NRC Research Press

ARTICLE

# A new genus and species of polychelid lobster (Crustacea, Decapoda, Eryonidae) from the Early Jurassic (Hettangian) of British Columbia

Rodney M. Feldmann, Carrie E. Schweitzer, and James W. Haggart

**Abstract:** A single specimen of decapod crustacean, preserved in ventral view and compressed, represents a new genus and species of eryonid lobster, ***Wrangelleryon perates***. The discovery in Lower Jurassic (Hettangian) sediments of the Sandilands Formation in British Columbia represents the first occurrence of Eryonidae in North America and reinforces a global distribution of the family in the Jurassic. The occurrence in British Columbia on the Wrangellia terrane supports the lower latitude setting in which the species lived.

**Résumé :** Un spécimen unique de crustacé décapode, préservé en vue ventrale et comprimé, représente un nouveau genre et une nouvelle espèce de homard éryonidé, ***Wrangelleryon perates***. La découverte, dans des sédiments du Jurassique inférieur (Hettangien) de la Formation de Sandilands, en Colombie-Britannique, représente la première occurrence d'un éryonidé en Amérique du Nord et consolide la thèse d'une répartition planétaire de cette famille au Jurassique. La présence du spécimen en Colombie-Britannique, dans le terrane de Wrangellie, appuie la thèse voulant que l'espèce ait vécu à basse latitude. [Traduit par la Rédaction]

## Introduction

Fossil decapod crustaceans of Jurassic age are quite rare in North America as compared with Europe. In Canada, *Eryma bordenensis* (Copeland 1960) and *Glyphea robusta* Feldmann and McPherson, 1980 have been reported from Arctic Canada (Feldmann and McPherson 1980), and *Eryma walkeri* Feldmann and Haggart, 2007 was described from British Columbia. *Uncina ollerenshawi* (Feldmann and Copeland 1988) and *U. pacifica* (Schweigert et al. 2003) were documented in Alberta. In the United States, Feldmann (1979) described *Eryma foersteri* from Wyoming, and Feldmann and Titus (2006) recognized a new species, *Eryma jungostrix*, from Utah. Thus, occurrences of Jurassic decapods in North America are unusual. Adding to the novelty of the new genus and species described herein is the observation that species of Eryonidae have previously been described only from Europe, Russia, and Japan (Karasawa et al. 2013). Quilty (1988) noted the presence of *Cycleryon* sp. from Antarctica, but no species attribution was given. Therefore, the purposes of the present study are to describe a new genus and species of Eryonidae, to add a new taxon to the sparse record of Jurassic decapods in North America, and to discuss the paleobiogeographic implications of its occurrence on the Wrangellia terrane in British Columbia.

## Depository

The specimen, GSC No. 136896, is deposited in the National Type Specimen Collection at the Geological Survey of Canada office in Ottawa, Ontario. ZooBank LSID number for publication: urn:lsid:zoobank.org:pub:17D87CE9-5380-4811-8421-496AB79ADE37.

## Systematic paleontology

Order Decapoda Latreille, 1802

Infraorder Polychelida Scholtz and Richter, 1995 (sensu DeGrave et al. 2009)

DIAGNOSIS: Polychelida include taxa exhibiting a dorsoventrally flattened carapace with an indistinct or reduced rostrum, lacking an antennal groove and generally, but not always, possessing median thoracic and branchial carinae. The epistome and carapace are not in broad contact. The pleon typically exhibits an axial keel and a sharp demarcation between the terga and pleura, and the telson is triangular. An antennular stylocerite is present and pereiopods 1–4 are chelate.

DISCUSSION: The specimen under consideration is difficult to interpret because it is imperfectly preserved and is oriented with the ventral surface exposed. However, it is dorsoventrally flattened, and the pleon has an axial keel and well-defined demarcation between terga and pleurae. The telson is triangular, and at least some of the pereiopods are chelate. For these reason, placement in Polychelida is considered to be certain. Polychelida ranges in age from Late Triassic to Holocene (Karasawa et al. 2013).

Family Eryonidae De Haan, 1831

INCLUDED GENERA: *Cycleryon* Glaessner, 1965; *Eryon* Desmarest, 1822; *Knebelia* Van Straelen, 1922; *Rosenfeldia* Garassino, Teruzzi, and Dalla Veccia, 1996; *Wrangelleryon* new genus herein. (Included genera from Schweitzer et al. 2010.)

DIAGNOSIS: Carapace subrectangular or subcircular, dorsoventrally flattened in adults; rostrum indistinct; antennal groove absent; cervical groove more or less deep; with branchial and thoracic median carinae; epistome and carapace not in broad contact. Pleon flattened, with axial keel and sharp demarcation between terga and pleura; pleura triangular; telson subtriangular; exopod of uropod without diaeresis. Antennular stylocerite present; dactylus of third maxilliped sharp; pereiopods 1–4 chelate; pereiopod 5 dactylus terminal in males, chelate in females.

DISCUSSION: The specimen under consideration is most reasonably placed within Eryonidae, although the nature of preserva-

Received 28 July 2012. Accepted 12 October 2012.

Paper handled by Associate Editor Jisuo Jin.

**R.M. Feldmann.** Department of Geology, Kent State University, Kent, OH 44242, USA.
**C.E. Schweitzer.** Department of Geology, Kent State University at Stark, 6000 Frank Ave., N.W., North Canton, OH 44720, USA.
**J.W. Haggart.** Geological Survey of Canada, 625 Robson Street, Vancouver, BC V6B 5J3, Canada.
**Corresponding author:** R.M. Feldmann (e-mail: rfeldman@kent.edu).

tion and the orientation of the specimen preclude evaluation of most of the characters of the dorsal carapace. The most parsimonious interpretation of the specimen is that the carapace is elongate, ovate, and with at least a diminutive rostrum. However, there is no direct evidence of the carapace outline because the specimen is preserved with the ventral side upward, and traces of the carapace margin are not in evidence. In fact, the only trace of the carapace is the poorly preserved rostrum area. The flattened, keeled pleuron with distinct terga and triangular pleurae, coupled with a subtriangular telson are essential characters in placement within the family. Perhaps the most important character, however, is the absence of a diaeresis on the exopod of the uropods. One other family of dorsoventrally flattened lobsters that has features similar to Eryonidae is Coleiidae; however, members of Coleiidae are typically more elongate than eryonids and always possess a diaeresis on the exopod of the uropods. Discovery of better preserved specimens, particularly in dorsal view, will permit a more detailed comparison and, perhaps, reevaluation of placement, but for now, assignment to Eryonidae is most likely. The relationship between Eryonidae, Coleiidae, and other families within Polychelida is detailed in a recent study (Karasawa et al. 2013) and will not be reiterated here. Eryonidae range from Late Triassic (Norian) to Early Cretaceous (Berriasian–Hauterivian) (Karasawa et al. 2013).

Genus ***Wrangelleryon*** n. gen.

ETYMOLOGY: The generic name is derived from Wrangellia, the exotic terrane of the western North America Cordillera from which the specimen was collected, and *Eryon*, type genus of the family. The gender is masculine.

TYPE SPECIES: *Wrangelleryon perates* new species herein. ZooBank LSID number for genus: urn:lsid:zoobank.org:act:BBD73B29-8329-43C6-A399-376D64D93744.

INCLUDED SPECIES: *Wrangelleryon perates* new species herein.

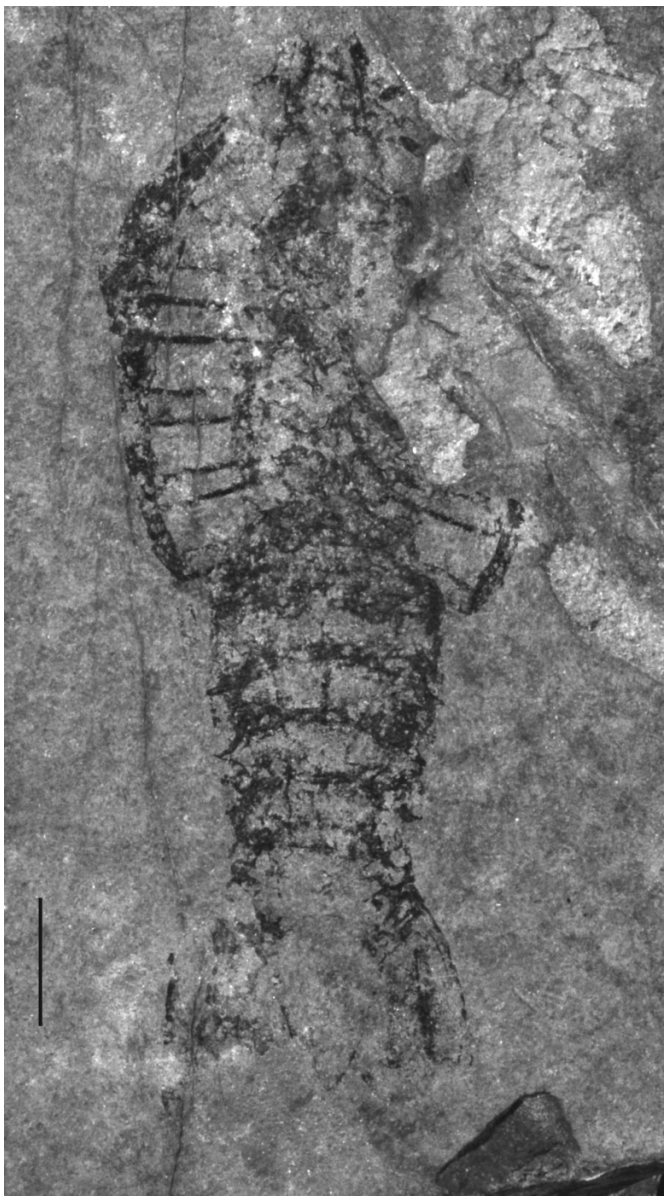
DIAGNOSIS: Carapace outline and surface not preserved. Pleon flattened, keeled on at least somites 2–4; with triangular pleura terminating in short, sharp, posterolaterally directed spine. Telson subtriangular with weakly convex lateral margins and acute tip. Uropods not extending to tip of telson, spatulate, with rounded tips; exopod of uropods without diaeresis. Pereiopod 2(?) with large, well-developed cheliped. Anterior and posterior margins of meri and outer surface of propodus with delicate, distally directed spines.

DISCUSSION: Although placement in Eryonidae is warranted as discussed in the preceding text, assignment to any of the presently known genera within the family is not consistent with their definitions. The plexus of characters typifying *Wrangelleryon*, and the sole known species, *W. perates*, is unique.

*Cycleryon* spp. have a nearly circular carapace outline and a telson that is more slender than that of *Wrangelleryon* with concave lateral margins. The uropods on *Cycleryon* spp. extend approximately to the tip of the telson and have an acuminate tip, whereas the uropods of *Wrangelleryon* are shorter than the telson and have rounded terminations. The tips of the pleura on *Cycleryon* spp. lack the short, sharp spines that characterize *Wrangelleryon*.

The carapace of *Eryon* spp. is more rectilinear and bears deep lateral cervical and branchiocardiac notches; neither character is typical of *Wrangelleryon.* The former genus also has a telson that is narrower than that of the new genus and the lateral margins are concave. The uropods of *Eryon* nearly extend to the tip of the telson and have acuminate tips, whereas the uropods of *Wrangelleryon* are shorter than the telson and have rounded terminations.

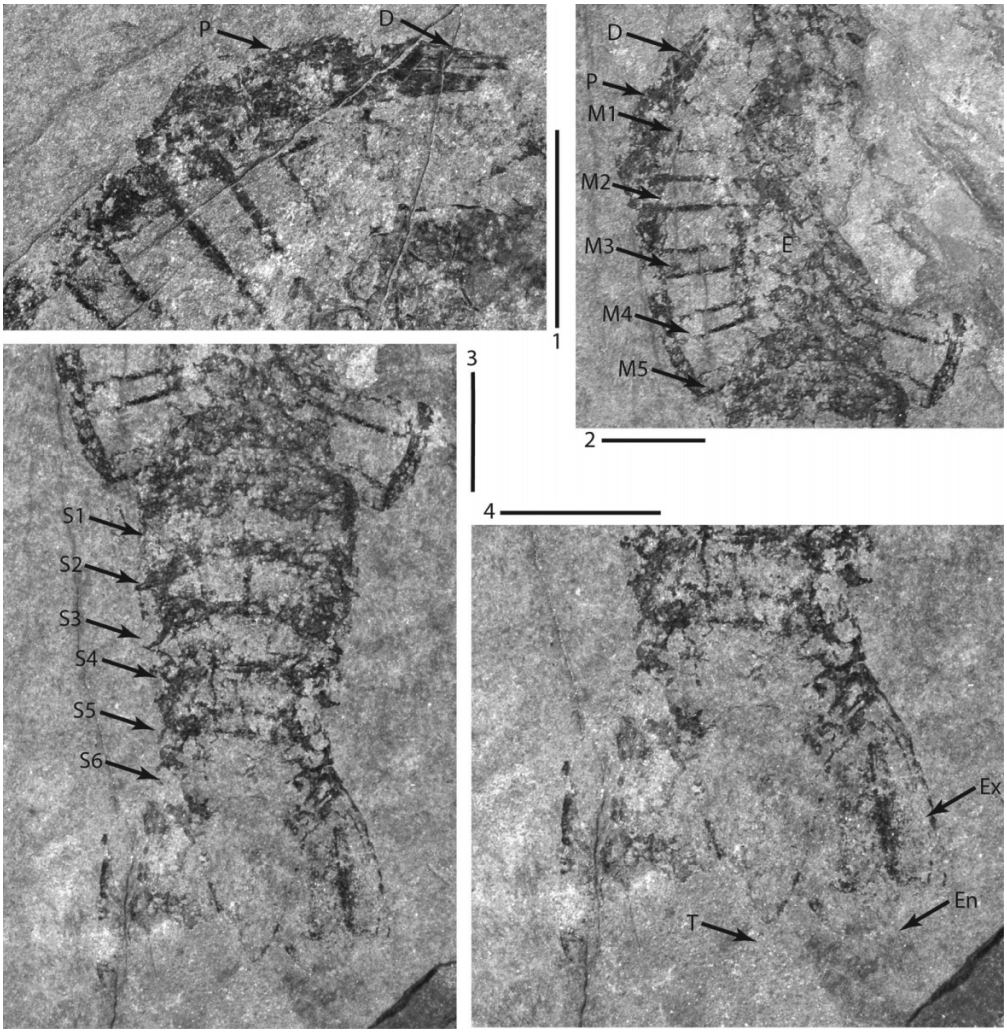
**Fig. 1.** *Wrangelleryon perates* n. sp., holotype, GSC C-156926. Scale bar equals 1 cm.



The monospecific *Knebelia* has a rectilinear carapace with a deeply concave posterior margin so that the posterolateral corners of the carapace extend posteriorly to the third pleonal somite. Sharp spines are lacking on the pleura, and the telson forms a nearly perfect isosceles triangle. The broadly acuminate tips of the uropods extend beyond the tip of the telson. None of these characters is typical of *Wrangelleryon perates*.

The morphology of *Rosenfeldia* spp. clearly separates them from other Eryonidae. The carapace is ovoid, wider than long or about as wide as long, and exhibits finely dentate carapace margins. The pleon is as wide as the carapace anteriorly and tapers posteriorly. Pleura lack the sharp spines of *Wrangelleryon*. The most distinctive feature of *Rosenfeldia* is the rounded, vaguely triangular telson bearing serrate margins and the flabellate uropods that are approximately the same length as the telson which are not typical of *Wrangelleryon*.

**Fig. 2.** *Wrangelleryon perates* n. sp. (2.1) Enlargement of right second (?) pereiopod showing propodus (P) and dactylus (D). (2.2) Ventral view of specimen showing the meri of pereiopods 1–5 (M1–M5), propodus and dactylus of second (?) pereiopod, and part of the endophragm (E). (2.3) Pleon of specimen denoting somites 1–6 (S1–S6). (2.4) Telson (T) and uropods of specimen showing endopod (En) and exopod (Ex). Scale bars equal 1 cm.




***Wrangelleryon perates*** n. sp.
(Figs. 1, 2.1–2.4)

ETYMOLOGY: The trivial name is derived from the Greek *perates* meaning wanderer, in reference to the displacement on the Wrangellia microplate, the location of the specimen, from an inferred low latitude locality to its present position in British Columbia, Canada.

TYPE SPECIMEN: The holotype and sole specimen, GSC No. 136896, collected from Locality GSC C-156926, is deposited at the National Type Specimen Collection at the Geological Survey of Canada office in Ottawa, Ontario, Canada. ZooBank LSID number for species: urn:lsid:zoobank.org:act:A0F34FEF-EEF3-493E-A6AF-26523DD016E0.

DIAGNOSIS: As for the genus.

DESCRIPTION: Specimen preserved in ventral aspect. Carapace known only from poorly preserved rostral area. Maximum width of specimen, ca. 30 mm, at about midlength of presumed carapace outline; length ca. 37 mm. Front poorly preserved, ca. 17 mm wide, appears to be smoothly concave forward with no indication of orbital notches. Lateral carapace margins not known with certainty. Posterior margin broad, ca. 23 mm wide, convex forward.

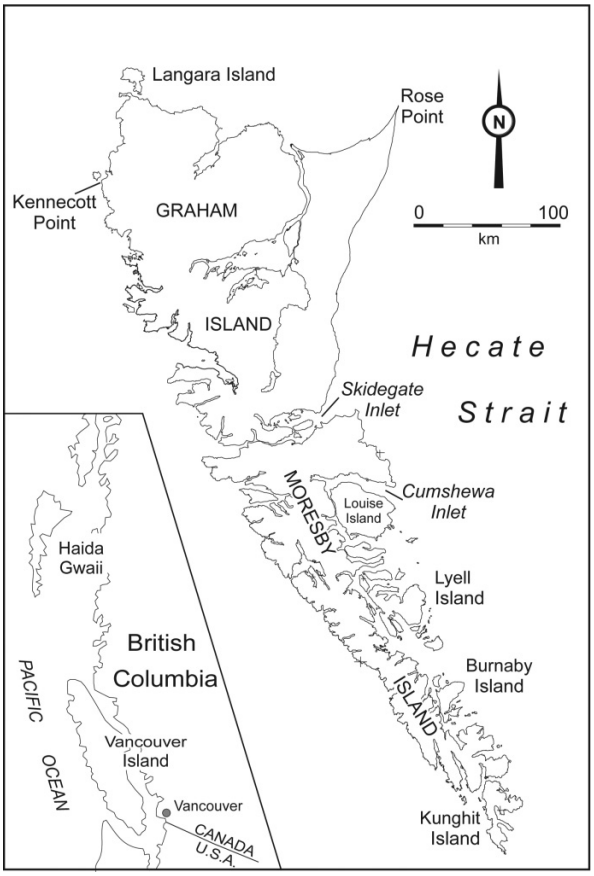
Pleon, excluding telson, ca. 32 mm long, with maximum width, ca. 19 mm, attained on somite 2; somites 1–5 approximately 5 mm long; somite 6 about 7 mm long; margins of pleon weakly convex. Pleura of somites 2–5 triangular, terminating in short, sharp, posterolaterally directed spines. Posterior rim of somites viewed on ventral surface appear to be thickened. Axial keel evident at least on posterior parts of somites 2–4.

Uropods with elongate, spatulate exopod and endopod with rounded tips, about 12 mm long and 3 mm wide; no evidence of a diaeresis. Tips of uropods do not extend to tip of telson. Telson triangular, lateral margins weakly convex, tip acute, 10 mm wide proximally, 10 mm long.

Sternum fragmentary, elongate, broadens posteriorly to maximum width of ca. 13 mm at sternite 6. Sternite 7 somewhat narrower.

Antennular and antennal bases extend directly forward from front of carapace and occupy a span of ca. 7 mm width. Meri (?) of pereiopods 1–4 ca. 3 mm wide and ca. 8 mm long; margins straight and bearing very fine, distally directed spines on anterior and posterior margins. Distal elements of pereiopods lie along carapace margin and those of pereiopods 1–4 appear to be narrower than meri. One cheliped, possibly on pereiopod 2, chelate; propo-

**Fig. 3.** Location map of western British Columbia showing the site from which *Wrangelleryon perates* was collected at Kennecott Point, Haida Gwaii.




dus 14 mm long, ca. 4 mm high, with slender fixed finger and dactylus about 7 mm long. Outer surface of manus with very fine, distally directed spines. Dactylus positioned outward relative to carapace position. Occlusal surfaces of both fingers smooth. Pereiopod 5 shorter than preceding pereiopods.

OCCURRENCE: The collection C-156926 was collected from the intertidal platform at Kennecott Point, Haida Gwaii (Fig. 3), by H.W. Tipper (deceased) or his assistant Beth Carter, in 1988. Strata of this intertidal platform are disrupted into a number of fault-bounded blocks, each with its own stratigraphic section; strata are correlated between the blocks using marker beds and biostratigraphic occurrences. The collection C-156926 is from Section B of the platform, located at the southern edge of the platform between 53°54′44.7″N latitude, 133°09′10.9″W longitude (section base) and 53°54′43.3″N latitude, 133°09′12.2″W longitude (section top) (Longridge et al. 2008). The collection C-156926 was made approximately 13 m above the base of the section, within the Sandilands Formation.

The collection C-156926 is well dated paleontologically. Ammonites collected from strata immediately underlying the collection include *Ectocentrites pacificus* Longridge et al. 2008 (C-156925; TD-88-6-6), while strata immediately overlying contain the ammonite *Pseudaetomoceras* cf. *P. doetzkirchneri* (Gümbel 1861) (C-156927; TD-88-6-8). According to Longridge et al. (2008), all these strata are assigned to the Sunrisensis Zone, of Early Jurassic (late middle Hettangian) age. Ammonites dominate these strata; other fossils are rare.

DISCUSSION: As discussed in the preceding text, the new genus and species exhibit a sufficient number of unique characters in a unique combination to warrant placement in a new taxon. That said, there are certain vexing aspects of the specimen that demand caution in making detailed comparisons.

The specimen is preserved in ventral view so that the nature of the dorsal carapace is unclear. Relief on the specimen is extremely low. It is possible that the carapace is not preserved at all, in which case statements regarding outline of the carapace in the description are unwarranted. The most parsimonious interpretation of carapace outline is based upon the position of pereiopods 2–4 that are superimposed upon one another in a gently convex array. In this scenario, the pereiopods are interpreted as lying along the lateral margins of the carapace, hence, defining an elongate, ovoid carapace outline. There is absolutely no direct evidence of any carapace material other than that which lies within the outline defined by the pereiopods.

However, examination of illustrations by Garassino and Schweigert (2006) introduce the possibility of an alternative interpretation. The eryonids they illustrate (2006, pls. 15–17) show the pereiopods arrayed beneath a very much wider carapace, so that they would not be visible in a dorsal view if the legs were bent markedly at the merus–carpus joint. Thus, although that possibility might exist with *Wrangelleryon perates*, the absence of physical evidence brings us to the conservative interpretation presented in the preceding text.

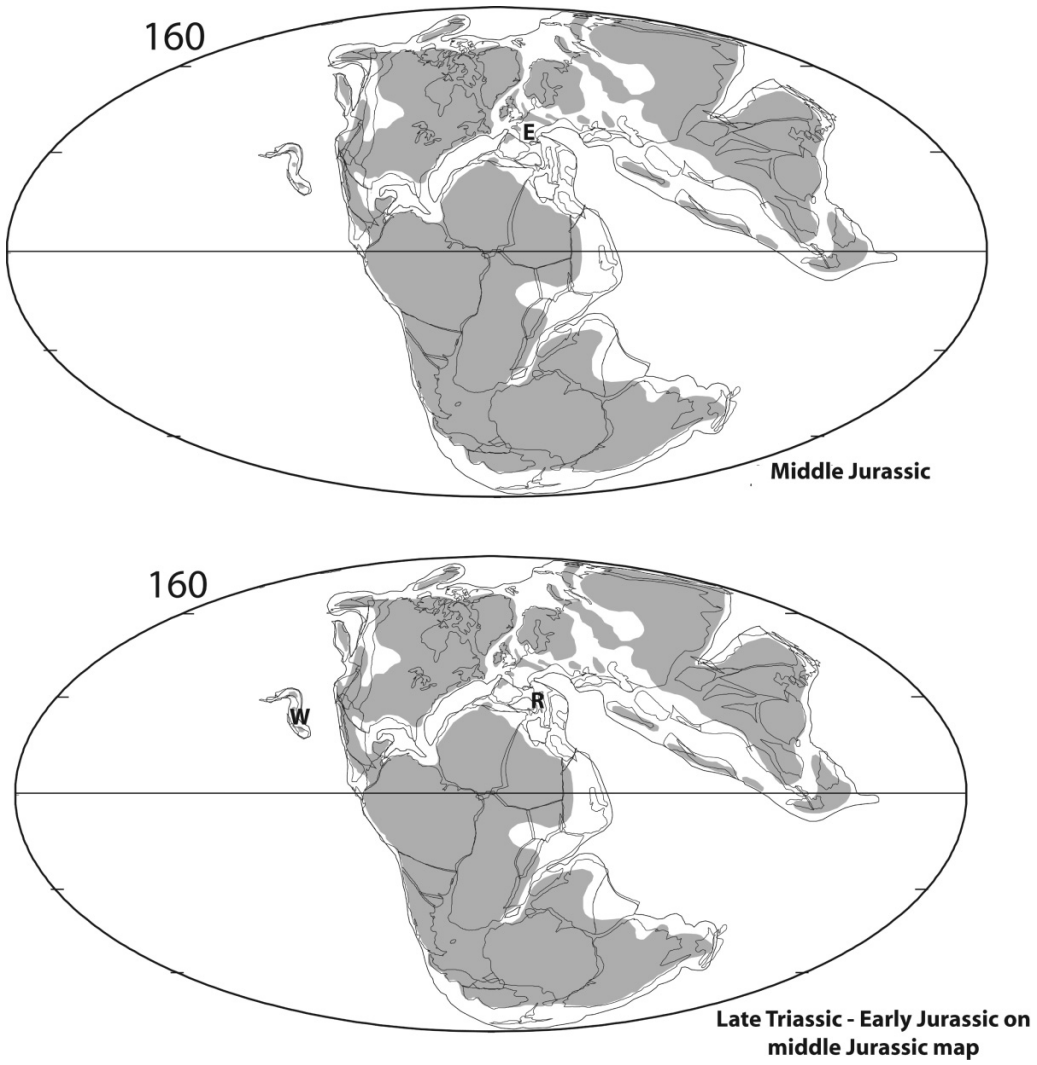
The ventral aspect of the specimen also precludes consideration of the nature of carapace grooves and carinae, although if either feature was strongly developed, it might be possible to see an expression of them from below. The nature of the pleon is more readily interpreted and the descriptors based upon that region can be taken to be reliable. The characters of the pleon and telson clearly document the unique character of *Wrangelleryon perates* and justify erection of a new genus and species.

Elements of the sternum are present, but the cuticle is badly broken up and displaced. Thus, it is difficult to say much about the structure other than to note that the overall outline is narrowly triangular. This shape is similar to that seen in other eryonids where vestiges of a sternum are presented (e.g., Glaessner 1969, fig. 274; Garassino et al. 1996, figs. 18–20; Garassino and Schweigert 2006, pls.15–17).

Even more than the orientation of the specimen, the mode of preservation of the specimen makes detailed interpretations difficult. The remains are preserved as black, replaced fragments of carapace and appendages preserved along a single plane within dark grey–black siltstone. The result is a tracery, or only a partial tracery, of the individual parts of the specimen. Surface features of most parts of the fossil are not preserved. The specimen has been viewed under normal light, plane polarized light, and long- and short-wave ultraviolet light. There was no evidence of fluorescence, and the best results were obtained with normal illumination from a moderately low angle from the upper left of the specimen using a Nikon D3100 camera with AF-S Micro NIKKOR 60 mm lens. The images were recorded in color, converted to grey-scale, and contrast was enhanced using Adobe© Photoshop.

Hettangian strata at Kennecott Point, Haida Gwaii, are assigned to the Sandilands Formation, part of the general Wrangellia terrane of western North America, with its distinctive tectonostratigraphic succession (Jones et al. 1977). The Sandilands Formation on Haida Gwai has a general age range of Rhaetian to Toarcian and is locally time-transgressive (Haggart 2004). The formation consists of shale and mudstone with interstratified thin-bedded siltstone and fine- to medium-grained sandstone; some sandstones are tuffaceous (Sutherland Brown 1968; Desrochers and Orchard 1991; Haggart 2004). Calcareous nodules are common throughout the formation, particularly in

**Fig. 4.** Late Triassic – Early Jurassic and Middle Jurassic paleogeographic maps (modified from Scotese 2006) showing the position of the Wrangellia microplate and the location of genera of eryonids. E, *Eryon*; R, *Rosenfeldia*; W, *Wrangellia*.



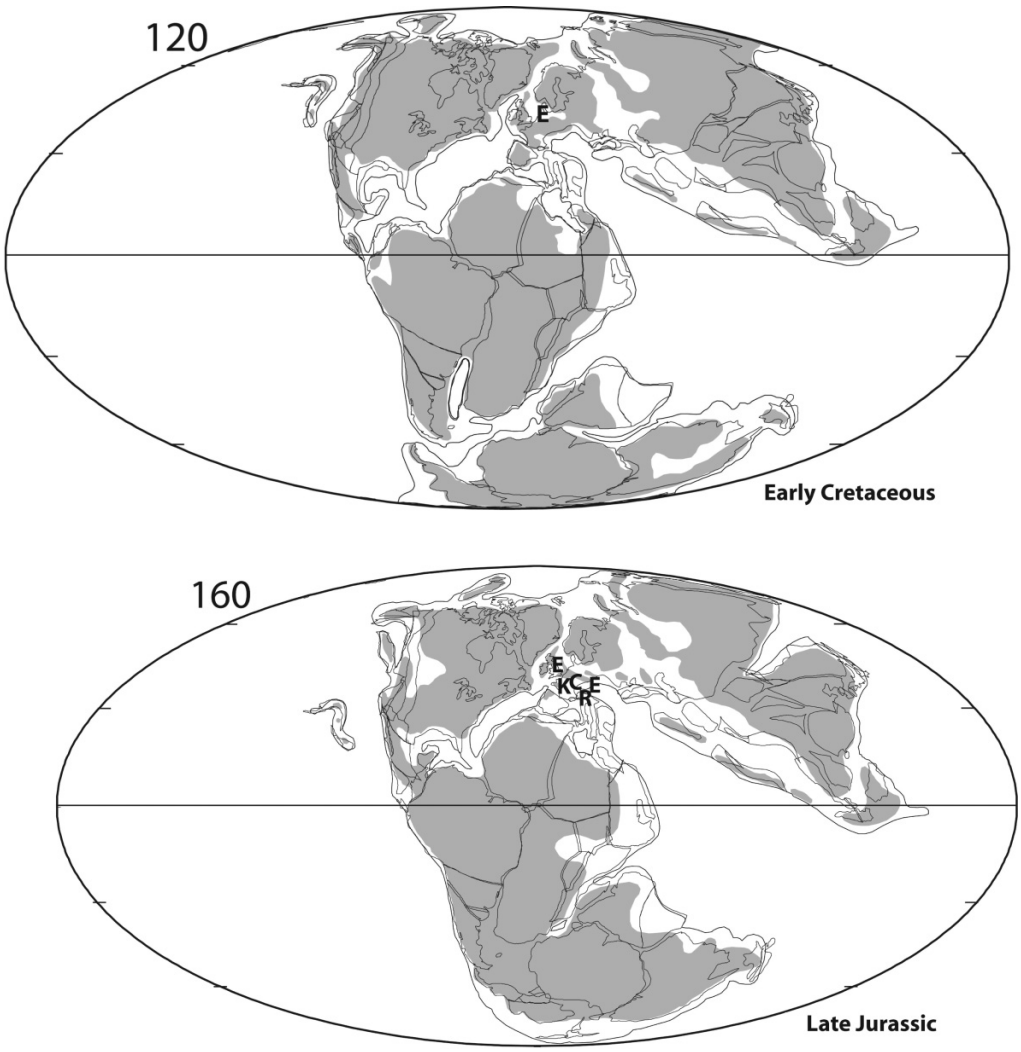

the finer grained facies, and the collection C-156926 came from one of these carbonate nodules, within a generally siltstone-dominated interval of the stratigraphic section. The tuffaceous aspect of parts of the Sandilands Formation attests to episodic volcanism locally along the Wrangellian arc during this time, although volcanic strata of this age are rare on Haida Gwaii (Haggart 2004) and also northern Vancouver Island (Nixon and Orr 2007); the vast succession of Lower Jurassic volcanic rocks of northern Vancouver Island (Bonanaza arc) suggests that volcanism was centered in this region of Wrangellia, rather than Haida Gwaii.

In general, lower strata of the Sandilands Formation are interpreted to have been deposited along the distal margins of submarine fans, following Late Triassic drowning of carbonate platform successions of Wrangellia (Desrochers and Orchard 1991). The up-section increase in coarse clastic content through the formation reflects a relative shallowing of sedimentation and basin filling in earliest Jurassic time; sedimentological evidence in the Sandilands Formation in the Kennecott Point section suggests that some strata of the formation may have accumulated above storm wave base.

A variety of paleomagnetic and paleontologic data have been used to infer a low-latitude origin for Wrangellia, including the Sandilands Formation, during latest Triassic and Early Jurassic time, probably in the eastern Pacific (Jones et al. 1977; Tozer 1982; Smith and Tipper 1986; Enkin 2006; Smith 2006; Longridge et al. 2008; Figs. 4, 5) Wrangellia is inferred to have completed its journey northwards along the western North American margin to its approximate latitudinal position by either Middle Jurassic time, based on faunal biogeography and tectonic interpretation (Taylor et al. 1984; van der Heyden 1992; Carter and Haggart 2006; Schröder-Adams and Haggart 2006), or by some time in the Late Cretaceous, based on paleomagnetic analysis (Ward et al. 1997; Enkin 2006). Based upon these data, the sole specimen of *Wrangelleryon* recognized to date is inferred to have inhabited a relatively offshore, deep-water marine environment of the lower latitudes, presumably around the limit of wave activity associated with the most extreme storm events.

Thus, the discovery of *Wrangelleryon perates* in offshore Hettangian deposits in British Columbia represents the first occurrence of Eryonidae in North America. Coupled with the previously noted occurrences of the family in Europe, Russia, Japan, and Antarctica, the occurrence in the western Pacific basin of *Wrangelleryon perates* permits suggesting that the Eryonidae had a global distribution during the Jurassic. Whether the relatively deep, offshore habitat is remarkable remains to be tested. Little is known about fossil decapods from deep-water settings.

**Fig. 5.** Late Jurassic and Early Cretaceous paleogeographic maps (modified from Scotese 2006) showing the position of the Wrangellia microplate and the location of genera of eryonids. C, *Cycleryon*; E, *Eryon*, K, *Knebalia*; R, *Rosenfeldia*.




## Acknowledgements

Laboratory work and photography supported by National Science Foundation grant DEB EF0531674 to Feldmann and Schweitzer. Careful reviews by Joachim Haug and Günter Schweigert substantially improved the manuscript.

## References

Carter, E.S., and Haggart, J.W. 2006. Radiolarian biogeography of the Pacific region indicates a mid- to high-latitude (>30°) position for the Insular superterrane since the late Early Jurassic. *In* Paleogeography of the North American Cordillera: Evidence For and Against Large-Scale Displacements. *Edited by* J.W. Haggart, R.J. Enkin, and J.W.H. Monger. Geological Association of Canada, Special Paper 46, pp. 109–132.

Copeland, M.H. 1960. *Erymastacus bordenensis*, a new Mesozoic decapod from the Canadian Arctic. Geological Survey of Canada, Bulletin, **60**: 55–57.

DeGrave, S., Pentcheff, N.D., Ahyong, S.T., Chan, T.-Y., Crandall, K.A., Dworschak, P.C., Felder, D.L., Feldmann, R.M., Fransen, C.H.J.M., Goulding, L.Y.D., Lemaitre, R., Low, M.E.Y., Martin, J.W., Ng, P.K.L., Schweitzer, C.E., Tan, S.H., Tshudy, D., and Wetzer, R. 2009. A classification of living and fossil genera of decapod crustaceans. The Raffles Bulletin of Zoology, Supplement, **21**: 1–109.

De Haan, W. 1833-1850. Crustacea. *In* Fauna Japonica sive Descriptio Animalium, quae in Itinere per Japoniam, Jussu et Auspiciis Superiorum, qui summum in India Batava Imperium Tenent, Suscepto, Annis 1823-1830 Collegit, Notis, Observationibus et Adumbrationibus Illustravit. *Edited by* P.F. von Siebold, J. Müller et Co., Lugduni Batavorum [= Leyden]. pp. i-xvii, i-xxxi, ix-xvi, 1-243, pls. A-J, I-Q, 1–55, circ. tab. 2.

Desmarest, A.G. 1822. Histoire naturelle des Crustacés fossiles. Les Crustacés proprement dits. F.G. Levrault, Paris. pp. **67**–154, pls. 5–11.

Desrochers, A., and Orchard, M.J. 1991. The Kunga Group (Late Triassic - Early Jurassic), Queen Charlotte Islands, British Columbia: stratigraphic revisions and carbonate sedimentology. *In* Evolution and Hydrocarbon Potential of the Queen Charlotte Basin, British Columbia. *Edited by* G.J. Woodsworth. Geological Survey of Canada, Paper 90–10, pp. 163–172.

Enkin, R.J. 2006. Paleomagnetism and the case for Baja British Columbia. *In* Paleogeography of the North American Cordillera: Evidence For and Against Large-Scale Displacements. *Edited by* J.W. Haggart, R.J. Enkin, and J.W.H. Monger. Geological Association of Canada, Special Paper 46, pp. 233–253.

Feldmann, R.M. 1979. *Eryma foersteri*, a new species of lobster (Decapoda) from the Jurassic (Callovian) of North America. American Museum Novitates, **2668**: 1–5.

Feldmann, R.M., and Copeland, M.J. 1998. A new species of erymid lobster from Lower Jurassic strata (Sinemurian/Pliensbachian), Fernie Formation, southwestern Alberta. Contributions to Canadian Paleontology, Geological Survey of Canada, Bulletin, **379**: 93–101.

Feldmann, R.M., and Haggart, J.W. 2007. A new species of lobster (Astacidea, Erymidae) from the Smithers Formation (Middle Jurassic) of British Columbia, Canada. Canadian Journal of Earth Sciences, **44**(12): 1791–1796. doi:10.1139/e07-058.

Feldmann, R.M., and McPherson, C.B. 1980. Fossil decapod crustaceans of Canada. Geological Survey of Canada, Paper 79-16: 1–20.

Feldmann, R.M., and Titus, A.L. 2006. *Eryma jungostrix* n. Sp. (Decapoda: Erymidae) from the Redwater Shale Member of the Stump Formation (Jurassic: Oxfordian) of Utah. Journal of Crustacean Biology, **26**: 63–68.

Garassino, A., and Schweigert, G. 2006. The Upper Jurassic Solnhofen decapod crustacean fauna: Review of the types from old descriptions, Part I. In-

fraorders Astacidea, Thalassinidea, and Palinura. Memorie della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano, **34**: 1–64.

Garassino, A., Teruzzi, G., and Dalla Vecchia, F.M. 1996. The macruran decapod crustaceans of the Dolomia di Forni (Norian, Upper Triassic) of Carnia (Udine, NE Italy). Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano, **136**: 15–60.

Glaessner, M.F. 1965. Vorkommen fossiler Dekapoden (Crustacea) in Fisch-Schiefern. Senckenbergiana Lethaia, **46**(a): 111–122.

Glaessner, M.F. 1969. Decapoda. *In* Treatise on Invertebrate Paleontology, R (4) (2). *Edited by* R.C. Moore. Geological Society of America, Boulder, Colorado, and University of Kansas Press, Lawrence, Kansas. pp. R400-R533, R626-R628.

Gümbel, C.W. 1861. Geognostische Beschreibung des bayerischen Alpengebirges und seines Vorlandes. Perthes, Gotha, 950 pp.

Haggart, J.W. 2004. Geology, Queen Charlotte Islands, British Columbia. Geological Survey of Canada, Open File 4681, 1 sheet, scale 1:250, 000.

Jones, D.L., Silberling, N.J., and Hillhouse, J. 1977. Wrangellia — a displaced terrane in northwestern North America. Canadian Journal of Earth Sciences, **14**(11): 2565–2577. doi:10.1139/e77-222.

Karasawa, H., Schweitzer, C.E., and Feldmann, R.M. 2013. Phylogeny and systematics of extant and extinct lobsters. Journal of Crustacean Biology, **50**: 78–123.

Latreille, P.A.1802- 1803. Histoire naturelle, générale et particulière, des Crustacés et des Insectes, **3**. F. Dufart, Paris. pp. 1–468.

Longridge, L.M., Pálfy, J., Smith, P.L., and Tipper, H.W. 2008. Middle and Late Hettangian (Early Jurassic) ammonites from the Queen Charlotte Islands, British Columbia, Canada. Revue de Paléobiologie, **27**(1): 191–248.

Nixon, G.T., and Orr, A.J. 2007. Recent revisions to the Early Mesozoic stratigraphy of northern Vancouver Island (NTS 102I; 092L) and metallogenic implications, British Columbia. Geological Fieldwork, 2006. British Columbia Geological Survey, Paper 2007-1, pp. 163-177.

Quilty, P.G. 1998. *Cycleryon* Glaessner (Crustacea, Decapoda) from the Jurassic of Ellsworth Land, Antarctica. Journal of Paleontology, **62**: 619–622.

Scholtz, G., and Richter, S. 1995. Phylogenetic systematics of the reptantian Decapoda (Crustacea, Malacostraca). Zoological Journal of the Linnaean Society, **113**(3): 289–328. doi:10.1006/zjls.1995.0011. PMID:10.1111/j.1096-3642.1995.tb00936.x.

Schröder-Adams, C.J., and Haggart, J.W. 2006. Biogeography of Foraminifera in tectonic reconstructions: limitations and constraints on the paleogeographic position of Wrangellia. *In* Paleogeography of the North American Cordillera: Evidence For and Against Large-Scale Displacements. *Edited by* J.W. Haggart, R.J. Enkin, and J.W.H. Monger. Geological Association of Canada, Special Paper 46, pp. 95–108.

Schweigert, G., Garassino, A., Hall, R.L., Hauff, R.B., and Karasawa, H. 2003. The lobster genus *Uncina* Quenstedt, 1851 (Crustacea: Decapoda: Astacidea: Uncinidae) from the Lower Jurassic. Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie), **332**: 1–43.

Schweitzer, C.E., Feldmann, R.M., Karasawa, H., and Garassino, A. 2010. Systematic list of fossil decapod crustacean species. Crustaceana Monographs, **10**: 1–222.

Scotese, C.R. 2006. Plate tyectonic maps and continental drift animations. (www.scotese.com).

Smith, P.L. 2006. Paleobiogeography and Early Jurassic molluscs in the context of terrane displacement in western Canada. *In* Paleogeography of the North American Cordillera: Evidence For and Against Large-Scale Displacements. *Edited by* J.W. Haggart, R.J. Enkin, and J.W.H. Monger. Geological Association of Canada, Special Paper 46, pp. 81–94.

Smith, P.L., and Tipper, H.W. 1986. Plate tectonics and paleobiogeography: Early Jurassic (Pliensbachian) endemism and diversity. Palaios, **1**: 399–412. doi:10.2307/3514477.

Sutherland Brown, A. 1968. Geology of the Queen Charlotte Islands, British Columbia. British Columbia Department of Mines and Petroleum Resources, Bulletin 54, 226 p., 18 pls.

Taylor, D.G., Callomon, J.H., Hall, R., Smith, P.L., Tipper, H.W., and Westermann, G.E.G. 1984. Jurassic ammonite biogeography of western North America: the tectonic implications. *In* Jurassic-Cretaceous Biochronology and Paleogeography of North America. *Edited by* G.E.G. Westermann. Geological Association of Canada Special Paper 27, p. 121–141.

Tozer, E.T. 1982. Marine Triassic faunas of North America: their significance for assessing plate and terrane movements. Geologische Rundschau, **71**(3): 1077–1104. doi:10.1007/BF01821119.

van derHeyden, P. 1992. A Middle Jurassic to Early Tertiary Andean-Sierran arc model for the Coast Belt of British Columbia. Tectonics, **11**(1): 82–97. doi:10.1029/91TC02183.

Van Straelen, V. 1922. Les Crustacés Décapodes du Callovien de la Voulte-sur-Rhône (Ardèche). Comptes Rendus Académie des Science, Paris, **175**: 982–983.

Ward, P.D., Hurtado, J.M., Kirschvink, J.L., and Verosub, K.L. 1997. Measurements of the Cretaceous paleolatitude of Vancouver Island: consistent with the Baja-British Columbia hypothesis. Science, **277**: 1642-1645. doi:10.1126/science.277.5332.1642.