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FOSSIL DECAPOD CRUSTACEANS OF CANADA

R.M. FELDMANN
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Energy, Mines and Resources Canada
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Foreword

For nearly 100 years, decapod crustaceans have been collected from Canada and the studied material is stored in the National Type Fossil Collection at Geological Survey headquarters. Almost invariably, this material has been collected incidental to some other paleontological or stratigraphic work - decapods are almost always exceedingly rare. The taxonomic treatment of these organisms has been the subject of numerous short papers describing the material, most of which were written 75 to 100 years ago. This present work is an attempt to compile all of the information available on decapods that have previously been described from Canada and to relate it to current stratigraphic and biologic concepts.

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FOSSIL DECAPOD CRUSTACEANS OF CANADA

Abstract

Examination of type and non-type material of fossil decapod crustaceans collected from Canada has resulted in the description of two new species, Glyphea robusta and G. jeletzkyi from Lower Jurassic and Lower Cretaceous rocks of Arctic Canada; reassignment of three taxa to other genera, Erymastacus bordenensis Copeland to Eryma, Eryma dawsoni Woodward to Phlyctisoma, and Hoploparia westoni Woodward to Palaeonephrops; and suppression of one taxon, Palaeastacus(?) ornatus Whiteaves as a nomen oblitum. One of the newly described species, Glyphea robusta exhibits not only the complete exoskeleton but also an exceptionally well preserved endoskeleton, the second such known to be described in decapod literature. A total of thirteen species of decapods, arranged in nine genera and seven families, are recorded from Canada.

Résumé

L'examen d'éléments, types et hors types, de crustacés décapodes fossiles ramassés au Canada a eu pour résultats: la description de deux nouvelles espèces Glyphea robusta et G. jeletzkyi appartenant au Jurassique inférieur et au Crétacé inférieur de l'Arctique canadien; le changement de genre de trois taxons, Erymastacus bordenensis Copeland attribué au genre Eryma, Eryma dawsoni Woodward au genre Phlyctisoma, et Hoploparia westoni Woodward au genre Palaeonephrops; la suppression d'un taxon, Palaeastacus(?) ornatus Whiteaves, qui devient nomen oblitum (nom supprimé). Une des espèces nouvellement décrite, Glyphea robusta, possède, non seulement un exosquelette complet, mais aussi un endosquelette exceptionnellement bien conservé; c'est la seconde espèce connue décrite dans la documentation concernant les décapodes. On a enregistré au Canada un total de treize espèces de décapodes, qui ont été groupées en neuf genres et sept familles.

FOSSIL DECAPOD CRUSTACEANS OF CANADA

INTRODUCTION

Decapod crustacean fossils have been collected from Canada over a span of nearly 100 years. In the late 19th and 20th centuries, associated with early geological investigation of the Cretaceous of the Rocky Mountain front and the Pacific coast, three workers - Whiteaves, Woodward, and Whitfield - examined all of the decapod material that had been collected until that time and erected ten species to embrace the material. As late as 1960, no new taxa had been added to the group. In that year, Copeland described the first Jurassic form to be collected from Canada, a result of the exploration of the Arctic Islands. In 1975, Richards described a new genus and species of crab from Cretaceous rocks on Vancouver Island. The purpose of this present work is to catalog and restudy the decapod material in the collections of the Geological Survey, to supplement the descriptions of the taxa that have not been completely described, to illustrate those that previously have been illustrated only by line drawings, to assemble a list of occurrences of these taxa, and to reassign taxa where earlier generic placement is inconsistent with modern decapod taxonomy.

AGE

The taxa and their ages are summarized in Table 1. The known specimens now can be arranged in thirteen species, two of which, Glyphea robusta and G. jeletzkyi, are described as new. Both these species result from examination of extensive collections of decapod material collected in Arctic Canada over the past 20 years. Only one of the earlier named taxa, Palaeastacus(?) ornatus Whiteaves, 1887 has been suppressed. It is apparently the senior synonym of Palaeonephrops browni (Whitfield, 1907) but is properly considered a nomen oblitum because the name has not been cited in the primary taxonomic literature for over 50 years.

Because many of the early records of collecting sites offer only sketchy information, it is difficult to upgrade stratigraphic or geographic data. Where this has been possible, with the aid of the staff of the Geological Survey of Canada, it is appended to the original data. It is interesting to note that all but two of the forms, Eryma bordenensis and Glyphea robusta, have been collected from Cretaceous strata; those two were collected from Jurassic sediments. This temporal distribution is consistent with the geologic distribution of decapods in the rest of North America where only a few taxa have been described from pre-Cretaceous rocks (van Straelen, 1936; Schram, 1971; Herrick and Schram, 1978; Feldmann, 1979).

In southern Alberta (Fig. 1), decapods occur almost exclusively in grey marine shale either in the Bearpaw Formation or the Alberta Group, both of Late Cretaceous age. Details of the stratigraphy of this sequence have recently been described by Wall and Rosene (1977). On the islands near Vancouver, British Columbia, decapods seem to be restricted to the Nanaimo Group, also of Late Cretaceous age. The Nanaimo Group consists of sediments accumulated in marine, brackish water and fluvial environments. Most of the fossil decapods probably are preserved in the Spray Formation, of marine origin, although some probably come from the Haslam and the Extension-Protection Formations (Jan Muller, pers. com., 1979). The stratigraphy of this sequence is described by Muller and Jeletzky (1970).

In northern Canada, decapods have been collected from the Arctic Islands and the Richardson Mountains, District of Mackenzie. On the Arctic Islands, Lower to Middle Jurassic rocks of the Borden Island and Wilkie Point Formations have yielded numerous specimens. The age of these units, based primarily on ammonite associations, has been determined by Tozer and Thorsteinsson (1964) and Frebold (1975). The Richardson Mountains area has yielded a few decapods of Early Cretaceous age in rocks of the Upper Sandstone Division, a unit informally designated by Jeletzky (1958).

PRESERVATION

Typical of decapods collected in the remainder of North America, specimens of nearly all the taxa are exceedingly rare. Those that are known have been preserved in concretionary structures similar to those described by Feldmann et al. (1977). The concretions are typically cemented by calcium carbonate and consist of a matrix of fine sand or calcareous material.

Richards (1975) noted the relationship between the concretions in which specimens of Longusorbis cuniculosus were preserved and occasional burrow structures. He suggested that the concretions were formed early in diagenesis as burrow fillings. Although the evidence for this mode of origin is compelling in the case of this taxon, there is little evidence to support the notion that other forms, in other rock units, were preserved by similar processes. Examination of concretions from other units shows no evidence of burrow structures and, in fact, the shape of the concretions would argue against it. Most are spherical or elliptical and give the impression of having formed as an aureole around the organism. In this regard, the concretions are quite similar to those described by Waage (1964) and others in the Fox Hills Formation in North and South Dakota, United States. Waage (1964, p. 546) suggested the possibility that they formed by organically induced precipitation of calcium carbonate very soon after burial of the animal.

This mode of origin appears to describe more closely the mode of formation of concretions surrounding most lobster specimens. Most decapod specimens preserved in concretions have been disarticulated to some degree, in contrast to the specimens of Longusorbis cuniculosus, almost all of which are complete. Some, such as a few specimens of Glyphea robusta, are clearly molt remains because they are in Salter's position (Schäfer, 1972, p. 435) but for most specimens there is no clear evidence that the remains are molts. Disarticulation of specimens would seem to argue that the organism was not protected within a burrow structure but, rather, was moved around on the substrate prior to entombment.

The general scarcity of decapod remains probably can be attributed to several factors. Decapods are never the most abundant invertebrate organisms in an assemblage so that there is relatively less likelihood of finding them

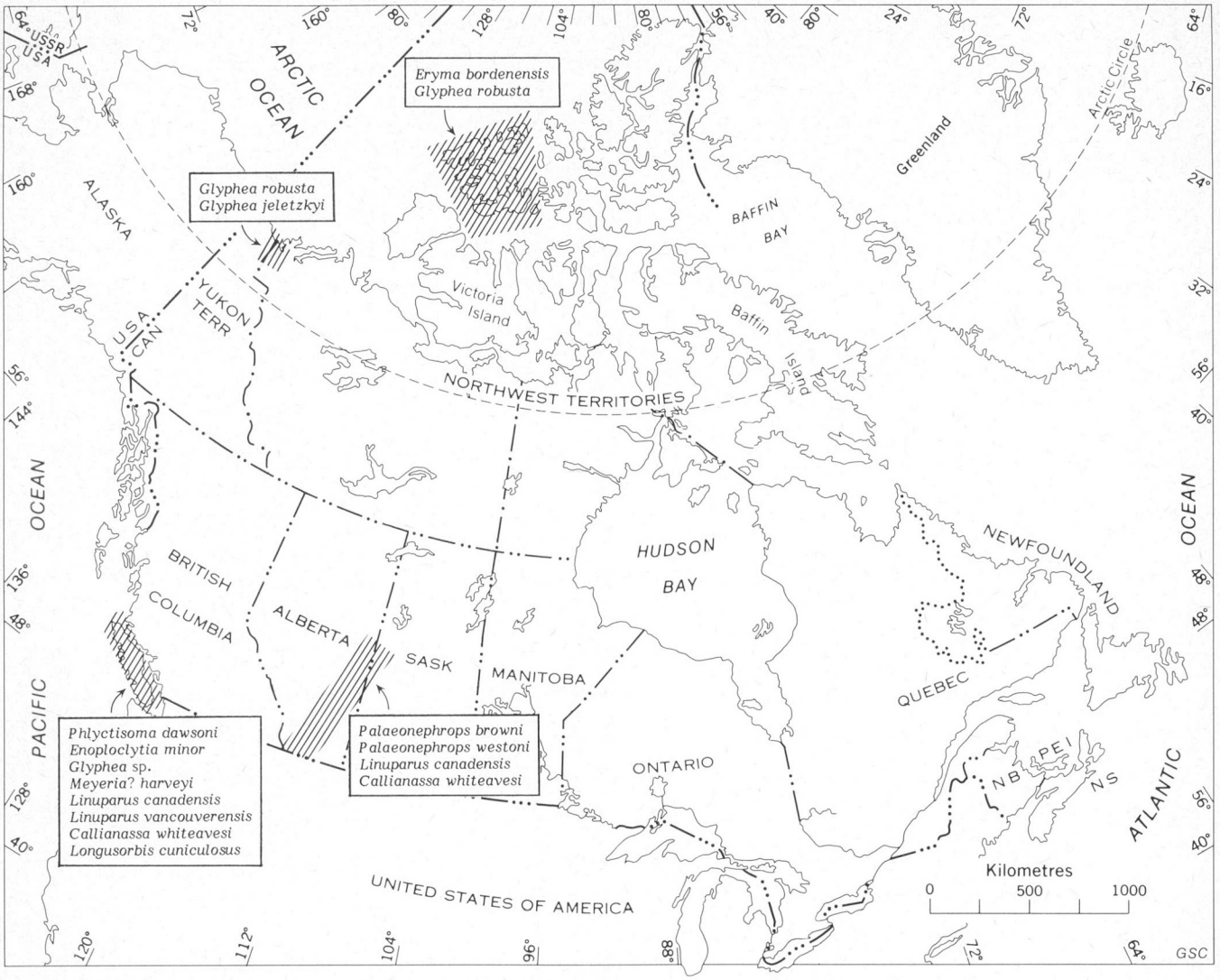


FIGURE 1. *Map showing generalized regions of Canada from which decapod fossils have been collected. The taxa listed adjacent each area have been collected at one or more sites within those areas.*

preserved as fossils than of the more abundant molluscs, for example. Additionally, the skeleton of lobsters is typically rather fragile, particularly when molted, further reducing the probability of preservation. Finally, predators and scavengers feeding on decapods would tend to break up the skeletal material when feeding on the organisms rather than extracting the soft tissues and discarding the hard parts as would be the case with most molluscs. The result appears to be that, unless the specimen is rapidly removed from the area of scavenging and abrasion by burial, the chances of preservation of recognizable material are negligible.

REPOSITORY

All type, figured and studied material is housed in the National Type Fossil Collection, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8, with the exception of the syntype of Palaeonephrops browni, AMNH 9572, deposited in the American Museum of Natural History, New York, New York.

ACKNOWLEDGMENTS

The material upon which this study was based was provided through the courtesy of T.E. Bolton and J.A. Jeletzky, Geological Survey of Canada, Ottawa. The original stratigraphic and geographic data have been updated, and refined in part, by J.R. McLean (southern Alberta), J.H. Wall (Willow Creek locality of southern Alberta), J.E. Muller (Vancouver Island area), and T.P. Poulton (Richardson Mountains and Arctic Islands) whose help is gratefully acknowledged. Their revised information is given in square brackets following data taken from the original labels. Harvey Geizer, Department of Geology, Kent State University made the line drawings in Figures 2 to 6.

TABLE 1

Systematic list of decapods from Canada with geological ranges.
Generalized locations from which these taxa have been collected are shown in Figure 1.

Order DECAPODA
- Suborder PLEOCYEMATA
  - Infraorder ASTACIDEA
    - Family ERYMIDAE
      - Eryma bordenensis (Copeland), 1960 - Early Jurassic (Sinemurian)
      - Phlyctisoma dawsoni (Woodward), 1900 -Late Cretaceous (late Campanian - early Maastrichtian)
      - Enoploclytia minor Woodward, 1900 -Late Cretaceous (late Campanian - early Maastrichtian)
    - Family NEPHROPIDAE
      - Palaeonephrops browni (Whitfield), 1907 -Late Cretaceous (Cenomanian - early Maastrichtian)
      - Palaeonephrops westoni (Woodward), 1900 -Late Cretaceous (Campanian?)
  - Infraorder PALINURA
    - Family GLYPHEIDAE
      - Glyphea robusta n. sp. - Early Jurassic (Sinemurian) to Early Cretaceous (early-mid Neocomian)
      - Glyphea jeletzkyi n. sp. - Early Cretaceous (late Barremian or Aptian)
      - Glyphea sp. - Late Cretaceous (middle Campanian)
    - Family MECOCHIRIDAE
      - Meyeria? harveyi Woodward, 1900 - Late Cretaceous (late Campanian - early Maastrichtian)
    - Family PALINURIDAE
      - Linuparus canadensis (Whiteaves), 1884 - Late Cretaceous (Cenomanian - early Maastrichtian)
      - Linuparus vancouverensis (Whiteaves), 1895 - Late Cretaceous (Santonian - early Maastrichtian)
  - Infraorder ANOMURA
    - Family CALLIANASSIDAE
      - Callianassa whiteavesi Woodward, 1896 -Late Cretaceous (late Santonian - Campanian, Maastrichtian?)
  - Infraorder BRACHYURA
    - Family CARCINERETIDAE
      - Longusorbis cuniculosus Richards, 1975 -Late Cretaceous (late Campanian - early Maastrichtian)

SYSTEMATIC PALEONTOLOGY

Order DECAPODA Latreille, 1803

Infraorder ASTACIDEA Latreille, 1803

Family ERYMIDAE van Straelen, 1924

Genus Eryma von Meyer, 1840

Eryma bordenensis (Copeland, 1960)

Plate 1, figure 3

Erymastacus bordenensis Copeland, 1960, p. 56.

Remarks. This species has been well described and illustrated by Copeland and the additional material cited below, and not described by Copeland, adds nothing new to the description. The additional material is even more fragmentary than the holotype but does show enough of the groove pattern and ornamentation in the cephalothorax to permit certain placement in the species. This new material was collected very near the type locality.

It is of note that Förster (1966, p. 106) considered Glyphea ornati to be properly referred to the genus Eryma thereby rendering Erymastacus Beurlen, 1928 the junior synonym of Eryma. The arguments of Förster are convincing and that classification is followed here.

Occurrences. Specimens of this taxon have been collected from the following localities in Canada:

1. East-central Borden Island, Northwest Territories, approximate Latitude 78°28'N, Longitude 110°07'W; holotype GSC 14496; sandstone, probably Early Jurassic (Sinemurian) (Frebold, 1975); collected by R. Thorsteinsson and E.T. Tozer, 1958. Locality 87 of Tozer and Thorsteinsson (1964).

2. Oyster River, Latitude 78°23'N, Longitude 110°41'W; GSC locality C-76362; GSC 61397, hypotype; Borden Island Formation, Sinemurian.

3. Oyster River, Latitude 78°25'N, Longitude 110°58'W; GSC locality C-76353; Borden Island Formation, Sinemurian.

Genus Phlyctisoma Bell, 1863

Phlyctisoma dawsoni (Woodward, 1900)

Plate 1, figures 4, 5, Figure 2

Eryma dawsoni Woodward, 1900, p. 400; Whiteaves, 1903, p. 321; Rathbun, 1926a, p. 128.

Remarks. The holotype of this species is the sole specimen referable to the taxon. Most of the left side of the cephalothorax and fragments of the abdomen and some of the chelae are visible. Re-examination of the holotype suggests that the species should better be referred to Phlyctisoma than to Eryma. Although he apparently did not see the holotype of this species, Förster (1966, p. 145) first noted this relationship and should be credited with the observation.

The characters displayed on P. dawsoni that confirm its placement in that genus relate to details of the groove pattern and ornamentation. The carapace on phlyctisomids is densely granular or nodose, as it is on P. dawsoni, and the groove pattern differs from that of representatives of Eryma by having a much reduced branchiocardiac groove and broad, strong hepatic, antennar, cervical and postcervical grooves (Fig. 2). In these regards, P. dawsoni very closely resembles P. tuberculata Bell, type species of the genus (Förster, 1966, p. 136).

Occurrence. Northwest side of Hornby Island, British Columbia; GSC 5969, 5969a, part and counterpart of holotype; Late Cretaceous; collected by J.B. Bennett, 1898. [Probably the marine Spray Formation but possibly the older Northumberland Formation; late Campanian to early Maastrichtian.]

Genus Enoploclytia M'Coy, 1849

Enoploclytia minor Woodward, 1900

Plate 1, figures 1, 2

Enoploclytia minor Woodward, 1900, p. 434; Whiteaves, 1903, p. 321; Rathbun, 1926a, p. 128.

Remarks. The single specimen of the species that was described by Woodward (1900, p. 434) as providing, "little comfort to the investigator" remains as the hypodigm. The specimen is extremely fragmentary but enough material is available to confirm its placement in the genus. The first three appendages are chelate, the first being the largest, which places the species in the Astacidea. The first cheliped appears to be entirely covered by rather coarse nodes and the fingers of the same appendage are extremely long and slender, confirming placement in the genus.

The integument of the cephalothorax must have been very thin because the specimen broke along the midline of the organism rather than along the exterior of the carapace. X-ray examination of the specimen does not show the presence of the carapace, and attempts to remove some of the enclosing concretion were unsuccessful; therefore, additional information regarding this species must await more, and better, material.

Occurrence. Hornby Island, British Columbia; GSC 5971, 5971a, part and counterpart of holotype; Late Cretaceous; collected by W. Harvey, 1893. [Probably Spray Formation but possibly older Northumberland or intervening Geoffrey Conglomerate; late Campanian to early Maastrichtian.]

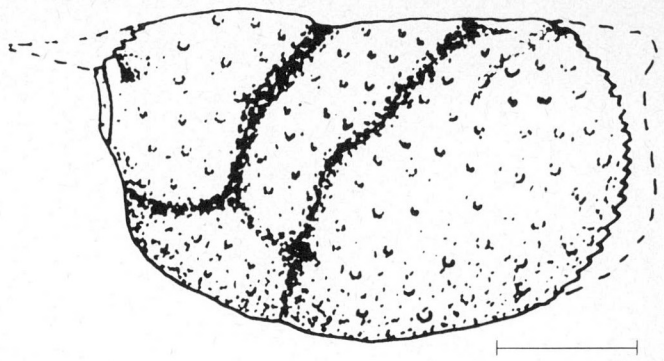


FIGURE 2. *Diagrammatic sketch of the cephalothorax of Phlyctisoma dawsoni showing groove pattern, distribution of ornamentation, and inferred outline. Bar scale = 1 cm.*

Family NEPHROPIDAE Dana, 1852

Genus Palaeonephrops Mertin, 1941

Palaeonephrops browni (Whitfield, 1907)

Plate 2, figures 1, 10

Palaeastacus(?) ornata Whiteaves, 1887, p. 161E; 1889, p. 183, Pl. 25, fig. 3; nomen oblitum.

Palaeastacus(?) ornatus Whiteaves, Woodward, 1900, p. 399.

Hoploparia browni Whitfield, 1907, p. 459, Pl. 36; Glaessner, 1929, p. 217; Jensen and Varnes, 1964, p. 8, 10.

Hoploparia westoni Woodward, Rathbun, 1930, p. 181.

Palaeonephrops browni (Whitfield), Mertin, 1941, p. 168; Woods, 1957, p. 156; Glaessner, 1969, p. R458, Fig. 264, 2; Feldmann et al., 1977, p. 1161, Pls. 1, 2.

Remarks. Specimens referable to this species have been collected from several Upper Cretaceous localities in Alberta and two of these, hypotypes GSC 45739, 45740, were incorporated in an earlier, extensive study (Feldmann et al., 1977) of Palaeonephrops browni. The additional material listed below extends the geological and geographical range of the taxon slightly but adds no new information to our understanding of the morphology.

Rathbun (1930, p. 181) referred a single specimen, University of Alberta 409, to Hoploparia westoni Woodward. Her description and illustrations (ibid., Figs. 1–3) clearly indicate that this specimen is better referred to P. browni.

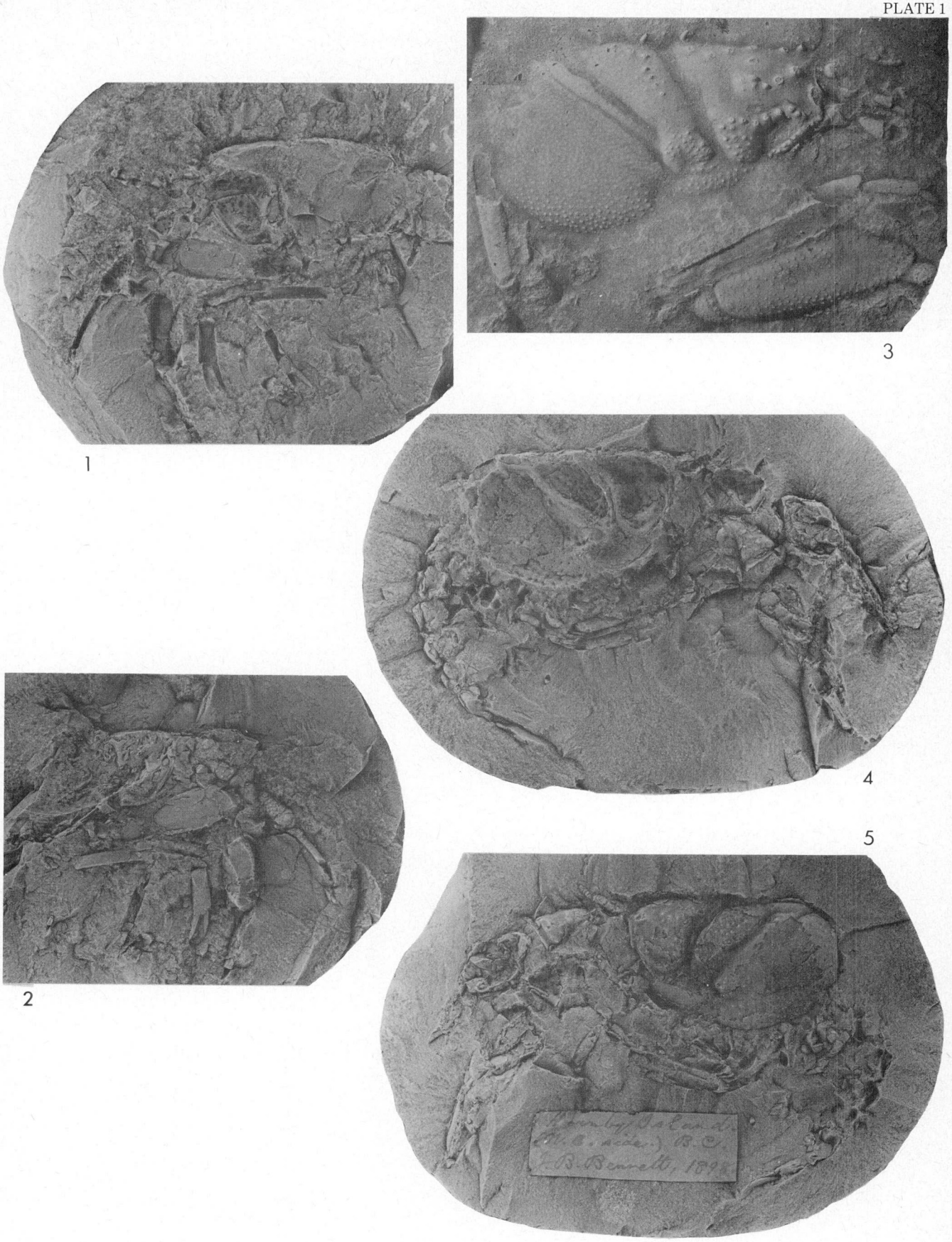
PLATE 1

All figures x1, unless otherwise indicated

Figure 1, 2. Enoploclytia minor Woodward
Part and counterpart of holotype GSC 5971a, fig. 1; GSC 5971, fig. 2.

Figure 3. Eryma bordenensis (Copeland)
Latex cast of hypotype GSC 61937, showing right lateral view of cephalothorax and part of first pereiopod, x1.5.

Figure 4, 5. Phlyctisoma dawsoni (Woodward)
Part and counterpart of holotype GSC 5969a, fig. 4; GSC 5969, fig. 5.



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Examination of Woodward's (1900, Pl. 17, fig. 1a-c) illustration and types of Hoploparia westoni, herein reassigned to Palaeonephrops, suggests that, although there is some similarity in form of Rathbun's and Woodward's specimens, primarily in the abdominal pleura, the morphology of the two is significantly different. The pleural elements of the two species appear to be very similar to one another, although those of H. westoni are poorly preserved. The terga, however, are quite different. The terga of P. browni are characterized by having a pronounced axial keel on all segments and ridges marking the anterior and posterior margins of each segment. These features are apparently absent on H. westoni, although a very faint axial keel may be present on at least the terminal segments. The fifth tergum is ornamented by a row of very small nodes along the dorsal midline and the sixth segment, which is badly crushed on the type specimen, seems to show a broad keel which widens toward the posterior termination. Another apparent difference in the abdominal region between the two species is that the sixth somite of H. westoni is much longer than wide, whereas it is about equant in P. browni. The cephalothorax of Hoploparia westoni does not seem to have the coarse ornamentation characteristic of P. browni, although Woodward (1900, p. 28) stated that the cephalothorax was "tuberculated". The cephalothorax of H. westoni, is, however, incomplete and better material would be necessary to make a complete and proper comparison. The only remnant of the walking legs is the left manus of the first pereiopod which is large, inflated, and covered with coarse tuberculations. The form appears to be more robust than would be typical of P. browni but, because the form of these claws in P. browni is extremely variable (Feldmann et al., 1977, p. 1168), it does not provide a significant point of distinction.

Another specimen appears to be best referred to Palaeonephrops browni. In 1887, Whiteaves described a specimen from Sounding Creek, Alberta and considered it the type of a new species, Palaeastacus(?) ornatus. This species subsequently has been referred to on only two occasions (Whiteaves, 1889; Woodward, 1900). Examination of the type specimen of this species indicates that it is identical to Palaeonephrops browni both in the details of the cephalothorax and that portion of the abdomen which is preserved (compare Pl. 2, fig. 1. and Pl. 2, fig. 10). Palaeastacus(?) ornatus is the senior name by 20 years but, because the name has not been referred to in the literature since 1900 and because Palaeonephrops browni has become firmly established in decapod literature, the former must be considered a nomen oblitum under Article 23 (b) of the International Code of Zoological Nomenclature (1961, p. 23).

Occurrences. Palaeonephrops browni has been collected from the following localities in western Canada:

1. Glenwoodville map area, south bank of Waterton River, 0.8 km below bridge, NW Sec. 23, T4, R28, W of 4th, Alberta; GSC loc. 18430; Field No. 49-1-31 Bearpaw Formation [middle or late Campanian], Late Cretaceous; collected by R.J.W. Douglas, 1949.

2. SE Sec. 7, T20, R12, near T18A, W of 4th(?), Alberta; Bur. Econ. Geol. No. 44999; Bearpaw Formation, Sand E, Campanian, Late Cretaceous; collected by R. Graham.

3. Willow Creek, Alberta(?); hypotype GSC 45739, Benton Shale, Late Cretaceous; collected by Sommers (Feldmann et al., 1977). [Probably from an outcrop of the Alberta Group (Cenomanian to Santonian) at the headwaters of Willow Creek.]

4. Misty Hills, T37(?), R5(?), W of 4th(?), Alberta; hypotype GSC 45740; Late Cretaceous; collected by G.S. Hume, Oct. 3, 1935 (Feldmann et al., 1977). [If the co-ordinates are correct, this refers to Neutral Hills, Bearpaw Formation (Campanian).]

5. South of Pincher Creek, NE Sec. 26, T4, R1, W of 5th, Alberta; sandstone in Benton Formation [Wapiabi Formation (Santonian or possibly Coniacian)], Cretaceous; collected by A.O. Hayes, July 6, 1920.

6. Sounding Creek, T30, R8, W of 4th, Alberta; holotype (of Palaeastacus ornatus) GSC 12397 [Bearpaw Formation (Campanian or possible early Maastrichtian)], Late Cretaceous; collected by J.B. Tyrrell, 1886 (Whiteaves, 1887).

7. Sec. 32, T6, R22, W of 4th, Alberta; Catalogue No. 409 (University of Alberta?); Bearpaw Shale, 71.9 m above base, L.S. 4, Late Cretaceous; collected by J.O.G. Anderson (Rathbun, 1930, p. 180).

PLATE 2

All figures x1, unless otherwise indicated

Figures 1, 10. Palaeonephrops browni (Whitfield)

1. Dorsal view of plaster cast of holotype GSC 12397, of Palaeastacus(?) ornatus Whiteaves, nomen oblitum. The specimen is herein referred to P. browni.

10. Dorsal view of syntype, AMNH 9572, of P. browni. This specimen was collected 200 km northwest of Miles City, Montana, U.S.A. by Barnum Brown in 1908.

Figures 2-7. Palaeonephrops westoni (Woodward)

2, 4, 5. Dorsal, lateral, and posterior views of part of the syntype GSC 5377, showing last four abdominal segments and the telson.

3. Left lateral view of part of the syntype GSC 5377a, showing posterior part of the cephalic region and anterior part of the thoracic region.

6. Left lateral view of part of syntype GSC 5377, showing posterior part of cephalothorax and first two somites of the abdomen.

7. Upper surface of the left manus of the first propodus, syntype GSC 5378.

Figures 8, 9. Glyphea robusta n. sp.

8. Left lateral view of endophragmal skeleton, x4, photographed from latex cast of holotype GSC 61398.

9. Left lateral view of latex cast of holotype, x1.5, GSC 61398, showing entire left side of exoskeleton and endophragmal skeleton, in molted position.

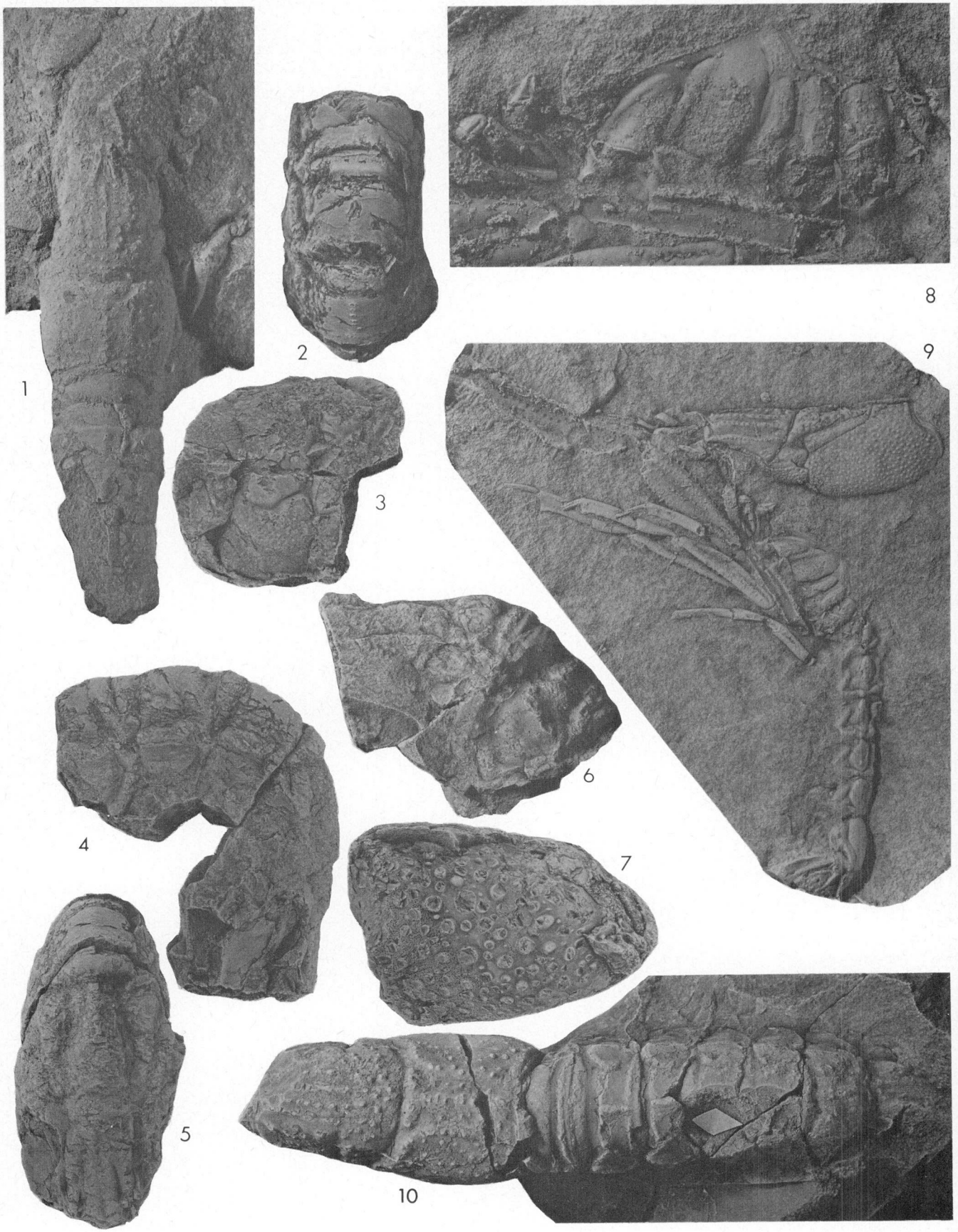
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TABLE 2

Measurements (in mm) taken on specimens of Glyphea robusta n. sp. P = pereiopod; L_1 - L_4 are illustrated on Figure 5; Roman numeral subscripts refer to somites of the abdomen and Arabic subscripts (P_1 - P_5) refer to the walking legs.

SPECIMEN	L_1	L_2	L_3	L_4	H	L_{XIV}	L_{XV}	L_{XVI}	L_{XVII}	L_{XIX}	L_{Telson}
GSC 61398 (Holotype)	29.9	26.1	12.4	3.4	11.6	>3.4	5.9	4.4	4.4	6.7	>5
GSC 61399 (Paratype)	52.5	44.5	21.5	-	19.5						
GSC 61400 (Paratype)	60.0	54.5	26.5	-	22.0						
GSC 61402 (Paratype)	50.6	43.0	20.5	2.5	20.4						
GSC 61403 (Paratype)	58.2	51.1	26.3	-	20.3						
GSC 61404 (Paratype)	55.3	49.1	23.5	-	-						

SPECIMEN	PEREIOPOD	MERUS L	MERUS H	CARPUS L	CARPUS H	PROPODUS L	PROPODUS H	DACTYLUS L	DACTYLUS H
GSC 61398 (Holotype)	P_1	17.4	4.8	7.7	> 3.4	> 17.6	4.4	-	-
	P_2	15.0	> 1.5	5.7	> 1.7	07.5	2.7	4.7	0.8
	P_3	14.8	2.1	5.5	1.5	07.7	2.2	> 2.0	0.8
	P_4	10.6	1.9	-	-	07.6	1.9	4.1	0.5
	P_5	07.3	1.6	4.2	1.5	08.2	1.5	-	-
GSC 61400	P_1	30.0	7.5	14.5	7.5	> 33.0	7.5	-	-

Palaeonephrops westoni (Woodward, 1900)

Plate 2, figures 2-7

Hoploparia westoni Woodward, 1900, p. 28, Pl. 17, fig. 1; non Rathbun, 1930, p. 181, Figs. 1-3.

Remarks. Woodward's original description of this species was based on fragments of a lobster which included a complete abdomen, the posterior portion and some of the cephalic portion of the cephalothorax, and the left manus of the first pereiopod. No other specimens appear to be referable to this taxon.

The posterior region of the cephalothorax seems to differ from the same region on Palaeonephrops browni. The outline of the cephalothorax on P. westoni is more angular than that of P. browni and the surface of the branchiostegite seems to be less heavily ornamented than on P. browni. In many other regards, however, the two species are similar enough to suggest referring Woodward's species to Palaeonephrops. The ornamentation of the pleura of the two species is apparently identical; however, the terga of the two species are quite different. That region on Palaeonephrops browni is ornamented by transverse ridges on the anterior and posterior margins of each segment and by a medial ridge. The terga are devoid of ornamentation on P. westoni except on the fifth somite where a weak medial structure is defined by a row of small pustules and on the sixth somite where a broad axial ridge seems to be present. No transverse ridges are evident on the preserved segments. Other points of comparison are discussed in the remarks on P. browni.

Rathbun (1930, p. 181) referred a specimen collected from the Bearpaw Formation to this species but the ornamentation of the terga on that specimen, as well as the outline of the carapace, would seem to suggest placement of it with P. browni.

Occurrence. Palaeonephrops westoni has been collected only from the type locality, Red Deer River, T23, R15, W of 4th, Alberta; syntypes GSC 5377, 5377a and 5378; Pierre-Fox Hills, Late Cretaceous; collected by T.C. Weston, 1889. [If township and range are correct, this must be in section 1 or 12, near base of Bearpaw Formation (Campanian).]

Infraorder PALINURA Latreille, 1803

Superfamily GLYPHEOIDEA Winckler, 1883

Family GLYPHEIDAE Winckler, 1883

Genus Glyphea von Meyer, 1835

Glyphea robusta n. sp.

Plate 2, figures 8, 9, Plate 3, figures 2-7, Figures 3-5

Description. Cephalothorax about average size for the genus (Table 2), height about two fifths total length. Dorsal margin nearly straight; posterior margin a sigmoid curve produced near posteroventral termination; posteroventral margin gently curved, deepest near the posterior; anteroventral margin nearly straight and inclined from anterior termination ventrally to near the posterior termination of the cephalic region where it curves abruptly ventrally to join posteroventral margin; anterior margin nearly vertical, rostrum short, smooth. Cervical groove straight, steeply

inclined, intercepting dorsal surface at an angle of about 70° at a distance four ninths of total length of dorsal margin from anterior. Branchiocardiac groove oblique, approaching dorsal surface at an angle of about 30° and then curving abruptly dorsally to intersect the dorsal surface at an angle of about 70°. Postcervical groove nearly parallel branchiocardiac groove through most of its length, approaching but not intersecting it at dorsal surface and diverging slightly from it ventrally to a point near the middle of carapace where it curves abruptly ventrally and posterially to join branchiocardiac groove. Postcervical groove then curves anterially for a short distance where it intersects the inferior groove which is arcuate and extends to the ventral margin. Hepatic groove sinuous, connecting postcervical corner of cephalic region. All grooves relatively deep, narrow and well defined. Cephalic region tapering toward anterior, strongly attenuated, ornamented by three spinose lateral carinae and a dorsal carina increasing in height and strength ventrally. Subdorsal carina extends obliquely upward from its posterior origin to intersect the dorsal margin just posterior the rostrum; supraorbital carina nearly parallel the dorsal margin; antennal carina parallel dorsal margin; intersecting the anteroventral margin at its junction with the anterior margin. Rostrum short, slightly arched dorsally, keeled along midline, not spinose. Cephalic region ornamented primarily by spines on carinae and a single spine in the suborbital position near the cervical groove. Region between branchiocardiac groove and cervical groove spinose, spines increasing in size toward dorsal margin. Branchiostegite very narrow near dorsal margin broadening to a length of about 80% of ventral margin; spinose with spines increasing in size from the anteroventral region to posterodorsal termination. Marginal furrow well developed on posterior and ventral margin.

Endophragmal skeleton (Fig. 3) weakly calcified; pentagonal in outline, anterior margin nearly straight and inclined slightly toward posterior, anterodorsal margin parallel to and subjacent to branchiocardiac groove (Fig. 4), posteroventral margin obscure but apparently slightly concave and inclined from flexure in branchiocardiac groove to posteroventral margin of cephalothorax, posterior margin short and convex, ventral margin slightly convex overall with six concave reentrants marking positions of thoracic somites VIII-XIII, borders only slightly reflexed; all somites convex with shallow sulcus and low ridge marking anterior edge, separated from one another by deep, narrow grooves; mxp_3 triangular, slightly inclined toward anterior; p_1 quadrate, inclined toward anterior, largest of somites; p_2 and p_3 elongate, arcuate, inclined slightly toward anterior; p_4 quadrate, inclined toward posterior; p_5 small, quadrate, steeply inclined toward posterior. Pleurobranchial openings (pl_2-pl_5) ovoid, located near anteroventral corner of p_2 - p_4 and near center of p_5. Podobranchial openings (pb_1, pb_2, pb_5) obscure but present on coxa of mxp_3, p_1, and p_4 respectively, other coxa not visible. Fragments of maxillipeds preserved but not adequate for description.

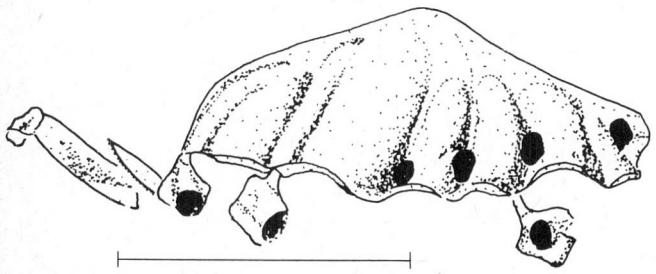


FIGURE 3. *Left lateral view of the endophragmal skeleton of Glyphea robusta n. sp. with attached fragments of a maxilliped and three coxae. The darkened regions are pleurobranchial and podobranchial openings. Bar scale = 1 cm.*

Abdomen well developed; first somite reduced, about half as long as second; second somite about one third longer than third through fifth somites which are of about equal length; sixth somite longer than the others. Tergal regions of all but first somite apparently nearly smooth, generally quadrate, bounded on all sides by a shallow sulcus and marginal ridge; tergum of first somite narrowest on midline and extends laterally to base of tergum. Pleura strongly developed, highly ornamented; antero- and posteroventral areas separated from medial region by smooth broad sulci extending obliquely from the points of articulation to near the ventral margin; major surface of pleura spinose or tuberculate; ventral and lateral margins finely punctuate; pleuron of second somite subrectangular, rounded on anteroventral corner and angular on posteroventral margin; pleura of third through fifth somites triangular with a small spine developed on the termination; pleuron of sixth somite reduced, triangular. Telson appears to be quadrate, bounded by raised ribs, axial region with bulbous protuberance and four small spines dorsal to anal region. Uropods poorly preserved, appear to be flabellate, longitudinally ribbed; no evidence of presence or absence of diaresis.

Antennal base elongate; first segment poorly preserved but appears to be quadrate; second segment about twice as long as high; third segment about six times as long as wide, flagellum slender; scaphocerite elongate, tapering, slender. First pereiopod elongate, slender, spinose. Merus about three times as long as high, widest near distal end, edges with numerous distally pointing spines, surface nodose; carpus narrow at proximal termination broadening distally so that maximum height is about three quarters the length, nodose; propodus at least seven times as long as high, nodose, terminating in a long arcuate spine on the inner surface; dactylus appears to rotate back onto this spine effecting a subchelate closure. Second through fourth pereiopod similar to first, decreasing in size posteriorly, terminations subchelate. Fifth walking leg smaller, smoother; termination unknown.

Type material. Holotype GSC 61398 (Pl. 2, figs. 8, 9), figured paratypes GSC 61399-61401 (Pl. 3, figs. 2, 7), and unfigured paratypes GSC 61402-61411 are deposited in the collections of the Geological Survey of Canada, Ottawa, Ontario.

Measurements. All measurements taken on the specimens of this species are recorded on Table 2. Those of the cephalothorax are illustrated on Figure 5.

Etymology. The trivial name alludes to the strength of the ornamentation on the branchiostegal region, a character that serves to distinguish this species from most other glypheids.

Remarks. Relatively few glypheids have been recognized in North America. Two forms, Triasiglyphea mulleri van Straelen, 1936, and Litogaster turnbullensis Schram,

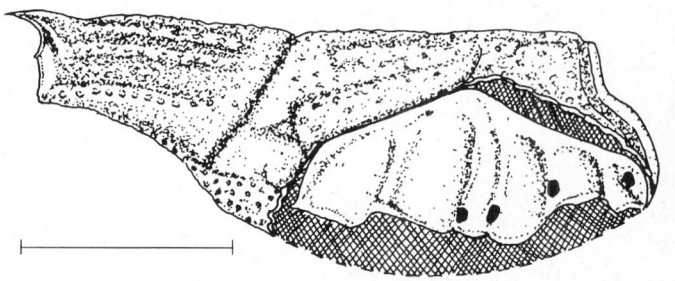


FIGURE 4. *Left lateral view of Glyphea robusta n. sp. with branchiostegite broken away to show inferred position of endophragmal skeleton. The reconstruction is based on the holotype GSC C-76307. Bar scale = 1 cm.*

1971, have been described from Triassic rocks in Nevada and Idaho, respectively. Two others, Glyphea(?) carolinensis Rathbun, 1923 and Glyphea sp. (Whiteaves, 1903) were described from Cretaceous rocks in North Carolina and British Columbia, respectively. Glyphea(?) carolinensis was based on two fragmentary specimens that rendered generic placement questionable and that make trivial comparisons difficult or impossible. Similarly, G. sp. Whiteaves was reported by Whiteaves (1903, p. 323) to have been so crushed and distorted that no complete description could be prepared. This material has never been illustrated and cannot now be located. Finally, Copeland (1960, p. 55) noted the occurrence of G. stonesfieldiensis van Straelen from the Wilkie Point Formation, Cape Canning, Prince Patrick Island. This specimen has not been examined but it may very well be G. robusta. Glyphea stonesfieldiensis is a junior synonym of G. rostrata (Phillips) (Woods, 1925-1931, p. 57). Therefore, the description of G. robusta, and the one to follow, represent the first notices of well preserved glypheids ranging into Jurassic and Cretaceous rocks on this continent.

Examination of specimens and illustrations of specimens assigned to previously described species of this genus leads to the conclusion that three, rather separate, sets of characters on the cephalothorax can be used as species discriminators. With regard to the groove pattern, one group of species has a small groove that connects the midpoints of the branchiocardiac and postcervical grooves. In this group, typified by G. regleyana (Desmarest), the postcervical groove is generally not straight but has a depressed region at the point where it joins the branchiocardiac region. The second group, containing among others G. rostrata (Phillips), G. cretacea McCoy, G. calloviensis Woods and G. robusta n. sp., has no such connection but does have straight or gently curved postcervical grooves.

A second key character useful in distinguishing species in this genus is that of the number of spinose or nodose ridges on the cephalic region. Some, such as G. calloviensis Woods, possess more than three such ridges which serve to distinguish them from a second group characterized by development of only three ridges. Included in this latter group are G. cretacea McCoy, G. prestwichi Woods, and G. robusta n. sp.

Finally, some species, for example G. regleyana (Desmarest), G. calloviensis Woods and G. cretacea McCoy, are ornamented over part, or all, of the cephalic region between the ridges whereas others, G. rostrata (Phillips), G. prestwichi Woods, G. robusta n. sp., tend to be smooth in this region.

Using these three sets of criteria it is possible to narrow down the number of comparable species efficiently and precisely and suggest that the three species morphologically most closely related to Glyphea robusta are G. vectensis Woods, G. tomesi Woodward, and G. rostrata (Phillips). Each, however, differs from Glyphea robusta in significant ways. Glyphea vectensis Woods is ornamented by much finer nodes on the branchiostegite and has an accessory groove which extends from the postcervical groove anteriorly and dorsally to the midline. Glyphea tomesi Woodward can be distinguished readily from G. robusta by noting that the postcervical and branchiocardiac grooves join before reaching the dorsal midline on G. tomesi. Glyphea rostrata (Phillips) differs from G. robusta in possessing a median ridge on the cephalic region, in having slightly undulatory cephalic ridges, and finer ornamentation of the branchiostegite.

The holotype GSC 61398, exhibits remarkable preservation. Molds of the interior of the carapace of both right and left sides are preserved in great detail and permit

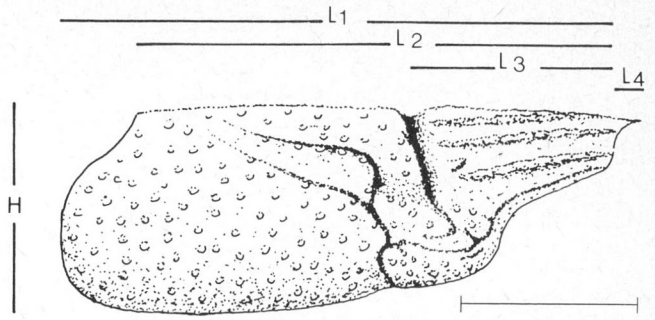


FIGURE 5. *Diagrammatic sketch of cephalothorax of Glyphea robusta n. sp. showing position of grooves, cephalic ridges, and ornamentation. Orientation of measurements taken on this region is also shown. Bar scale = 1 cm.*

detailed, complete description of the entire cephalothorax and abdomen. In addition, the endophragmal skeleton is preserved well enough to permit detailed description, only the second such description known to the writers (Feldmann et al., 1977, p. 1168). Study of this structure has never before been possible in a glypheid and reveals gill placement and rather advanced somite development similar to that of recent nephropids, such as Homarus, the genus that has received most study (e.g. Secretan, 1973). When details of the internal anatomy of the one living glypheid, Neoglyphea inopinata Forest and Saint Laurent, are known we will have an opportunity to describe the evolution of this strucutre.

The holotype also represents one of the best examples of ecdysis known from the fossil record. Examination of molted skeletons of modern crayfish reveals that, when the molted skeleton is not agitated, the cephalothorax is simply rotated dorsally around an axis passing through a point near the antennal region. This orientation is referred to as Salter's position (Schäfer, 1972, p. 435). Any agitation of the carapace results in its being separated completely from the endophragmal skeleton and abdomen. The latter two elements tend to remain attached to one another much more firmly than either does to the carapace. The holotype of G. robusta shows just such rotation, exposure, and preservation of the endophragmal skeleton, and only very slight separation of the carapace from the remainder of the skeleton. Curiously, even though preservation of the internal skeleton is extremely rare, two specimens, the holotype and one of the paratypes (GSC 61401), reveal the structure. These forms must have lived and been preserved in a very low energy environment but the rate of burial must have been rather rapid, otherwise this delicate arrangement would not remain.

Occurrences. Glyphea robusta has been collected from the following localities in Arctic Canada:

1. Intrepid Inlet, Prince Patrick Island, 91-93.5 m interval, Latitude 76°33', Longitude 117°55'; GSC loc. C–76307; holotype GSC 61398; Wilkie Point Formation, late Bajocian, Middle Jurassic.

2. Intrepid Inlet, Prince Patrick Island, Latitude 76°30', Longitude 117°51'; GSC loc. C-76329; paratype GSC 61409; Wilkie Point Formation, Middle-Late Jurassic. [The Wilkie Point Formation is never younger than Callovian, and is in a marine fossiliferous facies only as young as middle Bathonian.]

3. Melville Island, from section extending from Latitude 76°16'10", Longitude 115°42'15" (start), to Latitude 76°23'45", Longitude 115°19'30" (finish); GSC loc. C-63341; paratype GSC 61407; Lower Shale, Wilkie Point Formation, Toarcian-Bajocian, Early-Middle Jurassic.

4. Oyster River, Borden Island, Latitude 75°23', Longitude 110°47'; GSC loc. C-76361; paratype GSC 61409; Borden Island Formation, Sinemurian, Early Jurassic.

5. Middle part of a nameless rocky ridge extending across the alluvial plain [northeast of Jurassic Butte] about 3.2 km south of Bug Creek [West side of Mackenzie Delta northern Richardson Mountains, NWT]; loc. 27004, Field No. F. 17/6; paratypes GSC 61399-61406; [Middle part of Jeletzky's (1958) informal shale-siltstone Division, Barremian], Early Cretaceous; collected by J.A. Jeletzky, Aug. 6, 1955, in association with Crioceras fauna.

6. Oyster River, Borden Island, Latitude 78°23'N, Longitude 110°47'W; GSC loc. C-76368; paratype, GSC 61410; Borden Island Formation [Sinemurian, Early Jurassic].

7. Prince Patrick Island at head of Jamieson Bay; [GSC loc. C-11494; paratype GSC 61411; Wilkie Point Formation, Middle Bajocian]; collected by Atlantic Richfield Co., July, 1971, submitted by W.W. Nassichuk.

Glyphea jeletzkyi n. sp.

Plate 3, figure 1, Figure 6

Description. Cephalothorax moderately small for genus. Dorsal and posterior borders not well preserved; posteroventral margin gently convex, deepest near base of cervical groove; anteroventral border concave; all of anterior and most of anteroventral margin not preserved. Cervical groove deeply impressed, nearly perpendicular to dorsal margin in upper two thirds and gently curved anteriorly in the lower one third terminating at hepatic groove. Postcervical groove weak, steeply inclined, intersecting dorsal margin at about 33°, straight in upper portion and curving through nearly 90° to intersect the branchiocardiac groove. Branchiocardiac groove deeply impressed, intersecting dorsal surface at 45° and straight from dorsal surface to point of intersection with postcervical groove where it curves ventrally to join hepatic groove. Inferior groove arcuate, deeply impressed. Hepatic groove moderately impressed, curving anteriorly then anteroventrally to the point of intersection with the cervical groove. Antennar groove weak, paralleling ventral border. Cephalic region with two spinose ridges on a field ornamented only by tiny pustules. Antennal carina inclined from the elevation of postcervical-branchiocardiac intersection anteroventrally toward the ventral margin, slightly curved, ornamented by fine spines. Suborbital carina slightly inclined anteriorly, low, ornamented by fine spines. Subdorsal carina, if it exists, not preserved. Region between cervical and branchiocardiac grooves lobose, ornamented by coarse spines. Adductor testis muscle insertion reniform, well defined by surrounding grooves. Branchiocardiac region ornamented by spines increasing slightly in size from anteroventral margin to posterodorsal margin. All spines in this region smaller than those on the cardiac region.

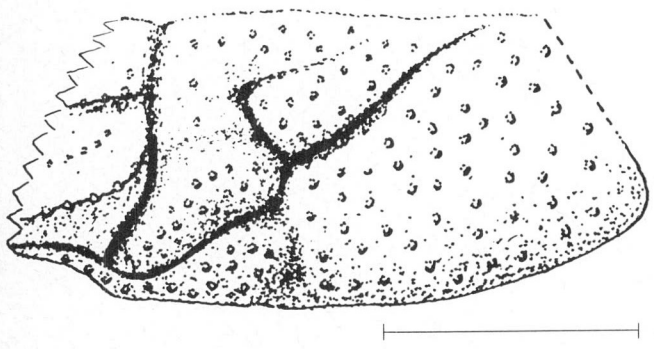


FIGURE 6. *Diagrammatic sketch of Glyphea jeletzkyi n. sp. showing the major morphological features of the cephalothorax. Bar scale = 1 cm.*

Type material. Holotype, and sole specimen, GSC 61412 (Pl. 3, fig. 1), is deposited in the collections of the Geological Survey of Canada, Ottawa, Ontario.

Etymology. The trivial name honours J.A. Jeletzky of the Geological Survey of Canada both for his discovery of the specimen and for his outstanding contributions to the study of the Mesozoic of Canada.

Remarks. This species appears to fall into the same category as G. robusta in that the postcervical and branchiocardiac grooves are not joined medially, the cephalic region does not appear to be ornamented between the cephalic ridges, except by minute pustules, and the number of cephalic ridges appears to be fewer than four. The single specimen of this species, however, is incomplete so that there is no way to determine the precise number and nature of subdorsal ridges.

The species is clearly distinct from other glypheids, including G. robusta. One of the most distinctive characters is the antennal carina which is inclined obliquely to the ventral margin and, if that trend were to continue, would intersect the ventral margin in advance of the front. In most other species, the antennal carina tends to parallel the ventral margin or parallel the dorsum. The ornamentation of the region between the cervical and branchiocardiac grooves is also distinctive. In Glyphea robusta this region is uniformly and sparcely pustulose whereas in G. jeletzkyi the dominant ornamentation is three subparallel rows of pustules aligned with the postcervical and branchiocardiac grooves. Finally, the adductor testis area on G. jeletzkyi is reniform in outline whereas the same region in G. robusta is ovoid.

Occurrence. On the south wall of the canyon of Longstick Creek opposite its first northwesterly confluence, northern Richardson Mountains, NWT; GSC loc. 35625, Field No. JA-F 58-83-16; holotype GSC 61412; informal Upper Sandstone Division of Jeletzky (1958), late Barremian or Aptian, Early Cretaceous; collected by J.A. Jeletzky, 1958.

Glyphea sp.

Glyphaea sp. Whiteaves, 1903, p. 323.

Glyphea sp. Rathbun, 1926, p. 134

Remarks. The material of this species has apparently been lost (Bolton, pers. com., 1978) and was never properly figured or described. Therefore, it is included here only for completeness.

Occurrence. Shale in roof of coal mine at No. 1 shaft, Vancouver Island, British Columbia; Nanaimo Group, Late Cretaceous; collected by W. Harvey, September, 1901. [Douglas Seam, in middle part of Extension-Protection Formation, middle Campanian.]

Family MECOCHIRIDAE Van Straelen, 1925

Genus Meyeria M'Coy, 1849

Meyeria(?) harveyi Woodward, 1900

Meyeria(?) harveyi Woodward, 1900, p. 434; Whiteaves, 1903, p. 323; Rathbun, 1926a, p. 128; Förster, 1971, p. 409.

Remarks. This species has been referred to by the authors cited in the synonymy and by some subsequent authors (Feldmann and West, 1978) and nothing new can be added here. The type material has apparently been lost for some time (Bolton, pers. com., 1978) and, therefore, it is unlikely that anyone has seen the material since the time of Woodward and Whiteaves.

Förster (1971, p. 409) noted that, because the material was never illustrated or completely described, the name should be considered a nomen nudum but that from the sketchy description given by Woodward the specimen might well be referable to M. vectensis (=M. magnus), a relationship first noted by Woodward.

Occurrence. Hornby Island, British Columbia; Late Cretaceous; collected by W. Harvey, 1895. [Probably the Spray Formation, but possibly the older Northumberland Formation of intervening Geoffrey Conglomerate, late Campanian to early Maastrichtian.]

Family PALINURIDAE Latreille, 1802

Genus Linuparus White, 1847

Linuparus canadensis (Whiteaves, 1884)

Plate 4, figures 1, 3, 5, Plate 5, figures 4, 9, 10

Hoploparia(?) canadensis Whiteaves, 1884, p. 237; 1885, p. 87, Pl. 11.

Podocrates canadensis (Whiteaves), Whiteaves, 1895, p. 133.

Linuparus atavus Ortmann, 1897, p. 293, Figs. 1-3; Woodward, 1900, p. 396.

Linuparus (Podocrates) canadensis (Whiteaves), Woodward, 1900, p. 396, Pl. 1, fig. 1.

Linuparus canadensis (Whiteaves), Whiteaves, 1903, p. 325; Rathbun, 1935, p. 36; Hattin, 1962, p. 97.

Podocratus canadensis (Whiteaves), Rathbun, 1926a, p. 134, Pl. 35, fig. 2; Pl. 36; Rathbun, 1926b, p. 185, Pl. 63, figs. 12, 16.

Remarks. Linuparus canadensis is one of the most widely distributed decapods in Cretaceous rocks in North America. It has been reported from Tennessee, Louisiana, Kansas and South Dakota in the United States and from British Columbia and Alberta in Canada. This distribution in the Atlantic Coastal Plain, Midcontinent, and Pacific faunal provinces is not known in any other decapod taxon on this continent. In addition, two other closely related species, L. grimmeri Stenzel, 1945 and L. watkinsi Stenzel, 1945, are known from Texas. Finally, Linuparus vancouverensis (Whiteaves) occurs with L. canadensis in British Columbia. Examination of specimens in the United States National Museum, which were collected from Louisiana and Tennessee and identified by Miss Rathbun, clearly indicate that they are conspecific with the Canadian forms. All are characterized by possession of a spinose medial ridge that extends from the postcervical groove to the posterior margin and widens toward the posterior. This and the nature of distribution of spines anterior of the postcervical groove serve to distinguish Linuparus canadensis from other North American species. Ortmann's specimens, originally assigned to L. atavus, have not been examined by the authors personally but, based on his original illustrations, there seems to be little doubt that they should correctly be assigned to L. canadensis, as was originally determined by Rathbun (1935, p. 36).

Some aspects of the morphology of the species have not been discussed previously. Most species of the genus have a cephalothorax that is quadrate in cross-section. In many, including L. canadensis and L. vancouverensis (which will be discussed later), the lateral axes are much longer than the dorsoventral axes. Therefore, specimens are often preserved in positions such that their ventral surfaces are exposed. This contrasts markedly with that of most macrurans which are preserved with their lateral surfaces parallel to planes of weakness in the rock. Preserved in this position, it is possible to examine the sternal elements of several specimens and to note that a significant difference exists between these species and other species of the genus in which the sterna are preserved. Linuparus canadensis has a triangular sternum that consists of six elements serving as the bases of attachment of maxilliped 3 and the five pereiopods. The regions of attachment of the sternum with the coxa of the pereiopods are elevated, thickened, and coarsely denticulate on at least segments 4-6, corresponding to pereiopods 1-3. Axial to the posterior edge of each segment is a pair of deep pits and axial to the anterior edge of each segment is a pair of deep pits and axial to the anterior edge of each segment is a pair of small spines. On specimens of L. vancouverensis, in which the same region is visible, the articulations are very finely denticulate, the axial pits are shallower, and the axial spines are absent.

PLATE 3

All figures x1, unless otherwise indicated

Figure 1. Glyphea jeletzkyi n. sp.
Left lateral view of holotype GSC 61412, x2, showing part of the cephalic region and most of the thoracic region.

Figures 2-7. Glyphea robusta n. sp.

2. Fragmentary specimen, GSC 61401, showing part of left side of cephalothorax and anterior part of endophragmal skeleton.

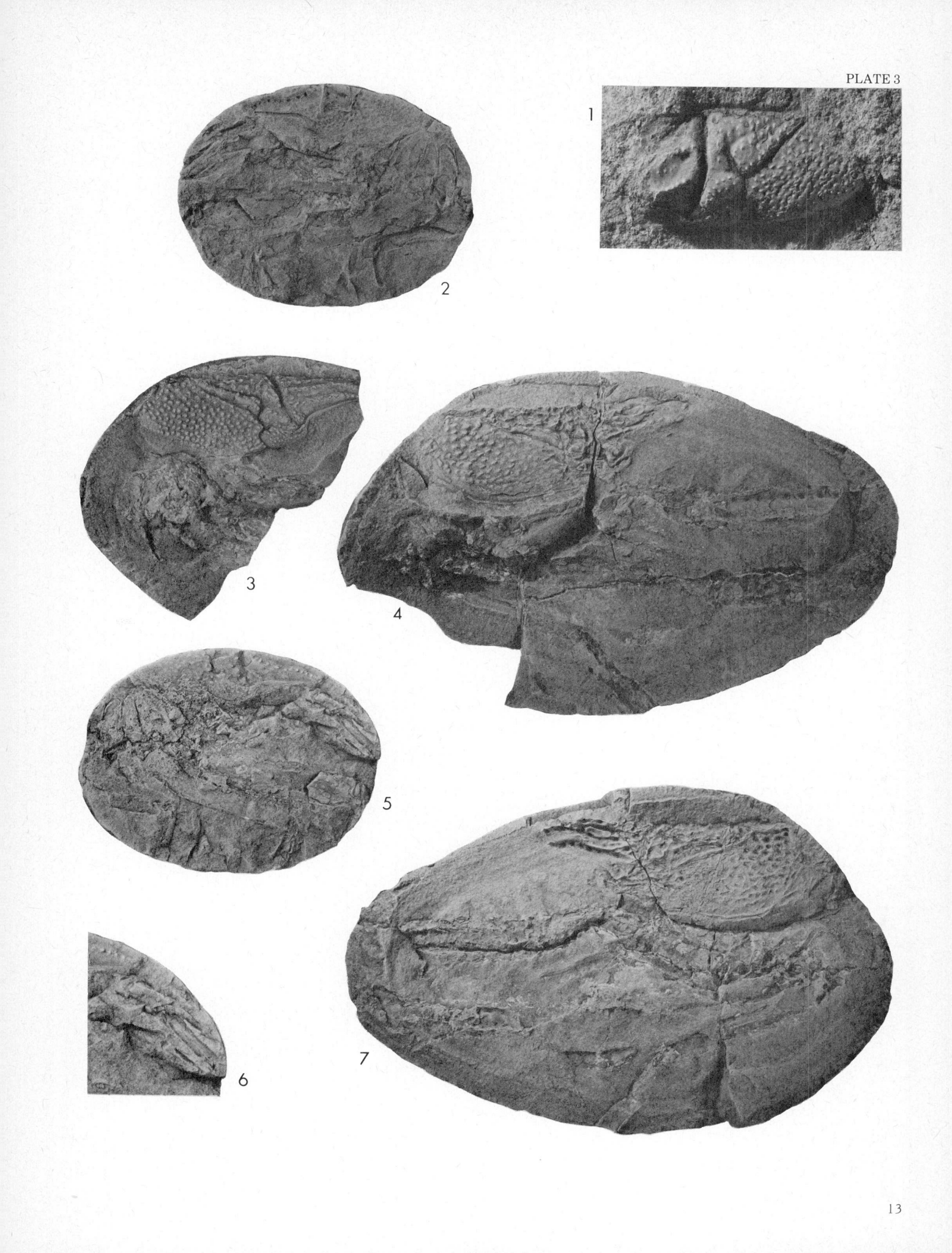
3. Right lateral view of nearly complete cephalothorax, GSC 61399.

4. Right lateral view of nearly complete cephalothorax and parts of walking legs, GSC 61400.

5. Counterpart of GSC 61401.

6. Anterior portion of counterpart of GSC 61401, showing base of antenna and antennal spine, x1.5.

7. Counterpart of GSC 61400.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The margins of the abdominal pleura apparently have never been described. It is of importance because they have been cited (Mertin, 1941, p. 215) as a character useful in defining the subgenera of Linuparus. Because the specimens of this species are often preserved in such an orientation that their dorsal surfaces are exposed, the pleura are only rarely visible. On the holotype (GSC 5057), however, the pleural margins of somites 2 and 3 are visible and appear to be moderately coarsely spinose on the anteroventral, ventral, and posterior margins similar to L. watkinsi Stenzel (1945, Pl. 34, fig. 6).

Occurrences. Linuparus canadensis has been collected from the following localities in Canada:

1. Highwood River tributary to Bow River, Alberta; holotype GSC 5057, Niobrara-Benton?, Late Cretaceous; collected by R.G. McConnell, 1882. [Could be any of numerous outcrops of Alberta Group (Cenomanian to Santonian).]

2. Hornby Island, British Columbia; hypotype GSC 5968; Late Cretaceous; collected by Robbins, 1896. [Probably Spray Formation but possibly older Northumberland Formation or intervening Geoffrey Conglomerate, late Campanian to early Maastrichtian.]

3. Right bank of Elbow River. Alberta; loc. K-149; Benton Formation, collected by W.A. Kelley. [Could be any one of several outcrops of Alberta Group (Cenomanian to Santonian).]

4. Jumping Pound River, Alberta; loc. H-337; paratype GSC 61413; Benton Formation, Late Cretaceous; collected by G.S. Hume. [Could be any one of several outcrops of Alberta Group (Cenomanian to Santonian).]

5. Alberta, loc. H-8; Upper Benton, collected by W.A. Kelley. [Probably Wapiabi Formation (Santonian-Coniacian).]

6. Sec. 33, T19, R3, Bearing 6; Argus well, 68.6 m in S. side of river, Alberta; loc. H-180; paratype GSC 61414. [Alberta Group, "upper" Benton suggests Wapiabi Formation (Santonian-Coniacian).] Late Cretaceous; collected by G.S. Hume, 1929. This specimen can be referred only questionably to the species because it is only a small fragment of the cephalothorax and sternum. The sternum resembles those of known L. canadensis in all regards except that it lacks the paired axial spines.

Linuparus vancouverensis (Whiteaves, 1895)

Plate 4, figures 2, 4, 6, 7, Plate 5, figures 5, 8

Podocratus vancouverensis Whiteaves, 1895, p. 132, Rathbun, 1926a, p. 135.

Linuparus (Podocratus) vancouverensis (Whiteaves), Woodward, 1900, p. 395.

Hoploparia bennetti Woodward, 1900, p. 433; Rathbun, 1926a, p. 129.

Hoploparia bennettii Woodward, Whiteaves, 1903, p. 320.

Linuparus vancouverensis (Whiteaves), Whiteaves, 1903, p. 323.

Remarks. This species differs from L. canadensis in several significant features. The three carinae that extend the length of the thorax are pustulose, rather than nodose as they are in L. canadensis and the triangular region along the midline of the cephalic region is slightly raised and ornamented by fine nodes rather than by the prominent spinose processes on L. canadensis. Further, the pleural margins of L. vancouverensis appear to be spinose only on the posterior margin and the spines are much smaller. Finally, the sternum of L. vancouverensis lacks the median spines, has shallower pits at the posterior margin of the somites, and has only very fine denticles on the region of articulation with the coxa. This species seems to be generally more delicate than L. canadensis. The possibility exists that the two forms are sexual dimorphs but that appears unlikely because the two species have been collected together at only one of eight localities.

Hoploparia bennetti appears to be synonymous with Linuparus vancouverensis. Careful examination of the holotype, and sole specimen of H. bennetti (Pl. 4, fig. 7), reveals that the pleural margin of abdominal somites two and three bear small spines along the posterior margin that are very similar to those on known specimens of L. vancouverensis. In addition, the sternum of H. bennetti has been preserved, a part of the anatomy of Hoploparia that is rarely viewed. The sternum was recognized by Woodward (1900, p. 434) but was improperly interpreted as the upper surface of that structure exposed as a result of removal of the cephalothorax. In fact, the cephalothorax may very well be present but obscured beneath the sternum. The entire anterior region of this animal rotated nearly 180° around the long axis so that the ventral surface of the cephalothorax came nearly into the plane of the dorsal surface of the abdomen prior to burial. The morphology of the sternum of this animal is identical to that of known Linuparus vancouverensis and, therefore, there seems to be little doubt of the synonymy.

This specimen, GSC 5972a, also shows some detail on the telson that has not previously been described. This structure seems to be broader than long, nearly smooth on the surface, and ornamented by fine spines along the posterior

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PLATE 4

All figures x1, unless otherwise indicated

Figures 1, 3, 5. Linuparus canadensis (Whiteaves)

1, 3. Dorsal and ventral views of holotype GSC 5057, x0.5, showing nearly complete cephalothorax and first three segments of the abdomen.

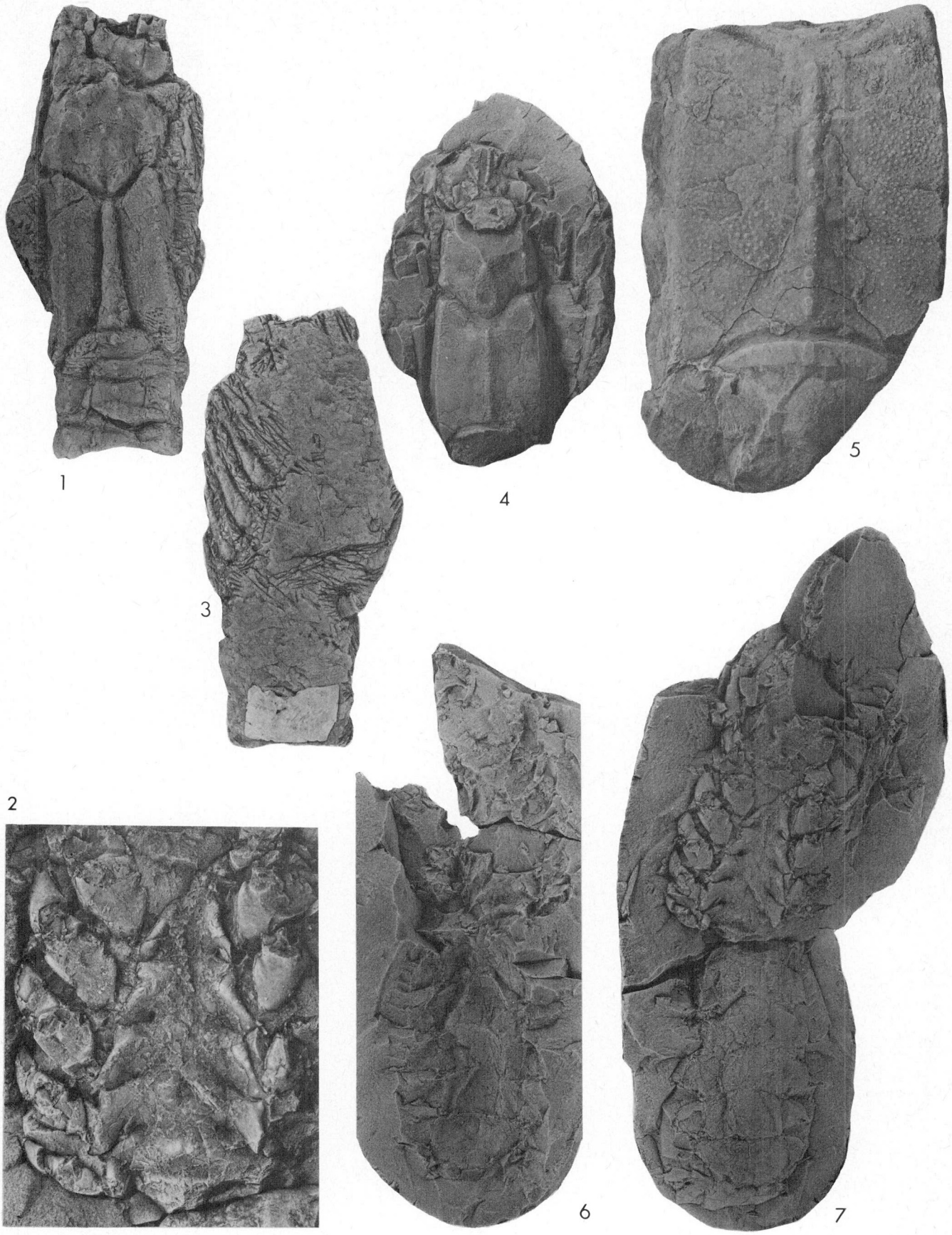
5. Dorsal view of the thoracic region of GSC 61413.

Figures 2, 4, 6, 7. Linuparus vancouverensis (Whiteaves)

2. Sternum of GSC 5972a, holotype of Hoploparia bennetti Woodward, junior synonym of L. vancouverensis, x2.5.

4. Dorsal view of syntype of L. vancouverensis, GSC 5964a.

6, 7. Part and counterpart of GSC 5972a, holotype of H. bennetti, junior synonym of L. vancouverensis.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margin. There is no evidence of a weakly calcified, soft termination which is often observed on palinurids but it may very well have existed.

Occurrences. Linuparus vancouverensis has been collected from the following localities in Canada:

1. 3.2 km up Puntledge River, Vancouver Island, British Columbia; syntype GSC 5964, 5964a, Nanaimo Group, Late Cretaceous; collected by G.W. Taylor, 1889. [Haslam Formation, or the underlying Comox Formation, late Santonian to early Campanian.]

2. Northwest side of Hornby Island, British Columbia; syntype GSC 5965, 5965a, Late Cretaceous; collected by W. Harvey, 1893. [Probably Spray Formation but possibly Northumberland Formaton, late Campanian to early Maastrichtian.]

3. Hornby Island, British Columbia; hypotypes GSC 5967, 5967a, Late Cretaceous; collected by Robbins, 1896. [Probably Spray Formation but possibly older Northumberland Formation or intervening Geoffrey Conglomerate, late Campanian to early Maastrichtian.]

4. Comox River*, Vancouver Island, British Columbia; hypotypes GSC 5966, 5966a; Late Cretaceous; collected by J.B. Bennett, 1895. [Haslam Formation or underlying Comox Formation, late Santonian to early Campanian.]

5. Comox River*, Vancouver Island, British Columbia; GSC 5972, 5972a, holotype of Hoploparia bennetti; Late Cretaceous; collected by J.B. Bennett, 1895. [Haslam Formation or underlying Comox Formation, late Santonian to early Campanian.]

Infraorder ANOMURA H. Milne Edwards, 1832

Family CALLIANASSIDAE Dana, 1852

Genus Callianassa Leach, 1814

Callianassa whiteavesi Woodward, 1896

Plate 5, figures 1-3, 6, 7

Callianassa whiteavesi Woodward, 1896, p. 223; Woodward, 1900, p. 435; Whiteaves, 1903, p. 319; Rathbun, 1926a, p. 107, Pl. 20, figs. 6-8a, b.

Description. Major chela rectilinear and large for the genus. Height of manus about two thirds length. Outer and inner surfaces smooth and uniformly convex. Lateral margins flattened. Propodus and dactylus ornamented by a row of evenly spaced punctate nodes along lateral margins. Dactylus about two thirds total length of manus. Dactylus and fixed finger both elongate triangular; fixed finger slightly shorter than dactylus. Dactylus ornamented along inner margin by a row of evenly spaced punctae. Fixed finger bordered along inner margin by a distinct ridge ornamented by a row of evenly spaced punctate nodes. Carpus broader than long; equal in height to propodus. Lower margin curved, narrowing proximally.

Minor chela rectilinear and large for genus. Length and height of manus approximately one half those of major claw. Height of manus about two thirds length. Inner and outer surfaces smooth and uniformly convex. Lateral margins of manus, dactylus and fixed finger flattened. Dactylus about equal in length to manus; finger four fifths length of dactylus. Dactylus and propodus ornamented on lateral margins by a row of evenly spaced punctate nodes. Dactylus ornamented along inner margin by a row of evenly spaced punctae; sulcus on occlusal surface. Carpus rectilinear; longer than broad and equal in height to propodus. Slight curvature of lower margin.

Remarks. The species was described by Woodward (1896) and cited without further description by Whiteaves (1903) and Rathbun (1926). Material not included in the type series includes fairly well preserved major chelae as well as a fragmented minor chela and the mold of a minor chela. Woodward's description was based on casts of major chelae which include only fragments of the remainder of the skeleton. The additional material permits expanded description of the major chela in that most of the skeletal material has been preserved.

Comparison of the new material with the syntypes reveals distinct variations of the size and shape of the major chelae within the species. Although the general shape of the manus is rectilinear, the length to height ratios reflect a variation in shape from square to rectangular (Table 3, Fig. 7). These variations are consistent with the paratypes identified by Woodward.

In describing the species, Woodward (1896, p. 223) stated that "the fixed thumb of the propodus is shorter than in any of the species hitherto recorded, and the movable

*There is no Comox River on Vancouver Island. This is probably the Puntledge River which flows out of Comox Lake, thus the specimens were collected probably from the Haslam Formation or possibly the Comox Formation, late Santonian to early Campanian.

PLATE 5

All figures x1, unless otherwise indicated

Figures 1-3, 6, 7. Callianassa whiteavesi Woodward

1. Mold of the exterior of the upper surfaces of major and minor chelae, GSC 61421, x2.
2. Lower surface of propodus and dactylus of major chela, GSC 61415, x3.
3. Nearly complete first pereiopod, syntype GSC 5818a, x3.
6. Major chela of first pereiopod, syntype GSC 5818b, x3.
7. Minor chela of first pereiopod, GSC 61417, x3.

Figures 4, 9, 10. Linuparus canadensis (Whiteaves)

4. Left lateral view of pleurae on second and third abdominal somites of holotype GSC 5057, x1.5.
9. Sternal view of GSC 61414, x1.5.
10. Sternal view of hypotype GSC 5968.

Figures 5, 8. Linuparus vancouverensis (Whiteaves)

5. Oblique view of abdomen of hypotype GSC 5966a, x2, showing spinose pleural margin.
8. Sternal view of hypotype GSC 5966a, x1.5.

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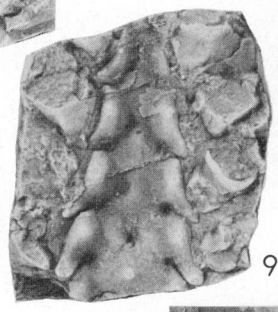

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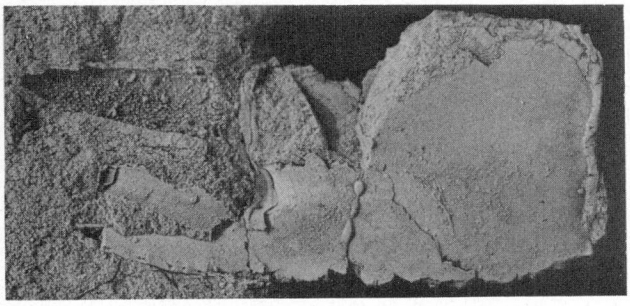

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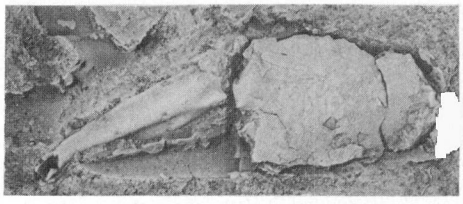

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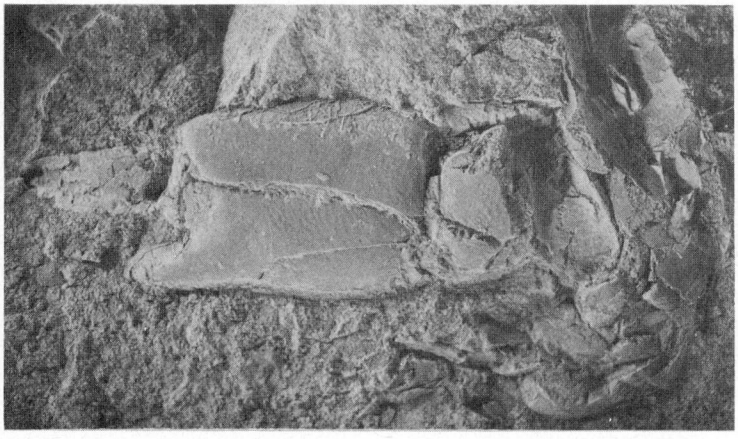

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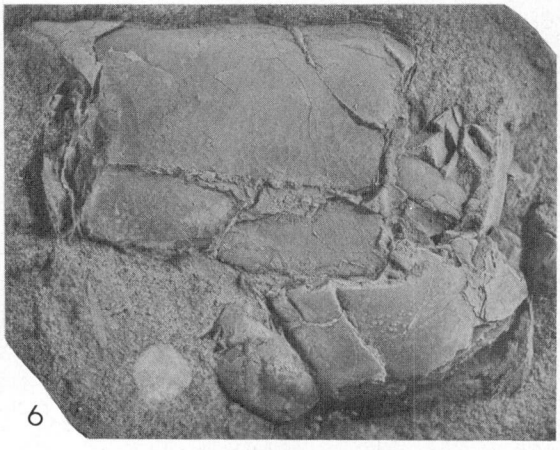

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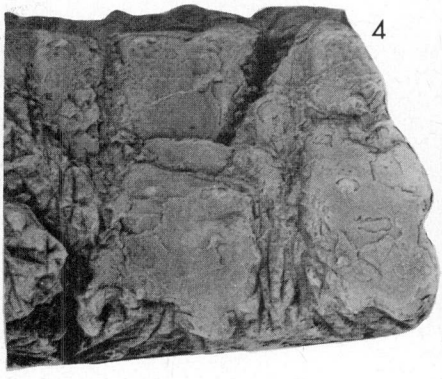

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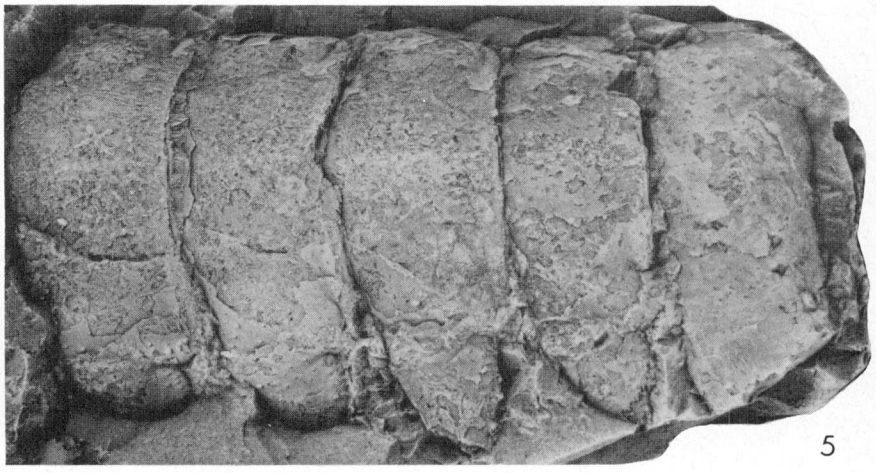

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TABLE 3

Length/height ratios of chelae of Callianassa whiteavesi Woodward, 1896.

SPECIMEN	L (mm)	MAJOR CHELA H (mm)	L/H
GSC 61415	14.1	12.5	1.1
GSC 61416	12.7	11.0	1.2
GSC 61418	14.6	12.8	1.1
GSC 61419	11.8	10.2	1.2
GSC 61420	13.1	11.1	1.2
GSC 61421	13.8	11.3	1.2
GSC 61422	15.0	11.9	1.3
SPECIMEN	L (mm)	MAJOR CHELA H (mm)	L/H
GSC 61417	10.0	6.7	1.5
GSC 61421	06.9	4.1	1.7

finger (dactylus) is straighter". However, close inspection reveals that the syntypes are aberrant, presumably damaged, forms (Pl. 5, figs. 3, 6). Rathbun (1926, p. 107, Pl. 20, fig. 8b) noted that hypotype GSC 5382 "apparently represents the normal length of the immovable finger". The fixed finger is normally slightly shorter than the dactylus. This is consistent with the other paratypes as well as with the new material (Pl. 5, figs. 1, 2).

Rathbun (1926, Pl. 20, fig. 8a) also indicated that the lateral margin of the fixed finger was serrated. However, examination of the material leads to the conclusion that the lateral margin is ornamented by a row of punctate nodes rather than serrations.

The minor chelae, not previously described, also show the same variation in size and shape as is found in the major chelae, although the trend is toward a lengthened rectangular shape (Table 3, fig. 7). The small size of the minor chela relative to the major chela is typical of the genus.

Occurrences. Callianassa whiteavesi has been collected from the following localities in western Canada:

1. NE 1/4 Sec. 34, T32, R5, W of 4th, Alberta; GSC loc. 9300; paratypes GSC 61415, 61416; Bearpaw Formation, Campanian, Late Cretaceous; collected by G.S. Hume, October 1935.

2. SE 1/4 Sec. 27, T28, R9, W of 4th, Alberta; GSC loc. 9302; Bearpaw Formation, Campanian, Late Cretaceous; collected by G.S. Hume, 1935.

3. NE 1/4 Sec. 20, T35, R4, W of 4th, Alberta; GSC loc. 9305; paratypes GSC 61417-61422; Bearpaw Formation. [lower Bearpaw Formation at this location (Campanian)], Late Cretaceous; collected by G.S. Hume, 1935.

4. Centre Sec. 2, T38, R9, W of 4th, Alberta; GSC loc. 9307; Bearpaw Formation. [probably Campanian, possible Maastrichtian], Late Cretaceous; collected by G.S. Hume, 1935.

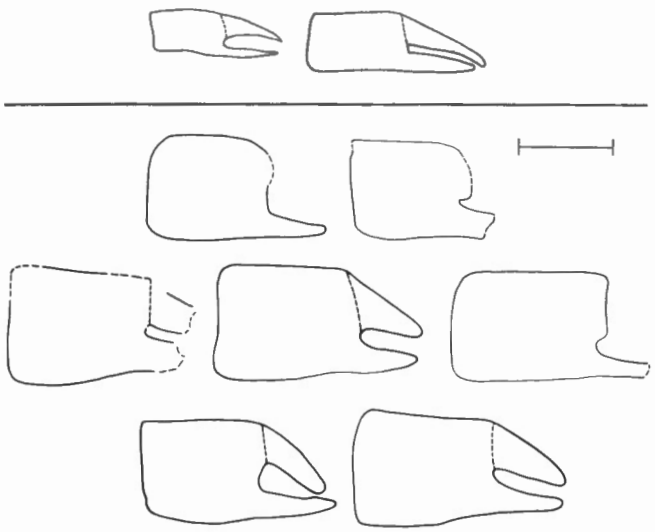

FIGURE 7. *Diagrammatic sketch of the major and minor chelae of Callianassa whiteavesi showing variations in size and shape within the species. Bar scale = 1 cm. The two outlines above the long line are minor claws, the remainder are major claws.*

5. Comox River*, Vancouver Island, British Columbia; syntypes GSC 5818a, b; paratypes (designated hypotypes on original label) GSC 5818c-e, g-i; Late Cretaceous(?); collected by C.F. Newcombe, 1892.

6. Comox River*, Vancouver Island, British Columbia; hypotype GSC 5975; Cretaceous; collected by J.B. Bennett, 1896.

7. Comox River*, Vancouver Island, British Columbia; hypotype GSC 5973; Puntledge River, Late Cretaceous; collected by G.W. Taylor, 1889.

8. T30, R8, W of 4th, Alberta; hypotypes GSC 5382a-g; Pierre-Fox Hills. [probably Campanian, possibly Maastrichtian], Late Cretaceous; collected by J.B. Tyrrell, 1880.

Infraorder BRACHYURA Latreille, 1803

Family CARCINERETIDAE Beurlen, 1930

Genus Longusorbis Richards, 1975

Longusorbis cuniculosus Richards, 1975

Longusorbis cuniculosus Richards, 1975, p. 1858.

Remarks. This species was described by Richards (1975) based on 83 well-preserved specimens. Placement in the Carcineretidae appears to be warranted and, in the absence of additional material, nothing new can be added. It is of interest to note that Richards interpreted the specimens as molts preserved within burrow structures. This mode of preservation, which assured that the specimens would be protected from scavenging prior to entombment, is apparently unique, at least as far as Canadian decapods are concerned. This species occurs in association with several shallow water molluscs and one other decapod, Callianassa sp., in rocks interpreted to have been deposited in intertidal or shallow subtidal habitats.

Occurrence. Shelter Point, 9.2 km northwest of mouth of Oyster River, Vancouver Island, British Columbia; holotype GSC 38473, paratypes GSC 38474-38479, and 76 specimens in the collection of B.C. Richards; Spray Formation of the Nanaimo Group, Late Cretaceous (probably late Campanian); collected and identified by B.C. Richards.

*See footnote, p. 32.

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