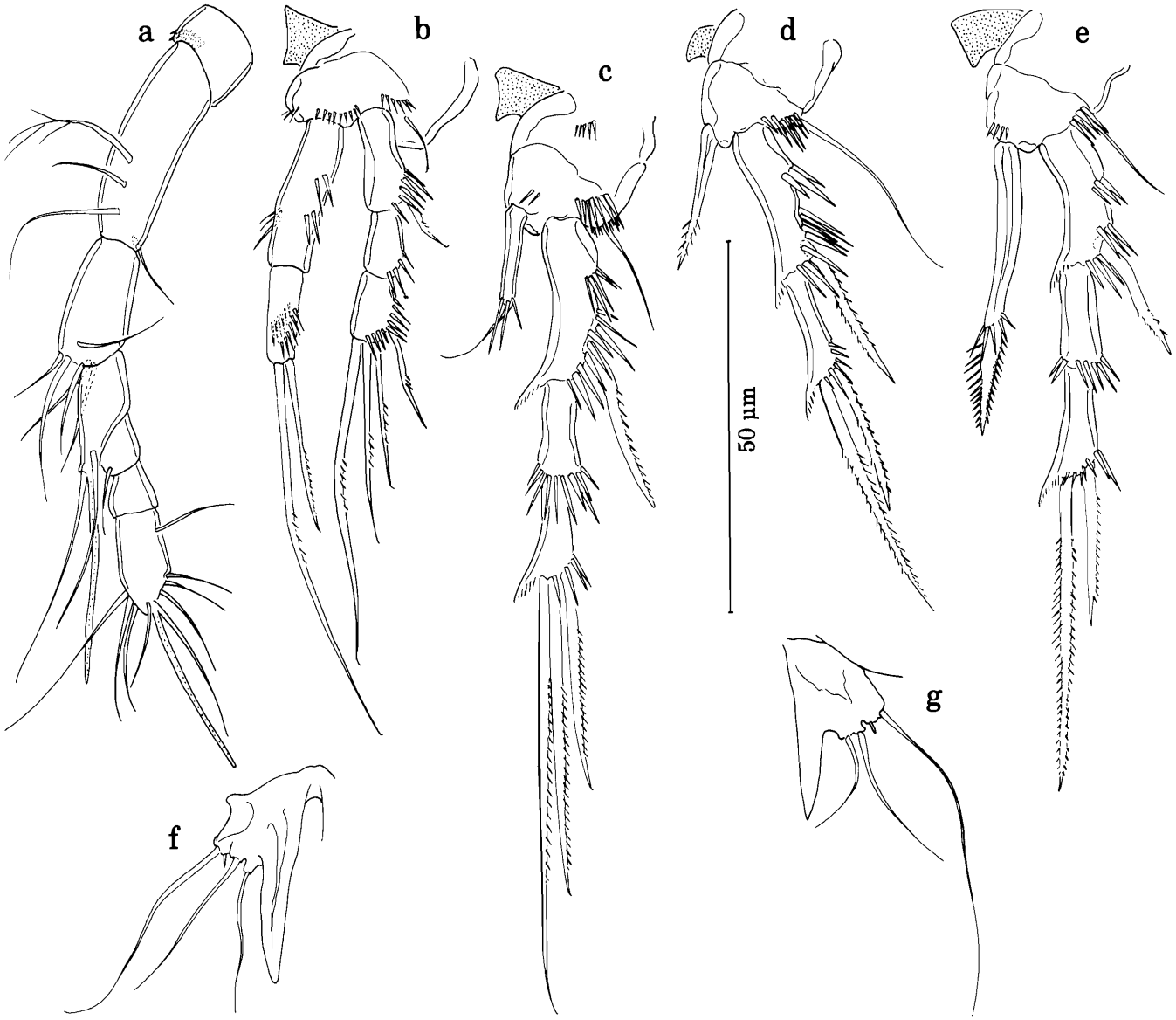
Only the specimens from Lake Biwa, Japan, presented a series of consistent differences from most other populations examined. The prominence of the caudal ramus bearing the dorsal seta appeared slightly more developed. The leg 1 endopodite article 1 had 2 hairlike spines on the medial surface in all specimens (as in Fig. 2*b*). In some males, the leg 3 appeared stouter than the norm, as illustrated by Miura (1969). Because a similarly stout leg 3 was illustrated by Shen (1979) for a male from China, it may be that leg 3 tends to be stouter in Asian populations. In all males from Japan, the leg 3 endopodite was spiniform (Fig. 2*i*), rather than hyaline and hairlike as in all other populations. In leg 4, the anterior sock-shaped medial appendage appeared slightly more sclerotized, and the setae on the endopodite were slightly stouter than in other populations. A small rounded denticle was visible on leg 5 of two of six males, but the other males and females had a rounded corner but no projection. Miura (1969) reported a projection below the anal operculum; such a projection was not present in the specimens from Lake Biwa. Possibly Miura was misled by the deeply sclerotized perianal region, which can appear as an extra operculum in diagonal view. These few slight differences do not appear to justify maintaining *P. biwae* as a separate taxon.

Other material examined

(A) 12 ♀♀, 3 ♂♂, Trout Lake, Wisconsin, 25 July 1935, removed from semi-dried slide, reconstituted in detergent, and preserved in 70% ethanol, and 2 ♀♀ on slide, labelled W5+ 6+, also from Trout Lake, coll. R.W. Pennak, labelled by him "*Parastenocaris brevipes*"; deposited as *Parastenocaris* sp., USNM 259667. Fifteen additional slides of the same series from Trout Lake in the Pennak Collection contain parastenocaridids, now dried and illegible.

Inspection of specimens labelled *P. brevipes* from Trout Lake, Wisconsin, in the Pennak Collection in the National Museum of Natural History established that the species identified as "*P. brevipes*" by Pennak (1939*a*, 1939*b*, 1940, 1951, 1953) is actually a still undescribed species, similar to *Parastenocaris palmerae* Reid, 1991. It is identical with "*Parastenocaris* sp. 1" of Strayer (1988). This species is quite different from *P. brevipes*, most obviously in the leg 3 exopodite of the male, which is narrow and ornamented with two groups of lateral spines, and in the fifth legs of both sexes, which are larger and have short medioterminal projections. It is common in sandy beaches in small lakes in Wisconsin (Pennak 1939*a*, 1939*b*, 1940, 1951, 1953) and in the Great Lakes (A. Robertson and R.L. Whitman, personal communications, 1992, 1993). In New York it occurs in interstitial habitats in springs and streams (Strayer 1988).

Fig. 4. *Parastenocaris brevipes* Kessler, 1913, female; *a*–*f* show a specimen from Massachusetts (USNM 63880) and *g* a specimen from Onkimanjärvi Lake, Finland (USNM 259764). (*a*) Antennule. (*b*) Leg 1. (*c*) Leg 2. (*d*) Leg 3. (*e*) Leg 4. (*f* and *g*) Leg 5. All figures are drawn to the same scale.



(B) 1 ♀ parastenocaridid, mounted semi-dissected on slide, Valley Creek, Minnesota, coll. and prep. D.K. Shiozawa.

Parastenocaris starretti was recorded from Minnesota by Shiozawa (1991); the determination was confirmed by H.C. Yeatman (D.K. Shiozawa, communication in a letter, 1993). However, the single specimen provided to me differs from *P. brevipes* in having the dorsal and lateral caudal setae inserted in the posterior 2/3 of the caudal ramus, the leg 3 endopodite unornamented, and the leg 4 endopodite much shorter than exopodite article 1. The fifth legs could not be located on the slide, and the specimen could not be assigned to species.

(C) 11 ♀ ♀ from Sycamore Creek, Arizona, U.S.A., station ABSS, 30–100 cm deep wells, 15 June 1990, coll. A. Boulton; R. Rouch collection.

Rouch (1992) reported females of the "*brevipes*"-group from the hyporheic zone of Sycamore Creek, Arizona. These female parastenocaridids have a terminally spinulate leg 4 endopodite that is shorter than exopodite article 1; a slender triangular leg 5; and a long, uniformly tapering caudal ramus with the lateral and dorsal setae inserted at about the distal 3/4. These characters are inconsistent with *P. brevipes* and with other members of the *brevipes*-group as defined herein.

Discussion and comparisons

Published descriptions of *P. brevipes*, although it is the type species of the genus, consist only of Kessler's (1913*a*, 1913*b*) ample original description and supplemental observations and figures provided by Donner (1927) and Lang (1931). Borutskii (1952, 1964) published a figure of the

dorsal habitus. Most subsequent authors simply reprinted Kessler's figures. Figures by Veldre and Maëmets (1956) may be original but include few details.

Chappuis (1957) asserted the identity of North American and European *P. brevipes* on the basis of observations of specimens from Wisconsin, but provided no corroborative detail. Chappuis and Delamare Debouteville (1957) considered that the presence of *P. brevipes* in North America was reasonable because of its broad distribution in Europe. Later workers remained unconvinced, mainly because of inconsistencies in descriptions of European and North American animals (Reid 1991; Rouch 1986; Whitman 1984). Kiefer (1967, 1978) twice reviewed the distribution of *P. brevipes* in Europe but mentioned American records only in the first revision. Dussart and Defaye (1990), in a fair statement of the inconclusive position, termed *P. wilsoni* "la forme américaine de *P. brevipes*."

The inconsistencies in descriptions seem to have resulted from differences in preparation of specimens and angle of view, from the difficulty of intepreting and perceiving minute structures, and from some real variations, which are, however, insignificant at the species level. As an example of the first kind, in most compressed mounts (e.g., Fig. 2*h*) the third leg of the male appears much broader than the third leg of the cotype male of *P. starretti* (Fig. 2*g*), which is not compressed and is turned outwards. The two views of the leg 4 endopodite complex in the male that were drawn in a supported mount in lactic acid and again after compression in a permanent preparation (Figs. 3*b*, 3*c*) also illustrate the problem. Real variations include the number of spines in some spine groups on legs 1–4 exopodites, and the state of medial basal fusion of the fifth legs (Figs. 3*g*, 3*h*, 4*f*, 4*g*); in the female, the length of the fifth leg medial spiniform extension (Figs. 4*f*, 4*g*); and in the male, the number of spines on the leg 2 endopodite (Figs. 2*d*, 2*e*), the degree of development of the proximomedial hyaline knobs and the tiny spines at the base of the "thumb" of the leg 3 exopodite (Figs. 2*f*–2*j*), and the shapes of the leg 4 medial claws and the endopodite (Figs. 3*a*–3*f*). In some specimens of both sexes the tiny leg 5 spine appears to be a denticle continuous with the baseoendopodite (Fig. 3*g*), but this is often difficult to distinguish.

The first report of *P. brevipes* from North America was from Massachusetts by C.B. Wilson (1932). Lang (1948) and Borutskii (1952, 1964) justifiably concluded from Wilson's description and figures that his specimens represented a separate taxon from the European *P. brevipes*. Borutskii (1952) named a new species, *P. wilsoni*, and wrote a diagnosis according to the information given by Wilson. However, Wilson's description and figures are inconsistent with his specimens in several respects; for instance, all the males bear 3, not 2, setae on leg 5, and the caudal rami of the females do not bear a transverse row of setae at midlength as claimed. In fact, Wilson's specimens are compatible with *P. brevipes* except for the 6 terminal setae on leg 2 in the males; the number of setae at this site is a variable character. Borutskii's diagnosis is of course made moot by examination of Wilson's specimens, and *P. wilsoni* enters into the synonymy of *P. brevipes*.

In describing *P. starretti*, Pennak (1939*a*) emphasized several features such as the spinulate leg 3 endopodite of the female and the spines at the base of the leg 3 "thumb" of the male, which had at that time not been described but on examination are now found to be present in European animals. The suspicions of M.S. Wilson (communication in a letter to H.C. Yeatman, 1958), R.L. Whitman (personal communication to the author, 1993), and Pennak himself (communication in a letter to H.C. Yeatman, 1958) were confirmed by this examination, and *P. starretti* also enters into the synonymy of *brevipes*.

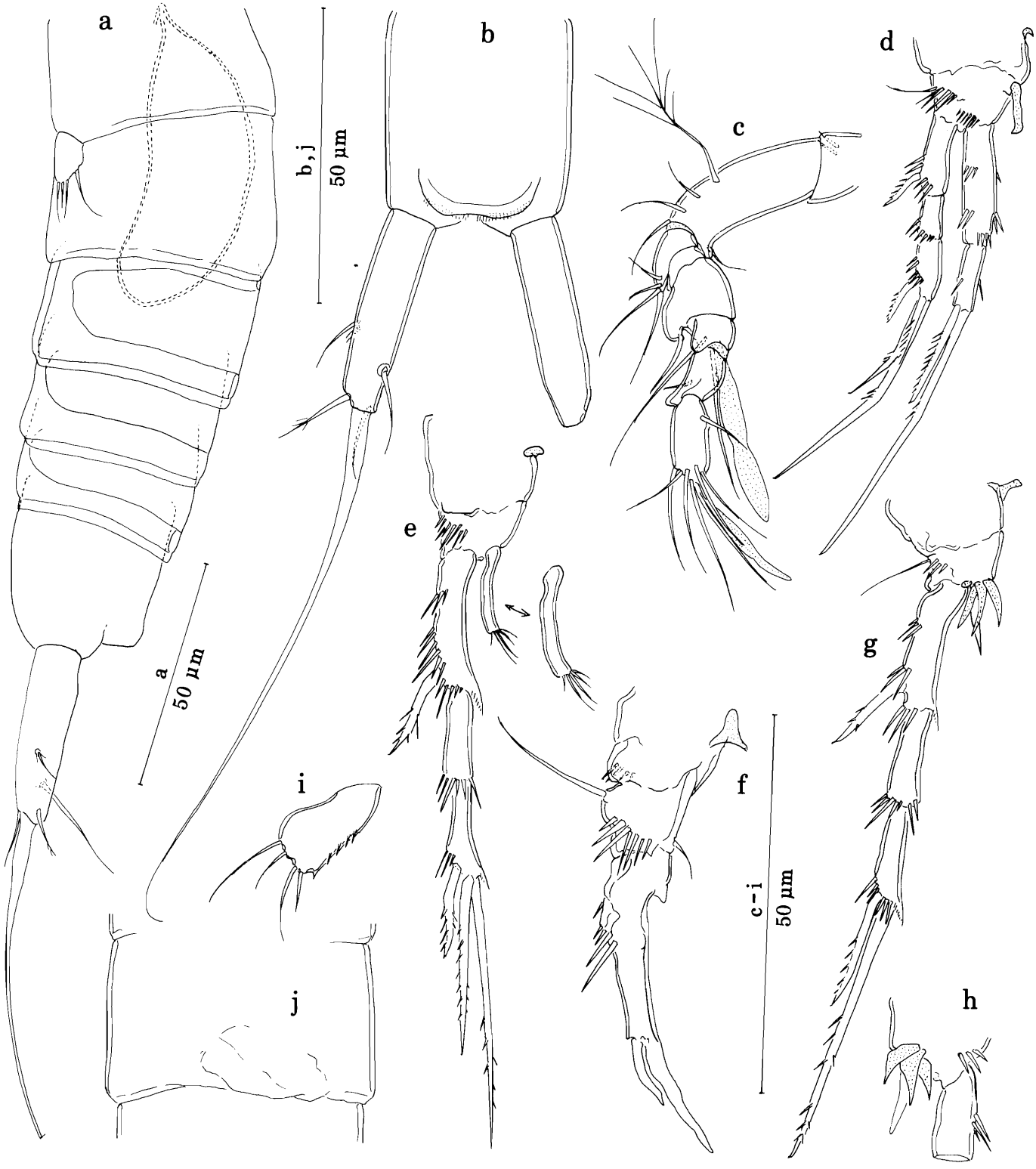
Examination of specimens of *Parastenocaris biwae* Miura, 1969 as described herein established that it is also a synonym of *P. brevipes*. The few consistent differences, namely the slightly stouter leg 3 endopodite and leg 4 endopodite setae of the Lake Biwa specimens, do not justify maintenance of *P. biwae* as a separate taxon. The genus *Biwaecaris*, which Jakobi (1972) proposed for *P. biwae*, of course now falls into the synonymy of *Parastenocaris*.

Parastenocaris arctica Borutskii, 1952, described from a single female from Novaya Zemlya, may represent a northern population of *P. brevipes*. The leg 5 is undescribed, and the taxon differs from *brevipes* only in the claimed lack of integumental windows, the relatively long leg 3 and 4 endopodites, and the caudal ramus "of uniform width." The first character is difficult to see in some specimens, the second may be a simple variation, and the third might depend on the angle of view. Because of the similarity of Borutskii's description to *P. brevipes*, this seems a likelier possibility than Enckell's (1969) suggestion that *P. arctica* is a synonym of *Parastenocaris glacialis* Noodt 1952, 1954 (originally named *Parastenocaris tenuis*).

Lang's (1948) argument that the habitats of the European and American taxa are distinct has been somewhat negated by subsequent collections. Although in Europe *P. brevipes* primarily inhabits *Sphagnum* bogs, it has also been found in floating lake vegetation (Borutskii 1952, 1964) and sometimes in the interstitial area of sandy lakeshores (Enckell 1969; Flössner 1985; Sarvala 1986) or in groundwater near lakes (Noodt 1954). American collections have been predominantly from psammic habitats including the Massachusetts ponds investigated by Wilson (1932), sandy lake beaches (as *P. starretti*; Pennak 1939*a*, 1939*b*, 1940) and the sandy interstitial area of Goose Creek. The record by Williams and Hynes (1974, as *P. starretti*) from hyporheic gravels in a small river in Quebec could not be verified because material is unavailable (D.D. Williams, communication in a letter, 1993). M.S. Wilson and Yeatman's (1959: 823) report of *P. brevipes* from bog mats in Michigan was confirmed. The Lake Biwa specimens are interstitial in sandy beaches (Miura 1969).

The species morphologically closest to *P. brevipes* are united by the tapering caudal ramus with the dorsal and lateral setae at midlength, the long, distally serrate leg 4 endopodite of the female, the leg 3 exopodite of the male without conspicuous spines, and the leg 4 endopodite complex of the male with 1 or 2 large claws and a hyaline endopodite which in most members of the *brevipes*-group bears subterminal setae. Most are tropical except for *P. brevipes*, *P. arctica*, and *P. hinumaensis* Kikuchi, 1970 from Japan. Shen and Tai (1973, repeated by Shen 1979) described *P. longipoda* from Guangxi Province, southern China. Others include *P. feuerborni* and *P. longicaudis*

Fig. 5. *Parastenocaris trichelata*, new species, holotype male (USNM 267444). (*a*) Urosome, left lateral. (*b*) Anal somite and caudal rami, dorsal. (*c*) Antennule. (*d*) Leg 1. (*e*) Leg 2. (*f*) Leg 3. (*g*) Leg 4. (*h*) Right leg 4 endopodite, medial. (*i*) Leg 5. (*j*) Leg 6.



Chappuis, 1931 from Sumatra; *P. brincki*, *P. irenae*, *P. lanceolata*, *P. noodti*, *P. singhalensis* Enckell, 1970 from Sri Lanka; and *P. oshimaensis* Miura, 1962 from Okinoérabu Island in the Ryukyus. Most are hypogean, except for *P. longicaudis*, collected in a *Sphagnum* bog and a spring on Sumatra (Chappuis 1931).

As is apparent from this list, except for *P. brevipes* itself, the *brevipes*-group as defined herein is exclusively Asian.

Following Lang's (1948) definition of the *brevipes*-group, some North American parastenocaridids have been loosely considered members of this group, but this is not actually the case. *Parastenocaris palmerae* Reid, 1991 could be considered a member on the basis of the structure of the leg 4 endopodite complex of the male and the long spinulate leg 4 endopodite of the female, but the short genital field of the female, the leg 3 of the male, and the caudal ramus setation are not compatible with the group. *Parastenocaris texana* Whitman, 1984 from Texas, U.S.A., initially assigned to the *brevipes*-group by its author, actually closely resembles three Central American species, *P. cuscatlanensis*, *P. panamericana*, and *P. salvadorensis* Noodt, 1962 (based on examination of holotype ♂, USNM 227003, and paratype ♂, USNM 227004, mounted whole and laterally on slide). The specimens from Arizona reported as members of the *brevipes*-group by Rouch (1992) differ as noted previously.

Parastenocaris brevipes is unique among parastenocaridids in its Palearctic–Nearctic distribution. In Europe, it is known from Austria, Fennoscandia, European Russia, northern Germany, Estonia, and a mountain in Bulgaria (Borutskii 1952, 1964; Enckell 1969; Kiefer 1967, 1978; Löffler and Neuhuber 1970; Michailova-Neikova 1973; Veldre and Maëmets 1956). North American populations have been found mainly in the north-central and northeastern U.S.A; the population in Goose Creek marks the southernmost limit of its known distribution in North America. This broad longitudinal distribution could be accounted for by the fact that *P. brevipes* often attains high populations in bogs, where it may be easily transported by aquatic birds and mammals.

The latitudinal distribution of *P. brevipes* is peculiar. Although in Europe and North America it seems to be arctic and temperate, in Asia it may extend farther south. Shen (1979) recorded *P. brevipes* from Fujian, Guangdong, Guangxi, and Yunnan provinces in southern China. Although Shen's figures provide few details, I see no reason to doubt the determination, especially in view of the presence of *P. brevipes* in Japan. This distribution could reflect the possible origin of the *brevipes*- group in tropical Asia. *Parastenocaris brevipes* seems to have been the only member of the group, besides *P. hinumaensis* and *P. arctica*, to move far from this probable Oriental center. This capacity for movement must have been a consequence of its adaptability to various habitats.

Parastenocaris trichelata, new species Figs. 5, 6

MATERIAL: Holotype ♂, sample Dam 21 T11 coarse, USNM 267444; allotype ♀, sample Dam 41 T10 Grab, USNM 267445; both from Goose Creek, Virginia, coll. M.A. Palmer and associates, June 1992; each partly dissected on slide in PVL.

Male

Length, excluding caudal setae, 328 μm (specimen somewhat telescoped).

Habitus (Fig. 5*a*) vermiform. No visible pitting on somites or on caudal rami; no dorsal integumental window visible on cephalothorax. Broad saddle-shaped integumental windows indistinctly visible on dorsal surfaces of urosomites 3–5. Anal somite (Figs. 5*a*, 5*b*) without ornamentation except for 2 rows of proctodeal spines beneath anal operculum; anal operculum slightly concave. Caudal rami slender, cylindrical, set broadly apart, divergent distally, their length slightly shorter than length of anal somite. Group of 3 lateral caudal setae inserted slightly posterior to midlength of caudal ramus. Basally articulated dorsal caudal seta located slightly medial to dorsal midline and midway between lateral setae and distal end of ramus. Middle terminal caudal seta slightly enlarged near base. Lateral terminal caudal seta directed at 45° angle to axis of ramus, sparsely plumed, ending in slender, hairlike tip. Medial terminal caudal seta about 1/2 thickness of lateral terminal caudal seta, naked, inserted ventrally to base of middle terminal caudal seta.

Antennule (Fig. 5*c*) geniculate, of 7 articles, article 1 with 2 spines on medial surface, articles 4 and 7 each with esthetasc. Antenna as in female. Maxilliped (not illustrated) slender, prehensile. Remaining mouthparts (not illustrated) reduced as usual in family, not otherwise examined.

Legs 1–4 (Figs. 5*d*–5*h*), exopodites and endopodites with segmentation and major armament as usual in family. Leg 1 basipodite with sclerotized, cylindrical, terminally hooked medial spine; endopodite article 1 with 2 groups of spines on medial surface. Leg 2 exopodite with fringed extensions on distomedial corners of articles 1 and 3; leg 2 endopodite cylindrical, medially curved, reaching past midlength of exopodite article 1, with 5 slender terminal setae of different lengths. Leg 3, exopodite with hyaline knob extending from proximal expansion of medial surface and distolateral hyaline "thumb" 1/2 length of mediolateral hyaline extension of exopodite, both thumb and extension simply curved medially; endopodite present as slender seta. Leg 4, exopodite with fringed extensions on distomedial corners of articles 1 and 3; endopodite complex consisting of 3 sclerotized claws, these slender in ventral view and broader basally in medial view, and slender hyaline unsegmented endopodite, longer than claws and inserted posteriorly to them.

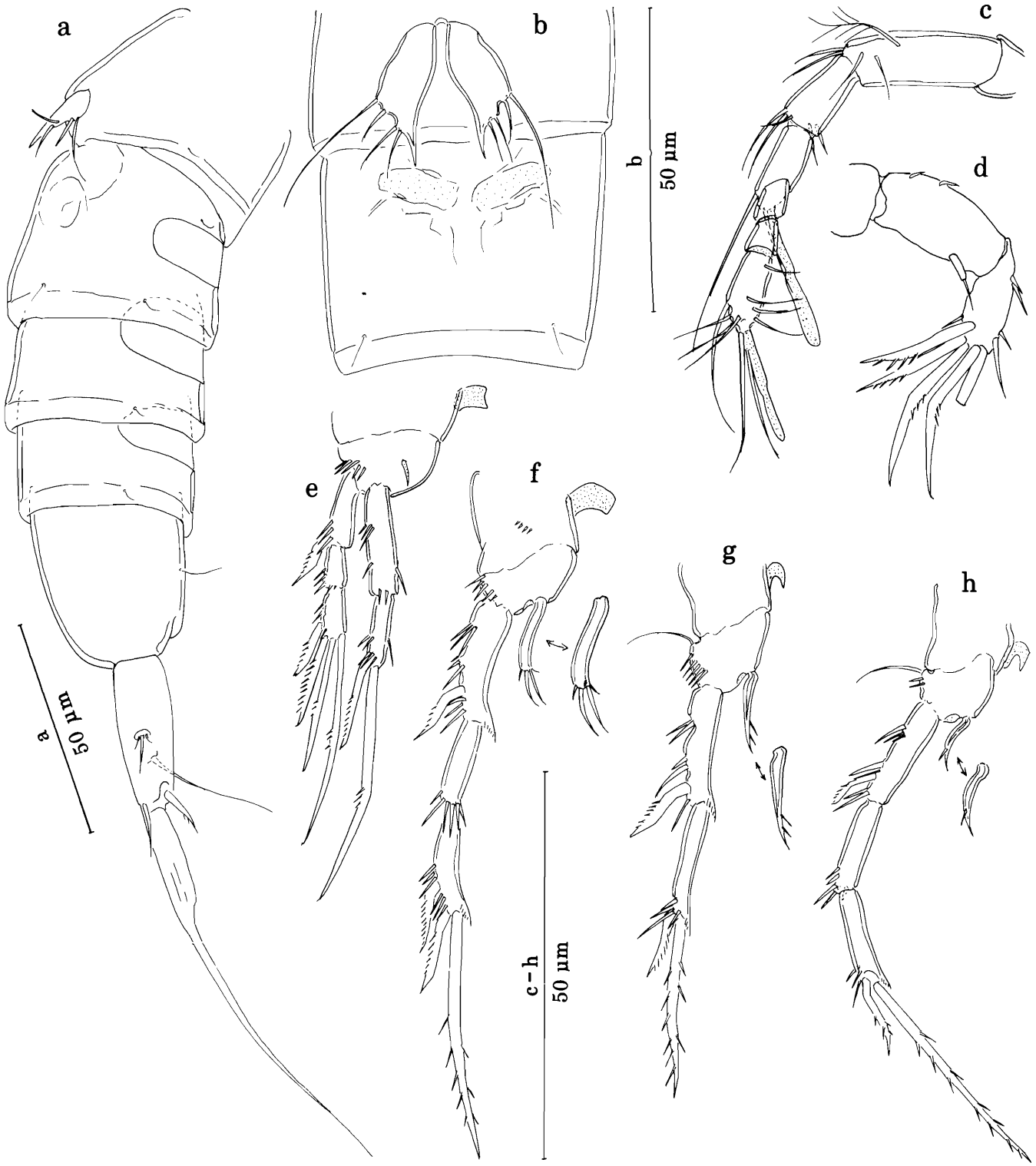
Leg 5 (Fig. 5*i*) short, subrectangular with sinuate, distally convex lateral margin, distal margin with 4 setae; distomedial corner of leg indicated by spiniform projection, medial margin with 4 tiny spines. Leg 6 (Fig. 5*j*) consisting of small unornamented irregular projection along distal margin of somite.

Female

Length 280 μm (specimen telescoped). Habitus (Fig. 6*a*) vermiform. No dorsal integumental window visible on cephalosome; genital segment and succeeding 2 urosomites each with dorsal oval integumental window. No pitting visible on somites or on caudal rami. Genital field (Fig. 6*b*) indistinct except for 2 densely sclerotized oval areas on each side of ventral midline. Anal somite, anal operculum, and dorsal aspect of caudal rami as in male, except caudal rami slightly shorter. Dorsal caudal seta with 2 basal articulations. Lateral terminal caudal seta shorter and stouter than corresponding seta of male. Medial terminal caudal seta slender, inserted ventral to middle terminal caudal seta as in male. Middle terminal caudal seta with basal dorsoventral expansion.

Antennule (Fig. 6*c*) of 7 articles, article 1 without ornament, articles 4 and 7 each with esthetasc. Antenna (Fig. 6*d*) with coxa–basipodite bearing 2 small spines on proximal

Fig. 6. *Parastenocaris trichelata*, new species, allotype female (USNM 267445). (*a*) Urosome, left lateral. (*b*) Legs 5 and genital segment, ventral. (*c*) Antennule. (*d*) Antenna. (*e*) Leg 1. (*f*) Leg 2. (*g*) Leg 3. (*h*) Leg 4.



part of anterior margin, uniarticulate exopodite bearing terminal seta, endopodite with 5 large terminal setae and 2 small spiniform setae on anterior margin (each of these with small spine near base). Mouthparts reduced, not otherwise examined; maxilliped (not illustrated) slender, prehensile.

Legs 1–4 (Figs. 6*e*–6*h*) with segmentation and major setation as in family. Leg 1, basipodite with small curved acute spine on medial surface. Leg 2, exopodite articles 1 and 3 each with fringed expansion on distomedial corner; endopodite as corresponding structure of male except with 4

terminal setae and spines. Leg 3, endopodite about 1/2 length of exopodite article 1, acute, with 2 tiny subterminal spines. Leg 4, endopodite short, acute, with 1 tiny subterminal spine.

Leg 5 (Fig. 6*b*) subrectangular, with distomedial spiniform projection and 4 setae on distal margin.

ETYMOLOGY: From Latin *tri*, "three," and *chela*, "claw," for the 3 distinctive broad spines on the leg 4 basipodite of the male.

TYPE LOCALITY: Goose Creek, Loudoun County, Virginia, U.S.A. (38°57′N, 77°45′W). Habitat described by Palmer (1990*a*, 1990*b*).

Comparisons

No other North American congener possesses a spine on the medial surface of the leg 1 basipodite, similar to that in both sexes of *P. trichelata* (Figs. 5*d*, 6*e*). Most North American species also differ from *P. trichelata* in having the lateral and dorsal caudal setae inserted in the proximal half or at midlength of the caudal ramus. Two species, *P. delamarei* Chappuis, 1957 (in Chappuis and Delamare Deboutteville 1957) and *P. palmerae* Reid, 1992, also have the lateral caudal setae inserted in the distal half of the caudal ramus. In the male of *P. delamarei* the distal "thumb" of leg 3 is small, and the leg 4 endopodite complex is composed of 2 spines, the insertion of the medial spine being distant from the more lateral, bifurcate spine. In both sexes of *P. delamarei* the leg 5 bears 3 setae. *Parastenocaris palmerae* differs from *P. trichelata* in having the dorsal and lateral setae inserted at the same level of the ramus, in its much longer and thicker lateral terminal caudal seta, in details of the endopodites of legs 2–4 of the females and legs 2 and 4 of the males, and in having 2 expansions on the medial surface of the leg 3 exopodite of the male, the larger expansion located about midlength of the exopodite. Strayer (1988) illustrated legs 3 and 4 of the males, but not the caudal rami, of *P. brevipes* (as "*Parastenocaris* sp. 2"; see preceding section) and two as yet unnamed species of *Parastenocaris* from New York. Strayer's species all differ from *P. trichelata* in having only one or two spines medial to the leg 4 endopodite. Further, *P. brevipes* and Strayer's *Parastenocaris* sp. 3 have no lateral spines on the leg 3 exopodite.

Parastenocaris trichelata shows no close morphological similarities to any presently defined parastenocaridid species-group. Its possession of a leg 4 with several spines medial to the endopodite and a 1-segmented leg 2 endopodite might suggest assignment to the *minuta*-group of Lang (1948). The many species of this group, most recently discussed by Rouch (1990), inhabit southern Europe and Africa. Of these, 12 taxa (*P. stammeri* Chappuis, 1937*b* and *P. stammeri gallicus* Chappuis and Rouch, 1959, *P. macaco* Chappuis, 1952, *P. dentulatus* and *P. micheli* Chappuis and Rouch, 1959, *P. amyclaea* and *P. hera* Cottarelli, 1969, *P. pasquinii* Cottarelli, 1972, *P. stellae* Cottarelli, Saporito and Puccetti, 1981, *P. numidiensis* Rouch, 1987, *P. trinacriae* Pesce, Galassi and Cottarelli, 1988, and *P. nertensis* Rouch, 1990) have 3 spines medial to the leg 4 endopodite. However, the leg 4 endopodites of most are complexly branched and about as long as the exopodite article 1. No member of the *minuta*-group has a spine on the leg 1 basipodite.

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