

Sexual Dimorphism, Ontogeny, and
Functional Morphology of
Rutiderma hartmanni Poulsen, 1965
(Crustacea: Ostracoda)

LOUIS S. KORNICKER

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ABSTRACT

Kornicker, Louis S. Sexual Dimorphism, Ontogeny, and Functional Morphology of *Rutiderma hartmanni* Poulsen, 1965 (Crustacea: Ostracoda). *Smithsonian Contributions to Zoology*, number 408, 28 pages, 20 figures, 1985.— The male of *Rutiderma hartmanni* Poulsen, 1965, is described and illustrated, and a supplementary description is given of the female with special emphasis on sexual dimorphism. Morphological differences in carapaces and limbs permitted functional analysis and reconstruction of the life history. All juveniles have the same life mode; they are unable to swim and thus are bottom dwellers; gut content and morphology of the mandible and maxilla indicate that they are predators. The adult male and female are able to swim, and the male is the more powerful swimmer; the adult female is a predator, whereas the adult male, which has mandibles much different from those of the female and has poorly developed maxillae, is probably a collector, feeding on detritus. Study of an A-1 adult male (last juvenile stage), preserved just prior to ecdysis and having adult male appendages visible within the appendages of the juvenile, supplied direct proof of the conspecificity of male and female rutidermatids, a conclusion previously based on indirect evidence. The central adductor muscle attachments are located close to valve midlength on the adult male and considerably anterior to valve midlength on adult females. It is suggested that the anterior location of the adductor muscle in the adult female provides room at the rear of the carapace for eggs, and that the midlength location of the adductor muscle in the adult male accommodates a greatly enlarged muscular protopodite of the 2nd antenna, essential for forceful swimming. Analysis of the muscles of the mandible disclosed that the strong chela on the end joint of the female is closed by 2 massive retractor muscles attached to a previously undescribed and unusual L-shaped sclerite; no protractor muscles are present to open the chela.

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Sexual Dimorphism, Ontogeny, and Functional Morphology of *Rutiderma hartmanni* Poulsen, 1965 (Crustacea: Ostracoda)

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Introduction

Rutidermatids have been collected only in bottom trawls and in other bottom sampling devices, indicating that they live in, on, or close to the substrate. They appear to be absent in the Arctic and Antarctic Oceans, are confined mostly to continental shelves, and rarely are found on the continental slope. Life studies are lacking; until these are conducted it is necessary to reconstruct their natural history from the study of preserved specimens. The amount of information concerning their life mode available by this means is not inconsequential.

Rutiderma hartmanni was described by Poulsen (1965:32) from 2 females and a juvenile male collected at San José Island, one of Pearl Islands, Gulf of Panama, in the eastern Pacific. Specimens collected from near the type-locality provided material for the present study. The male is described, and the morphology of the female is compared in detail to that of the male to elucidate the extent of sexual dimorphism. I then interpret the function of some of the limbs and from this reconstruct the life mode. Such inter-

pretations are speculative but promote consideration of aspects of morphology that otherwise might remain overlooked and unstudied.

Prior to Poulsen (1965:13) males of *Rutiderma* had been misidentified as males of *Philomedes*, a genus in the Philomedidae. The difference in appendage morphology of the male and female rutidermatid, combined with a similarity in the males of *Rutiderma* and *Philomedes*, masked their true relationship. Poulsen could offer only indirect evidence that some males that had been referred to *Philomedes* are indeed rutidermatids. Poulsen stated (p. 14), "The same scantiness [of males relative to females] also explains why the direct proof of identification: the observing of the final male mandible under the tissues of the female-like mandible of the juvenile male, is not available." An A-1 male (USNM 193068) of *R. hartmanni* in the present collection had been preserved in a stage of the molting process in which the appendages of the adult male are visible. Examination of this mandible (Figure 1) reveals that the large terminal claw of the 2nd joint of the A-1 instar is replaced by a bristle on the adult male, and that the small medial process at the base of the terminal claw is also replaced by a bristle. This is direct evidence of the relationship of male and female rutidermatids.

Louis S. Kornicker, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

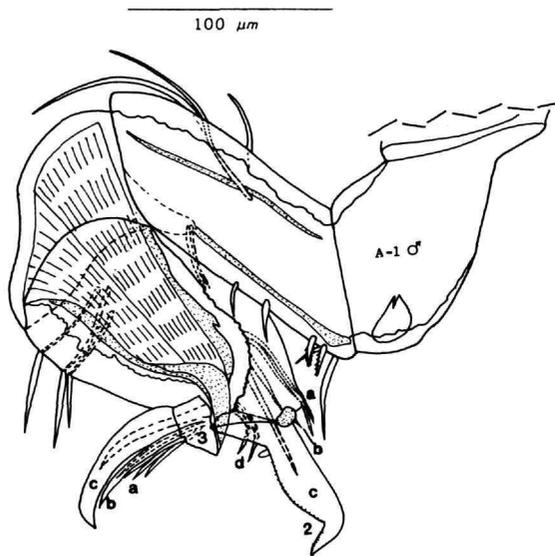


FIGURE 1.—*Rutiderma hartmanni*, medial view of right mandible of A-1 male, USNM 193068 (specimen at stage of ecdysis, with appendages of adult male visible inside appendages of juvenile). (Dashed bristles are mostly those of adult; long dashes = muscles; numbers = 2nd and 3rd endopodial joints; small letters = bristles defined in text.)

ACKNOWLEDGMENTS.—I wish to thank Meredith L. Jones and Herbert W. Kaufman for collecting the specimens upon which this study is based. I am grateful to several people who assisted in the preparation of this paper: Mrs. Carolyn Gast rendered the shaded drawings of the carapaces; Mrs. Kathryn Schroeder made many preliminary camera lucida drawings of appendages; Drs. Fenner A. Chace and I. Gregory Sohn criticized the manuscript. My appreciation also to Jack Korytowski, Smithsonian Press, for editing and preparing the manuscript for publication.

Terminology

In order to be more precise in descriptions, some new terms and measurements have been adopted.

Carapace measurements: a = distance from center of muscle attachments to anterior of car-

apace as percentage of distance from center of muscle attachments to posterior of carapace (includes caudal process).

First antenna measurement: a = distance from proximal dorsal corner of 2nd joint to apex of 8th joint measured parallel to dorsal margin of limb.

Second antenna measurements (Figure 8): a = maximum length of protopodite measured from anterior corner (point just dorsal to proximal end of exopodite) to apex of lower bulge of posterior margin of protopodite; b = length of chord of inner arc of exopodite measured from inner proximal hook of exopodite to posterodorsal corner of 9th joint; c = length of bristle of 6th joint; d = length of a distal natatory hair on measured bristle.

Mandible (Figure 9): Distal bristles on ventral margin of 2nd endopodial joint: a-bristles = pair of proximal bristles; b-bristle = single bristle distal to a-bristles; c-bristle = single bristle distal to b-bristle; d-bristles = pair of bristles having basal lateral to c-bristle. Bristles of 3rd endopodial joint: a-bristles = medial bristles; b-bristle = single bristle on distal margin (base lateral to bases of a-bristles); c-bristle = large terminal claw. Measurements: a = distance from proximal dorsal corner of basale to tip of 3rd endopodial joint measured along dorsal margin; b = length of c-bristle of 3rd endopodial joint.

Maxilla measurements (Figure 12): a = approximate length of limb excluding bristles; b = approximate width of distal margin of basale (inner to outer edge).

Fifth limb measurements (Figure 13): a = length of chord connecting bases of proximal and distal bristles of epipodite; b = distance from distal inner corner of endite I to base of distal bristle of epipodite (width at distal margin of endite I); c = length of one of longer epipodial bristles (in vicinity of 23rd bristle counted from distal end).

Sixth limb measurements (Figure 14): a = distance along posterior margin of stem from distal muscle attachment (measured at distal end of muscle bundle) to apex formed at intersection of

posterior margins of stem and end joint; b = angle formed at apex; c = distance from apex to base of posterior bristle on ventral margin of end joint; d = distance between posterior end of ventral margin of end joint and anterodistal corner of anterior projection of end joint.

Seventh limb measurements (Figure 15): a = length of stem plus terminus (terminus is end segment); b = width of terminus (measured from dorsal to ventral margins); c = width of 5th segment (counted from penultimate segment); d = length of longest dorsal and ventral terminal bristle respectively; e = length of shortest dorsal and ventral terminal bristle respectively; f = length of longest proximal bristle. (Clapper = process protruding from terminal bell.)

RUTIDERMATIDAE Brady and Norman, 1896

The Rutidermatidae comprises 3 genera, of which 1 genus, *Scleraner* Kornicker, 1975, is known from only 1 species; another, *Alternochelata* Kornicker, 1958, is known from 4 species; and the third, *Rutiderma* Brady and Norman, 1896, is known from more than 20 species.

***Rutiderma* Brady and Norman, 1896**

TYPE-SPECIES.—*Rutiderma compressa* Brady and Norman, 1896:673.

***Rutiderma hartmanni* Poulsen, 1965**

FIGURES 1–20

Rutiderma hartmanni Poulsen, 1965:32, fig. 8. [Does not include *Rutiderma rostrata* Hartmann, 1959:198 (= *R. pax* Kornicker, 1984:127), which was included by Poulsen in synonymy of *R. hartmanni*.]

HOLOTYPE.—Female (without eggs or embryos), length 0.95 mm. In collection of Zoological Museum of the University of Copenhagen.

TYPE-LOCALITY.—SW Bay, San José Island, Pearl Islands, Gulf of Panama, 8 or 9 m; collected 25 Jan 1916.

MATERIAL.—Bay of Panama, Pacific Ocean. Sta 150-B, 19 Apr 1973, about midway between

Changame Island and Bruja Point, 08°53'03"N, 79°34'07"W, depth 5 m, bottom with scallops, collected with trawl: USNM 193061, 1 adult male. Sta 150-D, 19 Apr 1973, about midway between Tortola Island and Tortolita Island, 08°51'50"N, 79°3'43"W, depth 7 m, coarse sand substrate, collected with trawl: USNM 193062, 1 adult female: USNM 193070, 1 instar II. Sta 161-2, 9 Nov 1973, SE of Batele Point, 08°53'49"N, 79°33'48"W, depth unknown, collected with dredge of trawl: USNM 193060, 1 ovigerous female. Sta 183-1, 10 Mar 1974, off Culebra Island, depth 16 m, water temperature 24°C: USNM 193065A, 1 adult male; USNM 193065B, 5 adult males; USNM 193066, 5 ovigerous females; USNM 193067, 5 ovigerous females, 6 A-1 females, 3 A-1 males plus 50 specimens; USNM 193069, 1 instar III; USNM 193068, 1 A-1 male. Sta 183-2, same station data as sta 183-1 except depth 7 m: USNM 158216, 1 adult male; USNM 158217, 1 adult female; USNM 158218, 1 adult male; USNM 158219, 1 ovigerous female; USNM 193063, 1 adult male; USNM 193064A, 1 ovigerous female, USNM 193064B, 1 adult female and 2 juveniles.

SEXUAL DIMORPHISM AND ONTOGENY

Adults

RELATIONSHIP BETWEEN BODY (soft parts) AND CARAPACE.—Male (Figures 2a, 3a, 4a). Location of central adductor muscle attachments slightly anterior to valve midlength and slightly below valve midheight; retracted appendages all capable of fitting within carapace, including bristles of 1st and 2nd antenna (an exception may be terminal claw of mandible, which lies outside of carapace in 10 males examined). In 10 preserved males examined, long c- and f-bristles of 1st antenna lying retracted within carapace, also exopodite of the 2nd antenna; 3rd joints of endopodites of all 2nd antennae with 3rd joint reflexed onto 2nd, and 2nd and 3rd joints fairly tightly folded, not extended as shown for illustrative purposes in Figure 3a.

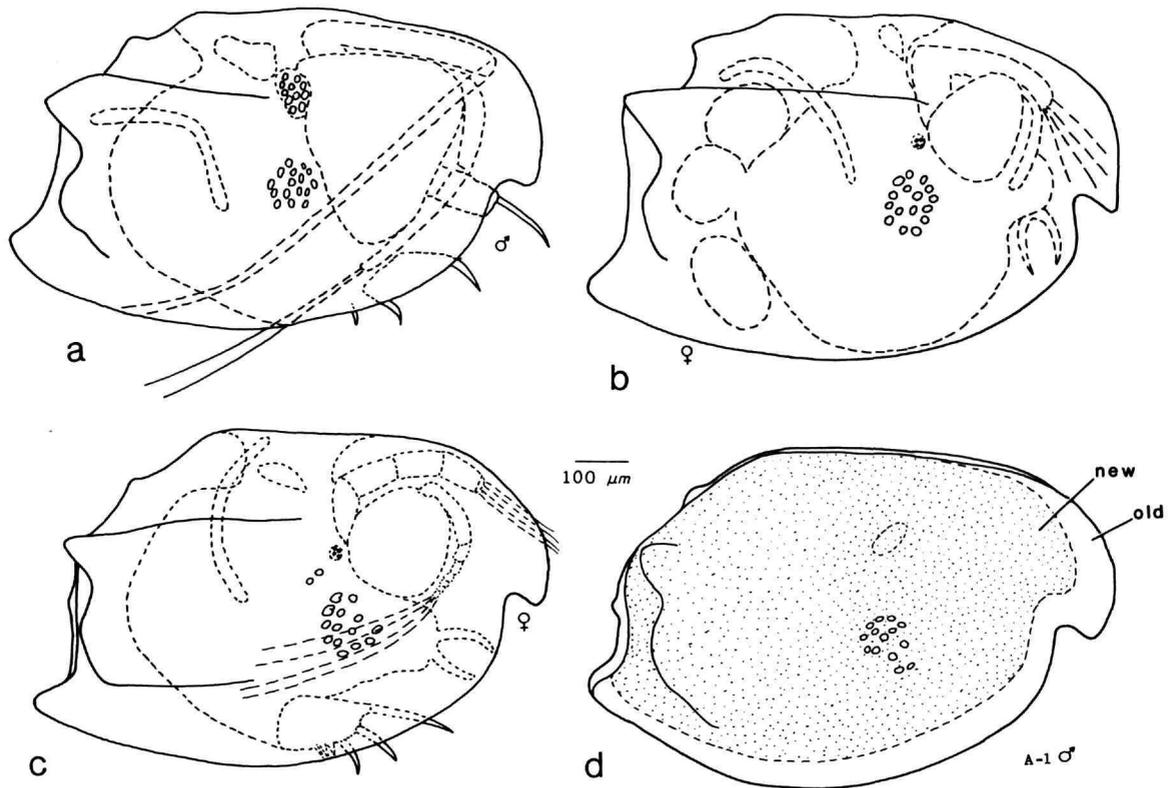


FIGURE 2.—*Rutiderma hartmanni*: a, adult male, USNM 193061, length 1.06 mm; b, ovigerous female, USNM 158060, length 1.02 mm; c, adult female, USNM 193062A, length 1.07 mm; d, molting A-1 male instar, with adult male carapace (stippled) visible, USNM 193068, length 0.99 mm.

Female (Figures 2*b,c*, 3*b*, 4*b*). Central adductor muscles attaching to valves farther forward than on male; appendages, including terminal claw of mandible, capable of being retracted entirely within carapace. Exopodite of 2nd antenna retracted in 10 females examined, and located a considerable distance from incisur; mandibles also retracted. Posterior of body farther from posterior margin of valves in ovigerous females (Figure 2*b*) than in nonovigerous females (Figure 2*c*).

RELATIONSHIP AMONG PARTS OF BODY.—Male (Figures 3*a*, 4*a*). In retracted positions the folded c- and f-bristles of 1st antenna and exopodial bristles of 2nd antenna lie between rest of body and valves. Posterior edge of protopodite

of 2nd antenna with "eye notch" accommodating lateral eye; upper anterior edge of lateral eyes lies lateral to protopodite, whereas lower anterior edge lies medial to protopodite (Figure 4*a*); shallow concavity near midheight of edge of protopodite may be accommodation for central adductor muscle attachments (Figure 4*a*).

Female (Figures 3*b*, 4*b*). c- and f-bristles of 1st antenna not extremely long as in male and not folded back. As in male exopodial bristles of 2nd antenna in the retracted position lie between body and valves. Posterior edge of protopodite of 2nd antenna evenly rounded, without eye notch or central adductor muscle accommodation. Protopodite of 2nd antenna much smaller relative to other appendages than that of male.

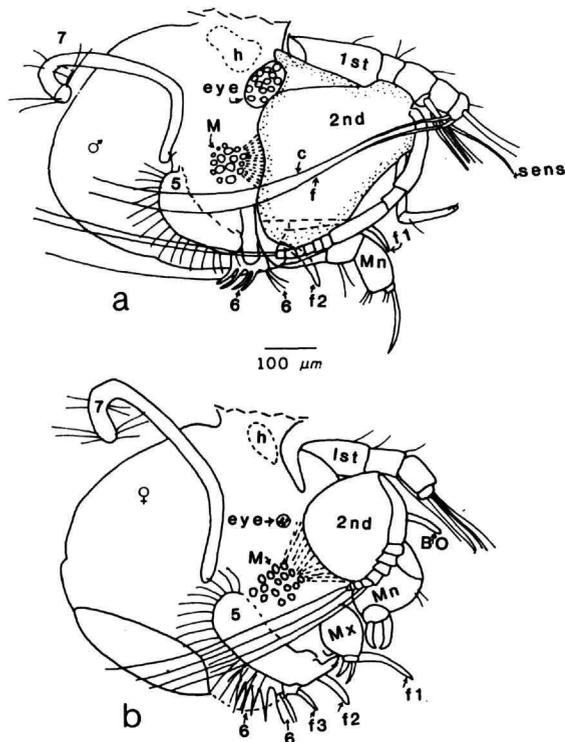


FIGURE 3.—*Rutiderma hartmanni*, adult specimens with carapaces removed: *a*, male, USNM 158216; *b*, female USNM 158217. (BO = bellonci organ; c, f, sens = bristles of 1st antenna; f1, f2, f3 = furcal claws; h = heart; M = central adductor muscles; Mn = mandible; Mx = maxilla; 1st = 1st antenna; 2nd = 2nd antenna; 5 = 5th limb; 6 = 6th limb; 7 = 7th limb; not all bristles or details of appendages illustrated.)

DESCRIPTION.—*Carapace:* Male (Figures 2*a*, 5*a*, 6*a-c*). Carapace elongate with greatest height in posterior half and greatest width near middle; rostrum and caudal process well developed; ventral margin of rostrum forming almost right angle with anterior margin of valve ventral to incisure; lateral projection of tip of rostrum overlapping ventral margin of rostrum, forming slight overhang; posterior vertical rib concave near middle, with triangular, backward-pointing process at dorsal end and rounded, backward-pointing process at ventral end; triangular process at dorsal end of rib projecting past posterior end of

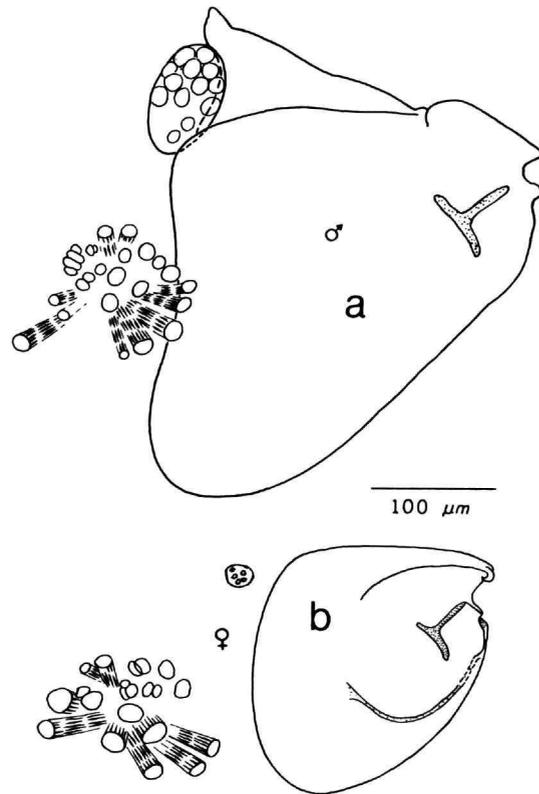


FIGURE 4.—*Rutiderma hartmanni*, lateral views of protopodite of 2nd antenna, lateral eye, and central adductor muscles of adult specimens: *a*, male, USNM 158218; *b*, female, USNM 158217.

valve on some specimens but not on others; faint lateral ribs extending anteriorly from dorsal and ventral ends of vertical rib, one passing dorsally and the other ventrally of central adductor muscle attachments; these ribs better developed on some specimens than on others; ventral margin of valve evenly convex; anterior of rostrum with scalloped edge formed by about 15 minute processes; dorsal margin of valve linear in anterior $\frac{2}{3}$; posterodorsal margin of valve only slightly convex, with minute process near middle; posterior margin of valve dorsal to caudal process linear on both valves, with minute process barely extending past posterior edge observed on left valve of some specimens; surface with abundant,

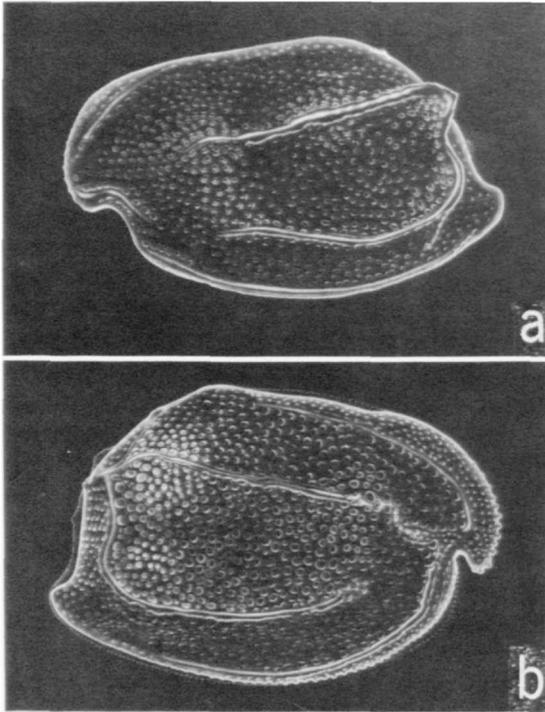


FIGURE 5.—*Rutiderma hartmanni*, lateral views of carapaces of complete specimens: *a*, male, USNM 158216, length 1.06 mm; *b*, female, USNM 158217, length 1.12 mm.

minute, oval fossae; long bristles with stout proximal sections numerous along anterior margin of rostrum and anteroventral margin of valve, less numerous along ventral margin, and sparsely distributed on lateral surface; valves only weakly calcified.

Female (Figures 2*b,c*, 5*b*, 6*d-f*). Differing from that of male in being higher relative to length, in having greatest width posteriorly, an overhanging rostrum, a well-defined process at midlength of posterior margin of left valve, better-defined lateral ribs, and in being more strongly calcified. (The carapace of many ovigerous females has a brownish cast, probably because they have lived longer than adult males and juveniles, the additional time permitting coating of valves with debris.)

Infold: Male (Figure 6*a-c*). Rostral infold with 8 bristles parallel to outer edge of rostrum

and 2 smaller bristles at inner end of incisur; anteroventral infold weakly striated, with 1 bristle near incisur separated by space from 4 bristles forming row; posterior half of infold anterior to caudal process with 7–9 bristles near inner margin; caudal process of left valve (USNM 158218) with “pocket” having concave anterior lip with bifurcate sclerotized process and 1 minute bristle at each end (Figure 6*b*); caudal process of right valve (USNM 158218) with anterior lip of “pocket” with 2 minute sclerotized processes at ventral end and 3 bristles (1 ventral, 1 dorsal, and 1 near midheight; Figure 6*c*). Posterior infold with 1 small bristle near dorsal end of caudal process (Figure 6*b,c*).

Female (Figure 6*d-f*). Rostral infold with 7 or 8 bristles, otherwise similar to that of male; striated anteroventral infold with 1 bristle near incisur separated by space from 6 bristles forming row; posterior half of ventral infold anterior to caudal process with 9 bristles mostly near inner margin; caudal process of left valve (USNM 158219) with sclerotized process and minute bristle at dorsal end of anterior lip and sclerotized process with 2 bristles at ventral end (Figure 6*e*); caudal process of right valve (USNM 158219) with 3 bristles on anterior lip (1 ventral, 1 dorsal, 1 near midheight; Figure 6*f*).

Selvage: Male (Figure 6*b,c*). Lamella prolongation of selvage divided at inner end of incisur and near midheight of outer edge of caudal process; prolongation with fringe of hairs except along outer edge of caudal process; hairs longest along anterior margin of rostrum; prolongation with indistinct narrow striations perpendicular to margin.

Female (Figure 6*e,f*). Lamella prolongation similar to that of male; prolongation of USNM 158219 with division near midheight of outer edge of caudal process on right valve (Figure 6*f*); but not left (Figure 6*e*; left valve probably aberrant).

Central Adductor Muscle Attachments: Male (Figures 2*a*, 20). Numerous ovoid scars located slightly below midheight and close to midlength. Measurements: *a*, distance from center of muscle

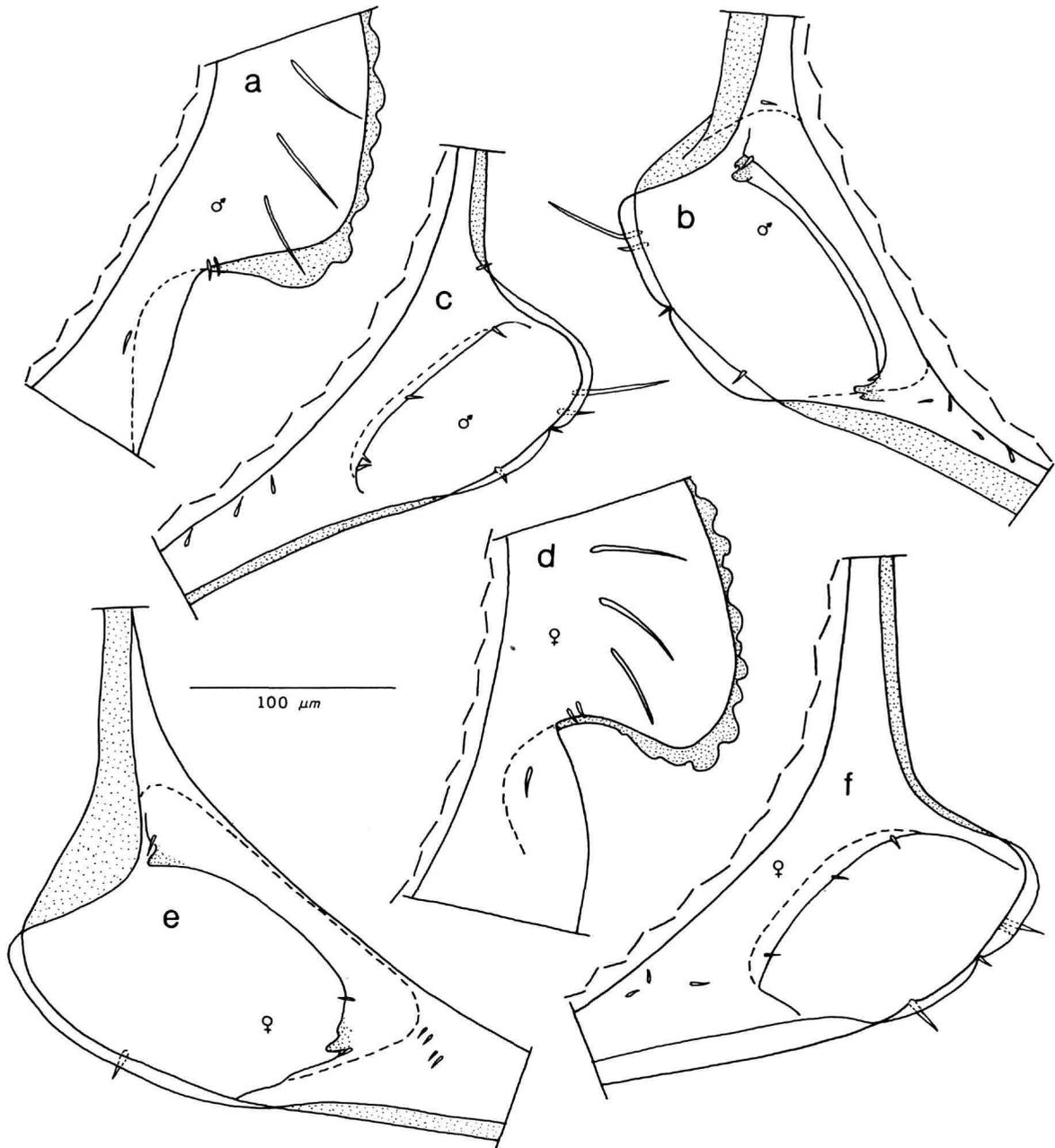


FIGURE 6.—*Rutiderma hartmanni*, inside views of carapaces, male, USNM 158218: a, rostrum and incisor; b, c, left and right caudal processes. Female, USNM 158219: d, rostrum and incisor; e, f, left and right caudal processes.

attachments to anterior of carapace as percentage of distance from center of muscle attachments to posterior of carapace (includes caudal process): USNM 158061, 91; USNM 193063, 98; USNM 193065, 6 specimens, 82, 93, 94, 98, 113, 102. Mean of a (8 specimens) 96 percent; range of a 82–113 percent.

Female (Figures 2*b*, 20). Similar in number to adductor muscles of male. Located farther forward than on male carapace. Measurements: a, USNM 158064A, 67; USNM 193062A, 64; USNM 193060, 67; USNM 193066, 9 specimens, 62, 63, 66, 64, 63, 68, 61, 63, 67. Mean of a (12 specimens) 65 percent; range of a 61–68 percent.

Size: Male. USNM 158216: length 1.06 mm, height 0.65 mm; USNM 158218: length 1.04 mm, height 0.66 mm; USNM 193061: length 1.06 mm, height 0.63 mm; USNM 193063: length 1.07 mm, height 0.63 mm; USNM 193065, 7 specimens: length 1.03 mm, height 0.65 mm; length 1.04 mm, height 0.65 mm; length 1.06 mm, height 0.61 mm; length 1.08 mm, height 0.66 mm; length 1.04 mm, height 0.60 mm; length 1.06 mm, height 0.61 mm; length 1.04 mm, height 0.63 mm. Range in length of 10 specimens, 1.03–1.08 mm; range in height of 10 specimens, 0.55–0.66 mm; mean length 1.05 mm, mean height 0.64 mm; mean height as percent of mean length, 61.

Female. USNM 158217: length 1.12 mm, height 0.78 mm; USNM 158219: length 1.03 mm, height 0.72 mm; USNM 193060: length 1.02 mm, height 0.66 mm; USNM 193062A: length 1.07 mm, height 0.73 mm; USNM 193064, 2 specimens: length 1.11 mm, height 0.74 mm; length 1.04 mm, height 0.73 mm; USNM 193066, 4 specimens: length 1.10 mm, height 0.72 mm; length 1.06 mm, height 0.72 mm; length 1.07 mm, height 0.74 mm; length 1.08 mm, height 0.71 mm. Range in length of 10 specimens, 1.02–1.12 mm; range in height of 10 specimens, 0.66–0.78 mm; mean length 1.07 mm, mean height 0.73 mm; mean height as percent of mean length, 68. Length of females similar to length of males but height of females greater than height of males.

First Antenna: Male (Figure 7*a*). 1st joint with few, minute, lateral spines forming distal rows. 2nd joint with short, spinous, dorsal bristle distal to midlength and spines forming rows along ventral and dorsal margins and laterally along distal margin near dorsal corner. 3rd joint shorter on medial side than on lateral side but with distal margin well defined on both sides; 3 bristles present (1 ventral, 2 dorsal; ventral bristle broken on illustrated limb). 4th joint about twice length 3rd joint, with 4 bristles (3 ventral, 1 dorsal). 5th joint small, wedged medially between 4th and 6th joints near ventral margin; sensory bristle with stout proximal part having obtuse distal end bearing about 25 slender filaments; stem of bristle with minute filament just distal to stout proximal part and with minute terminal spine. 6th joint about same length as combined length of joints 3 to 5; short medial bristle near distal dorsal corner. 7th joint: a-bristle spinous, about same length as bristle of 6th joint; b-bristle about same length as combined length of joints 4 to 6, with 2 short proximal filaments and minute spine at tip; c-bristle extremely long (twice length of combined 2nd to 8th joints), with about 14 marginal filaments. 8th joint: d- and e-bristles about same length as combined length of joints 3 to 8, bare with blunt tips; f-bristle similar to c-bristle; g-bristle about same length as d-bristle, with 1 short proximal filament and minute spine at tip. Measurement: a = 0.39 mm.

Female (Figure 7*b*). Limb smaller than that of male. 2nd joint smaller than that of male and without spines forming rows along ventral margin. 3rd joint differing from that of male in being fused to 4th joint. 4th joint differing from that of male in having 2 instead of 3 bristles on distal ventral corner and in relative lengths and spinosity of bristles. 5th joint not minute like that of male, similar in size to 6th joint of male; sensory bristle without stout proximal part bearing numerous filaments like on male, but with minute proximal filament and minute terminal spine like those on stem of male. 6th joint differs from that of male in being minute and fused to 5th joint, but with medial bristle similar to that of male.

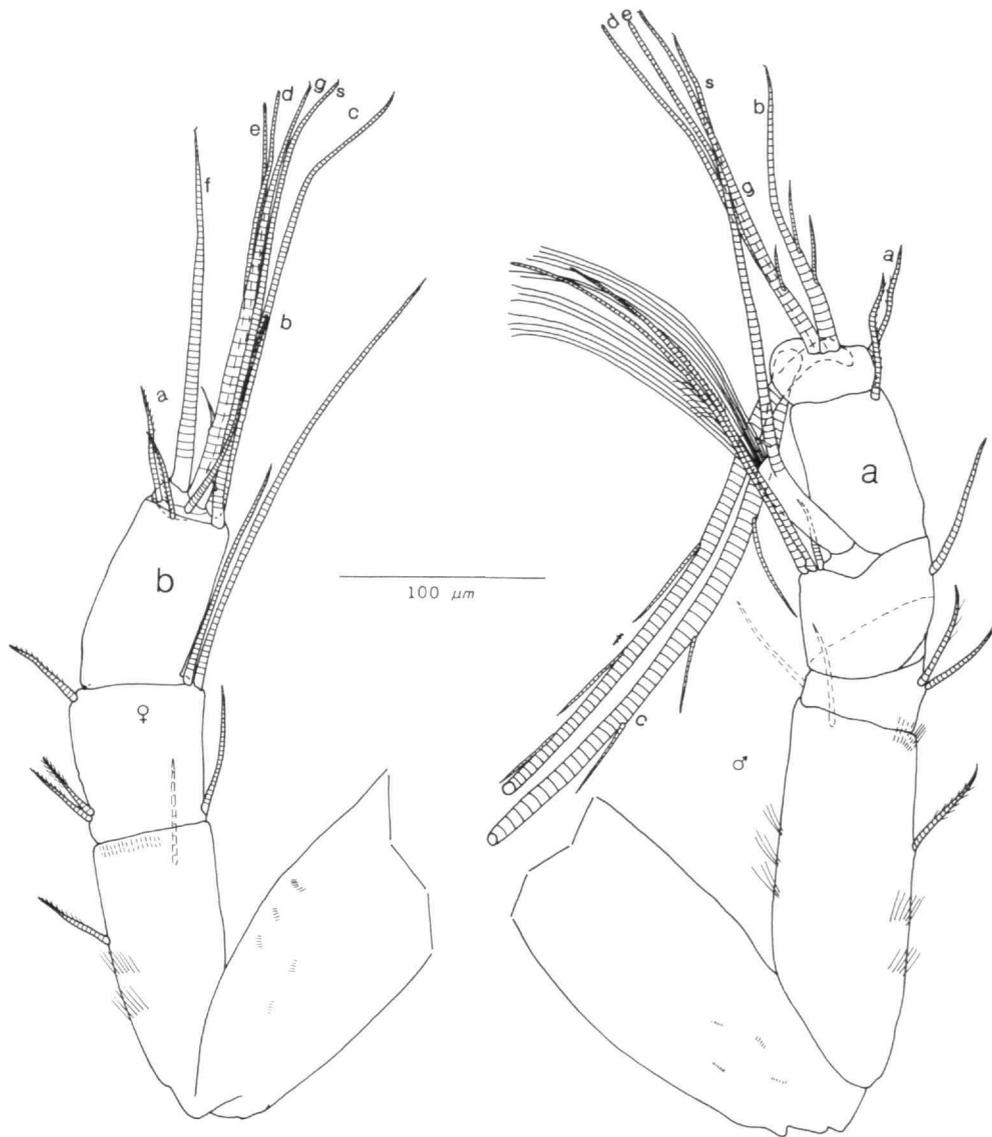


FIGURE 7.—*Rutiderma hartmanni*, 1st antennae of adults, medial views: *a*, male right limb, USNM 158218; *b*, female left limb, USNM 158219. (Small letters = bristles.)

Combined 7th and 8th joints smaller than those of male. 7th joint: *a*-bristle similar to that of male; *b*-bristle much narrower than that of male and shorter, without the 2 marginal filaments on male but with similar minute terminal spine; *c*-bristle about same length as sensory bristle of 5th joint, not extremely long as on male, with similar min-

ute spine at tip. 8th joint: *d*- and *e*-bristles similar to those of male; *f*-bristle shorter than *c*-bristle, not extremely long as on male, with similar minute spine at tip; *g*-bristle similar to that of male but slightly shorter. $a = 0.32$ mm (82 percent that of male).

Second Antenna: Male (Figure 8*a*). Protopod-

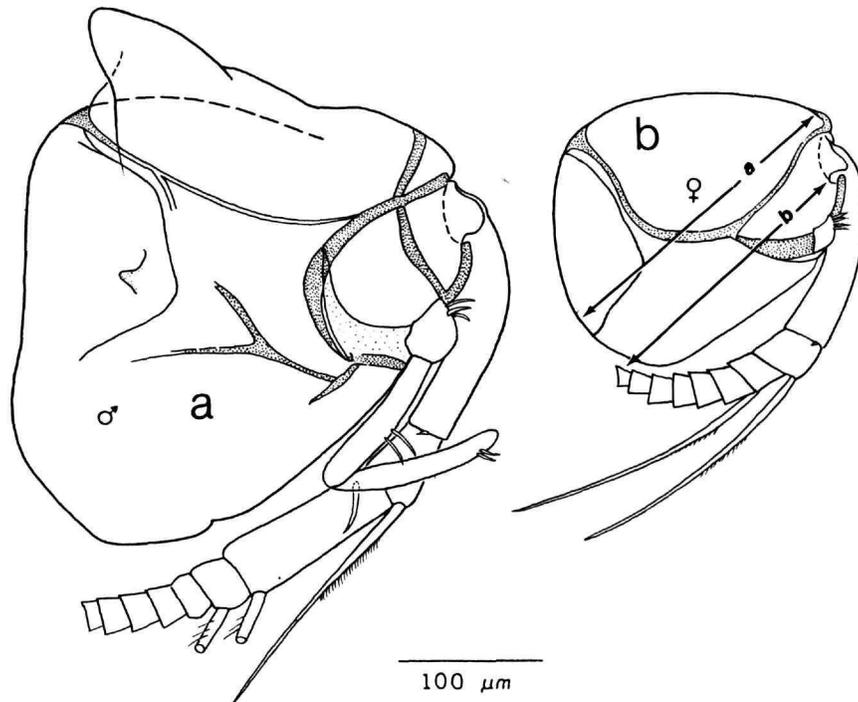


FIGURE 8 (left).—*Rutiderma hartmanni*, medial views of left antennae of adults: *a*, male, USNM 158218; *b*, female, USNM 158219. (Small letters = measurements; some exopodial bristles omitted.)

ite muscular, bare, subtriangular with concavities on posterior edge near dorsal margin and at midheight; complex sclerites present on medial side, especially in distal corner in vicinity of attachments of endopodite and exopodite. Exopodite: 1st joint elongate with minute medial spine near middle of distal margin; 2nd joint $\frac{1}{3}$ to $\frac{1}{4}$ length of 1st joint; 3rd joint about $2\frac{1}{2}$ times longer than 2nd joint; joints 4 to 9 decreasing in size distally along exopodite and with total length about $\frac{1}{4}$ length of exopodite; bristle of 2nd joint reaching 6th joint, with two sets of minute spines along ventral margin; bristles of joints 3–8 about $2\frac{1}{2}$ times length of bristle of 2nd joint, with natatory hairs, no ventral spines; 9th joint with 1 minute bare bristle and 4 with natatory hairs (3 ventral bristles same length as bristle of 8th joint; dorsal bristle about $\frac{3}{4}$ length of others); distal edge of 3rd joint with long lateral hairs

forming row; distal edge of joints 4–8 with minute lateral spines forming row; no basal spines. Endopodite 3-jointed: 1st joint short with 4 small anterior bristles; 2nd joint elongate with 2 small bristles near midlength; 3rd joint reflexes on 2nd, with 1 small proximal bristle and 2 minute subterminal bristles. Measurements: *a* = 0.38 mm; *b* = 0.39 mm; *c* = 0.49 mm; *d* = 0.065 mm.

Female (Figure 8*b*). Limb smaller than that of male. Protopodite bare, without posterodorsal projection or concavities on posterior edge near dorsal margin; posterior margin more evenly curved than on male; sclerites fewer and seemingly less complex than on male. (More detailed comparison of male and female sclerites will require further study.) Exopodite: medial spine on distal margin of 1st joint closer to ventral margin than spine on male; joints 2 to 9 decreasing in size distally along exopodite and total length

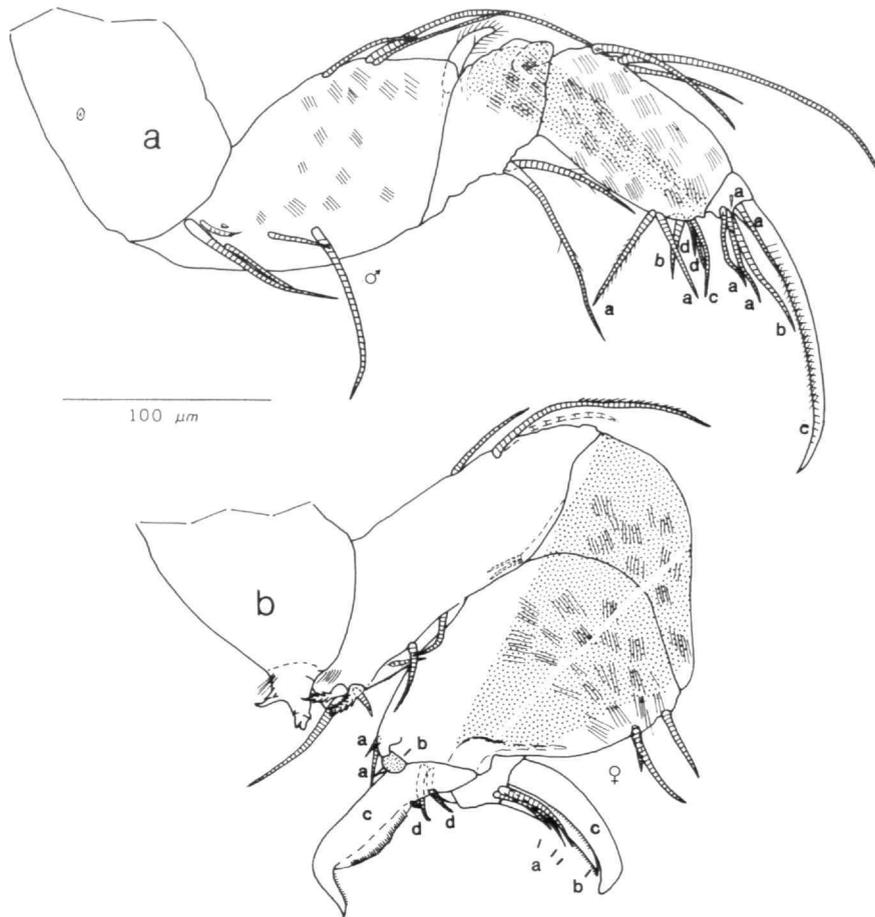


FIGURE 9 (below).—*Rutiderma hartmanni*, medial views of left mandibles of adults: *a*, male, USNM 158218; *b*, female, USNM 158219. (Stippled area = muscles; small letters = bristles.)

about $\frac{1}{2}$ length of exopodite; joints 4 to 9 about $\frac{1}{3}$ length of exopodite, not $\frac{1}{4}$ length as on male; 3rd joint shorter than 2nd joint not $2\frac{1}{2}$ times longer as on male; bristle of 2nd joint reaching past 9th joint and with minute spines along ventral margin (length of bristle about same as that of male); bristles of joints 3 to 5 only slightly longer than bristle of 2nd joint, with minute ventral spines (these bristles much longer on male and have natatory hairs, no ventral spines); bristles of joints 6–8 slightly longer than twice length of bristle of joint 2, with natatory hairs, no spines

(bristles similar to those of male); 9th joint with 6 bristles (3 long and 1 short, all with natatory hairs; and 2 minute, bare); distal edge of joints 2–8 with minute spines forming row. Endopodite 1-jointed with 4 small anterior bristles. Measurements: *a* = 0.24 mm (63 percent that of male); *b* = 0.21 mm (54 percent that of male); *c* = 0.43 mm; *d* = 0.070 mm. Both *c* and *d* of female fairly similar to *c* and *d* of male.

Mandible: Male (Figures 9*a*, 10*a*). Coxale endite absent or represented by minute medial spine near midlength of joint. Basale: dorsal mar-

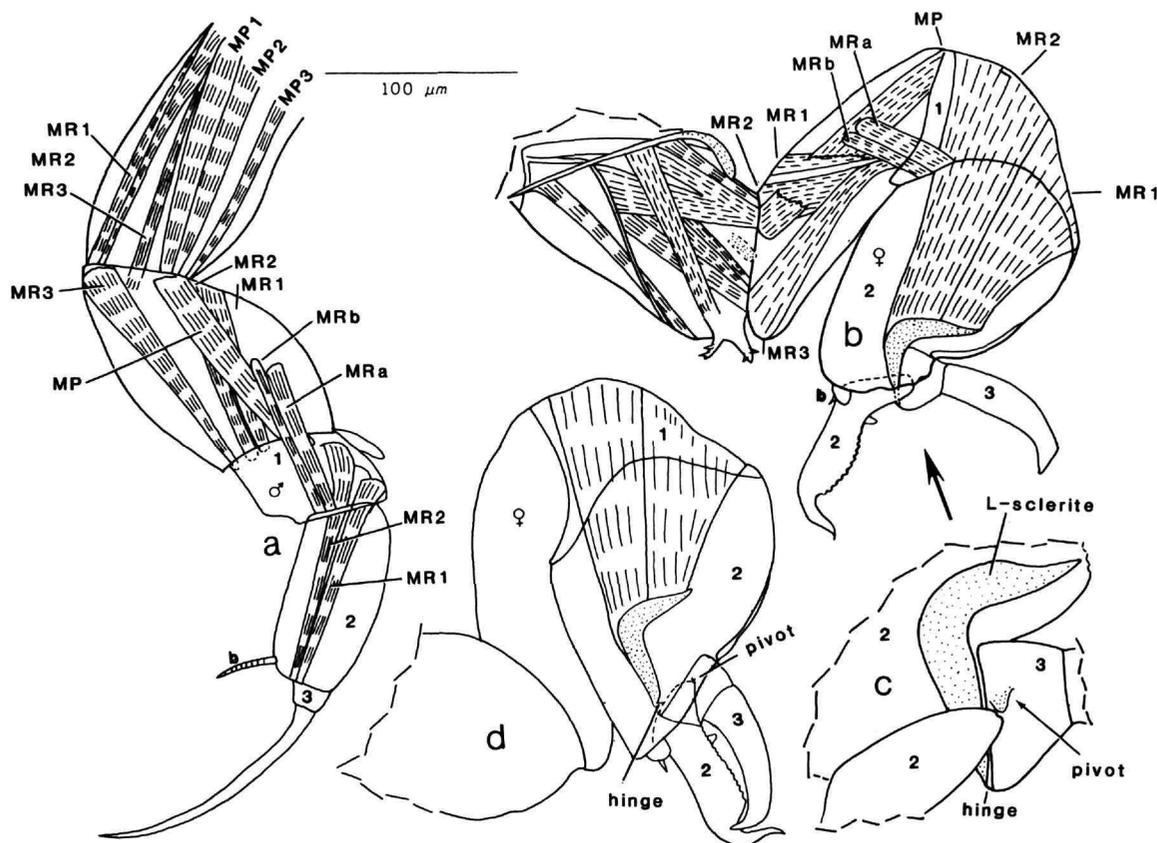


FIGURE 10.—*Rutiderma hartmanni*, medial views of left mandibles of adults: a, male, USNM 158218; b, female with chelae open, USNM 158219; c, detail from b; d, female with chelae closed, USNM 158217. (Dashed lines = muscles; MR = remotor muscle; MP = promotor muscle; stippled area = sclerite and pivot; most bristles omitted; separate numbers = endopodial joints.)

gin with bristles forming 2 groups near mid-length (1 bristle in proximal group, 2 in distal group); medial surface with anteroventrally pointing spines forming oblique rows, 3 short bristles and 1 minute indistinct bristle in posteroventral corner, and 2 slender bristles near mid-length of ventral margin. Exopodite finger-like, hirsute, no terminal bristles observed. 1st endopodial joint: medial surface with anteroventrally pointing spines forming oblique rows; ventral margin with 2 slender bristles distal to midlength. 2nd endopodial joint: medial surface with anteroventrally pointing spines forming mostly

oblique rows; dorsal margin with bristles forming 2 proximal groups (1 bristle in proximal group, 2 in distal); ventral margin with 2 a-bristles, 1 b- and 1c-bristle, and 2 smaller d-bristles. 3rd endopodial joint with 4 a-bristles, 1 b-bristle, and 1 c-bristle with ventral spines. Measurements: a = 0.27 mm; b = 0.13 mm.

Musculature (Figure 10a): Muscles from apodemes within body inserted into proximal half of coxale (these not shown on illustrated limb); coxale muscles obscure in limbs cleared only in glycerine, but apparently with 3 promotor muscle bands (MP 1-3) and 3 remotor muscle bands

(MR 1–3) attached to proximal end of basale. Basale with 1 stout promotor muscle and 3 remotor muscles attached to proximal end of 1st endopodial joint, and 2 remotor muscles (MRa, MRb) with proximal insertions at midlength of basale and distal insertions at proximal end of 2nd endopodial joint. 1st endopodial joint with 2 remotor muscles inserted into sclerotized, crescent-like structures near dorsal margin of joint; distal end of muscles inserted into ventral end of proximal margin of 3rd endopodial joint. (It is possible that ventral of the 2 muscles is inserted into 2nd rather than 3rd endopodial joint, but exact location difficult to resolve because attachment so close to suture separating 2nd and 3rd joints.)

Female (Figures 9b, 10b–d, 11). Coxale shorter than that of male; endite differs from that of male in location and in being well developed, bifurcate (distal prong slightly stouter than proximal prong, with trifid tip and marginal, triangular tooth; proximal prong with about 4 marginal, triangular teeth near tip and slender spines forming 2 rows near base). Basale more elongate

than that of male; dorsal margin with 3 bristles forming 2 groups as on male (smaller bristle in distal group broken off on illustrated limb); medial surface differs from that of male in being without spines and in having marginal teeth on 2 of the bristles in the posteroventral corner, other bristles differ in length from that of male, and an additional bristle present (always?). Exopodite absent. 1st endopodial joint differs from that of male in having a much longer dorsal margin and shorter ventral margin (triangular joint in female, trapezoidal in male); the 2 ventral bristles on female much shorter than those of male. 2nd endopodial joint: triangular in shape rather than rectangular as in male; 3 dorsal bristles shorter than those of male; 2 a-bristles shorter than those of male; b-bristle in form of small process with terminal spine; c-bristle in form of stout claw with serrate dorsal margin, pointed produced tip, and small, proximal, dorsal tooth; 2 d-bristles similar to those of male; medial side with spines absent in distal half. 3rd endopodial joint: 3 a-bristles, not 4 as on male; b-bristle broader than that of female, about same

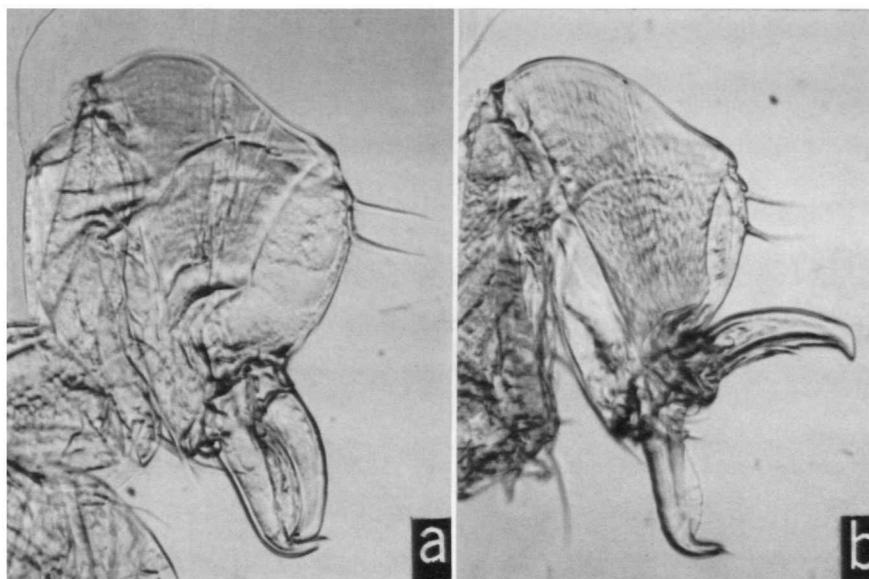


FIGURE 11.—*Rutiderma hartmanni*, medial views of left mandibles of adult females: *a*, chelae closed, USNM 158217; *b*, chelae open, USNM 158219.

length, claw-like; c-bristle claw-like, shorter but broader than claw of male, with truncate tip. Measurements: a = 0.37 mm (37 percent longer than that of male); b = 0.07 mm (46 percent shorter than that of male).

Musculature (Figure 10b-d): Muscles from apodemes within body inserted into proximal half of coxale not all shown on illustrated limb; coxale muscles obscure as in male but apparently also with 3 promotor and 3 remotor muscle bands attached to proximal end of basale. Same number of basale muscles (5) as in male but MRa and MRb much shorter. 1st endopodial joint with same number of muscles (2) as in male but muscles much stouter; proximal end of each muscle inserted on dorsal margin of 1st endopodial joint rather than on crescent-like structures as on male; distal insertions on L-shaped process (L-sclerite) having distal tip attached by short tendon to proximoventral corner of 3rd endopodial joint, insertions not directly on proximal edge of 3rd joint as on male.

Remarks Concerning d-Bristles of 2nd Endopodial Joint: 2 short bristles with bases located lateral to the large terminal claw of the 2nd endopodial joint of the female mandible (also juveniles of both sexes) are interpreted herein as being on the 2nd endopodial joint and are designated as d-bristles. These bristles were interpreted by Poulsen (1965:10, table 1) as being on the 3rd joint; in my previous papers in which rutidermatids were described, I followed Poulsen. The location of the bases of the 2 bristles is difficult to determine, especially when the pincers of the 2nd and 3rd joints are closed. When they are open, the 3rd joint forms a right angle with the 2nd; the 2 d-bristles do not move with the 3rd joint, showing them to be on the 2nd joint. Examinations of an A-1 male *R. hartmanni*, in which the new adult mandible is visible within that of the juvenile, supported the observation that the bristles on the A-1 male are equivalent to bristles on the 2nd endopodial joint of the adult male. The observation that the d-bristles are lateral to the c-bristle (claw in female) on both adult males and females is additional sup-

port for the interpretation that the d-bristles are on the 2nd joint. The equivalency of the c-bristles of the male and female is based partly on observation of the A-1 male mandible, in which the adult mandible is visible, and partly on the spatial relationships of all ventral bristles on the 2nd endopodial joints of adult male and female mandibles. The illustration of the adult male mandible by Poulsen (1965, fig. 1b) suggests that the 4th bristle (counting from the distal end) on the ventral margin of the 2nd endopodial joint is equivalent to the stout claw of the 2nd joint of the adult female. The present study concludes that the bristle on the male is equivalent to the small medial process with a terminal spine present on the female, and that the distal medial bristle (c-bristle) on the male is equivalent to the stout claw of the adult female.

In his comprehensive study of the Rutidermatidae Poulsen (1965) described the female-type mandible (p. 25) in detail only for *Rutiderma normani* Poulsen, 1965:22. The legend of the text-figure in which the mandible is illustrated states that fig. 6e is a lateral view and that 6e''' is a medial view. Poulsen (1965:25) stated correctly that the round process with a short terminal bristle is medial to the large claw, the reverse of that shown in fig. 6e''' according to the legend. On the other hand the position of the bristles of the 3rd joint are described in accordance to the legend, which is incorrect. It may be added that the legends are correct in Poulsen's illustrations of the mandibles of *R. hartmanni* (fig. 8e) and *R. rotunda* Poulsen, 1965:35 (fig. 9f).

MAXILLA: Male (Figure 12a). Limb extremely small, indistinct, details difficult to resolve. Endites (presumably 3) present but boundaries between them indistinct, each endite with several weakly developed bristles (not all shown on illustrated limb). Precoxale and coxale with fringes of long hairs; coxale with long, hirsute, dorsal bristle. Basale with 2 distal bristles. Exopodite with 1 long spinous bristle and 1 shorter bare bristle. 1st endopodial joint with bare alpha-bristle and spinous beta-bristle (only basal part shown on illustrated limb). 2nd endopodial joint

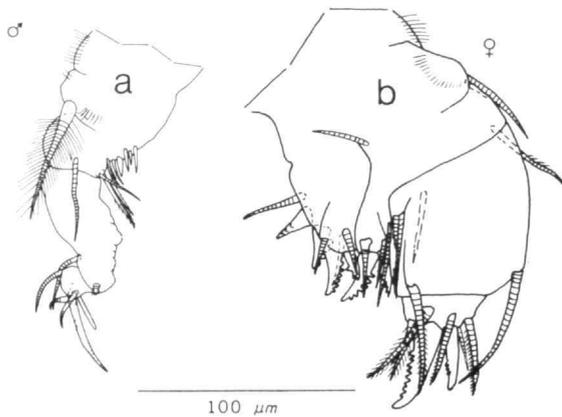


FIGURE 12.—*Rutiderma hartmanni*, maxillae of adults: *a*, male, USNM 158218; *b*, female, USNM 158219.

with 1 long bristle and 4 or 5 shorter bristles. Measurements: *a* = 0.15 mm; *b* = 0.05 mm.

Female (Figure 12*b*). Robust, not weakly developed like maxilla of male. 3 well-defined endites: endite I with 2 pectinate claws and 2 ringed bristles; endite II with 2 pectinate claws and 3 ringed bristles; endite III with 3 pectinate claws, 2 distal ringed bristles, and 1 proximal ringed bristle. Precoxale and coxale similar to that of male in having dorsal fringes of long hairs; bristle on dorsal margin of coxale bare (or with few minute spines), not hirsute like that of male, also shorter. Basale with 3 short distal bristles (1 dorsal with indistinct short hairs, 1 ventral bare, 1 medial bare). Exopodite with 1 short and 1 long bristle (bare or with few, small, indistinct spines). 1st endopodial joint broader but about same length as that of male, also similar in having 1 bare alpha-bristle and 1 spinous beta-bristle. 2nd endopodial joint with 2 short spinous α -bristles, 2 terminal pectinate claws (inner of these stouter than other), 2 short terminal bristles dorsal to base of outer marginal claw, and 1 short bristle with base just medial to inner edge of inner marginal claw (stouter of the terminal claws probably equivalent to long terminal bristle of male; α -bristles probably equivalent to 2 weakly developed bristles of male; weaker of terminal claws and 2 terminal bristles probably equivalent

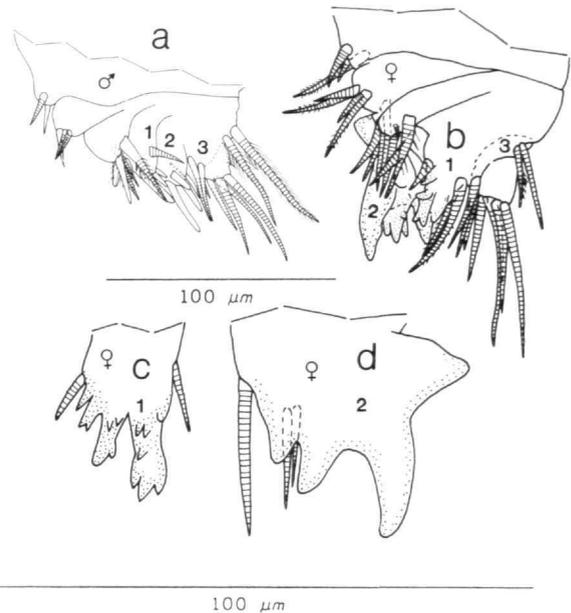


FIGURE 13.—*Rutiderma hartmanni*, anterior views of right 5th limbs of adults: *a*, male, USNM 158218; *b*, female, USNM 158219; *c*, 1st exopodial joint, from *b*; *d*, 2nd exopodial joint, from *b*. (Numbers = exopodial joints; upper scale for *a* and *b*; lower scale for *c* and *d*.)

to other 2 or 3 weakly developed bristles of male). Measurements: *a* = 0.17 mm (not greatly different than that of male); *b* = 0.07 mm (40 percent wider than that of male).

FIFTH LIMB: Male (Figure 13*a*). Epipodite with 39 spinous bristles; proximal and distal bristles shorter than others. 3 well-defined endites: endite I with 1 ringed and 1 unringed bristle; endite II with 3 small bristles (1 or 2 unringed); endite III with 1 stout ringed bristle with slender marginal spines, 2 small ringed bristles, and 2 weakly developed, unringed, finger-like bristles with indistinct marginal hairs. 1st exopodial joint with 1 short, pointed, ringed bristle and 3 weakly developed, unringed, finger-like bristles. 2nd exopodial joint with 1 ringed bristle and 4 weakly developed, unringed, finger-like bristles. 3rd exopodial joint with 3 bare, weakly ringed, pointed bristles on inner lobe and 2 stout, ringed, hirsute bristles on outer lobe. 4th and 5th exopodial

joints fused, hirsute, with total of 4 bare, ringed, pointed bristles. Measurements: $a = 0.22$ mm; $b = 0.07$ mm; $c = 0.17$ mm.

Female (Figure 13*b-d*). Epipodite with about 35 bristles; proximal and distal bristles shorter than others (bristles similar to those of adult male). 3 well-defined endites: endite I with 3 ringed bristles, longest with short marginal spines; endite II with 4 ringed terminal bristles (2 longer bristles with short marginal spines and more distinctly ringed) and 3 slender ringed bristles on distal margin (endite II of male with total of only 3 bristles); endite III with 4 ringed bristles: inner stout bristle with long proximal and short distal spines (position of bristle suggests equivalency to stout bristle bearing short marginal spines on male; unringed hirsute bristles of male not present on female). 1st exopodial joint with 4 constituent teeth (Figure 13*c*): proximal tooth small, smooth; 2nd to 4th teeth larger and with marginal teeth; 1 short, ringed bristle with indistinct marginal spines proximal to small smooth tooth; 1 short, ringed bristle on margin proximal to 4th tooth (Figure 13*c*) (2nd to 4th teeth may be homologous to 3 unringed, finger-like bristles of male; small bristle adjacent to small smooth tooth may be equivalent to inner, ringed, anterior bristle of male). 2nd exopodial joint consisting of large, flat, sclerotized tooth having 3 smooth lobes forming inner margin, 1 stout proximal bristle on inner margin, and 2 smaller posterior bristles near proximal lobe of inner margin of flat tooth (Figure 13*d*) (homologies between 2nd exopodial joints of male and female uncertain: the proximal, anterior, finger-like bristle on the male could be equivalent to the large, flat, lobed tooth of the female, or the large flat tooth could be equivalent to the whole joint, possibly fused with some of the finger-like bristles). Inner lobe of 3rd exopodial joint with 2 short bristles. Outer lobe with 1 short bare bristle and 1 longer bristle with indistinct marginal hairs (bristles quite different from stout hirsute bristles of male). 4th and 5th exopodial joints fused, with total of 4 ringed bristles bearing short marginal spines (joint somewhat longer than that of male).

Measurements: $a = 0.23$ mm (about same as male); $b = 0.085$ mm (about 21 percent greater than on male); $c = 0.17$ mm (same as male). Summary of sexual dimorphism: epipodite of male and female similar; endites I and II differing only slightly, some bristles unringed in male; endite III of male differing in having unringed, finger-like bristles; 1st endopodial joint of female differing considerably from that of male in having stout teeth; 2nd endopodial joint differing considerably from that of male in having large, flat, lobate tooth; 3rd to 5th exopodial joints differing mainly in having bristles of outer lobe of 3rd joint long in male and short in female.

Sixth Limb: Male (Figure 14*a*). Two small bare bristles in place of epipodite (distal bristle slightly longer). Endite I small, with 3 small bare bristles; endite II larger than endite I, with 2 bare bristles (proximal bristle longer than distal bristle); endites III and IV larger than endite II, with 3 bristles (2 proximal bristles longer; all bristles with small indistinct marginal spines). End joint with projecting anterior part (similar in size to endite IV) with 3 terminal bristles (proximal bristle longer; all bristles with short marginal spines); posterior part of distal margin of end joint with 1 bristle, hirsute except for short spines near tip, followed by 3 slightly longer hirsute bristles (1st bristle with indistinct suture at base, remaining 3 without suture). Distal posterior margin of end joint, as well as medial and lateral sides, with long hairs forming rows (not all shown on illustrated limb). Measurements: $a = 0.035$ mm; $b = 145^\circ$; $c = 0.070$ mm; $d = 0.075$ mm.

Female (Figure 14*b*). Epipodial bristles differ from those of the male in bearing long marginal hairs, endite I differs from that of the male in having a longer proximal bristle (broken on illustrated limb) and in the 2 distal bristles having long marginal hairs; endite II differs from that of the male in the proximal bristle being much longer and bearing minute indistinct spines, and in the short distal bristle having long marginal hairs; endite III differs from that of male in having long proximal hairs and short distal spines on short distal bristle; endite IV differs from that

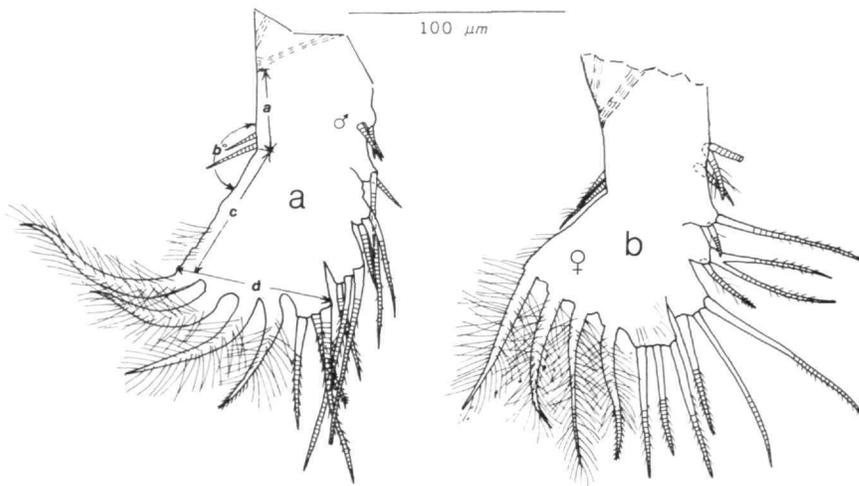


FIGURE 14.—*Rutiderma hartmanni*, 6th limbs of adults: *a*, male; *b*, female. (Small letters = measurements explained in "Terminology.")

of male in having longer bristle at midwidth of distal margin. End joint similar to that of male. Measurements: *a* = 0.031 mm (11 percent shorter than on male); *b* = 129° (16 degrees less than on male); *c* = 0.058 mm (17 percent shorter than on male); *d* = 0.081 mm (8 percent longer than on male). Summary of dimorphism: most noticeable differences are the greater length of the posterior margin of the end joint on the male (dimension *c*) and the smaller angle formed at the intersection of the posterior margins of the stem and end joint (dimension *b*) on the female.

Seventh Limb: Male (Figure 15*a*) Stem with about 55 segments; distal 15 or 16 segments of stem slightly wider; distal end tending to bend or coil posteriad (in lateral view), thus convex margin dorsal, and concave margin ventral. Terminus with 4 bristles (2 dorsal, 2 ventral) of subequal length, each with indistinct marginal spines and 4 distal bells; each terminal bell with clapper broadening at midlength and tip; 6th or 7th ring and 9th ring of stem (counting from distal ring) with dorsal bristle about half length of terminus bristles and bearing few indistinct marginal spines, 2 distal bells, and terminal clap-

per similar to those on bristles of terminus; 8th and 9th rings with ventral bristle similar to those of dorsal margin of stem. Distal end of terminus with 4 recurved teeth (with marginal fronds), 2 dorsal, 2 ventral. Measurements: *a* = 0.54 mm; *b* = 0.033 mm; *c* = 0.030 mm; *d* = 0.09 mm, 0.09 mm; *e* = 0.085 mm, 0.085 mm; *f* = 0.040 mm (all proximal bristles about same length).

Female (Figure 15*b*). Stem with 53 segments (about same number as that of male); distal 14 or 15 segments of stem slightly wider (similar to that of male); distal end coiled as on male, possibly more tightly. Terminus with 6 bristles (3 dorsal, 3 ventral), 2 more than on male; distal dorsal and distal ventral bristle shorter and with marginal spines and 2 distal bells; long bristles with marginal spines and 4 distal bells; clapper similar to that of male; 5th and 7th ring of stem (counting from distal ring) with dorsal bristle about half length of long terminus bristles and bearing distinct marginal spines, 3 distal bells, and clapper similar to those on bristles of terminus; 7th and 9th rings with ventral bristle similar to those of dorsal margin of stem. Distal end of terminus with 5 indistinct trifid teeth (3 ventral,

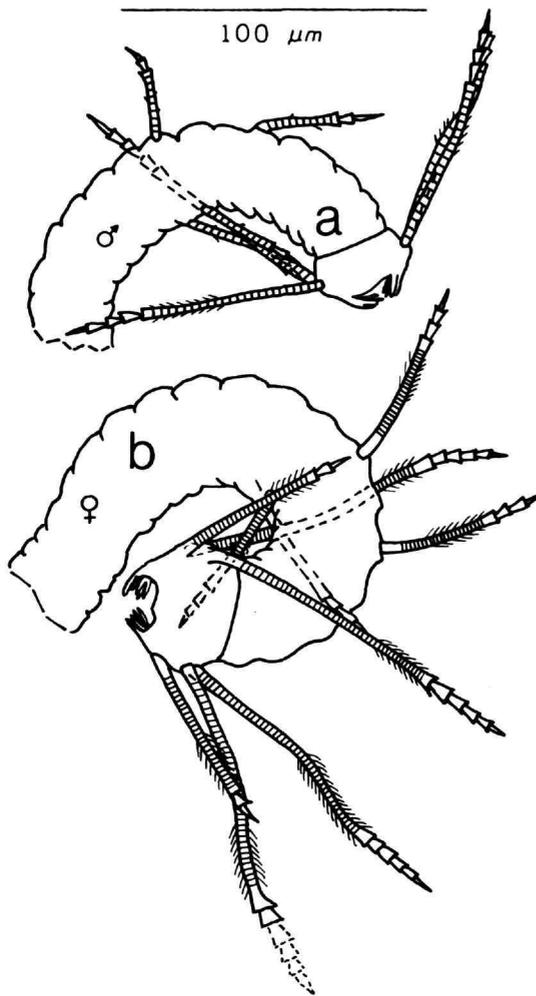


FIGURE 15.—*Rutiderma hartmanni*, 7th limbs of adults: a, male, USNM 158218; b, female, USNM 158219.

2 dorsal), not spinous teeth like those of male. Measurements: a = 0.56 mm (similar to that of male); b = 0.040 mm (21 percent broader than male); c = 0.035 mm (17 percent broader than male); d = 0.11 mm (22 percent longer than male), 0.12 mm (33 percent longer than male); e = 0.06 mm, 0.06 mm (33 percent shorter than male); f = 0.06 mm (all proximal bristles not greatly different in length; 50 percent longer than male). Summary of sexual dimorphism: distal end of limb broader on female; terminus with

more teeth on female, and teeth trifid rather than with fronds; female with additional ventral and dorsal bristle on terminus; bristles mostly longer on female and bear stouter marginal spines; stem bristles with additional bell.

Furca: Male (Figure 16a,b). Each lamella with 4 primary claws followed by 2 secondary claws; claw 1 with slender lateral and medial teeth along posterior margin, some lateral teeth longer than others (Figure 16b); posterior teeth of claw 2 more numerous and more slender than those on claw 1 (Figure 16b); claws 1 and 2 with long medial hairs forming row near base; primary claws 3 and 4 with slender spines along posterior margin; secondary claws with slender spines along anterior and posterior margins; primary claws with few slender spines along anterior margin; long hairs on distal anterior margin of lamella, and on lamella between and posterior to secondary claws.

Female (Figure 16c,d). Primary claws 1 and 2 shorter than those of male; lateral teeth along posterior margin of claw 1 longer and stouter than those of male (Figure 16d). Lamella slightly shorter than that of male. In remaining characters female furca similar to that of male.

Organ of Bellonci: Male (Figure 17a). Elongate with broad, short, central part bounded on some specimens by indistinct suture; distal part broadening slightly and terminating in rounded tip (in some specimens tip in outline shaped like gothic arch). When viewed at high magnification ($\times 50$ objective) broad middle segment with fine striations, and distal segment with few minute spines.

Female (Figure 17b). Similar but slightly shorter than that of male. Illustrated specimen having broad middle segment partly retracted like sleeve over proximal segment.

Eyes: Male (Figure 17a). Lateral eye larger than medial eye, with brown or black pigment and about 20 weakly divided ommatidia, some much smaller than others. Medial eye pigmented, tapering distally. Pigment light on some specimens.

Female (Figure 17b). Lateral eye unpigmented, minute, with 4 or 5 ommatidia. Medial

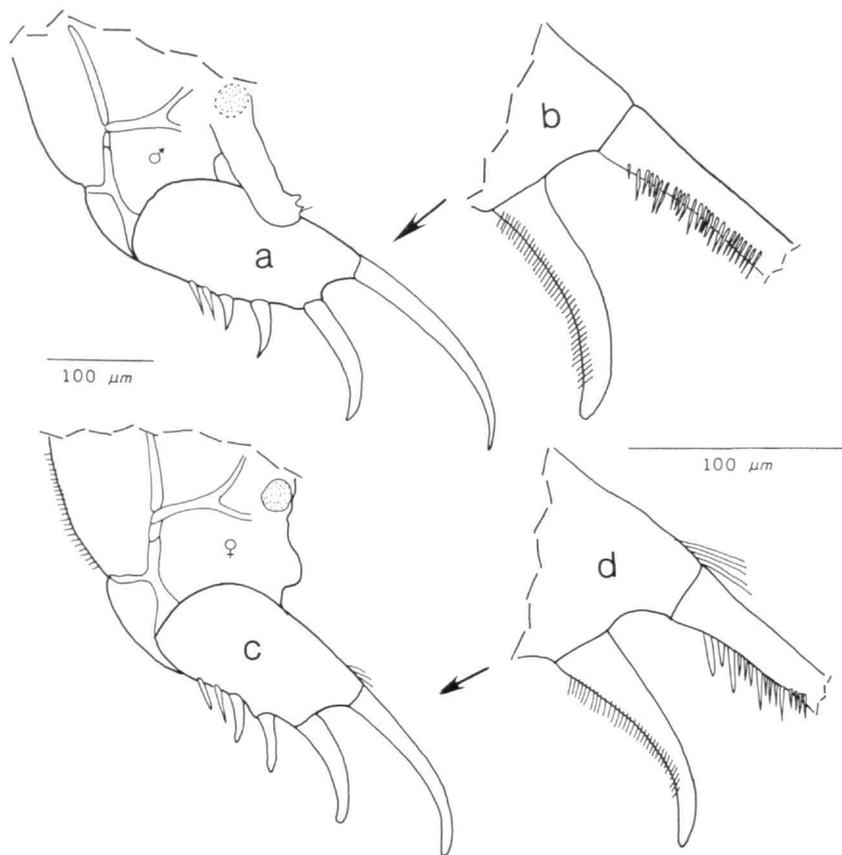


FIGURE 16.—*Rutiderma hartmanni*, right lateral views of bodies of adults showing right lamellae of furca, right genitalia, and internal sclerites: *a, b*, male, USNM 158218; *c, d*, female, USNM 158219. (Left scale for *a* and *c*; right scale for *b* and *d*; stippled area = part of genitalia.)

eye similar to that of male but somewhat larger. (Lateral eyes not observed on all specimens).

Upper Lip: Similar in male (Figure 17*a*) and female (Figure 17*b*); simple, rounded.

Anterior of Body: Male (Figure 17*a*). With broad anterior projection at midheight.

Female (Figure 17*b*). With small rounded process at midheight.

Posterior of Body: Male (Figure 3*a*). Evenly rounded. Hairs not observed on 2 specimens examined.

Female (Figure 3*b*). Similar to that of male but with distinct hairs.

Genitalia: Male (Figure 16*a*). Elongate cop-

ulatory limb on each side terminating in small lobes bearing minute processes and bristles.

Female (Figure 16*c*). Small oval on each side of body.

Posterior Sclerites: Similar on male (Figure 16*a*) and female (Figure 16*c*). Y-sclerite normal for genus, branching distally (Figure 16*a, c*).

Heart: Well defined in male (Figure 3*a*); less well defined and smaller in female (Figure 3*b*).

Number of Eggs in Marsupium of Female: USNM 158219 with 4; USNM 193060 with 3; USNM 193064 with 4; USNM 193066, 3 specimens each with 3, 1 specimen with 4.

Gut Content: Male. USNM 158218 with fairly

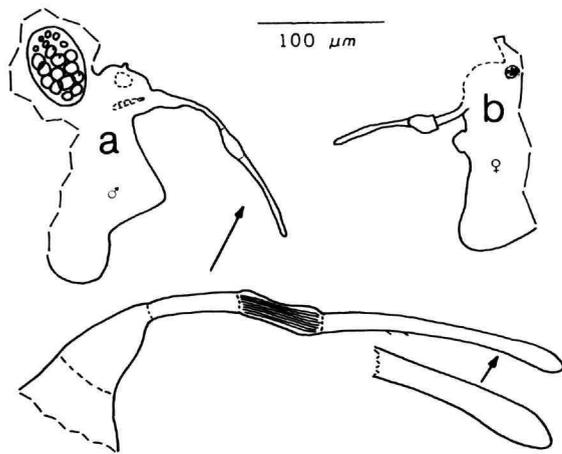


FIGURE 17.—*Rutiderma hartmanni*, lateral view of anterior of bodies of adults showing lateral eyes, medial eyes and bellonci organ, upper lip: a, male, USNM 158218; b, female, lateral eye from USNM 158217, remaining part from USNM 158219.

large, egg-like spheres (Figure 18a); USNM 190365A with egg-like spheres and minute sclerites of unknown organism (Figure 18b).

Female. USNM 193064A with nematode remains (Order Desmodorida according to Dr. Duane Hope, Smithsonian Institution). This order comprises only free-living forms; only the outer integument was in the gut.

Juveniles

Carapace: Juvenile carapaces of both sexes resemble in outline and ornamentation that of the adult female (Figures 2d, 19a,f). Dimensions of stage II male: length 0.60 mm, height 0.44 mm (Figure 19a). Dimensions of stage III female (Figure 19f): length of 0.75 mm, height 0.50 mm. Growth factor for length of 2 stages 1.25. Dimensions of stage IV males: USNM 193068: length 0.99 mm, height 0.66 mm (Figure 2d); USNM 193067, 2 specimens: length 0.96 mm, height 0.67 mm; length 0.98 mm, height 0.65; USNM 193064C: length 0.94 mm, height 0.58 mm, mean length 0.97 mm, mean height 0.63 mm. Dimensions of stage IV females: USNM 193067, 6 specimens: length 0.93mm, height

0.59 mm; length 0.89 mm, height 0.60 mm; length 0.97 mm, height 0.65 mm; length 0.94 mm, height 0.65 mm; length 0.90 mm, height 0.59 mm; length 0.90 mm, height 0.62 mm; USNM 193064D: length 0.97 mm, height 0.65 mm; mean length 0.93 mm, mean height 0.62 mm. Growth factor for length of female at stage III and female at stage IV 1.24. Growth factor for length of female at stage IV and female adult 1.15.

First Antenna: Instar II male (Figure 19b): 1st joint bare, 2nd joint with 1 dorsal and 1 lateral bristle, 3rd joint with 1 dorsal and 1 ventral bristle, 4th joint with 1 dorsal bristle, 5th joint with bare sensory bristle, 6th joint with distal medial bristle, 7th joint with bare a-, b-, and c-bristles, 8th joint with d-, e-, f-, and g-bristles; g-bristle with 1 proximal filament, other bristles bare. Instar III female (Figure 19g): 3rd joint with additional dorsal bristle; 4th joint with 1 ventral bristle. Instar IV male: 4th joint with additional ventral bristle and 1 dorsal bristle; g-bristle with 2 proximal filaments (1 more than on adult female).

Second Antenna: Instar II male (Figure 19c): protopodite pear-shaped, similar to that of adult female; exopodite with 9 joints bearing short bristles; 9th joint with 3 bristles; endopodite with small 1st joint bearing 1 proximal anterior bristle; 2nd joint slightly longer than 1st joint, with rounded tip bearing minute subterminal process. Instar III female: 9th exopodial joint with 4 short bristles; endopodite single-jointed with 2 proximal anterior bristles. Instar IV male: 9th exopodial joint with 5 short bristles; endopodite 3-jointed: 1st joint with 3 proximal and 1 distal bristle, all on anterior margin; 2nd joint elongate with short distal bristle; 3rd joint elongate with rounded tip and 2 short terminal bristles.

Mandible: Instar II male: coxale endite bifurcate at tip, pectinate; basale with 4 proximal ventral bristles (2 unringed, pectinate; 2 ringed), 1 ventral bristle near midlength and 3 dorsal bristles; 1st endopodial joint with 2 ventral bristles; 2nd endopodial joint with 3 dorsal bristles, 1 small ventral a-bristle, no b-bristle, 1 stout c-bristle similar to that of adult female, 1 stout d-

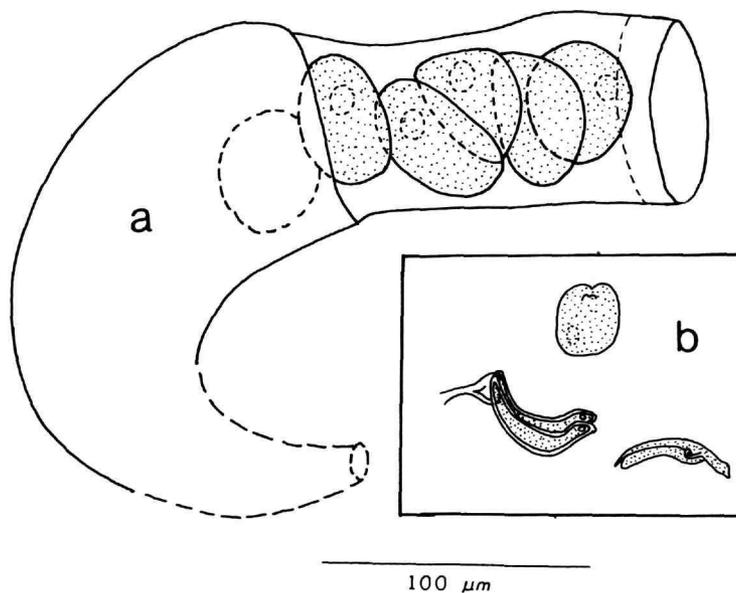


FIGURE 18.—*Rutiderma hartmanni*, gut contents of adult males: *a*, egg-like spheres within gut (anterior of gut to right, anus dashed to bottom), USNM 158218; *b*, egg-like spheres and sclerites in gut of USNM 190365A.

bristle with proximal ventral teeth (bristle about twice width of normal d-bristle but about same length); 3rd endopodial joint with 2 a-bristles, otherwise like that of adult female. Instar III female (Figure 19g): basale with additional ventral bristle near midlength; 2nd endopodial joint with additional a-bristle, b-bristle similar to that of adult female, 1 slender ringed d-bristle; 3rd endopodial joint with additional a-bristle. Instar IV male: mandible similar to that of adult female and also instar III female.

Maxilla: Instar II male: 3 endites present, each with 2 or 3 stout pectinate claws and few slender bristles; endite I also with proximal lateral bristle; coxale with 1 dorsal bristle; basale with 3 distal bristles (1 dorsal, 1 ventral, 1 medial); exopodite short with 2 bristles (1 about half length of other); 1st endopodial joint with 1 alpha- and 1 beta-bristle; 2nd endopodial joint with 2 stout pectinate claws and 5 slender ringed bristles. Instar III female (Figure 19g): precoxale with dorsal fringe of fine hairs, limb otherwise similar to that of instar II male. Instar IV male:

similar to instar III female.

Fifth Limb: Instar II male (Figure 19e): epipodial appendage with 27 bristles; endite I with 3 bristles; endite II with 5 bristles; endite III obscure, with about 5 bristles; main tooth of 1st exopodial joint with 2 large teeth with secondary teeth followed by smaller smooth tooth, and with 2 proximal bristles (1 on inner edge and 1 on outer edge); large, tooth-like 2nd joint with 2 lobes on inner edge (not 3 as on adult female), 1 bristle proximal to proximal inner lobe, and 2 smaller bristles adjacent to inner lobe; 3rd exopodial joint with 2 or 3 bristles on inner lobe and 2 on outer lobe; fused 4th and 5th joints with total of 4 bristles. Instar III female (Figure 19g): epipodial appendage with 32 bristles.

Sixth Limb: Instar II male (Figure 19d,e): limb with 1 bristle on anterior margin in place of endite, a minute nub with several hairs at anterior end of end joint, and with hairs along ventral margin of end joint. Instar III female (Figure 19g): endite I with 1 or 2 short bristles and 1 longer bristle; endite II with 1 long and 1 short

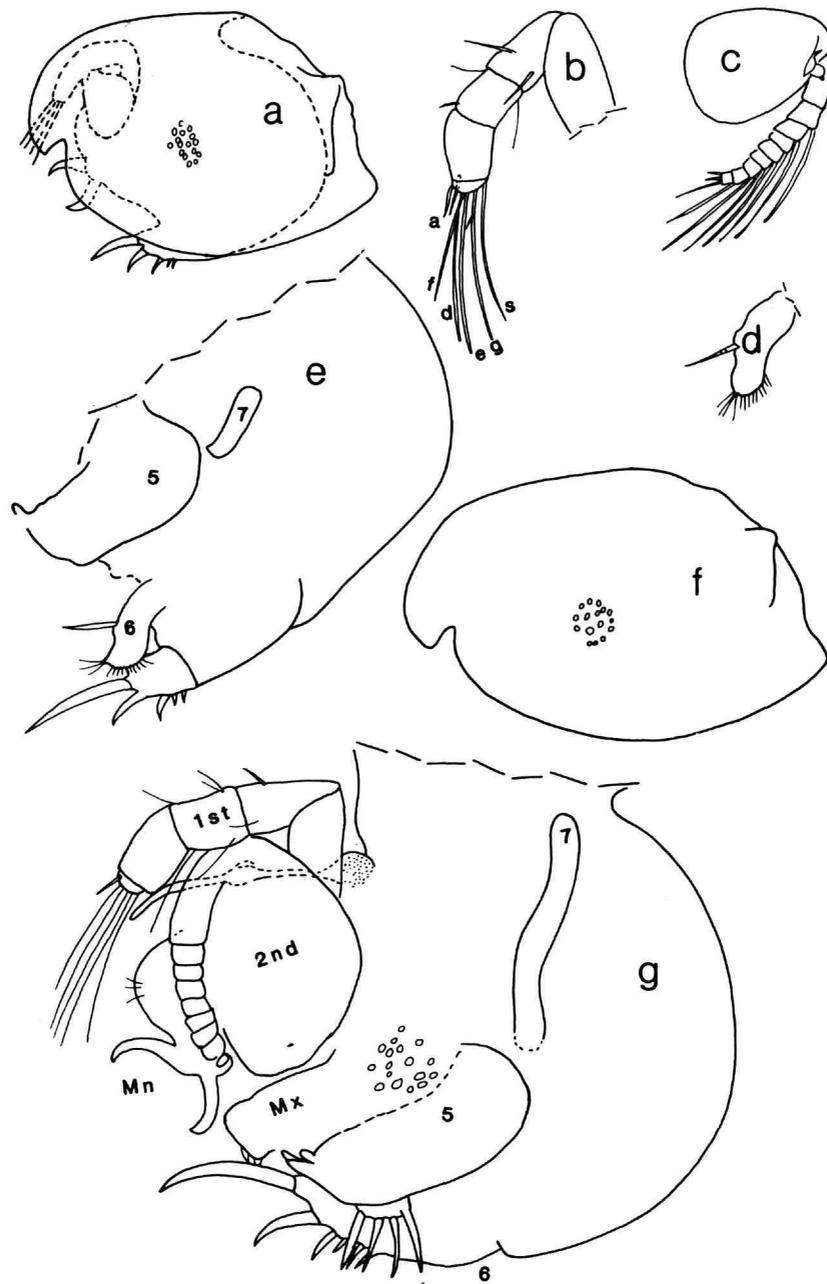


FIGURE 19.—*Rutiderma hartmanni*, instar II, male, USNM 193070, length 0.60 mm: *a*, complete specimen; *b*, left 1st antenna, lateral view; *c*, left 2nd antenna, medial view; *d*, left 6th limb, lateral view; *e*, posterior of body showing 5th, 6th, 7th limbs, and left lamella of furca (bristles omitted from 5th limb). Instar III, female, USNM 193069, length 0.75 mm: *f*, complete specimen; *g*, body without carapace. (Abbreviations same as in Figure 3; many bristles omitted from appendages.)

bristle; endite III with 2 long and 1 short bristle; endite IV with 1 long and 1 short bristle; end joint with 2 bristles on anteroventral projection, and 3 stouter bristles along posterior end of ventral margin. Instar IV male: end joint with total of 6 bristles.

Seventh Limb: Instar II male (Figure 19e): cylindrical, short, bare. Instar III female (Figure 19g): about 3 times longer than limb of instar II, bare. Instar IV male: about twice length of limb of instar III female, with 4 tapering proximal bristles (2 on each side) and 4 slightly tapering terminal bristles (2 on each side); proximal bristles with 2 or 3 distal bells, terminal bristles with 4 distal bells; tip with opposing combs with few teeth.

Furca: Instar II male (Figure 19e): with 3 primary claws followed by 2 secondary claws. Instar III female (Figure 19g): with additional small primary claw following claw 3. Instar IV male: 4th primary claw becoming larger.

Lateral Eye: Instar II male and instar III female: not observed. Instar IV male: almost as large as medial eye, pigmented black, with about 12 ommatidia.

Medial Eye: Instar III female and instar IV male: pigmented brown.

Organ of Bellonci: Instar III female and instar IV male: elongate, broadening near middle, with rounded tip.

Y-Sclerite: Instar II male, instar III female, instar IV male: similar to that of adult.

Gut Content: Instar II male: with 2 copepod exoskeletons in gut (protoplasm not present). Instar III female: with copepod and egg-like mass in gut.

Molting: Valves of almost all juveniles in the collection contain abundant minute granules of unknown composition; these are sparse or absent in the carapaces of adults, and differ considerably from sparse, larger, calcareous nodules observed in a few adults. In a male A-1 instar (USNM 193068) in which the new carapace as well as new appendages could be seen within the old, the new carapace contains abundant granules, whereas the old carapace is without granules

(Figure 2d). Possibly, granule formation is related to molting, specifically to deposition of calcium, but additional study is needed to determine if the granules are related to smaller granules observed in podocopid ostracodes by Rosenfeld (1982:12) and Okada (1982, fig. 4), or to spherulites observed in a halocyprid ostracode by Bate and Sheppard (1982:27).

FUNCTIONAL MORPHOLOGY

Carapace: The central adductor muscles are attached to the valves close to valve midlength on the adult male of *R. hartmanni* and considerably anterior to valve midlength on adult females (Figure 20). On the A-1 instar (male and female) the location of the muscle attachment is between that found on adults of both sexes, but closer to the location of the muscle attachment of the female than that of the male (Figure 20). The posterior migration of the adductor muscle of the male may be required to make room for the massive protopodite of the 2nd antenna. The posterior margin of the protopodite is slightly

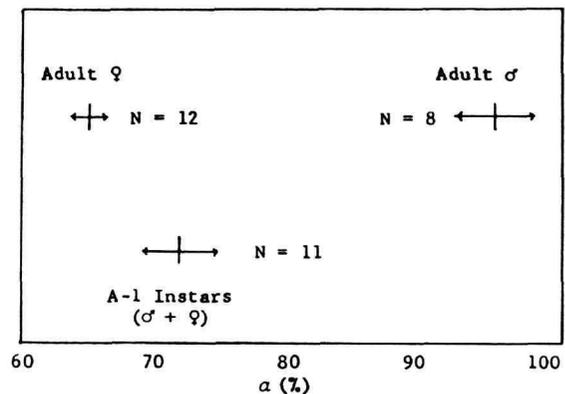


FIGURE 20.—Diagram showing position of central adductor muscles in carapaces of adult males and females and the A-1 instars of *Rutiderma hartmanni*. (a = distance from center of muscle attachments to anterior of carapace as percentage of distance from center of muscle attachments to posterior of carapace; N = number of specimens; vertical bar represents mean; arrows extend 2 standard errors in each direction.)

indented to accommodate the adductor muscle (Figure 2a). The anterior migration of the adductor muscle of the female may be required in order to accommodate the 3 or 4 fairly large eggs carried by the ovigerous female within the carapace posterior to the body (Figure 2b).

First Antenna: The 1st antenna of the adult male is longer than that of the adult female but both extend about the same length past the protopodite of the 2nd antenna (Figure 3). This suggests that the greater length of the male 1st antenna is required because the male protopodite of the 2nd antenna is much longer than that of the female. Unlike the female the adult male bears on the 5th joint a sensory bristle with numerous filaments probably used for seeking the female. The c- and f-bristles of the 8th and 9th joints, respectively, of the adult male are extremely long and bear many short filaments. Müller (1894:24) believed that similar bristles on a species of the family Philomedidae may be feelers; he observed that the 2 bristles remain folded back and inside the carapace during swimming and burrowing. On preserved specimens the long c- and f-bristles of Rutidermatidae are invariably folded back but in life they probably can be extended forward, because similar bristles on some species of Philomedidae have been preserved in both forward and backward positions (e.g., Kornicker, 1978, fig. 21b for preservation in forward position). Because male *Rutiderma* are probably not predatory, it seems likely that the c- and f-bristles are for seeking females, and possibly used also after contact with a female. The d- and e-bristles of both males and females, as well as juveniles, have a blunt tip and probably have a sensory function (chemical?).

Second Antenna: Juvenile rutidermatids are unable to swim. All exopodial bristles of the 1st antenna are without natatory hairs and are extremely short. Exopodial bristles of distal joints (6–9) of the adult female have natatory hairs (except for 2 minute bare bristles of 9th joint), showing that females are capable of swimming. In the rutidermatid genus *Alternochelata*, natatory bristles of the adult female are broken off

after mating, relegating the female to a crawling or borrowing existence (Kornicker, 1983:12). Known females of *Rutiderma* retain natatory bristles. Bristles on joints 2–5 are without natatory hairs and have ventral spines, suggesting that they may be used in crawling or burrowing. The protopodite of the adult male is massive, covering about $\frac{2}{3}$ of the body anterior to the adductor muscles (Figure 3a). Only bristle of the 2nd joint and a small bristle on the 9th joint are without natatory hairs, and the proximal bristles are much longer than those of the female. The length of the exopodite relative to the protopodite is about the same on males and females, but the exopodite of the male is much longer than that of the female (Figure 8). The additional length is mainly the result of the male having a 3rd joint about 3 times the length of that of the female (Figure 8). The morphology of the male 2nd antenna indicates that the male is a much more powerful swimmer than that of the female; this suggests that the male may range widely in seeking females.

The endopodite of the female consists of a small joint, but that of the male is 3-jointed, with a long 3rd joint capable of being reflexed on a long 2nd joint. There is little doubt that the male endopodite clasps the female during copulation. It is not known whether copulation takes place on or above the bottom. Preadult male instars have endopodial appendages more developed than those on females but probably have little function. Why the male endopodite develops gradually from instar to instar, and the male protopodite and exopodite develop in one step is not known.

The posterior margin of the protopodite of the adult male bears a notch near the upper end to accommodate the lateral eye and a shallow indentation near the middle to accommodate the central adductor muscles.

Mandible: The male mandible resembles in morphology and musculature the mandible of members of the genus *Philomedes* (Philomedidae), especially the male *Philomedes*, which, like *Rutiderma*, has a minute or no coxale endite. It

has been concluded that although the end claw of *Philomedes* cannot be bent back to reach the mouth with food, it may be used "to kick up food particles towards it" (Mahoon, 1965:56) or "to disturb particles which are then sucked into the shell" (Cannon, 1933:755). The male mandible of *Rutiderma* probably serves a similar function. The mandible of the male *R. hartmanni* may be without a coxale endite, or if present the endite is represented by a minute spine near midlength of the coxale (the presence or absence of the spine could not be resolved with certainty). The small spine, if present, is unlikely to serve in feeding, even though it is positioned in the vicinity of the mouth (for illustration showing relationships of mandible and anterior of body see SEM micrograph of *R. ovata* in Kornicker, 1975, fig. 422A).

The chelate end of the female mandible (and juveniles of both sexes) is not found on other Ostracoda, nor, as far as I know, is it present on any known crustacean. The function of the chela has not been determined by observation of living specimens, nor have any preserved specimens been reported having prey caught between the pincers. Even without such direct evidence, the morphological similarity of rutidermatid pincers and those of other arthropods (on appendages other than the mandible), on which they are known to have a grasping function, leads to a conclusion that the pincers have a similar function on rutidermatids. When the limb is in a withdrawn position the pincers are near the mouth and maxilla (Figure 3b). (For illustration showing relationship of mandible and maxilla, see photographs of *R. darbyi* in Darby, 1965, pl. 13: fig. 1.) A small process with a minute terminal spine is located medially on the 2nd endopodial joint, near the base of the terminal claw on that joint (Figure 10b). A narrow passage extending to the tip of the spine is visible at high magnification ($\times 100$ objective), but whether the process and spine has a sensory function or one related to food capture is not known. Unlike the coxale endite of the male, that of the female-type mandible is well developed, and could be used to

move food into the mouth area, where it could be acted upon by the maxilla. The coxale of the female is shorter than that of the male, requiring the endite to be near the distal end of the joint for it to be adjacent to the mouth. The need to activate the chela of the 3rd joint has produced powerful remotor (retractor) muscles. The greatly increased mass of these muscles compared to the slender equivalent muscles of the male requires additional space in the 1st and 2nd endopodial joints. The resulting broadening of the 2 joints accounts for much of the morphological divergence of this limb in males and females.

Muscles inserted on the coxale permit extension and retraction of the joint relative to apodemes within the body to which the proximal end of the muscles are attached; an inward movement towards the mouth is also probable. Muscles inserted on the basale permit extension and retraction of the joint relative to the coxale, and muscles inserted on the 1st endopodial joint permit extension and retraction of that joint relative to the basale. Muscles inserted on the 2nd and 3rd endopodial joints permit only their retraction (Figure 10b). Apparently the 1st to 3rd endopodial joints are extended as a unit.

The base of the 3rd endopodial joint of the male is parallel to the distal end of the 2nd endopodial joint and the relationship probably changes only slightly on retraction of the 3rd joint (Figure 10a). The relationship of the 2nd and 3rd joints of the female (also juveniles of both sexes) is quite different. The base of the 3rd joint forms a right angle with the distal end of 2nd joint when the remotor muscles (retractors) are relaxed (Figure 10b). In this position the chela (claw) of the 3rd joint is in an open position (Figures 10b, 11b).

The pincer-like claws of the 2nd and 3rd endopodial joints of the female-type mandible are closed by an unusual mechanism. Movement is entirely by the 3rd joint; the claw of the 2nd joint remains in place. A crescent- or L-shaped apodeme (designated herein as the L-sclerite) considered herein to be part of the 3rd joint, but a part absent on the adult male, lies within the

distal part of the 2nd endopodial joint (Figure 10*b-d*). The distal end of the L-sclerite is connected to the ventral corner of the base of the 3rd joint with a short flexible tendon serving as a hinge (Figure 10*c*). Two powerful remotor muscles are attached to the proximal margin of the sclerite (Figure 10*d*). When the muscles are in the retracted state they exert a proximal pull on the L-sclerite. This pull is transmitted to the ventral corner of the base of the 3rd joint through the tendon at the distal end of the L-sclerite. The 3rd joint is then rotated, effectively closing the pincers (Figure 10*d*). The pivot on which the 3rd joint rotates may be a minute, ball-and-socket arrangement with the "ball" being near the middle of the medial side of the 3rd joint and the "socket" being at the dorsal tip of the proximal end of the terminal claw of the 2nd joint (Figure 10*c,d*) but the pivot could not be observed with sufficient clarity to be certain of its presence, or of its purpose if present.

The conclusion that the relaxed position of the 3rd joint leaves the pincers open is based on 2 observations. The primary observation is the absence of muscles that could open the pincers; only muscles for closing the pincers were observed. The secondary observation is based on the examination of 13 preserved specimens: the pincers were open on 9, closed on 3, and 1 had one limb with open pincers and the other with closed pincers. A conclusion drawn from the secondary observation must be tenuous as it assumes that the preservative encourages relaxation of the muscles, which may not be warranted. Possibly, the pincers are mostly open on preserved specimens because of it being a "defensive" position assumed by the animal immediately prior to death and retained after death.

The mechanism opening the pincers when the remotor muscles are relaxed is not known. Possibly, when the remotor muscles of the 3rd joint close the chela the flexible integument connecting the 2nd and 3rd joints is stretched. Then, when the muscles are relaxed, the integument returns to its original length, effectively closing the chela. Initially, I thought that 3 or 4 indis-

tinct, barely visible filaments extending from the vicinity of the distal edge of the 2nd joint to the proximal part of the L-sclerite of the 3rd joint might be tendons. Such tendons could close the pincers, but I concluded that the "filaments" are too slender and vague to be tendons. Cannon (1933:75) concluded that blood-pressure, not muscle activity, relaxes the mandible of members of the Philomedidae and Cypridinidae. Opening the pincers in the mandible of Rutidermatidae by blood-pressure seems unlikely but remains a possibility.

Maxilla: The female maxilla bears powerful, pectinate, claw-like bristles on both the endites and the end joint of the endopodite. The bristles are well adapted for pushing food into the mouth and possibly also maturing it (Figure 12*b*). The male maxilla is relatively weak and is without pectinate, claw-like bristles (Figure 12*a*). The end joint of the male endopodite bears a bristle longer than those of the female, and the endites as well as the end joint of the maxilla have unringed hyaline bristles; the function of these bristles is unknown but clearly the male eats in a different manner than the female. If it were not that food was found in adult males of *R. hartmanni* herein, and was reported previously in an adult male of *R. ovata* by Kornicker (1975:65), I might have concluded that the male does not eat. The vestigial nature of the male maxilla does suggest that its role in feeding is minimal. Skogsborg (1920:375) concluded that the reduced maxilla of male *Philomedes* (Philomedidae) "cannot be used as a masticatory organ"; the maxillae of male *Philomedes* and *Rutiderma* are fairly similar.

Fifth Limb: The epipodial appendages of males and females are similar in size and have about the same number and types of bristles. A function of the epipodite is to pull in water through the front of the shell, and that water may bring food with it (see Cannon, 1933, for the action of the epipodite on members of the Philomedidae, Cypridinidae, and Cylindroleberididae). The same amount of water might be drawn in by the male and female but the food in

the water may play a greater role in nourishing the male than the female, which has a chelate mandible for capturing prey. The stout teeth of the 1st exopodial joint and also the large sclerotized 2nd joint of the female are probably used to push food towards the mouth (Figure 13*c,d*). The male bears finger-formed hyaline bristles on the 1st and 2nd exopodial joints, but their role in feeding is unknown (Figure 13*a*).

Lateral Eyes: The lateral eye of the males is large and contains many well-developed ommatidia (Figure 4*a*). That of the female is minute (possibly absent on some specimens) with few poorly developed ommatidia (Figure 4*b*). The lateral eye is probably used by the male in seeking or recognizing females. The poorly developed eye of the female suggest that it is of minimal use to the female, which probably spends most of its life crawling or burrowing. In late juveniles (A-1) the lateral eye of males is smaller than that of

the adult but much larger than that of females. Because juvenile males and females appear to occupy the same niche (crawling or burrowing), the better development of the eye may have little benefit to the juvenile male. Probably the lateral eye requires gradual ontogenetic development, more than the one-step observed for some characters such as the c- and f-bristles of the male 1st antenna.

Heart: The heart in *R. hartmanni* seems to vary somewhat in size from specimen to specimen, but in general the male heart (Figure 3*a*) is larger than that of the female (Figure 3*b*), and the integument enclosing the vessel appears to be more strongly sclerotized (based on greater density of amber-colored integument covering heart of male). Possibly, the observed difference results from the male requiring a higher circulation rate because of its swimming life mode.

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Bibliography, depending upon use, is termed "Literature Cited," "References," or "Bibliography." Spell out titles of books, articles, journals, and monographic series. For book and article titles use sentence-style capitalization according to the rules of the language employed (exception: capitalize all major words in English). For journal and series titles, capitalize the initial word and all subsequent words except articles, conjunctions, and prepositions. Transliterate languages that use a non-Roman alphabet according to the Library of Congress system. Underline (for italics) titles of journals and series and titles of books that are not part of a series. Use the parentheses/colon system for volume(number):pagination: "10(2):5-9." For alignment and arrangement of elements, follow the format of recent publications in the series for which the manuscript is intended. Guidelines for preparing bibliography may be secured from Series Section, SI Press.

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