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New Miocene crab (Brachyura: Portunidae) from southern California, USA

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Abstract

A new species of portunoid crab from the Miocene of California is one of many representatives of Portunoidea Rafinesque, 1815, from the West Coast of North America. However, *Portunus* (*Portunus*) *pankowskiorum* new species is the first notice of *Portunus* Weber, 1795, from the region. All of the specimens for which sex can be determined are male. Segregation by sex and age is common within members of extant Portunidae Rafinesque, 1815, that have been studied for fisheries.

Key words: crab, Portuninae, Serravallian, Tortonian, North America, Neogene

Introduction

The middle–late Miocene Monterey Formation and its equivalents in Southern California have yielded relatively few decapod crustaceans. Rathbun (1932) reported three species of pinnotherid crabs, *Pinnixa galliheri* Rathbun, 1932; *Pinnixa montereyensis* Rathbun, 1932; and *Pinnixa miocenica* (Rathbun, 1932), from the type section of the Monterey Formation near Pacific Grove. This corresponds to the general area of a reported "typical section" near Monterey, California, about 3 km from Pacific Grove (Blake, 1856). Nations (1975) named *Cancer* (*Romaleon*) *dereki* from the Monterey Formation in San Mateo County, California. *Romaleon* has subsequently been elevated to generic rank. Subsequently, Feldmann (2003) recognized an indeterminate penaeid shrimp and *Metacarcinus danai* Nations, 1975, from the Puente Formation in Riverside County. *Metacarcinus danai* was originally described by Nations from the Briones Formation in Northern California which is the temporal equivalent of the Monterey Formation (Weaver, 1944). The rocks from which the latter taxa were described have been referred to the Monterey Formation, but current best usage seems to favor use of Puente Formation in Riverside County (Dibblee, 1999a, b; Dibblee and Ehrenspeck, 2000, 2001). Regardless of the terminological issues, the discussions in these studies support the contention that the Puente Formation is the physical and temporal equivalent of the Monterey Formation. Thus, the discovery of a new species of brachyuran from the unit represents a significant addition to the fauna, and it is the basis for this work.

Locality

The specimens were collected from middle to late Miocene rocks of California. The rocks were collected in an abandoned quarry near Santa Maria, California, in the San Rafael Mountains, previously leased by Antolini & Sons in the middle part of the 20th century and from which collections were made at about that time and later (M. Pankowski, personal communication, March, 2014). Howard (1957a) described the rocks at this quarry as siliceous limestone of Serravallian to Tortonian age. The lithologic description accords with the specimens at hand. She also reported that fish, marine mammals, marine birds, and some plant material were preserved in the rocks, although some of the birds were reportedly somewhat older, of Relizian foraminiferal stage, which corresponds to about Langhian age (Howard, 1957b; Turner, 1970). The rocks were reported as the Monterey Formation (Howard, 1957a; Miller, 1989), and Miller described the locality of the Antolini & Sons quarry as on the west bank of the Tepusquet Creek, Santa Barbara County, California, lat. 34°51′32″N, long. 120°15′28″W.

Systematics

Infraorder Brachyura Latreille, 1802
Section Eubrachyura de Saint Laurent, 1980
Family Portunidae Rafinesque, 1815

Diagnosis: See Karasawa *et al.* (2008).

Discussion: Karasawa *et al.* (2008) provided diagnoses for families within the Portunoidea, upon which the following discussion is based. The new species is placed within Portunidae and Portuninae Rafinesque, 1815, based upon its possession of nine anterolateral spines (see discussion under species) with last longest, a carapace about two-thirds as long as wide, widest about 70% the distance posteriorly; chelipeds longer than other pereiopods and with keels and spines; and male pleon with somites 3–5 fused and somite 3 or 4 extending laterally in rounded

extension. Among Portunoidea, the new taxon is easily excluded from Longusorbiidae Karasawa *et al.*, 2008, by having fused pleonal somites in males, whereas in Longusorbiidae they are all free. In Geryonidae Colosi, 1924, the male pleonal somites are fused but with sutures that are clearly visible. In the new taxon, the sutures are not visible. Catoptridae Borradaile, 1902, have a lateral margin that is entire or with few spines on it, whereas the new taxon has at least eight, and probably nine, anterolateral spines. Carcineretidae Beurlen, 1930, have a carapace that is about as long as wide and a male pleon with clear sutures on somites 3–5; the new species has a carapace much wider than long. Carcinidae MacLeay, 1838, also have carapaces that are about as wide as long and usually with five anterolateral spines. Macropipidae Stephenson and Campbell, 1960, have three to five anterolateral spines and usually clear evidence of sutures on the male pleonal somites 3–5.

Portunidae is composed of numerous subfamilies. Atoportuninae Števčić, 2005, has the same basic shape as the new taxon but in general it possesses fewer anterolateral spines (usually seven) and seems to have longer pereiopods than the new taxon. However, recovery of new material might suggest placement in this subfamily, when we can confirm details of the front and orbits. Caphyrinae Paul'son, 1875, have a very broad fronto-orbital width, 70–80% the maximum width, and a carapace about as long as wide, excluding the new taxon from this subfamily. Carupinae Paul'son, 1875, have fewer anterolateral spines and possibly incomplete fusion of male pleomeres. Podophthalminae Dana, 1851, and Thalamitinae Paul'son, 1875, have much different orbits than the new material, either very wide with a very narrow front (Podophthalminae) or situated at the lateral corners of the frontal margin (Thalamitinae). Necronectinae Glaessner, 1928, are in general very similar to the new material but male pleonal somites have remnant sutures between sutures 3–5 and stout chelae that often lack keels, different from the slender chelae with keels on the new material. Lupocyclinae Paul'son, 1875, have a very tightly arched anterolateral margin and very wide frontal margin that cannot accommodate the new material.

Genus *Portunus* (*Portunus*) Weber, 1795

Type species: *Cancer pelagicus* Linnaeus, 1758, by subsequent designation of Rathbun (1926).

Included species: See Ng *et al*. (2008) for extant species and Schweitzer *et al.* (2010) for fossil species.

Diagnosis: Carapace longer than wide; frontal margin usually with six spines including inner orbital spines; anterolateral margin usually with nine spines including outer-orbital spine; chelae with keels on outer surface; proximal elements of chelipeds may have spines; merus of third maxilliped with rounded anterior margin, not extending laterally.

Discussion: The genus *Portunus* has had a convoluted history, with many synonyms and subgenera, a summary of which may be found in Davie (2002) and Ng *et al.* (2008). Subgenera have not typically been used in recent works, but that is beginning to change. Davie (2002) used subgenera in his work on Australian decapods, whereas Poore (2004) did not. Ng *et al.*'s (2008) recent checklist of all brachyuran species worldwide placed all species of *Portunus* within subgenera. For fossils, it is often difficult to place species of any genus within subgenera, and within *Portunus*, the bases for placement are aspects of the male gonopods (Stephenson and Campbell, 1959), the third maxillipeds (Barnard, 1950), and shape of the carapace and spines (Rathbun, 1930). Some of these preserve as fossils but some do not. Stephenson and Campbell (1959) also discussed forms that were intermediate between some subgenera, but some of those issues appear to have been resolved by creation of new genera (Ng and Takeda, 2003).

Based upon Rathbun (1930) and Ng *et al*. (2008), it appears that *Portunus* (*Achelous*) de Haan, 1833, and *Portunus* (*Portunus*) are by far the most abundant subgenera in North America in the Holocene. We examined those two subgenera and found that the new taxon best fits the diagnosis of *Portunus* (*Portunus*). The two subgenera are quite similar in shape of the carapace and number and form of anterolateral spines. Barnard (1950) reported that in *Achelous*, the last anterolateral spine was not larger than the others, but examination of species in Rathbun (1930) that have been corroborated as members of *Portunus* (*Achelous*), according to Ng *et al*. (2008), shows that the last spine is often larger than the remainder. The conformation is similarly variable in species of *Portunus* (*Portunus*) illustrated by Rathbun (1930) and similarly corroborated for subgeneric placement. Species of *Portunus* (*Achelous*) are characterized by a merus of the third maxilliped that has a squared anterior margin and that extends laterally (Stimpson, 1862; Barnard, 1950; Mantelatto *et al.*, 2009), whereas *Portunus* (*Portunus*) is characterized by a rounded anterior margin of the third maxilliped merus that does not extend laterally (Rathbun, 1930, fig. 7; Barnard, 1950). The specimens described herein are characterized by the latter morphology, thus our placement of them within *Portunus* (*Portunus*). Although the new specimens do exhibit the male gonopods, the tips are not preserved. Mantelatto *et al.* (2009) elevated *Achelous* to generic level based on molecular phylogenic study but did not similarly elevate the other subgenera of *Portunus*. We await further clarification on the various subgenera of this genus before we attempt to designate subgenera for

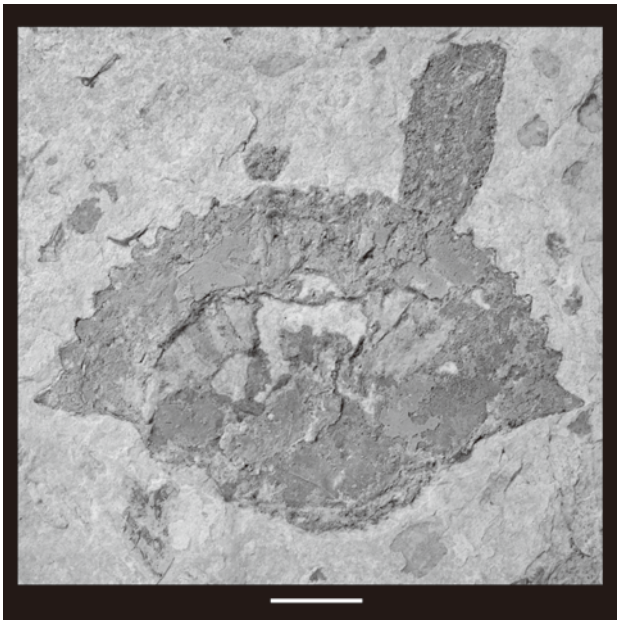

Fig. 1. *Portunus* (*Portunus*) *pankowskiorum* new species, holotype USNM 605057, ventral view of carapace and proximal elements of left pereiopod. Scale bar = 1 cm.

Fig. 2. 1–2. *Portunus* (*Portunus*) *pankowskiorum* new species, paratype USNM 605058. 1, ventral view of male sternum and first pereiopods; 2, close up of male sternum showing male gonopods (arrows). Scale bars = 1 cm.

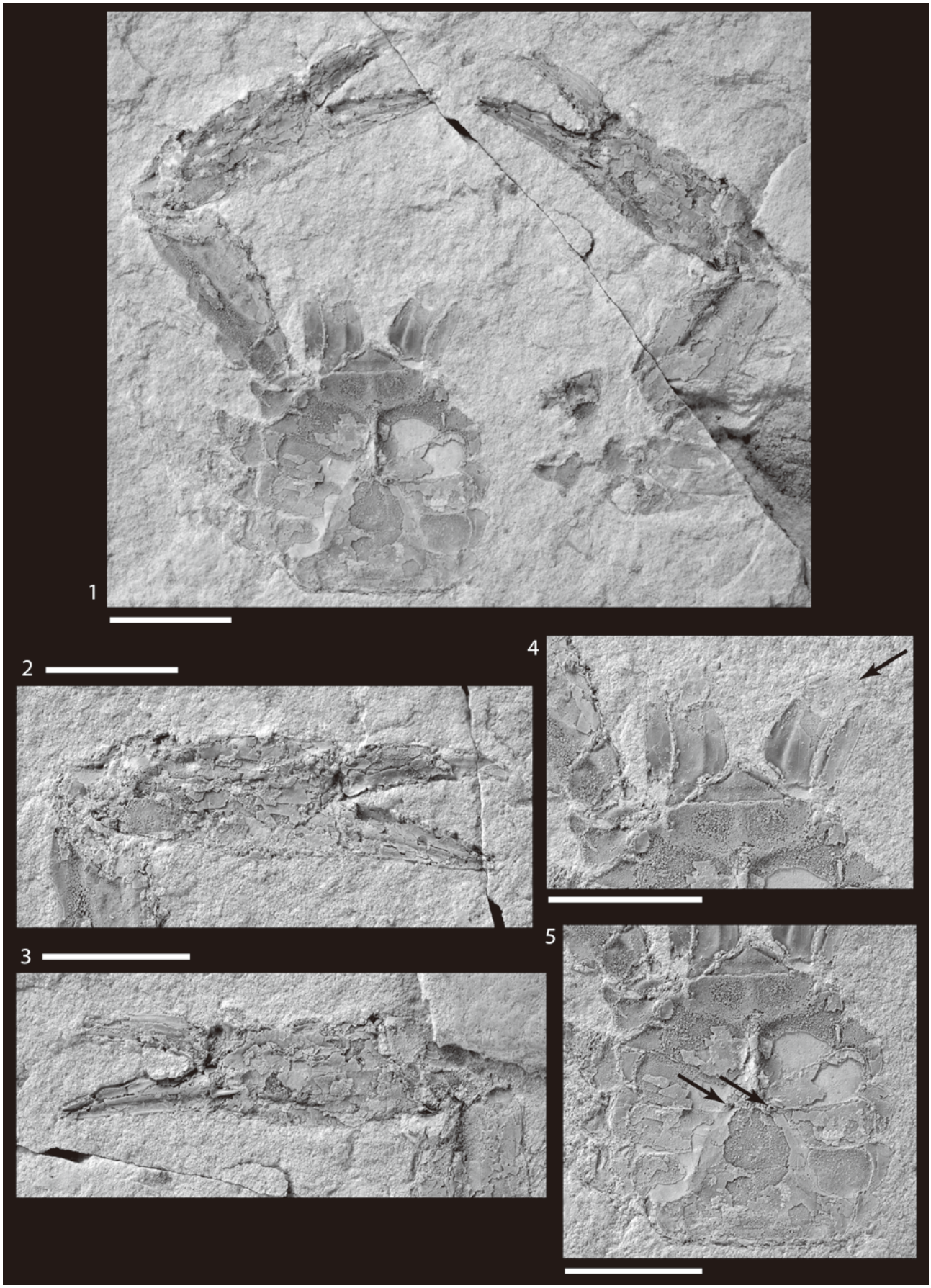

Fig. 3. 1–5. *Portunus* (*Portunus*) *pankowskiorum* new species, paratype USNM 605059. 1, ventral view of male sternum, pleon, and weakly heterochelous first pereiopods; 2, right chela, showing slightly stouter manus and fingers; 3, somewhat more slender left chela; 4, third maxillipeds showing rounded merus (arrow); 5, sternum and male pleon, arrows indicate position of pleonal locking mechanism. Scale bars = 1 cm.

the many fossil species. North American Holocene species of *Portunus* (*Portunus*) are known from the Atlantic and Pacific Coast as well as from northern South America south to Chile (Rathbun, 1930). Thus, a Miocene species of the subgenus does not extend its geographic range.

Portunus (*Portunus*) *pankowskiorum* new species

(Figs. 1–4)

Diagnosis: Carapace about 70% as long as wide, widest about two-thirds the distance posteriorly; with at least nine anterolateral spines, eight of which are clearly preserved, last spine longest and stoutest; male pleon with marked, rounded lateral projection on somite 4?; chelae with well-developed keels on outer and upper surfaces, spines on upper surfaces of meri.

Description: Carapace ovate, wider than long, length about 65% carapace width, widest about 70% distance posteriorly. Carapace regions and grooves unknown due to flattened preservation, cuticle degraded, some specimens with mosaic-like appearance in cuticle.

Frontal margin possibly with four spines to six spines including inner orbital spine; inner two closely spaced, remainder of frontal margin poorly preserved and broken. Anterolateral margin arcuate; with at least eight anterolateral spines, spines becoming slightly larger posteriorly, each with straight anterior margin and curved posterior margin, first seven directed anterolaterally; last spine longest and stoutest, directed laterally, marking widest part of carapace. Posterolateral margin arcuate, concave; posterior margin straight, probably rimmed.

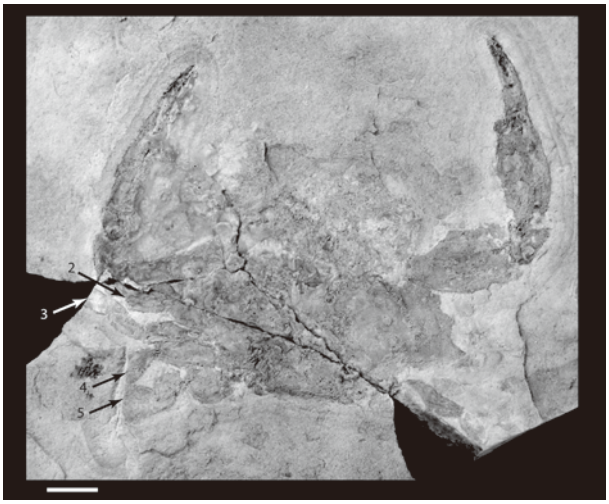

Fig. 4. *Portunus* (*Portunus*) *pankowskiorum* new species, paratype USNM 605061, carapace and 2–5 (arrows), all much shorter than chelipeds. Scale bar = 1 cm.

Subhepatic region and pterygostome granular. Eyes apparently on short stalks. Third maxillipeds operculiform; exopod longer than wide, inner margin convex, outer margin straight; ischium with groove about two-thirds the distance axially, proximal margin concave, outer margin weakly concave, inner margin straight distally and curving strongly proximally into convex distal margin; merus about as long as wide, with convex distal margin not extending laterally.

Sternite 1 triangular, separated from sternite two by groove; sternite 2 trapezoidal, much wider than long, separated from sternite 3 by suture; sternite 3 wider than long, posterior margins separated from sternite 4 by groove; sternite 4 wider than long, with deep axial groove and long episternal projections; sternite 5 about one and one-half times as wide as long, widening distally, with long episternal projections, with small, knob-like pleonal holding structures in males; sternites 6 and 7 about same shape, 7 slightly shorter, each with episternal projections; sternite 8 visible in ventral view in males.

Male pleonal somites 3–5 fused, somite 3 wider than 4 and 5 with rounded lateral projections, somite 6 longer than wide; telson triangular, reaching to about base of coxa 4. Male gonopods 1 and 2 long, slender.

Chelipeds weakly heterochelous. Major chelipeds with short ischium, possibly with spines on upper surface. Merus much longer than wide, outer surface keeled, upper and lower surfaces with spines. Carpus very short, poorly known. Manus much longer than high, outer surface with 2 keels, upper surface with keel, large tubercles above base of fixed finger; fixed finger long, slender, with molariform denticles with black tips on occlusal surface; movable finger arcuate, slender, with denticles on occlusal surface. Minor chelipeds not much smaller than major chelipeds, somewhat more slender, similar in shape, manus with one or no keels on outer surface.

Pereiopods 2–4 with more flattened proximal elements than chelipeds; pereiopod 5 with flattened, short, ovate carpus, manus, and dactylus.

Types: The holotype USNM 605057, and paratypes USNM 605058–605070, are deposited in the United States National Museum of Natural History, Smithsonian Institution, Washington, DC, USA.

Etymology: The trivial name honors Mark Pankowski and his family, recognizing their contribution to science by acquiring fossils and donating them for scientific study.

Measurements: Measurements (in mm) taken on the dorsal carapace of specimens of *Portunus* (*Portunus*) *pankowskiorum* new species: holotype USNM 605057, maximum width (W1), 54.0; maximum length (L1), 34.9; length from front to position of maximum width, (L2), 24.2; fronto-orbital width (W2) (estimated), 11.8; frontal width (W3) (estimated), 5.0; paratype USNM 605063, W1, 47.8; L1, 31.0; L2, 20.8.

Occurrence: The specimens were collected from middle–late Miocene (Serravallian–Tortonian) rocks of the Monterey Formation in southern California, USA.

Discussion: The frontal and anterior-most portions of the anterolateral margins are difficult to interpret. They are poorly preserved on all specimens. None of the specimens retains an unbroken frontal and orbital region. One specimen retains what appears to be a pair of axial frontal spines, but it is not possible to determine the total number of frontal spines due to breakage. It appears likely that there were six, due to the width of the area, but this remains to be confirmed. The anterolateral margin has at least eight confirmed spines, and there must be at least nine including the outer-orbital spine, although the orbits cannot be observed. This is due to breakage and to one of the chelipeds lying directly on that region of the carapace (Fig. 1). Although these regions of the carapace are poorly preserved, the sternum and pleonal areas are well-preserved. The male gonopods can be observed in two different specimens (Fig. 2), and the pleonal locking mechanism can be seen in another specimen (Fig. 3.5).

Other species from various genera within Portunoidea have been described from Paleogene and Neogene rocks of California and the west

coast of North America, but all differ from the new species described here. Most, in fact, are referred to different families. Several species of *Longusorbis* Richards, 1975, of Longusorbiidae are known from the west coast of North America, but these are easily distinguished from the new species by their very broad orbits (nearly equal to the maximum width of the carapace), apparently unfused male pleonal somites, and short chelipeds that are shorter than other pereiopods (Karasawa *et al.*, 2008). All of these differ significantly from the new species. Many species within genera of Macropipidae are known from the west coast of North America, including *Coeloma (Litoricola)* Woodward, 1873; *Maeandricampus* Schweitzer and Feldmann, 2002; *Minohellenus* Karasawa, 1990; and *Portunites* Bell, 1858. However, Macropipidae as previously stated have only 3 to 5 anterolateral spines, unfused or clear sutures on male pleonal somites 3 to 5, usually a less broad carapace with respect to the length, and with some pereiopods as long as the chelipeds (Karasawa *et al.*, 2008). All of these features differ from the new species. *Necronectes nodosus* Schweitzer *et al.*, 2002, of Necronectinae, a subfamily of Portunidae, was described from Oligocene rocks of Baja California Sur. Although it is similar to the new species in overall ovate shape and poorly marked regions of the carapace, it has one fewer anterolateral spine and lacks keels on the chelae. The chelae of *N. nodosus* are also stout and with relatively short fingers, whereas in the new species the chelae have keels, are long, and have long, slender fingers. Within Portuninae, *Acanthoportunus buchanani* Schweitzer and Feldmann, 2002, was described from the Eocene of California but it has a long anterolateral spine that is itself spinose, clearly distinct from the new species. Rathbun (1926, p. 75) reported *Callinectes bellicosus* (Stimpson, 1862), from the Pleistocene of California based only on a movable finger. Species of *Callinectes* have a very distinctive T-shaped male pleon not seen in the new species. Thus, we are confident that the new species is in fact new and not previously reported from the Cenozoic of California or elsewhere.

All of the specimens for which sex can be determined are male, six out of fourteen. Species of *Callinectes* within Portuninae that have been widely studied for the fisheries industry display segregation based upon sex and age. Immature females and males often inhabit one region, and mature females seek other regions for development of eggs and larval dispersal (Segura de Andrade *et al.*, 2013). Juveniles often inhabit different environments that are safer for development, and concomitantly, mature females inhabit such environments as well (Araújo *et al.*, 2012). It seems that males and females are separated in many species of *Callinectes*, and one report suggested that 70% of adults of each sex lived in environments different from one another (Rodríguez-Domínguez *et al.*, 2012). Indeed, Warner (1977) reported that such separation by sex was common among decapods. This may explain the 100% male occurrence seen in the population of *Portunus* (*Portunus*) *pankowskiorum* new species seen here.

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References

Araújo, M. S. L. C., A. V. Barreto, A. O. Negromonte, and R. Schwamborn. 2012. Population ecology of the blue crab *Callinectes danae* (Crustacea: Portunidae) in a Brazilian tropical estuary. Anais da Academia Brasileira de Ciências 84(1): 129–138.

Barnard, K. H. 1950. Descriptive Catalogue of South African Decapod Crustacea (Crabs and Shrimps). Annals of the South African Museum 38: 1–937, figs. 1–154.

Bell, T. 1858. A monograph of the fossil malacostracous Crustacea of Great Britain, Pt. I, Crustacea of the London Clay. Monograph of the Palaeontographical Society, London 10 [1856]: i–viii, 1–44, 11 pls.

Beurlen, K. 1930. Vergleichende Stammesgeschichte Grundlagen, Methoden, Probleme unter besonderer Berücksichtigung der höheren Krebse. Fortschritte in der Geologie und Paläontologie 8: 317–586.

Blake, W. P. 1856. Notice of remarkable strata containing the remains of infusoria and polythalmia in the Tertiary formation of Monterey, California. Proceedings of the Academy of Natural Sciences of Philadelphia 7: 328–331.

Borradaile, L. A. 1902. Marine Crustaceans. I. On varieties. II. Portunidae. In J. S. Gardiner (ed.), The fauna and geography of the Maldive and Laccadive archipelagoes 1 (2): 191–208.

Colosi, G. 1924. Una specie fossile de Gerionide (Decapodi brachiuri). Bolettino della Società dei Naturalisti in Napoli 35 (series 2, vol. 15 for 1923): 248–255.

Dana, J. D. 1851. On the classification of the Cancroidea. American Journal of Science and Arts (2) 12 (34): 121–131.

Davie, P. J. F. 2002. Crustacea: Malacostraca: Eucarida (Part 2): Decapoda—Anomura, Brachyura. In A. Wells and W. W. K. Houston (eds.), Zoological Catalogue of Australia. Vol. 19.3B. CSIRO Publishing, Melbourne, Australia, pp. xiv, 1–641.

de Saint Laurent, M. 1980. Sur la classification et la phylogénie des Crustacés Décapodes Brachyoures. I. Podotremata Guinot, 1977, et Eubrachyura sect. nov. Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, Paris (D) 290: 1265–1268.

Dibblee, T. W., Jr. 1999a. Geologic map of the El Monte and Baldwin Park Quadrangles, Los Angeles County, California. Dibblee Geological Foundation map DF-69 (not seen).

Dibblee, T. W., Jr. 1999b. Geologic map of the Palos Verdes Peninsula and vicinity, Redondo Beach, Torrance, and San Pedro quadrangles, Los Angeles County, California. Dibblee Geological Foundation map DF-70 (not seen).

Dibblee, T. W., Jr., and H. Ehrenspeck. 2000. Geology of the Palos Verdes Hills, California. American Association of Petroleum Geologists Bulletin 84: 865.

Dibblee, T. W., Jr., and H. Ehrenspeck. 2001. New geologic maps of the Puente Hills, Southern California. American Association of Petroleum Geologists Bulletin 85: 1119–1120.

Feldmann, R. M. 2003. Decapod crustaceans from the Puente formation (late middle to early late Miocene), California: A possible mass death. Bulletin of the Southern California Academy of Sciences 102: 107–118.

Glaessner, M. F. 1928. Die Dekapodenfauna des Osterreichischen Jungtertiärs. Jahrbuch der Geologischen Bundesanstalt 78:161–219, figs. 3, 4.

Haan, W. de. 1833–1850. Crustacea. In P. F. de Siebold (ed.), 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. J. Müller et Co., Lugduni-Batavorum (= Leiden). i–xvii, i–xxxi, ix–xvi, pp. 1–243, pls. A–J, L–Q, circ. tab. 2.

Howard, H. 1957a. A new species of passerine bird from the Miocene of California. Los Angeles County Museum Contributions in Science 9: 1–16.

Howard, H. 1957b. A gigantic "toothed" marine bird from the Miocene of California. Santa Barbara Museum of Natural History Bulletin No. 1, Department of Geology, 23 p.

Karasawa, H. 1990. Decapod crustaceans from the Miocene Mizunami Group, central Japan, Pt. 2. Oxyrhyncha, Cancridea, and Brachyrhyncha. Bulletin of the Mizunami Fossil Museum 17: 1–34, pls. 1–8.

Karasawa, H., C. E. Schweitzer, and R. M. Feldmann, 2008. Revision of the Portunoidea Rafinesque, 1815 (Decapoda: Brachyura) with emphasis on the fossil genera and families. Journal of Crustacean Biology 28: 82–127.

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

Linnaeus, C. [von], 1758. Systema Naturae per Regna tria Naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis (ed. 10) 1. Laurentii Salvii, Holmiae [= Stockholm], 824 p.

MacLeay, W. S. 1838. On the brachyurous decapod Crustacea brought from the Cape by Dr. Smith. In A. Smith, Illustrations of the Annulosa of South Africa; consisting chiefly of figures and descriptions of the objects of natural history collected during an expedition into the interior of South Africa, in the years 1834, 1835, and 1836; fitted out by "The Cape of Good Hope Association for Exploring Central Africa..": 53–71, 2 pls. Smith, Elder and Company, London.

Mantelatto, F. L., R. Robles, C. D. Schubart, and D. L. Felder. 2009. Molecular phylogeny of the genus *Cronius* Stimpson, 1860, with reassignment of *C. tumidus* and several American species of *Portunus* to the genus *Achelous* De Haan, 1833 (Brachyura: Portunidae). In J. W. Martin, K. A. Crandall, and D. L. Felder (eds.), Decapod Crustacean Phylogenetics, Crustacean Issues 18. CRC Press, Taylor and Francis Group, Boca Raton, FL, p. 567–579.

Miller, S. E. 1989. Paleontological type specimens in the Santa Barbara Museum of Natural History. Proceedings of the Biological Society of Washington 102: 1–2.

Ng, P. K. L., and M. Takeda. 2003. *Atoportunus*, a remarkable new genus of cryptic swimming crab (Crustacea; Decapoda; Brachyura; Portunidae), with descriptions of two new species from the Indo-West Pacific. Micronesica 35–36: 417–430.

Ng, P. K. L., D. Guinot, and P. J. F. Davie. 2008. Systema Brachyurorum: Part I. An annotated checklist of extant brachyuran crabs of the world. Raffles Bulletin of Zoology (Supplement) 17: 1–286.

Paul'son, O. 1875. Studies on the Crustacea of the Red Sea with notes regarding other seas. Part 1. Podophthalmata and Edriophthalmata (Cumacea): 1–164, 21 pls. (S. V. Kul'zhenko, Kiev). [Translation published for The National Science Foundation, Washington, D. C. and Smithsonian Institution, U.S.A., by the Israel Program for Scientific Translations, 1961.]

Poore, G. C. B. 2004. Marine Decapod Crustacea of Southern Australia. A Guide to Identification. Museum Victoria, Melbourne. i–ix + 574 pp.

Rafinesque, C. S. 1815. Analyse de la nature, ou tableau de l'univers et des corps organisée. L'Imprimerie de Jean Barravecchia, Palermo, 224 p.

Rathbun, M. J. 1926. The fossil stalk-eyed Crustacea of the Pacific slope of North America. United States National Museum Bulletin 138: i–viii, 1–155.

Rathbun, M. J. 1930. The cancroid crabs of America of the families Euryalidae, Portunidae, Atelecyclidae, Cancridae and Xanthidae. United States National Museum Bulletin 152: 1–609.

Rathbun, M. J. 1932. Fossil pinnotherids from the California Miocene. Journal of the Washington Academy of Sciences 22: 411–413.

Richards, B. C., 1975. *Longusorbis cuniculosus*: a new genus and species of Upper Cretaceous crab with comments on the Spray Formation at Shelter Point, Vancouver Island, British Columbia. Canadian Journal of Earth Sciences, 12: 1850–1863.

Rodríguez-Domínguez, G., S. G. Castillo-Vargasmachuca, R. Pérez-González, and E. A. Aragón-Noriega. 2012. The size at maturity of the brown crab *Callinectes bellicosus* (Decapoda, Portunidae) in the Gulf of California. Crustaceana 85: 1513–1523.

Schweitzer, C. E., and R. M. Feldmann. 2002. New Eocene decapods (Thalassinidea and Brachyura) from southern California. Journal of Crustacean Biology 22: 938–967.

Schweitzer, C. E., R. M. Feldmann, G. Gonzáles-Barba, and F. J. Vega. 2002. New crabs from the Eocene and Oligocene of Baja California Sur, Mexico and an assessment of the evolutionary and paleobiogeographic implications of Mexican fossil decapods. Paleontological Society Memoir 76: 1–43.

Schweitzer, C. E., R. M. Feldmann, A. Garassino, H. Karasawa, and G. Schweigert. 2010. Systematic list of fossil decapod crustacean species. Crustaceana Monographs 10: Brill, Leiden, 222 pp.

Segura de Andrade, L., V. Fransozo, V. J. Cobo, A. L. Castilho, G. Bertini, and A. Fransozo. 2013. Ontogenetic distribution of *Callinectes ornatus* (Decapoda, Portunoidea) in southeastern Brazil. Ciencias Marinas 39: 371–385.

Stephenson, W., and B. Campbell. 1959. The Australian portunids (Crustacea: Portunidae) III. The genus *Portunus*. Australian Journal of Marine and Freshwater Research 10 (1): 84–124, pls. 1–5.

Stephenson, W., and B. Campbell. 1960. The Australian portunids (Crustacea: Portunida) IV. Remaining genera. Australian Journal of Marine and Freshwater Research 11 (1): 73–122, pls. 1–6.

Števčić, Z. 2005. The reclassification of brachyuran crabs (Crustacea: Decapoda: Brachyura). Natura Croatica 14 (suppl.) (1): 1–159.

Stimpson, W. 1862. Notes on North American Crustacea, in the Museum of the Smithsonian Institution. No. II. Annals of the Lyceum of Natural History of New York, **7** [1862]: 176–246, pls. 2, 5 [read April 1860]. [Pages 49–118, pls. 2, 3 on separate.]

Turner, D. L. 1970. Potassium-Argon dating of Pacific Coast Miocene foraminiferal stages, p. 91–129. In O. L. Bandy (ed.), Radiometric dating and paleontologic zonation. Geological Society of America Special Paper 124, Boulder Colorado. 247 p.

Warner, G. F. 1977. The Biology of Crabs. Van Nostrand Reinhold Company, New York, 202 p.

Weaver, C. E. (Chairman, Western Cenozoic Subcommittee). 1944. Correlation of the marine Cenozoic formation of western North America. Bulletin of the Geological Society of America 55: 569–598.

Weber, F. 1795. Nomenclator entomologicus secundum Entomologiam Systematicum ill. Fabricii adjectis speciebus recens detectis et varietatibus. C. E. Bohn, Chilonii et Hamburgi, 171 p.

Woodward, H. 1873. Further notes on Eocene Crustacea from Portsmouth. Quarterly Journal of the Geological Society of London 29: 25–31, pls. 1, 2.

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