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A NEW SPECIES OF CANCROID CRAB FROM THE PLIOCENE OF CALIFORNIA

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ABSTRACT—A new cancroid crab, *Cancer davidi* n. sp., is described from the middle Pliocene Etchegoin Formation of Kettleman Hills, California. It shows affinities with the Pleistocene to Recent *Cancer gracilis* Dana of the west coast of North America and is probably ancestral to it. A brief summary of fossil species of *Cancer* from the West Coast is given.

Cancer davidi was associated with *Anadara*, *Forreria*, *Kelletia* and *Trachycardium*, genera which are characteristic of intertidal to sublittoral depths in areas where the minimum average surface temperature (February) is 13° C. or higher. Salinity of 20 ppm, or above, is indicated by the presence of *Dendraster*.

INTRODUCTION

A FAIRLY complete carapace of a crab was collected by the author from the *Patinopecten* "zone" (Woodring, et al., 1941) of the Etchegoin Formation (middle Pliocene) in the Kettleman Hills area, California. It was found in a fine- to medium-grained quartzose sandstone and was closely associated with the following species:

Pelecypods:
Glycimeris grewingki Dall
Patinopecten lohri (Hertlein)
Pseudocardium densatum (Conrad)
Cirriped:
Balanus gregarius (Conrad)
Echinoid:
Dendraster gibbsii (Rémond)

The specimen is well preserved, consisting of about two-thirds of the carapace plus the carpus and manus of the left cheliped. The missing third of the carapace, the right postero-lateral portion, is represented by an internal mold. The merus and the portions of the fixed and movable fingers beyond the first cutting tooth of the left cheliped are missing. No other appendages are preserved.

The specimen was compared with Recent specimens of various species of *Cancer* in the collections of the Allan Hancock Foundation, University of Southern California, Los Angeles, California. Dr. John S. Garth of that institution generously granted access to the collections. He and Miss Janet Haig, Research Assistant at the Foundation, read the original manuscript and offered many helpful suggestions. The writer's appreciation is also due to Dr. J. Wyatt Durham of the Department of Paleontology, University of California at Berkeley, for advice and critical reading of the manuscript, and to Mr. Joseph H. Peck of the Museum of Paleontology, University of California (Berkeley), for assistance in photographing the specimens.

SYSTEMATIC DESCRIPTION

Family CANCRIDAE Alcock
Genus CANCER Linnaeus
CANCER DAVIDI, n. sp.
Pl. 10, figs. 1,2,4,5,7,10

Carapace.—Carapace broadly oval, moderately convex, very slightly aerolated and densely granulated. Fronto-orbital border about one-third the width of carapace; with five teeth, the outer pair forming the inner angles of the orbits

EXPLANATION OF PLATE 10

FIGS. *1,2,4,5,7,10*—*Cancer davidi* new species. UCMP no. 37,889. *1*, Dorsal view of carapace, ×1.5; *2*, ventral view of carapace, ×1.5; *4*, chela and carpus, dorsal view, ×2.0; *5*, chela and carpus, inner side, ×2.0; *7*, anterior view, ×1.5; *10*, chela and carpus, outer side, ×2.0. From middle Pliocene Etchegoin Formation, Kettleman Hills, Calif.

3,6,8,9—*Cancer gracilis* Dana. UCMP no. 37,883. *3*, Dorsal view of carapace, ×1.5; *6*, anterior view, ×1.5; *8*, chela and carpus, inner side, ×2.0; *9*, chela and carpus, ×2.0. Recent, Monterey Bay, Calif.

and the three median teeth extending more anteriorly than the other two. Orbits small (3.5 mm in diameter) with two fissures in each dorsal and ventral margin; inner angles more produced anteriorly than the outer ones. Antero-lateral margin of carapace slightly indented at closed fissures separating the teeth; evenly beaded with granulations approximately two or three times as large as those on the dorsal surface, but less than half the size of those on the margin of *Cancer gracilis* Dana.

Antero-lateral teeth sub-truncate with a small granulated tubercle which is usually located one-third the distance from the anterior fissure of each tooth. Four left and two right antero-lateral teeth preserved. The first tooth, with its prominent granulated tubercle forming the outer angle of the orbit, is two-thirds the width of the others. Second, third and fourth teeth of equal width; with a prominent granulated tubercle one-third the distance back from the anterior fissure bordering each tooth.

Carpus.—Upper surface of carpus bounded by a band of coarse granules. Three high granulated tubercles on upper surface, one near the articulation with the manus and the other two arranged transversely about one-third the length of the carpus from the anterior end. The tubercle nearest the lower margin is on an elevated, granulated carina which extends nearly the length of the carpus. This closely resembles the carpus of *C. gracilis* except that the spines are lacking.

Manus.—Outer surface with six distinct and one less distinct longitudinal, beaded carinae. Upper one with two short spines, one at the upper-distal angle and one slightly anterior of the middle of the upper margin; also with a small pustulose elevation midway between the latter spine and the posterior end of the manus at about the point of downward curvature of the upper margin.

Second carina (from the upper margin of manus) with four prominent granulated tubercles equally spaced along its length; the largest, most proximal tubercle terminates the carina just above the articulation with the carpus. A prominent pustule is located one millimeter proximally from each of the two middle tubercles.

The third carina originates at the articulation with the dactylus and extends proximally only one-third the length of the manus. The fourth, fifth, sixth and seventh carinae are evenly beaded and distinct, with the sixth and seventh continuing onto the surface of the fixed finger.

Inner surface of manus smooth with faint, evenly distributed granulations.

Movable finger.—Incomplete, broken anteriorly just beyond the first cutting tooth which consists of two sub-equal, conical cusps that are joined in a common base. The more distal cusp is slightly elongate due to the presence of a subsidiary cusp on its distal side. The cutting teeth are darker brown and appear to be more dense than the skeletal material in which they are set. The outer and inner surfaces of the finger are uniformly granulated.

Fixed finger.—Incomplete, broken anteriorly just beyond the first cutting tooth which is a small conical structure of the same material as those on the fixed finger.

Holotype.—University of California Museum of Paleontology collections (UCMP no. 37,889). Incomplete carapace plus the carpus and manus (less distal part of fixed and movable fingers) of the left cheliped.

Type locality.—La Cima, California: USGS 7.5′ Quadrangle, scale 1:24,000, 1963; T. 22 S. R. 18 E., on boundary between secs. 16 and 17, about 1800 feet from south line of sections. Specimen collected on north side and near bottom of a branch of Arroyo Doblegado. UCMP invertebrate locality D 2506.

Discussion.—The marked overall similarity between *Cancer davidi* n.sp. and Recent individuals of *Cancer gracilis* Dana indicates that they are closely related. Such features as the shape of the carapace, character of fronto-orbital region, and the shape and position of antero-lateral teeth suggest that the fossil might be referred to the species *C. gracilis*. However two distinct and diagnostic differences are exhibited by the cheliped of *C. davidi* which preclude its referral to *C. gracilis*. These are: absence of spines on the upper-distal and inner angles of the carpus (pl. 10, fig. 4, 5, 8, 9, 10) and the presence of two small, conical cutting teeth on the movable finger of *C. davidi* in the same position as a single, large, bulbous tooth on the movable finger of *C. gracilis* (pl. 10, figs. 5, 8). The carpus of *C. davidi* clearly shows a well preserved beaded carina on the distal angle and demonstrates conclusively that the absence of spines is not due to erosion (pl. 10, fig. 4). The two small cutting teeth on the movable finger of *C. davidi* arise from a common base which occupies the same position as the large cutting tooth in *C. gracilis* and strongly suggests that they are homologous structures (pl. 10, figs. 5, 8).

In addition to the above-mentioned differences in the chelipeds, several less diagnostic differences may be noted. Comparison with a similar size specimen of *C. gracilis* (see table 1) shows that *C. davidi* has: 1) lower medial areolations with resultant lower convexity of the carapace, 2) carapace less expanded laterally, 3) anterolateral teeth less advanced and less pointed, 4) orbits at a lower level relative to antero-lateral

TABLE 1—Comparison of *Cancer davidi* n. sp. with *Cancer gracilis* Dana.

	Cancer davidi	*Cancer gracilis*
Carapace:		
Length	35 mm	35 mm
Width	47 mm (estimated)	51 mm
Height above central median tooth	4.7 mm	8.0 mm: variable, increasing with maturity.
Texture	Densely and uniformly granular.	Densely granular, coarser on elevated portions.
Fronto-orbital region:		
Width	17 mm	17 mm
Position of orbits	Lower margin of orbits at level of antero-lateral margins.	Lower margin of orbits above level of antero-lateral margins.
Antero-lateral teeth:	Sub-truncate, with a small, granulated tubercle $\frac{1}{3}$ distance from anterior fissure of each tooth. Only 6 preserved.	Low, project less than $\frac{1}{3}$ length of base, small spine at anterior angle. Typically 9 teeth.
Cheliped:		
Carpus	Lacks spines on upper and inner-distal angles, otherwise identical with that of *C. gracilis*. Height—9 mm. Length of upper margin—12.5 mm.	Two spines, one on upper-distal angle and one on inner angle. Height—9 mm. Length of upper margin—14 mm.
Manus	Similar to *C. gracilis* except upper two carinae more spinulose; upper margin curves downward more abruptly at proximal end. Height—12 mm. Length of upper margin—8 mm.	Outer surface with seven longitudinal, beaded carinae, the upper two spinulose. Height—13 mm. Length of upper margin—9.5 mm.
Movable finger	First cutting tooth divided into two small, sharp, conical cusps mounted on a common base.	First cutting tooth large, massive and elongate (2 mm long).

margins, 5) tubercles on the superior surface of manus more prominent, and 7) frontal region produced farther anteriorly beyond the outer angles of the orbits.

The total number of antero-lateral teeth on *C. davidi* cannot be determined because only six are preserved. The position and width of those six teeth are nearly identical with the corresponding six teeth in *C. gracilis*. *Cancer gracilis* is typified by nine antero-lateral teeth which are of unequal width and not spiny pointed.

Based primarily upon the above mentioned differences in the carpus and movable finger between the fossil and the most similar living species, *Cancer gracilis*, the fossil is assigned to a new species *Cancer davidi*. This differentiation from *C. gracilis* is further supported by the differences designated as 1) through 7) in the discussion above.

Cancer davidi has been compared with illustrations or the holotypes of all other known fossil species of *Cancer* from the West Coast and differs from all of them. Those species and their geologic ranges are listed below:

Cancer anthonyi Rathbun	Pleistocene–Recent
Cancer branneri Rathbun	Pleistocene–Recent
Cancer gracilis Dana	Pleistocene–Recent
Cancer jordani Rathbun	Pleistocene–Recent
Cancer magister Dana	Pleistocene–Recent
Cancer productus Randall	Pliocene–Recent
Cancer fissus Rathbun	Pliocene
Cancer granti Rathbun	Pliocene
Cancer urbanus Rathbun	Pliocene
Cancer bainbridgensis Rathbun	Oligocene
Cancer gabbi Rathbun	Eocene

Three of the species listed above are similar enough for possible confusion with *C. davidi*. *Cancer gracilis* is compared elsewhere in this paper. *Cancer fissus* differs by the unequal widths of the second, third and fourth antero-lateral teeth, the deeper indentations in the margin between the teeth, the lack of a granulated tubercle on each tooth. *Cancer granti* differs by the serrated, upturned antero-lateral teeth of which the second, third and fourth are unequal in width.

The close similarity between *Cancer davidi* and *Cancer gracilis* is interpreted by the writer as evidence of close genetic relationship between the two species. This similarity, in addition to

the stratigraphically lower occurrence of *C. davidi* than that of *C. gracilis*, whose oldest reported occurrence is Pleistocene (Rathbun, 1926), suggests that *C. davidi* is ancestral to *C. gracilis*. The differences between the two species can be attributed to evolutionary changes that have occurred during the three to five million year interval (Evernden, et al., 1964) from middle Pliocene to Pleistocene.

ECOLOGY AND PALEOECOLOGY

Cancer gracilis is known from Kasaan Bay, Prince of Wales Island, Alaska, to Playa Maria Bay, Lower California (Rathbun, 1931). However it is reported to be uncommon south of Point Conception, California (Menzies, 1951). Its bathymetric range is intertidal to 56 fathoms (Rathbun, 1930). *Cancer gracilis* in San Francisco Bay occurs most abundantly at depths less than 12 fathoms and in areas of predominantly muddy bottom (Schmitt, 1921). It is also reported to occur in other shallow-water bay localities having a sandy bottom, often occurring where *Cancer magister* is abundant (Menzies, 1951). The temperature range in San Francisco Bay within which *C. gracilis* lives is from 8.8°C to 15.9°C, and in water with a salinity not less than 21.3 ppm (Schmitt, 1921). The minimum average surface temperature (February) of the ocean in the San Francisco Bay is about 11°C to 12°C (Durham, 1950).

Cancer davidi was collected from a light-gray, medium-grained quartzose sandstone within the *Patinopecten* "zone" of the Etchegoin Formation. A paleoecological analysis of the faunal assemblage from this "zone" indicates that the minimum average surface temperature of the sea during the time of deposition (Middle Pliocene) was at least 13°C. This is based on the occurrence of *Anadara*, *Forreria*, *Kelletia* and *Trachycardium*, which live only in waters with minimum average surface temperature higher than 13°C (Keen, 1963). The reportedly rare occurrences of *Cancer gracilis* south of Point Conception, California, where the minimum average surface water temperature (February) is 13°C (Durham, 1950) indicates that the species prefers cooler temperatures than those which existed in the type locality of *Cancer davidi*. This could mean either than *C. davidi* preferred warmer water than *C. gracilis* or that the two species were adapted to similar temperature ranges and that the optimum temperature for *C. davidi* would have been farther north during the middle Pliocene.

The salinity of the environment must have been "normal" marine because all known living species of *Cancer* are exclusively marine (MacKay, 1943), as is the genus *Dendraster* of which the species *D. gibbsii* was found in association with *Cancer davidi*. All available records of *Dendraster* indicate that the genus lives only in water with salinity above 20 ppm (J. W. Durham, personal communication, 1967).

The faunal assemblage with *C. davidi* indicates that the depth of water was not greater than 75 fathoms because none of the genera mentioned above are found living below that depth (Keen, 1963). It is probable that the environment of deposition was between the littoral zone and 20 fathoms because these are the limits of occurrence of *Kelletia*, and all the genera mentioned are capable of ranging into the intertidal zone.

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