

Three new species of the genus *Normanella* Brady (Copepoda: Harpacticoida) from the Gulf of Mexico

W. LEE*†, P. A. MONTAGNA† and M.-S. HAN‡

† Marine Science Institute, The University of Texas at Austin,
750 Channel View Drive, Port Aransas, TX 78373, USA

‡ Department of Life Science, College of Natural Sciences, Hanyang
University, Seoul 133-791, Korea

(Accepted 24 August 2001)

Three new species of Normanellidae are described from the Texas coast, Gulf of Mexico. *Normanella texana* sp. nov. has limited areolated patterns on the cephalothorax, short P5 exopod and endopod, short caudal ramus and short caudal seta VI–V. *Normanella brevispina* sp. nov. is characterized by its relatively long caudal rami, and areolated rostrum. *Normanella chanhoi* sp. nov. has well-developed areolated patterns on the cephalothorax, six-segmented antennule and a smooth apical margin of the rostrum. *N. texana* belongs to the *bolini*-lineage, and *N. brevispina* to the *minuta*-lineage. *Normanella chanhoi* establishes a new lineage of its own.

KEYWORDS: *Normanella*, Normanellidae, Harpacticoida, Copepoda, Gulf of Mexico.

Introduction

Normanellidae is one of the smallest families in the order Harpacticoida. However, Lee and Huys (1999) recently described several new members of the family and suggested the species diversity of the normanellid copepods is underestimated. The family was first established by Nicholls (1945) for the genera *Normanella* Brady and *Cleptosyllus* Willey, but was refuted by Lang (1948). Lang (1944) introduced the subfamily name Normanellinae in the Laophontidae, which included *Normanella*, *Cleptosyllus*, *Pseudocleta* Lang and *Laophontopsis* Sars. Huys and Willems (1989) proposed Laophontopsidae for the genus *Laophontopsis*, and upgraded the subfamily Normanellinae to full family rank. The remaining genera were allocated to two subfamilies within the upgraded Normanellidae. Normanellinae was restricted to its type genus *Normanella*, Cleptosyllinae included *Cleptosyllus* and *Pseudocleptosyllus* Vervoort was regarded as genus *incertae sedis*. Huys and Lee (1998) upgraded Cleptosyllinae to full family rank, Cleptosyllidae, and automatically upgraded

*Corresponding author: wlee@hanyang.ac.uk

Normanellinae to family rank. The family Normanellidae currently includes two genera, *Normanella* and *Sagamiella* Lee and Huys, 1999.

Lee and Huys (1999) reported the family Normanellidae to be remarkably conservative in mouth part structure, swimming leg sexual dimorphism and overall setation patterns. They recommended that future descriptions and identifications pay particular attention to six characters: (1) shape of rostrum, (2) surface texture of the cephalic shield, (3) shape of the exopod and endopodal lobe of the P5 in both sexes, (4) shape of the caudal ramus, (5) form and length of caudal ramus setae IV and V and (6) the P2 endopod of the male. They also suggested that new species are likely to be discovered even in intensively investigated areas.

The current material was discovered during an ecological study of meiofauna near offshore platforms (Montagna and Harper, 1996). One species, *Normanella brevispina*, sp. nov. was the subject of a detailed population study on the loss of genetic diversity in harpacticoid copepods near offshore platforms in the Gulf of Mexico (Street and Montagna, 1996). The species, called *Normanella* sp. B, was used to determine the relationship between ecological integrity and contaminants resulting from hydrocarbon exploration and production. As a part of a further study, meiofauna samples were collected near artificial reefs, and sites from where platforms were removed. Among these samples three new *Normanella* species were found, and are described herein.

Materials and methods

Specimens were dissected in lactic acid and the dissected parts were mounted on slides in lactophenol mounting medium. Preparations were sealed with transparent nail varnish. All drawings have been prepared using a camera lucida on a Leica DMLB differential interference contrast microscope.

The descriptive terminology is adopted from Huys *et al.* (1996). Abbreviations used in the text are: ae, aesthetasc; P1–P6, first to sixth thoracopod; exp(enp)-1(2, 3) to denote the proximal (middle, distal) segment of the exopod or endopod ramus. Type series are deposited in collections of The Natural History Museum (NHM), London, UK and the National Museum of Natural History (USNM), Smithsonian Institution, Washington, DC, USA. Scale bars in figures are indicated in μm .

Meiofaunal harpacticoids were collected from four stations (table 1). The stations were part of a field experiment designed to determine the relationship between ecological integrity and contaminants and distinguish this from natural background in marine ecosystems. The field experiment was composed of four treatments: artificial reefs (sunken ships and deactivated platforms without contamination), sites

Table 1. Station locations and characteristics.

Station	Treatment	Latitude	Longitude	Temperature (°C)	Salinity (psu)	Depth (m)
MI 686	Platform	27°57.46'	96°33.56'	29.96	35.76	26.9
MI 700	Control	27°54.57'	96°32.58'	30.14	35.86	29.8
MI 712	Reef	27°49.98'	96°30.38'	30.06	35.92	38.8
MI 712R	Removal	27°52.10'	96°32.06'	30.44	35.83	33.9

The station is named after the Gulf of Mexico Lease Block; the treatment is the type of location.

where platforms were removed (no reef but contaminants still exist), operating platforms (reef and contaminant effects), and control sites (normal shelf sediments at least 3 km away from natural or artificial structures). Samples were collected with a Tom Tom corer on board R/V *Longhorn* (Marine Science Institute, The University of Texas at Austin) on 1 and 15 September 2000.

Systematics

Family NORMANELLIDAE Lang, 1944

Genus *Normanella* Brady, 1880

Normanella texana sp. nov.

Material examined. (1) The Natural History Museum, London: holotype ♀ (dissected on nine slides; NHM 2001.396) from MI 712, paratypes one ♀ and one ♂ (NHM 2001.397–398) dissected on eight, seven slides; paratypes 19 ♀♀ and two ♂♂ (NHM 2001.399–419) in 70% alcohol, all from MI 712, coll. R. Kalke and W. Lee on 15 September 2000. (2) The National Museum of Natural History, Smithsonian Institution, Washington, DC: paratypes one ♀ and one ♂ (USNM310780) in 70% alcohol, from MI 712R, coll. W. Lee on 15 September 2000; paratype one ♀ (USNM310781) in 70% alcohol, from MI 700, coll. R. Kalke and M. Ma on 1 September 2000.

Description of female. Total body length 384–456 µm ($N=10$; mean = 420 µm; measured from anterior margin of rostrum to posterior margin of caudal rami). Body slender. Largest width measured at posterior margin of cephalic shield: 102 µm. Urosome narrower than prosome (figure 1A).

Cephalothorax with serrulate posterior margin, pleural areas well developed, and rounded, posterolateral angles minutely crenate, ornamentation consisting of sensillae as illustrated in figure 1A, B, paired longitudinal surface lamellae present dorsally, and areolated pattern present dorsally only between paired longitudinal surface lamellae. Cephalothorax without minute denticles as found on free body somites.

Rostrum triangular (figure 3A), with inwardly curved lateral margins and pointed anterior margin, with one pair of tiny sensillae and one mid-dorsal tube-pore near the apex, dorsal surface smooth, and without denticles.

Pedigerous somites covered with minute spinules. All prosomites without defined hyaline frills, and hind margin serrulate.

Urosome (figures 1A, B, 2A) five-segmented, comprising P5-bearing somite, genital double-somite and three free abdominal somites. All urosomites with surface ornamentation consisting of small spinules dorsally and laterally, ventral surface smooth without spinules, and hind margin distinctly serrate dorsally and laterally. Ventral hind margin of urosomites 2–4 with spinules medially and laterally.

Genital double-somite (figures 1A, B, 2A) with original segmentation indicated by transverse, serrate surface ridge dorsally and dorsolaterally, short surface suture ventrolaterally and completely fused ventrally. Genital field (figure 2C) with large copulatory pore located in median depression. Gonopores fused medially forming single genital slit covered on both sides by opercula derived from sixth legs. P6 with small protuberance bearing one pinnate outer seta and one bare inner seta, and bare seta much larger than in other congeners.

Anal somite (figure 2A, B) with well-developed, deeply serrate anal operculum

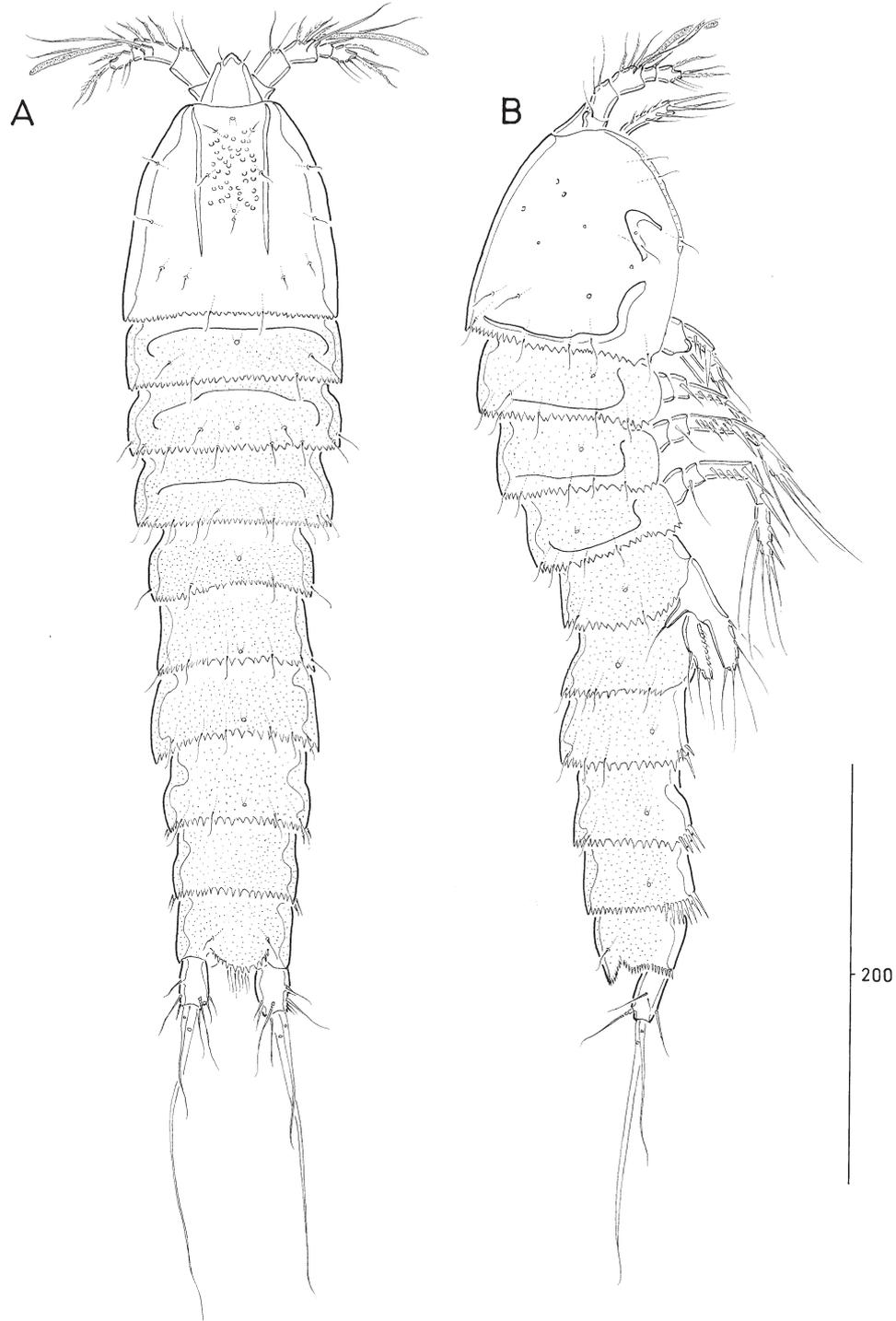


FIG. 1. *Normanella texana* sp. nov. (♀). (A) Habitus, dorsal; (B) habitus, lateral.

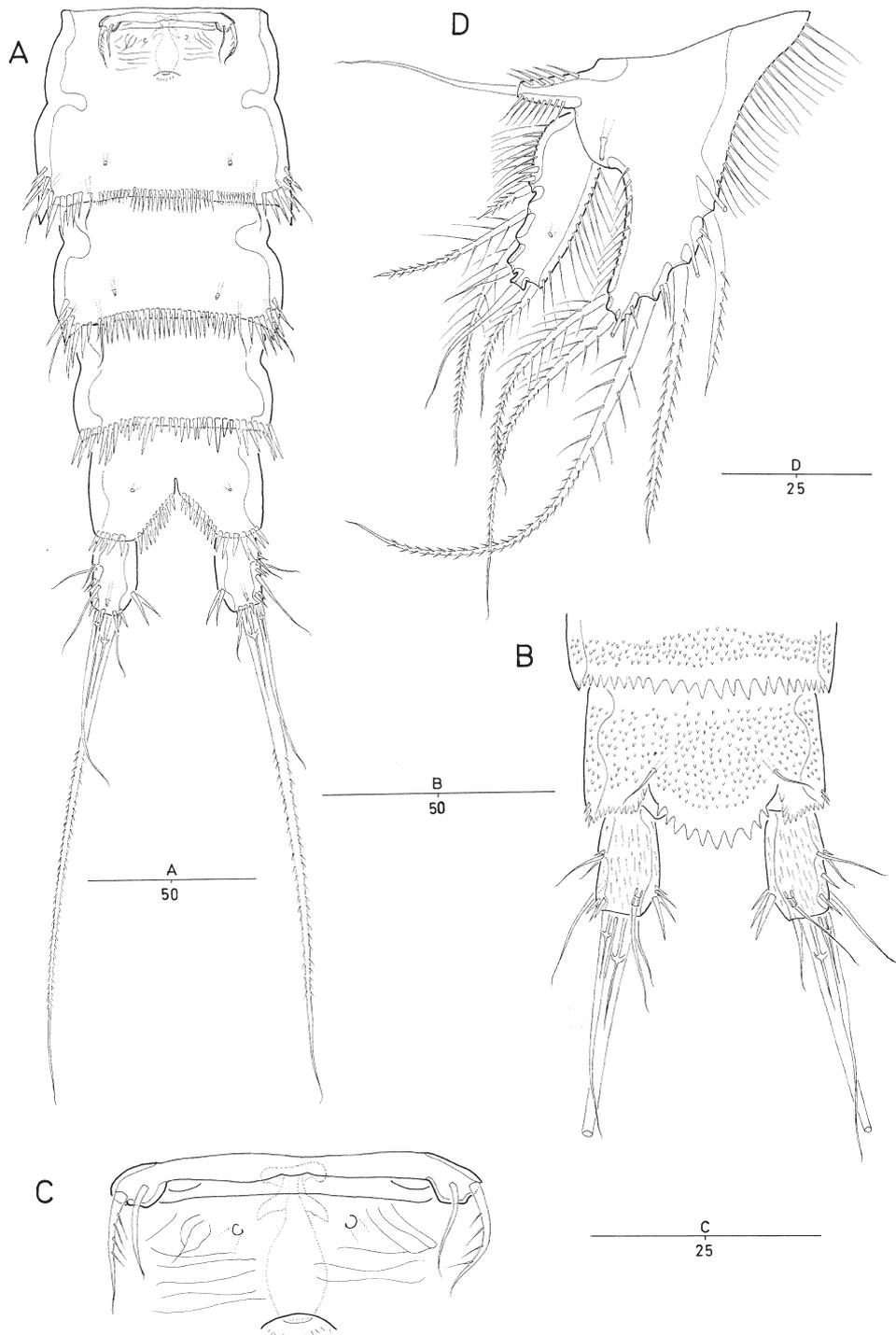


FIG. 2. *Normanella texana* sp. nov. (♀). (A) Urosome, ventral (excluding P5-bearing somite); (B) anal somite and rami, dorsal; (C) genital field; (D) P5, anterior.

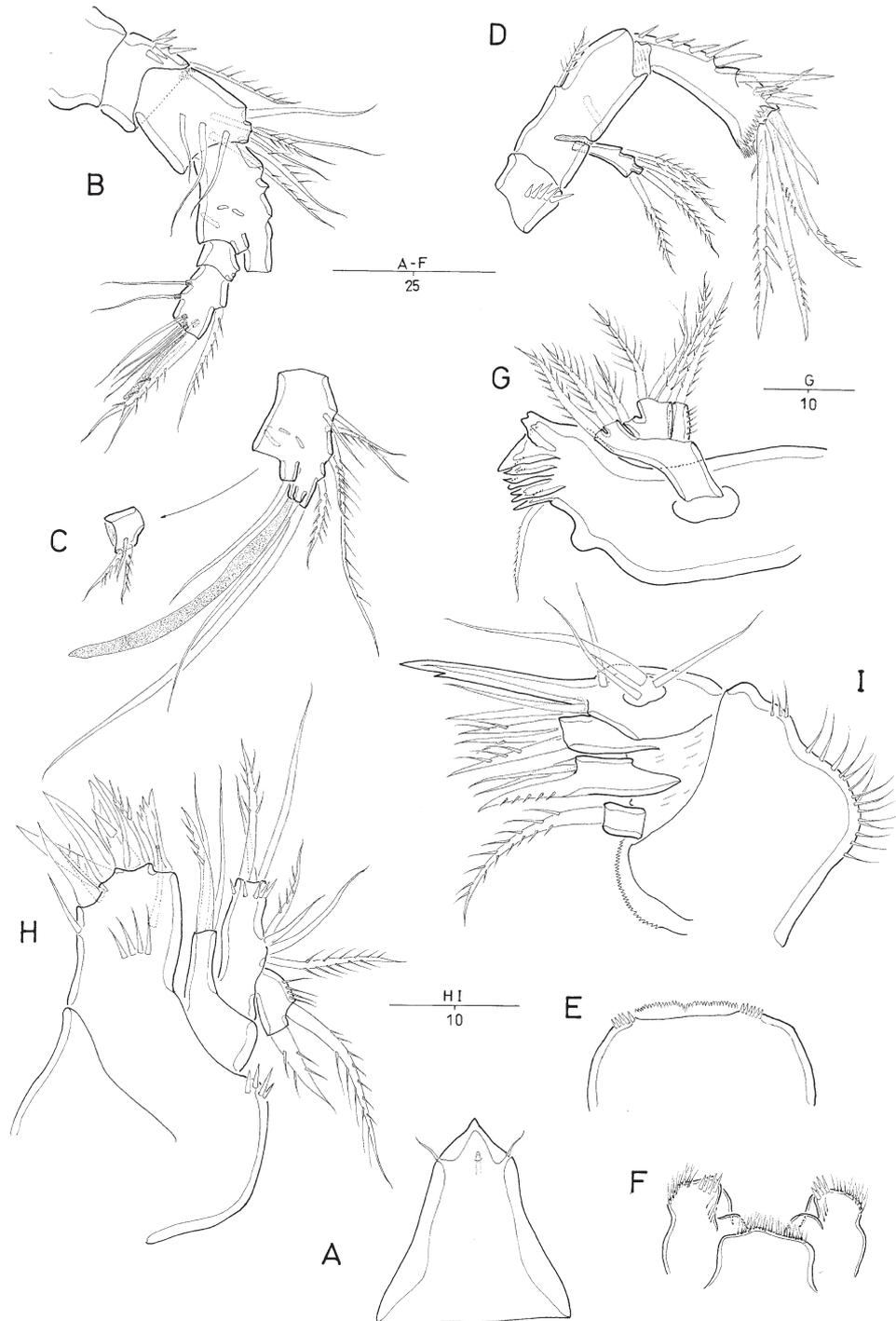


FIG. 3. *Normanella texana* sp. nov. (♀). (A) Rostrum, dorsal; (B) antennule (armature on segments 3 and 4 omitted); (C) 3rd and 4th antennular segments; (D) antenna; (E) labrum; (F) paragnath; (G) mandible; (H) maxillule; (I) maxilla.

flanked by row of spinous processes. Anal opening with fringe of long setular extensions, and bordered by fine spinules ventrally.

Caudal rami (figure 2A, B) short, just over 1.5 times as long as maximum width. Each ramus with one tube-pore and seven setae: seta I bare, shortest and closely set to bare seta II; seta III bare and positioned ventrolaterally; setae IV and V fused basally, with fracture plane (seta IV bare; seta V longest, but shorter than urosomites combined; with internal fracture plane); seta VI bare and small; seta VII tri-articulate at base. Each ramus surface wrinkled dorsally. Sparse additional spinular ornamentation present along outer margin (around base of setae I–II), inner margin (near base of seta VII), and around ventral hind margin.

Antennule (figure 3B, C) five-segmented, segment 3 longest (with vestigial suture). Armature formula: 1-[1 pinnate], 2-[6+3 pinnate], 3-[4+4 pinnate+(1+ae)], 4-[1+2 pinnate], 5-[6+1 pinnate+1 acrothek]. Apical acrothek consisting of small aesthetasc fused basally to one slender seta and one strong pinnate spine. Segment 1 with spinular rows around anterior margin. Segment 3 with aesthetasc fused basally to seta and set on distinct pedestal.

Antenna (figure 3D) three-segmented comprising coxa, allobasis and free one-segmented endopod. Coxa small with one row of spinules. Basis and proximal endopod segment fused forming elongate allobasis with transverse surface sutures marking original segmentation anteriorly and posteriorly, and with one abexopodal pinnate seta in distal half. Exopod small, three times longer than width, with two pinnate setae laterally, and two pinnate setae apically. Endopod slightly shorter than allobasis. Lateral armature consisting of two slender spines, arising in proximal half. Apical armature consisting of one bare, and two pinnate spines, one geniculate spine, and one strong pinnate spine (fused basally to short seta).

Labrum (figure 3E) with elaborate spinular ornamentation without any pores.

Mandible (figure 3G) with well-developed gnathobase bearing several multicuspitate teeth around distal margin and one long pinnate spine at dorsal corner. Palp small, biramous. Basis with two plumose setae. Exopod one-segmented, smaller than endopod, with one plumose seta apically and one row of setules laterally. Endopod one-segmented, with three plumose setae apically, and one plumose seta laterally.

Paragnaths (figure 3F): well-developed lobes with medially directed hair-like setules, and separated by medial lobe covered with dense patterns of short setules.

Maxillule (figure 3H): praecoxa with few short spinules around distal outer margin. Arthrite strongly developed, with one naked seta on anterior surface and eight spines/setae around distal margin. Coxa with cylindrical endite bearing one naked seta and one curved, pinnate spine. Basis with two naked setae, and one curved spine distally, and one row of spinules along distal margin. Endopod incorporated in basis, represented by two naked and two plumose setae. Exopod one-segmented, with two pinnate setae, and one row of setules along inner lateral side.

Maxilla (figure 3I) with row of spinules along outer lateral margin, and three endites on syncoxa. Praecoxal endite small and cylindrical, with one strong, pinnate spine. Proximal coxal endite with one strong pinnate spine fused to endite, and two naked setae. Distal coxal endite with three pinnate spines. Allobasis drawn out into strong, slightly curved claw. Accessory armature consisting of one naked seta on anterior surface, one naked spine on posterior surface, and one naked seta along outer margin. Endopod represented by three naked setae.

Maxilliped (figure 4E) with two pinnate spines and row of spinules on syncoxa.

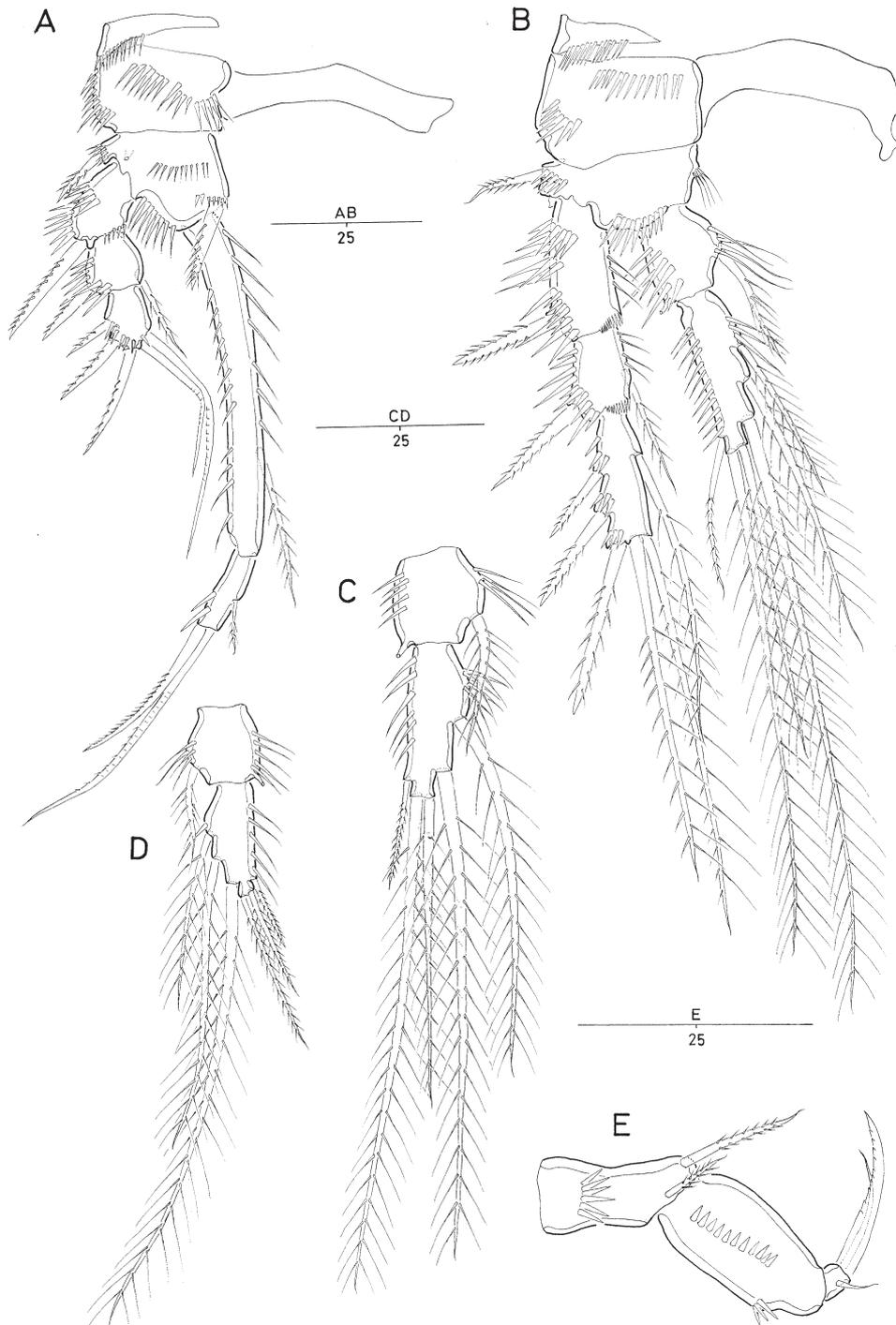


FIG. 4. *Normanella texana* sp. nov. (♀). (A) P1, anterior; (B) P2, anterior; (C) P2 endopod, anterior (abnormal); (D) P2 (♂), endopod, anterior; (E) maxillipede, anterior.

Basis with one row of spinules on outer lateral margin, and smooth along palmar region. Endopod small with a long, sparsely pinnate claw. Accessory armature consisting of long naked seta and minute outer seta.

Swimming legs P1–P4 (figures 4A–C, 5A, B) with wide intercoxal sclerites and well-developed praecoxae. Coxae and bases with anterior rows of surface spinules as figured. Exopods three-segmented, endopod two-segmented.

P1 (figure 4A) with large coxa, with long spinules along outer margin and on anterior surface. Basis with one strong, pinnate spine and spinules along inner margin, and with one stout pinnate spine and few spinules along outer margin. Exp-1 with one stout pinnate outer spine (longer than outer spine of exp-2). Exp-2 with one pinnate, outer spine and one short, plumose, inner seta (extending beyond exp-3 distal margin). Exp-3 with three pinnate spines and two geniculate setae. Endopod 2.3 times as long as exopod. Enp-1 about 10 times longer than width, and 4.5 times longer than enp-2, with plumose inner seta. Enp-2 with one slender, denticulate claw, one geniculate seta and one small plumose seta.

P2–P4 (figures 4B, C, 5A, B). Coxae and bases with spinular rows along outer margin. Outer margin of basis with bipinnate spine (P2) or naked seta (P3–P4). Exp-1 and -2 with coarse frill at inner distal corner. All segments with pattern of spinules as figured. Inner margins of exopod and endopod segments with long setules or spinules.

P2 enp-1 with short tubular extension from outer distal corner. Enp-2 twice longer than enp-1. Endopod reaching to middle of exp-3. Aberrant setal formation showed in other paratype (figure 4C).

P3 enp-2 twice longer than enp-1. Endopod reaching to distal margin of exp-2. Inner distal corner of enp-2 produced into short tubular extension.

P4 enp-2 twice longer than enp-1. Endopod reaching to just beyond distal margin of exp-1. Inner distal corner of enp-2 produced into long tubular extension.

Spine and setal formula as follows:

	Exopod	Endopod
P2	0.1.123	1.321
P3	0.1.223	1.321
P4	0.1.223	1.221

P5 (figure 2D): baseoendopod forming short, outer setophore bearing basal seta and row of spinules, and with one pore near boundary with exopod. Endopodal lobe long, exceeding distal margin of exopod, with three pinnate setae laterally and two bipinnate setae apically, rows of long spinules along outer margin, and long setules plus two tube-pores along inner margin, and one tube-pore near apical seta. Exopod elongate, tapering distally; with one naked terminal seta, one bipinnate inner seta, one naked and three pinnate setae of different lengths along outer margin, one terminal seta arising from small cylindrical process, and inner and outer margins with numerous long setules.

Description of male. More slender than female. Body length 331–371 μm ($N=2$; mean = 351 μm ; measured from anterior margin of rostrum to posterior margin of caudal rami). Largest width measured at distal margin of P3-bearing somite: 76 μm . Urosome narrower than prosome (figure 6a).

Prosome (figure 6A) four-segmented, comprising cephalothorax and three free pedigerous somites. Rostrum distinct at base as in ♀. Cephalothorax with posterior margin weakly crenulated. One pair of longitudinal ridges present as in ♀, but

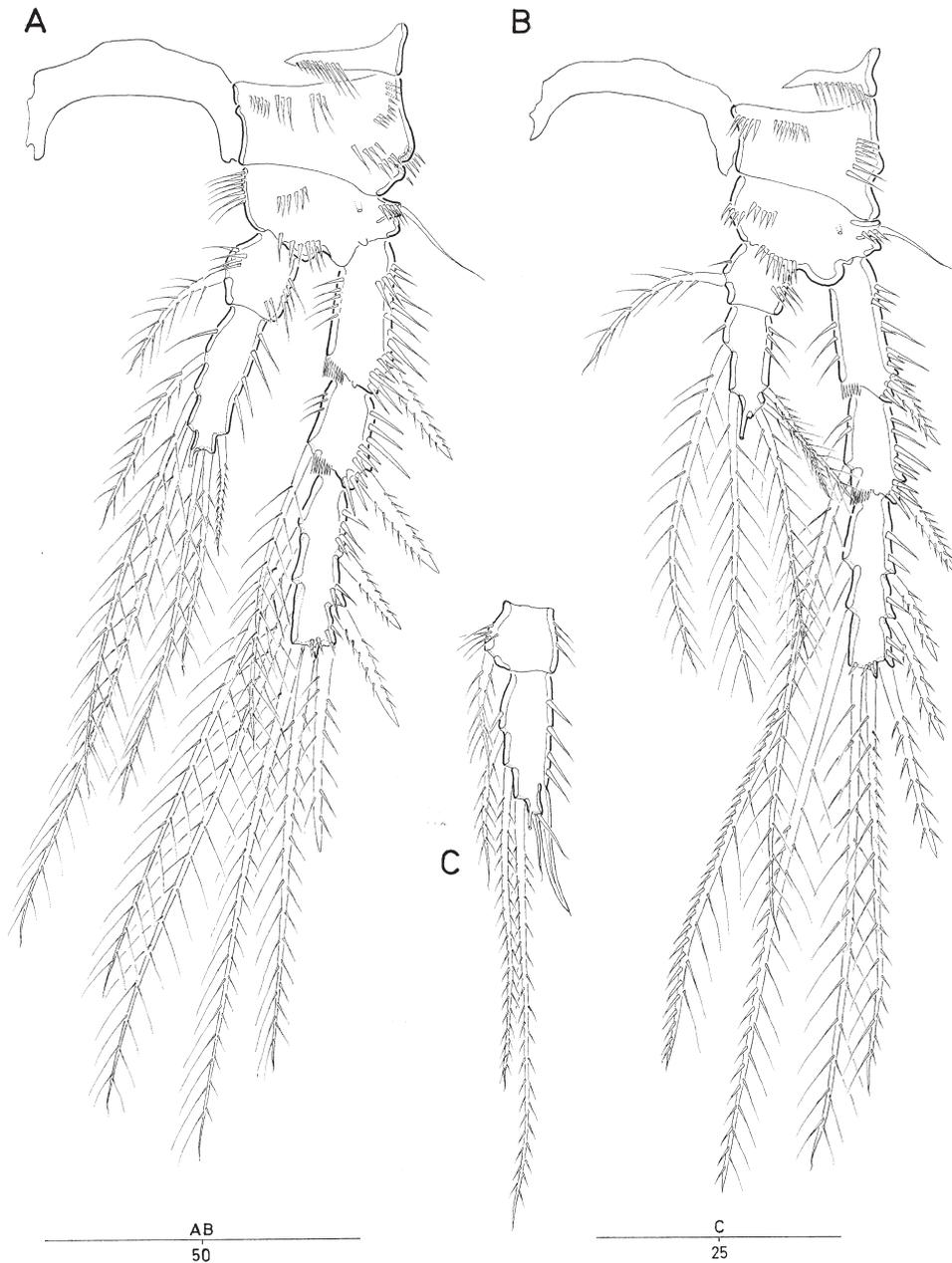


FIG. 5. *Normanella texana* sp. nov. (♀). (A) P3, anterior; (B) P4, anterior; (C) P3 endopod (♂).

without areolated surface pattern. Ornamentation consisting of sensillae, and pores as figured. Pedigerous somites covered with minute denticles. Prosomites with crenulated hind margin.

Urosome (figures 6F) six-segmented, comprising P5-bearing somite, genital somite and four abdominal somites. Surface ornamentation pattern consisting of

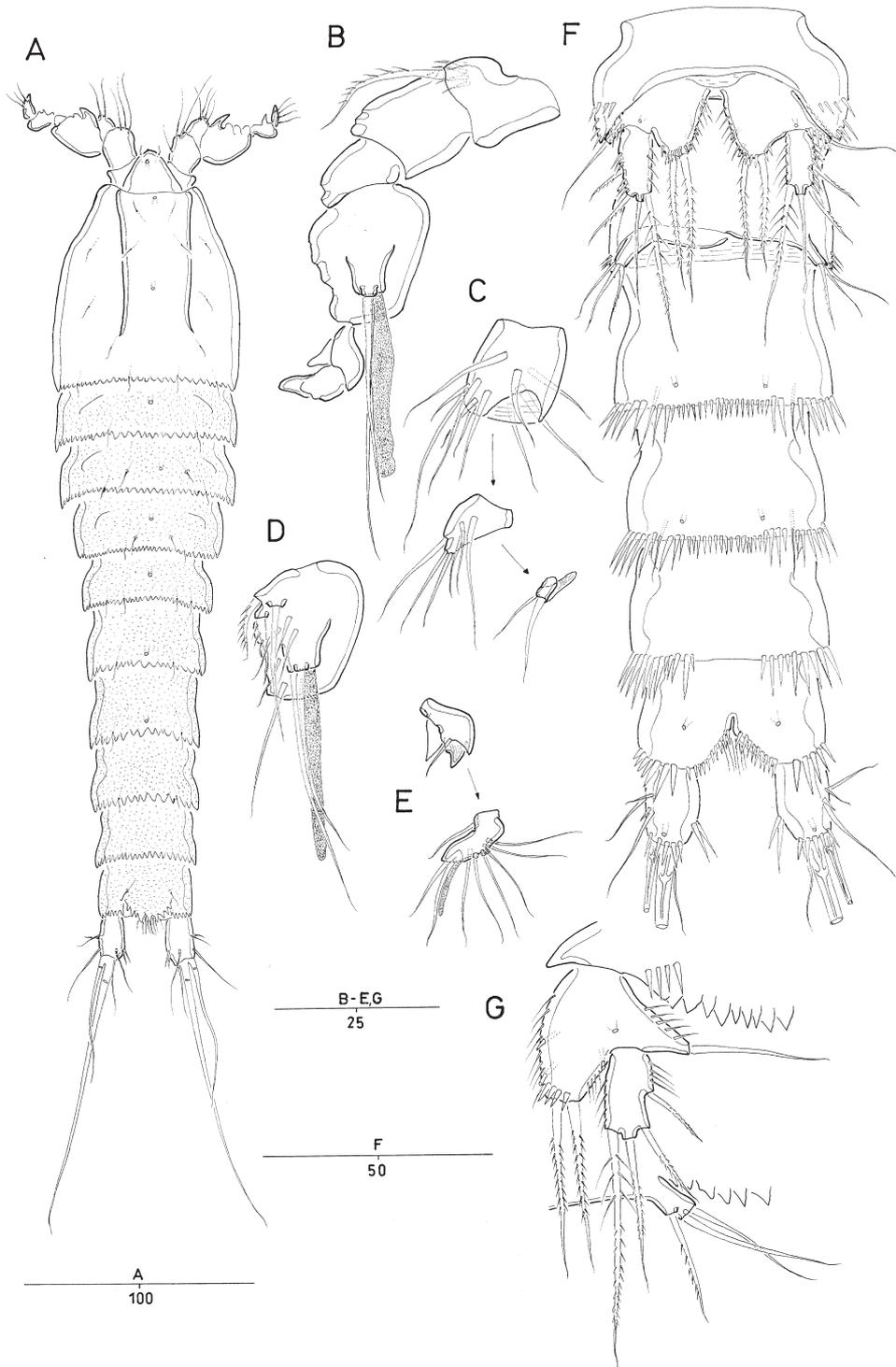


FIG. 6. *Normanella texana* sp. nov. (♂). (A) Habitus, dorsal; (B) antennule (armature omitted except for segment 1); (C) antennular segments 2–4; (D) antennular segment 5; (E) antennular segments 6–7; (F) urosome, ventral; (G) left P5 and P6, anterior.

patches of minute denticles present dorsally and laterally, and posterior margin irregularly serrate dorsally and laterally.

Antennule (figure 6B–E) seven-segmented. Subchirocer with geniculation between segments 5 and 6. Segment 1 with row of spinules along anterior margin. Segment 4 represented by small sclerite along anterior margin (insert in figure 6C). Segment 7 triangular. Segment 5 largest and swollen. Segment 6 forming dorsal spinous process overlying anterior part of segment 7. Segmental homologies: 1-I, 2-(II–VIII), 3-(IX–XII), 4-XIII, 5-(XIV–XX), 6-(XXI–XXIII), 7-(XXIV–XXVIII). Armature formula: 1-[1 pinnate], 2-[11], 3-[6], 4-[2], 5-[7+2 pinnate+(1+ae)], 6-[1+1 spinous process], 7-[7+acrothek]. Apical acrothek consisting of minute aesthetasc and two naked setae.

P2 endopod (figure 4D) two-segmented. Both apical setae of enp-2 distinctly shorter than in ♂. Outer apical seta shortest and about 1.6 times as long as outer spine.

P3 endopod (figure 5C) two-segmented, and modified. Enp-2 shorter than in ♀. Outer margin with short mucroniform process being homologous with outer spine of enp-2 of ♀. Both apical setae strongly reduced and set on small lobe together with tube-pore. Inner setae not modified.

Fifth pair of legs (figure 6F, G) fused medially. P5 defined at base. Baseoendopod with short setophore bearing outer basal seta, and well-developed trapezoid endopodal lobe with two pinnate setae apically. Two tube-pores along inner margin and one tube-pore near articulation with exopod. Exopod about twice as long as maximum width, with one bipinnate inner seta, one bipinnate apical seta and two pinnate setae along outer margin.

Sixth pair of legs (figure 6F, G) asymmetrical, represented on both sides by a small plate (fused to ventral wall of supporting somite along one side, articulating at base and covering gonopore along other side). Outer distal corner produced into cylindrical process bearing one pinnate and two naked setae.

Etymology. The species is named after the type locality, off the Texas coast.

Remarks. *Normanella texana* is most closely related to the Californian species *Normanella bolini* Lang, 1965, which belongs to the *bolini*-lineage with *Normanella similis* Lang (Lee and Huys, 1999). The *bolini*-lineage has a short oval exopod, and broad triangular endopodal lobe in female P5, short caudal rami with relatively short seta IV–V, a triangular-pointed rostrum and five-segmented antennule. *Normanella texana* shares the above characters with the *bolini*-lineage except for the P5 exopod having a flask shape, rather than oval shape. The present new species also has five additional differences from *N. bolini*: (1) rostrum apex with sharper tip, and concave lateral margins; (2) slightly longer caudal rami (1.5 times longer than width) than in *N. bolini* (1.2 times); (3) longer caudal seta V; (4) areolated patterns only present between the dorsal longitudinal ridges on the cephalothorax; (5) P1 endopod (10 times longer than wide) slender and longer than in *N. bolini* (7.5 times longer than wide).

The present new species has variability in the setal formation of P2 endopod (figure 4C). The reduced setal number was found in only one specimen.

Normanella brevispina sp. nov.

Material examined. (1) The Natural History Museum, London: holotype ♀ (dissected on nine slides; NHM 2001.420), paratypes two ♀♀ (NHM 2001.421–422)

in 70% alcohol all from MI 700, coll. W. Lee on 15 September 2000; paratype one ♂ (NHM 2001.423) dissected on seven slides, paratype one ♀ (NHM 2001.424) in 70% alcohol, from MI 700, coll. R. Kalke and M. Ma on 1 September 2000. (2) The National Museum of Natural History, Smithsonian Institution, Washington, DC: paratypes three ♀♀ (USNM310782), from MI 686 and one ♀ (USNM310783) from MI 712R in 70% alcohol, coll. W. Lee on 15 September 2000.

Description of female. Total body length 454–500 μm ($N=7$; mean = 473 μm); measured from anterior margin of rostrum to posterior margin of caudal rami). Body slender. Largest width measured at posterior margin of P1-bearing somite: 93 μm . Urosome narrower than prosome (figure 7A, B).

Cephalothorax with serrulate posterior margin, pleural areas well-developed and rounded, posterolateral angles minutely crenate, ornamentation consisting of sensillae as illustrated in figure 7A, B, one paired longitudinal surface lamellae present dorsally, and areolated pattern present forming incomplete H-shape on dorsal surface, similar to *Normanella bifida* Lee and Huys, 1999. Cephalothorax without minute denticles as found on free body somites.

Rostrum triangular (figure 9A) with inwardly curved lateral margins and pointed anterior margin, one pair of tiny sensillae, and one mid-dorsal tube-pore near the apex. Dorsal surface areolated.

Pedigerous somites covered with minute spinules. All prosomites without defined hyaline frills and hind margin serrulate.

Urosome (figures 7A, B, 8F) five-segmented, comprising P5-bearing somite, genital double-somite and three free abdominal somites. All urosomites with surface ornamentation consisting of small spinules dorsally and laterally, ventral surface smooth without spinules, and hind margin distinctly serrate dorsally and laterally. Ventral hind margin of urosomites 2–4 with spinules medially and laterally.

Genital double-somite (figures 7A, B, 8F) with original segmentation indicated by transverse, serrate surface ridge dorsally and dorsolaterally, one short surface suture ventrolaterally, and completely fused ventrally. Genital field [not figured] with large copulatory pore located in median depression. Gonopores fused medially forming one single genital slit covered on both sides by opercula derived from sixth legs. P6 with small protuberance bearing one pinnate outer seta and one bare inner seta.

Anal somite (figure 8F) with well-developed, deeply serrate anal operculum flanked by row of spinous processes. Anal opening with fringe of long setular extensions, and bordered by fine spinules ventrally. Ventral surface wrinkled.

Caudal rami (figure 8F) 2.5 times longer than maximum width. Each ramus with one tube-pore and seven setae: seta I bare, shortest and closely set to bare seta II; seta III bare and positioned ventrolaterally; setae IV and V fused basally, with fracture plane (seta IV bare; seta V longest, about two-thirds of all urosomites combined, pinnate; with internal fracture plane, but internal core unobservable); seta VI bare and small; seta VII tri-articulate at base. Each ramus surface with minute spinules on dorsal surface. Sparse additional spinular ornamentation present along outer margin (around base of setae I–II), and around ventral hind margin.

Antennule (figure 8A) five-segmented, segment 3 longest (with vestigial suture). Armature formula: 1-[1 pinnate], 2-[5+3 pinnate], 3-[5+4 pinnate+(1+ae)], 4-[2+1 pinnate], 5-[6+1 pinnate+1 acrothek]. Apical acrothek consisting of small aesthetasc fused basally to one slender seta and one strong pinnate spine. Segment 1 with two spinular rows around anterior margin. Segment 3 with aesthetasc fused basally to seta and set on distinct pedestal.

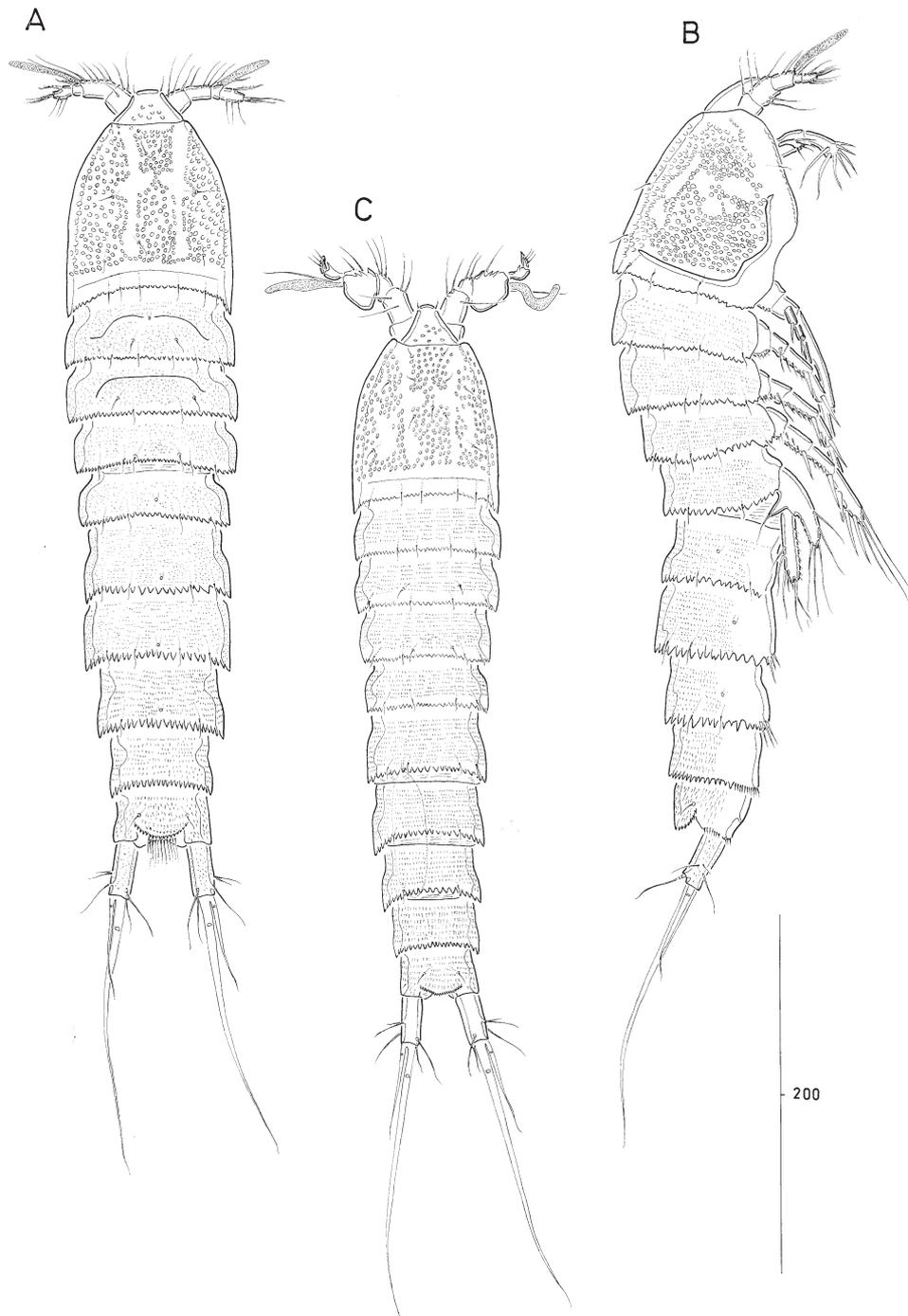


FIG. 7. *Normanella brevispina* sp. nov. (♀). (A) Habitus, dorsal; (B) habitus, lateral; (C) habitus, dorsal (♂).

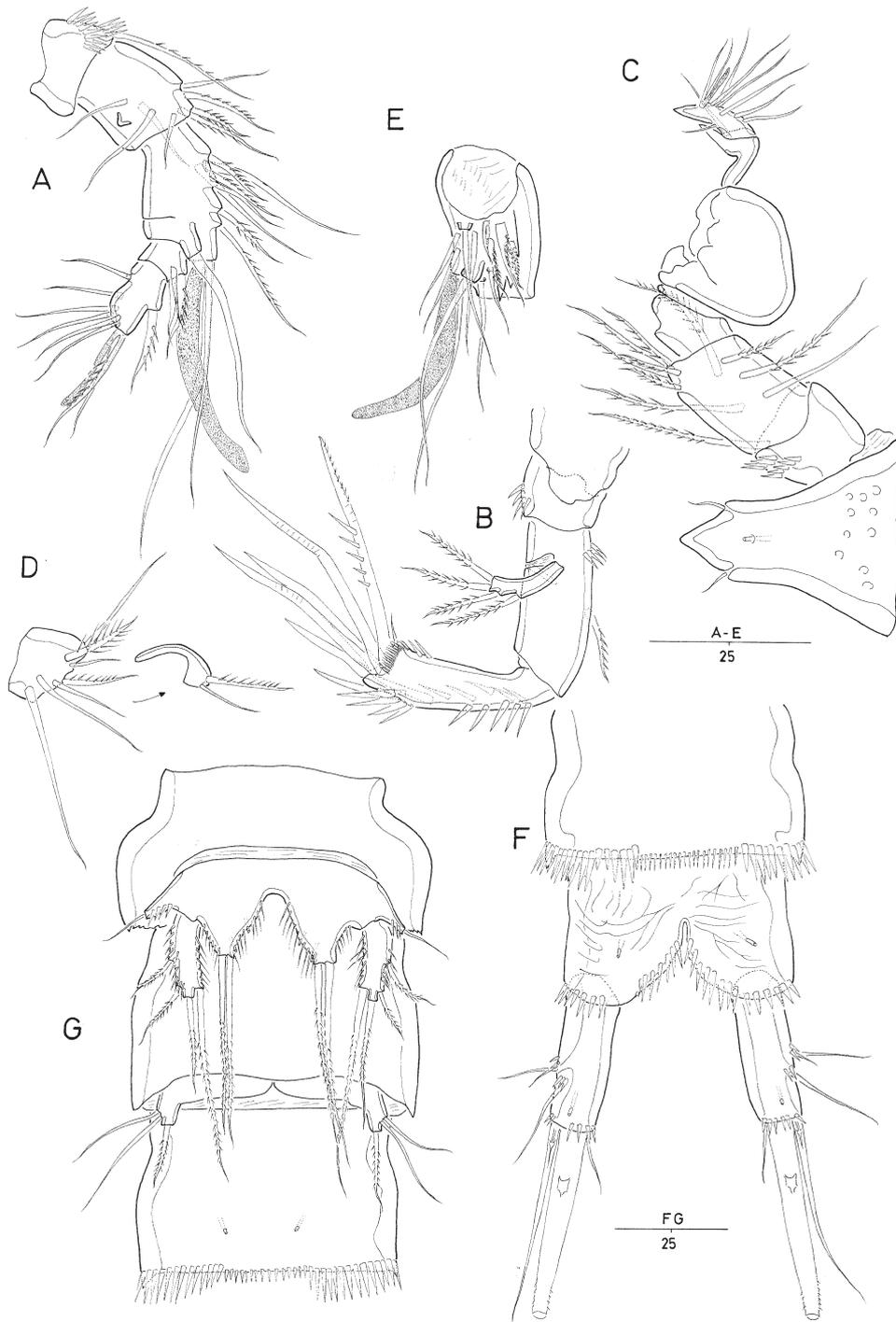


FIG. 8. *Normanella brevispina* sp. nov. (♀). (A) Antennule; (B) antenna; (C) antennule (♂), (armature on segments 3–5 omitted); (D) antennular segments 3–4 (♂); (E) antennular segment 5 (♂); (F) anal somite and caudal rami, ventral; (G) P5 and P6 (♂) (abnormal P6 showing the separation from the somite on both sides).

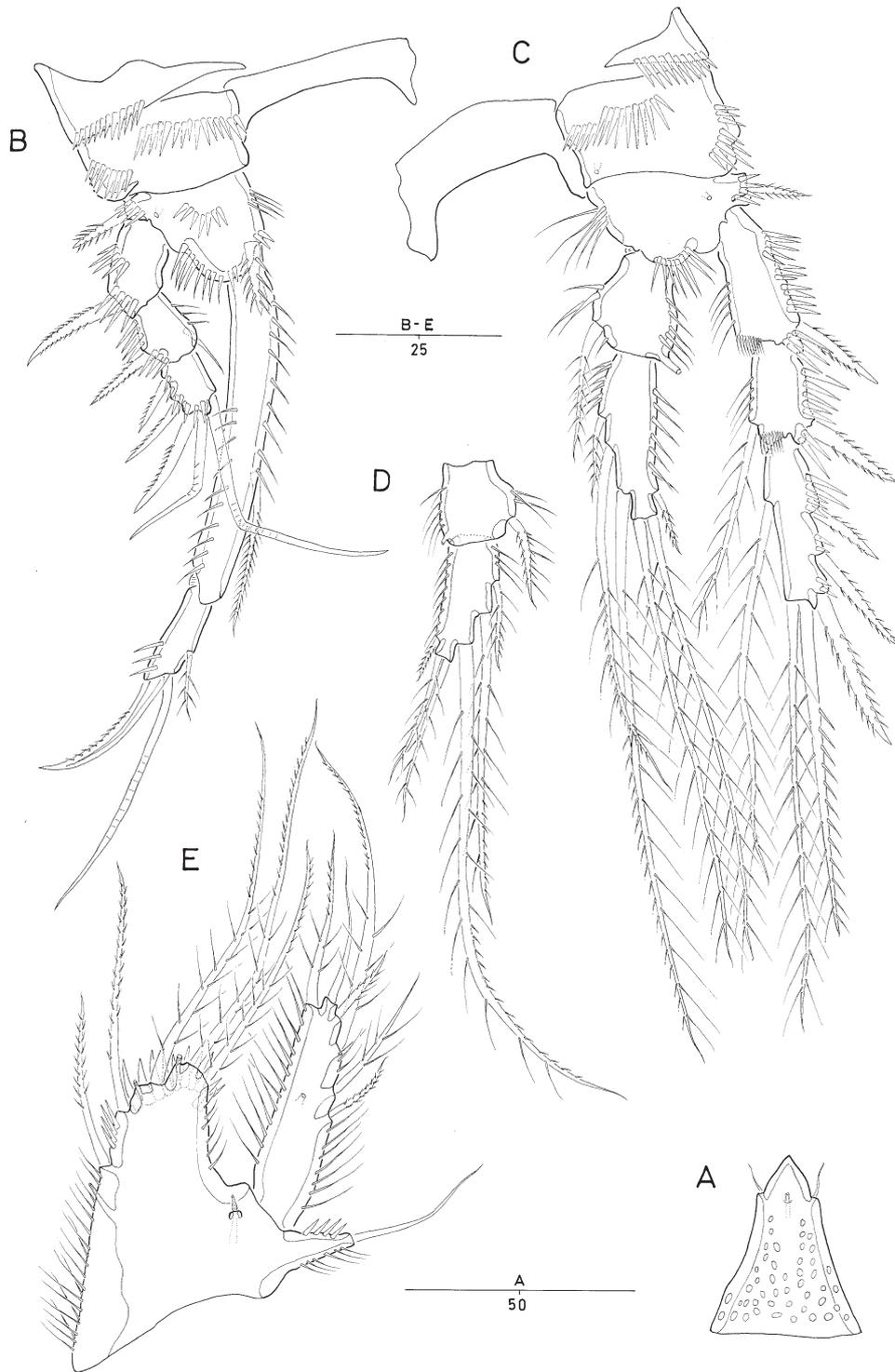


FIG. 9. *Normanella brevispina* sp. nov. (♀). (A) Rostrum, dorsal; (B) P1, anterior; (C) P2, anterior; (D) P2 (♂), endopod; (E) P5, anterior.

Antenna (figure 8B) three-segmented, and comprising coxa, allobasis and free one-segmented endopod. Coxa small with one row of spinules. Basis and proximal endopod segment fused, forming elongate allobasis with transverse surface sutures marking original segmentation anteriorly and posteriorly, and with one abexopodal pinnate seta in distal half. Exopod small, 3.8 times longer than width, with two pinnate setae laterally, and two pinnate setae apically. Endopod slightly longer than allobasis. Lateral armature consisting of two slender spines, arising in proximal half. Apical armature consisting of two bare spines, two geniculate spines and one strong pinnate spine (fused basally to short seta).

Other mouth part appendages identical to *Normanella texana*.

Swimming legs P1–P4 (figures 9B, C, 10A, B) with wide intercoxal sclerites and well-developed praecoxae. Coxae and bases with anterior rows of surface spinules as figured. Exopods three-segmented, endopod two-segmented.

P1 (figure 9B) with large coxa, with long spinules along outer margin and on anterior surface. Basis with one strong, pinnate spine and spinules along inner margin, and with one stout pinnate spine and few spinules along outer margin. Exp-1 with one stout pinnate outer spine (longer than outer spine of exp-2). Exp-2 with one pinnate, outer spine and one short, bare, inner seta (not extending to exp-3 distal margin). Exp-3 with three pinnate spines and two geniculate setae. Endopod 2.2 times as long as exopod. Enp-1 about seven times longer than width, and 3.5 times longer than enp-2, with pinnate inner seta. Enp-2 with one slender, denticulate claw, one geniculate seta and one small plumose seta.

P2–P4 (figures 9C, 10A, B). Coxae and bases with spinular rows along outer margin. Outer margin of basis with bipinnate spine (P2) or naked seta (P3–P4). Exp-1 and -2 with coarse frill at inner distal corner. All segments with pattern of spinules as figured. Inner margins of exopod and endopod segments with long setules or spinules.

P2 enp-1 with one short tubular extension from outer distal corner. Enp-2 1.8 times longer than enp-1. Endopod extending to proximal area of exp-3. Proximal inner seta of enp-2 slightly longer than outer spine.

P3 enp-2, 2.3 times longer than enp-1. Endopod not reaching to distal margin of exp-2. One short tubular extension on anterior distal surface of enp-2.

P4 enp-2, 2.5 times longer than enp-1. Endopod reaching to distal margin of exp-2. One long tubular extension on anterior marginal surface of enp-2.

Spine and setal formula identical to *Normanella texana*.

P5 (figure 9E): baseoendopod forming short, outer setophore bearing basal seta and row of spinules, and with one pore near boundary with exopod. Endopodal lobe short, just reaching to middle of exopod, with three pinnate setae laterally and two bipinnate setae apically, rows of long spinules along outer margin, long setules plus two tube-pores along inner margin, and one tube-pore near apical seta. Exopod elongate, and tapering distally, with one naked terminal seta, one bipinnate inner seta and four pinnate setae of different lengths along outer margin. One terminal seta arising from small cylindrical process, and inner and outer margins with numerous long setules.

Description of male. More slender than female. Body length 414 μm (measured from anterior margin of rostrum to posterior margin of caudal rami). Largest width measured at distal margin of P1-bearing somite: 82 μm . Urosome narrower than prosome (figure 7C).

Prosoma (figure 7C) four-segmented, and comprising cephalothorax and three

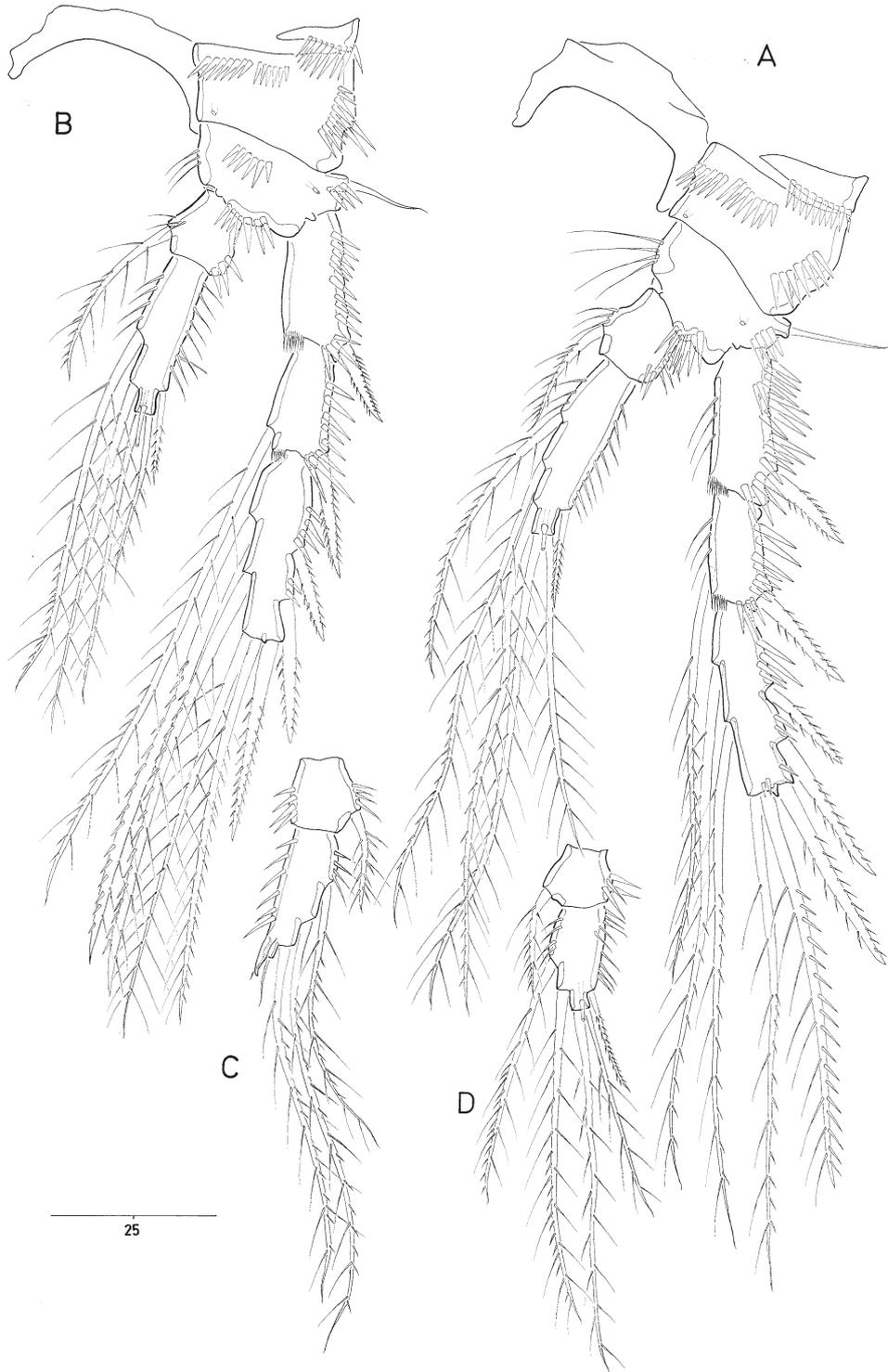


FIG. 10. *Normanella brevispina* sp. nov. (♀). (A) P3, anterior; (B) P4, anterior; (C) P3 (♂), endopod; (D) P4 (♂), endopod, anterior.

free pedigerous somites. Rostrum distinct at base as in ♀, but less areolated than in ♀ (figure 8C). Cephalothorax with posterior margin weakly crenulated. Areolated surface pattern present as in ♂. Ornamentation consisting of sensillae, and pores as figured. Pedigerous somites covered with minute denticles. Prosomites with crenulated hind margin.

Urosome (figures 7C) six-segmented, comprising P5-bearing somite, genital somite and four abdominal somites. Surface ornamentation pattern consisting of patches of minute denticles present dorsally and laterally, and posterior margin irregularly serrate dorsally and laterally.

Antennule (figure 8C–E) seven-segmented. Subchirocer with geniculation between segments 5 and 6. Segment 1 with row of spinules along anterior margin. Segment 4 represented by small sclerite along anterior margin (insert in figure 8D). Segment 7 triangular. Segment 5 largest and swollen. Segment 6 forming dorsal spinous process overlying anterior part of segment 7. Segmental homologies: 1-I, 2-(II–VIII), 3-(IX–XII), 4-XIII, 5-(XIV–XX), 6-(XXI–XXIII), 7-(XXIV–XXVIII). Armature formula: 1-[1 pinnate], 2-[1+9 pinnate], 3-[5+2 pinnate], 4-[1+1 pinnate], 5-[7+4 modified+(1+ae)], 6-[1+1 spinous process], 7-[7+acrothek]. Apical acrothek consisting of minute aesthetasc and two naked setae.

P2 endopod (figure 9D) two-segmented. Both apical setae of enp-2 distinctly shorter than in ♀. Outer apical seta shorter than inner seta. Proximal inner lateral seta shortest as in ♀. Enp-2 about 1.6 times longer than enp-1.

P3 endopod (figure 10C) two-segmented and modified. Enp-2 shorter than in ♀, 1.9 times as long as enp-1. Outer margin with short mucroniform process being homologous with outer spine of enp-2 of ♀, and smaller than in other congeners. Both apical setae strongly reduced and set on small lobe together. Tube-pore not clear and presumably too small to see. Inner setae not modified.

P4 endopod (figure 10D) two-segmented. Enp-2 shorter than in ♀, and 1.9 times as long as enp-1. Enp-2 broader than in ♀, about twice longer than width.

Fifth pair of legs (figure 8G) fused medially. P5 defined at base. Baseoendopod with short setophore bearing outer basal seta, and well-developed trapezoid endopodal lobe with two pinnate setae apically, and two tube-pores along inner margin. Exopod about three times as long as maximum width, with one bipinnate inner seta, one bipinnate apical seta and two bipinnate setae along outer margin.

Sixth pair of legs (figures 8G) symmetrical, and represented on both sides by a small plate. Both side articulating at base and covering gonopore. Outer distal corner produced into cylindrical process bearing one pinnate and two naked setae. Both naked setae longer than pinnate seta.

Etymology. The species name is derived from the Latin *brevi*, meaning short, and *spina*, meaning thorn and spine. It refers to the short inner proximal seta on the second endopodal segments of P2 in both sexes, and the short modified outer process on the second endopodal segment of P3 in ♂.

Remarks. *Normanella brevispina* is most closely related to the Patagonian species *Normanella pallaresae* Lee and Huys, 1999, which belongs to the *minuta*-lineage (Lee and Huys, 1999). *Normanella brevispina* can be easily distinguished from *N. pallaresae* by five characters: (1) the areolated patterns on the rostrum; this character is uncommon within the genus, and is shared with only *Normanella bifida* Lee and Huys, 1999. (2) Longer caudal ramus; *N. brevispina* has the longest caudal ramus among the congeners except for *Normanella tenuifurca* Sars, 1909 and *Normanella*

paratenuifurca Lee and Huys, 1999. Pallares (1975) originally described *N. pallaresae* as *N. minuta* (Boeck) from Patagonia. She mentioned that the caudal ramus is about 2.5 times longer than the width in her text description, but it is at best twice longer than the width in the drawing (see Pallares, 1975: 225, Lám XI. 4). (3) Smaller mucroniform process on the second endopodal segment of P3 in ♂. Additionally each endopodal segment of P3 is much broader in *N. brevispina*. (4) Larger and longer P5 exopod in ♂. (5) Longer naked setae of P6 in ♂. Finally, *N. brevispina* is much smaller than *N. pallaresae* (*N. brevispina*; ♀ 454–500 µm, ♂ 414 µm *N. pallaresae*; ♀ 650–750 µm, ♂ 430–501 µm).

Male genital area has a unique appearance among the congeners. The sixth pair of legs (figure 8G) is symmetrical, and each side forms a small plate articulating at the base and covering the gonopore along each half. It appears as if both sides are active in delivering spermatophores. Two spermatophores are observed in each side of the urosome (spermatophore is not figured). It is uncertain if the two active gonopores are one of the typical characteristics of the species, because only one male of *N. brevispina* was found. However, it is likely that it is an abnormality because the congeners usually have an asymmetrical P6 and only one active gonopore in one side (cf. *N. texana*, figure 6F).

Normanella chanhoi sp. nov.

Material examined. The Natural History Museum, London: holotype ♀ (dissected on nine slides; NHM 2001.425); paratype one ♀ (NHM 2001.426) in alcohol, all from MI 712, coll. W. Lee on 15 September 2000.

Description of female. Total body length 451–462 µm ($N=2$; mean = 457 µm; measured from anterior margin of rostrum to posterior margin of caudal rami). Largest width measured at posterior margin of cephalic shield: 100 µm. Urosome slightly narrower than prosome (figure 11A, C).

Cephalothorax with crenulate posterior margin. Pleural areas well developed and rounded. Posterolateral angles minutely crenulate, and ornamentation consisting of sensillae as illustrated in figure 11A, B. One paired longitudinal surface lamella present dorsally. Areolated patterns well developed, consisting of scattered areolated patches dorsally and laterally. Cephalothorax without minute denticles as found on free body somites.

Rostrum bell-shaped (figure 12A), with almost straight lateral margins and rounded anterior margin, with one pair of tiny sensillae and mid-ventral tube-pore near the apex. Dorsal surface finely striated and ventral surface smooth without denticles.

Pedigerous somites covered with minute spinules. All prosomites without defined hyaline frills and hind margin serrulate (figure 11A, B).

Urosome (figure 11A–C) five-segmented, comprising P5-bearing somite, genital double-somite and three free abdominal somites. All urosomites with surface ornamentation consisting of small spinules dorsally and laterally, and hind margin distinctly serrate dorsally and laterally. Ventral hind margin of urosomites 2–4 with setular extensions medially and large spinules laterally.

Genital double-somite (figure 11A–C) with original segmentation indicated by transverse, serrate surface ridge dorsally and dorsolaterally. Short surface suture ventrolaterally, and completely fused ventrally. Genital field with small copulatory pore located in median depression. Gonopores fused medially forming single genital slit covered on both sides by opercula derived from sixth legs. P6 with small

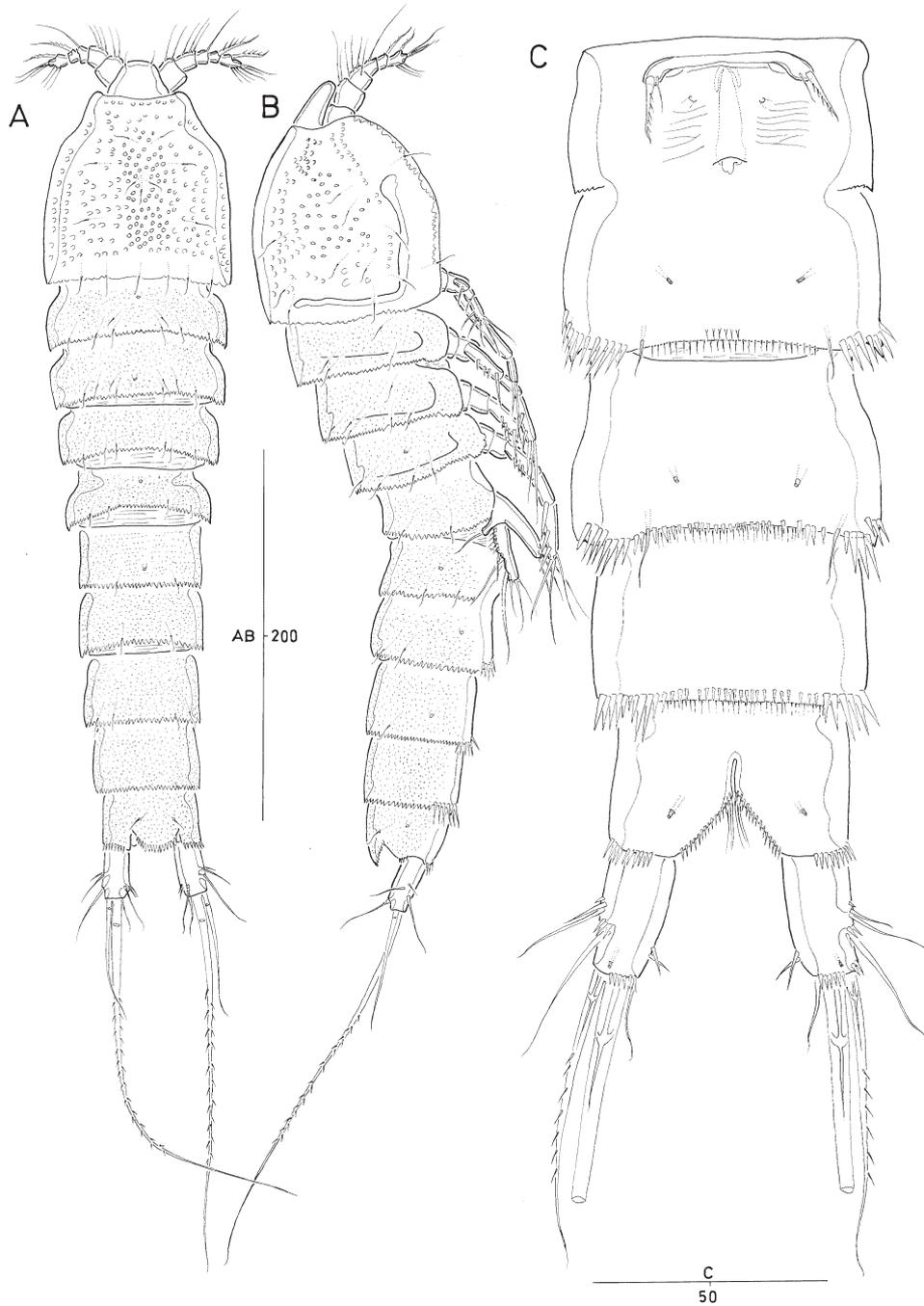


FIG. 11. *Normanella chanhoi* sp. nov. (♀). (A) Habitus, dorsal; (B) habitus, lateral; (C) urosome (excluding P5-bearing somite), ventral.

protuberance bearing one pinnate outer seta and one minute, naked inner seta (figure 11C).

Anal somite (figure 11A–C) with well-developed, serrate anal operculum flanked

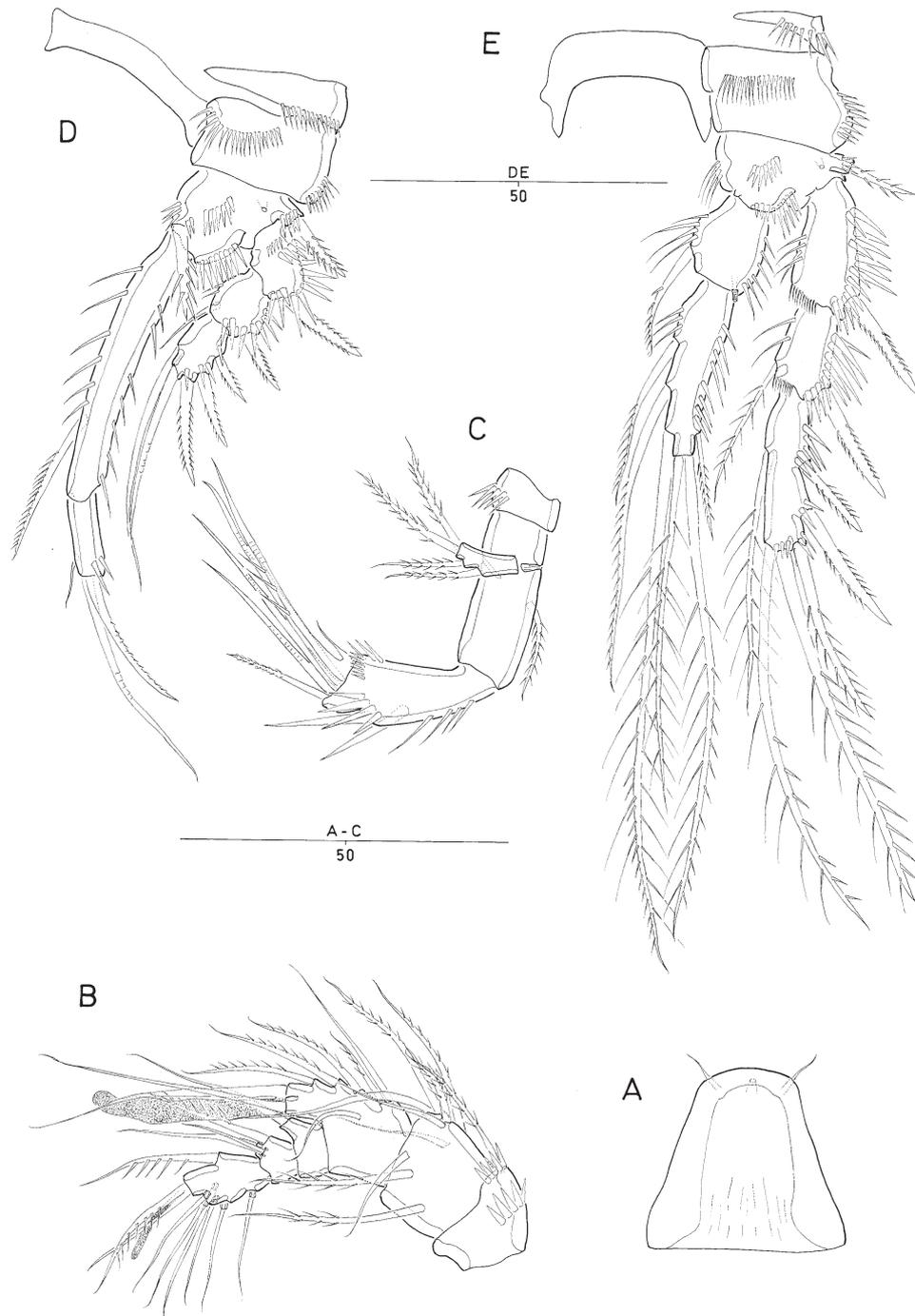


FIG. 12. *Normanella chanhoi* sp. nov. (♀). (A) Rostrum, dorsal; (B) antennules; (C) antenna; (D) P1, anterior; (E) P2, anterior.

by row of spinous processes. Anal opening with fringe of long setular extensions, and bordered by spinules ventrally.

Caudal rami (figure 11A–C) about twice as long as maximum width. Each ramus with one tube-pore and seven setae: seta I bare, shortest and closely set to bare seta II; seta III bare and positioned ventrolaterally; setae IV and V fused basally, with internal fracture plane, and pinnate [seta V longest, about equal length to urosomites (excl. caudal rami) combined]; seta VI bare and small; seta VII tri-articulate at base. Each ramus with sparse spinular ornamentation present along inner and outer margins and around ventral hind margin.

Antennule (figure 12B) six-segmented, segment 3 longest (with vestigial suture). Armature formula: 1-[1 pinnate], 2-[4+5 pinnate], 3-[3+4 pinnate+(1+ae)], 4-[1], 5-[2+1 pinnate], 5-[6+1 pinnate+1 acrothek]. Apical acrothek consisting of small aesthetasc fused basally to one slender seta and one strong pinnate spine. Segment 1 with two spinular rows around anterior margin. Segment 3 with aesthetasc fused basally to seta and set on distinct pedestal.

Antenna (figure 12C) three-segmented comprising coxa, allobasis and free one-segmented endopod. Coxa small with one row of spinules. Basis and proximal endopod segment fused forming elongate allobasis with transverse surface sutures marking original segmentation anteriorly and posteriorly, with one abexopodal bipinnate seta in distal half. Exopod small, 2.5 times longer than width, with two pinnate setae laterally and two pinnate setae apically. Endopod distinctly shorter than allobasis. Lateral armature consisting of two slender spines and arising in proximal half. Apical armature consisting of one pinnate spine, three geniculate spines and one strong pinnate spine (fused basally to short seta).

Other mouth part appendages identical to *Normanella texana*.

P1 (figure 12D) with large coxa, and with long spinules along outer margin and on anterior surface. Basis with one stout, bipinnate spine and few long setules along inner margin and with one stout bipinnate spine and few spinules along outer margin. Exp-1 with one long, bipinnate spine (distinctly longer than other exopodal spines). Exp-2 with one bipinnate, outer spine and one naked, inner seta (not extending to exp-3 distal margin). Exp-3 with three bipinnate spines and two geniculate setae. Endopod about twice as long as exopod. Enp-1 with one pinnate inner seta. Enp-2 with one slender, denticulate curved claw and one geniculate seta apically, and one small naked seta along inner margin.

P2–P4 (figures 12E, 13A, B). Coxae and bases with spinular rows along outer margin. Outer margin of basis with bipinnate spine (P2) or naked seta (P3–P4). Exp-1 and -2 with coarse frill at inner distal corner. All segments with pattern of spinules as figured. Inner margins of exopod and endopod segments with long setules or spinules.

P2 enp-1 with one short tubular extension from outer distal corner. Enp-2 twice longer than enp-1. Endopod reaching to middle of exp-3.

P3 enp-2 twice longer than enp-1. Endopod reaching to distal margin of exp-2. Inner distal corner of enp-2 produced into short tubular extension.

P4 enp-2 twice longer than enp-1. Endopod exceeding beyond distal margin of exp-1. Inner distal corner of enp-2 produced into long tubular extension.

Spine and setal formula identical to *N. texana*.

P5 (figure 13C): baseoendopod forming short, outer setophore bearing basal seta and row of spinules, with one pore near boundary with exopod. Endopodal lobe long and slender, but not reaching to apex of exopod, with three bipinnate setae



FIG. 13. *Normanella chanhoi* sp. nov. (♀). (A) P3, anterior; (B) P4, anterior; (C) P5, anterior.

laterally and two bipinnate setae apically. Rows of long spinules along outer margin and long setules plus one tube-pore along inner margin. Exopod flask-shaped, distinctly tapering distally, with one naked terminal seta, one bipinnate inner seta, and one naked and three pinnate setae of different lengths along outer margin. Terminal seta arising from small cylindrical process. Inner and outer margins with numerous long setules.

Male. Unknown.

Etymology. The species is named after Chanho Park, a Korean professional baseball player from the Texas Rangers in the USA.

Remarks. The present new species is most closely related to *Normanella serrata sensu* Božić (1964) by the species key in Lee and Huys (1999). However, *Normanella chanhoi* has four clear differences to *N. serrata sensu* Božić: (1) bell-shaped rostrum with a smooth tip, (2) each urosomal segment is clearly longer than in *N. serrata sensu* Božić, (3) shorter setae and spines on P2–P4 endopod, and (4) less slender and shorter P5 exopod. *Normanella chanhoi* also has well-developed areolated patterns, but not a pair of longitudinal ridges on the cephalothorax. The smooth apical margin of the rostrum in the new species is a rare character within the family, and can be seen only in the *dubia*-lineages and *Sagamiella ratirostrata* Lee and Huys.

Discussion

There are few reports on the species of the family Normanellidae in North America, and only three species have been described taxonomically from the area. Willey (1930) described *Normanella minuta* from the Bermuda Islands. However, Lee and Huys (1999) pointed out the differences between *N. minuta sensu* Willey and *N. minuta* (Boeck), and regarded *N. minuta sensu* Willey as a *species inquirenda* in the *minuta*-lineage. Lang (1965) described *N. bolini* and *N. confluens* from the Californian Pacific coast. The species belong to the *bolini*-lineage and the *mucronata*-lineage, respectively. There are other records of *N. minuta* and *N. mucronata* from the North Carolina continental shelf (Coull, 1971) and from the Gulf of Maine (Coffin, 1981; *N. minuta* only), but only as names recorded in a species list. An unidentified *Normanella* species has also been reported from the Bermuda Platform (Coull, 1971) and South Carolina (Coull and Dudley, 1985), but these records are undeterminable. Only *Normanella* sp. from the northwestern Gulf of Mexico (Street and Montagna, 1996), which is from the same study area as the present report, belongs to *N. brevispina* sp. nov. The family Normanellidae has morphological uniformity in mouth part structure, swimming leg sexual dimorphism and overall setation patterns. This morphological uniformity can be responsible for misidentifications caused by not separating species (Lee and Huys, 1999).

Lee and Huys (1999) suggested five lineages within the genus *Normanella*. *Normanella texana* sp. nov. belongs to the *bolini*-lineage with the characters of (1) triangular rostrum, (2) short caudal rami and seta IV–V, and (3) five-segmented antennule. *Normanella texana* sp. nov. does not have an oval-shaped P5 exopod, but the exopod is still short, and the endopodal lobe appears similar to the species of the *bolini*-lineage. *Normanella brevispina* sp. nov. can be accommodated into the *minuta*-lineage without any doubt. The areolated rostrum is found only in *N. bifida*, except for *N. brevispina*. It is uncertain whether the characteristic rostrum is shared by only two species, because the surface structure of the rostrum might easily have been ignored or overlooked in past reports. *Normanella chanhoi* sp. nov. is similar to *N. serrata sensu* Božić in the *minuta*-lineage, but it has a strikingly different,

bell-shaped rostrum with a smooth apical margin. The species of the *minuta*-lineage usually have a pointed apical tip on the rostrum. The bell-shaped rostrum is found only in the *dubia*-lineage and in *Sagamiella ratirostrata*. *Normanella chanhoi* sp. nov. constitutes a new unique lineage.

A single female of *N. texana* has a reduced setal number on the endopodal segment 2 of the P2 (figure 4C) and is the first observed abnormality of the swimming legs within the family. The symmetrical P6 of *N. brevispina* is also unique within the family. In contrast to the abnormality of the swimming legs and P6, the P5 abnormality is relatively common among the congeners. Lee and Huys (1999) reported five setae on the P5 exopod, and malformation of the endopodal lobe on one side (Lee and Huys, 1999: 245, figure 22D) in a single male specimen of *N. sarsi* Lee and Huys, and the aberrant endopodal lobe in the male of *N. tenuifurca* Sars. It is likely the abnormalities are teratological, because each abnormality is observed only in a single specimen, respectively.

All the three new species have relatively small sizes (*N. texana*: ♀ 420 µm, ♂ 351 µm; *N. brevispina*: ♀ 473 µm, ♂ 414 µm; *N. chanhoi*: ♀ 457 µm) compared to the other congeners. Usually, *Normanella* species are larger than 500 µm, with a few exceptions. There is an ongoing project on the deep-sea harpacticoid copepods in the Gulf of Mexico, and many species from the area have relatively small sizes compared to the congeners from other areas (Lee, personal observation). It would be interesting to determine whether the size of harpacticoids in the Gulf of Mexico is generally smaller than in other areas.

Acknowledgements

The authors thank the crew of R/V *Longhorn* (University of Texas at Austin, Marine Science Institute), Mr Richard Kalke and Dr Mary Ma for their help in the collecting samples. This research was supported partially by National Research Laboratory Program (2001-N-NL-01-C-290) of the Korean Ministry of Science and Technology.

References

- BOŽIĆ, B., 1964, Copépodes Harpacticoides et Cyclopoïdes de la Réunion. II. Plage St. Pierre, *Bulletin du Muséum national d'Histoire naturelle, Paris*, (2) **36**(4), 481–499.
- COFFIN, W. L., 1981, A list of harpacticoid copepods from northern New England, USA, *Vie et Milieu*, (AB) **28–29**(4), 589–595.
- COULL, B. C., 1971, Meiobenthic Harpacticoida (Crustacea, Copepoda) from the North Carolina continental shelf, *Cahiers de Biologie Marine*, **12**(2), 195–237.
- COULL, B. C., and DUDLEY, B. W., 1985, Dynamics of meiobenthic copepod populations: a long term study (1973–1983), *Marine Ecology Progress Series*, **24**(3), 219–229.
- HUYS, R., and LEE, W., 1998, On the relationships of the Normanellidae and the recognition of Cletopsyllidae grad. nov. (Copepoda, Harpacticoida), *Zoologischer Anzeiger*, **237**, 267–290.
- HUYS, R., and WILLEMS, K. A., 1989, *Laophontopsis* Sars and the taxonomic concept of the Normanellinae (Copepoda: Harpacticoida): a revision, *Bijdragen tot de Dierkunde*, **59**, 203–227.
- HUYS, R., GEE, J. M., MOORE, C. G., and HAMOND, R., 1996, *Marine and Brackish Water Harpacticoid Copepods. Part 1. Synopses of the British Fauna (New Series)*, No. 51, i–viii, 1–352.
- LANG, K., 1944, *Monographie der Harpacticiden (Vorläufige Mitteilung)*. Uppsala: Almqvist & Wiksells Boktryckeri Ab., 39 pp.
- LANG, K., 1948, *Monographie der Harpacticiden*. Lund: Håkan Ohlsson, 1682 pp.

- LANG, K., 1965, Copepoda Harpacticoida from the Californian Pacific coast, *Kungliga Svenska Vetenskapsakademiens Handlingar*, (4) **10**(2), 1–560.
- LEE, W., and HUYS, R., 1999, New Normanellidae (Copepoda: Harpacticoida) from western Pacific cold seeps including a review of the genus *Normanella*, *Cahiers de Biologie Marine*, **40**, 203–262.
- MONTAGNA, P. A., and HARPER, D. E. JR, 1996, Benthic infaunal long-term responses to offshore production platforms, *Canadian Journal of Fisheries and Aquatic Sciences*, **53**, 2567–2588.
- NICHOLLS, A. G., 1945, Marine Copepoda from Western Australia. III. Littoral harpacticoids from Port Denison, *Journal of the Royal Society of Western Australia*, **29**, 1–16.
- PALLARES, R. E., 1975, Copépodos marinos de la Ría Deseado (Santa Cruz, Argentina). Contribución sistemático-ecológica. IV. Conclusión, *Physis*, (A) **34**(89), 213–227.
- STREET, G. T., and MONTAGNA, P. A., 1996, Loss of genetic diversity in Harpacticoida near offshore platforms, *Marine Biology*, **126**, 27–281.
- WILLEY, A., 1930, Harpacticoid Copepoda from Bermuda. Part I, *Annals and Magazine of Natural History*, **6**(10), 81–114.