PROC. BIOL. SOC. WASH.
106(2), 1993, pp. 315–324

PSEUDONICOTHOE BRANCHIALIS (CRUSTACEA: COPEPODA: SIPHONOSTOMATOIDA: NICOTHOIDAE), LIVING ON THE PANDALID SHRIMP *HETEROCARPUS SIBOGAE* OFF NORTHWESTERN AUSTRALIA

Arthur G. Humes and Geoffrey A. Boxshall

Abstract.—Both sexes of *Pseudonicothoe branchialis* (Siphonostomatoida: Nicothoidae), living on the marine shrimp *Heterocarpus sibogae* off the coast of northwestern Australia, are described, the male for the first time. Both sexes have hyaline flaps (suckers?) on the exopods of legs 1–3. The innermost element on the free segment of leg 5 is sexually dimorphic. *Pseudonicothoe* is recognized as a valid genus, to which *Paranicothoe procircularis* (Carton) is transferred as a new combination.

The siphonostomatoid copepod family Nicothoidae Dana, 1852, includes several genera whose species live on decapod crustaceans. Except *Choniostoma* Hansen, 1897, all genera living on the decapods belong to the *Nicothoe* group, as recognized by Boxshall & Lincoln (1983). These genera are *Nicothoe* Audouin & Milne Edwards, 1826, *Choniosphaera* Connolly, 1929, *Choniomyzon* Pillai, 1962, *Paranicothoe* Carton, 1970a (see also 1970b), *Hadrothoe* Humes, 1975, and *Pseudonicothoe* Avdeev & Avdeev, 1978. In *Nicothoe, Choniosphaera, Choniomyzon,* and *Hadrothoe,* the prosome of the female is swollen. Only *Paranicothoe* and *Pseudonicothoe* have a flattened prosome in the female.

All species of *Paranicothoe* live on the gills of penaeid and pandalid shrimps in warm regions of the Indo-Pacific. As mentioned by Boxshall & Lincoln (1983), two species of *Paranicothoe, P. procircularis* (Carton, 1967) (see also Carton, 1970b) and *P. cladocera* Carton, 1970a, may parasitize epicaridean isopods which are in turn parasitic on shrimps. *Paranicothoe procircularis* parasitizes *Pseudione affinis* (Sars) (Isopoda) which lives in the branchial cavity of the pandalid shrimp *Plesionika ensis* (A. Milne Edwards) in the Java Sea. *Paranicothoe cladocera* inhabits the brood cavity of *Orbione natalensis* Bourdon (Isopoda) found in the gill cavity of the penaeid shrimp *Hymenopenaeus triarthrus* Stebbing, in the Mozambique Channel, off Natal, South Africa.

Pseudonicothoe branchialis Avdeev & Avdeev, 1978, lives on the gills of the pandalid shrimp *Heterocarpus laevigatus* Bate in the Marshall Islands.

The purpose of this paper is to describe the male of *Pseudonicothoe branchialis* for the first time, and to redescribe certain features of the female.

Siphonostomatoida Thorell, 1859
Nicothoidae Dana, 1852
Pseudonicothoe Avdeev & Avdeev, 1978

Redescription of the genus *Pseudonicothoe,* based on both sexes: Body cyclopiform, flattened, relatively unmodified. Somite bearing leg 1 fused with cephalosome. Urosome in female 5-segmented, in male 6-segmented. Caudal ramus with very long inner terminal seta.

Rostrum weakly developed. Antennule 11-segmented. Antenna 4-segmented with small exopod bearing 1 seta. Siphon short with terminal sucking disk. Mandible slender blade. Maxillule with 2 lobes. Maxilla small, strongly sexually dimorphic. Maxilliped 5-segmented with terminal claw. Ventral surface of cephalosome sexually dimorphic, with maxillules and maxillae much more widely separated in female than in male, and with transverse arched sclerotization in front of maxillae in female.

Legs 1–4 with 3-segmented rami. Leg 1 with inner spine on basis. Second and third segments of exopods of legs 1–3 in both sexes with small round hyaline flaps. Second segment of endopods in legs 1–3 with 1 inner seta but this segment in leg 4 with 2 such setae.

Leg 5 with elongate free segment bearing 4 setae in both sexes, but innermost of these setae sexually dimorphic, short and spiniform in male, but long and setiform in female.

Pseudonicothoe branchialis Avdeev & Avdeev, 1978

Material.—2 ♀♀, 5 ♂♂, 3 copepodids from the pandalid shrimp *Heterocarpus sibogae* de Man, in shrimp trawl in 392–400 m, FRV *Soela,* station NWS-7, 18°33.2′S, 117°30.9′E, 25 Apr 1983. One adult ♀, 3 adult ♂♂, and 3 copepodids (2 ♀♀, 1 ♂) deposited in the Northern Territory Museum, Darwin, Northern Territory, Australia; 1 ♀, 1 ♂, and 1 dissected ♂ in The Natural History Museum, London, England, BM(NH) Reg. Nos. 1992.1067–1069.

Male.—Body (Fig. 1a) with flattened prosome subcircular in dorsal view. Length 1.20 mm (1.05–1.32 mm) and greatest width 0.61 mm (0.51–0.66 mm), based on 4 specimens in lactic acid. Somite bearing first pair of legs fused with cephalosome. Epimera of metasomal somites rounded. Tergum of somite bearing leg 3 arched forward medially, exposing broad tergum of somite bearing leg 4, this tergum crenulated posteriorly and showing median longitudinal sclerotization. Ratio of length to width of prosome 1.15:1. Ratio of length of prosome to that of urosome 1.45:1.

Somite bearing leg 5 (Fig. 1b) 65 × 170 μm. Genital somite (Fig. 1c) rectangular in dorsal view, 83 × 135 μm (length including leg 6 but not its setae). Four postgenital somites from anterior to posterior 70 × 104, 78 × 92, 78 × 78, and 47 × 81 μm. Anal somite indented medially.

Caudal ramus (Fig. 1d) elongate, outer side 91 μm, inner side 127 μm, and width at midregion 29 μm. Ratio of outer length to width 3.14:1. Ratio of inner length to width 4.38:1. Outer lateral seta, placed dorsally, 77 μm, dorsal seta 44 μm, outermost terminal seta 67 μm, and innermost terminal seta, placed subterminally, short, 28 μm, all these setae smooth. Two long median terminal setae 122 μm (outer) and 890 μm (inner), both with very small serrations along their midregions (Fig. 1e). Rami with thick sclerotized inner and outer walls.

Rostrum (Fig. 1f) weakly developed. Antennule (Fig. 2a) 11-segmented, 450 μm long, first 2 segments stout, remaining 9 segments slender. Lengths of its segments (measured along their posterior nonsetiferous margins): 56 (52 μm along anterior margin), 117, 16, 21, 42, 39, 39, 36, 36, 37, and 18 μm, respectively. Formula for armature: 3, 14, 2, 2, 2, 2, 2, 2, 2, 2, and 7 + 1 aesthete. Six setae on second segment, associated with conspicuous, incomplete, segmental sclerotizations, noticeably stronger than other setae. All setae smooth. In 4 males segmental sclerotizations in segments 4–11 stronger in left antennule (Fig. 2b) than in right antennule (Fig. 2a).

Antenna (Fig. 2c) short, 130 μm long including terminal seta (compare length with that of antennule, 450 μm). Four segmented, but terminal seta showing trace of subdivision. First segment (coxa) unarmed. Second segment (basis) with minute exopod 4 × 4.5 μm with 1 seta 30 μm and ornamented with patch of spinules. Endopod with large first segment having prolonged inner distal corner and dense field of small

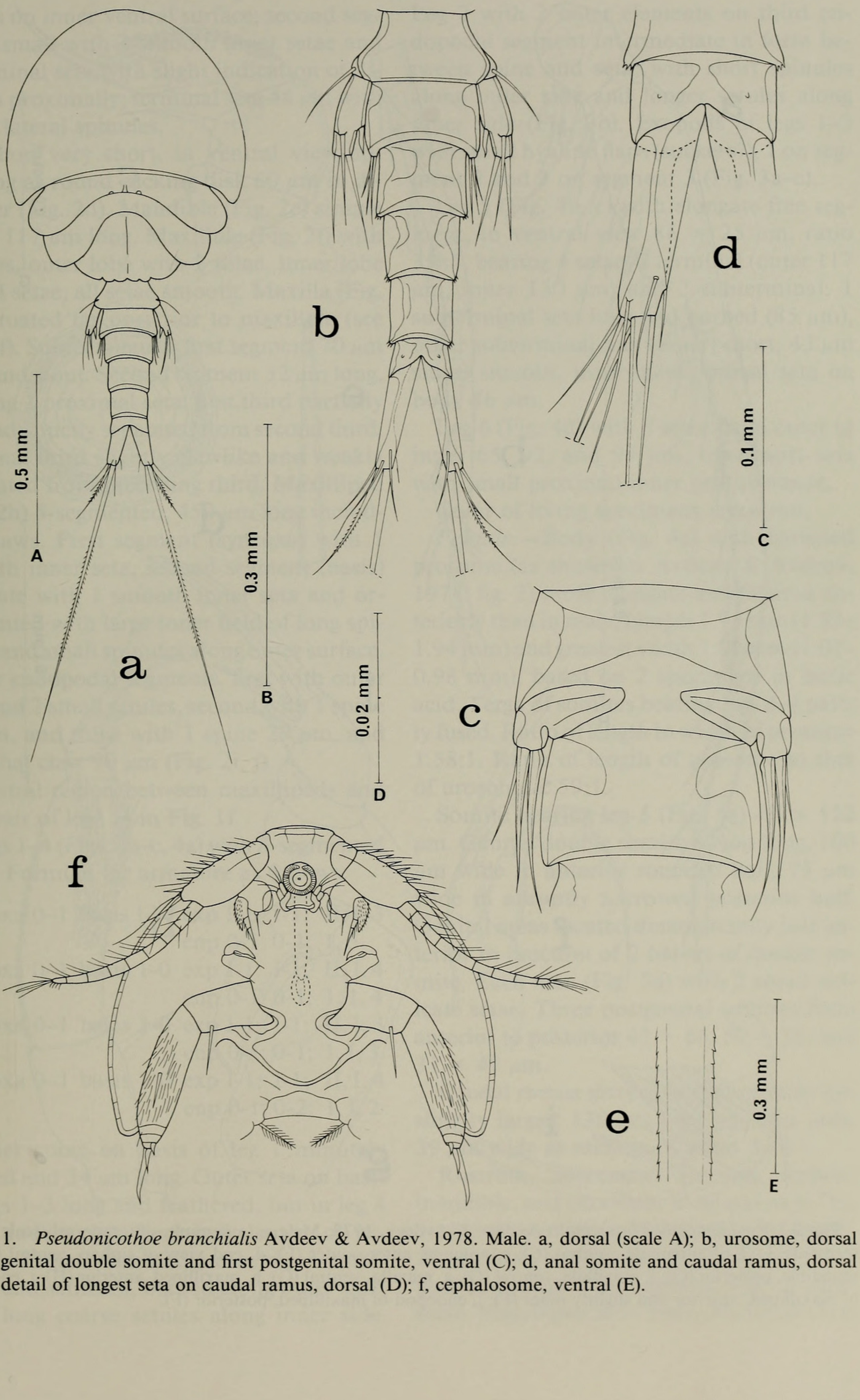

Fig. 1. *Pseudonicothoe branchialis* Avdeev & Avdeev, 1978. Male. a, dorsal (scale A); b, urosome, dorsal (B); c, genital double somite and first postgenital somite, ventral (C); d, anal somite and caudal ramus, dorsal (C); e, detail of longest seta on caudal ramus, dorsal (D); f, cephalosome, ventral (E).

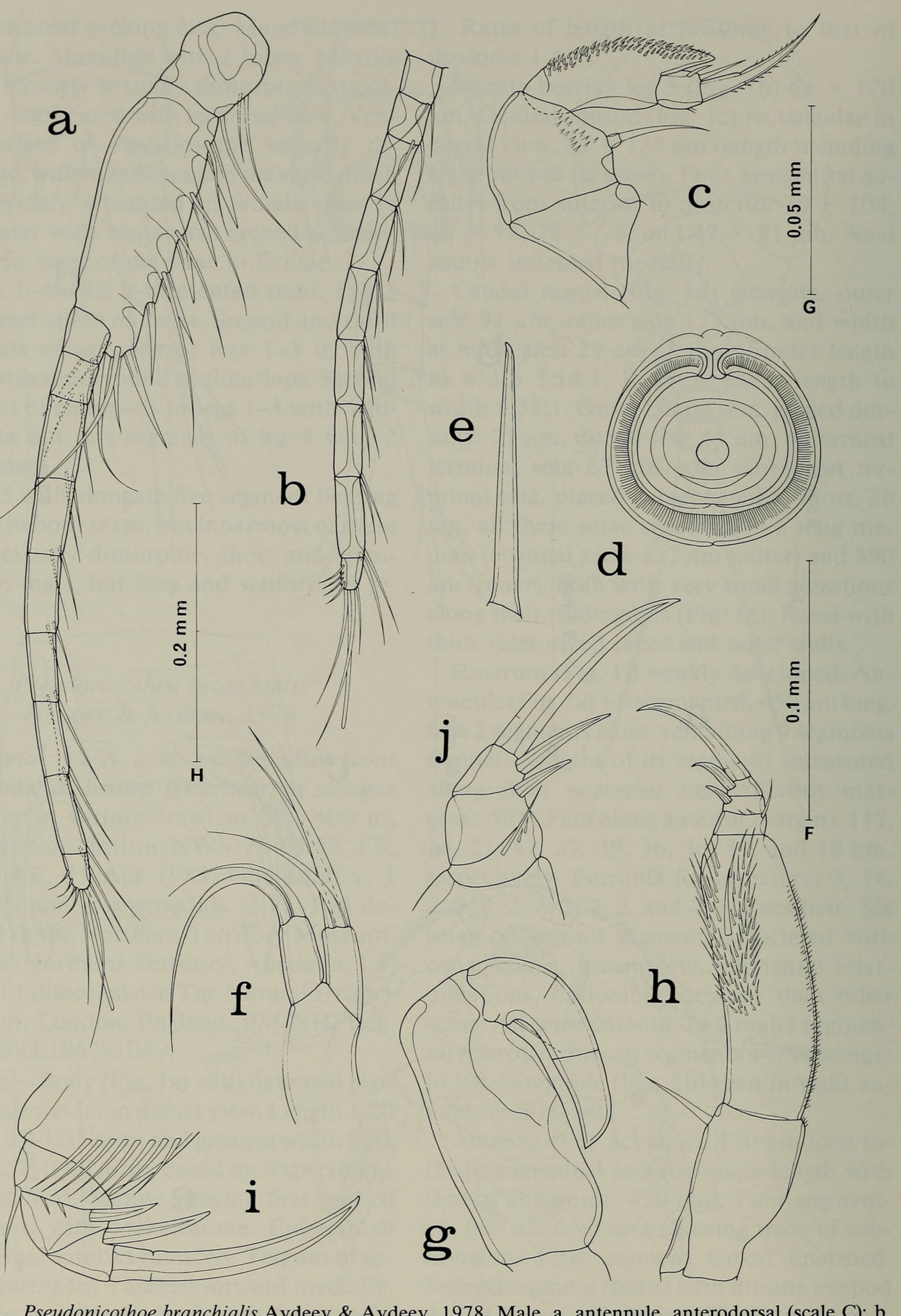

Fig. 2. *Pseudonicothoe branchialis* Avdeev & Avdeev, 1978. Male. a, antennule, anterodorsal (scale C); b, segments 3–11 of antennule, ventral (C); c, antenna, antero-outer (F); d, end view of siphon, ventral (G); e, mandible, posterior (G); f, maxillule, ventral (G); g, maxilla, ventral (G); h, maxilliped, anterior (H); i, endopod of maxilliped, anterior and slightly inner (F); j, endopod of maxilliped, posterior (F).

spines on inner ventral surface; second segment small with 2 smooth inner setae and 1 terminal seta with slight indication of division proximally; terminal seta 44 μm with small lateral spinules.

Siphon very short, in ventral view appearing as round sucking disk 60 μm in diameter (Fig. 2d). Mandible (Fig. 2e) simple blade 117 μm long. Maxillule (Fig. 2f) with 2 lobes, outer lobe with 2 setae, inner lobe with 3 setae, all setae smooth. Maxilla (Fig. 2g) situated far posterior to maxillule (see Fig. 1f). Subrectangular first segment 70 μm long and stout. Second segment 52 μm long, bearing 1 proximal seta; first third partially and indistinctly separated from second third, terminal third slightly clawlike and weakly separated from preceding third. Maxilliped (Fig. 2h) 5-segmented, 450 μm long including claws. First segment (syncoxa) with 1 smooth inner seta, second segment (basis) elongate with 1 smooth inner seta and ornamented with large inner field of long spinules and small spinules along outer surface. Three endopodal segments, first with outer seta and 2 small setules, second with 1 spine 18 μm, and third with 1 spine 29 μm, and terminal claw 90 μm (Fig. 2i, j).

Ventral region between maxillipeds and first pair of legs as in Fig. 1f.

Legs 1–4 (Figs. 3a–c, 4a) with 3-segmented rami. Formula for armature as follows:

P_1	coxa 0–1	basis 1-I	exp	I-1; I-1; II, I, 3
			enp	0-1; 0-1; 1, 5
P_2	coxa 0–1	basis 1-0	exp	I-1; I-1; II, I, 4
			enp	0-1; 0-1; 1, 1, 4
P_3	coxa 0–1	basis 1-0	exp	I-1; I-1; II, I, 3
			enp	0-1; 0-1; 1, I, 3
P_4	coxa 0–1	basis 1-0	exp	I-1; I-1; II, I, 4
			enp	0-1; 0-2; 1, I, 2

Inner spine on basis of leg 1 minutely barbed and 34 μm long. Outer seta on basis of legs 1–3 long and feathered, but in leg 4 short and smooth. Terminal element on exopod of leg 1 intermediate between spiniform and setiform, barbed along outer side, with long coarse setules along inner side. Leg 2 with 2 outer elements on third endopodal segment intermediate in form between spine and seta, with short spinules along outer side and longer setules along inner side (Fig. 3b). Exopods of legs 1–3 with small hyaline flaps (suckers?), 1 on segment 2 and 3 on segment 3 (Fig. 3a–c).

Leg 5 (Fig. 4b, c) with elongate free segment, in ventral view 86 × 25 μm, ratio 3.4:1, bearing 4 setae, 2 terminal (outer 117 μm, inner 130 μm) and 2 subterminal; 1 subterminal seta long and barbed (85 μm), other subterminal seta (inner) short, 43 μm stout, smooth, mucronate. Dorsal seta on body 86 μm.

Leg 6 (Fig. 4d) with 3 setae from outer to inner 65, 92, and 99 μm, innermost seta with small proximal inner protuberance.

Color of living specimens unknown.

Female.—Body (Fig. 4e) with flattened prosome (as shown in Avdeev & Avdeev, 1978: fig. 2) more elongate and tapered anteriorly than in male. Length 1.93 mm (1.93–1.94 mm) and greatest width 1.00 mm (1.01–0.98 mm), based on 2 specimens in lactic acid. Terga of somites bearing legs 2–4 partly fused. Ratio of length to width of prosome 1.58:1. Ratio of length of prosome to that of urosome 2.59:1.

Somite bearing leg 5 (Fig. 5a) 47 × 122 μm. Genital double somite 83 μm long, 100 μm wide in anterior rounded half, 73 μm wide in abruptly narrowed posterior half. Genital areas located dorsolaterally just anterior to junction of 2 halves of double somite. Each area (Fig. 5b) with 2 small delicate setae. Three postgenital somites from anterior to posterior 47 × 65, 50 × 55, and 31 × 49 μm.

Caudal ramus similar to that of male but slightly larger, 130 μm long on outer side, 39 μm wide at midregion, ratio 3.33:1.

Rostrum, antennule, antenna, siphon, mandible, and maxillule, arranged as in Fig. 5c, like those of male. Maxilla (Fig. 5d) small, 55 μm long, apparently 2-segmented, with terminal spine. First segment with 2 small setae. Maxilliped as in male. Maxillules and

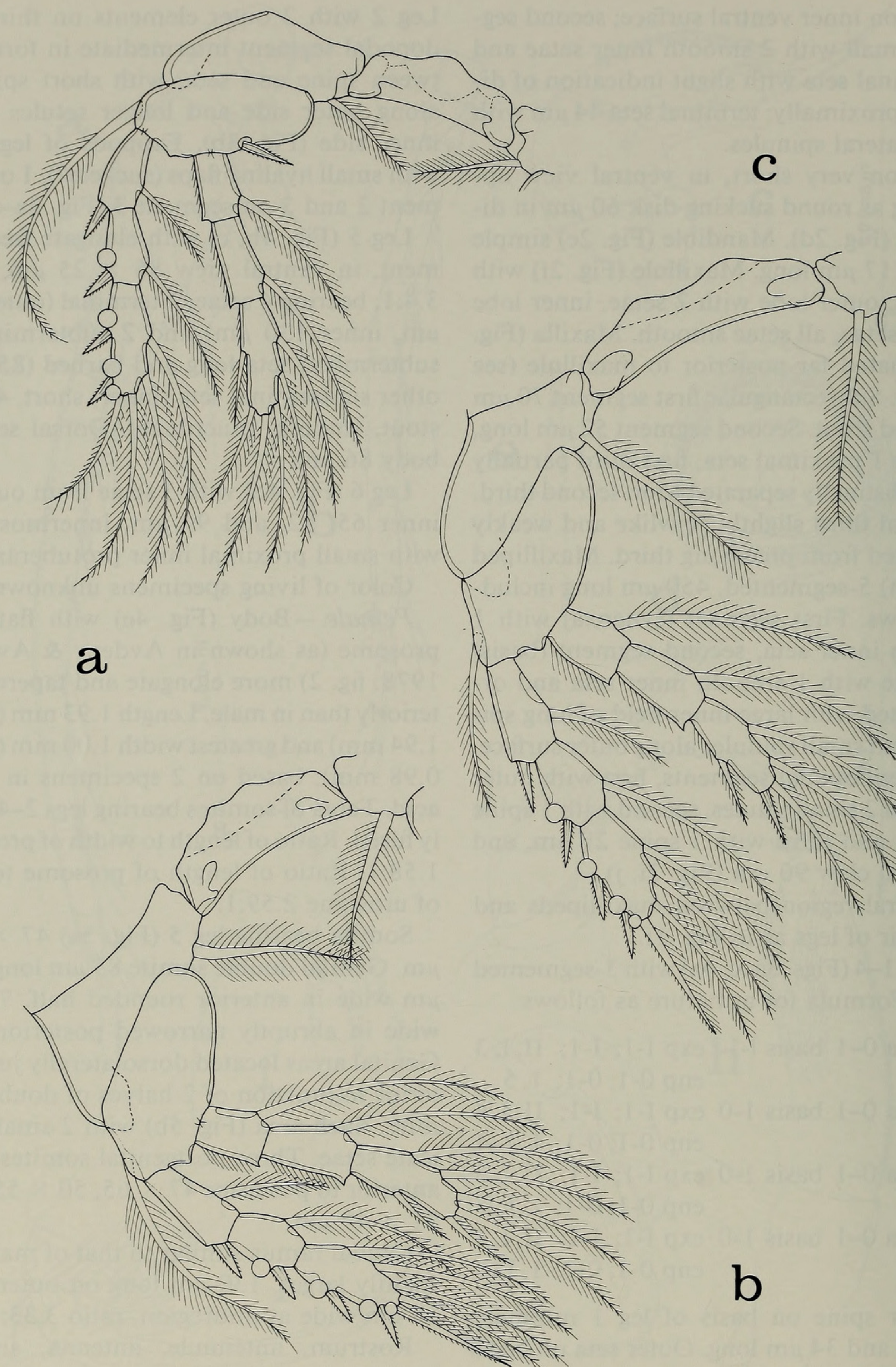

Fig. 3. *Pseudonicothoe branchialis* Avdeev & Avdeev, 1978. Male. a, leg 1 and intercoxal plate, anterior (scale H); b, leg 2 and intercoxal plate, anterior (H); c, leg 3 and intercoxal plate, anterior (H).

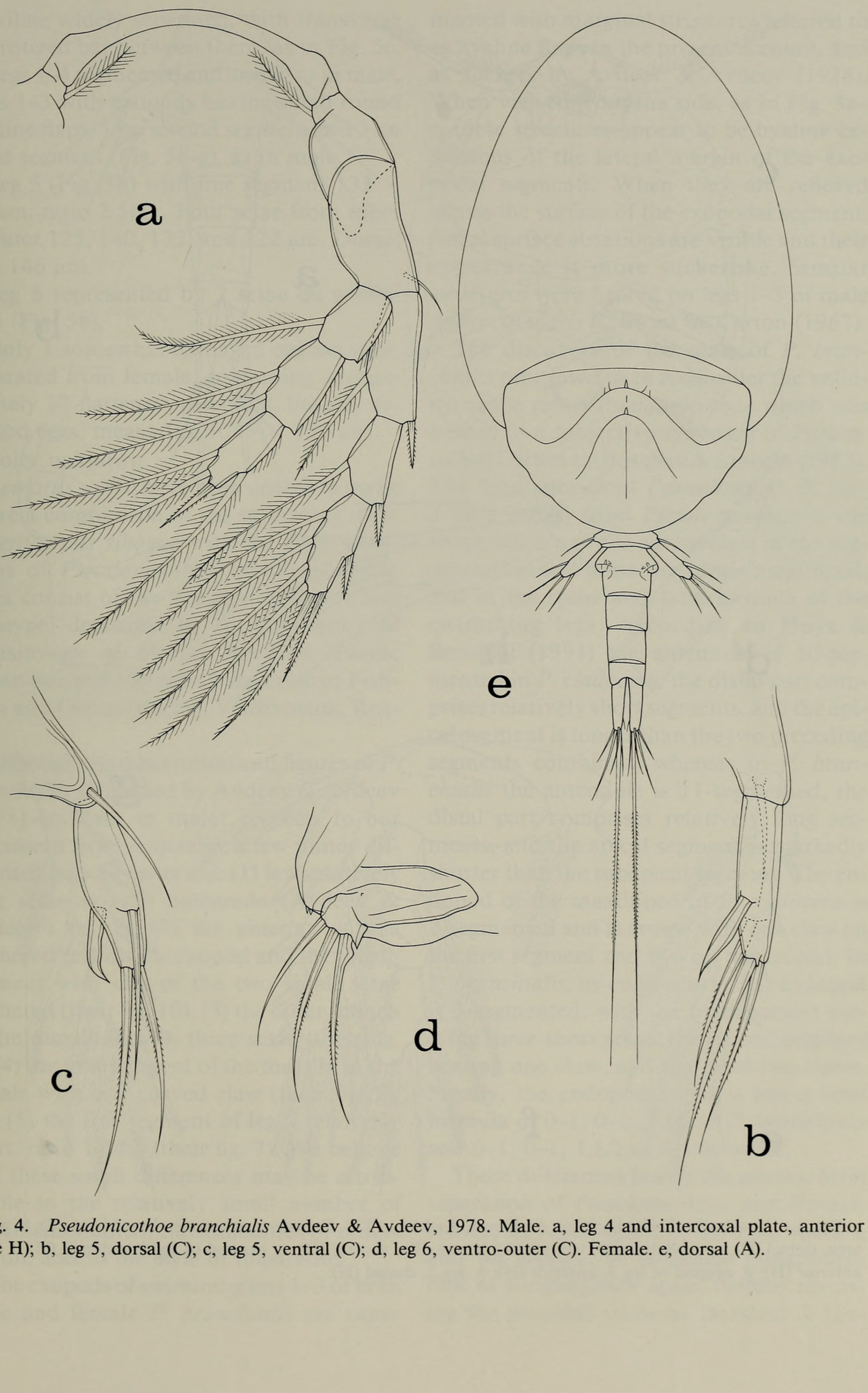

Fig. 4. *Pseudonicothoe branchialis* Avdeev & Avdeev, 1978. Male. a, leg 4 and intercoxal plate, anterior (scale H); b, leg 5, dorsal (C); c, leg 5, ventral (C); d, leg 6, ventro-outer (C). Female. e, dorsal (A).

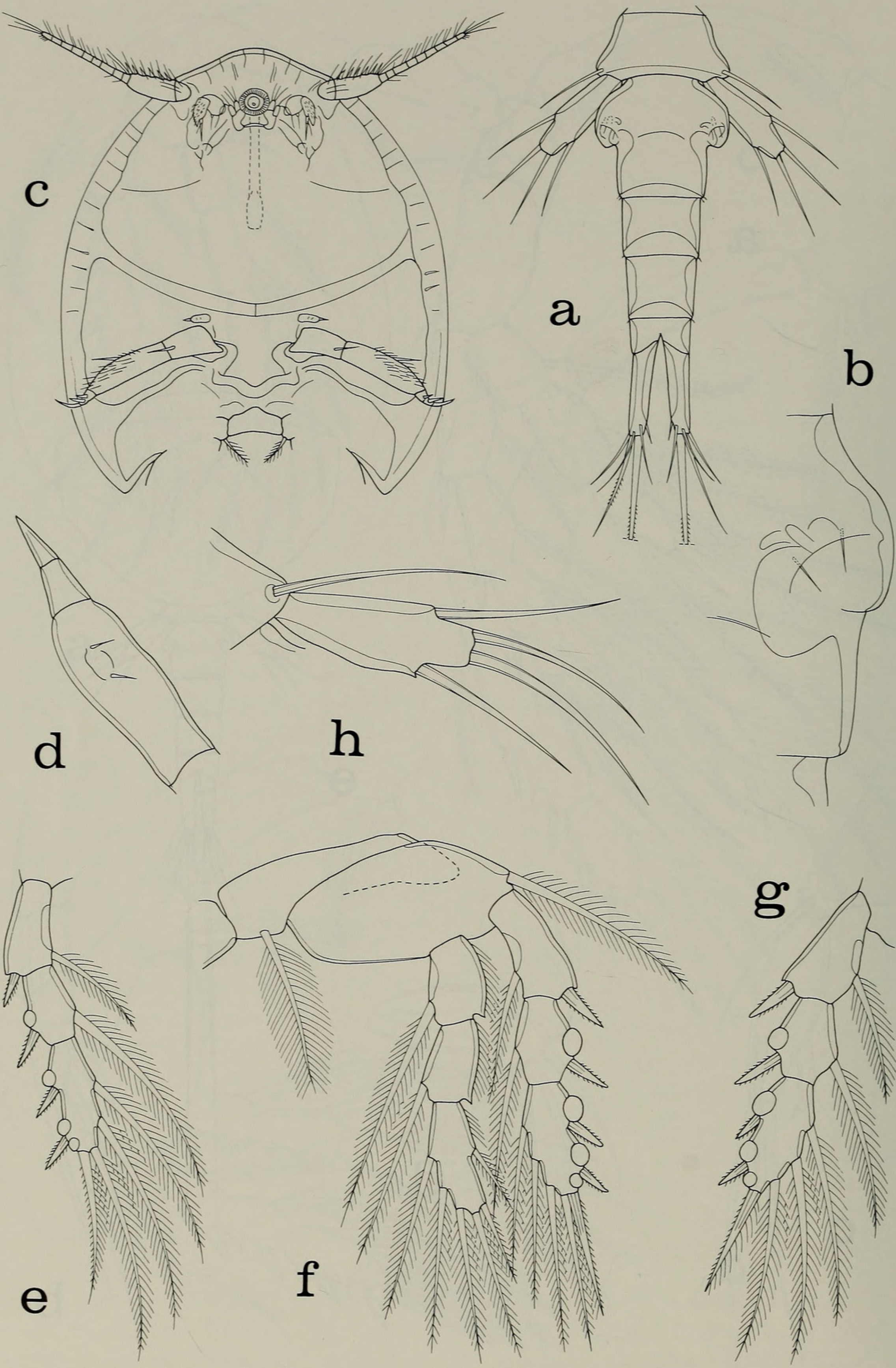

Fig. 5. *Pseudonicothoe branchialis* Avdeev & Avdeev, 1978. Female: a, urosome, dorsal (scale E); b, genital area, dorsal (C); c, cephalosome, ventral (A); d, maxilla, ventral (G); e, exopod of leg 1, anterior (H); f, leg 2, anterior (H); g, exopod of leg 3, anterior (H); h, leg 5, dorsal (H).

maxillae widely separated, with transverse sclerotized bar between them, as in Fig. 5c.

Legs 1–4 segmented and armed as in male. Legs 1–3 with exopods having small round hyaline flaps, 1 on second segment and 3 on third segment (Fig. 5e–g), as in male.

Leg 5 (Fig. 5h) with free segment 133 × 52 μm, ratio 2.56:1. Four setae from inner to outer 125, 140, 133, and 122 μm. Dorsal seta 146 μm.

Leg 6 represented by 2 setae on genital area (Fig. 5b).

Only 1 somewhat damaged egg sac seen, separated from female, containing approximately 12 flattened, discoidal, linearly arranged eggs, measuring 1045 × 330 μm.

Color unknown.

Remarks.—We have been unable to make a direct comparison of the specimens from *Heterocarpus sibogae* with the type specimens of *Pseudonicothoe branchialis.* The types consist of two females, holotype and paratype, deposited in the Laboratory of Parasitology of Marine Animals, Pacific Ocean Scientific Research Institute of Fisheries and Oceanography, Vladivostok, Russia.

Although the description and figures of *P. branchialis* published by Avdeev & Avdeev (1978) conform in major respects to our specimens from Australia, a few minor differences may be observed: (1) few relatively long setae on the antennule (Avdeev & Avdeev's fig. 5), (2) the antenna with a feathered seta on the exopod and the fourth segment with one of the two small setae feathered (their fig. 10), (3) the outer branch of the maxillule with three setae (their fig. 6), (4) the first segment of the maxilla in the female with one curved claw (their fig. 7), and (5) the free segment of leg 5 relatively short, ratio 1.64:1 (their fig. 7). We believe that these small differences may be attributable to the relatively small number of specimens studied, the difficulties of observation, and to the style of illustration.

The exopods of swimming legs 1–3 of both male and female *P. branchialis* are ornamented with marginal structures referred to as hyaline flaps in the present account, and as suckers by Avdeev & Avdeev (1978). When viewed from the side, as in Fig. 3a–c, these structures appear to be hyaline extensions of the lateral margin of the exopodal segments. When they are reflexed across the surface of the exopodal segment, radial surface striations are visible and their appearance is more suckerlike. Similar structures were figured on legs 1–3 of male *P. procircularis* (Carton) by Carton (1967).

The discovery of the male of *P. branchialis* prompted us to reconsider the validity of the genus *Pseudonicothoe* which was treated as a subjective synonym of *Paranicothoe* Carton by Boxshall & Lincoln (1983). The type species of *Paranicothoe, P. cladocera,* differs from *Pseudonicothoe* in the segmentation of the antennules, in the segmentation and armature of the maxilliped, and in the spine and setal formula of the swimming legs. According to Huys & Boxshall (1991) the antennule is 10-segmented in *P. cladocera,* the distal part comprises relatively short segments, and the apical segment is longer than the two preceding segments combined, whereas in *P. branchialis* the antennule is 11-segmented, the distal part comprises relatively long segments, and the apical segment is markedly shorter than the subapical segment. The endopod of the maxilliped of *P. cladocera* is 2-segmented and is armed with one claw on the first segment and two on the second. In *P. branchialis,* by comparison, the endopod is 3-segmented, with the first segment carrying three short setae, the second segment bearing one claw, and the third two claws. Finally, the endopod of leg 4 has a setal formula of 0–1; 0–2; 1,I,2 in *P. branchialis* and 0–1; 0–1; 1,I,2 in *P. cladocera.*

These differences justify the generic level separation of *Pseudonicothoe* and *Paranicothoe,* as represented by its type species, and we propose to recognize *Pseudonicothoe* as a valid genus again, thereby reversing the proposal made by Boxshall & Lincoln (1983). The type species of *Pseudonicothoe* is *P. branchialis. Paranicothoe* is also a valid genus, containing only the type species, *P. cladocera.* We propose to transfer *Paranicothoe procircularis* (Carton) to *Pseudonicothoe,* as a new combination, *Pseudonicothoe procircularis* (Carton, 1967). This transfer is based on the 11-segmented condition of the antennule, and on the spine and setal formula of the swimming legs.

Acknowledgment

We thank Dr. A. J. Bruce, Northern Territory Museum, Darwin, Australia, for sending specimens of the nicothoid to us for study. The study of the copepods was aided by a grant (BSR 88 21979) to AGH from the National Science Foundation of the United States.

Literature Cited

Audouin, V., & H. Milne Edwards. 1826. Mémoire sur la Nicothoe, animal singulier qui suce le sang des homards.—Annales de Sciences Naturelles 9:345–358.

Avdeev, G. V., & V. V. Avdeev. 1978. *Pseudonicothoe branchialis* gen. et sp. n. (Crustacea, Copepoda) from gills of *Heterocarpus laevigatus* from the Pacific Ocean.—Zoologicheskii Zhurnal 57:1893–1897.

Boxshall, G. A., & R. J. Lincoln. 1983. Some new parasitic copepods (Siphonostomatoida: Nicothoidae) from deep-sea asellote isopods.—Journal of Natural History 17:891–900.

Carton, Y. 1967. Description de *Nicothoe procircularis* n. sp. (Crustacea, Copepoda) discussion sur la forme mâle.—Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening 130:143–152.

———. 1970a. Description de *Paranicothoe* n. gen. un nouveau représentant de la famille des Nicothoidae.—Galathea Report 11:239–246.

———. 1970b. Le genre *Paranicothoe,* un nouveau représentant de la famille des Nicothoidae.—Second International Congress of Parasitology, Journal of Parasitology 56(II):47–48.

Connolly, C. J. 1929. A new copepod parasite *Choniosphaera cancrorum,* gen. et sp. n., representing a new genus, and its larval development.—Proceedings of the Zoological Society of London 1929:415–427.

Dana, J. D. 1852. Conspectus crustaceorum quae in orbis terrarum circumnavigatione Carolo Wilkes e classe reipublicae foederatae duce, lexit e descripsit Jacobus D. Dana. Part 2.—Proceedings of the American Academy of Arts and Sciences 2:9–61.

Hansen, H. J. 1897. The Choniostomatidae. A family of Copepoda, parasites on Crustacea Malacostraca. Copenhagen, Denmark. Pp. 1–205.

Humes, A. G. 1975. *Hadrothoe crosnieri* n. gen., n. sp. (Crustacea, Copepoda), from a penaeid shrimp (Crustacea, Decapoda) in Madagascar.—Zoologischer Anzeiger 195:21–34.

Huys, R., & G. A. Boxshall. 1991. Copepod evolution. The Ray Society 159:1–468.

Pillai, N. K. 1962. *Choniomyzon* gen. nov. (Copepoda: Choniostomatidae) associated with *Panulirus.*—Journal of the Marine Biological Association of India 4:95–99.

Thorell, T. 1859. Till kannedomen om vissa parasitiskt lefvande Entomostracer.—Ofversigt af Kongliga Akademiens Forhandlingar 16(8):335–362.

(AGH) Boston University Marine Program, Marine Biological Laboratory, Woods Hole, Massachusetts 02543, U.S.A.; (GAB) The Natural History Museum, Cromwell Road, London, England SW7 5BD.