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A new species of *Tymolus* and a report on *Metacarcinus* (Crustacea: Decapoda: Brachyura) from the Miocene of Alaska

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Abstract

Tymolus alaskensis new species (Cyclodorippidae) is described from the Bear Lake Formation, a Miocene shallow water deposit from Alaska. The geographical range of the genus is extended to the northern-most margin of the Pacific basin. A large collection of *Metacarcinus goederti* Schweitzer and Feldmann, 2000 (Cancridae) permits a more complete description than was previously possible. Its occurrence in the Bear Lake Formation suggests a temperate-water depositional environment for the upper Bear Lake Formation.

Key words: Brachyura, Crustacea, Decapoda, Miocene, Alaska

Introduction

In this paper we describe a new species of the decapod crustacean *Tymolus* Stimpson, 1858, from the Miocene Bear Lake Formation of Alaska, yielding a wider geographic distribution for the genus than was previously known. Additionally, a sizable number of specimens of *Metacarcinus goederti* Schweitzer and Feldmann, 2000, were also recovered, allowing for a variety of morphometric comparisons of aspects of the dorsal carapace and suggesting a temperate-water depositional environment for the upper Bear Lake Formation.

The Bear Lake Formation was named by Burk (1965), with the type section designated from an area east of Bear Lake. The Bear Lake Formation is up to 1600 m thick, consisting of sandstone, shale, and conglomerate (Nilsen, 1985). Fossils including *Mytilus gratacapi* Allison and Addicott, 1976, indicate that it is Miocene in age. The site of deposition was a shallow-marine environment adjacent to a steep and forested landmass, as indicated by the presence of fossilized plant matter and non-marine debris flows (Wisehart, 1971; Allison and Addicott, 1976; Nilsen, 1984; Nilsen, 1985; Marincovich and Kase, 1986). Crossbedding preserved in the strata indicates strong currents in the area (Wisehart, 1971; Nilsen, 1984). The Bear Lake Formation is interpreted to represent back-arc tidal deposits in an area that experienced transgression and regression (Wisehart, 1971; Nilsen, 1984). The specific horizon in the formation from which the decapod fossils were collected is in the vicinity of Port Moller (Fig. 1), where members of the Alaska Division of Geological and Geophysical Survey found a fossiliferous zone (field locality 05RB11 of Blodgett) approximately 13 m thick, composed of silty sandstone containing harder, calcite-cemented, sandstone lenses. Burk (1965) made a short and cursory list of the fauna found in the formation. Allison (1978) and Marincovich and McCoy (1984) later conducted more thorough examinations of the molluscan fauna. Zullo and Marincovich (1990) studied the barnacle assemblage of the Bear Lake Formation, discovering a new species in the process.

Systematic Paleontology

Institutional abbreviations: CAS, California Academy of Sciences, San Francisco, California, USA; USNM, United States National Museum of Natural History, Smithsonian Institution, Washington, DC, USA.

Order Decapoda Latreille, 1802
Infraorder Brachyura Latreille, 1802
Section Podotremata Guinot, 1977
Superfamily Cyclodorippoidea Ortmann, 1892
Family Cyclodorippidae Ortmann, 1892
Genus *Tymolus* Stimpson, 1858

Tymolus Stimpson, 1858, p. 163. Ortmann, 1892, p. 559; Alcock, 1896, p. 274; Imaizumi, 1952, p. 201; Shikama, 1954, p. 71; Balss, 1957, p. 1609; Gordon, 1963, p. 53; Glaessner, 1969, p. 492; Števčić, 1969, p. 75; Takeda, 1973, p. 82; Sakai, 1976, p. 32; Guinot, 1978, p. 243; 1979, p. 129; Abele and Felgenhauer, 1982, p. 316; Takeda and Tomida, 1984, p. 43, 45; Tomida, 1985, p. 56; Tavares, 1990, p. 627; 1991, p. 4442; 1992, p. 202; 1993, p. 267; 1997, p. 262; Karasawa, 1993, p. 43; Kato, Suzuki, and Karasawa, 1994, p. 78; Tan and Huang, 2000, p. 135; Nyborg, 2002, p. 50.

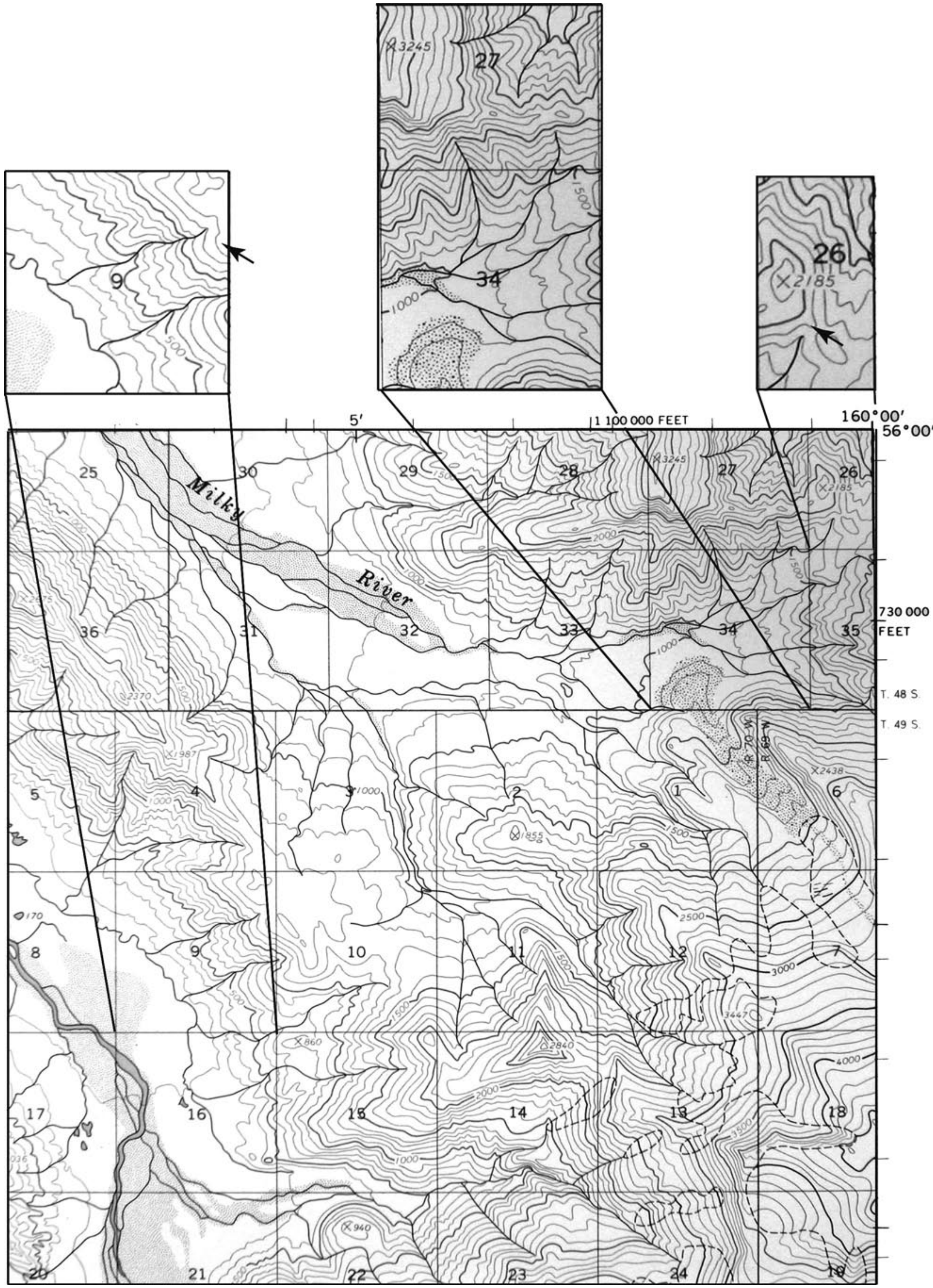

Fig. 1. Locality map indicating the sections from which fossil decapods were collected. Arrows indicate the position of decapod localities. Map modified from Port Moller (D-1) Quadrangle, Alaska, 1:63, 360 series topographic.

Cyclodorippe Ortmann, 1892, p. 559. Alcock, 1896, p. 274; Ihle, 1916, p. 128; Sakai, 1976, p. 32; Abele and Kim, 1986, p. 39 (non *Cyclodorippe* A. Milne Edwards, 1880).

Cymonomops Alcock, 1894, p. 406. Alcock, 1896, p. 274, 286, 1905; p. 572; Grant, 1905, p. 315.

Cyclodorippe (*Cyclortmannia*) Ihle, 1916, p. 128.

Type species: *Tymolus japonicus* Stimpson, 1858.

Other species: *Tymolus brucei* Tavares, 1991; *T. daviei* Tavares, 1997; *T. dromioides* (Ortmann, 1892), as *Cyclodorippe*; *T. hirtipes* Tan and Huang, 2000; *T. kamadai* Imaizumi, 1952 (fossil); *T. ingens* Takeda and Tomida, 1984 (fossil); *T. itoigawai* Takeda and Tomida, 1984 (fossil); *T. similis* (Grant, 1905) as *Cymonomops*; *T. truncatus* (Ihle, 1916) as *Cyclodorippe* (*Cyclortmannia*); *T. uncifer* (Ortmann, 1892) as *Cyclodorippe*; *Tymolus* sp. in Karasawa, 1993 (fossil); *Tymolus* sp. *in* Nyborg, 2002 (fossil).

Diagnosis: Carapace subcircular, ranging from length 83% to 115% of width; dorsal surface not separated from the flank by lineae. Frontal region bearing four pairs of spines or truncated; fronto-orbital width less than half the maximum width of the carapace. Eyes short; stalked; retractable; arranged longitudinally, parallel to axis of carapace. Front endostome concave, narrowing anteriorly until front edge of the carapace is reached. Exopodite of 1st and 2nd maxilliped with reduced flagella; 3rd maxillipeds lacking flagella. Dactylus of pereiopod 2 and pereiopod 3 compressed dorsoventrally. Female abdomen with 6 segments [fide Tavares, 1993]; articulated pleopods on the ventral side of segments 2–5. Male abdomen formed of 5 segments [fide Tavares, 1993] (after Tavares, 1993).

Remarks: Over the past several decades, and particularly the last fifteen years, there has been a renewed interest in the taxonomic history of the genus *Tymolus* with many species having been transferred into *Tymolus* from *Cymonomops* as well as new extant and fossil species being discovered (Imaizumi, 1952; Takeda and Tomida, 1984; Tavares, 1990; 1991; 1992; 1993; Karasawa, 1993; Tan and Huang, 2000; Nyborg, 2002). During this interval, the scientific community has gained a much better understanding of the distribution and evolutionary history of *Tymolus*.

Stimpson erected the genus in 1858 to describe the extant species *Tymolus japonicus*. Currently the genus is known to have existed from the Miocene to the present, with all known species, including the one to be described herein, having an Indo-Pacific distribution (Tavares, 1990; 1991; 1992; 1993; Karasawa, 1993). *Tymolus* was initially placed within the Dorippidae MacLeay, 1838. Subsequent taxonomic work by Ortmann (1892) led to the suggestion that the original concept of the Dorippidae actually embraced two families: the Dorippidae MacLeay, 1838, and the Cyclodorippidae Ortmann, 1892. Later work by Bouvier (1897) revealed a distinction between the forms within the Dorippidae sensu MacLeay, 1838, with some being peditremes and some being sternitremes. This justified Ortmann's earlier proposal, with the sternitremes placed in the subfamily Dorippinae and the peditremes were placed into the Cyclodorippinae. Bouvier also suggested that these groupings be elevated to the family level, and they are currently treated as such (Martin and Davis, 2001). In the same paper, Bouvier suggested that the Cyclodorippinae consisted of two tribes, with the tribe he referred to as Cyclodorippae containing *Tymolus*.

Tymolus is often confused with the closely allied *Cyclodorippe* A. Milne Edwards, 1880. Ortmann (1892) suggested that they were synonymous, a view that was recognized by Abele and Felgenhauer (1982), who considered *Cyclodorippe* as the junior synonym. Among those who did not consider the taxa synonymous, recent work has led to the transfer between genera of current members of *Tymolus*, including *T. uncifer* and *T. truncatus*, each at one time having been considered to be referable to *Cyclodorippe*. Careful study of such features as the carapace, eyes, and respiratory structures led to a clearer understanding of the two genera (Tavares, 1990). The other taxonomic point of note is that *Tymolus* has been determined to be the senior synonym of *Cymonomops* Alcock, 1896 (Abele and Felgenhauer, 1982).

The most unusual member of the genus is one of the species that recently has been transferred to it, *Tymolus truncatus*. Unlike all other species in the genus, *T. truncatus* exhibits a truncated front, lacks a U-shaped ridge on the protogastric region, lacks well-defined and raised regions of the carapace (save for the cardiac region which is the only distinctive region), and does not possess a series of pits defining the axial region. Ihle (1916) originally placed *T. truncatus* within *Cyclodorippe* because of the close resemblance to the carapace shape of members of that genus, known at that time from the two species *C. uncifera* and *C. similis*. However, Tavares (1991), reclassified *Cyclodorippe truncata*, placing it in *Tymolus* based on the fronto-orbital width being less than half the maximum length of the carapace, the possession of retractable eyes aligned in a longitudinal direction of the carapace, and the extension of the endostome to the frontal edge of the carapace. Still, the stark difference between the carapace of *T. truncatus* in comparison with the other members of the genus does seem problematic and future study may well reveal that it is best placed in its own genus.

Another taxonomic issue regarding the genus was recently raised by the questioning of Tavares' (1991) placement of *Tymolus glaucoma* (Alcock, 1894) as a junior synonym of *T. uncifer* (Tan and Huang, 2000). Tan and Huang pointed out that when the reassignment was made, the type specimens were not observed and that there are differences in carapace shape between *T. glaucoma* and *T. uncifer*. However, their observations on carapace shape were not made based on examination of type specimens either, and so they did not claim definitively that the synonymy of *T. glaucoma* with *T. uncifer* was mistaken. They did suggest that a reconsideration of the placement was in order.

The new species of *Tymolus* does not extend the temporal range of the genus though it does extend slightly the geographic range. Before the discovery of these fossils, the furthest extent of *Tymolus* in the northeastern Pacific was limited to sites in the present day state of Washington (Karasawa, 1993; Nyborg, 2002). With the discovery of this new fossil from deposits in the state of Alaska, *Tymolus* now has a range that spanned virtually the entire length of the northwestern coast of North America.

***Tymolus alaskensis* new species**

(Fig. 2)

Types: Holotype, CAS 69543, and paratype, CAS 68548.

Diagnosis: Carapace typical shape for genus, large in size, slightly longer than wide; posterior width approximately 28% maximum carapace width, uniformly granulose, percentage of maximum cardiac width to maximum mesogastric width approximately 1:1.

Description: Carapace subcircular, length and width almost equal, maximum length slightly longer (27 mm) than maximum width (25.5 mm) measured through longitudinal axis just posterior to cervical groove. Mesogastric, protogastric, cardiac, intestinal, hepatic, and epibranchial regions raised centrally. Entire carapace surface granulose, particularly on elevated regions. Cervical groove well-defined, continuous across axis, intersecting groove defining lateral edge of mesogastric region, continuing posteriorly and bordering mesogastric region, curving anterolaterally to hepatic region, forming concave arc to lateral margin. Concave-forward, weak ridge crossing carapace on branchial region posterior to cervical groove, crossing branchiocardiac groove, continuing across cardiac region, curving anterolaterally and terminating posterior to position of cervical groove. Three pairs of elongate pits situated in grooves defining the axial regions: two pairs separating epibranchial region from mesogastric region and one pair separating branchial region from cardiac region, finger-like projections situated in lateral grooves near cardiac region.

Rostrum bifid, with at least two spines, preservation not sufficient to detect greater detail. Fronto-orbital region projected, fronto-orbital width about 40% maximum carapace width. Anterior margin weakly convex. Anterolateral and posterolateral margins moderately convex, not readily distinguishable from one another. Posterior margin weakly concave, about 28% maximum carapace width.

Frontal region merging with carapace, slightly depressed just in advance of gastric regions, rising distally. Protogastric region longer than wide, with U-shaped ridge forming axial depression separating region into three raised portions. Mesogastric region with long anterior process terminating just posterior to frontal region, most strongly inflated posteriorly, widening posteriorly, bounded posteriorly by cervical groove. Urogastric region depressed, rectangular, relatively small compared to adjoining regions. Cardiac region hexagonal, length and width equal, all sides straight or only slightly curved, most inflated of all carapace regions. Posterior margin of cardiac region lacking distinct separation from intestinal region. Intestinal region depressed.

Hepatic region generally triangular in shape, broadening posteriorly, separated from protogastric region by smooth depression, bounded posteriorly by cervical groove. Epibranchial region generally oblanceolate, widening axially, most elevated along cervical groove, directed obliquely axially, having no clear groove or border extending along lateral margin. Branchial region weakly elevated, broadly crescent-shaped, widening axially.

Appendages, abdomen, and ventral aspect of carapace unknown.

Measurements: Measurements (in mm) taken on the dorsal carapace represent maximum values of specimens described here. Holotype CAS 69543: length = 27.0; width = 26.1; posterior margin width = 13.8. Paratype CAS 68548: length = 27.0; width = 25.5; posterior margin width indeterminate.

Etymology: The trivial name is derived from the geographic region from which the material was collected, reflecting its significance as an extension of the generic range.

Occurrence: The material was collected from a conglomerate bed within the type section of the Bear Lake Formation located in Sec. 26, T48S, R69W, Port Moller (D-1) Quadrangle, USGS 1, 63 360

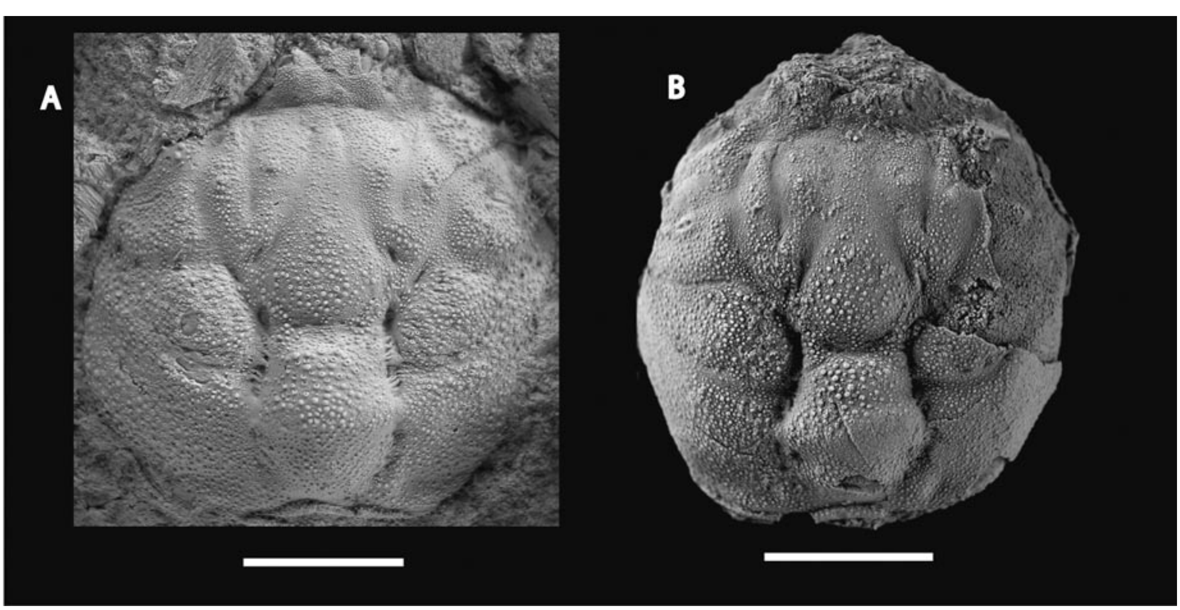

Fig. 2. Dorsal carapace views of *Tymolus alaskensis* new species collected from the Bear Lake Formation, Alaska. A, holotype, CAS 69543; B, paratype, CAS 68548. Scale bars = 1 cm.

series topographic (J. DeMouthe, personal communication, 2005).

Discussion: The measurements are based on two specimens that have incomplete rostra but are otherwise well-preserved. Neither specimen has the ventral surface or appendages preserved.

Tymolus alaskensis new species, like other members of the genus, exhibits a generally subcircular shape with a projected fronto-orbital region. The cardiac region is the most elevated area on the carapace. *Tymolus alaskensis*, like all other members of the genus except *T. truncatus*, has well-defined mesogastric, protogastric, cardiac, and intestinal regions that are raised centrally. Only the cardiac region is distinctive on *T. truncatus*. Furthermore, *T. alaskensis* shares with all members of the genus, except *T. truncatus*, the characters of a U-shaped ridge on the protogastric region, an anteriorly tapering mesogastric region, a series of pits defining the axial regions, granulation on the carapace regions, and a ridge that traverses the carapace posterior to the cervical groove and crosses the midline of the cardiac region.

Tymolus alaskensis is considered to be a new species based upon a variety of factors (Fig. 3). *Tymolus alaskensis* is distinguished from *T. japonicus*, the type species of the genus, because *T. alaskensis* exhibits the following features: a lower percentage of posterior margin width compared to maximum carapace width, a length that is greater than width, and a more circular as opposed to a broadly ovate outline as in *T. japonicus*. *Tymolus alaskensis* differs from *T. ingens* in a slight, but noticeable, difference in the degree to which the carapace is subcircular; *T. alaskensis* is more circular and *T. ingens* is more rectangular. The two species also differ in carapace length/width measurements. *Tymolus alaskensis* is longer than wide, whereas *T. ingens* is wider than long. Another clear difference is maximum cardiac width to maximum mesogastric width, with *T. alaskensis* exhibiting a percentage of 100% and *T. ingens* 133%. Lastly, the width of the posterior margin to maximum carapace width also differs, 28% in *T. alaskensis* and 34% in *T. ingens*. *Tymolus alaskensis* is separated from *Tymolus* sp. (Karasawa, 1993) for a variety of reasons. The carapace of *T. alaskensis* is more subcircular, whereas *Tymolus* sp. of Karasawa is more rectangular. Furthermore, the posterior margin width of *T. alaskensis* is only 28% of the maximum carapace width, whereas in *Tymolus* sp. of Karasawa it is 33%. *Tymolus alaskensis* also shows a lower percentage of maximum cardiac width to maximum mesogastric width, (100%) compared to *Tymolus* sp. of Karasawa which has a percentage of 122%. And lastly, *T. alaskensis* is longer than wide, whereas *Tymolus* sp. of Karasawa is wider than long.

Tymolus alaskensis is most similar to *T. itoigawai*, though there are still significant differences. *Tymolus alaskensis* is evenly granulose, whereas *T. itoigawai* has 14 large, distinct tubercles and is more quadrate than *T. alaskensis*. *Tymolus alaskensis* is distinguished from *T. brucei*, because *T. alaskensis* is more circular, and *T. alaskensis* has a lower posterior margin width compared to maximum carapace width than *T. brucei*, 28% to 51% respectively. *Tymolus alaskensis* is unlike *T. uncifer*, because *T. alaskensis* possesses a smaller posterior margin width compared to maximum carapace width than *T. uncifer* (28% to 45% respectively), and *T. alaskensis* possesses a maximum cardiac width to maximum mesogastric width of 100% instead of 140% as seen in *T. uncifer*. Should *T. glaucoma* be revalidated and separated from *T. uncifer,* then *T. alaskensis* would be distinguished from *T. glaucoma* based on carapace length. *Tymolus alaskensis* is longer than wide whereas *T. glaucoma* is wider than long. *Tymolus alaskensis* is distinguished from *T. similis* based on *T. alaskensis* being uniformly granulose, less narrowed anteriorly, having a smooth lateral margin, and having a smaller posterior margin width compared to maximum carapace width than *T. similis* (28% to 43% respectively). *Tymolus alaskensis* is contrasted with *T. daviei*, because *T. alaskensis* has a smaller posterior margin width compared to maximum carapace width than *T. daviei* (28% to 34% respectively), and *T. alaskensis* is longer than wide and has a smooth lateral margin. *Tymolus alaskensis* is dissimilar from *T. kamadai* in *T. alaskensis* being uniformly granulose, having a smaller posterior margin width to maximum carapace width than *T. kamadai* (28% to 31% respectively), and having a smooth lateral margin. *Tymolus alaskensis* is separated from *T. truncatus*, the species that is least like any other member of the genus, because *T. alaskensis* possesses a carapace with well defined regions. *Tymolus alaskensis* differs from *Tymolus* sp. of Nyborg (2002), because *T. alaskensis* has a less distinct cervical groove, is uniformly granulose, has a smaller posterior margin width compared to maximum carapace width, and has a smoother lateral margin than *Tymolus* sp. of Nyborg (2002). *Tymolus alaskensis* is distinguished from *T. dromioides*, by *T. alaskensis* having a more circular shape than *T. dromioides*. Furthermore, *T. alaskensis* has a smooth lateral margin while *T. dromioides* displays tubercles, and *T. alaskensis* has a smaller posterior margin width to maximum carapace width than does *T. dromioides* (28% to 47% respectively). Lastly, *T. alaskensis* is separated from *T. dromioides* based on the cervical groove, which in *T. alaskensis* completely traverses the carapace and distinguishes the cardiac and mesogastric regions but in *T. dromioides* disappears in the mesogastric region, thus leaving no groove to separate the cardiac and mesogastric regions. *Tymolus alaskensis* is distinguished from *T. hirtipes* based on *T. alaskensis* being longer than wide whereas *T. hirtipes* is wider than long. Furthermore, *T. alaskensis* and *T. hirtipes* differ in the shape of the rostrum. The rostrum of *T. alaskensis* projects more uniformly and in a wider manner than *T. hirtipes*, whose rostral projection is more narrow and elongate.

Tymolus is known, both from the fossil record and extant collections, exclusively from Indo-Pacific regions (Tavares, 1990; 1991; 1992; 1993; Karasawa, 1993). Fossils assigned to the genus are known from Miocene and Pliocene deposits from Japan and the Miocene of Sakhalin, Russia (Zhildkhova and Sal'nikov, 1992; Kato et al., 1994) as well as the Miocene of Washington state (Karasawa, 1993; Nyborg, 2002). This is only the second fossil species reported from the northeastern Pacific (Nyborg, 2002). The finding of this species supports the assertion of Nyborg (2002) that *Tymolus* arose in the North Pacific by at least the Miocene before dispersing in a

Character	*T. japonicus*	*T. ingens*	*T. itoigawai*	*T. brucei*	*T. uncifer*	*T. similis*	*T. daviei*	*T. kamadai*	*T. truncatus*	*T. dromioides*
Transverse dorsal carapace ridge	yes	yes	yes	yes	yes	yes	yes	yes	no	yes
Mesogastric region tapering anteriorly	yes	yes	yes	yes	yes	yes	yes	yes	no*	yes
Mesogastric region raised	only posteriorly	yes	yes	yes	yes	yes	yes	yes	no	yes, but not separated from cardiac
Protogastric region with U-shaped ridge	yes	yes	yes	yes	yes	yes	yes	yes	no	yes
Cervical groove shape and position similar to *T. alaskensis*	yes	yes	yes	yes	yes	yes	yes	yes	cervical groove not pronounced	no, does not separate cardiac & mesogastric
Centrally raised intestinal region	yes	yes	yes	yes	yes	yes	yes	yes	no	yes
Posterior margin concave	nearly straight	yes	yes	yes	yes	yes	yes	yes	yes	yes
Centrally raised hepatic region	yes	yes	yes	yes	yes	yes	yes	yes	no	yes
Centrally raised epibranchial region	yes	yes	yes	yes	yes	yes	yes	yes	no	yes
Uniformly granulose carapace	yes	no	no	yes	yes	no (texture is different)	yes	no	no	Yes
3 pairs of pits along grooves defining axial regions	yes, but more pronounced posteriorly	yes, but deeper	yes, but deeper	yes	yes	yes	yes	yes	no	unable to determine
Overall carapace shape compared to *Tymolus alaskensis*	broadly obovate	more rectangular	not as circular	not as circular	more rectangular	tapered anteriorly	similar	similar	similar	broader posteriorly
Posterior width 28% maximum carapace width	50%	34%	yes	51%	33%	43%	34%	31%	33%	47%
Length > Width	no	no	yes	yes	no	yes	no	yes	no	yes
Cardiac width/ mesogastric width about 100%	yes	133%	yes	122%	122%	108%	80%	133%	unable to determine	unable to determine
Lateral margin smooth	yes	yes	yes	yes	yes	irregular	irregular and projected	possesses tubercles	possesses tubercles	no

Fig. 3. Chart comparing *Tymolus alaskensis* new species to other species of the genus. All characters listed for comparison are those of *T. alaskensis*. Values entered as "unable to determine" are due to lack of a quality illustration or description for comparative purposes. *Tymolus hirtipes* is not included in the table due to the poor illustrations of this species. Only taxa named to the species level are included in the chart.
* only the cardiac region is distinct in *T. truncatus*.

predominantly southwestward manner to its current Indo-Pacific range. From a paleoceanographic perspective the presence of *Tymolus* neither supports nor refutes the accepted notion of the environment of deposition of the Bear Lake Formation, as extant members of *Tymolus* range from shallow to the upper limits of deep water. The presence of *Tymolus* also can do little to add to the climatic understanding of the depositional environment because the genus is known from temperate to warm water regions (Alcock, 1894; Tavares, 1991, 1992; Karasawa, 1993; Tan and Huang, 2000).

Section Heterotremata Guinot, 1977

Superfamily Cancroidea Latreille, 1802

Family Cancridae Latreille, 1802

Subfamily Cancrinae Latreille, 1802

Genus *Metacarcinus* A. Milne Edwards, 1862

Metacarcinus A. Milne Edwards, 1862, p. 33; Schweitzer and Feldmann, 2000, p. 235, figs. 4, 5; Feldmann, 2003, p. 112, fig. 4.

Cancer (*Metacarcinus*) Nations, 1975, p. 23; Williams, 1984, p. 351; Sakumoto, Karasawa, and Takayasu, 1992, p. 447, pl. 60, figs, 5a–c, pl. 61, fig. 1; Karasawa, 1993, p. 50, pl. 10, fig. 4; Berglund and Goedert, 1996, p. 830, figs. 2, 3; Karasawa, 1997, p. 46, pl. 10, figs. 2–3.

Type species: *Cancer magister* Dana, 1852, by original designation.

Table 1. Measurements (in mm) taken on the dorsal carapace of *Metacarcinus goederti*. Abbreviations are as follows: Angle = Angle between posterior margin and posterolateral margin, AML = anterolateral margin length, FOW = fronto-orbital width, FW = frontal width, LMW = length from front to position of maximum width, MCL = maximum carapace length, PW = posterior width, PML = posterolateral margin length, MCW = maximum carapace width.

SpecimenNumber	MCL	MCW	FOW	FW	AML	PML	LMW	PW	Angle
CAS 68568	41	53	18	8	28	23	25	15	42
CAS 68547	27	40	17	7	15	10	13	10	58
CAS 68545	50	71	23	10	37	30	21	20	28
CAS 68555	32	43	15	5	22	16	18	12	32
CAS 68562	35	51	18	-	30	15	23	16	58
CAS 68557	40	52	16	10	28	23	28	11	40
CAS 68566	18	22	10	-	13	6	11	5	38
CAS 68552	28	37	14	5	22	15	19	10	40
CAS 68558	38	51	25	12	27	16	24	12	38
CAS 68541	26	37	15	-	22	15	18	20	60
CAS 68561	40	50	16	8	31	23	30	18	46
CAS 68539	40	47	-	-	30	25	29	20	51
CAS 68549	56	75	-	-	-	34	43	22	36
CAS 68559	23	30	12	6	16	11	15	8	69
CAS 69542	60	87	-	-	-	31	38	25	-
CAS 68543	42	57	23	11	31	21	30	19	50
CAS 68542	-	65	24	13	-	-	28	-	-
CAS 68572	-	-	28	19	-	-	-	-	-
CAS 68571	26	33	12	5	16	10	16	9	49
CAS 68567	-	28	-	-	-	-	-	-	-
CAS 68556	-	-	-	-	-	30	29	-	-
CAS 68554	39	46	16	6	29	20	26	16	57
USNM507772	39.7	52.7	16.6	8.2	-	-	-	21.4	-
USNM507771	35	53.2	16	8.8	-	-	-	-	-
USNM507773	31.7	43.2	15.2	6.2	-	-	-	15.7	-

Diagnosis: As in Schweitzer and Feldmann (2000).

Metacarcinus goederti Schweitzer and Feldmann 2000

(Fig. 4)

Metacarcinus goederti Schweitzer and Feldmann, 2000, p. 236–238. figs. 4, 5.

Material examined: In total, 33 specimens of *Metacarcinus goederti* specimens, CAS numbers 68538–68547, 68549–68561, 68563–68564, 68566 – 68572, and 69542, were collected and sent to the authors for study. Of those, 22 were sufficiently preserved to take at least partial measurements of the dorsal carapace which were compared to samples of *M. goederti*, USNM 50771–507773, from the Bear Lake Formation previously studied by Schweitzer and Feldmann (2000).

Emendation to diagnosis: Carapace wider than long, widest at position of last anterolateral spine located about 60% the distance posteriorly on carapace, carapace surface smooth or finely granular, regions weakly defined; orbits large for genus; anterolateral margin with nine sharp spines separated to bases, ornamented with fine granules; posterior margin entire, rimmed (from Schweitzer and Feldmann, 2000). Sternum granulose, first three sternites fused, third and fourth sternites separated by shallow groove.

Emendation to description: Carapace description as in Schweitzer and Feldmann (2000). Sternum of female finely granulose, longer than wide, maximum width about 60 percent maximum length, widest at position of episternites of sternite 6; sternites 1–3 fused, suture between sternites 3 and 4 a shallow groove. Sternites 3–7 with episternal projections, sternite 8 not visible.

Abdominal features not preserved.

Measurements: Measurements (in mm) were taken on the dorsal carapace, where possible, and recorded in Table 1.

Occurrence: The material examined in this study was collected from two localities in the Bear Lake Formation. One was the same conglomerate bed within the type section of the Bear Lake Formation from which the specimens of *Tymolus alaskensis* were collected in Sec. 26, T48S, R69W, of the Port Moller (D-1) Quadrangle USGS 1:63, 360 series topographic, (J. DeMouthe, personal communication, 2005). The other collecting locality (field locality 05RB11 of Blodgett) was a fossiliferous zone of silty sandstone containing calcite-cemented sandstone lenses in Sec. 9, T49S, R69W, of the Port Moller (D-1) Quadrangle USGS 1:63, 360 series. The type material of *Metacarcinus goederti* came from Sec. 27 or 34, T48S, R69W Port Moller (D-1) Quadrangle, USGS M8170 as well as from the stratigraphically slightly higher Milky River section of the Bear Lake Formation in Sec. 27 and 34, T48S, R69W of the Port Moller (D-1) Quadrangle, USGS M8171 (Schweitzer and Feldmann, 2000).

Discussion: Whereas *Metacarcinus goederti* has been previously described, its occurrence in the Bear Lake

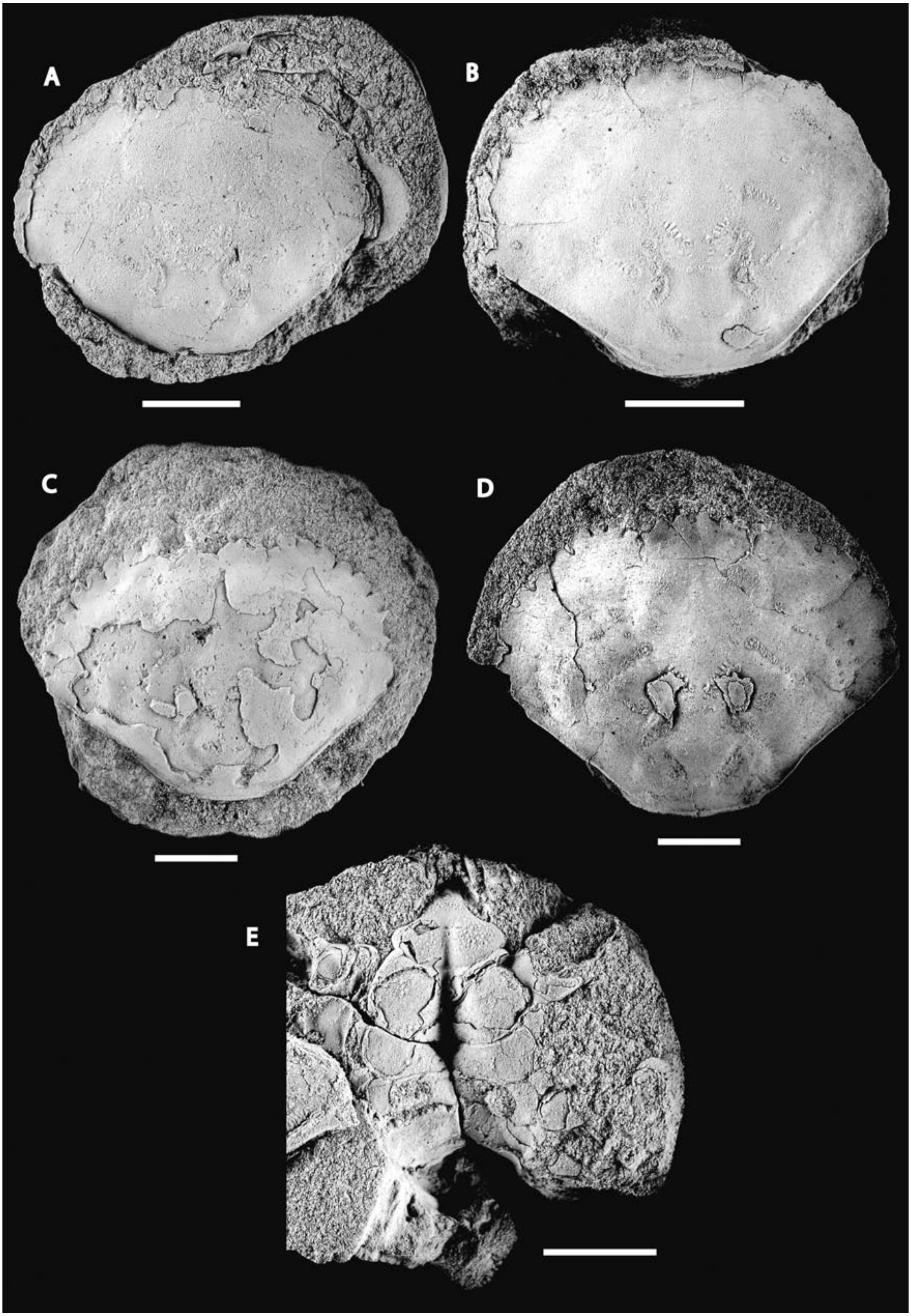

Fig. 4. *Metacarcinus goederti* Schweitzer and Feldmann, 2000. Specimens A–D show dorsal view of carapace and illustrate size differential among the specimens collected. Specimen E shows ventral view of carapace with sternites 1–7 present. Scale bar for each specimen = 1 cm.

Formation has yet to be interpreted in a paleoecological context. The presence of *Metacarcinus* provides support for the prevailing shallow water interpretation. *Metacarcinus* may also be able to provide insight into the water temperature of the area of deposition of the Bear Lake Formation. The current accepted habitat range of extant *Metacarcinus* is in temperate water (Feldmann, 2003). A more thorough examination of the fossil assemblage of the Bear Lake Formation is therefore needed to properly interpret temperature regimes. For instance, in the lower unit of the section, interpreted to be early mid-Miocene, the presence of *Turritella* (*Hataiella*) *sagai* Kotaka, 1951, indicates a warm water environment (Marincovich and Kase, 1986). The occurrence of *Isurus oxyrhynchus* Rafinesque, 1810, the mako shark, collected near the crabs in the upper section, indicates a temperature range of tropical to temperate. This is the typical range preferred by that shark today, which still inhabits the waters off the Aleutian Islands (Passarelli *et al*., 2005).

A second significance of the newly discovered specimens of *Metacarcinus goederti* is that a large sample size (23) has allowed for comparison of dorsal carapace features. The results of these comparisons (Fig. 5A–D) indicate a large time averaged population, a rare occurrence for the Decapoda in the fossil record. Further study of this time averaged population, especially in comparison with extant populations of *Metacarcinus*, may lead to greater understanding of the development of population dynamics within the genus through time.

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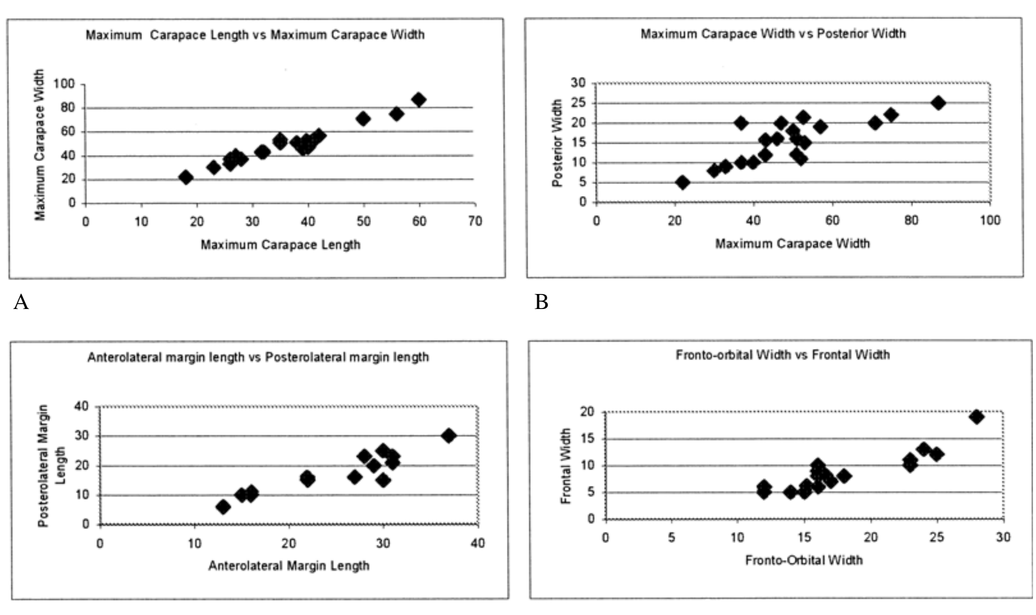

Fig. 5. A–D, Scatter diagrams of ratios between selected dorsal carapace features showing a general linear trend for each, suggesting a time-averaged population.

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