Some decapods (Crustacea; Brachyura and Stomatopoda) from the Pleistocene Beaumont Formation of Galveston, Texas

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Seven species of crab and an indeterminate stomatopod are recorded from the Pleistocene Beaumont Formation of Galveston Island, Texas. Of these, *Hepatus pauli* sp. nov., plus the extant *Persephona aquilonaris* and *Callinectes danae* are recorded as fossils for the first time, whereas the modern *Callinectes sapidus* and *Menippe mercinaria* had already been recorded from Miocene and/or Pleistocene strata in the Caribbean. A new description is given for *Herbstia milnei*, founded on better-preserved specimens, and the species is transferred to the genus *Libinia*. An unnamed species is tentatively placed in the extant Indo-Pacific genus *Dromidiopsis*; likewise unnamed, a fragmentary abdomen is assigned to the Stomatopoda.

Contents

Introduction

Pleistocene fossil material has been collected from the Beaumont clays of Galveston Island, Texas, and other shore-line exposures in the vicinity, at least since the 1920s, and a rich fauna is now known (Maury, 1920, 1922; Plummer, 1933; Lundelius, 1972; Wolf, 1991). The Beaumont Formation was named by Hayes & Kennedy (1903, p. 27) for exposures near Beaumont, Texas, and is characterised by plastic, poorly bedded clays and silt, interbedded lentils of sand, decaying organic matter, and calcareous and ferruginous nodules. The Beaumont Formation rests unconformably on the Lissie Formation and is Late Pleistocene in age (DuBar *et al.*, 1991; Rodriguez *et al.*, 2005) and represents the second of three Quaternary depositional systems in Texas. The first is an aggradational phase at 120,000 BP, the second a phase of a gradual fall in sea level dominated by deltaic systems (120,000-20,000 BP) and the final transgressive phase (20,000-4,000 BP) (Winkler, 1997). Herein, we describe a new collection of fossil decapod crustaceans (crabs and mantis shrimps) from the Beaumont Formation.

Perhaps the most enigmatic species in the present collection is a fragmentary carapace with affinities to extant members of *Dromidiopsis* Borradaile, 1900, a dromiid quite unlike any inhabiting the Caribbean at the present time. Regrettably, the specimen lacks critical details of the front and is therefore only tentatively referred to that genus. With the exception of the possible *Dromidiopsis*, the other five crab genera from the Beaumont Formation, viz. *Hepatus*, *Persephona*, *Libinia*, *Menippe* and *Callinectes*, have been well established throughout the Caribbean since the Middle Miocene. However, all are new to the fossil record of Texas. The earliest known members of *Hepatus* Latreille, 1802, are three species from the Middle Miocene. Of these, the most easterly in the Western Hemisphere is *H. nodosus* Collins & Morris, 1976, from the Brasso Formation of Trinidad, while the others, *H. lineatinus* Collins & Todd *in* Todd & Collins, 2005, and *H. biformis* Collins & Todd *in* Todd & Collins, 2005, are known from Panama and Costa Rica, respectively. The former ranges to the Plio/Pleistocene boundary, while the latter extends only to the Early Pliocene. Both are also known from the Pacific side of the isthmus. A fragmentary, unnamed, propodus was recorded by Collins & Portell (1998) from the Upper Pliocene Bowden shell bed of Jamaica. Also from Jamaica, *H. praecox* Collins, Donovan & Dixon, 1997, is from the Pleistocene Port Morant Formation. *Hepatus* sp. was recorded from the Lower to Middle Pleistocene Bermont Formation of Florida (Portell & Agnew, 2004), and of the extant *H. chiliensis* H. Milne Edwards, 1837, a limb fragment is on record from the Pleistocene of Panama (Rathbun, 1919a). *Hepatus pauli* sp. nov., described below, appears to be the youngest known fossil member of the genus.

The earliest fossil record for *Persephona* Leach, 1817 in the Caribbean is that of limb segments described as *P. praepunctata* Rathbun, 1919b, from the Upper Miocene Cercado Formation of the Dominican Republic, and subsequently recorded from the Gurabo Formation of the Dominican Republic by Collins *et al.* (2009, p. 65, pl. 3, figs. 3, 4), who figured an attributed 6th female abdominal somite and 4th/5th male somite.

Collins & Morris (1976) described a carapace from the Brasso Formation of Trinidad as *Persephona* cf. *punctata punctata* Rathbun, 1937. It is not surprising that subsequent limb segments should be recognised as *P. punctata punctata*; such were designated limb fragments from the Pliocene Bowden shell bed of Jamaica (Collins & Portell, 1998) and from the Pleistocene Port Morant Formation of that island by Collins *et al.* (1997). Two other Late Miocene species, *Persephona manningi* (Escudo do Veragas Formation) and *Persephona enigmata* (Cayo Aqua Formation) of Panama, were described by Collins & Todd *in* Todd & Collins (2005). Varela & Rojas-Consuega (2009, fig. 1B) illustrated, as *Persephona* sp., a limb segment from the Lower Miocene of Cuba. Previously, Portell & Agnew (2004) had recorded a carapace and chelipeds of *P. mediterranea* (Herbst, 1794) from the Caloosahatchee Formation and extended its range to the Bermont Formation of Florida.

Two well-preserved carapaces conforming with the previously described *Herbstia milnei* Collins & Donovan, 2012, from the Pleistocene of Jamaica, which was described from a poorly preserved internal cast, have all the characters typical of *Libinia* Leach, 1815 and the species is herewith transferred to that genus and a completely revised description is supplied. Strangely, the larger carapace (Pl. 2, fig. 6) is almost identical in size with the holotype. A propodus from the Caloosahatchee Formation of Florida was referred to as *Libinia* sp. and figured by Portell & Agnew (2004, pl. 6, fig. A).

Menippe mercenaria (Say, 1818) is represented in the present collection only by limb fragments, including propodi with characteristic stridulating ridges. The geographic fossil range of the genus is now also extended from the Plio/Pleistocene Caloosahatchee, Fort Thompson and Coffee Mill Hammock formations of Florida, in which well-preserved carapaces are said to be abundant (Portell & Schindler, 1991).

Again, mostly identified from limb segments, reports of extinct species of *Callinectes* are recorded from across the Caribbean. Although described only from a fragmentary propodus, the earliest known species, *C. jamaicensis*, was described by Withers (1924) from the Middle Eocene Yellow Limestone Group. Rathbun (1935, p. 107) recorded *Callinectes sapidus* Rathbun, 1896, from the Miocene of Florida and its presence was confirmed by Portell & Agnew (2004), who recorded chelae from the Chipola Formation of Florida. This particular species is represented by fragmentary carapaces in the present collection; as *Callinectes* aff. *sapidus* it was recorded by Collins & Portell (1998) from the Pliocene Bowden shell bed of Jamaica. *Callinectes declivis* Rathbun, 1919a, was described from the Pliocene Rio Bananos Formation of Panama; Collins & Todd *in* Todd & Collins (2005, p. 61) minimally increased its range to the Plio/Pleistocene boundary of Costa Rica. A further Pleistocene species, tentatively identified as *Callinectes* sp. aff. *C. toxodes* Ordway, 1863, was recorded by Collins *et al.* (1997, p. 59) from the Port Morant Formation of Jamaica.

So far, fossil records for mantis shrimps (stomatopods) in the Caribbean have been founded on a fragment of the extant species *Chloridella empusa* (Say, 1818) from the Pleistocene of Florida, and an unnamed distal end of a raptorial claw from the Pleistocene Bowden Formation of Jamaica (Collins & Portell, 1998). Thus, it would appear that the fragment of articulated abdominal somites from the Beaumont Formation is only the third evidence of fossil mantis shrimps in the area.

History, geology and environmental setting of the site

The Central American isthmus has been closed for at least 3.1 million years (Saito, 1976; Kerwin, 1982), but recent work has shown the closure may have occurred even earlier in the Pliocene (Bacon *et al.*, 2012), at about 5 Ma. This must have allowed the arthropod faunas on either side of the isthmus to diverge into separate species by the time the strata of the Beaumont Formation were laid down. The arthropods, the subject of the present paper, were collected from a beach in Seawolf Park (GPS co-ordinates 29° 20′ 6.13′′ N, 94° 46′ 46.2′′ W) on Pelican Island, an island just north of Galveston Island and now part of the city of Galveston. The location is no longer collectable as during the 1980s seashore defenses, consisting of large boulders, were deposited on the beach. In 1816 the island was only a narrow salt marsh and its present extent is the result of fill obtained from dredging the Houston Ship Channel. The Galveston estuary, which encompasses Galveston Island, Pelican Island and the western part of Bolivar Peninsula, are part of a barrier island complex composed of Holocene sediments, while most of the mainland surrounding the estuary is Beaumont Formation (Rodriguez *et al.*, 2005). Much of the dredged material making up Pelican Island as well as the Texas City Dyke, an artificial breakwater north of the island, is most likely composed of Beaumont Formation. Investigation by the Texas Water Development Board (Young *et al.*, 2011) shows Beaumont thickness in excess of 122 m (400 ft) in the Galveston area.

In addition to arthropod remains, indurated nodules composed primarily of shells and cemented by gypsum are also fairly common. Occasionally a nodule will also contain a shark tooth or arthropod chela, and sometimes the larger shells show encrusting corals and bryozoans. Very little post-depositional wear is evident on the shells or arthropods, as the material is either composed of complete specimens or, if broken, the breakage areas are sharp. This indicates material may have been swept shorewards from a more open marine area by a violent storm, followed by quiet deposition. The occurrence of gypsum is often indicative of deposition in a coastal, tidal flat environment forming under high evaporative conditions. The shell taxa are representative of those in modern neritic to littoral nearshore Gulf faunas, but with a higher proportion of mud-loving specimens than found in the area today. The lack of solitary corals indicates the source is unlikely to have been too far offshore. The source of the arthropods and shells indicates most likely dredged material as Pelican Island is located above the Trinity River incised valley where the Pleistocene surface should be quite deep (Rodriguez *et al.*, 2005), although a localised Pleistocene high is possible (J.B. Anderson, pers. comm., 2013). This location, which apparently was not known to the academic community, appears almost unique in its rich Pleistocene fauna. With the exception of one crab discovered from the Beaumont at McFaddin Beach on the upper Texas coast (G. Wolf, pers. comm., 2013), no other Pleistocene crabs are known from Texas.

Mr George Wolf (Pasadena, Texas) for kindly loaning specimens from his personal collection (= Wolf Collection in the present paper). Specimens prefixed with NHM IC were collected by the second author and are deposited at the Natural History Museum, London.

Systematic palaeontology

Section Podotremata Guinot, 1977
Superfamily Dromioidea De Haan, 1833
Family ?Dromiidae De Haan, 1835
Genus ?*Dromidiopsis* Borradaile, 1900

Type species – *Dromia australensis* Haswell, 1882, by the subsequent designation of McLay (1993).

?*Dromidiopsis* sp.
Pl. 1, fig. 1.

Material – A decorticated, fragmentary carapace, NHM IC 768 (CLG 16790B).

Description – The carapace is almost circular in outline, moderately arched transversely and becoming flatter anteriorly in longitudinal section. There is just the suggestion of a median ridge. Circular orbital peduncles occupy the lower, inner corner of circular orbital cavities. The front is not preserved; the lateral part of the broad upper orbital margin is weakly sinuous and bounded by a fine ridge which continues onto the antero-gastric margin as far as an incipient branchial notch about mid-carapace length, where there is a slight protuberance bounded by a fine groove, leading onto the dorsal surface. The straighter posterolateral margin ends in a relatively sharp posterior angle. The posterior margin is probably as wide as the orbitofrontal margin. There is a short, straight cardiac furrow opposite the branchial notch. Anteriorly tumid, incurved sides extend to a broad, forwardly curved furrow extending from the branchial notch. The pterygostomian process appears to have been tumid and a strong ridge and groove bounds the buccal margin.

Remarks – The Texas carapace has much in common with species assigned to *Dromidiopsis* by McLay (1993, pp. 137-143, figs. 15c-f, 16c). It has a vague ridge and lateral cardiac furrows similar to those seen in *D. lethrinusae* (Takeda & Kurata, 1976) (see McLay, 1993, fig. 15e). Furthermore, the three anterolateral marginal teeth peculiar to species of *Dromidiopsis* are, in *D. lethrinusae*, 'quite variable to the extent of being absent' (McLay, 1993, p. 138), which may be related to the absence of teeth in the earlier *Dromidiopsis.* Not previously known as a fossil, the present range of the genus is Indo-Pacific.

Section Eubrachyura de Saint Laurent, 1980
Subsection Heterotremata Guinot, 1977
Superfamily Aethroidea Dana, 1851
Family Aethridae Dana, 1851
Genus *Hepatus* Latreille, 1802

Type species – Calappa angustata Fabricius, 1798, by monotypy.

Remarks – As preserved, while retaining the principal characters, the dorsal surface of the new species trends from nodose to almost smooth; to designate the extremes as distinct species would necessitate leaving intermediate forms in limbo. Of *H. lineatus*, Rathbun (1935, p. 235) noted, 'Carapace crowded with transverse lines or almost smooth'.

Hepatus pauli sp. nov.
Pl. 1, figs. 2-12.

Etymology – In recognition of Pál Müller (Budapest, Hungary), who has made significant contributions to our knowledge of fossil crabs.

Material – The holotype is a male carapace, NHM IC 769 (Pl. 1, figs. 2, 3, 5); paratypes are seven carapaces, NHM IC 770-776 (CLG 16790C); an additional male carapace in the Wolf Collection.

Diagnosis – Carapace nodose with prominent lines of granules or nearly smooth; tridenticulate lateral spines extending from behind orbits; front slightly produced; 4th male abdominal somite tuberculate.

Description – Carapace length about three quarters of the width at the lateral angles two-thirds distant from the front, strongly arched longitudinally and moderately so transversely, becoming thin towards the margins. Anterolateral margins are lined with 12-13 tridentate spines gradually increasing in size from behind the orbit to the lateral angle. Even-sized granules line the concave posterolateral margins and continue round the posterior margin which is about half the width of the orbitofrontal margin. The orbitofrontal margin occupies about half of the carapace width and is raised above the anterolateral margin. Taking up about the median two-fifths, the front is slightly in advance of the curvature of the anterolateral margins; it is broadly indented, lined with a median pair of granules with three or four smaller ones leading to rounded inner orbital angles. Small, ovate orbits are forwardly directed and the orbital peduncles are slightly upturned. Both the upper and lower orbital margins are granulated, as are the margins of the antorbital cavity. The lower angle of the antorbital cavity is not visible from above. The regions and lobes grade from nodose to almost smooth. Eight transverse rows of granules are arranged; one on each protogastric lobe, longer, stronger ones on each epibranchial lobe are separated by one on the mesogastric and one on the cardiac region separates those on the metabranchial lobes. The rows on the epibranchial lobes remain obvious throughout the transitions. The cardiac furrow is straight across the midline, two-thirds distant from the front, turning abruptly forwards and outwards round the mesogastric lobe; it curves round the protogastric lobes and becomes obsolete before reaching the margin. The subovate cardiac lobe is conjoined with the urogastric lobe. Pits of several diameters crowd the dorsal surface. The fourth somite of the male abdomen has two tubercles preceding a row of pits, the fifth and sixth somites have two rows of pits. All somites are coarsely granulated.

The chelipeds are more or less homochelate. The distal height of the right propodus is a little less than the length. Four forwardly facing triangular spines, the third the largest, line the upper margin. The outer surface is lined with five rows of tubercles; the uppermost row has four median tubercles between two widely spaced ones, extending from the base of the dactylus; the second row has a downcurved line of nine tubercles: the third row consists of coarser tubercles converging into a line of three; the fourth and fifth rows extend from the fixed finger, on the fourth the tubercles are united and the fifth row is a thin ridge. Granules line the basal margin. The fixed finger is deflexed, about one third the length of the manus and half the distal height; punctae line the space between the extensions of the fourth and fifth manus ridges which unite at the tip; fine granules line the occludent margin.

Remarks – *Hepatus pauli* sp. nov. has affinities to two extant species, *H. princeps* (Herbst, 1794) from the Caribbean and *H. kossmanni* Neumann, 1878 from the eastern Pacific. In common with *H. princeps*, *H. pauli* has an advanced front, a similar number of dorsal linear granules and tridentate marginal spines, but unlike *H. princeps* the anterolateral margins commence at the outer orbital angle. In that respect, *H. pauli* is similar to *H. kossmanni*, but in that species the front lies within the arc of the anterolateral margins. Tubercles occur on the fourth abdominal somite of *H, kossmanni.* Neither species has a granulate front.

Hepatus lineatinus Collins & Todd *in* Todd & Collins, 2005, ranging from the Middle Miocene to the Plio/Pleistocene boundary, from deposits on both sides of the isthmus, was compared with extant *H. lineatus* Rathbun, 1898, a Caribbean species, while *H. biformis* Collins & Todd *in* Todd & Collins, 2005, from the Middle Miocene to Early Pliocene, of the Caribbean side, was considered to approach *H. kossmanni* in having finely granulated margins. Both species are readily distinguished from *H. pauli* sp. nov. The identity of dactyli belonging to *H. lineatus* from two Pleistocene localities in California was confirmed by Rathbun (1926, p. 84) on the presence of stridulating ridges on the inner surface, not visible on the present specimens. Although damaged, the (apparently) lobate anterolateral margin distinguishes *H. nodosus* Collins & Morris, 1976 (Miocene of Trinidad) and *H. guraboensis* Collins, Portell & Donovan, 2009 (Upper Miocene/ Lower Pliocene of the Dominican Republic), likened to *H. lineatus*, but differs from *H. pauli* in having a greater number of granular, rather than tridentate, spines.

Superfamily Eriphioidea MacLeay, 1838
Family Menippidae Ortmann, 1893
Genus *Menippe* De Haan, 1833

Type species – *Cancer rumphii* Fabricius, 1798, by the subsequent designation of Glaessner (1929).

Menippe mercenaria (Say, 1818)
Pl. 2, figs. 1-3.

Material – Three propodi, an associated fixed finger and dactylus, NHM IC 777-779 (CLG 17925).

Remarks – Stridulating ridges, peculiar to this species are clearly visible under a lens. The present record extends both the geological and stratigraphical ranges of the species.

Superfamily Leucosioidea Samouelle, 1819
Family Leucosiidae Samouelle, 1819
Subfamily Ebaliinae Stimpson, 1871
Genus *Persephona* Leach, 1817

Type species – *Persephona latreillei* Leach, 1817, by the subsequent designation of Rathbun (1922).

Persephona aquilonaris Rathbun, 1933
Pl. 2, figs. 4, 5.

1933 *Persephona punctata aquilonaris* Rathbun, p. 184.
1937 *Persephona punctata aquilonaris* Rathbun; Rathbun, p. 154, pl. 42, figs. 6, 7.
1964 *Persephona punctata aquilonaris* Rathbun; Leary, p. 47.
2008 *Persephona aquilonaris* Rathbun; Ng, Guinot & Davie, p. 92.

Material – A single carapace in the private collection of G. Wolf (Pl. 2, figs 4, 5).

Remarks – Originally described by Rathbun (1933) as a subspecies of *Persephona punctata*, this form was recognised as a distinct species by Ng *et al.* (2008, p. 92). The principal differences of the fossil material are: the carapace of *P. aquilonaris* is more convex, the granulation is coarser, plainly visible to the naked eye, the front is narrower and more produced, the posterior margin is narrower and the three spines more slender and the subhepatic angle is tipped with a granule (compare Rathbun, 1937). As far as preserved, with the exception of the posterior spines, which are tuberculate, the Beaumont carapace falls within the range of variation of the Recent species. The other Recent species, *P. crinitus* Rathbun, 1931, common in Texas, is clearly differentiated by its truncated front, and much reduced posterior spines.

Superfamily Majoidea Samouelle, 1819
Family Epialtidae MacLeay, 1838
Subfamily Pisinae Dana, 1851
Genus *Libinia* Leach, 1815

Type species – *Libinia emarginata* Leach, 1815, by original designation.

Libinia milnei (Collins & Donovan, 2012)
Pl. 2, figs. 6, 7.

2012 *Herbstia milnei* Collins & Donovan, p. 138, fig. 2A.

Material – A carapace, NHM IC 780 (CLG 17976) and an additional one in the Wolf Collection.

Revised description – Carapace subpyriform in outline; from base of rostrum, about one sixth longer than wide immediately before a posterolateral tubercle; transversely moderately convex, in longitudinal section, the front is flat before two arcs, the anterior one slightly higher. A stout tubercle occurs midway along the posterolateral margins. The front takes up almost half of the orbitofrontal margin which is about half the carapace width. The rectangular rostrum, terminating in a shallow U-shaped notch, has thickened margins extending a short distance beyond the upper orbital margin from which they are separated by a deep notch. Medially the upper orbircular margins are deeply indented, the thickened inner orbital spine is sharply triangular, the inner spine less so. An equally deep sinus separates ridges forming the suborbital margins; the inner orbital spines are bluntly triangular and weakly granulated upper margins continue to an infilled sinus before a broadly triangular outer orbital spine. An infraorbital spine projects beyond the inner orbital spine. The cervical furrow runs straight and deep across the midline, turns sharply forwards before curving round the hepatic region to a deep, U-shaped marginal notch. There is a more or less straight line of four blunt tubercles on each protogastric lobe and median tubercles occur on the mesogastric, short, rectangular urogastric lobes, the large, subtriangular cardiac region and barely differentiated rectangular intestinal lobe. A short posterior tubercle does not overhang the posterior margin. The metabranchial lobes form a ridge either of the urocardiac junction. The dorsal surface lacks secondary ornament.

Remarks – The holotype, from the Early Pleistocene Manchioneal Formation of Jamaica, was founded on a poorly preserved internal cast of a carapace, with which the present carapace, of similar size, does not only agree in all basic details, but it also possesses sufficient defining characters to necessitate a revised description. Apart from a similar carapace outline and advanced rostrum, *L. milnei* has little in common with *L. emarginata* (Pl. 2, fig. 9), a common Texas species, immediately distinguished by having well-developed marginal spines and a dense secondary ornament. *Libinia emarginata* is known from a dactylus from the Pleistocene of North Carolina (Rathbun, 1935, p. 121). Likewise known by a dactylus, from the Pleistocene of Virginia (Rathbun, 1935, p. 119), the Recent species *Libinia dubia* H. Milne Edwards, 1834, also common to Texas, has a carapace which lacks secondary ornament and varies in outline from subpyriform to circular as growth advances (Rathbun, 1925, pl. 114, fig. 1905); it has only six median tubercles surrounded by a more or less similar distribution of dorsal surface tubercles. Rathbun (1925, p. 26), also recorded dactyli of *Libinia setosa* Lockington, 1877, a Recent Pacific species, from the Pleistocene of California and it is to this form that *L. milnei* would appear to have a greater affinity for, although the carapace of the former has a more circular, spinose outline and there is a more or less similar distribution of tubercles on an otherwise smooth dorsal surface.

Superfamily Portunoidea Rafinesque, 1915
Family Portunidae Rafinesque, 1815
Subfamily Portuninae Rafinesque, 1815
Genus *Callinectes* Stimpson, 1862

Type species – *Callinectes sapidus* Rathbun, 1896 [ICZN Opinion 712].

Callinectes danae Smith, 1869
Pl. 3, figs. 1-10; Pl. 4, figs. 1, 2.

Material – Twenty-seven carapaces, NHM IC 1169-1195 and NHM IC 781-786 (Pl. 3, figs. 1-10), plus an attributed chela, NHM IC 787 (CLG 16790) (Pl. 4, figs. 1, 2).

Remarks – As far as preservation allows this to be stated, the carapaces agree in all respects with Rathbun's description and figures (1930, p. 118, text-figs. 15d, 16d; pl. 51) particularly in the form of the front and juxtaposition of the male telson to the sternites. Although superficially similar, the extant *Callinectes rathbunae* Contreras, 1930, also common to Texas, differs from *C. danae* in having more even frontal spines separated by a wider median sulcus and slender, isosceles triangular anterolateral spines, whereas those of *C. danae* are equi-triangular with curved posterior margins. The form of the front, together with the prominent anterior transverse granular ridge, readily distinguishes *C. danae* from *Callinectes bocourti* A. Milne-Edwards, 1879. Carinae on chelae attributed to this species are fine and sharply ridged. Two carapaces (Pl. 3, figs. 5, 6) have an epifauna which on one (Pl. 3, fig. 6) comprises several solitary corals, a dorsal and ventral growth of a bryozoan, which, on the ventral surface, partially covers two tubes of a serpulid worm. On the other carapace (Pl. 3, fig. 5) there is the basis of a balanid cirripede. The origin of the epifauna, whether modern or fossil, is not definitely known, although a fossil origin might be considered more likely, as, with the exception of the balanid, the remaining epifaunal species are indicative of an open marine environment rather than the occasionally brackish/lagoonal character of Galveston Bay.

Interestingly, with but one exception, all specimens are male corpses, ranging in carapace width between *c.* 25 and *c.* 55 mm, which contrasts sharply with the size, *c.* 175 mm, of Recent specimens (Rathbun, 1930, p. 138). The exception is a slightly smaller (*c.* 20 mm) carapace, lacking undersides, which could possibly be a moult.

Callinectes sapidus Rathbun, 1896

Pl. 4, figs. 4-7.

Material – Three fragmentary carapaces, NHM IC 788, 789 (Pl. 4, figs. 4, 5) and NHM IC 1195; two left attributed chelae, NHM IC 1196-1197, and a right attributed chela, NHM IC 790 (Pl. 4, figs. 6, 7) (CLG 16790E).

Remarks – As far as preservation allows comparison, the carapaces conform favourably with the Recent specimen figured in Portell & Agnew (2004, pl. 4b, c). The blunt, subtriangular frontal spines immediately distinguish it from the tuberculated front of *C. danae*. The chelae have granulated ridges as remarked by Rathbun (1923, p. 104). With a width of approximately 56 mm, the one measurable preserved carapace is about half the size of Recent individuals recorded by Rathbun (1930, p. 135).

Class Stomatapoda Latreille, 1817

Stomatopoda gen. et sp. indet.

Pl. 4, fig. 3.

Material – NHM IC 791, a fragmentary abdomen (Pl. 4, fig. 3 (CLG 16790E)).

Remarks – Although only fragments of abdominal somites (III-VI) are preserved, the longitudinal ridges peculiar to stomatopod abdomina are clearly discernible. The median carina is broad and continuous; also continuous, but less obvious on somite V, the submedian carina tapers from a median tubercle on each somite; the lateral carina is thinner, sharper. Matrix obscures the marginal carina. Pits of several diameters crowd the dorsal surface.

The Recent *Chloridela empusa* (Say, 1818), common in Texas waters, differs from the Beaumont Formation specimen in having smooth, regularly aligned carinae.

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Plate 1

Fig. 1. ?*Dromidiopsis* sp. NHM 768, dorsal view of partial carapace.

Figs. 2-12. *Hepatus pauli* sp. nov. , dorsal views of carapaces to show variation of ornament unless stated otherwise.
Figs. 2, 3, 5. Holotype, NHM IC 769, dorsal , frontal and ventral views of male.
Fig. 4. NHM IC 770.
Fig. 7. NHM IC 771.
Fig. 8. NHM IC 772.
Fig. 10. NHM IC 773.
Fig. 11. NHM IC 774.
Fig. 12. NHM IC 775.
Figs. 6, 9. Wolf Collection, dorsal and ventral views of a male.

Scale bars represent 10 mm. Specimens uncoated.


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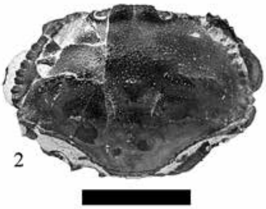
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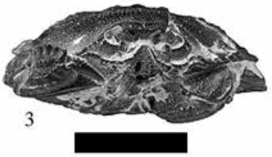
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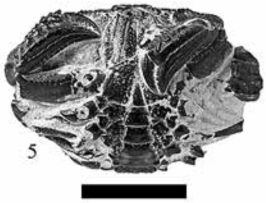
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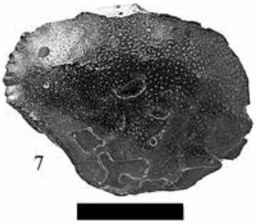
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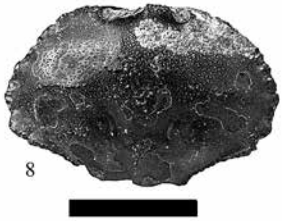
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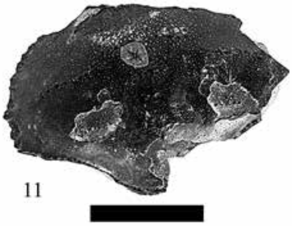
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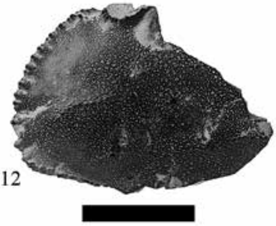
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Plate 2

Figs. 1-3. *Menippe mercenaria* Say, 1818.
Fig. 1. NHM IC 777, outer surface of right dactylus.
Fig. 2. NHM IC 778, outer surface of right chela.
Fig. 3. NHM IC 779, outer surface of right dactylus and fixed finger.

Figs. 4-5. *Persephona aquilonaris* Rathbun, 1933, Wolf Collection, dorsal and ventral views of a male.

Figs. 6-8. *Libinia milnei* (Collins & Donovan, 2012).
Figs. 6, 7. NHM IC 780, dorsal and frontal views.
Fig. 8. Wolf Collection; dorsal view of carapace.

Fig. 9. *Libinia emarginata* Leach, 1851, Recent carapace for comparison, Galvaston, Texas (J.S.H. Collins Colln.).

Scale bars represent 10 mm. Specimens uncoated.


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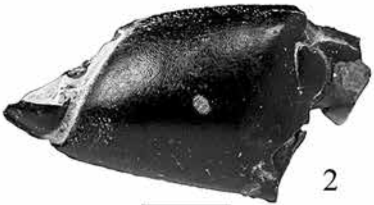
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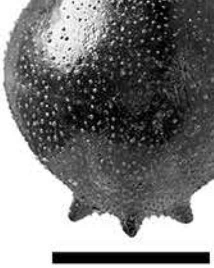
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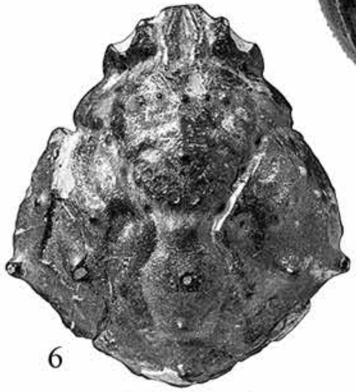
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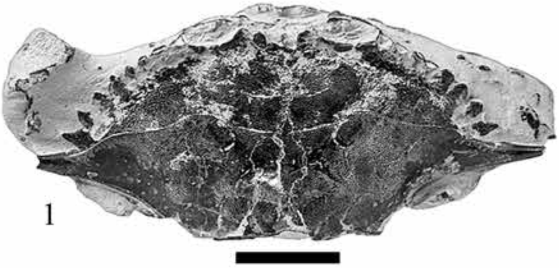
Plate 3

Figs. 1-10. *Callinectes danae* Smith, 1869.
Figs. 1, 2. NHM IC 781, dorsal and ventral views.
Fig. 3. NHM IC 782, dorsal surface with basis of cirripede.
Fig. 4. NHM IC 783, carapace with solitary corals and bryozoan.
Figs. 5-6. NHM IC 784, dorsal and ventral views.
Figs. 7,10. NHM IC 785,dorsal and ventral views.
Figs. 8, 9. NHM IC 786, ventral and dorsal views.

Scale bars represent 10 mm. Specimens uncoated.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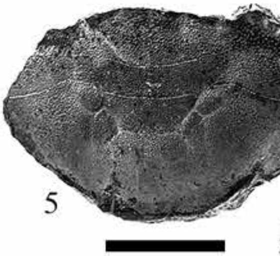
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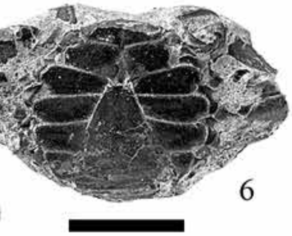
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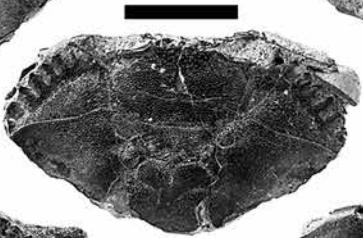
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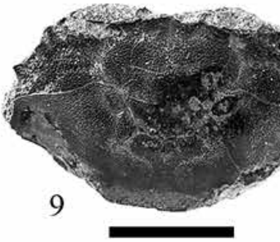
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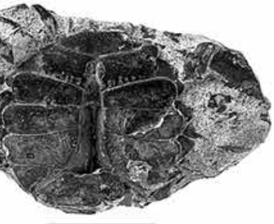
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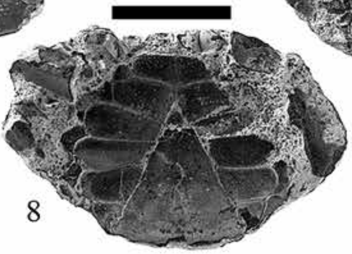
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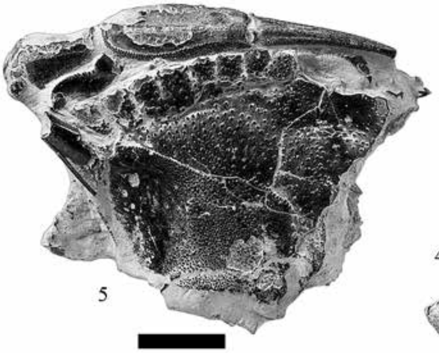
Plate 4

Figs. 1, 2. *Callinectes danae* Smith, 1869, NHM IC 787, inner and outer views of right propodus.

Fig. 3. Stomatopod gen. et sp. indet. NHM IC 791, partial abdomen.

Figs. 4-7. *Callinectes sapidus* Rathbun, 1895.
Fig. 4. NHM IC 788, partial carapace and left cheliped.
Fig. 5. NHM IC 789, partial carapace.
Figs 6, 7. NHM IC 790, inner and outer surface of right chela.

Scale bars represent 10 mm. Specimens uncoated.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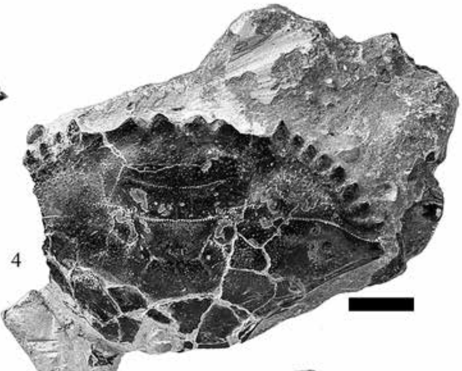
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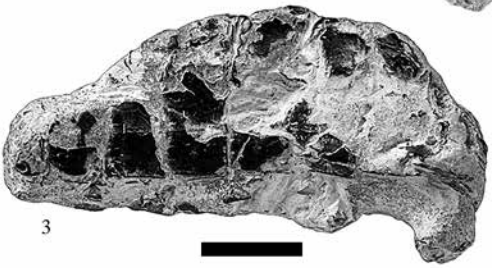
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