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Studies on the Recent Marine Ostracoda from Hokkaido, I

By

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(With 12 Text-figures, 1 Plate and 1 Table)

Recent outcomes from bio-ecological studies of the marine benthos have clearly revealed that micrometazoans such as nematodes, harpacticoid copepods, ostracods, turbellarians, etc. usualy play certain important roles in various types of benthic community. Among these animal groups in Japan, rather little attention has been payed to the ostracods despite of their ecological importance. This condition is chiefly caused by the insufficient taxonomic work on recent marine Ostracoda, especially on plant-dwelling forms from Japan. Therefore it seems to be natural that the information of their biological aspects, life cycle, breeding season, seasonal change of abundance, habitat preference, etc. is very poorly known at species level for Japanese forms, while microdistributional studies have been done by Ishizaki (1968, 1969, 1971).

Many of the so far reported living ostracods from Japan have been given no statments of so-called soft parts, appendages. In order to get a more natural classification it seems rightful that we have to give more attention to the soft parts as well as the calcareous parts.

In recent years I have surveyed the ostracods in various habitats, sandy and muddy bottoms, sea-weed regions, etc., along the coasts of Hokkaido. During the survey I have collected a number of species of many different genera, most of which are previously unrecorded from Japan, further, some of which are probably new to science.

In the present paper, as the first report of serial taxonomic works on ostracods from Hokkaido, four new species of the genus *Paradoxostoma* Fischer 1855 are described from Oshoro, a small inlet on the west coast of Hokkaido. Most of the hitherto known members within the genus are of typical epiphytic form, and in Japan seven species have been already reported by Kajiyama (1913) from sea-weed region in Misaki, Kanagawa Prefecture. Being alike to his species, all the species

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described in the present paper were also collected from sea-weed region, mainly of *Sargassum*.

Specimens were collected by means of weed-washing, used a plankton net of mesh number NXX 13 in the Japanese standard and preserved in 70 per cent ethyl alcohol or 5 per cent formaline-seawater solution. All the type specimens were dissected and mounted in Hoyer's solution (appendages) or glycelin (carapaces). They are deposited in the Zoological Institute, Faculty of Science, Hokkaido University.

Before going further I express my sincere thanks to Professor Mayumi Yamada of the Hokkaido University for his guidance and reading the manuscript. Cordial thanks are also expressed to Dr. T. Itô, Zoological Institute, Hokkaido University and Mr. I. Okubo, Biological Laboratory, Okayama Shujitsu Junior College, who gave me much important information and kind encouragment for my study. I am also indebted to Mr. K. Shinta, Oshoro Marine Biological station, Hokkaido University, who helped me for my field work.

Paradoxostoma pedale n. sp.

(Figs. 1～3; Plate IV–1)

Male carapace (Fig. 1–1,2,3,4) round, oval in lateral view; greatest height of carapace in posterior third and about half the length; dorsal margin well arched behind and slowly sloping anteriorly; ventral margin flattened in anteromedian part, evenly curving into posterior margin; anterior extremity narrowly produced, posterior one much broader and rounded smoothly meeting both dorsal and ventral margins; carapace oblong oval in outline in dorsal view, with greatest width in posterior third and longer than two-fifths the length; both extremities obtuse. Hinge lophodont. Inner lamella wide. Marginal zone narrow. Radial pore canals sparse. Surface smooth, polished, with a few scattered hairs. Adductor muscle scars located slightly anterior to center, four scars in a vertical row. A single eye present. *Female carapace* (Fig. 1–5,6) a little smaller than male but of almost the same outline as that of male.

First antenna (Fig. 2–1) six-segmented, slender; second and fourth segment subequal in length, both slightly shorter than first one; third segment slightly shorter than second one, with fine hairs both near proximal edge of anterior margin and along proximal half of posterior margin; a seta on anterior distal margin of third segment shorter than half the length of third segment; fourth segment with one posterodistal seta and two anterodistal setae, the former and one of the latter subequal to each other and longer than fifth segment, the other about 1.5 times as long as fourth segment; fifth segment one-third the length of fourth segment, with three setae of subequal lengths, one of which arises from posterodistal margin and others from anterodistal margin, each being about three times as long as sixth segment. *Second antenna* (Fig. 2–2) five-segmented; first segment broader and longer than others, slightly tapering distally; second segment half the length of first one, with a ciliated seta on posterior distal margin being slightly shorter than third segment, and with fine hairs on distal half of anterior margin; third

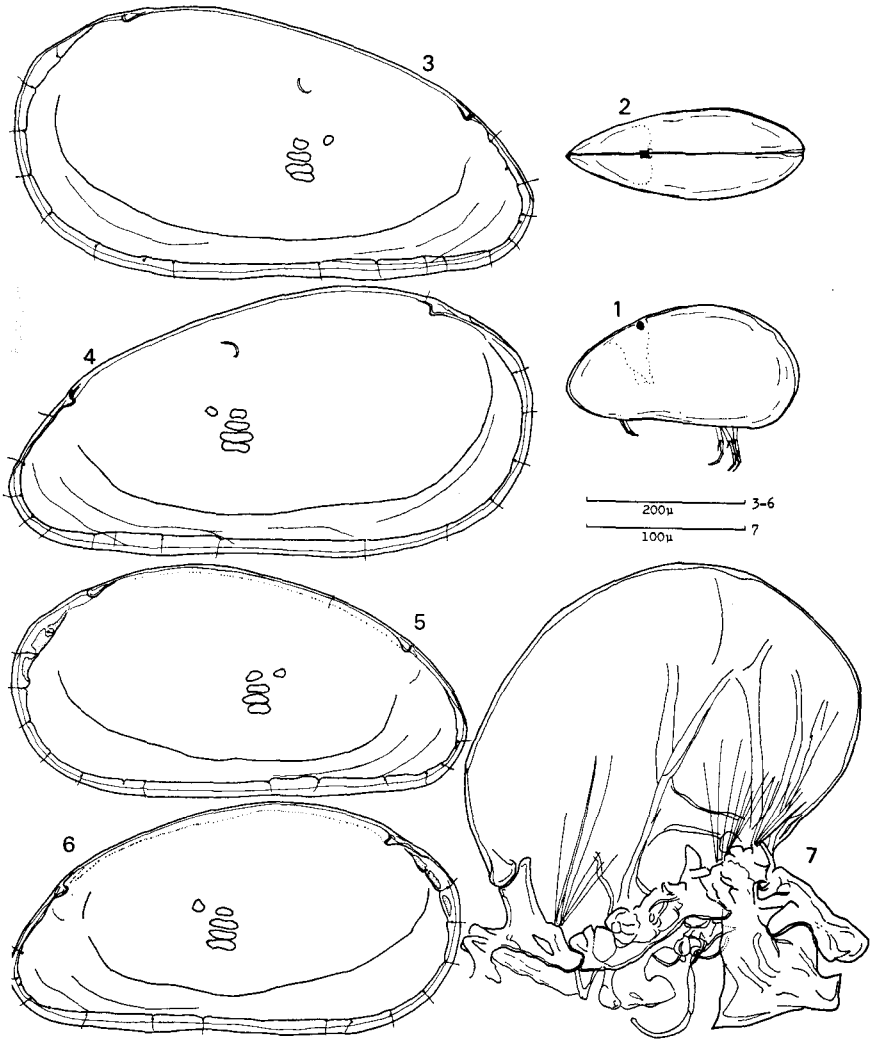

Fig. 1. *Paradoxostoma pedale* n. sp. Male. 1. lateral view; 2. dorsal view; 3. left valve; 4. right valve. Female. 5. left valve; 6. right valve. 7. copulatory appendage.

segment more than half the length of first one, with a ciliated seta on posterior distal margin being slightly shorter than fourth segment, and with fine hairs on proximal half of anterior margin; setiferous ledge on anterior margin of fourth segment more than one-third the distance from proximal edge, bearing a fine seta with the same length as fifth segment; a seta on posterior distal margin of fourth

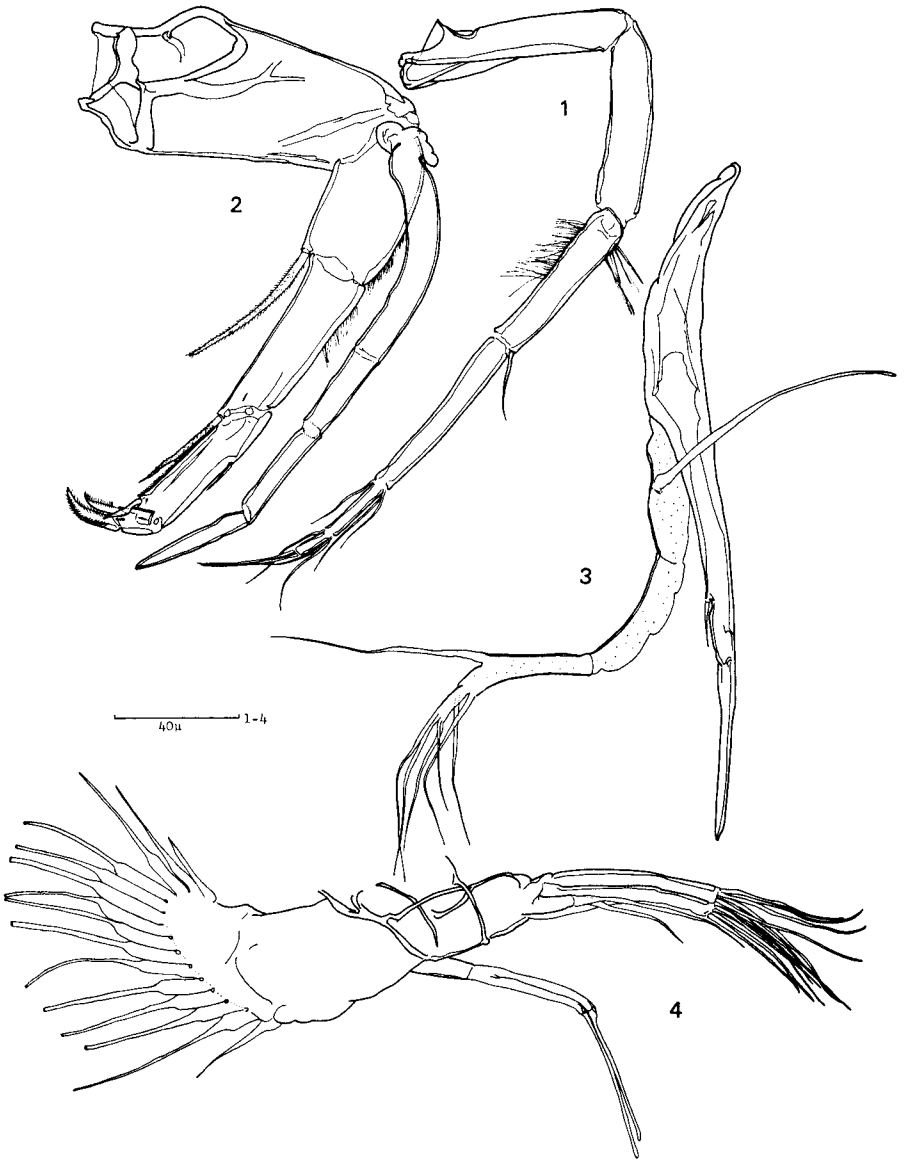

Fig. 2. *Paradoxostoma pedale* n. sp. Male. 1. first antenna; 2. second antenna; 3. mandible; 4. maxilla.

segment equal to the length of fifth segment, swelling in middle and tapering distally; distal two-thirds the length of posterior margin of fourth segment ciliated; fifth segment small, with two claws of different length, posterior claw longer than fifth segment and ciliated on posterior margin, anterior one more than twice as long as fifth segment, stout, ciliated on posterior margin. Flagellum articulated at three places, extending to the distal end of endopodite segment; distal three segments gradually increasing in length apically; first segment longer than second and third segments combined.

Mandible (Fig. 2–3). Body of mandible stiliform, terminating in a sharp point; broadest point in proximal third; setiferous ledge on outer margin of the stilet about one-third the distance from distal end, bearing a fine seta. Palp three-segmented, each segment subequal in length; third segment with seven setae, one seta arising from two-fifths the distance from distal end, next two from one-fifth the distance from the distal end and other four from distal edge. Branchial plate rudiment, with a long seta about as long as first and second segment of palp combined. *Maxilla* (Fig. 2–4) with three masticatory lobes; the innermost one small, with two setae having the length ratio of 3:2, the second and third subequal to the length of fore-mentioned longer seta, each with long setae, five of which arising from second lobe and other six from third lobe. Palp wanting. Vibratory plate with two deflexed setae of an equal length at the base. *Oral corn* (Fig. 3–4) like in a usual *Paradoxostoma*, with well-developed sucking disk, and with hairs chiefly on anterior middle part of hypostome.

Legs (Fig. 3–1, 2, 3) four-segmented, rapidly increasing in length posteriorly. *First leg* (Fig. 3–1); first segment about twice as long as second one; setiferous ledge on anterior margin of first segment, in the middle bearing a long seta with one-third the length of first segment; distal seta of first segment very robust, slightly shorter than second segment, ciliated posterior margin; anterior margin of second and third segment ciliated along the entire length; distal seta of second segment subequal to the length of third segment, ciliated on posterior margin; fourth segment one-third the length of first segment, ciliated along distal half of the anterior margin; apical claw half the length of fourth segment, curving at the tip, ciliated on anterior margin. *Second leg* (Fig. 3–2): first segment equal to the length of second and third segment combined; setiferous ledge on anterior margin of first segment posterior to the middle, bearing a seta; distal seta of first segment four-fifths the length of fore-mentioned seta; second segment equal to the length of third and fourth segment combined, ciliated on the whole anterior margin; length of distal seta of second segment equal to the distal seta of first segment; third segment less than half the length of second one ciliated on distal half of anterior margin; fourth segment about 1.5 times as long as third one, ciliated on the whole anterior margin; apical claw two-fifths the length of fourth segment, curving at the tip, ciliated on anterior margin. *Third leg* (Fig. 3–3) long, strong; first segment longer than second one, with a small distal seta; distal ciliated seta of second segment extending to the distal end of third segment accompanied with about

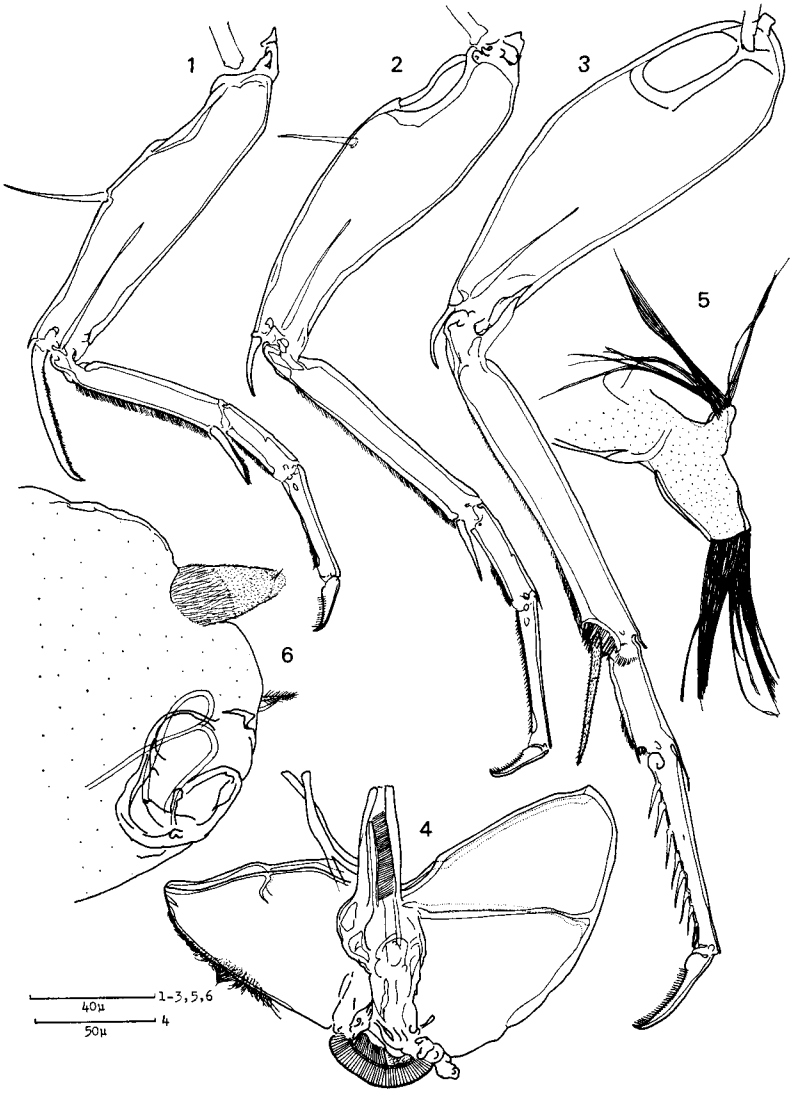

Fig. 3. *Paradoxostoma pedale* n. sp. Male. 1. leg 1; 2. leg 2; 3. leg 3; 4. oral corn; 5. brush-shaped organ. Female. 6. caudal lamella.

twenty spinules basally; third segment one-fourth the length of second one, ciliated along distal half of anterior margin; anterior margin of fourth segment forms eight spinules; apical claw half the length of fourth segment, curving at the tip ciliated on anterior margin.

Brush-shaped organ (Fig. 3–5) like in a usual *Paradoxostoma*, with two processes at both sides; in lateral view larger one slightly tapering distally, greatest width about two-thirds the length, bearing long hairs on distal edge which are 1.5 times as long as the base, smaller one three-eighths the length of larger one, bearing long hairs at the tip with about the same length as fore-mentioned hairs.

Caudal lamella (Fig. 3–6) with a ciliated bud-like furca and a pair of two small setae, one plumose, the other shorter and bare.

Copulatory appendage (Fig. 1–7; Plate IV–1). Basal portion large oval, with two diverging processes; anterior process smaller, narrow and obtuse, posterior one larger and lamelliform with irregularly curved outline.

Measurements (in mn)

	length	height	width
male	0.60–0.69	0.31–0.33	0.11–0.14
female	0.56–0.58	0.29–0.30	0.10–0.12

Remarks. This species is characterized by the longer size of the third leg with a row of eight spinules on the anterior margin of the fourth segment and with the grouped spinules around the distal seta of the second segment and by the shape of copulatory appendage. *P. pedale* n. sp. resembles *P. variabile* (Baird) 1850 cited by Sars (1922–1928) in the general appearance of the outline of carapace, but in detail it differs from the latter in the shape of both extremities of carapace, namely in *P. variabile* the anterior extremity is much narrower than in *P. pedale* n. sp. and the posterior one has a caudal process but in *P. pedale* n. sp. it is absent and the posterior margin joints both dorsal and ventral margin almost smoothly. And the basal portion of the copulatory appendage in the present new species is also similar to that in *P. variabile*, but two diverging processes are different between two. This new species is common in Oshoro Bay, chiefly from August to December.

Specimens examined. Syntypes; one male and one female (30-IX-'74 S. Hiruta leg.), and three males and three females (16-VIII-'74 S. Hiruta leg.).

***Paradoxostoma spineum* n. sp.**

(Figs. 4~6; Plate IV –2)

Female carapace (Fig. 4–1,2,5,6) oval in lateral view; greatest height slightly posterior to middle and less than half the length; dorsal margin evenly arched, flattening posteriorly into a straight line and meeting posterior margin in a slight angle, slowly sloping anteriorly and joining anterior margin smoothly; ventral margin somewhat sinuated in anterior half, evenly curving into posterior margin; anterior extremity narrowly produced, posterior one broader; carapace oblong oval in dorsal view, with greatest width in posterior third and equal to two-fifths the length, both extremities obtusely pointed. Hinge lophodont. Inner lamella wide. Marginal zone narrow. Radial pore canals sparse. Surface

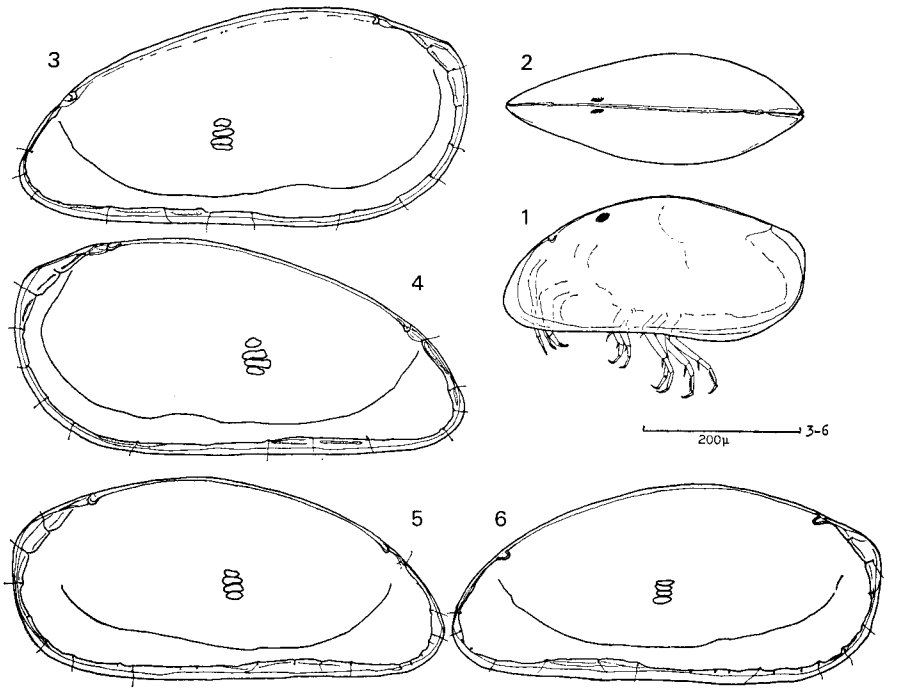

Fig. 4. *Paradoxostoma spineum* n. sp. Female. 1. lateral view; 2. dorsal view. Male. 3. right valve; 4. left valve. Female. 5. left valve; 6. right valve.

smooth, polished, with a few scattered haris. Adductor muscle scars located slightly anterior to center, four scars in a vertical row. A single eye present. *Male carapace* (Fig. 4–3,4) slightly larger than female; posterior dorsal margin slightly more arched than that of female.

First antenna (Fig. 5–1) six-segmented, slender; first and second segment subequal in length, both slightly longer than third one; both proximal third of anterior margin and proximal half of posterior margin of third segment with fine hairs; a seta of anterior distal margin of third segment three-fifths the length of third segment; fourth segment slightly shorter than third one, with one posterior distal seta and two anterior distal setae, which are subequal in length and extending slightly beyond the distal end of sixth segment; fifth segment two-fifths the length of third segment, with one posterior distal seta and two anterior distal setae, which are subequal in length and less than twice as long as sixth segment; sixth segment more than half the length of fifth one, with four distal setae of an equal length about 2.5 times as long as sixth segment. *Second antenna* (Fig. 5–2) five-segmented; first segment broad, twice as long as second one; second segment with a ciliated

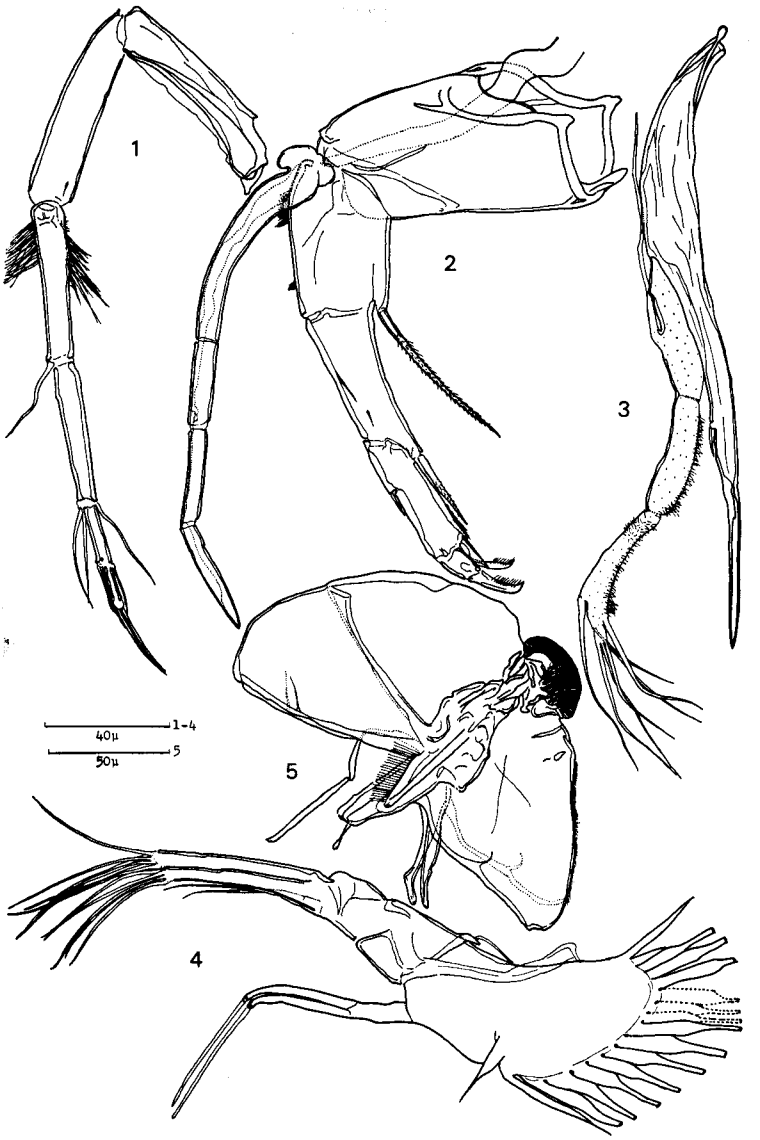

Fig. 5. *Paradoxostoma spineum* n. sp. Female. 1. first antenna; 2. second antenna. Male. 3. mandible. Female. 4. maxilla; 5. oral corn.

seta on posterior distal margin extending beyond distal end of third segment, and with fine hairs along proximal third and near distal edge of anterior margin; third segment subequal to the length of second one, with a ciliated seta on posterior distal margin of fourth segment; fourth segment slightly shorter than third one, with fine hairs along distal half of posterior margin; distal seta on posterior margin of fourth segment slightly longer than fifth segment, swelling in middle and tapering distally; setiferous ledge on anterior margin of fourth segment two-fifths the distance from proximal margin, bearing a fine seta; fifth segment small, with two claws of different size, posterior one equal to the length of distal seta of fourth segment, anterior one longer, stronger, more than twice as long as fifth segment, both ciliated on posterior margin. Flagellum articulated at three places, subequal to the length of endopodite; distal three segments gradually increasing in length; first segment longer than the length of second and third segment combined.

Mandible (Fig. 5–3) almost the same as in the preceding species; one of the setae of third segment of palp arising from three-tenths the distance from distal end and next two from one-sixth the distance from distal end and four setae from distal edge. *Maxilla* (Fig. 5–4) with three masticatory lobes, the innermost one small with two setae, one slightly longer than the other, the second and third subequal and slightly shorter than the fore-mentioned longer seta, each with the same setal formula as that of preceding species. Palp wanting. Vibratory plate with two deflexed setae of an equal length at the base. *Oral corn* (Fig. 5–5) like in a usual *Paradoxostoma*, with well-developed sucking disk. Hypostome with hairs on anterior margin.

Legs (Fig. 6–1, 2, 3) four-segmented, each shape similar to that of preceding species respectively. *First leg* (Fig. 6–1): first segment more than twice as long as second one; setiferous ledge on anterior margin of first segment slightly distal to the middle, bearing a seta with the length of fourth segment; anterior distal seta of first segment robust, shorter than second segment, ciliated on posterior margin; anterior margin of second segment ciliated; distal seta of second segment more than half the length of third segment; this seta is different between male and female, male seta ciliated on posterior margin, much longer, stronger than female one; third segment three-fifths the length of fourth one, ciliated along distal half of the anterior margin; anterior distal third of fourth segment ciliated; apical claw about half the length of fourth segment, ciliated on anterior margin. *Second leg* (Fig. 6–2): first segment less than twice as long as second one; setiferous ledge on anterior margin proximal to the middle, bearing a seta with one-fourth the length of first segment; distal seta of first segment two-thirds the length of fore-mentioned seta; anterior margin of second segment ciliated; distal seta of second segment two-fifths the length of second one, ciliated along distal half of anterior margin; fourth segment half the length of second one, ciliated along distal two-thirds of anterior margin; apical claw about half the length of fourth segment, ciliated on anterior margin. *Third leg* (Fig. 6–3): second segment four-fifths the length of first one;

distal seta of first segment one-fifth the length of second segment; distal seta of second segment equal to the length of third segment accompanied with some spinules basally which are shorter than those of preceding species; anterior margin of second and third segment ciliated; fourth segment half the length of second one with a row of eight spinules on anterior margin; apical claw less than three-fifths the length of fourth segment, ciliated on anterior margin.

Brush-shaped organ (Fig. 6–5) similar to that of the preceding species but smaller processes relatively short.

Caudal lamella (Fig. 6–4) with a row of three spinules at both sides and with furca which has hairs at the tip and upper basal portion.

Copulatory appendage (Fig. 6–6; Plate IV–2). Basal portion large, oval in outline, with two diverging processes, the anterior one smaller, narrow and obtuse, the posterior one larger and lamelliform, terminating in front in a round edge, behind in an acute corner.

Measurements (in mm)

	length	height	width
male	0.58–0.59	0.28–0.29	0.11
female	0.51–0.55	0.25–0.26	0.10

Remarks. This new species is similar to preceding species in almost appendages but shows some differences between them in the shape of carapace, copulatory appendage and cardal lamella. *P. spineum* n. sp. also resembles *P. variabile* but the posterior part of carapace is narrower than the latter in shape. The basal porition of the copulatory appendage is remarkably similar to that of *P. variabile* but two diverging processes are different between them, especially in posterior process of which in *P. spineum* n. sp., much broader than in *P. variabile.* So, *P. spineum* n. sp. is chiefly characterized by copulatory appendage.

On the other hand the present species is clearly discernible from *P. pilosum* Kajiyama 1913 from Misaki in carapace size and shape of copulatory appendage and of posterior margin of carapace. The latter species reported by Ishizaki (1971) from Aomori, however, is fairly similar to the present species in the outline of carapace. Since important taxonomic characters such as the copulation organ in male and others are entirely unknown for *P. pilosum* sensu Ishizaki, I am unable now to realize well the species reported by Ishizaki. And it is here noted that the species reported by Ishizaki is intermediate in the length and further its locality is between *P. pilosum* and *P. spineum* n. sp.

Specimens examined. Syntypes; three males and three females (16-VIII-'74 S. Hruita leg.).

***Paradoxostoma oshoroense* n. sp.**

(Fig. 7, 8; Plate IV–3)

Female carapace (Fig. 7–3,4) rather elongate in lateral view, greatest height slightly posterior to the middle and about two-fifths the length; dorsal margin well

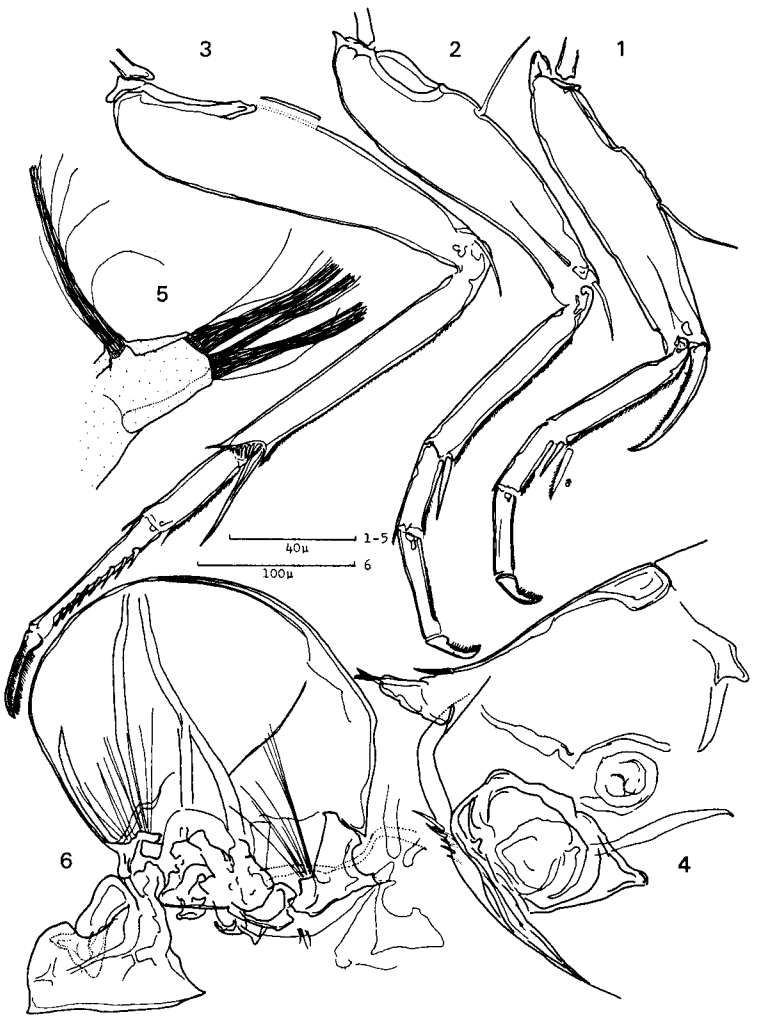

Fig. 6. *Paradoxostoma spineum* n. sp. Female. 1. leg 1; 2. leg 2; 3. leg 3; 4. caudal lamella. Male. 5. brush-shaped organ; 6. copulatory appendage.

arched behind and slowly sloping anteriorly; ventral margin slightly sinuated anterior to the middle and evenly curving into posterior margin; anterior extremity narrowly produced, posterior one terminating in a well-marked obtuse corner; carapace narrow oblong in outline in dorsal view, with greatest width anterior to the middle and subequal to one-fourth the length; side-edges somewhat irregularly curved, posterior extemity more contracted than the anterior one. Carapace thin

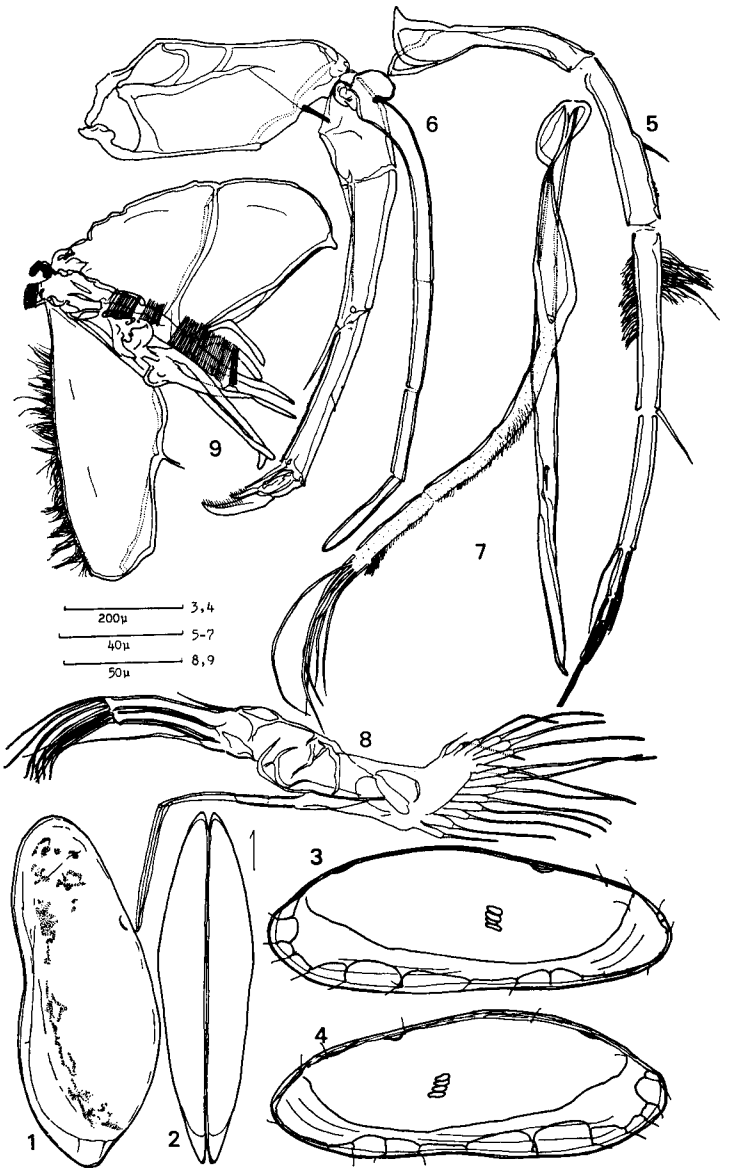

Fig. 7. *Paradoxostoma oshoroense* n. sp. Male. 1. lateral view; 2. dorsal view. Female. 3. left valve; 4. right valve; 5. first antenna; 6. second antenna; 7. mandible; 8. maxilla; 9. oral corn.

and pellucid and surface very smooth and polished. Inner lamella wide. Marginal zone in front narrow, middle except for the concave part and behind broad. Radial pore canals developing a distinctive pattern (as illustrated). Adductor muscle scars located slightly anterior to center, four scars in a vertical row. A single eye present. Hingement not distinct. *Male carapace* (Fig. 7–1,2) slightly smaller than female one but of almost the same outline as the latter.

First antenna (Fig. 7–5) sixth-segmented, slender; first and third segment subequal and slightly longer than second one; distal half of second segment thicker than proximal half, with fine hairs on anterior margin; proximal third of anterior margin and proximal half of posterior margin of third segment with fine hairs; distal seta of third segment one-third the length of third segment; fourth segment three-fourths the length of third one, with one posterior distal seta and two anterior distal setae, which are subequal and extending beyond the distal end of sixth segment; fifth segment one-third the length of fourth one, with one posterior distal seta and two anterior distal setae, which are subequal in length and extending to half the length of distal seta of sixth segment; sixth segment about half the length of fifth segment, with four distal setae, which are four times as long as sixth segment. *Second antenna* (Fig. 7–6) five-segmented, more slender than that of preceding species; first segment less than three times as long as second one; distal seta of second segment shorter than third segment; third segment more than half the length of first one, with a distal seta about half the length of fourth segment; setiferous ledge on anterior margin distal to the middle, bearing a very small fine seta; posterior margin of fourth segment ciliated; distal seta of fourth segment extending beyond distal end of fifth segment; fifth segment small, with two claws, anterior claw stout and posterior one very small, less than half the length of anterior one, both ciliated on posterior margin. Flagellum four-segmented extending beyond distal end of fifth segment of endopodite; first segment more than the length of second and third segment combined; second and fourth segment subequal in length and longer than third one.

Mandible (Fig. 7–7). Body of mandible stiliform, much slender than that of preceding species; setiferous ledge on outer margin of the stilet less than two-fifths the distance from distal end, bearing small fine seta. Palp indistinctly three-segmented, segments subsequal in length; inner margin of the palp with fine hairs; third segment with six setae, which extend beyond distal end of stilet. Branchial plate absent. *Maxilla* (Fig. 7–8) with three masticatory lobes, the innermost one small with two setae, one slightly longer than half the length of the other, the second and third subequal in length and extending almost to the end of fore-mentioned shorter seta and both with the same setal formula as that of preceding species. Palp forming a seta with half the length of outer masticatory lobe. Vibratory plate with two deflexed setae of an equal length at the base. *Oral corn* (Fig. 7–9): sucking disk small; hypostome elongate with hairs on whole anterior margin.

First leg (Fig. 8–1). First segment subequal to the length of other segments

and apical claw combined; setiferous ledge on anterior margin of first segment in middle, bearing a seta with the length of second segment; distal seta of first segment stout, strong, about half the length of first segment and curving at the tip; distal three segments having length ratio of 8:5:6; distal seta of second segment half the length of second segment, ciliated on posterior margin; anterior margin of distal three segments ciliated along entire length; apical claw half the length of fourth segment, curving at the tip and ciliated on anterior margin. *Second leg* (Fig. 8–2). First segment subequal to the length of second and third segment combined; distal three segments having length ratio of 7:4:4; setiferous ledge on anterior margin of first segment proximal to the middle, bearing a seta; distal seta of first segment half the length of second segment; distal seta of second segment more than three-fifths the length of third segment, ciliated along posterior margin; anterior margin of distal three segments ciliated along the entire length; apical claw half the length of fourth segment, curving at the tip and ciliated on anterior margin. *Third leg* (Fig. 8–3). First segment slightly longer than second one; distal seta of first segment slender and ciliated; second segment twice as long as fourth one; third segment more than two-fifths the length of second one; anterior margin of distal three segments ciliated along the entire length; distal seta of second segment half the length of third segment, ciliated on posterior margin; setiferous ledge on posterior margin of fourth segment distal to the middle and with a small fine seta; apical claw two-thirds the length of third segment, curving at the tip and ciliated on anterior margin.

Brush-shaped organ (Fig. 8–5). Smaller process comparatively longer than that of preceding two species, and two-thirds the length of larger one; hairs of larger branch about twice as long as their base and about two-thirds the length of those of smaller one.

Caudal lamella (Fig. 8–4) with furca diverging distally and having hairs at both tips; with two setae, outer one bare, inner one hairy, on both sides of postero-ventral portion of body.

Capulatory appendage (Fig. 8–6; Plate IV–3). Basal portion subrectangular with two diverging processes, anterior one narrow and spiniform, curving ventrally, posterior one larger and lamelliform, triangular, terminating behind in an acute corner; two setae on both sides of ventral portion, anterior one bare, posterior one hairy.

Measurements (in mm)

	length	height	width
male	0.63	0.23–0.24	0.08
female	0.65–0.66	0.25	0.08–0.09

Remarks. This new species resembles *P. ensiforme* Brady 1868 cited by Sars (1922–1928) in lateral view of carapace, but copulatory appendage is different between two in basal portion and its two diverging processes. The carapace and copulatory appendage in this new species are also useful for identification.

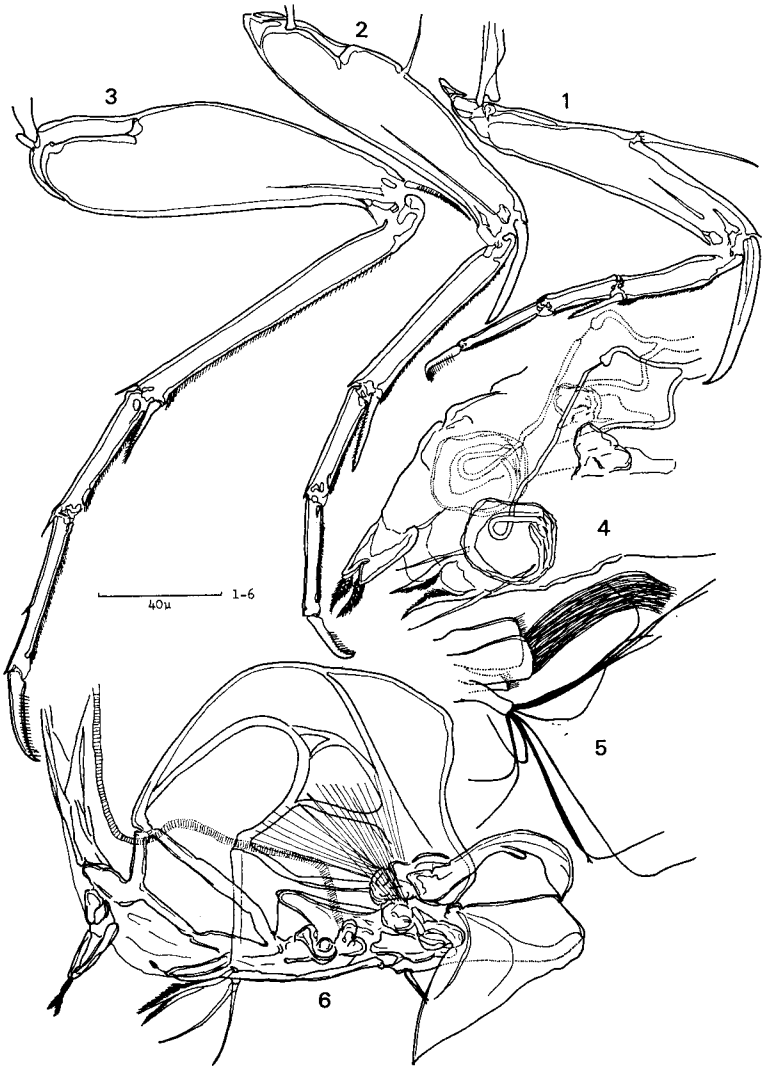

Fig. 8. *Paradoxostoma oshoroense* n. sp. Female. 1. leg 1; 2. leg 2; 3. leg 3; 4. caudal lamella. Male. 5. brush-shaped organ; 6. copulatory appendage.

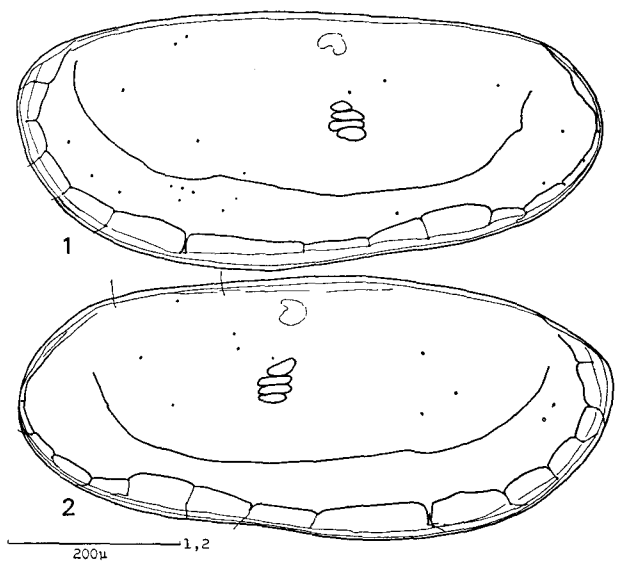

Fig. 9. *Paradoxostoma ezoense* n. sp. Male. 1. left valve; 2. right valve.

Specimens examined. Syntypes; three males and three females (20-XI-'74 S. Hiruta leg.).

Paradoxostoma ezoense n. sp.

(Figs. 9~12; Plate IV–4)

Male carapace (Fig. 9–1,2) elliptical in outline in lateral view, greatest height slightly posterior to the middle and a little less than half the length; dorsal margin very slightly arched, rounded anterior and joining anterior margin smoothly, slightly downcurved posteriorly and meeting posterior margin in a slight angle; ventral margin somewhat sinuated anterior to the middle and evenly curving into the posterior margin; anterior extremity rounded, posterior one much broader than anterior one; carapace oblong oval in dorsal view, with greatest width slightly anterior to the middle and about two-sevenths the length. Inner lamella wide. Marginal zone in front narrow, middle and behind broad. Radial pore canals sparse. Surface smooth, polished. Adductor muscle scars located slightly anterior to center, four scars in a vertical row. A single eye present. Coloration of the body forming a distinctive pattern, black patches covering anterior, middle and posterior parts (as illustrated in the carapace of female). *Female carapace* (Fig. 10–1,2) slightly larger than male but of almost the same outline and coloration as those of male.

First antenna (Fig. 11–1). First segment about 1.4 times as long as second one;

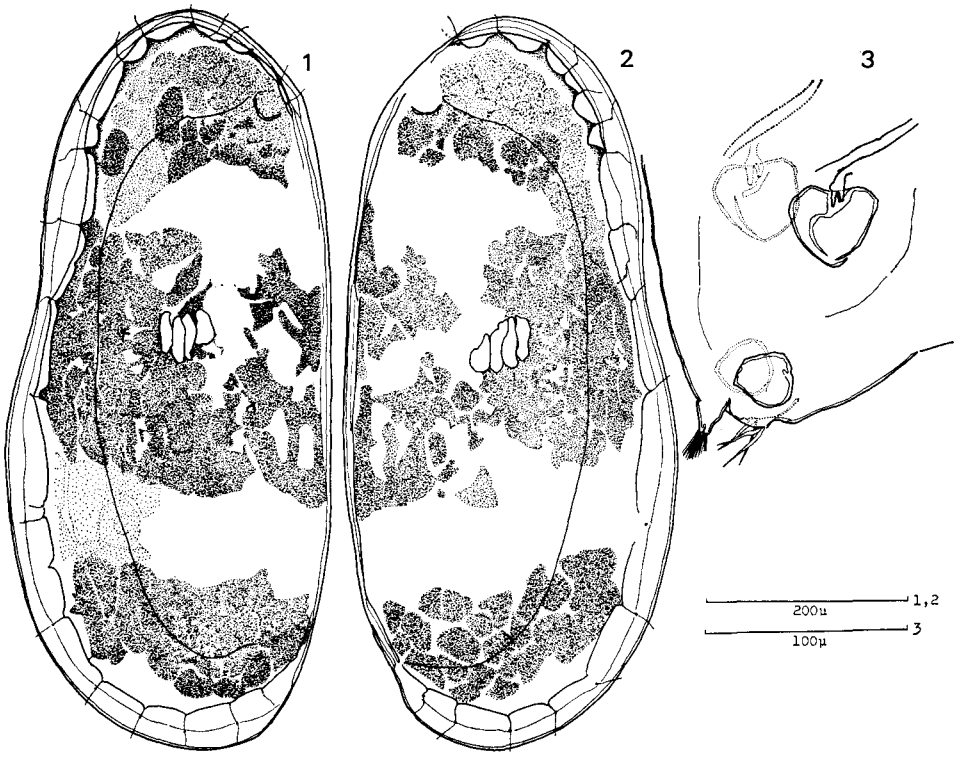

Fig. 10. *Paradoxostoma ezoense* n. sp. Female. 1. left valve; 2. right valve; 3. caudal lamella.

third segment five-sixths the length of second one and two-thirds the length of fourth one with hairs on the middle portion of posterior margin and with an anterior distal seta which is more than two-thirds the length of third segment; fourth segment with a posterior distal seta and two anterior distal setae, which are subequal in length and extending beyond distal end of sixth segment; fifth segment one-fifth the length of fourth one and 1.5 times as long as sixth one; fifth segment with a posterior distal seta and two anterior distal setae, which are subequal in length and extending to two-thirds the distance from proximal edge of setae of sixth segment; sixth segment with four distal setae of an equal length about 3.5 times as long as sixth segment. *Second antenna* (Fig. 11–2) five-segmented; first segment stout, more than twice as long as second one; second segment two-thirds the length of third one with a distal seta on posterior distal edge about two-thirds the length of third segment; middle part of anterior margin of third segment with hairs; distal seta of third segment less than half the length of anterior margin of fourth segment; fourth segment equal to the length of third one with setiferous ledge in

Fig. 11. *Paradoxostoma ezoense* n. sp. Male. 1. first antenna; 2. second antenna; 3. mandible; 4. maxilla; 5. brush-shaped organ.

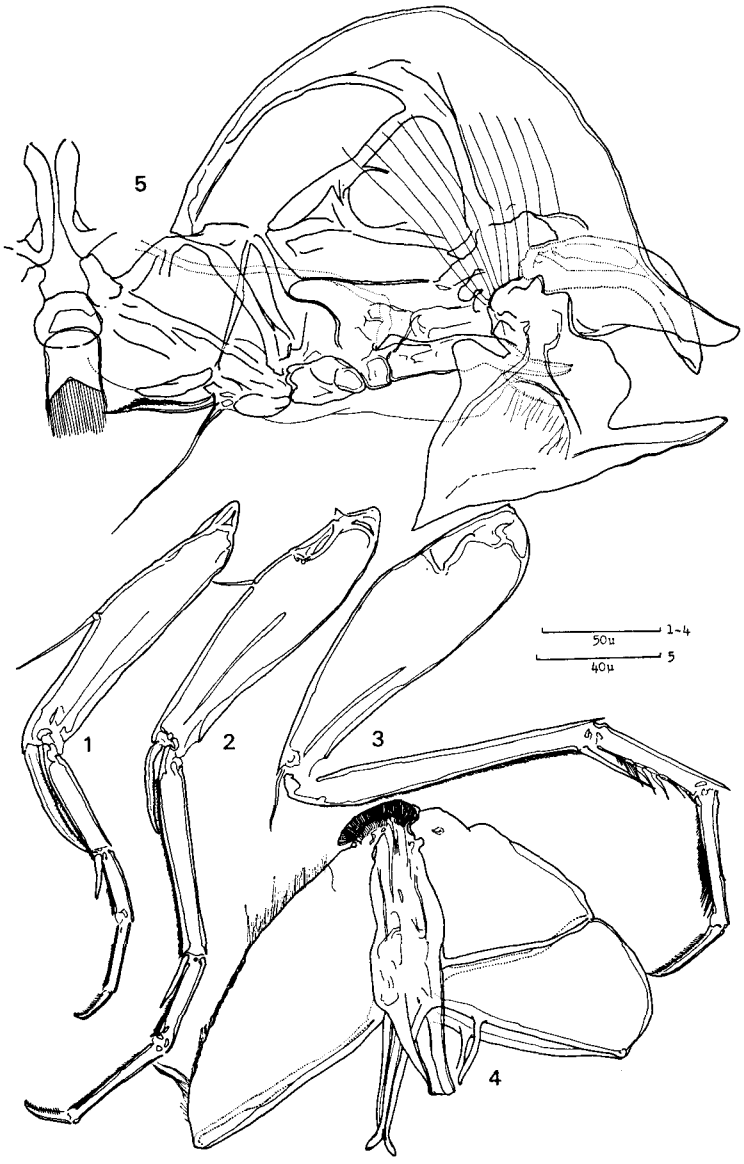

Fig. 12. *Paradoxostoma ezoense* n. sp. Male. 1. leg 1; 2. leg 2; 3. leg 3; 4. oral corn; 5. copulatory appendage.

the middle of anterior margin bearing a small fine seta, and with distal seta about 1.5 times as long as fifth segment; fifth segment small, one-sixth the length of fourth one with two apical claws, posterior one small, more than half the length of anterior one, each ciliated on posterior margin. Flagellum four-segmented, extending to distal end of apical claw of endopodite; first segment more than the length of second and third segment combined; distal three segments having length ratio of 9:6:8.

Mandible (Fig. 11–3) similar to that of preceding species. Palp indistinctly three-segmented, having length ratio of 9:6:8. *Maxilla* (Fig. 11–4) with three masticatory lobes, the innermost one small with two setae, one less than two-fifths the length of the other, the second and third ones extending to about three-fourths the distance from proximal end of the fore-mentioned longer seta, and both with the same setal formula as that of preceding species; palp forming a seta about one-fourth the length of third masticatory lobe. Vibratory plate with two deflexed setae of an equal length at the base. *Oral corn* (Fig. 12–4): hypostme elongate, with hairs on whole anterior margin.

First leg (Fig. 12–1). First segment subequal to the length of other segments and apical claw combined; setiferous ledge on anterior margin of first segment in the middle bearing a seta with three-fourths the length of second segment; distal seta of first segment stout, extending to distal end of second segment and ciliated along posterior margin; distal three segments having length ratio of 5:3:3; whole anterior margin of second and fourth segment and distal half of anterior margin of third segment ciliated; distal seta of second segment three-fifths the length of third segment; apical claw subequal to the length of distal seta of second segment, ciliated on anterior margin. *Second leg* (Fig. 12–2): first segment 1.5 times as long as second one; setiferous ledge on anterior margin of first segment three-sevenths the distance from proximal end, bearing a small seta; distal seta of first segment extending to three-sevenths the distance from proximal end of second segment; second segment twice as long as third one, ciliated along anterior margin and with a distal seta about four-sevenths the length of third segment; distal half of anterior margin of third segment ciliated; fourth segment slightly longer than third one ciliated along anterior margin; apical claw half the length of third segment, ciliated on anterior margin. *Third leg* (Fig. 12–3): first segment longer than second one, with a small distal seta; anterior margin of second segment ciliated along the entire length; distal seta of second segment subequal to the length of apical claw; third segment slightly shorter than fourth one, with five spinules distally and cilia proximally on anterior margin; cilia on anterior margin of fourth segment getting longer and stronger distally; setiferous ledge on posterior margin of fourth segment about one-third the distance from distal edge, bearing a small fine seta; apical claw curving at the tip and ciliated on anterior margin.

Brush-shaped organ (Fig. 11–5) similar to that of the preceding species; hairs on the larger branch about 1.5 times as long as their base, and about two-thirds the length of hairs on the smaller one.

Caudal lamella (Fig. 10–3) with furca having hairs at the tip, and with two setae below the furca on both sides.

Copulatory appendage (Fig. 12–5; Plate IV–4). Basal portion well arched in dorsal ridge, rounded triangular in outline, and protruded at the anterior ridge, with two diverging processes, anterior one narrow and spiniform curving ventrally, posterior one broad and lamelliform terminating in front in a narrow process and behind in an acute corner; two setae, one bare and the other hairy, on postero-ventral margin.

Measurements (in mm)

	length	height	width
male	0.65–0.69	0.30–0.31	0.09
female	0.66–0.73	0.33–0.34	0.10

Remarks. The coloration of the body and the ornamentation on the anterior margin of third and fourth segments of third leg as well as the copulatory appendage characterize this species. This new species resembles *P. rarum* Müller 1894 and *P. atrum* Müller 1894 in the general appearance of outline of carapace, and this new species and *P. atrum* are also remarkably alike in coloration. This new species, however, is clearly distinguishable from the two species in copulatory appendages.

Specimens examined. Syntypes; two males and one female (3-VII-'74 S. Hiruta leg.), one female (3-IX-'74 S. Hiruta leg.), and one male and one female (18-XII-'74 S. Hiruta leg.).

The species within the genus *Paradoxostoma* have been distinguished mainly by the characters of carapace and copulatory appendage (Penis). Four species reported in this paper are identifiable by these characters and they are separable into two groups (*P. pedale, P. spineum*; *P. oshoroense, P. ezoense*) in the difference in other appendages, mandible and maxilla (see Table 1). As clearly shown in the table, the two groups are different from each other in number of distal setae of mandibular palp, seta on branchial plate of mandibular palp and maxillary palp.

The mandibular palp of the so far reported species has two, three or four segments, and in the present new species the palp has three segments. Detailed information about the number of distal seta of mandible is very few (Smith 1952, McKenzie 1971), while it is known that the branchial plate of mandible has one seta or no seta. It is evident from the illustrations of mandible showed by workers that five setae (*P. romei*) were seen by McKenzie (1967) and (*P. variabile, P. pulchellum*) by Sars (1922–1928), and eight setae (*P. rostratum*) by Elofson (1940), etc.. And it is generally noted that maxillary palp is represented by a seta or is quite wanting. With regard to the masticatory lobes of maxilla, at least three different setal formulae have been recognized, i.e. 2·3·3 (McKenzie 1967), 2·4·4 (Klie 1942, Smith 1952) and 2·4·5 (Elofson 1940), though the four species described in this paper have a distinct formula 2·5·6. For further comparisons, more precise examination

Table 1. The distinguishing characters of four new species of *Paradoxostoma*, except for carapace and penis.

Paradoxostoma		*pedale*	*spineum*	*oshoroense*	*ezoense*
Setal formula for distal four segments of first antenna		anterior 1·2·2 / posterior 0·1·1 · 4			
Number of segments of flagellum		4	4	4	4
Mandibular palp	Number of segments	3	3	3	3
	Number of distal setae	7	7	6	6
	Seta on branchial plate	present		absent	
Maxilla	Setal formula for masticatory lobes	2·5·6			
	Palp	absent		present	
Setal formula for anteromedial, distal and posteromedial areas of first segment of leg 1,2,3		leg 1 1·1·0 leg 2 1·1·0 leg 3 0·1·0			

of such appendages is essential since these characteristics have been ignored for most of the species previously reported.

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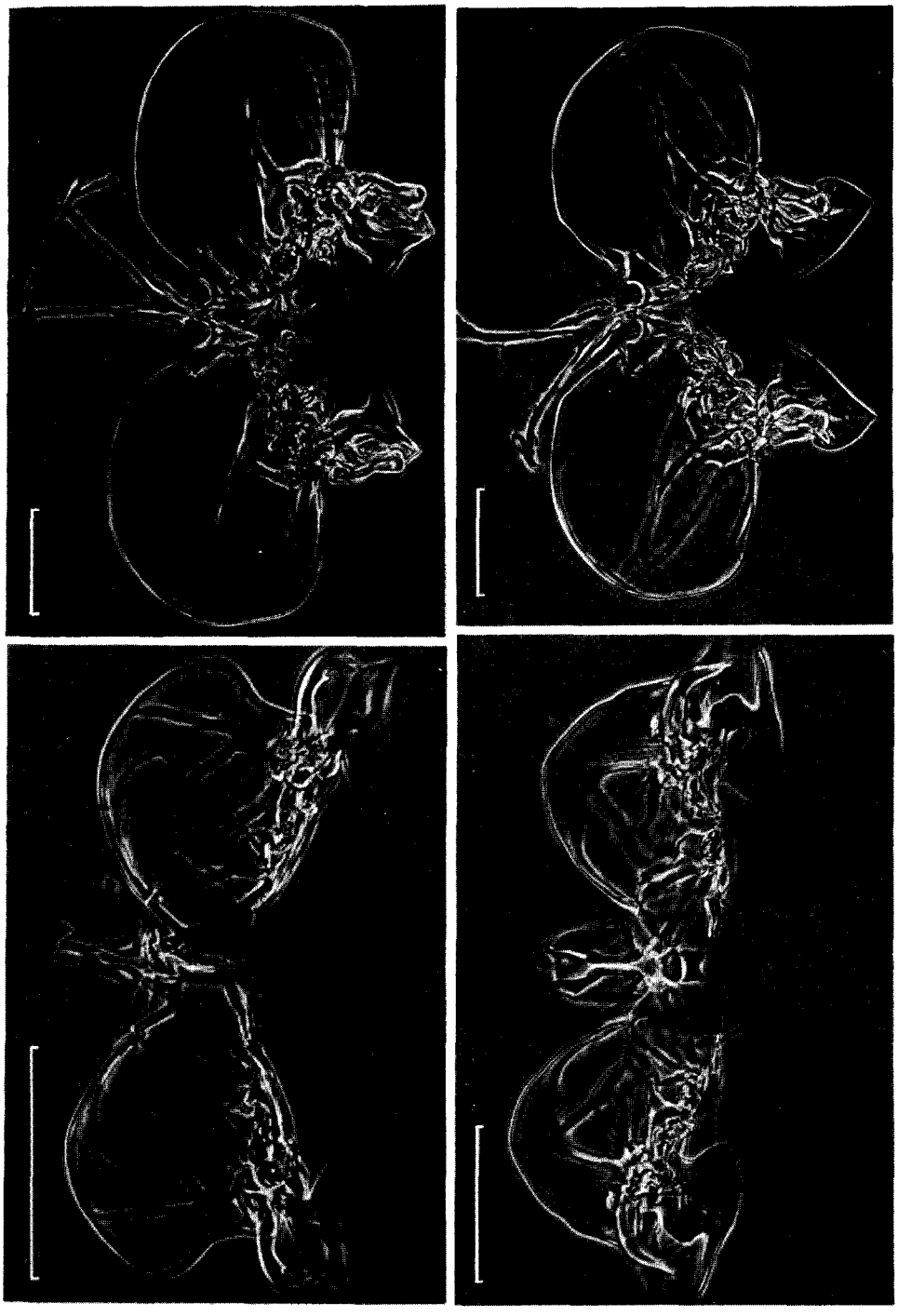
Explanation of Plate IV

Copulatory appendages

Fig. 1. *Paradoxostoma pedale* n. sp.
Fig. 2. *Paradoxostoma spineum* n. sp.
Fig. 3. *Paradoxostoma oshoroense* n. sp.
Fig. 4. *Paradoxostoma ezoense* n. sp.
Each bar represents 100 μ.



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