

**A New Species of *Leptochelia* (Crustacea, Tanaidacea)
from Japan, with a Redescription of *L. savignyi*
(Krøyer, 1842)**

By

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With Text-figures 1-17, Tables 1-3

In 1981, I studied the biology of a tanaid which was commonly found in sandy bottoms of Oshoro Bay, Hokkaido, northern Japan. A close examination revealed that it was a previously undescribed species of the genus *Leptochelia* (family Paratanaididae) and belonged to the "*Leptochelia*-Gruppe 2" that was defined by Lang (1973) to accommodate a sole valid species, *Leptochelia savignyi* (Krøyer, 1842). The aim of the present paper is to describe this new species. To clear distinction between this new species and *L. savignyi* which has been believed to be polymorphic and involves many synonyms, here a precise redescription of a North Pacific form of *L. savignyi* is also given based upon specimens collected from Japan and North America. In addition, some notes on the structures of the genital cone and the mouth parts, using scanning electron microscopy, are presented.

Orientation and terminology of appendages follow Lang (1968). Type-series are deposited in the Zoological Institute, Faculty of Science, Hokkaido University.

Abbreviations. ds, dorsal view; vt, ventral view; lt, lateral view; md, medial view; rt, rostral view; cd, caudal view; R, L, right, and left appendage; SI, Shin-ichi Ishimaru.

***Leptochelia itoi* n. sp.**

(Figs 1-7, 15-A, B, 16-A, 17)

This new species is proved to be a protogynous potential hermaphrodite by field observations and rearing experiments (Ishimaru, unpublished). A secondary male is designated as holotype, and is fully described. A primary male is chosen to supplement the description of the holotype.

Type-series. Holotype: secondary ♂, 2.6 mm, subtidal, 1 m deep, sand, Oshoro Bay, Hokkaido, 29-VI-1981, SI coll. —Allotype: first copulatory ♀ without oostegites, 2.8 mm, locality same as the holotype, 14-VII-1981, SI coll. —Paratypes: 13♂♂, 2.0 to 4.0 mm; 4 first manca, 0.9 mm; 6 second manca, 1.4 mm; 4 first neuters, 2.0 to 2.3 mm; 2 second neuters, 2.7 mm; 2 first preparatory ♀♀, 2.8 mm, 3.3 mm; 4 first copulatory ♀♀, 2.8 to 3.3 mm; 3 second preparatory ♀♀,

3.0 to 3.2 mm, locality same as the holotype, collected through the periodical sampling from 15-IV-1981 to 25-IX-1981, SI coll. — 3 ♂♂, 1.9 to 2.9 mm, subtidal, 4 m deep, sand, Kitahama beach, Shirahama-cho, Wakayama Pref., 2-XII-1982, SI coll.

Secondary male (holotype): Body (Fig. 1-A, B) 2.6 mm long from apex of rostrum to posterior projection of pleotelson; color pale brown, scattered with small white patches sparsely all over the tergites when alive, when fixed these patches immediately disappearing.

Carapace (Figs 1-D, 15-A) 25% as long as body, longer than first three pereonites combined, 1.6 times as long as wide, considerably narrowing in front of respiratory chamber, so that obviously contracted from dorsal view; a setule arising from the middle of lateral face, and from the point just behind ocular lobe. Respiratory chamber very slightly swollen, not outstanding. Ocular lobe triangular-oval, not reaching apex of rostrum; ocular margin of carapace concave. Rostrum short, subacute apically, with oblique margin slightly concave. Coxa of cheliped not outstanding from dorsal view.

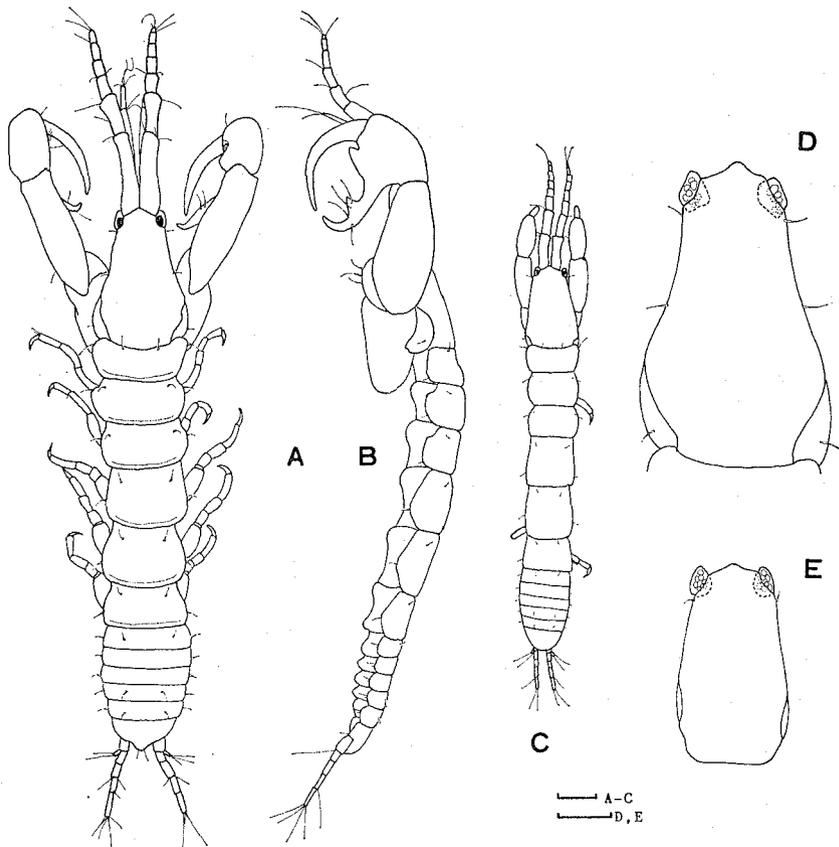


Fig. 1. *Leptocheilia itoi* n. sp. Secondary male (holotype): A, habitus (ds); B, habitus (lt); D, cephalothorax (ds). Primary male (paratype): C, habitus (ds); E, cephalothorax (ds). Bar scales 0.2 mm.

Pereonites (Fig. 1-A, B) increasing in length from 2 to 5, pereonites 5 and 6 of equal length, and pereonite 7 as long as 3; sternite of each pereonite slightly ridged along median line, weakly produced ventrally at anterior region. *Pereonite 2* three times as broad as long, anteriorly extended at lateral region, bearing a pair of dorsal setules on anterior margin near median line, and a setule at posterior edge of lateral margin. *Pereonites 3 and 4* about twice as broad as long, a little swollen at middle part, with tergite subquadrately extended at lateral region, bearing a pair of dorsal setules lateral to those of pereonite 2 behind anterior margin, and bearing a setule at posterior edge of lateral margin. *Pereonites 5 and 6* 1.3 times, and *pereonite 7* twice as broad as long, swollen at posterior region, with lateral region of tergite ventrally extended at posterior half, with a pair of dorsal setules medial to those of pereonites 3 and 4, and with a setule at apex of lateral expansion.

Pleon (Fig. 1-A, B) about 25% as long as body, as broad as pereonite 5, gradually decreasing in length posteriorly. Each pleonite equal in length; pleonites 1, 4 and 5 set with a pair of dorsal setules, and with a pair of a long and a short setule on lateral margin; pleonites 2 and 3 bearing only marginal setules as above. Genital cone indistinct, composed of a single protuberance. *Pleotelson* (Fig. 3-H) longer than a pleonite, pointed posteriorly, with a lateral setule, a pair of subapical setules, and 2 pairs of a long and a short apical setule on tip of caudal point; anus represented only by a median cleft, closed, with anal flaps furrowed and not thickened.

Antenna 1 (Fig. 3-A) 35% as long as body. Length ratios of peduncular articles 1-3 100:65:30. Peduncular article 1 about 60% as long as carapace, bearing 2 distal setae and a few distal pncicillate hairs, set with 3 pncicillate hairs, which are

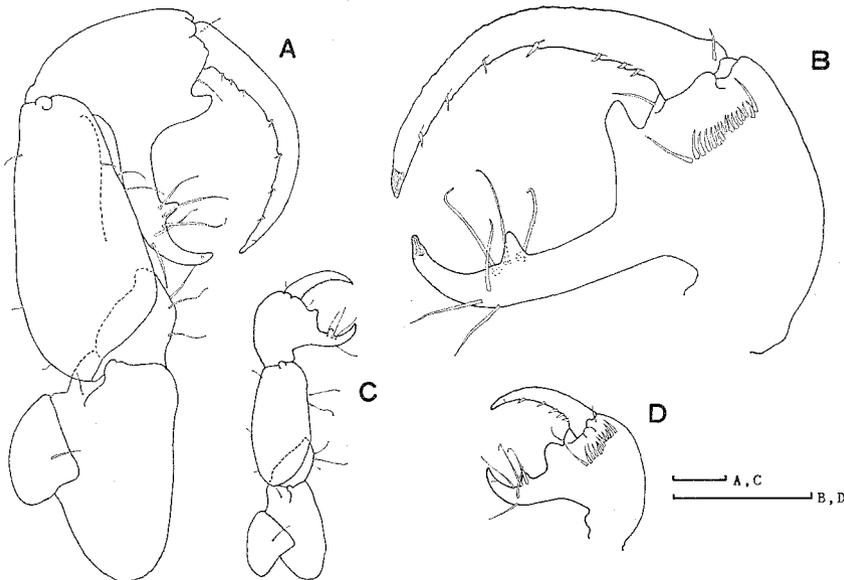


Fig. 2. *Leptochelia itoi* n. sp. Secondary male (holotype): A, cheliped (R, cd); B, chela (R, rt). Primary male (paratype): C, cheliped (R, cd); D, chela (R, rt). Bar scales 0.2 mm.

longitudinally located and distal one of which is apart from the other two, on lateral face proximally. Peduncular article 2 as broad as article 1, with 2 distal setae and a few penicillate hairs. Peduncular article 3 with only a distal seta. Flagellum 4-articulate; flagellar articles 1-3 furnished with aesthetascs; flagellar articles 3 and 4 with 1 and 5 setae respectively. *Antenna 2* (Fig. 3-B) 65% as long as antenna 1, 5-articulate, but article 1 possibly composed of true 1st and 2nd articles completely fused with each other. Length ratios of articles 1-5 100:65:280:90:10. Article 1 dorsoventrally flattened and expanded, bearing a short spine on the shoulder of lateral expansion, and armed with 3 distal spines (one on dorsal margin, the others on medioventral edge). Article 2 armed with a distal spine dorsally. Article 3

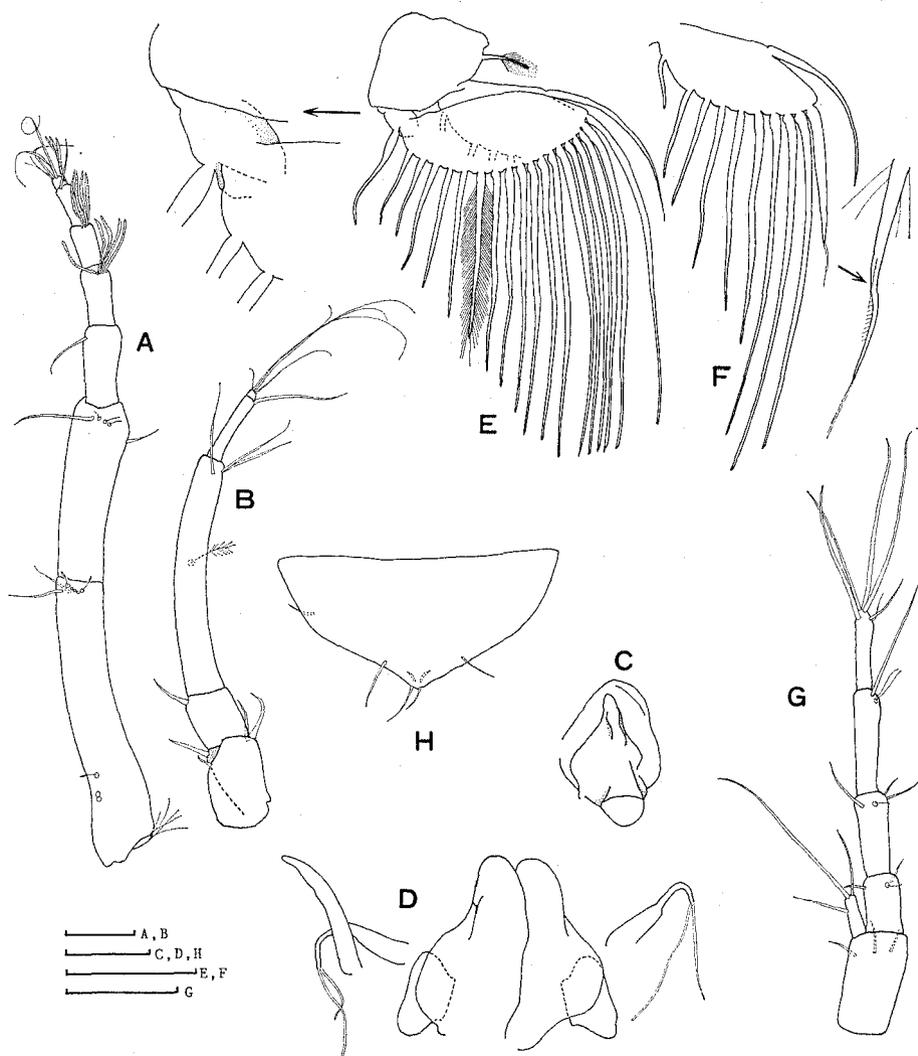


Fig. 3. *Leptochelia itoi* n. sp. Secondary male (holotype): A-B, antennae 1-2 (R, lt); C, labrum (vt); D, mouth parts (vt); E, pleopod I (R, rt); F, endopodite of pleopod I (rt); G, uropod (R, ds); pleotelson (ds). Bar scales 0.1 mm.

bearing a large penicillate hair at the middle of inner face, with 3 distal setae. Article 4 with a distal seta. Article 5 minute, with 6 apical setae.

Mouth parts (Fig. 15-A, B) reduced, smoothly connected with inclined ventral face of carapace. *Epistome* (Figs 3-C, 15-B) fused with carapace, elongate, not reaching base of antenna 2, not notched anteriorly. *Labrum* (Figs 3-C, 15-B) attached to larger epistome, indistinct. *Mandible* (Fig. 15-A, B) exceedingly degenerated, completely fused with carapace, remaining only as circular furrow of carapace. *Labium* absent. *Maxilla 1* (Fig. 3-B). Endite absent. Palp uniaarticulate, bearing 2 apical setae. *Maxilla 2* (Fig. 3-D) kidney-shaped. *Maxilliped* (Figs 3-D, 15-B) reduced. Both bases almost separate but minutely fused with each other at bottom, widest at the middle, without any armature. Endite absent. Palp indistinct, represented by uniaarticulate bulb which is insufficiently articulated from basis. Epignath falciform.

Cheliped (Fig. 2-A) strong. Coxa with a caudal seta. Basis 1.8 times as long as broad, greatly extended posteriorly, with a caudal seta behind carpus. Merus with 3 sternal setae. Carpus 1.3 times as long as basis, conspicuously swollen proximally, with its widest width about 50% as long as its length, touching basis, bearing 3 sternal setae and 3 tergal setules. Propodus (Fig. 2-B) with a setule just behind the junction of dactylus; comb-like spine row located on rostral face, whose axis is perpendicular to dactylus. Fixed-finger close to the base of propodus, with its axis perpendicular to that of the rest of propodus, armed with a small and a large tooth, the latter of which is tall and very close to the rest of propodus, bearing 3 caudal setae near the small tooth, and 3 rostral setae near sternal margin; tip sclerotized and brown-colored. Dactylus with a rostral seta basally, armed with a row of stout spines along sternal margin; tip sclerotized and brown-colored.

Pereopod II (Fig. 4-A) the longest of all pereopods. Coxa with a tergal seta. Basis with a tergal seta and a penicillate hair proximally. Ishium very short, with a sternal seta. Merus with a sternal seta distally. Carpus a little shorter than merus, with a few distal setae. Propodus with a short and 2 long tergal setae, and with a short sternal seta distally. Dactylus as long as propodus, with 2 obscure articulations. *Pereopods III-VII*. All spines non-articulated basally. *Pereopods III, IV* (Fig. 4-B, C). Coxa with a tergal seta. Basis with a tergal seta and a few penicillate hairs proximally. Ishium very short, with a sternal seta. Merus with a sternal spine. Carpus with a sternal and a tergal seta distally, armed with a sternal and a rostral spine, the latter of which is triangular and scale-like. Propodus (Fig. 4-G) with a sternal spine, bearing 3 tergal setae about half as long as dactylus. Dactylus with 2 obscure articulations, bearing a thin setule tergally. *Pereopods V, VI* (Fig. 4-D, E). Coxa fused with sternite and only distinguishable by circular furrow surrounding the bottom of basis. Basis swollen, with a few penicillate hairs, with or without a seta. Ishium very short, with 2 sternal setae. Merus with 2 sternal spines distally, one rostral and another caudal. Carpus as long as merus, with 2 tergal setae distally, armed with a rostral and 2 caudal spines distally, a caudal one of which is larger than the others (Fig. 4-J). Propodus (Fig. 4-H) with a rostral and a caudal

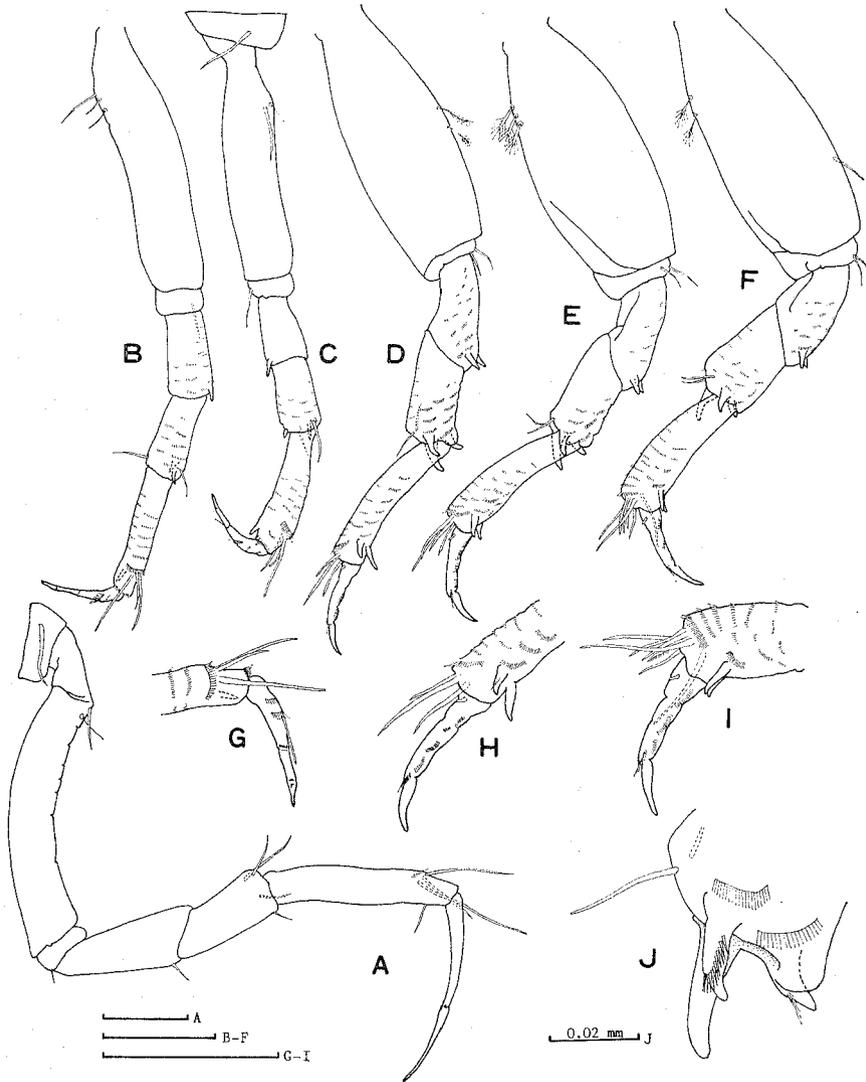


Fig. 4. *Leptocheilia itoi* n. sp. Secondary male (holotype): A-C, pereopods II-IV (R, cd); D-F, pereopods V-VII (R, rt); G-I, propodi and dactyli of pereopods III, IV and VII; J, carpus of pereopod VI (rt). Bar scales 0.1 mm, if not mentioned.

spine sternodistally, bearing 3 tergal setae about half as long as dactylus. Dactylus gently curved sternally, with a minute proximal scale whose apex is truncate. *Pereopod VII* (Fig. 4-F) similar to pereopods V and VI except for distal setal bundle of propodus (Fig. 4-I), which comprises 3 long or short bare setae and 4 short comb-like setae.

Pleopods I-V (Fig. 3-E, F). Peduncle with a short plumose seta on inner margin. Exopodite divided into 2 components by a strong constriction near base (Fig. 3-E); first component a small bulb, with an outer plumose seta; second component foliaceous, lined with a row of plumose setae along outer margin. Endopodite (Fig.

3-F) foliaceous, smaller than exopodite, with a short plumose seta basally on outer margin, with a plumose seta at the middle of inner margin, lined with a row of plumose setae along outer margin; the distalmost one of outer marginal setae thicker and shorter than others, bearing particular structure as shown.

Uropod (Fig. 3-G) biramous. Basis longer than broad, with a few ventral setae. Exopodite small, uniarticulate, with 2 apical and 1 subapical seta. Endopodite 4-articulate; length ratios of each article 100 (basis):60:80:105:75 (terminal); articles 1-4 bearing 2, 3, 1 and 5 setae respectively; each article with a penicillate hair distally.

Primary male: Differing from secondary male as follows. Body (Fig. 1-C) 2.0 mm long.

Carapace (Fig. 1-E) not swollen laterally.

Cheliped (Fig. 2-C) proportionally smaller. Basis less extended posteriorly. Carpus not so swollen basally. Fixed-finger (Fig. 2-D) shorter; both distal and proximal teeth closer to each other; proximal tooth blunter and less tall. Dactylus shorter.

Female (first copulatory female without oostegites: allotype): Body (Fig. 5-A, B) 2.8 mm long; color pale green, scattered with small white patches sparsely all over the tergites when alive, when fixed these patches immediately disappearing.

Carapace (Fig. 5-C) 15% as long as body, as long as first two pereonites combined, 1.4 times as long as broad, gradually narrowing distally, with armature equal to male *L. itoi*. Respiratory chamber not swollen. Ocular lobe triangular-oval, reaching apex of rostrum; ocular margin of carapace concave. Rostrum short, subacute apically, with oblique margin slightly concave. Coxa of cheliped not outstanding from dorsal view; shallow groove present across coxal region.

Pereonites (Fig. 5-A, B) increasing in length from 2 to 5, pereonites 5 and 6 of equal length, and pereonite 7 as long as 3; sternite of each pereonite smooth. *Pereonite 2* 1.6 times as broad as long, bearing a pair of dorsal setules on anterior margin near median line, and a setule at posterior edge of lateral margin. *Pereonites 3* and *4* 1.3 times as broad as long, bearing a pair of dorsal setules lateral to those of pereonite 2 behind anterior margin, and bearing a setule at posterior edge of lateral margin. *Pereonites 5* and *6* 1.1 times, and *pereonite 7* 1.3 times as broad as long, with lateral region of tergite ventrally extended at posterior half, with a pair of dorsal setules, and with a setule at apex of lateral expansion.

Pleon (Fig. 5-A, B) as in male *L. itoi*.

Antenna 1 (Fig. 5-D) as long as carapace, tapering. Length ratios of peduncular articles 1-3 100:35:40. Peduncular article 1 bearing 2 distal and 2 middle setae, set with 3 proximal penicillate hairs arranged in the same way as in male *L. itoi*. Peduncular article 2 with 2 distal setae. Peduncular article 3 with 2 distal setae and an aesthetasc. Flagellum uniarticulate, set subapically and dorsally on article 3, minute, with 4 apical setae. *Antenna 2* (Fig. 5-E) 85% as long as antenna 1, 6-articulate. Article 2 armed with a stout spine on inner distal edge and on dorsodistal

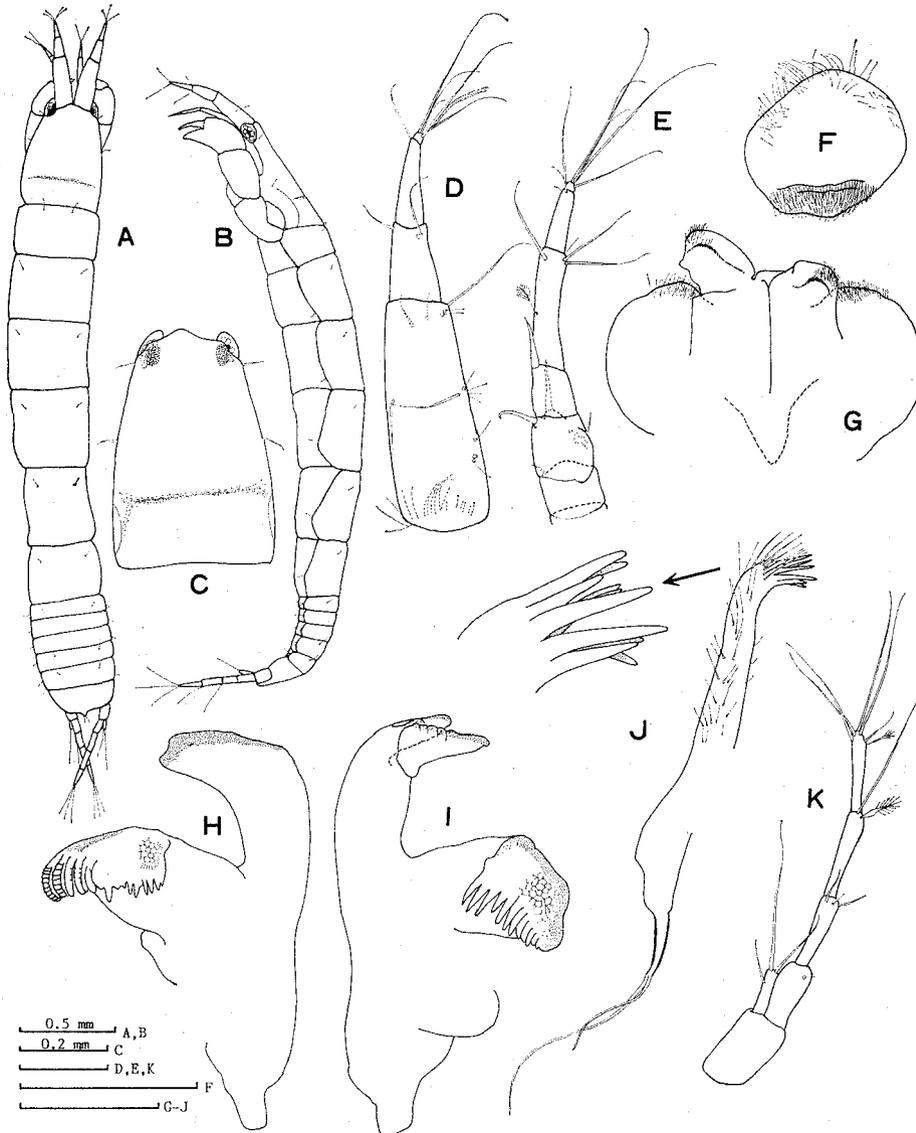


Fig. 5. *Leptochelia itoi* n. sp. Female (allotype): A, habitus (ds); B, habitus (lt); C, cephalothorax (ds); D, antenna 1 (R, ds); E, antenna 2 (L, vt); F, labrum (vt); G, labium (cd); H-I, right and left mandibles (md); J, maxilla 1 (R, cd); K, uropod (R, ds). Bar scales 0.1 mm, if not mentioned.

edge respectively, bearing a minute setule at the middle of outer margin. Article 3 with a stout spine on dorsodistal edge. Article 4 as long as articles 2-3 combined, bearing a large penicillate hair at the middle of inner face, with 3 distal setae. Article 5 with a distal seta. Article 6 minute, with 6 apical setae.

Epistome undeveloped. *Labrum* (Fig. 5-F) circular from ventral view, notched anteriorly. *Mandible* (Fig. 5-H, I). Molar process strong, triturative, armed with rasps on inner half, brown-colored; grinding surface transverse (left) and inclined

(right). Incisor smooth, right one larger than left. Lacinia mobilis on left mandible, cuspidate, larger than left incisor. *Labium* (Fig. 5-G). Inner lobe well developed, separate from each other. Outer lobe circular. *Maxilla 1* (Fig. 5-J). Endite armed with 11 apical spines, sparsely bristly, furnished with a transverse row of long bristles just behind the apical spines. Palp half as long as endite, abruptly decreasing in width at the middle, with 2 long or short apical setae. *Maxilla 2* (Fig. 6-A) as in male *L. itoi*. *Maxilliped* (Fig. 6-A). Bases almost separate from each other but minutely fused at bottom, widest at proximal one-third, with 3 distal long setae. Endite (Fig. 6-C) reaching distal edge of palp article 1, trapezoid, furnished with a bare seta distally on caudal face, armed with a short and 2 long spatulate spines apically, with 2 retinacula on rostral face. Palp 4-articulate. Palp article 1 triangular. Palp article 2 triangular, armed with a stout spine on outer distal edge, bearing 4 setae on inner distal edge. Palp article 3 oval, lined with a row of 5 feathered setae along inner margin, bearing 3 bare setae on inner distal edge. Article 4 geniculate, lined with a row of 7 feathered setae along inner margin, bearing a feathered seta subapically on outer margin, with a bare seta on rostral face. Epignath (Fig. 6-B) as in male *L. itoi*.

Cheliped (Fig. 6-D). Coxa with a caudal setule. Basis 1.5 times as long as broad, with a caudal seta behind carpus. Merus with 3 sternal setae. Carpus as long as basis, slightly expanded distally, bearing 3 sternal setae and 3 tergal setules. Propodus (Fig. 6-E) with a seta behind dactylus; spine row located on rostral face,

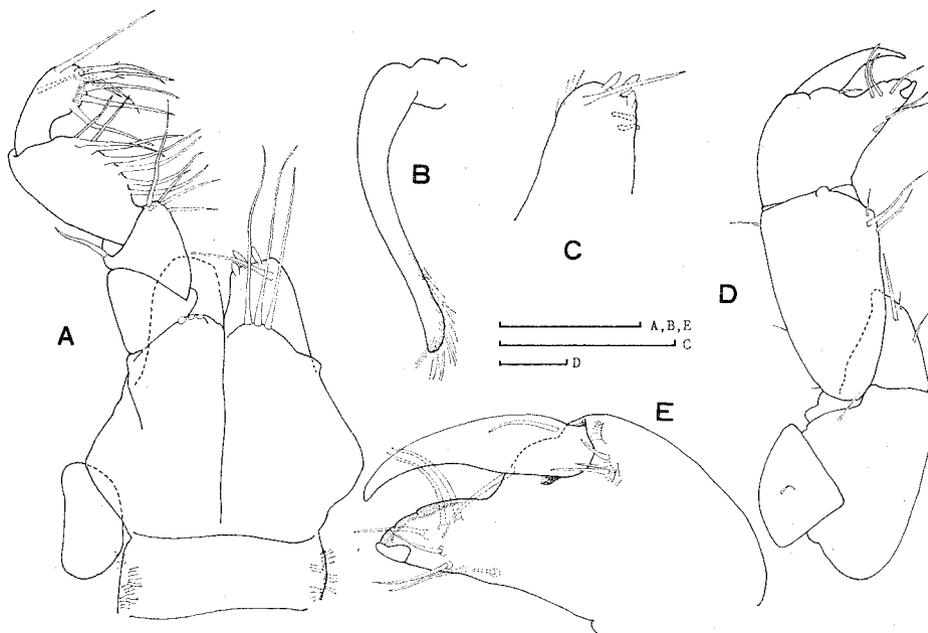


Fig. 6. *Leptochelia itoi* n. sp. Female (allotype): A, maxilla 2 and maxilliped (cd); B, epignath (R, vt); C, endite of maxilliped (R, cd); D, cheliped (R, cd); E, chela (R, rt). Bar scales 0.1 mm.

perpendicular to dactylus, composed of 3 spine-setae. Fixed-finger thick, armed with a stout tooth apically, ridged and brown-colored along tergal margin which is twice incised minutely, bearing 3 caudal setae and 4 rostrosternal setae. Dactylus with a rostral seta basally.

Pereopods a little shorter than those of male *L. itoi*. *Pereopod II* (Fig. 7-A) similar to that of male *L. itoi*. *Pereopods III, IV* (Fig. 7-B, C) similar to male, except for distal setal bundle reaching apex of dactylus. *Pereopods V, VI* (Fig. 7-D, E). Carpus (Fig. 7-G) armed with a rostral and 2 caudal spines distally, a caudal one of which is larger than the other but apparently smaller than that of male *L. itoi*. Propodus (Fig. 7-I) armed with a membranous spine distally on caudal face, furnished

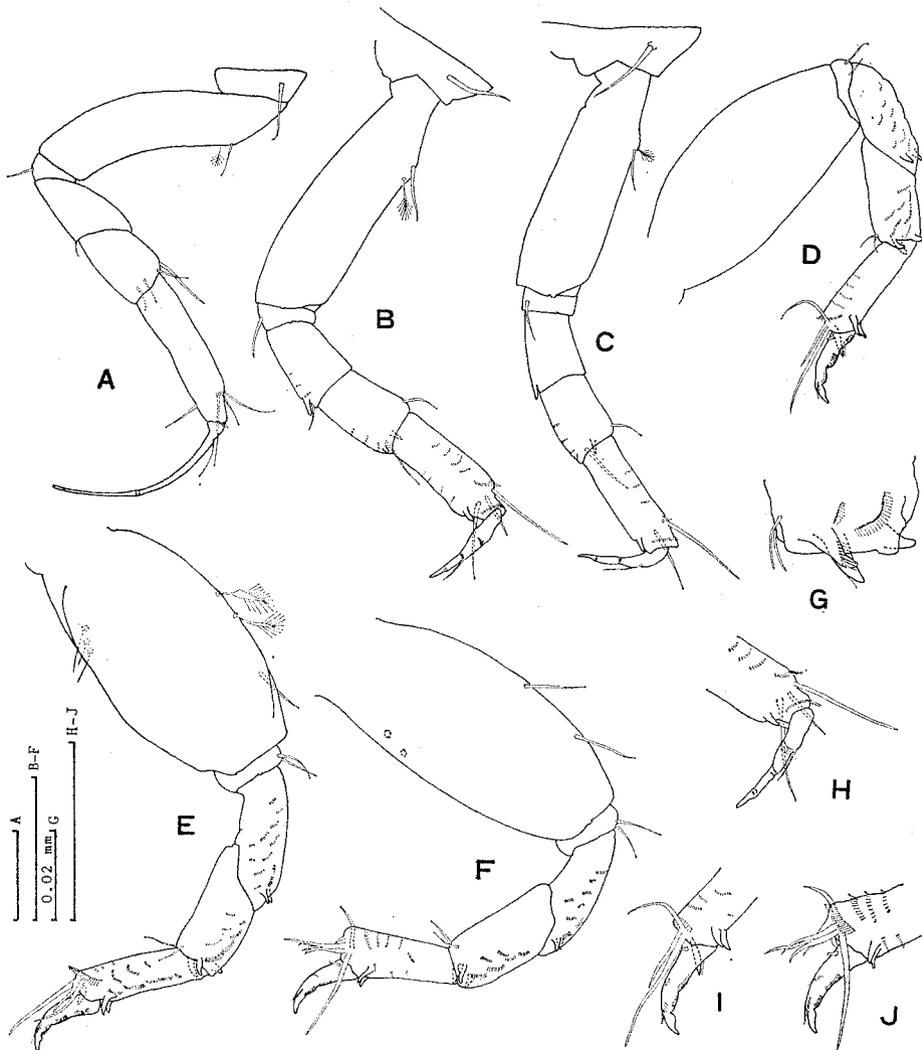


Fig. 7. *Leptochelia itoi* n. sp. Female (allotype): A-C, pereopods II-IV (R, cd); D-F, pereopods V-VII (R, rt); G, carpus of pereopod V (rt); H-J, propodi and dactyli of pereopods III, V, VII. Bar scales 0.1 mm, if not mentioned.

with 3 long setae exceeding apex of dactylus. *Pereopod VII* (Fig. 7-F) similar to pereopods V and VI, except for lack of a membranous spine and for different composition of distal setal bundle which is same as that of male *L. itoi*.

Pleopods I-V as in male *L. itoi*.

Uropod (Fig. 5-K) similar to male's. Basis without setae. Article 1 of endopodite lacking setae.

Remarks. The new species exhibits distribution sympatric with its relative, *L. savignyi* in Japan (Fig. 17).

Leptochelia savignyi (Krøyer, 1842)

(Figs 8-14, 15-C, D, 16-B, D, 17)

Material examined. 1♂, 1.9 mm, subtidal, 1 m deep, sand, Oshoro Bay, Hokkaido, 15-VI-1981, SI coll. —1♂, 2.0 mm (partially described: small male); 1 preparatory ♀, 3.2 mm (fully described), 2.1 m deep, muddy sand, Samani, Hokkaido, 6-VIII-1982, SI coll. —4♂♂, 3.2 to 3.6 mm (one of them fully described: large male), intertidal, sandy bottom containing much of organic matters derived from *Phyllospadix*, within *Phyllospadix* bed, Notoro Cape, Abashiri, Hokkaido, 21-V-1983, SI coll. —2♂♂, 2.5, 5.5 mm; 1♀, 4.9 mm, intertidal, sand, False Bay, San Juan Is., Washington, U.S.A., P.M. Mace coll.

Large male (possibly secondary male): Body (Fig. 8-A, B) 3.6 mm long; color white after fixation.

Carapace (Fig. 8-C) shorter and broader than that of male *L. itoi*, about 20% as long as body, a little shorter than first three pereonites combined, 1.2 times as long as wide, gradually narrowing distally, not contracted; a lateral setule arising from the point just behind ocular lobe. Respiratory chamber not swollen. Ocular lobe triangular-oval, not reaching apex of rostrum; ocular margin of carapace concave. Rostrum short, not acuminate, convex. Coxa of cheliped not outstanding from dorsal view.

Pereonites (Fig. 8-A) of the same structure as male *L. itoi* except for its armament. *Pereonite 2* bearing 4 dorsal setules along anterior margin, with a few minute setules between the outermost one of the above 4 setules and coxa of pereopod II; a marginal setule issued from posterior edge of lateral margin. *Pereonites 3* and *4* bearing 2 pairs of medial and lateral setules behind anterior margin of dorsal face; a marginal setule issued from posterior edge of lateral margin. *Pereonites 5* and *6* similar to pereonites 3 and 4, except for a marginal setule located at the middle. *Pereonite 7* similar to pereonites 5 and 6 except for absence of medial setules on dorsal face.

Pleon (Fig. 8-A, B) of the same structure as male *L. itoi* except for its armament. Each pleonite having a pair of dorsal setules and a pair of lateral setules (one long, the other short). Genital cone (Fig. 16-B) composed of a single protuberance, the same as that of male *L. itoi*. *Pleotelson* (Fig. 10-G) longer than a pleonite, pointed posteriorly, with 2 dorsal setules, a setule just behind the conjunction of uropod, 2 subapical setules marginally, and with 2 pairs of long and short apical setules on caudal point; anus (Fig. 16-C) as in male *L. itoi*.

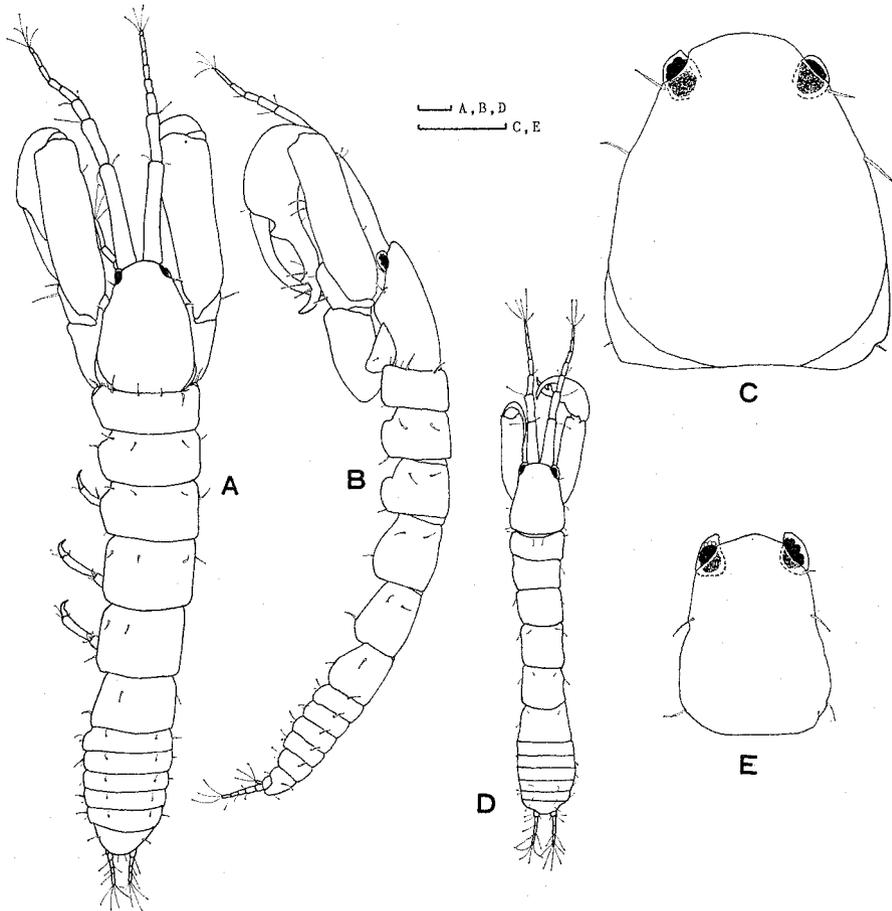


Fig. 8. *Leptochelia savignyi* (Krøyer). Large male: A, habitus (ds); B, habitus (lt); C, cephalothorax (ds). Small male: D, habitus (ds); E, cephalothorax (ds). Bar scales 0.2 mm.

Antenna 1 (Fig. 10-A) half as long as body. Length ratios of peduncular articles 1-3 10:5:2. Peduncular article 1 about 80% as long as carapace, bearing 2 distal setae and a few penicillate hairs, set with 2 penicillate hairs transversely located on lateral face proximally. Peduncular article 2 slightly less broad than article 1, with 2 distal setae and a few penicillate hairs. Peduncular article 3 with a distal seta and aesthetascs. Flagellum 6-articulate; flagellar articles 1-5 furnished with aesthetascs; flagellar article 5 with 1 seta, article 6 with 5 setae. *Antenna 2* (Fig. 10-B) 40% as long as antenna 1, 6-articulate. Length ratios of articles 1-6 3:7:5:20:13:1. Article 2 dorsoventrally flattened and expanded, bearing a short setule on outer distal edge, armed with a medioventral spine distally. Article 3 armed with a distal spine dorsally, which is twice as long as article 3. Article 4 not curved, with a large penicillate hair on the middle of medial face, bearing 3 distal setae. Article 5 with a seta, article 6 with 6 setae.

Mouth parts (Fig. 15-C, D) reduced, abruptly swelling from plain ventral face

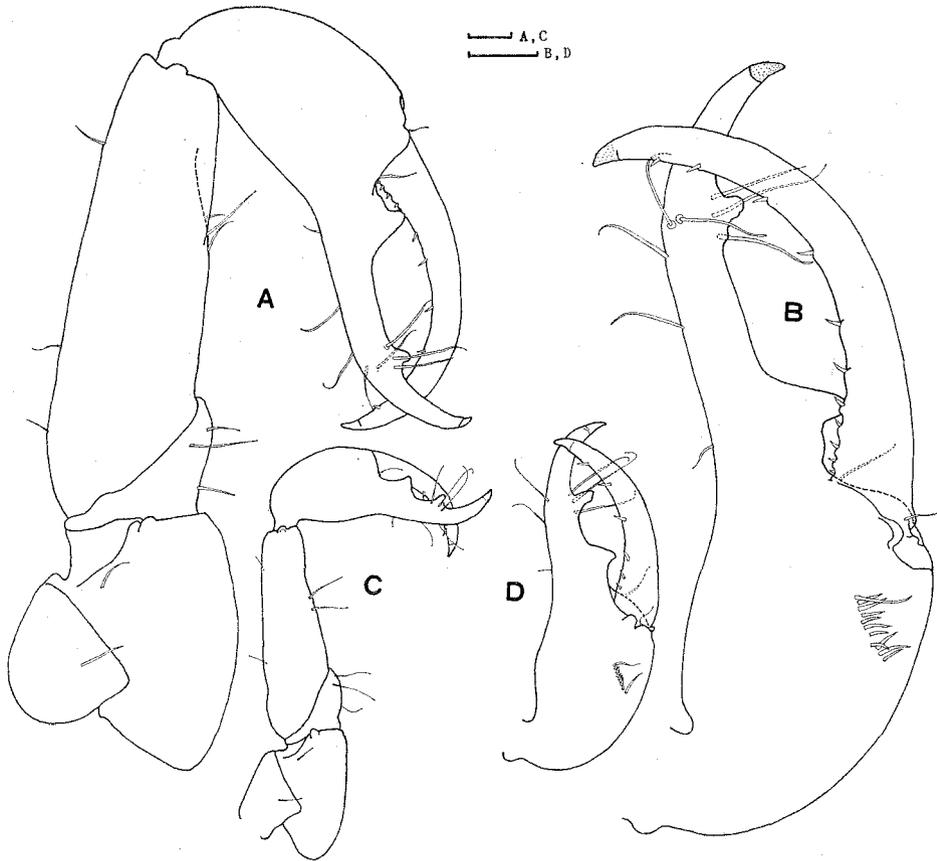


Fig. 9. *Leptochelia savignyi* (Krøyer). Large male: A, cheliped (R, cd); B, chela (R, rt). Small male: C, cheliped (R, cd); D, chela (R, rt). Bar scales 0.1 mm.

of carapace. *Epistome* (Figs 10-C, 15-D) elongate, reaching distal margin of article 2 of antenna 2, not notched anteriorly. *Mandible* (Fig. 15-C, D) exceedingly degenerated, fused with carapace, remaining only as triangular furrow of carapace. *Labium* absent. *Maxilla 1* (Fig. 10-D). Endite absent. Palp uniarticulate, bearing 2 apical setae. *Maxilla 2* (Fig. 10-D) triangular-oval. *Maxilliped* (Figs 10-D, 15-D) similar to that of male *L. itoi*, but basis widest at bottom.

Cheliped (Fig. 9-A) strong. Coxa with 1 caudal seta. Basis 1.6 times as long as broad, less extended posteriorly than in male *L. itoi*, with a caudal seta behind merus. Merus with 3 sternal setae. Carpus 1.8 times as long as basis, not so swollen, with its widest width about 30% as long as its length, untouching basis, bearing 3 sternal setae and 3 tergal setules. Propodus (Fig. 9-B) more elongate than that of male *L. itoi*, with a setule just behind the conjunction of dactylus; comb-like spine row located on rostral face, which is shorter than in male *L. itoi* and whose axis is nearly parallel to dactylus. Fixed-finger apart from the base of propodus, with its axis almost parallel to that of the rest of propodus, armed with a small and a large tooth, the latter of which is less tall and less close to the rest of propodus than in male

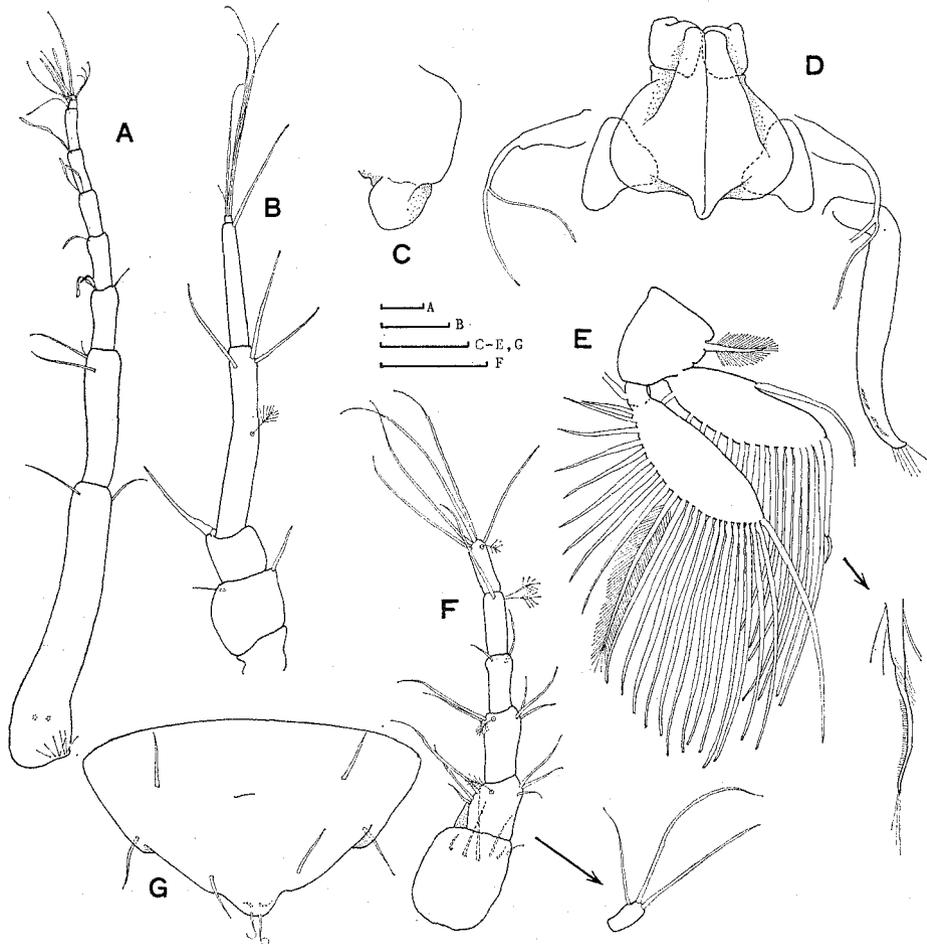


Fig. 10. *Leptochelia savignyi* (Krøyer). Large male: A-B, antennae 1-2 (R, lt); C, labrum (obliquely lt); D, mouth parts (vt); E, pleopod I (R, rt); F, uropod (R, ds); G, pleotelson (ds). Bar scales 0.1 mm.

L. itoi, bearing 3 caudal setae near the small tooth, and 5 rostral setae along sternal margin; tip sclerotized and brown-colored. Dactylus with a rostral seta basally, armed with a row of stout spines along sternal margin; tip sclerotized and brown-colored.

Pereopod II (Fig. 11-A) the longest of all pereopods, similar to that of male *L. itoi*, except dactylus two-thirds as long as propodus. *Pereopods III-VII* similar to those of *L. itoi*, but all spines slightly articulated basally in contrast with non-articulated spines of *L. itoi*. *Pereopods III, IV* (Fig. 11-B, C). Coxa with a tergal seta. Basis with a tergal and a few penicillate hairs proximally. Ishium very short, with 1 or 2 sternal setae. Merus with a sternal seta and a sternal spine, the latter of which abruptly turns tergally. Carpus with a sternal and a few tergal setae distally, armed with a sternal blunt and a rostral spine, the latter of which is not scale-like. Propodus (Fig. 11-G) with a sternal spine, bearing 3 tergal setae less than half as long

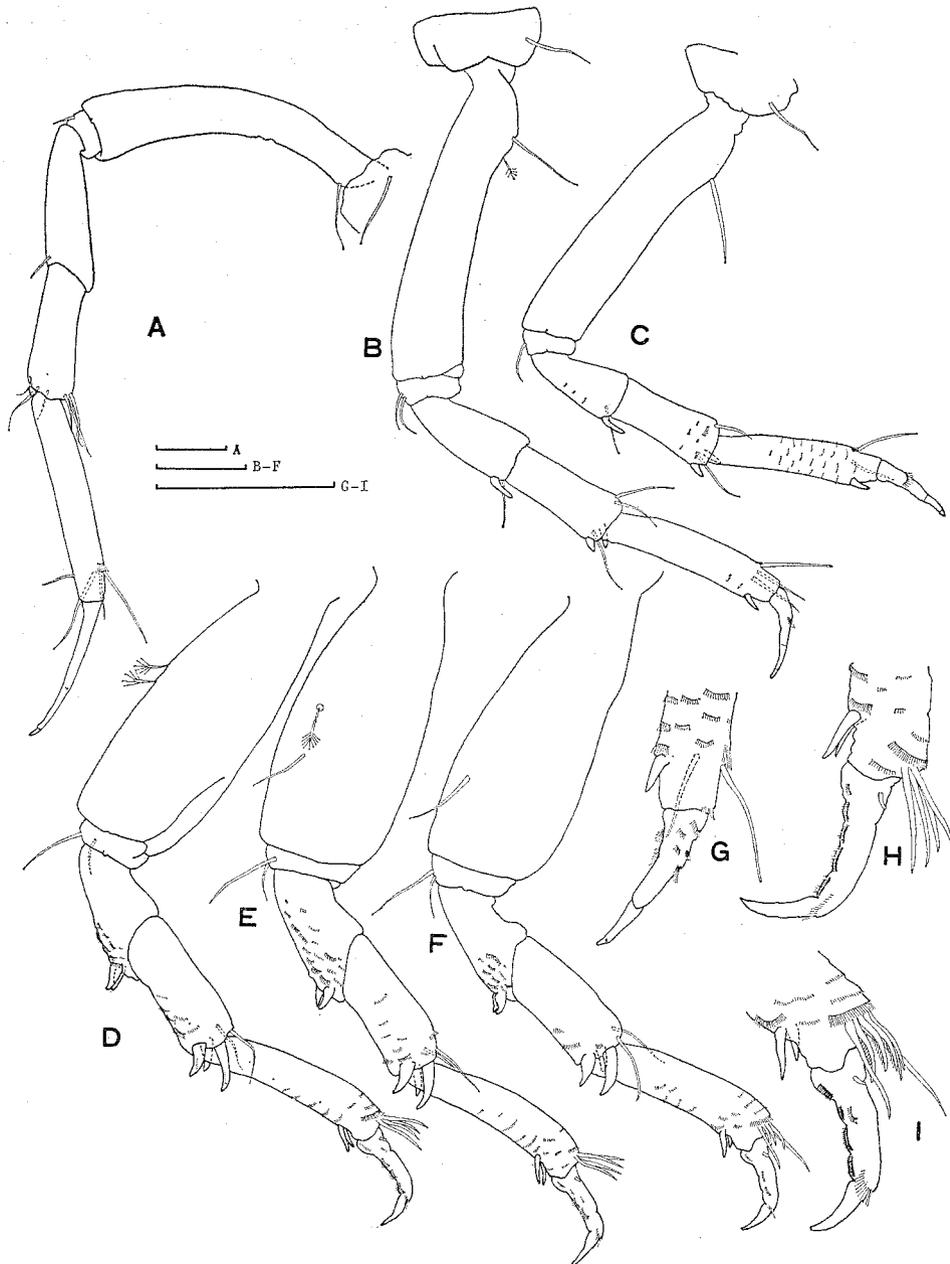


Fig. 11. *Leptochelia savignyi* (Krøyer). Large male: A-F, pereopods II-VII (R, cd); G-I, propodi and dactyli of pereopods IV, V, VII. Bar scales 0.1 mm.

as dactylus. Dactylus with 2 obscure articulations, bearing a thin setule tergally. *Pereopods V, VI* (Fig. 11-D, E) very similar to those of male *L. itoi* except for the followings. Carpus a little longer than that of male *L. itoi*. Propodus (Fig. 11-H) bearing 4 tergal setae less than half as long as dactylus. Dactylus abruptly curved

sternally at distal one-third. *Pereopod VII* (Fig. 11-F) similar to pereopods V and VI except for distal setal bundle of propodus (Fig. 11-I), which comprises 2 long bare setae and 5 short comb-like setae.

Pleopods I-V as in male *L. itoi*.

Uropod (Fig. 10-F) biramous. Basis about as long as broad, with a few ventral setae. Exopodite small, uniarticulate, with 2 apical and 1 subapical seta. Endopodite 5-articulate; length ratios of each article 100 (basis):55:65:55:60:50 (terminal); articles 1-5 bearing 6, 5, 2, 1 and 5 setae respectively; each article with a penicillate hair distally.

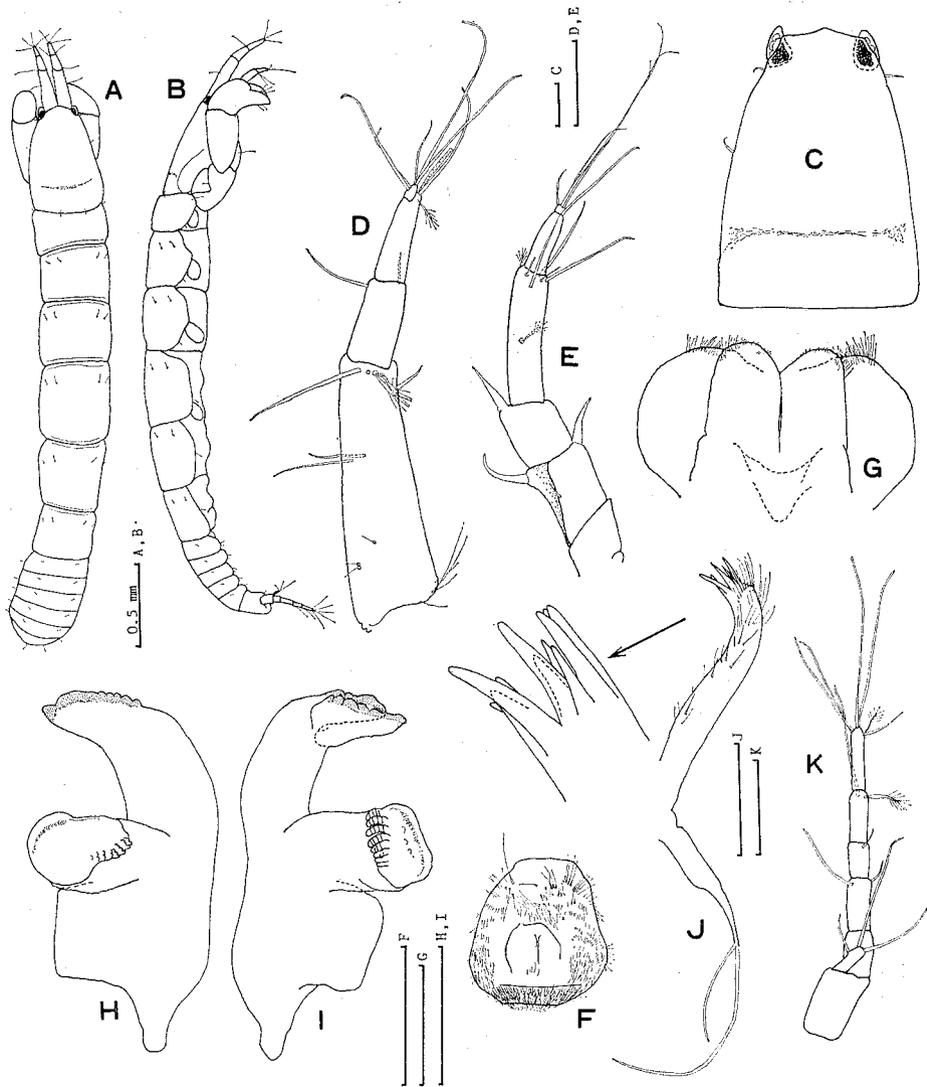


Fig. 12. *Leptochelia savignyi* (Krøyer). Female: A, habitus (ds); B, habitus (lt); C, cephalothorax (ds); D-E, antennae 1-2 (R, lt); F, labrum (vt); G, labium (cd); H-I, right and left mandibles (md); J, maxilla 1 (L, cd); K, uropod (ds). Bar scales 0.1 mm, if not mentioned.

Small male (possibly primary male): Differing from large male as follows. Body (Fig. 8-D) 2.0 mm long.

Carapace (Fig. 8-E) less broad. Rostrum slightly angular apically. Ocular lobe scarcely reaching apex of rostrum.

Cheliped (Fig. 9-C) proportionally smaller. Distal and proximal teeth of propodus closer to each other (Fig. 9-D).

Female (preparatory female): Very similar to female *L. itoi*. Body (Fig. 12-A, B) 3.2 mm long; color white after fixation.

Carapace (Fig. 12-C) as that of female *L. itoi*.

Pereonites (Fig. 12-A, B) of the same structure as female *L. itoi* except for tergal setules, which are of the same distribution as male *L. savignyi*.

Pleon (Fig. 12-A, B) of the same structure and armament as male *L. savignyi*, except pleotelson. *Pleotelson* (Fig. 13-F) longer than a pelonite, pointed posteriorly, with a pair of 2 dorsal setules which are longitudinally located and shorter than those of male *L. savignyi*, with a setule just behind the conjunction of uropod, 2 marginal setules subapically, and with 2 pairs of long and short setules on caudal point, longer one of which is more than twice as long as that of male *L. savignyi*; anus (Fig. 16-D) as that of female *L. itoi*.

Antennae 1-2, labrum, mandible, labium, maxilla 1 (Figs 12-D-J) of the same structures as female *L. itoi*. *Maxilla 2* (Fig. 13-A) triangular-oval. *Maxilliped* (Fig. 13-A-C) similar to that of female *L. itoi*, except for 4 distal long setae of basis.

Cheliped (Fig. 13-D) similar to that of female *L. itoi*, except for the bottom of fixed-finger which is apparently concave on tergal margin (Fig. 13-E).

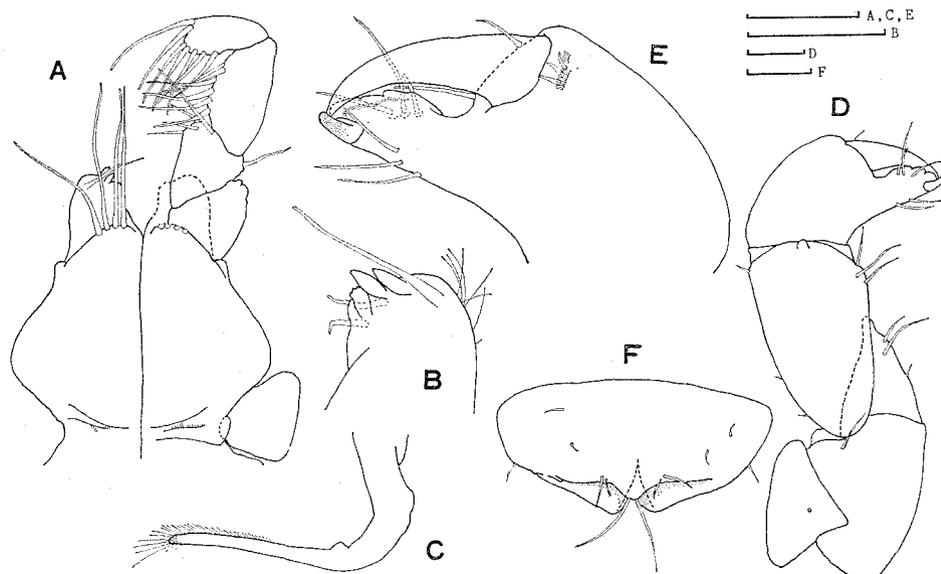


Fig. 13. *Leptocheilia savignyi* (Krøyer). Female: A, maxilla 2 and maxilliped (cd); B, endite of maxilliped (L, cd); C, epignath (L, cd); D, cheliped (R, cd); E, chela (R, rt); F, pleotelson (ds). Bar scales 0.1 mm, if not mentioned.

Pereopods rather shorter than those of male *L. savignyi*, very similar to those of female *L. itoi* except the followings. *Pereopods III, IV* (Fig. 14-B, C). Carpus with 2 tergal setae distally. *Pereopods VI-VII* (Fig. 14-D-F). Propodus with a distal setal bundle, which is equal in setal number and fundamental structure to that of female *L. itoi*, but about as long as dactylus.

Pleopods I-V as in male *L. itoi*.

Uropod (Fig. 12-K) similar to that of male *L. savignyi*. Basis lacking ventral setae. Articles 1-5 of endopodite with 0, 2, 1, 1 and 5 setae respectively.

Remarks. Though the North American material coincides morphologically with the Japanese one, some minute differences were recognized in female specimens. For example, the number of setae issued from the basis of maxilliped is 5 in the

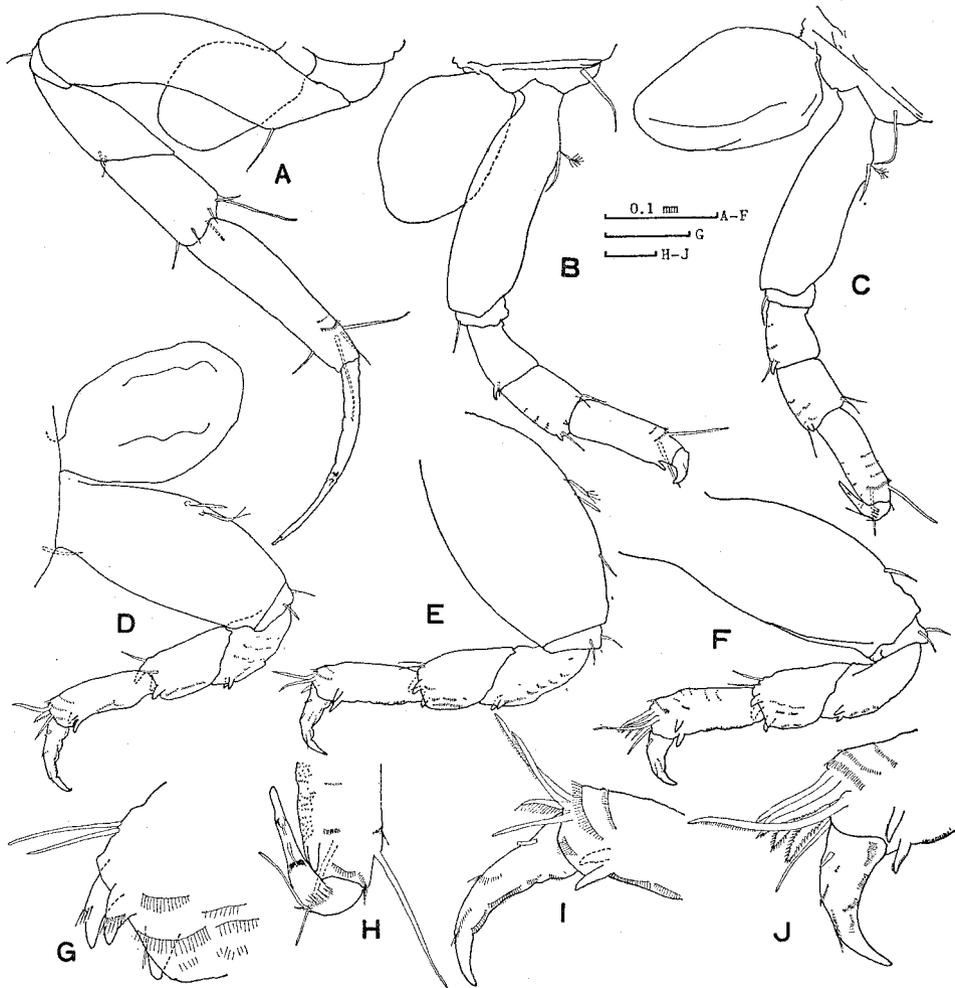


Fig. 14. *Leptochelia savignyi* (Krøyer). Female: A-C, pereopods II-IV (R, cd); D-F, pereopods V-VII (R, rt); G, carpus of pereopod VI (rt); H-J, propodi and dactyli of pereopods IV, V, VII. Bar scales 0.02 mm, if not mentioned.

American material, and 4 in the Japanese one. As a periodical sampling was not conducted in either locality, the comparison was made only between large females (possibly second copulatory females) of Pacific U.S.A. and small preparatory females (possibly first preparatory females) of Japan. Differences noticed might be referred to developmental changes of a single species.

This species is sympatric with its relative, *L. itoi* in Japan (Fig. 17). In Oshoro Bay, heretofore, only two males have been collected among 6,500 individuals of *L. itoi* from the neighborhood of the periodical sampling site. At Shirahama where *L. savignyi* was recorded by Shiino (1950), I could not rediscover it, though *L. itoi* was abundant there. From these facts, both *L. savignyi* and *L. itoi* are sympatric, and seem allotopic.

Discussion

1. Species Problem in "*Leptochelia*-Gruppe 2"

Lang (1973) classified the members of the genus *Leptochelia* into two species-groups, one of which is characterized by male cheliped exceedingly longer than the body of the animal, and the other group by moderately long male cheliped. He called the former species-group "*Leptochelia*-Gruppe 1", and the latter "*Leptochelia*-Gruppe 2". According to his system, "*Leptochelia*-Gruppe 1" comprises several species, whereas "*Leptochelia*-Gruppe 2" does only one valid species, *L. savignyi* (Krøyer, 1842), which has complicated synonymy. Taxonomy of the "*Leptochelia*-Gruppe 2" has been complicated since Krøyer (1842, cited from Sieg, 1983) described first three species of this species-group. These were *Tanais Savignyi*, *T. Edwardsii*, and *T. dubius*. Müller (1864, cited from Sieg, 1983) noticed two different types of males in *T. dubius* and, on the other hand, suggested that *I. Edwardsii* and *T. Savignyi* were the male and the female of a single species. Czerniavski (1868, cited from Sieg, 1983) indicated that *Leptochelia Edwardsii* (= *T. Edwardsii*) was actually one of the dimorphic males of *T. dubius* sensu Müller (1868). Afterward, relationships of the above three species, along with several affinitive species later described, were discussed by many authors (e.g. Harger, 1879; Sars, 1882, 1886; Stebbing, 1896; Smith, 1906). These discussions led to general consensus that all species of this species-group should be downgraded to synonymy of only one species. Smith (1906), who regarded *L. dubia* as a senior synonym, listed up the following four junior synonyms under *L. dubia*: *L. Algicola* (Harger, 1878), *L. Savignyi*, *L. Edwardsii*, and *L. neapolitana* Sars, 1882. Lang (1973), in his treatise on *Leptochelia* and its allied genera, tried to put this species-group in order. He assigned 10 species in "*Leptochelia*-Gruppe 2" (Table 1) under one and only representative of this species-group, that is, *L. savignyi*. Though some workers regard *L. dubia* as a senior synonym, nowadays Lang's statement seems widely accepted by most tanaid workers (e.g. Holdich & Jones, 1983). However, the discovery of the present new species suggested that Lang's synonymization of all 10 species might be partly based on overestimate of the range of the morphological

Table 1. Synonymy of *Leptochelia savignyi* s. lat. proposed by Lang (1973).

Species	Sex originally described	Type-locality
<i>Leptochelia affinis</i> Hansen, 1895	♀	Cape Verde
<i>Paratanais algicola</i> Harger, 1878	♂, ♀	Noank and Woods Hole
<i>Leptochelia corsica</i> Dollfus, 1898	♂, ♀	Corsica and Tunisia
<i>Tanais dubius</i> Krøyer, 1842	♂	Salvador (Brazil)
<i>Tanais edwardsii</i> Krøyer, 1842	♂	Madeira
<i>Leptochelia incerta</i> Moore, 1901	♀	Puerto Rico
<i>Paratanais krøyerii</i> Kossmann, 1890	♀	Mediterranean
<i>Leptochelia lifuensis</i> Stebbing, 1900	♂, ♀	Loyalty Is. (Melanesia)
<i>Leptochelia neapolitana</i> Sars, 1882	♂, ♀	Naples
<i>Tanais savignyi</i> Krøyer, 1842	♀	Madeira

variation. A possibility still remains that some of the junior synonyms of *L. savignyi* may be valid species, distinctive from *L. savignyi*.

L. itoi n. sp. apparently belongs to "Leptochelia-Gruppe 2" of Lang (1973). When we take a large variation range of *L. savignyi* (sensu Lang) into account, *L. itoi* may be regarded as a mere variety of the former not worthy to be ranked even subspecifically. However, the present new species is evidently distinctive throughout its postmarsupial development (Ishimaru, unpublished) from the North Pacific materials of *L. savignyi* redescribed above, as shown in Tables 2-3. These differences sufficiently deserve the erection of the new species separate from *L. savignyi*, which was here represented by the North Pacific form (well corresponding with one of the junior synonyms, "*L. dubia*" described by Sars (1886)). However, this does not necessarily mean that *L. itoi* is distinctive from all the known members of *L. savignyi* s. lat. Among the all known forms of *L. savignyi* s. lat., *L. itoi* is closest to "*L. neapolitana*", that was first described by Sars (1882), accompanied with no figure. Figures of this species were presented afterward by Sars himself (1886), and these are the one and only picture from which we can obtain precise information of this form. As far as Sars' figures are concerned, "*L. neapolitana*" is somewhat distinct morphologically from other members of *Leptochelia savignyi* s. lat., and bears a great resemblance to *L. itoi* particularly in the shapes of carapace and chelipeds (Tables 2-3). Though taxonomic status of "*L. neapolitana*" will have to be reconsidered based on the type material, here I tentatively retain "*L. neapolitana*" within the synonymy of *L. savignyi* s. lat. With no doubt I can clearly point out is that *L. itoi* is not conspecific with the North Pacific "*L. dubia*"-form of the polymorphic *L. savignyi* s. lat.

Besides the above *neapolitana-itoi-dubia* problem, in my opinion, synonymy of "Leptochelia-Gruppe 2" is not clear-cut, and still unresolved. Some kinds of confusion probably originated from overestimate of morphological variation, resulted from misunderstanding of the taxonomic significance of some characters. I can point out an example of such an overestimate. Lang (1973) tried to evaluate the taxonomic significance of the number of articles of female antenna 1, and the number

Table 2. Male diagnostic characters of *Leptochelia itoi* n. sp. and two forms of *L. savignyi* s. lat. ("dubia" and "neapolitana"). *L. itoi* and *L. "dubia"* are of the North Pacific material, and *L. "neapolitana"* is based on the figures provided by Sars (1886). The specimens examined here are primary and secondary males (*L. itoi*), and small and large males possibly corresponding to primary and secondary ones (*L. "dubia"*). Shared conditions are bolded.

Characters/Species	<i>itoi</i>	" <i>dubia</i> "	" <i>neapolitana</i> "
1 Carapace	contracted, long	non-contracted, short	medium
2 Pereon and pleon dorsal setal formula		different	?
3 Mouth parts		different	?
4 Antenna 1	short , robust	long, weak	short
flagellum	short	long	long
5 Antenna 2	long	short	short
articles 1-2	fused	articulate	articulate
article 4	long, curved	short, straight	short, straight
article 5	short	long	long
6 Cheliped	robust	weak	robust
chela	short	long	rather similar to <i>itoi</i>
7 Pereopod II dactylus	long	short	?
8 Pereopods III-IV sternal spine	bent	straight	?
9 Pereopods III-VII spines	articulate	inarticulate	?
10 Uropod endopodite	4-articulate long	5-articulate short	6-articulate long

Table 3. Female diagnostic characters of *Leptochelia itoi* n. sp. and two forms of *L. savignyi* s. lat. ("dubia" and "neapolitana"). *L. itoi* and *L. "dubia"* are of the Japanese material, and *L. "neapolitana"* is based on the figures provided by Sars (1886). The conditions of *L. itoi* are based on all adult stages. The specimens of *L. "dubia"* examined here are probably of first preparatory stage. Shared conditions are bolded.

Characters/Species	<i>itoi</i>	" <i>dubia</i> "	" <i>neapolitana</i> "
1 Pereon and pleon dorsal setal formula		different	?
2 Pleotelson posterior setae	short	long	short?
3 Maxilla 2	kidney-shaped	triangular-oval	?
4 Maxilliped setal number of basis	3	4	?
5 Cheliped fixed-finger	non-concave	concave	non-concave
6 Pereopods V-VII length of distal setal bundle of propodus	=dactylus	=0.5 × dactylus	=0.5 × dactylus
7 Uropod endopodite	4-articulate short	5-articulate long	6-articulate short

of articles of uropod. He examined more than 1,200 individuals of different size-groups of female *L. forresti* (Stebbing, 1896) ("*Leptocheilia*-Gruppe 1" of Lang, 1973) and showed that both characters were variable; the number increases grossly depending on body size increase. He decided from this result to abandon the above two characters as both generic and specific key characters. In my opinion, however, the fact that these characters are variable for *L. forresti* cannot be simply extended to other species. It does not mean that the number of uropodal articles is useless as a specific character. The number of uropodal articles of *L. itoi* gradually increases with their growth and reaches the maximal number that is always four (Ishimaru, unpublished). What can be said from Lang's examination is only the tested characters have no absolute quality to determine boundaries of genera and species. There is no doubt that it can be used as a specific character, if it is cautiously and properly applied together with other character complex. Correct evaluations of specific characters will be achieved when postmarsupial development of one population is rigidly clarified, and that is compared with those of other populations.

This kind of false character evaluation may easily lead to an overestimate of the range of morphological variation. Such an overestimate might have brought several valid species to being submitted to false synonymizing with *L. savignyi*. I would like to emphasize a probability that *L. savignyi* s. lat. might contain some cryptic species. The synonymy of *L. savignyi* s. lat. would have to be submitted to the modern interpretation to clarify a range of morphological variation within a population and a degree of discontinuity between such populations.

2. Comments on the Taxonomic Significance of Some Characters

In the course of the present study, observations using SEM were employed. Some noticeable items obtained by the SEM observations are mentioned below.

2-1. *Mouth parts morphology.*

Males of certain species of tanaid families do not feed. Bückel-Ramirez (1965) stated that males of *Heterotanais oerstedii* (Paratanaidae) did not feed after the maturation molt. Highsmith (1983) reported the same situation in *L. dubia* of the Pacific coast of North America. In *L. itoi* either, males do not feed after the maturation molt (Ishimaru, unpublished). Evidently correlated with these facts, male mouth parts of some tanaid families are more or less degenerated. This reduction of male mouth parts was considered synapomorphy of the family members of the superfamily Paratanaoidea, excluding Pseudozeuxidae (Sieg, 1982). Reduction of male mouth parts is also observed in both *L. itoi* and *L. savignyi* examined here (Fig. 15). Among these male mouth parts, parts keeping normal states as females do are only epignath and the palp of maxilla 1, both of which function as devices for respiration (Holdich & Jones, 1983). All other mouth parts, which function as handling food particles in females, are degenerated in males of *L. itoi* and *L. savignyi*. The endite of maxilla 1, the endite of maxilliped, and labium are completely lacking. The remaining

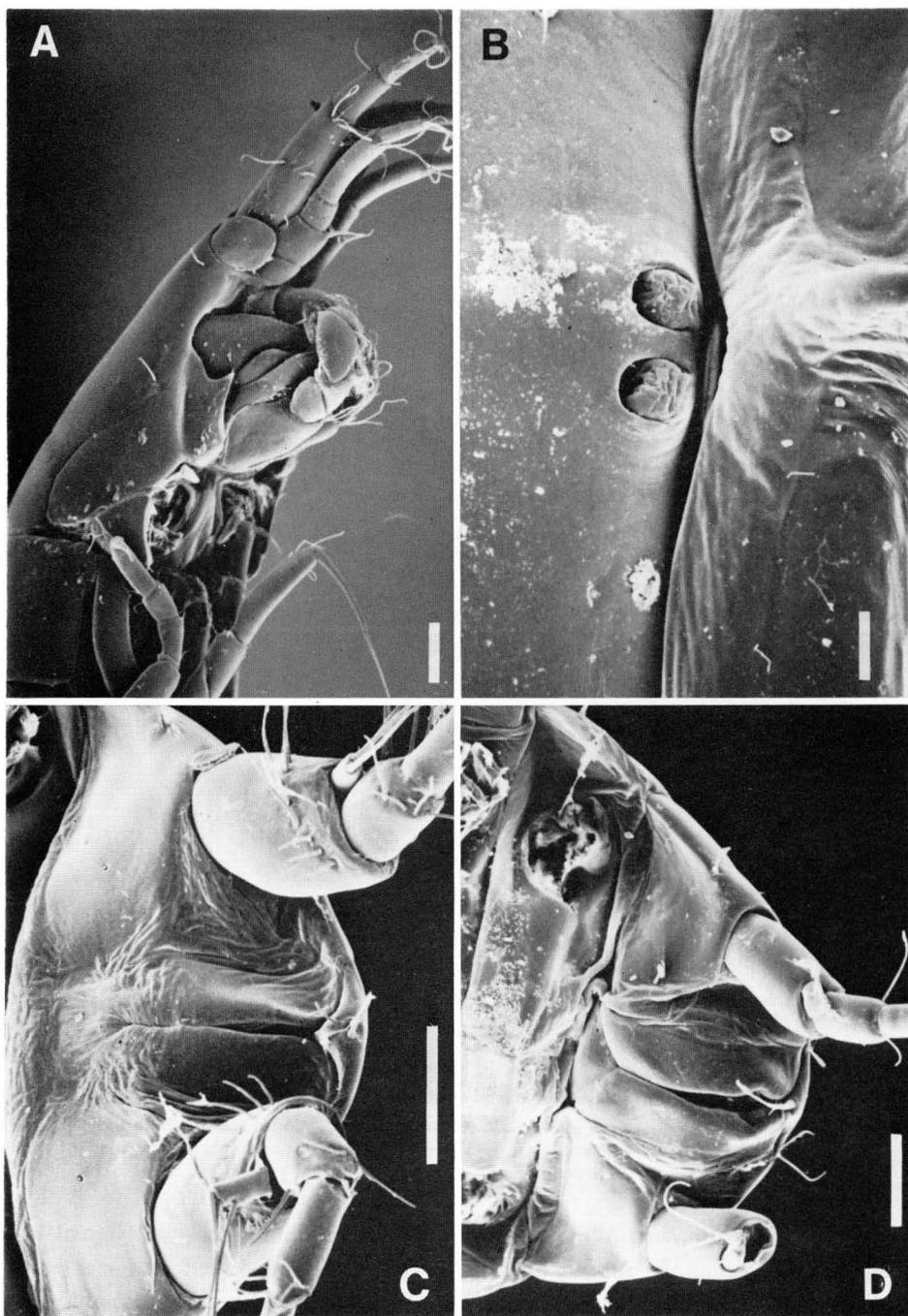


Fig. 16. *Leptochelia itoi* n. sp. Female (Oshoro): A, mouth region. *Leptochelia savignyi* (Krøyer). Large male (San Juan Is.): B, genital cone; C, anus. Female (San Juan Is.): D, anus. Bar scales 0.1 mm (A, C, D), 0.02 mm (B).

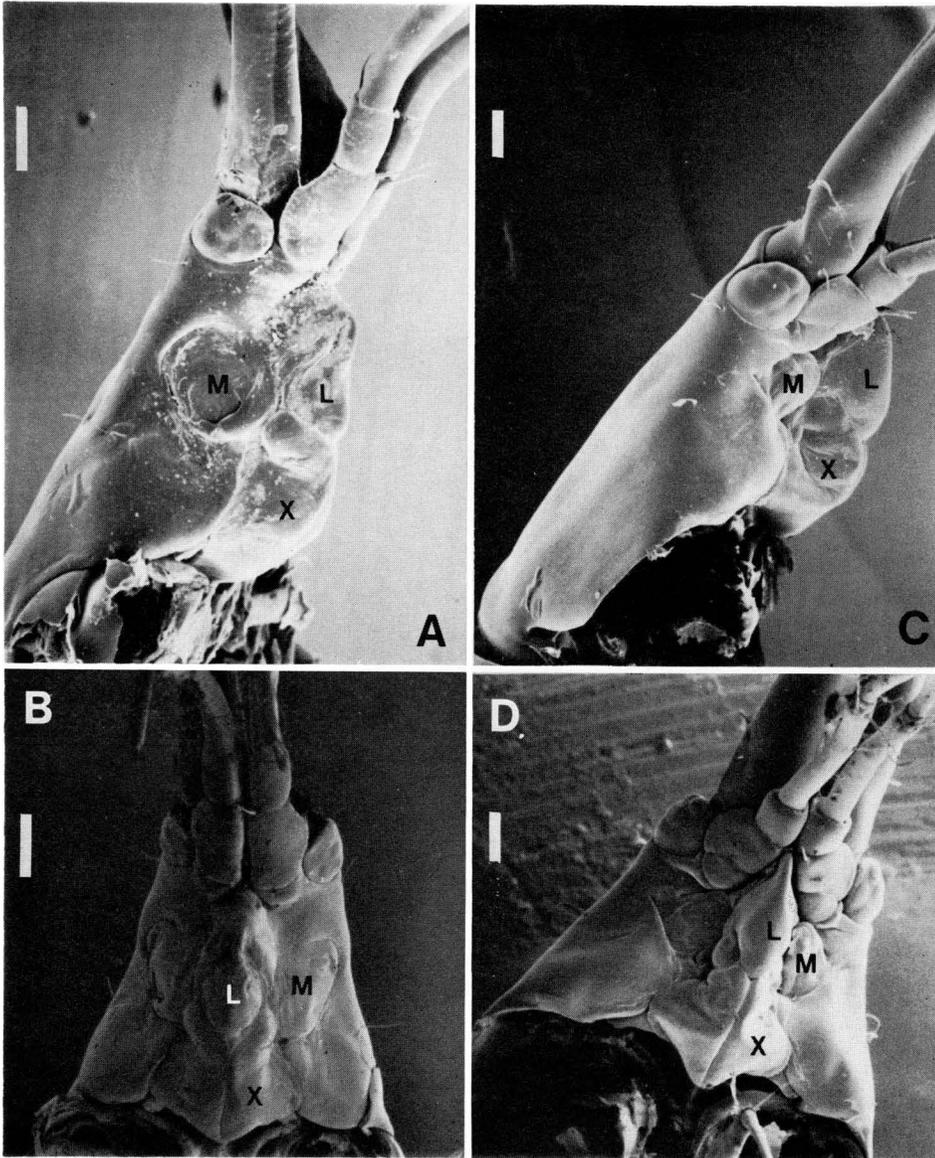


Fig. 15. *Leptochelia itoi* n. sp. Secondary male (Oshoro): A-B, mouth region (lt and vt). *Leptochelia savignyi* (Krøyer) (San Juan Is.): C-D, mouth region (lt and vt). Bar scales 0.1 mm. L, labrum; M, mandible; X, maxilliped.

parts, namely, labrum, mandible and maxilliped, are immovable and joined altogether tightly, so that the mouth opening is completely concealed under them.

As one of the generic characters, Lang (1973) defined the male maxilliped of *Leptochelia* as bearing a vestigial uniarticulate palp. He provided a clear figure of the male maxilliped of *L. lifuensis* Stebbing, 1900 (a junior synonym of *L. savignyi* s. lat.), showing a uniarticulate palp evidently articulated from basis. As evidenced

by SEM microphotographs, however, the male maxilliped in both *L. itoi* and *L. savignyi* ("*L. dubia*"-form of the North Pacific) has a pair of blunt processes (presumable vestiges of palps) which are not articulated from basis (Fig. 15). This condition is difficult to observe, even if the mouth region was released from the cephalothorax, adequately squashed by a cover slip, and observed under the light microscope. Since conditions of the male maxillipeds of other *Leptochelia* species are rarely known, they must be examined by means of SEM before the male maxillipedal palp is qualified for the generic character. For the time being, it would be proper to exclude the condition of male maxillipedal palp from the diagnosis of *Leptochelia*.

Up to the present, the condition of the male mandible has been hardly referred to, since it could not be sufficiently observed by using usual techniques. From SEM observations, it was revealed that the conditions of the male mandibles are different between *L. itoi* and *L. savignyi*. In *L. savignyi* (Fig. 15-C) the mandible is fused with the cephalothorax, bears no molar or incisor, looks like only a cuticular hump of the carapace. It is clearly defined from the neighboring cuticle by deep furrow, that forms the sharp incision of the carapace. In *L. itoi* (Fig. 15-A), the male mandible is perfectly fused with the cephalothorax, scarcely distinguishable only as a shallow cuticular furrow of the carapace.

2-2. The number of male genital cones.

The number of male genital cones had been adopted as one of the defining characters of suborders "Monokonophora" (name derived from a single cone) and "Dikonophora" (from paired cones) until Sieg (1980) discarded these characters.

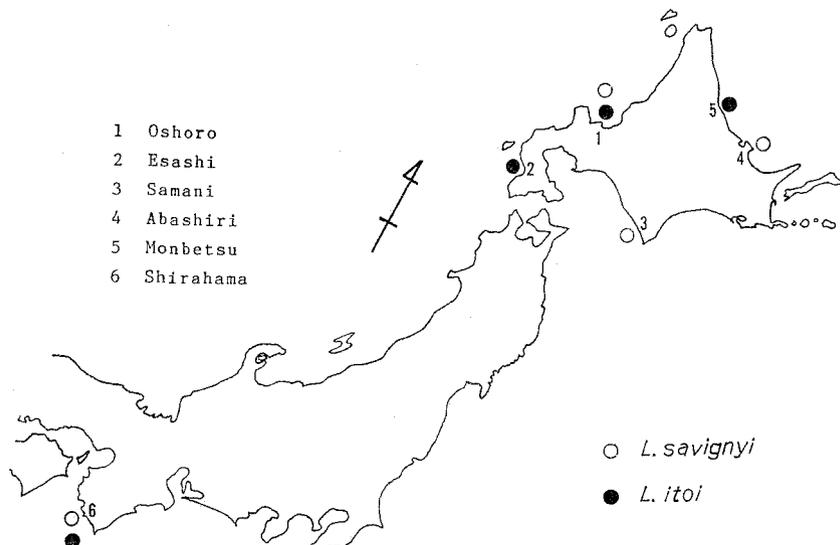


Fig. 17. Known localities of both *Leptochelia itoi* n. sp. and *L. savignyi* (Krøyer) in Japan. (Record of *L. savignyi* at Shirahama was cited from Shiino, 1950).

He cited Malzahn (1965) and showed that a fossil "monokonophoran" tanaid *Ophthalmapseudes rhenanus* (Malzahn, 1957) bears a pair of genital cones. He (op. cit.) further showed that two recent "dikonophoran" tanaids, *Hexapleomera robusta* (Moore, 1894) and *Pancoloides litoralis* (Vanhöffen, 1914) (Tanaidae) bear a single genital cone. Based on these facts, Sieg invalidated the number of the genital cones as a defining character of suborders. Incorporating other characters, he established a new classification system of the order Tanaidacea. The old suborder Monokonophora was reestablished as a suborder Apseudomorpha, and the old suborder Dikonophora was divided into two suborders, that is, Neotanaidomorpha and Tanaidomorpha.

The genital cone of *L. itoi* and *L. savignyi* (both belonging to old Dikonophora) is composed of only a single cone (Fig. 16-B). It is very inconspicuous, recognizable only as a very low hump of sternite. These are the first report of the single genital cone in the superfamily Paratanaoidea, and support Sieg's statement (1980) that the possession of the paired genital cones cannot be regarded as synapomorphy of Dikonophora.

Interestingly, *L. longimana* Shiino, 1963 ("Leptochelia-Gruppe 1" of Lang, 1973) has a pair of very conspicuous genital cones clearly separate from each other (Shiino, 1963). This means that both alternative character states coexist even within a single genus. Exemplified by *L. itoi*, *L. savignyi*, *Hexapleomera robusta* and *Pancoloides litoralis*, transformation from the paired cones to the single cone may have occurred several time within Tanaidomorpha. These facts support Sieg's invalidation of the male genital cones as defining character of suborders.

Summary

1. *Leptochelia itoi* n. sp. (Tanaidacea, Tanaidomorpha, Paratanaidae) was described from Japan, and *L. savignyi* (Krøyer, 1842) was redescribed based on North Pacific materials. The male of the new species diagnostically differs from *L. savignyi* by his shortened chela. The female of the new species closely resembles the female of *L. savignyi*, but it can be distinguished by the shape of the fixed-finger of cheliped and the terminal setal bundles of pereopods.

2. Synonymy of *L. savignyi* was discussed. It was supposed that so overestimated polymorphism of *L. savignyi* might hides some cryptic species.

3. The uniaarticulate palp of male maxilliped was so far regarded as a generic diagnostic character of *Leptochelia*. SEM observations, however, revealed that the male maxillipeds of *L. itoi* and *L. savignyi* are not articulated at all. It seems appropriate to exclude the condition of the male maxillipedal palp from the diagnosis of *Leptochelia*.

4. The male genital cones of *L. itoi* and *L. savignyi* are composed of a single protuberance. This is the first record of the single genital cone in the superfamily Paratanaoidea.

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References

- Büchel-Ramirez, L.F. 1965. Untersuchungen über die Biologie von *Heterotanaeis oerstedii* (Krøyer). Z. Morph. Ökol. Tiere, 55: 714-782.
- Czerniawski, V. 1868. Materialia ad zoographiam ponticam. Trudy Congr. Natur. Rossic Petropol (Zool.), 1: 19-136 (In Russian, not seen).
- Harger, O. 1879. Notes on New England Isopoda. Proc. U.S. Nat. Mus., 79: 157-165.
- Highsmith, R.C. 1983. Sex reversal and fighting behavior: coevolved phenomena in a tanaid crustaceans. Ecology, 64: 719-726.
- Holdich, D.M. & J.A. Jones. 1983. British tanaids. Synopses of the British Fauna, 27, 95 pp. Cambridge Univ. Press.
- Krøyer, H. 1842. Nye arter af slagten *Tanaeis*. Naturhist. Tids., 6: 167-188 (not seen).
- Lang, K. 1968. Deep-sea Tanaidacea. Galathea Rep., 9: 23-209.
- . 1973. Taxonomische und phylogenetische Untersuchungen über die Tanaidaceen (Crustacea). 8. Die Gattungen *Leptochelia* Dana, *Paratanaeis* Dana, *Heterotanaeis* G.O. Sars und *Nototanaeis* Richardson. Dazu einige Bemerkungen über die Monokonophora und ein Nachtrag. Zool. Scr., 2: 197-229.
- Lauterbach, K.E. 1970. Der Cephalothorax von *Tanaeis cavolinii* Milne-Edwards ein Beitrag zur vergleichenden Anatomie und Phylogenie der Tanaidacea. Zool. Jahrb. (Anat.), 87: 94-104 (not seen).
- Malzahn, E. 1965. Eine neue fossile Scherenassel (*Ophthalmapseudes friedericianus* nov. spec.) aus dem Norddeutschen Dogger. Ann. Naturh. Mus. Wien, 68: 223-235 (not seen).
- Müller, F. 1864. Für Darwin. 91 pp. W. Engelmann, Leipzig (not seen).
- Sars, G.O. 1883. Oversigt over Norges Crustaceer med Forelobige Bemaerkninger over de nye eller mindre bekjendte arter. I. Podophthalmata-Cumacea-Isopoda-Amphipoda. Forh. Vidensk. Christiania, 1882, 18: 1-124.
- . 1886. Nye bidrag til kundskaben om middelhavets invertebratfauna. III. Middelhavets Saxipoder (Isopoda Chelifera). Arch. Math. Naturv., 11: 263-368.
- Shiino, S.M. 1950. Notes on three species of Tanaidace from Japanese coast. Misc. Rep. Res. Inst. Nat. Resour., 19-21: 32-38 (In Japanese).
- . 1963. Tanaidacea collected by Naga Expedition in the Bay of Nha-Trang, South Vietnam. Rep. Fac. Fish., Pref. Univ. Mie, 4: 437-507.
- Sieg, J. 1980. Sind die Dikonophora eine polyphyletische Gruppe? Zool. Anz., 205: 401-416.
- . 1982. Über ein "connecting link" in der Phylogenie der Tanaidomorpha (Tanaidacea). Crustaceana, 43: 65-77.
- . 1983. Tanaidacea. In: H.E. Gruner & L.B. Holthius ed., Crustaceorum Catalogus, Pars 6, 552 pp.
- Smith, G. 1906. High and low dimorphism. Mitt. Zool. Stat. Neapel, 17: 312-340.
- Stebbing, T.R.R. 1896. On the isopod genus *Leptochelia*. Ann. Mag. Nat. Hist., Ser. 6, 17: 157-160.