New fossil squat lobsters (Crustacea: Anomura: Munididae) from the Eastern Pacific

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Abstract

Two new species of fossil squat lobsters from Cenozoic deposits of Washington State, USA are assigned to *Munida* Leach, 1820, with *M. witteae* from the early Oligocene Makah Formation of the northwestern Olympic Peninsula of Washington and *M. branti* from the early to middle Miocene Astoria Formation of southwestern Washington. These new reports increase the number of fossil species of *Munida* to 14, three of which are reported from Washington State.

Keywords: Crustacea, Decapoda, Anomura, Cenozoic, Washington, USA.

1. Introduction and geology

Two new species of the squat lobster *Munida*, *M. witteae* n. sp. and *M. branti* n. sp., are described from the Eocene-Oligocene Makah Formation and the early to middle Miocene Astoria Formation respectively. These two new species increase the known fossil species from one to three reported from Washington State. *Munida quadroblonga* Schweitzer & Feldmann, 2000, was previously reported from the middle Eocene Hoko River Formation. *Munida branti* n. sp. is the first report of the genus in Miocene rocks of Washington State.

Makah Formation. The Makah Formation is one of three formations Hoko River, Makah, and Pysht that are part of the Twin River Group, an Eocene to Oligocene deposit, exposed in a northward-dipping homoclinal sequence along the northwestern coast of the Olympic Peninsula of Washington (Snavely et al. 1978; Prothero et al. 2009). The Twin River group unconformably overlies pillow basalts and breccias of the Crescent volcanics (MacLeod & Snavely 1973; Snavely & MacLeod 1977; Snavely et al. 1978). The Makah Formation consists of five members named (from lowest to highest): the Baada Point, Dtokoah Point, Klachopis Point, Third Beach, and Jansen Creek members (Snavely et al. 1978). The Formation consists of deep-water siltstone and turbidite sandstone, interfingered with shallow-marine sandstone and conglomerate (Snavely et al. 1978). The Jansen Creek Member correlates with early Oligocene Chron (31–32.8 Ma) (Prothero et al. 2009: Fig. 10). The Makah Formation is highly fossiliferous with terrestrial plants (Underwood & Miller Jr. 1980; Miller & Crabtree 1989; Miller 1990), benthic foraminifera (Snavely et al. 1980), mollusks (Snavely et al. 1980; Squires et al. 1999), crustaceans (Snavely et al. 1980; Feldmann 1989; Wieder & Feldmann 1989; Feldmann et al. 1991; Schweitzer 2000, 2001; Schweitzer & Feldmann 2000, 2001), birds (Goedert & Cornish 2002), and fossil baleen and toothed whales (Barnes & Goedert 1996) previously reported. *Munida witteae* n. sp. was collected from the Jansen Creek Member of the Makah Formation within a concretion exposed at low-tide along a wave cut platform along the beach in the northwestern coast of the Olympic Peninsula.

Astoria Formation. A sequence of early to middle Miocene, continental and marine beds of conglomerate, sandstone, and siltstone, exposed in the southwesternmost portion of Washington, is tentatively correlated with the Astoria Formation of Oregon on the basis of their contained fauna, their stratigraphic position, and their lithologic characteristics (Rau 1948; Snaveley et al. 1958). Fossil decapod crustaceans are limited to southwesternmost Washington, in exposures along the Columbia River and a tributary of the Naselle River within Wahkiakum County, and in southwestern Washington in the Montesano and Willapa Hills area. Age control for the Astoria Formation in Washington is based upon mineral composition (Wolfe & McKee 1972), and molluscan (Moore & Addicott 1987) and foraminiferan (Rau 1948) distribution. The Astoria Formation of Washington interfingers with the Grande Ronde Basalt and the Wanapun Basalt of the Columbia River Basalt Group, which have been dated at near the boundary between the early and middle Miocene (Walsh et al. 1987). Fossil decapod crustaceans collected from the Astoria Formation of Washington appear to represent that part of the Astoria Formation below these basalt flows, placing the fossil decapod crustaceans within the early Miocene. In southwestern Washington, rocks referred to the Astoria Formation unconformably overlie the upper Eocene-upper Oligocene Lincoln Creek Formation and are unconformably overlain by the upper Miocene Montesano Formation (WEAVER 1912; ETHERINGTON 1931; RAU 1967; MOORE & ADDICOTT 1987; PROTHERO 2001; PROTHERO et al. 2001).

Acknowledgements

We would like to thank the late ROSS BERGLUND for donating the specimen of *M. witteae* for this research and his help and thoughtful advice given to us over the years. BRANT NYBORG is thanked for collecting and donating the specimen of *M. branti*. MICHELA MURA, Natural History Museum, Milan, is thanked for the reconstructions of the species. We also thank RODNEY M. FELDMANN and CRISTINA M. ROBINS, Kent State University, Ohio, for their very thorough reviews of this paper.

2. Material

The studied specimens retain cuticle and are three-dimensionally preserved inside concretions. They are assigned to *Munida* LEACH, 1820, as *M. witteae* n. sp. and *M. branti* n. sp. within the family Munididae AHYONG, BABA, MACPHERSON & POORE, 2010. The specimens are housed in The Burke Museum of Natural History and Culture, University of Washington, Seattle, Washington (UWBM).

Abbreviations: L1: length of dorsal carapace; rl: rostral length; W1: maximum carapace width; W2: frontal width; W3: fronto-orbital width; W4: posterior width.

3. Systematic palaeontology

Infraorder Anomura MACLEAY, 1838

Superfamily Galatheoidea SAMOUELLE, 1819

Family Munididae AHYONG, BABA, MACPHERSON & POORE, 2010

Genus *Munida* LEACH, 1820

Type species: *Pagurus rugosus* FABRICIUS, 1775, by monotypy.

Extant species: Cosmopolitan; see AHYONG et al. (2010).

Fossil species: *Munida branti* n. sp. (this study); *M. cobbani* (BISHOP, 1985) as *Eomunidopsis* from the Late Cretaceous Pierre Shale, Colorado, USA; *M. cretacea* (STENZEL, 1945), as *Galathea*, from the Early Cretaceous Pawpaw Shale, Texas, USA; *M. deangelii* ROBINS, FELDMANN & SCHWEITZER, 2012 from the late Oligocene–early Miocene of Río Negro Province, Argentina; *M. grossetana* GARASSINO & PASINI, 2015, from the Pliocene of Tuscany, Italy; *M. konara* SCHWEITZER & FELDMANN, 2000, from the late Oligocene–early Miocene of Alaska, USA; *M. limonitica* (STENZEL, 1945), as *Galathea*, from the Early Cretaceous (early Albian) of Pawpaw Shale, Texas, USA; *M. nishioi* KARASAWA, 1993, from the middle Eocene of Japan; *M. ogaensis* (HATAI & KOTAKA, 1970), as *Kazuoia*, from the middle–late Miocene of Japan; *M. primaeva* SEGERBERG, 1900, from the Danian of Denmark; *M. prolata* FELDMANN, SCHWEITZER & BOESSENECKER, 2015 from the Pliocene Purisima Formation, California, USA; *M. quadroblonga* SCHWEITZER & FELDMANN, 2000, from the middle Eocene Hoko River Formation, Washington, USA; *M. tomitai* (KARASAWA & HAYAKAWA, 2000), as *Luisogalathea*, from the Cretaceous of Japan; *M. witteae* n. sp. (this study).

Diagnosis: Carapace rectangular to ovoid, longer than wide; rostrum slender and needle-like flanked by two supraocular spines; frontal margin of carapace without spine mesiad to anterolateral spine; two or three anterolateral spines, three to five brachial margin spines posterior of cervical groove; cervical grove deep, arcuate; distinct transverse terraced ridges (striae in extant species).

Munida witteae n. sp.
Fig. 1

Etymology: The species name is in honor of BEVERLY WITTE, who was the museum curatorial associate for many years at The Burke Museum of Natural History and Culture and who prepared many fossils crabs including this specimen for study.

Holotype: UWBM 97168.

Type locality: This locality is situated along the Strait of Juan de Fuca near the northwest tip of the Olympic Peninsula in Clallam County, Washington. Rocks here are part of the Jansen Creek Member of the Makah Formation, which are exposed in a broad wave-cut platform 3.0 miles west of the mouth of Jansen Creek, in the SW ¼, Sec22, T33N, R14W of the Cape Flattery Quadrangle 15 minute series topography map.

Type horizon: Makah Formation, early Oligocene.

Material and measurements: One carapace in dorsal view (UWBM 97168 – L1: 9.3 mm; rl: 2.1 mm; W1: 6.5 mm; W2: 1.4 mm; W3: 5.1 mm; W4: 5.4 mm).

Diagnosis: Carapace (excluding rostrum) longer than wide; rostrum slender and needle-like; supraocular spines half the length of rostrum; carapace with regularly spaced transverse terraced ridges; gastric region with two epigastric spines; anterolateral margin with two spines; branchial margin with five small spines.

Description: Carapace rectangular, longer than wide, slightly convex laterally; dorsal transverse terraced ridges and cervical groove distinct; gastric region weakly convex, with two epigastric spines broken, located posterior to supraocular spines; hepatic, cardiac, intestinal, and branchial regions lacking spines; all regions with regularly broadly spaced transverse terraced ridges, with very few secondary transverse terraced ridges; anterior and posterior cervical grooves wide and deep; rostrum circular in cross-section; rostrum slender, elongate, needle-like; supraocular spines long, length half of rostrum, subparallel, and slightly upwardly directed; anterolateral margins with two spines; first anterolateral spine situated at anterolateral angle directed anteriorly extending well beyond level of sinus between rostrum and supraocular spine; second anterolateral spine directed anterior, smaller than preceding one; epibranchial margins with three anterior spines larger than two branchial ones.

Discussion: The new species is based upon one complete dorsal carapace. The new species is referred to *Munida* based upon its possession of a distinct transverse terraced ridges, rostrum slender and needle-like flanked by supraocular spines, and frontal margin of carapace without spine mesiad to anterolateral spine.

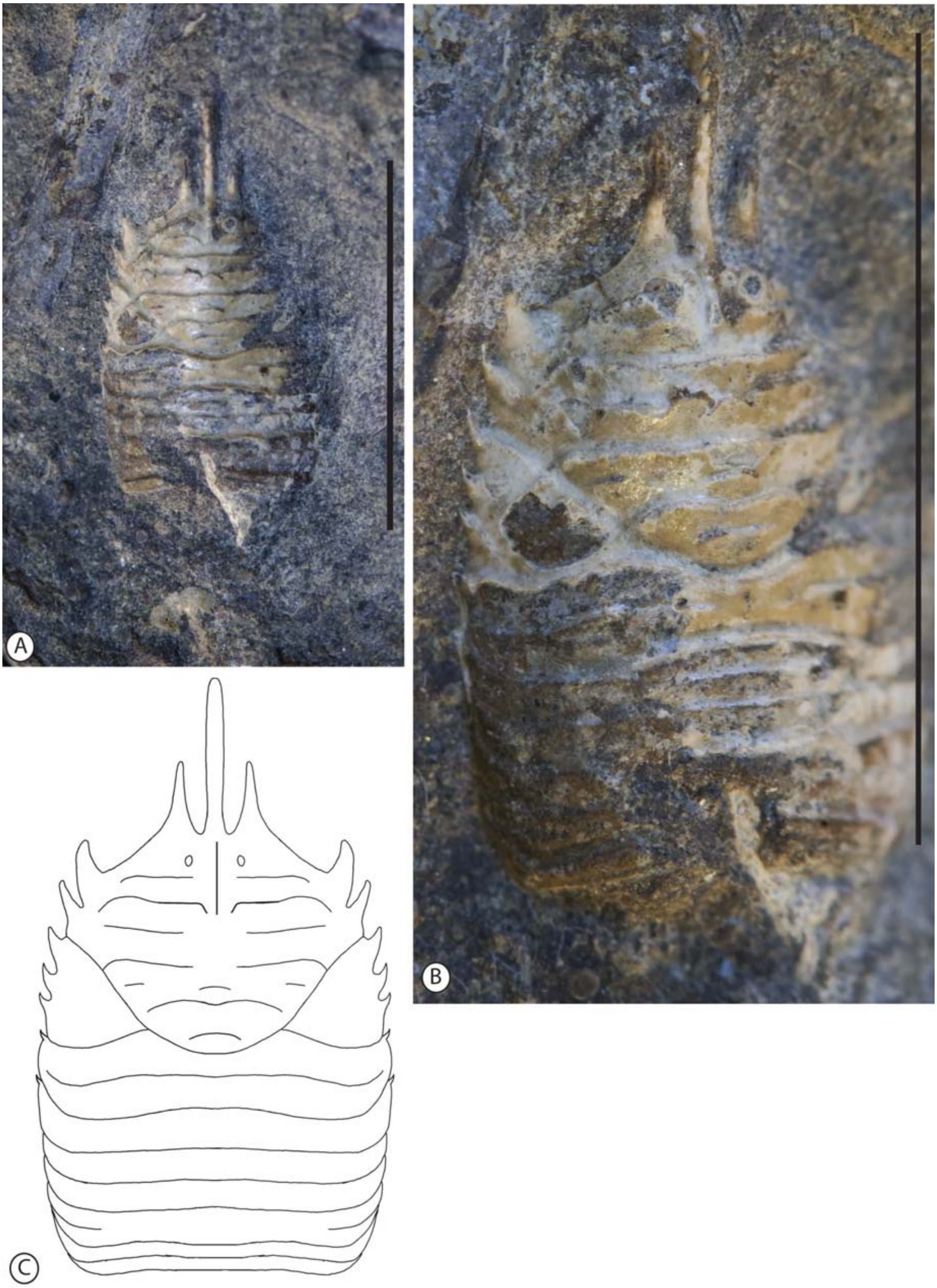

Fig. 1. *Munida witteae* n. sp., UWBM 97168. A. Dorsal carapace. B. Oblique view of carapace emphasizing anterolateral margin with spines. C) Idealized drawing of dorsal carapace. Scale bar equals 1 cm.

Munida witteae n. sp. is most similar to *Munida quadroblonga*. Both species are close in age, *M. quadroblonga* from the middle Eocene Hoko River Formation and *M. witteae* from the Eocene-Oligocene Makah Formation, and both species were collected from the Olympic Peninsula of Washington. However, *M. witteae* n. sp. differs from *M. quadroblonga* in having two anterolateral spines, whereas *M. quadroblonga* has three, the rostrum has a more triangular base and is less needle-like compared to *M. witteae* n. sp., and *M. quadroblonga* has a row of gastric spines and no epigastric spines, whereas *M. witteae* has no gastric spines and two epigastric spines.

Munida witteae n. sp. differs from *M. deangelii* in that *M. deangelii* the rostrum is very long and the supraorbital spines are very short, about fourth the size of the rostrum, whereas in *M. witteae* the supraocular spines are about half the length of the rostrum.

Munida witteae n. sp. differs from *M. grossetana* in that *M. grossetana* the carapace is as long as wide and has only one anterolateral spine, whereas *M. witteae* n. sp. the carapace is longer then wide and has an anterolateral margin with two spines. In addition, the epigastric margin in *M. grossetana* lacks spines, whereas *M. witteae* n. sp. has three epigastric spines.

Munida witteae n. sp. differs from *M. konara* in that *M. konara* has three anterolateral spines, whereas *M. witteae* n. sp. has two. In addition, the transverse ridges in *M. konara* are more complex and deeply furrowed than in *M. witteae* n. sp.

The two species from Japan, *M. nishioi* and *M. ogaensis*, have shorter anterolateral spines then *M. witteae* n. sp. and the transverse ridges in *M. witteae* n. sp. are regularly spaced with few secondary ridges, whereas in the two species from Japan the transverse ridges are not complete, often bifurcating laterally.

Munida witteae n. sp. differs from *M. primaeva* in that *M. primaeva* has a broad rostrum and shorter supraorbital spines than *M. witteae* n. sp.

Munida prolata has much longer anterolateral spines than in *M. witteae* n. sp. and a cervical groove that is nearly straight axially compared to *M. witteae* n. sp. that has a cervical groove that is axially more parabolic in shape.

FRANTESCU (2014) recently reassigned several species to *Munida*: *Munida cobbani*, *M. cretacea*, *M. limonitica*, and *M. tomitai*. These species have similar transverse terraced ridges on the dorsal carapace as the other fossil *Munida* species; however, none of them have the prominent supraorbital spines as seen in *M. witteae* n. sp. and *M. branti* n. sp. described below.

Munida branti n. sp.
Fig. 2

E t y m o l o g y : The trivial name honours BRANT NYBORG, who collected the sole specimen of this new species used in this study.

H o l o t y p e : UWBM 97167.

T y p e l o c a l i t y : The type locality is situated near the town of Naselle, Washington, USA, in the NW1/4, NE1/4, T10N, R9W of the Knappton Quadrangle, Washington-Oregon 7.5 minute series topographic map. The concretion containing the specimen was collected as float in stream gravels interpreted to have been derived from the early to middle Miocene Astoria Formation (WOLFE & MCKEE 1972).

T y p e h o r i z o n : Astoria Formation, early to middle Miocene.

M a t e r i a l a n d m e a s u r e m e n t s : One carapace preserved in concretion as part and counterpart (UWBM 97167 – L1: 37.2 mm; W1: 28.4 mm; W2: 4.7 mm; W3: 15.9 mm; W4: 21.1 mm).

D i a g n o s i s : Carapace (excluding rostrum) slightly longer than wide, about 1.3 times as long as wide; rostrum slender and needle-like; supraocular spines half the length of rostrum; carapace with regularly spaced transverse terraced ridges; gastric region without epigastric spines; anterolateral margin with two spines; epibranchial margin with three spines.

D e s c r i p t i o n : Carapace rectangular, slightly longer than wide, about 1.3 times as long as wide and slightly convex laterally; dorsal transverse terraced ridges and cervical groove distinct; gastric region weakly convex, without epigastric spines; epigastric, hepatic, cardiac, intestinal, and branchial regions moderately defined, lacking spines; all regions ornamented with mostly continuous, nearly straight to sinuous, spaced transverse terraced ridges with very few secondary ridges; anterior ridge edges serrated; anterior and posterior cervical grooves broad and deep; rostrum circular in cross-section; rostrum slender, elongate, and needle-like, about one-third carapace length; supraocular spine needle-like, half rostrum length, slightly upwardly directed; anterolateral margins with two spines; first anterolateral spine situated at anterolateral angle, directed posteriorly and extending beyond level of sinus between rostrum and supraocular spine; second anterolateral spine smaller than preceding one, directed anteriorly; epibranchial margins with three small anterior spines of similar size; posterior margin strongly, transversely vaulted.

D i s c u s s i o n : The new species is based upon one complete dorsal carapace preserved as part and counterpart within a concretion. The new species is referred to *Munida* based upon its possession of a distinct transverse terraced ridges, rostrum slender and needle-like flanked by supraocular spines, and frontal margin of carapace without spine mesiad to anterolateral spine.

Munida branti n. sp. is most similar to *M. prolata* in that both species have long anterolateral spines and similar placement of transverse terraced ridges. However *M. prolata* has a cervical groove that is nearly straight axially compared to *M. branti* n. sp. that has a cervical groove that is axially more parabolic in shape.

Munida branti n. sp. differs from *M. deangelii* in that *M. deangelii* the rostrum is very long and the supraorbital spines are very short, about fourth the size of the rostrum, whereas in *M. branti* the supraocular spines are about half the length of the rostrum.

Munida branti n. sp. differs from *M. grossetana* in that *M. grossetana* has only one small anterolateral spine whereas *M. branti* n. sp. has an anterolateral margin with two spines. In addition, *M. grossetana* the epigastric margin is spineless whereas *M. branti* n. sp. has three epigastric spines.

Munida branti n. sp. differs from *M. konara* in that *M. konara* has three anterolateral spines, whereas *M. branti* n. sp. has two. In addition, the transverse ridges in *M. konara* are more complex and deeply furrowed than in *M. branti* n. sp.

The two species from Japan, *M. nishioi* and *M. ogaensis*, have shorter anterolateral spines then *M. branti* n. sp. and the transverse ridges in *M. branti* n. sp. are regularly spaced with few secondary ridges, whereas in the two species from Japan the transverse ridges are not complete often bifurcating laterally.

Munida branti n. sp. differs from *M. quadroblonga* in that *M. quadroblonga* has two anterolateral spines, whereas *M. branti* n. sp. has three; the rostrum has a more triangular base and is less needle-like compared to *M. branti* n. sp., and *M. quadroblonga*

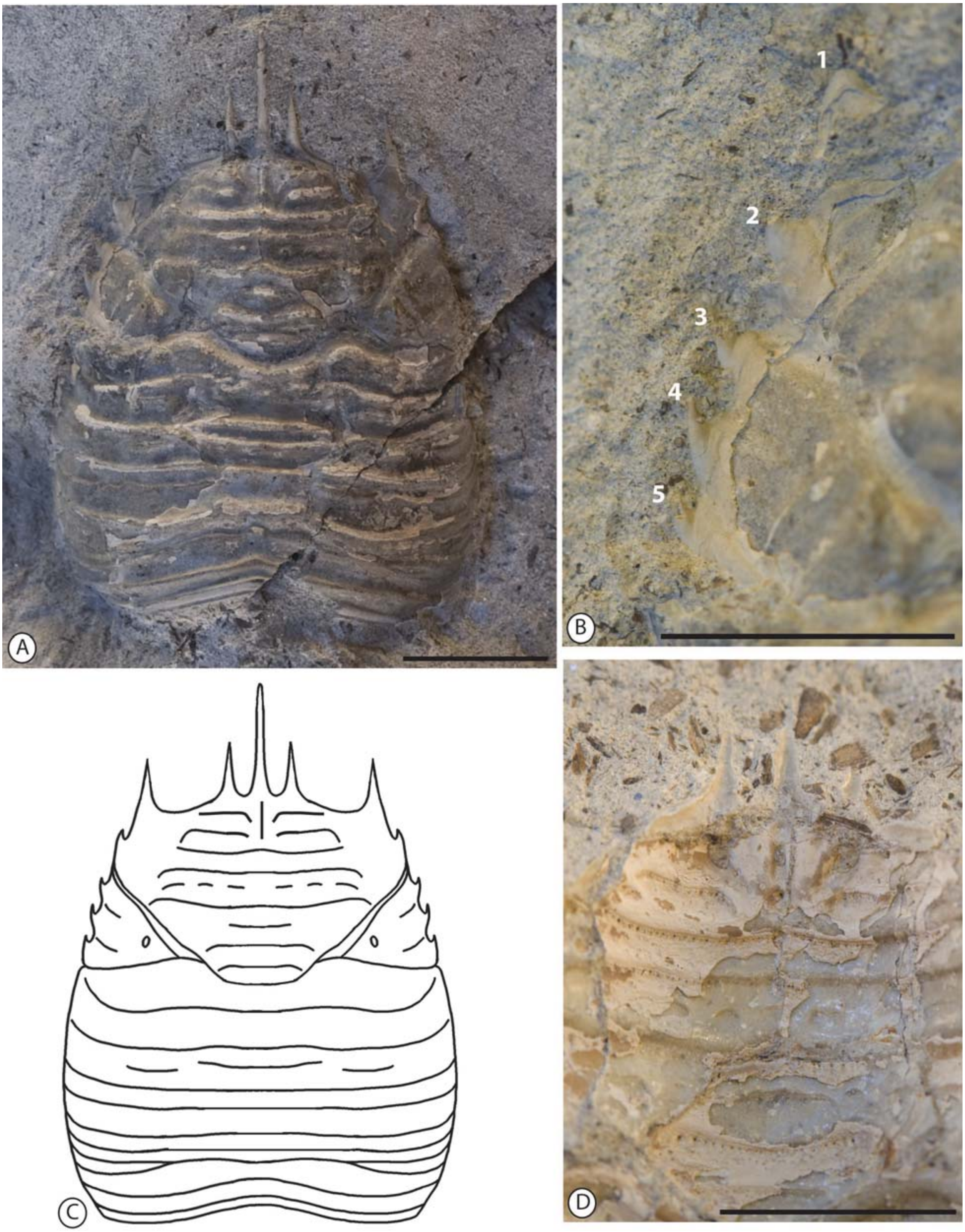

Fig. 2. *Munida branti* n. sp., UWBM 97167. A. Dorsal carapace. B. Close-up view of anterolateral spines. C) Idealized drawing of dorsal carapace. D) Close-up view of rostrum. Note the spaced transverse terraced ridges; concretion counterpart. Scale bar equals 1 cm.

has a row of gastric spines and no epigastric spines, whereas *M. branti* n. sp. has no gastric spines and three epigastric spines.

Munida branti n. sp. differs from *M. primaeva* in that *M. primaeva* has a broad rostrum and shorter supraorbital spines than *M. branti* n. sp.

The discovery of a new species of *Munida* from the early to middle Miocene Astoria Formation does not extend the geologic age of the genus; however, it is the first report of the genus in Miocene rocks of Washington State.

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