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FOSSIL CRABS FROM GUAM

BY

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MUSEUM OF PALEONTOLOGY  
UNIVERSITY OF MICHIGAN  
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# CONTRIBUTIONS FROM THE MUSEUM OF PALEONTOLOGY

Director: LEWIS B. KELLUM

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## FOSSIL CRABS FROM GUAM

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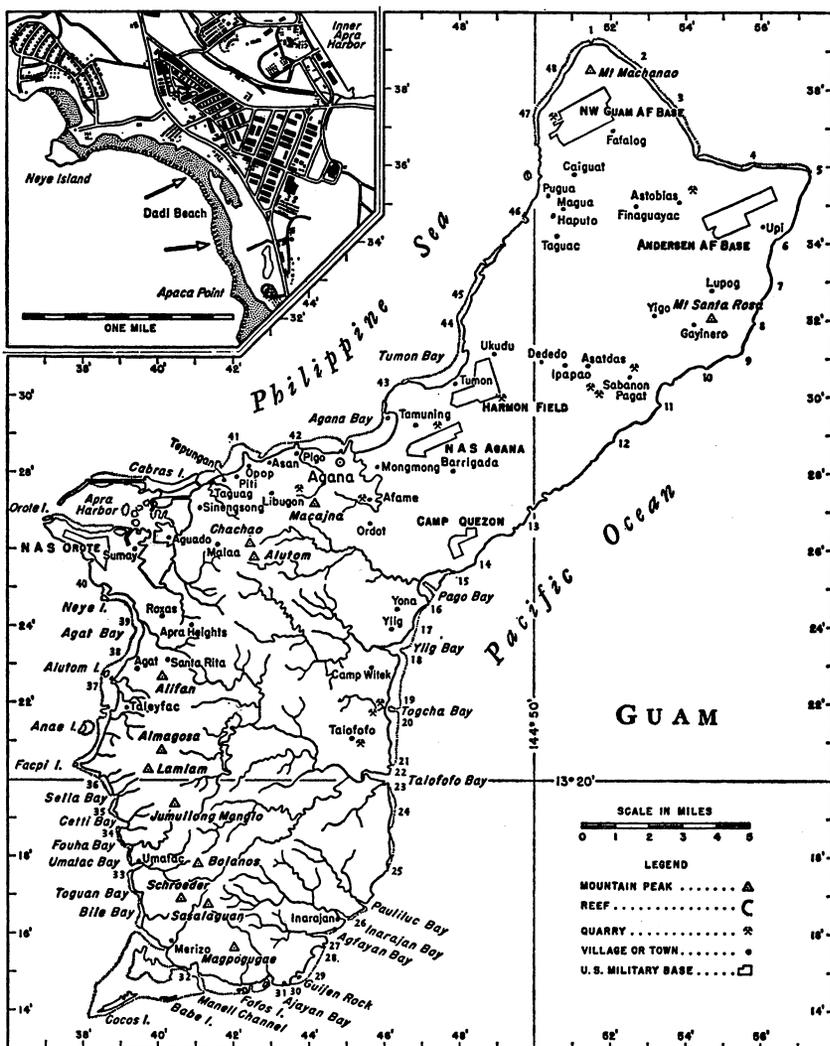
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## INTRODUCTION

OF THE fossil crabs from the island of Guam discussed here, one belongs in the portunid genus *Podophthalmus*, two are classified as species of the ocypodid genus *Macrophthalmus*, and a fourth establishes a new genus and species of the family Goneplacidae. The two forms previously known as fossils, *Macrophthalmus latreillei* and *Podophthalmus vigil*, are species still living in the Pacific region. A study of their habits provides supporting evidence with regard to the paleoecology of the fossil crabs. Their age cannot be determined precisely at this time. The crabs came from rocks dredged from the bottom of Apra Harbor and the stratigraphic sequence there is not known. Both occurrence and zoological affinities indicate, however, that they lived at some time between the late Miocene and Recent, probably in the Pleistocene.

Although incomplete the specimens are remarkably well preserved. When collected, each crab was still partly embedded in a very hard tuffaceous limestone. Particularly where protected by matrix, the surfaces of most retain even the minute ornamental structures. Preliminary cleaning was done with an electric vibro-tool and final cleaning with small steel needles and chisels. The preservation is sufficiently good that identification of species is regarded as certain.



MAP 1. Guam, based on AMS Series W743 map prepared by several organizations of the United States military services in 1955. Inset is an enlargement of the base of the Orote Peninsula on the western side of the island; the two arrows mark the limits of the area along Dadi Beach in which fossil crabs were picked up. On the map, small numbers along the coast refer to the following named Points: 1, Ritidian; 2, Pajon; 3, Mergagan; 4, Tagua; 5, Pati; 6, Lafac; 7, Anao; 8, Mati; 9, Catalina; 10, Lujuna; 11, Pagat; 12, Campanaya; 13, Fadian; 14, Iates; 15, Taogam; 16, Pago; 17 Tagachan; 18, Ylig; 19, Togcha; 20, Tartuguan; 21, Asanite; 22, Adjoulan; 23, Gayloup; 24, Asiga; 25, Jalaigai; 26, Guaifan; 27, Agtayyan; 28, Acho; 29, Donggua; 30, Aga;

The limestone around a few of the fossils is dark reddish brown and contains so much tuffaceous sand that it strongly resembles a weathered tuff. When such a piece is treated with hydrochloric acid, the calcium carbonate cement dissolves and leaves about half of the rock as insoluble particles. The matrix around most specimens, however, is light yellowish gray to light grayish tan and contains a large percentage of tuffaceous clay and silt. In each case, the rock appears to be a water-laid tuffaceous sand, silt, and clay cemented with calcium carbonate into a compact limestone.

I am deeply grateful to Dr. C. T. Flotte, Assistant Professor in Surgery at the University of Michigan, for the first collection of crabs and for information on their occurrence. I also thank Dr. Joshua I. Tracey, Jr., of the United States Geological Survey, for information concerning the geology of Guam and for efforts in securing additional specimens. Porter Ward, also of the U. S. Geological Survey, kindly made the second collection of crabs on Guam. Dr. Rikizo Imaizumi of Tohoku University, Sendai, Japan, and Dr. Tsune Sakai of Yokohama National University, Kamakura, Japan, offered many helpful suggestions on classification. Dr. George M. Ehlers, Dr. Chester A. Arnold, and Dr. Lewis B. Kellum read the manuscript critically.

Specimens are catalogued and deposited in the Museum of Paleontology of the University of Michigan (UMMP) and in the United States National Museum (USNM).

#### DISCOVERY AND OCCURRENCE OF THE FOSSILS

Immediately after a typhoon in 1948, Dr. Flotte, then a medical officer in the United States Navy, picked up about fifty fossil crabs from Dadi beach, south of the Orote Peninsula on Guam (see Map 1). The specimens, which were still partly embedded in hard limestone containing much tuffaceous material, were presented by Dr. Flotte to the Museum of Paleontology of the University of Michigan in 1952. He was of the opinion that they had been cast up from offshore banks or had been uncovered in place by wave action during the typhoon.

In 1956, after preliminary work on classification of the fossil crabs I consulted Dr. Tracey, who was working on a report on the geology of

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31, Matilog; 32, Manell; 33, Machadgan; 34, Fouha; 35, Pinay; 36, Chii; 37, Bangi; 38, Gaan; 39, Apaca; 40, Tantapalo; 41, Asan; 42, Adelup; 43, Saupon; 44, Bija; 45, Amantes; 46, Haputo; 47, Uruno; and 48, Achae. Older maps of Guam show villages of Jinapson Beach and Tarague between Ritidian Point and Pati Point, and Falcona Anchorage between Uruno Point and Amantes Point. Bolanos was formerly Mount Sasalaguan; Alifan was Alamagosa; Alutom, Mount Tenjo; and Apra Harbor, Port San Louis d'Apra.

Guam. He was interested in their occurrence and, particularly, in their paleoecology. He suggested (letter dated March 7, 1956), "If you know the exact beach or locality from which these were collected, it might be possible to find out considerably more about the crabs. A Survey geologist is on the island now . . . and if I knew the specific site it would be easy for him to try at least to dope out the occurrence. Any further collections of crustacea will be sent to you . . ." On May 1, 1956, Dr. Flotte came to the Museum of Paleontology and located on a recent map of Guam the site where he found the fossils. He also wrote out his recollections on the topography and nearby naval installations. This information I forwarded to Dr. Tracey, as a result of which he wrote July 14, 1956:

I have just received a letter from Porter Ward on Guam, who went out to the locality indicated on the map you returned to me. He collected "several pounds" of material, which he will send on to me at the museum, and which I shall send on to you as soon as we have looked over the matrix for possible clues as to formation or age.

HOWEVER: Ward says definitely that the beach and bank from which the material came was fill, as I had suspected, dredged from Apra Harbor. The beach was used after the war as a landing beach for landing craft coming in over the reef, and a large pad of fill was spread out over the reef. This pad shows in some of the earlier pictures of the area. The possibility of tying this dredged material in with the mapped formations now exposed is of course remote.

Of the crabs collected by Ward, some arrived at the Museum of Paleontology in November, 1956, and others in March, 1957. They include three of the same species as those collected eight years previously by Dr. Flotte, but for the most part they are not as well preserved.

The outcrop of the crab-bearing beds cannot be located exactly. It lies somewhere at the bottom of Apra Harbor, probably in the inner harbor. The depth is not known; the rocks may have been from relatively shallow water or from the deepest dredging, about 50 feet below water level. The time of dredging was between 1941, the year the Japanese captured Guam in World War II, and 1948, the year the crabs were picked up on the beach by Dr. Flotte. Guam fell to the Japanese on December 12, 1941, and was recaptured by the American armed forces on July 21, 1944. During their occupation, the Japanese are said to have deepened some parts of the harbor. Dr. Tracey wrote (January 20, 1958):

The main enlargements came, however, in the years from 1946 to 1950. I have aerial color photographs of 1946 showing much of the present Inner Harbor containing large reefs where now there is deep water. Photographs taken in 1948 show that much of the enlarging had been accomplished, although I think a great deal of dredging continued to 1950. At any rate, the program of enlarging and deepening the inner harbor was in full sway in 1948, and at that time the pad of fill had already been laid down on the reef near Agat.

One can only say with certainty that the rocks containing the fossil crabs crop out in Apra Harbor at a depth of 50 feet or less, and were dredged up between 1941 and 1948, but it seems likely that most of them were not exposed until the typhoon in 1948 washed and abraded the limestone in which they were encased.

The matrix around the crabs collected by Dr. Flotte is very hard and extremely difficult to remove without damage to the fossils; that around those obtained by Ward is considerably leached and more easily chipped off. Weathering has also affected all the specimens, but those from the earlier collection are the much better preserved.

Nearly all are partly hollow, partly filled with very light gray to dark yellowish-gray calcium carbonate. The holotype of the new species of *Carcinoplacoides* is completely empty, so that one can see the interior through either of the eye sockets; its shell material is hard but thin and translucent.

#### GEOLOGY OF GUAM

Guam, the setting in which the crabs occur, is the largest of the Mariana Islands, about 225 square miles including reefs and lagoons. It lies in the southern part of the Islands near latitude 13° N. and longitude 145° E. (Maps 1 and 2). Although the island has been known to the western world since its discovery by Magellan in 1521, its geology has been more or less ignored. Published references are brief; many mention little more than that Guam is an example of a volcanic island with coral reefs. A few years ago the U. S. Geological Survey started geologic mapping of the island and reports are in preparation. Tectonically, Guam is related to other islands in the Marianas, and these islands, in turn, are related to other chains in the western Pacific region.

*Island arcs.*—As more and more islands were charted in the western half of the Pacific Ocean, early navigators recognized that they were not scattered at random, but were distributed in linear groups, often called "chains." Later, after numerous soundings had been made, the islands were shown on bathymetric charts as the peaks of submarine mountain ranges. Each range is arcuate (Map 2) and connected at each end to one or more other arcs, a pattern referred to by many geologists (Hobbs, 1923, 1953; Koto, 1931; Lawson, 1932; and Willis, 1940).

In addition to their bow shape, the island arcs have for the most part similar features. All have eruptive rocks of about the same composition; most have a deep submarine trench parallel to the convex, basinward side; and many have a line of volcanoes parallel to the concave side. Moreover, epicenters of earthquakes in this part of the world are concentrated in the arcs.

Eruptive or volcanic rocks in the island arcs are almost exclusively andesites. The limits of the andesitic region in the southwestern Pacific were established by Marshall (1910, maps), and in the northwestern Pacific by Hobbs (1922, p. 494; 1926, p. 842) and others. Chubb (1934, Fig. 1) compiled an accurate map of the "andesite zone" from several



MAP 2. Western Pacific region, showing the locations of principal mountain ranges and island arcs. Deep submarine trenches are hatched. Many island arcs are also known by names other than those used here. The following groups of equivalent names may assist the reader in locating island arcs mentioned in literature: Kurile = Chishima (Tokuda, 1926, Fig. 1); Ryu Kyu = Loochoo (Tokuda, 1926, p. 45) = Riu Kiu (Hobbs, 1953, Fig. 2) = Nansei Shoto (Hess, 1948, Pl. 1); Parece Vela = Palau-Kyushu (Hess, 1948, Pl. 1); Bonin = Ogasawara (Tokuda, 1926, Fig. 6); Schichto = Volcano (Hobbs, 1944, p. 240) = Sulphur (Hobbs, 1944, Map 9) = Iwo (Hobbs, 1944, p. 240) = Iwo Jima (Hess, 1948, Pl. 1); Marianas = Ladrone (Koto, 1931, Pl. 8) = Marianna (Tokuda, 1926, p. 50) = Marianne (Lawson, 1932, Fig. 1); Palau = Pelew (Lawson, 1932, Fig. 1); and Yap = West Caroline (Hess, 1948, Pl. 1).

sources. The Marianas (Map 2) lie on the eastward or basinward margin of the andesitic region, near the basaltic region of the central Pacific.

On the basinward side and nearly parallel to many of the island arcs (Map 2) are long, narrow trenches, called "fore-deeps" (Hobbs, 1914, Fig. 5), "trough-deeps" (Hobbs, 1923, p. 725), and "troughs" (Betz and Hess, 1942, p. 102), which are the deepest parts of the oceans. The Nero deep, off the southeast coast of Guam, extending 31,600 feet below sea level, is a small depression in the Mariana trench.

Around the islands lying south of Japan and north of New Caledonia extensive coral reefs have developed, which not only add to the mass of the islands but serve to indicate the numerous changes in sea level during the Cenozoic. Terraces in reef limestones record uplifts of the islands and show the directions of several tilts.

*Rocks of the Southern Mariana Islands.*—Saipan Island, at latitude 15° N. and longitude 146° E., was investigated by Japanese geologists during the long period of Japanese mandate. Tayama (1938) and Asano (1939*a*, 1939*b*) worked out a table of formations for Saipan, which American geologists revised and added to after World War II. The names used by Cole and Bridge (1953) were repeated by Avais and others (1956, pp. 13–69) in Chapter 1 of the Oceania volume of the *Lexique stratigraphique international*. The latest work on the geology of Saipan is by Cloud, Schmidt, and Burke (1956). The sequence of formations which they used is given in Table I.

*Rocks of Guam.*—From a study of foraminifera, Cole (1939) established the presence of Miocene rocks on Guam. In 1953, Cloud and Cole found Eocene foraminifera in limestone fragments in the volcanics. Dating of other rocks on the island is being worked out by members of the U. S. Geological Survey. It is expected that the sequence will be very similar to that on Saipan. The structure of Guam was noted by Stearns (1940, p. 1948), but his work was more or less of a reconnaissance nature.

Early scientific voyages that included Guam are mentioned by Cloud, Schmidt, and Burke (1956, pp. 9–16), who report on the study of limestone terraces on Guam by Quoy and Gaimard in 1824, lavas by d'Urville in 1830, water supply by Marche in 1898, and general geologic sequence by Cox in 1904. The current investigations on the island will undoubtedly alter most, if not all, of the prior conclusions.

#### AGE OF THE FOSSILS

The age of the Guam fossils can be established only within rather broad limits, limits inferred from the nature of the crabs and from their occurrence. The sedimentary formations on Guam range from Eocene to

**TABLE I**  
**ROCKS EXPOSED ON SAIPAN**  
 From Cloud, Schmidt, and Burke, 1956

Age	Formation	Description
Recent	Present reef and beach deposits	Fringing and barrier reefs, terraced ramps. Beach sand and gravel (mostly calcium carbonate).
	Gravel and sand on emerged reef surfaces	Gravel and sand of organically derived calcareous fragments.
	Marsh deposits	Soft, sticky bluish to brown muck.
	Recently emerged lime-sands	Loose, uncemented, coarse at places, numerous mollusks and foraminifera.
Pleistocene and Recent	Alluvium and clay wash	Primarily clay deposits in depressions and valleys.
	Deposits formed by mass wasting Younger terrace deposits	Chaotically mixed blocks of limestone. Mostly gravels and sandy clays of reworked volcanic materials.
Pleistocene	<b>TANAPAG LIMESTONE</b>	Coral and algal-rich reef limestone, highly porous. Shell material of mollusks and corals well preserved.
	Post-Mariana terrace deposits	Iron-stained clay sands and minor gravels of volcanic sources.
	<b>MARIANA LIMESTONE</b>	Coarsely porous, nonbedded, bioclastic to constructional limestones. Mollusk shells poorly preserved.
Pliocene	Older terrace deposits	Quartz-rich, iron-stained clay sands and minor gravels of volcanic sources.
Miocene	<b>TAGPOCHAU LIMESTONE</b>	Complex of varied calcareous facies, intergrading with one another. Distinguished from other limestones by its fossils.
Oligocene	<b>FINA-SISU FORMATION</b>	Well-stratified, andesitic marine tuffs and andesitic flows.
Eocene	<b>MATANSA LIMESTONE</b>	Pure to impure, white to pink clastic limestone with a distinctive Upper Eocene foraminiferal assemblage.
	<b>DENSINYAMA FORMATION</b>	Volcanic breccia, tuffaceous sandstone, calcareous sandstone, tuffaceous limestones and conglomerate. Rock types varied in fragments, with andesite and quartzose rocks.
	<b>HAGMAN FORMATION</b>	Andesitic rocks of subaerial and marine detrital facies, as well as massive andesite flow rock. Mostly quartz-free.
	<b>SANKAKUYAMA FORMATION</b>	Dacitic rocks, mainly breccias and massive flow rocks. Glassy, locally vesicular.
Eocene (?)	<b>SANKAKUYAMA FORMATION</b>	Dacitic rocks, mainly breccias and massive flow rocks. Glassy, locally vesicular.

Recent; hence, it follows that these specimens, dredged from near shore, must be at least as young as Eocene and may be as young as Recent. Within this range, a consideration of the following factors shows the time boundaries can, I believe, be greatly narrowed.

1. Two of the species represented, *Macrophthalmus latreillei* (Desmarest) and *Podophthalmus vigil* (Fabricius), still live in the Pacific region. This implies that the fossils are not very old. They are probably no older than Miocene and possibly as young as Recent.

2. Fossil specimens of *Macrophthalmus* occur in the Pacific region. Apparently, members of this genus migrated eastward from the Mediterranean after the Miocene, for, as pointed out by Remy (1952a), even though the oldest known species, *M. vindobonensis* Glaessner, is from middle Miocene strata of the Mediterranean and central European region, all of the more than thirty living forms are from the Red Sea, the Indian Ocean, and the western Pacific region—not one of them is from the Mediterranean. Moreover, many of the living species, including *M. latreillei*, have previously been found in the fossil state but were reported as “subfossil” (by which I assume that the authors, although uncertain of the age, did not believe them to be geologically very old). Such “subfossils” are known from Japan to Australia and from the Red Sea to New Caledonia; their known range coincides with that of their living relatives. From this, and because the migration from the Mediterranean must have taken some time, the crabs from Apra Harbor are most probably younger than Miocene.

3. The fossil crabs are well preserved but none of the chitinous integument remains, since, when subjected to heat by a blowpipe, they give off no acrid odor. Because of the destruction of the chitin, it is safe to say that the crabs are not very recent. On the other hand, the excellent preservation of the carapace—the ornamentation is intact even to the delicate denticles—presupposes no great geologic age.

4. Associated with the crabs are a few fragments of gastropods and pelecypods, which are unfortunately too incomplete for identification. However, although broken into small pieces, the shells have not suffered solution, so that it is possible to compare their preservation with that of mollusks from deposits on Saipan. On Saipan, where a complete succession of rocks is known, specimens yielded by the late Pleistocene Tanapag limestone are well preserved, whereas those from the older Pleistocene Mariana limestone are poorly so, with most of the calcium carbonate dissolved away (Cloud, Schmidt, and Burke, 1956, Chart 1). There is, then, a good possibility that the rock containing the Guam crabs is equivalent to the Tanapag limestone on Saipan. Relevant to this are the remarks by Cloud, Schmidt, and Burke (1956, p. 87), who state that “. . . the oldest Tanapag

beds would presumably offlap toward the low level of maximum glaciation, or perhaps as far as 50 fathoms below present sea level, with inhibited reef growth at greater depths," and (p. 88), "Probable time and facies equivalents are also found on Tinian, Guam, and among other recently emerged reef limestones and clastic deposits of the western Pacific."

5. The matrix around the fossil crabs consists of a highly indurated water-laid tuffaceous sand and clay, tightly cemented with calcium carbonate. This rock should be classified as a limestone, in spite of containing a high percentage of tuffaceous fragments, because it is doubtful that they are primary. According to Dr. Tracey (letter dated March 7, 1956), the last authenticated volcanism on Guam was Miocene; there is now some evidence of primary post-Miocene volcanic materials but these probably derive from volcanoes somewhere near the island (letter dated December 27, 1957). The calcium carbonate cement is evenly distributed and present in all pieces of the rock; the tuffaceous fragments were quite likely re-worked from the older volcanic deposits.

Induration of the matrix in itself does not indicate great age, for the crabs were not broken up, as one would expect were the matrix as hard when dredged as it is now. Some compaction and hardening may have taken place subsequent to dredging from Apra Harbor. Tayama (1938, translation by H. Nisihara) reported that hard rock was brought up from below the foraminiferal sand at the time of the construction of Saipan Harbor, but the age of this rock, a coral limestone resembling the beach conglomerate of Recent limestone, has not been definitely fixed.

6. Of the species reported here, two are new, and one of them belongs to the genus *Macrophthalmus*. This is a group which has been thoroughly investigated over a long period by many zoologists and in which over thirty species have been distinguished. It seems very unlikely that this new species was overlooked. If *M. guamensis* is, as I believe, extinct, then the fossil crabs did not live in historic time.

In summary, the crabs cannot be older than Eocene, since the first sedimentary rocks of Guam are that age. The range of *Macrophthalmus*, species of which occur in the fauna, has been established as Miocene to Recent; because this genus originated in the Mediterranean region in middle Miocene, it probably could not have migrated to Guam before at least the Pliocene. That the crabs are not geologically very old is attested by the presence of two living species in the fauna and by the good preservation of the fossils. That they did not live in the historic past, and presumably are older than Recent, is evidenced by the absence of chitin and the occurrence of a new species of the much-studied genus *Macrophthalmus*. The excellent condition of gastropod and pelecypod fragments in

the matrix suggests that the rocks in Apra Harbor may correlate with the late Pleistocene Tanapag limestone of Saipan. One must admit that, until further geologic work is done on Guam, the exact age of the crabs will remain in doubt. But in the light of present evidence, the most plausible age for them is Pleistocene. Moreover, a strong possibility exists that they will be found to be late Pleistocene.

## SYSTEMATIC DESCRIPTIONS

Order DECAPODA

Suborder REPTANTIA

Tribe Brachyura

Subtribe Brachygnatha

Superfamily Brachyrhyncha

Family Ocypodidae Milne-Edwards, 1837

In 1837 Henri Milne-Edwards (p. 39) listed a suprageneric taxon as "Ocypodiens." Since the stem of *Ocypoda* was used, this appears to meet the requirements for authorship of the family Ocypodidae. Later Dana (1852, p. 315) used "Ocypodinae" as a subfamily of Macrophthalmidae. His family Macrophthalmidae is synonymous with the family Ocypodidae as used here.

Subfamily Macrophthalminae Dana, 1851a

Genus *Macrophthalmus* Latreille, 1829

*Type species.*—*Macrophthalmus transversus* Latreille.

*Remarks.*—Living species of *Macrophthalmus* are difficult to classify because many of them are closely related and distinguishable only by minute details. Certain of the species are extremely variable, so that there is no sharp distinction between individual and specific variations. Dr. Michael W. F. Tweedie, Director of the Raffles Museum, Singapore, who has studied crabs of the Pacific region for many years, wrote (letter dated July 4, 1956), "*Macrophthalmus*, especially, is a genus that I despair of, and I have copious material in Singapore which I cannot identify with certainty." In addition, the literature contains many synonyms, and the descriptions of a particular species by different authors are incompatible (for example, see Table II, which will be referred to again later).

Fossil species present an even more difficult problem. First, not all structures are preserved. The chelipeds, on the nature of which part of the classification depends, are present in only a few of the specimens described here. Second, small structures may have been worn by abrasion before the crab was buried and may be further modified by weathering after it has been exposed from the matrix. In nearly all specimens that have been

cleaned, the ornamentation of the dorsal surface is low and indistinct on the parts exposed, but clearly defined on the adjacent parts from which matrix was chipped. Third, the fossil crabs were ancestors of those living today, and, although closely similar in most characteristics, may not belong to the same species. A fossil species may partly resemble each of two or more living species which evolved from it.

TABLE II  
COMPARISON OF DESCRIPTIONS OF *Macrophthalmus latreillei* (DESMAREST)  
BY TESCH (1915) AND SAKAI (1939)

Character	Tesch	Sakai
Granules on branchial region	On each branchial region there may be seen two longitudinal rows of small granules (p. 183)	Branchial regions are even and not at all marked with patches or rows of granules (p. 626)
Grooves on the carapace	The grooves on the carapace are not very conspicuous (p. 183)	The regions on the dorsal surface are rather deeply impressed (p. 626)
Curvature of upper orbital border	The upper orbital border is nearly straight and has slightly any curve in adult specimens (p. 183)	The upper orbital borders are moderately arcuate (p. 626)
Tooth of dactyl (movable finger)	Dactylus with a large tooth near the base (p. 184)	The movable finger not armed with a large tooth (p. 626)
Tooth of index (immovable finger)	Index regularly denticulate at the cutting margin, without larger tooth (p. 184)	The immovable finger bears a broad serrate tooth near its base (p. 626)
Size of granules on dorsal surface	The whole surface is closely covered with large granules and, in young specimens, with hairs, which disappear in older stages (p. 183)	The entire animal is covered with very soft fur, beneath which the surface is finely granular (p. 626)
Width $\times$ length (in mm.)	Ortman's specimen: 41 $\times$ 28. Milne-Edwards': 50 $\times$ 35 (p. 184)	26.7 $\times$ 19 (p. 626)

Tesch (1915), in his monographic study of *Macrophthalmus*, separated the species on the basis of the following characters: (1) general shape of carapace; (2) proportions of length and width of carapace; (3) ornamentation of carapace; (4) length of ocular peduncles; (5) nature of joints of rear legs; (6) rims or granules on chelipeds; (7) teeth of male chela; (8) shape and size of external orbital angle and of anterolateral teeth of carapace; (9) presence or absence of a "musical ridge" on merus of

cheliped; (10) presence or absence of rows of tubercles on branchial regions; (11) width of front; (12) curvature of fixed finger of cheliped; (13) presence or absence of a spine on merus of rear legs; (14) tubercles on lower margin of orbital groove; (15) curvature of upper margin of orbital groove; and (16) hairiness of legs.

Ocular peduncles are not preserved in any of the fossil crabs, but some idea of their length can be gained from the length of the orbital grooves into which they fitted. Furthermore, no specimen shows all of the other features regarded as diagnostic by Tesch; some specimens lack one, and some another. There are enough features preserved in each, however, to make identification possible. For example, the general shape, proportions, and ornamentation of the carapace, the shape of the front, and the tubercles on the branchial regions are all alike on the crabs described below as *Macrophthalmus latreillei*, indicating that they belong to one species, and the presence in certain specimens of male chelae makes the specific identification certain.

Tesch (1915) listed 42 names for living species of *Macrophthalmus*. Of them, he determined that one is a junior homonym, 16 are synonyms, and 25 apply to valid species. The names for valid species of *Macrophthalmus* include (Tesch, 1915, pp. 150-51):

<i>brevis</i> Herbst, 1804	<i>latifrons</i> Haswell, 1882
<i>consobrinus</i> Nobili, 1906	<i>latipes</i> Borradaile, 1903
<i>convexus</i> Stimpson, 1858	<i>latreillei</i> (Desmarest), 1822
<i>crassipes</i> H. Milne-Edwards, 1852	<i>pacificus</i> Dana, 1851
<i>crinitus</i> Rathbun, 1913	<i>pectinipes</i> Guérin, 1839
<i>definitus</i> Adams and White, 1848	<i>punctulatus</i> Miers, 1884
<i>dentatus</i> Stimpson, 1858	<i>quadratus</i> A. Milne-Edwards, 1873
<i>depressus</i> Rüppell, 1830	<i>setosus</i> H. Milne-Edwards, 1852
<i>dilatatus</i> De Haan, 1835	<i>sulcatus</i> H. Milne-Edwards, 1852
<i>erato</i> De Man, 1888	<i>telescopicus</i> (Owen), 1839
<i>grandidieri</i> A. Milne-Edwards, 1867	<i>tomentosus</i> Eydoux and Souleyet, 1841
<i>hilgendorfi</i> Tesch, 1915	<i>transversus</i> (Latreille), 1817
<i>japonicus</i> De Haan, 1835	

In order to complete the list of known valid species of *Macrophthalmus*, there should be added to Tesch's list:

<i>aguensis</i> A. Milne-Edwards and Brocchi, 1879	<i>malayensis</i> Tweedie, 1937
<i>granulatus</i> De Man, 1904	<i>sandakani</i> Rathbun, 1914
<i>impressus</i> (Desmarest), 1822	<i>travancorensis</i> Pillai, 1951
<i>incisus</i> (Desmarest), 1822	<i>vindobonensis</i> Glaessner, 1924
<i>malaccensis</i> Tweedie, 1937	

As shown by the extensive list above, particular attention has been given by many authors to the discrimination of species of *Macrophthalmus*.

The genus has been recognized for over a century and during that time species have been studied intensively. In addition, crab faunas, both fossil and Recent, have been investigated in many parts of the Pacific region, from Japan to Australia and from Singapore to Hawaii. In view of the vast amount of work already done on crabs of this genus, I was surprised to find a distinctive new species in the fossils from Guam. It is described below as *M. guamensis*, sp. nov.

*Macrophthalmus latreillei* (Desmarest)

(Pl. I, Figs. 1-4; Pl. II, Figs. 1-7; Pl. III, Figs. 5-8, 11-15; Pl. IV, Figs. 1-6;  
Pl. V, Figs. 1-4, 6-7, 9-11; Pl. VI, Figs. 1-8; Pl. VII, Figs. 1-3;  
Pl. VIII, Figs. 1-2; Pl. IX, Figs. 1-17)

- Fossil crab from the East Indies. Parkinson, 1811, p. \*261<sup>1</sup>, Pl. 17, Fig. 12.  
*Gonoplax Latreillii* Desmarest, 1822, p. 99, Pl. 9, Figs. 1, 4. Geinitz, 1845, p. 215.  
 Quenstedt, 1852, p. 262, Pl. 20, Fig. 1 (*G. Latreillei* on explanation of plate).  
*Macrophthalmus Latreillii* H. Milne-Edwards, 1837, p. 66. Reuss, 1859, pp. 61-66, 82,  
 Pl. 20, Figs. 1-5; Pl. 23, Fig. 2.  
*Gonoplax Latreillaei* [sic] Lucas, 1839a, pp. 569-70.  
*Gonoplax Latreilli* Mantell, 1850, p. 156, Pl. 68, Fig. 10.  
*Macrophthalmus Desmarestii* Lucas, 1839a, pp. 570-72, Pl. 20. Lucas, 1840, pp. 63-64.  
*Macrophthalmus Desmaresti* Reuss, 1859, p. 82.  
*Macrophthalmus serratus* Gray, 1847, p. 37. Adams and White, 1848, p. 51. Stimpson,  
 1858, p. 97. Miers, 1886, p. 250, Pl. 20, Fig. 1. Stimpson, 1907, p. 96, Pl. 13,  
 Figs. 3a-d. Rathbun, 1910b, p. 323. Etheridge and McCulloch, 1916, pp. 11-12,  
 Pl. 4, Figs. 1-2. Suvatti, 1938, p. 64. Suvatti, 1950, p. 155.  
*Macrophthalmus Latreillei* A. Milne-Edwards, 1873, pp. 278-79, Pl. 13, Figs. 3, 3a-c.  
 Nobili, 1899, p. 272. Glaessner, 1929, p. 243.  
*Macrophthalmus Polleni* Hoffman, 1874, p. 19, Pl. 4, Figs. 27-30. De Man, 1879, p. 66.  
 Lenz and Richters, 1881, pp. 424-25, Figs. 24-27.  
*Macrophthalmus latreillei* Ortmann, 1894, p. 747. Ortmann, 1897, p. 341. Rathbun,  
 1910a, p. 306. Tesch, 1915, pp. 181-84. Tweedie, 1937, p. 163. Sakai, 1939, Pl. 105,  
 Fig. 2. Suvatti, 1950, p. 154. Barnard, 1950, p. 102. Remy, 1952a, pp. 28, 34-36.  
 Remy, 1952b, pp. 114-16. Roger, 1953, Pl. 11, Figs. 12A-B.  
*Macrophthalmus laniger* Ortmann, 1894, pp. 747-48, Pl. 23, Fig. 15. Ortmann, 1897,  
 p. 341.  
 not *Macrophthalmus latreillei* Sakai, 1939, pp. 623, 626, 727.  
*Gonoplax emarginata* Desmarest, 1822, p. 101, Pl. 9, Figs. 7-8.  
*Macrophthalmus* [sic] *Latreillii* Lamarck, 1835, p. 468.

*Description*.—Carapace distinctly trapezoidal, its dorsal surface moderately convex from anterior to posterior, slightly convex transversely through the hepatic regions (Pl. V, Fig. 9) and very strongly convex transversely through the branchial regions (Pl. 1, Fig. 1; Pl. VII, Figs.

<sup>1</sup> Parkinson's publication included supernumerary pages which were interleaved with the regularly numbered pages and designated by numbers preceded by an asterisk. The page referred to is not page 261, but page \*261.

1-3). Greatest width between the outer orbital angles (Pl. VII, Fig. 1). Length/width variable, in large specimens 1/1.3 to 1/1.5.

Upper orbital borders nearly straight, each only slightly sinuous in adults (Pl. VII, Fig. 1), more strongly sinuous in very young crabs (Pl. III, Fig. 5). Acute small tubercles or small spinelets along the upper orbital border (Pl. VII, Fig. 2). Outer orbital angle acute, directed obliquely outward and slightly forward in most specimens (Pl. III, Fig. 5; Pl. VII, Fig. 1) but directed outward in a few (Pl. II, Fig. 1). Front narrow, about one-tenth of the width, conspicuously constricted at its base, with a deep groove along its midline (Pl. II, Fig. 1; Pl. V, Fig. 3).

Four anterolateral teeth, including that forming the outer orbital angle. First and second teeth large, distinct; third tooth narrower, more spiniform; and fourth tooth a very small prominence close behind the third tooth. Distal edges of teeth ornamented with small, sharp tubercles similar to those along the upper orbital border (Pl. VII, Fig. 2). Teeth varying greatly in shape. First two teeth flat, slightly turned up in some specimens (Pl. VII, Fig. 2) and more elongate, acutely pointed in others (Pl. II, Fig. 1). Third tooth inflated, with a broad base and blunt tip in some (Pl. VI, Fig. 1), flat, upturned, and short in others (Pl. VII, Fig. 2), and elongate, narrow in a few specimens (Pl. VIII, Fig. 2; Pl. IX, Fig. 9). Fourth tooth larger in some (Pl. VIII, Fig. 2) than in others (Pl. I, Figs. 3-4; Pl. VII, Fig. 2). Indentations between the teeth rather sharp, varying in depth and angle according to the shape of the adjacent teeth (compare Pl. VI, Fig. 1, Pl. VII, Fig. 2, and Pl. VIII, Fig. 2). Posterolateral borders strongly convex, except for slight concavity above insertion of rear pereopods, their forward sections (just behind the fourth anterolateral teeth) parallel; entire posterolateral borders "beaded" with small, distinct, elongate tubercles with rounded tips (Pl. VI, Fig. 3; Pl. VII, Fig. 2). Posterior border straight, about one-half as wide as the carapace.

Regions of the dorsal surface rather well defined. Cervical groove deep in the part around the gastric regions except in a very narrow middle section between two transversely elongate pits at the rear of the urogastric region (Pl. III, Figs. 12, 14; Pl. IV, Figs. 3, 5). Pits probably at positions of attachment of the internal adductor muscles of the mandibles. Inner segment of each cervical groove not joined to the distal segment; distal segment shallow but distinct, behind the hepatic region, terminating at the anterolateral border behind the first anterolateral tooth (Pl. IV, Fig. 1; Pl. VI, Fig. 1; Pl. IX, Fig. 9). Gastric regions subcardiform, posteriorly bluntly acuminate. Deep grooves, continuous with the deep inner segments of the cervical groove, bounding the protogastric regions laterally. Meso-gastric region partly separated from the protogastric regions by very

shallow depressions extending obliquely forward from the cervical groove (Pl. III, Figs. 12, 14; Pl. IV, Figs. 3, 5). Mesogastric and urogastric regions joined. Each hepatic region subtriangular, transversely elongate, terminating distally in the first anterolateral tooth. Cardiac region broad, with posterolateral expansions, laterally and posterolaterally bounded by distinct grooves, its central part joined to the intestinal region. Intestinal region subtrapezoidal, much narrower than cardiac region in its anterior half, flaring, posteriorly wide, separated from the branchial regions by shallow grooves becoming indistinct near the posterior border (Pl. III, Fig. 12). Branchial regions strongly convex, distally strongly but evenly deflected. Each mesobranchial region large, most strongly convex of the branchial regions, separated from the narrow, transversely elongate epi-branchial region by a shallow groove nearly parallel to the distal segment of the cervical groove, separated from the small, much less convex meta-branchial region by a rather broad depression.

Dorsal surface tuberculate; large low tubercles in adults, smaller, higher tubercles in specimens of intermediate size, and low, inconspicuous tubercles in very young specimens. On each branchial region, two rows of closely spaced, higher tubercles, essentially parallel to the lateral border; the inner row located from the midline about two-thirds the distance to the lateral border and the outer row about midway between the inner row and the lateral border (Pl. I, Figs. 1, 3-4; Pl. VII, Fig. 2). Tubercles of the inner row less conspicuous than those of the outer. Outer row continuous (Pl. I, Fig. 3; Pl. IV, Figs. 3, 5) or separated into two (Pl. VI, Fig. 3), three (Pl. VI, Fig. 1), or four (Pl. I, Fig. 4) segments; extremely variable, in some crabs differing on the left and right sides (Pl. I, Figs. 3-4). A row of tubercles on a low ridge near and parallel to the posterolateral border just above the insertion of the rear pereopods.

Inflected part of the carapace (the pterygostomian region) meeting the dorsal part at a sharp angle (Pl. VII, Fig. 3), smooth except for low tubercles in its posterior part. A crescentic depression below the base of the first anterolateral tooth.

Plastron very large, suboval, about three-fourths as wide as the carapace. The anterior segment of the plastron (probably the fused sterna of the last postoral cephalic and first four thoracic somites) tapering abruptly, then prolonged with a round anterior end (Pl. II, Fig. 2; Pl. V, Fig. 4); the lateral indentations at the junctions of the abruptly tapering and prolonged parts probably representing the division between the third and fourth thoracic somites. The following three sterna (of the fifth, sixth, and seventh thoracic somites) of about the same width (Pl. I, Fig. 2), the posterior one (of the eighth thoracic somite) narrower. Each episternum of

the fused sterna and of the fifth, sixth, and seventh thoracic somites elongate, triangular, nearly excised from its corresponding sternum by a sharp fissure, its tip extending to the posterior edge of the succeeding sternum. A short, outwardly directed spur at the base of each episternum, forming, with the adjacent part of the sternum, a socket to accommodate the ventral projection on the coxa of the pereopod of that somite. Plastron with a very deep trough for reception of the abdomen, both in the male (Pl. I, Fig. 2; Pl. III, Fig. 15) and in the female (Pl. IV, Fig. 2). Abdomen of the male narrow, thick, with parallel sides,<sup>2</sup> composed of five pleonites, representing the six abdominal somites and the telson (assuming that, as usual in the brachyurans, the third, fourth, and fifth abdominal somites are fused in the male) (Pl. II, Fig. 3; Pl. III, Figs. 8, 11, 13); first pleonite nearly covered by the dorsal part of the carapace, only a narrow band exposed; second pleonite with a median transverse ridge and bluntly acuminate lateral projections; third and fourth pleonites rectangular, of about the same size; last pleonite (the telson) the longest, slightly tapering, its end round. Abdomen of the female composed of seven pleonites, representing the six abdominal somites and the telson, varying in size and shape according to sexual maturity; in very young crabs (Pl. III, Fig. 6) only a little wider than the abdomen of the male, tapering slightly from the base to the telson; in specimens a little more developed (Pl. IX, Fig. 1) the sides slightly convex; in more mature specimens (Pl. II, Fig. 2; Pl. IV, Fig. 6; Pl. V, Fig. 4; Pl. IX, Figs. 2-4) "bottle-shaped,"<sup>2</sup> with the basal three-fourths transversely expanded and with a shallow concavity on each border near the telson; in nearly mature specimens (Pl. II, Fig. 7; Pl. IX, Figs. 5-7, 10) greatly expanded, suboval; and in adult females (Pl. II, Fig. 4; Pl. IV, Fig. 2; Pl. VI, Figs. 6, 8; Pl. IX, Figs. 8, 12-15) subcircular, covering the entire plastron. No definite boundary between the gently convex tergum and the flat pleura in each abdominal somite.

Mouth parts not well preserved. Buccal cavity oblong, transversely elongate. Of the outer (third) maxillipeds, only the exopod and part of the basi-ischium preserved. Exopod of each outer maxilliped elongate, tapering slightly toward its anterior end, lying proximal to the edge of the pterygostomian region (Pl. I, Fig. 2; Pl. II, Fig. 3; Pl. III, Fig. 6; Pl. IX, Figs. 1, 3). Basi-ischium of each outer maxilliped with a straight outer border fitting against the exopod, its posterior part subtriangular, a small inner projection on the inner edge, anterior part (as much as preserved) subquadrate (Pl. II, Fig. 4; Pl. III, Figs. 13, 15; Pl. IX, Fig. 11). Part

<sup>2</sup> This descriptive term was suggested by Dr. Tsune Sakai (letter, October 26, 1956).

of epistoma seen in a few specimens, a more or less T-shaped small plate at the front of the buccal cavity, with concave sides and a straight dorsal border with lateral extensions, obviously incomplete (Pl. III, Fig. 8; Pl. IV, Fig. 6). A small curved bar with a small median projection, lying between the posterior ends of the outer maxillipeds and in front of the plastron (Pl. VI, Fig. 6; Pl. IX, Figs. 8, 11), probably representing the first maxillary sternum (the sternum of the first postoral somite).

Chelipeds slender; merus of each exceptionally slender, about the same diameter as that of the rear pereopod (Pl. II, Figs. 2, 7; Pl. IV, Fig. 4; Pl. IX, Fig. 1). Male chela elongate; propus long, its lower border deflected downward at the junction of the palm and the fixed finger; fixed finger regularly dentate without larger teeth; dactyl with a large quadrate tooth near its base and small denticles between the large tooth and the tip, the large tooth with a blunt, serrate end (Pl. V, Fig. 11; Pl. IX, Fig. 17).

Second, third, and fourth pereopods with large coxae, closely spaced, set just under the edges of the dorsal part of the carapace, with distinct ventral articulating projections (Pl. I, Fig. 2; Pl. IX, Fig. 5). Basi-ischia short, about the same length as the coxae. Meri long, subtriangular in cross section, with tubercles and a large subdistal spine on the anterodorsal edge of each (Pl. II, Fig. 2; Pl. IX, Fig. 16); merus of each second pereopod about three-fifths as long as the carapace, merus of each third pereopod about four-fifths as long as the carapace, and merus of each fourth pereopod about the same length as the carapace. Carpi a little shorter than the propi; carpus and propus of each walking pereopod with a combined length about the same as that of the merus. Dactyls missing from walking pereopods in all specimens.

Posterior pereopods attached on the posterior sides of the abdomen, just under the posterolateral concavities of the dorsal part of the carapace, more slender and shorter than the other walking pereopods, with a subdistal spine on each merus.

*Remarks.*—Many specimens have been abraded, so that the outer parts of the upper orbital borders and the anterolateral teeth are worn off, making it very difficult to estimate their original shape and size. Abrasion has also affected the ornamentation in the central part of the carapace in many crabs. Enough specimens however, were obtained with these features intact so that identification could be made with certainty.

The synonymy offered above may not include all references to this species. It is, however, the most nearly complete list that has yet been assembled. Particular attention was given to the exact spelling in each reference.

The characteristics ascribed to *Macrophthalmus latreillei* by Tesch (1915, pp. 183–84) and by Sakai (1939, p. 626) do not agree (see Table II). Descriptions and figures by other authors match those of Tesch. From his and other accounts, I have assumed that *M. latreillei* is a crab having longitudinal rows of tubercles on the branchial regions, rather straight upper orbital borders, a large tooth near the base of the dactyl on the male chela, regular denticulation on the index of the male chela, and distinct tubercles ornamenting the dorsal surface of the carapace. Sakai's figure (1939, Pl. 105, Fig. 2) appears to be of a true *Macrophthalmus latreillei*, but his description (1939, p. 626) is misleading.

The characters in the fossil specimens of *Macrophthalmus latreillei* have been described in great detail, including certain morphological features not usually regarded as taxonomically significant. It seems advisable, at least for fossil crabs, to list all features which can be observed, because they may at some future time be useful in classification.

*Illustrated specimens.*—Males: UMMP Nos. 34306, 34308, 34310–34311, 34313, 34316, 34318, 34327–34328, and 34631–34362. Females: UMMP Nos. 34305, 34307, 34309, 34312, 34315, 34317, 34319–34320, 34322, 34323, 34326, 34360, 34623–34629, and 34633–34634; USNM Nos. 562479–562482. Sex unknown: UMMP No. 34621.

***Macrophthalmus guamensis*, sp. nov.**

(Pl. III, Figs. 9–10, Pl. VIII, Fig. 3; Pl. X, Figs. 10–13;  
Pl. XI, Figs. 4–8; Pl. XII, Fig. 18)

*Description.*—Carapace subquadrate, rather strongly arched from front to rear, slightly arched from side to side through the anterior region, and strongly arched through the branchial region; outer parts of the meso-branchial regions very declivitous (Pl. VIII, Fig. 3). Length/width ratio approximately 5/6, or 1/1.2, the highest known for any species of *Macrophthalmus*. Carapace constricted anteriorly; width through the branchial region greater than that between the outer orbital angles; greatest width between the third anterolateral teeth.

Front, broad, about one-sixth the distance between the outer orbital angles, not constricted at its base, with a short, deep groove through its middle (Pl. VIII, Fig. 3). Upper orbital and lateral borders, including the anterolateral teeth, "beaded" with distinct, discrete, closely spaced, rather acuminate, very small tubercles. Each upper orbital border sinuous, concave at its junction with the front, strongly convex about one-third its length from the front, and sloping back nearly straight, slightly concave for the rest of its length to the outer orbital angle (Pl. X, Figs. 12–13). Outer orbital angles located behind the base of the front. Lower orbital

border arcuate, sloping back to distal end, its outer four-fifths regularly "beaded" with small, discrete, regularly spaced tubercles; no larger tubercles present.

On each side, four anterolateral teeth. First tooth formed by the outer orbital angle; flat, short, subquadrate, the angle at its apex slightly obtuse, just a little more than a right angle; separated from the second tooth by a narrow indentation. Second tooth only a little larger than the first, also short and subquadrate, its outer border slightly convex, separated from the third tooth by a narrow indentation. Third tooth, lying close behind the second, longest of the anterolateral teeth, tapering, bluntly pointed, its upper surface concave, separated from the fourth tooth by an inconspicuous indentation. Fourth tooth at about the middle of the length, set close behind the third tooth, consisting of a very small projection, similar to the fourth tooth in *M. latreillei*.

Prominent grooves along the outer borders of the gastric, cardiac, and intestinal regions; shallow grooves behind each hepatic region, on the anterolateral borders of the mesogastric region, and between each epi-branchial and mesobranchial region; and a shallow depression between each mesobranchial and metabranchial region. Cervical groove very shallow behind the urogastric region, marked by two small pits, such as those found in other species of the genus, near the midline. Each branch of the cervical groove deep along the sides of the urogastric and mesogastric regions and the posterolateral border of the protogastric region, thence sharply deflected outward as a shallow groove between the hepatic and epibranchial regions, and becoming indistinct near the rear edge of the second anterolateral tooth.

Most of the carapace smooth or faintly tuberculate, except the postero-central part of each hepatic region, a lunate area (anteriorly concave) in each epibranchial region, and the outer half of each mesobranchial region, where the carapace is covered by higher and more distinct tubercles. No rows of larger tubercles discernible on the branchial regions.

Two elevated areas, perhaps representing the epigastric regions, one on each side of the rear part of the deep median groove which bisects the front. Upper orbital border with a raised rim. Each orbital region narrow, smooth, not marked off from the protogastric or from the hepatic region. Each protogastric region subtriangular, its apex directed posteriorly. Posterior part of the border between the mesogastric and each protogastric region a shallow groove, and the anterior part scarcely defined. Deep groove between each protogastric and hepatic region, continuous with posterior part of the cervical groove. No distinct boundary between the mesogastric and urogastric regions.

Each hepatic region nearly subquadrate, bearing the first two anterolateral teeth on its outer border, separated from the protogastric region by a deep groove and from the epibranchial region by a shallow part of the cervical groove. Cardiac region subquadrate with its posterior part laterally expanded, separated from the mesobranchial region by a deep groove continuous with the cervical groove, anteriorly bounded by the cervical groove containing the two pits mentioned above, posteriorly separated from the intestinal region by a transverse groove, very shallow in its middle part and deep in its outer parts. Intestinal region narrower than cardiac region, quadrate in its anterior two-thirds, abruptly widening in its posterior one-third, separated from the branchial region by a distinct groove.

Branchial regions not sharply divided. Mesobranchial the largest of the branchial regions, anteriorly separated from the epibranchial region by a transverse, shallow groove, posteriorly separated from the metabranchial region by an oblique depression.

Merus of cheliped large, short, in cross section subtriangular with broadly round edges. A few small papillae along the lower inner edge, the rest of the merus very smooth except for numerous tiny punctae, probably pores of hairs. Carpus smooth, short.

Propod entirely smooth, subelliptical in cross section, about three-fourths as long as the carapace. Palm of propod of the male with ratio of height/length about 7/10, its length approximately one-half the length of the carapace. Upper and lower borders of palm parallel in its distal half, lower border straight, upper border sloping down towards the junction with the carpus. Fixed finger of propod straight, its lower border aligned with that of the palm, armed on the middle of its upper edge with an elongate, serrate tooth. A faint groove along the outer face of the finger, becoming indistinct on the palm. Chela with a large gap between the base of the dactyl and the fixed finger. Dactyl long, slightly arcuate, armed with a very narrow, blunt tooth near its base and low, discrete, inconspicuous denticles between the basal tooth and the tip. A shallow groove near and parallel to the lower edge of the dactyl, finely pitted, probably hairy originally.

*Remarks.*—*Macrophthalmus guamensis* has several features in common with many living species of the genus, but this does not prove that it was ancestral to any of them. Two others, *M. latreillei* (Desmarest) and *M. dentatus* Stimpson, also have four anterolateral teeth; all the rest have three. *M. guamensis* differs from *M. latreillei* in having the greatest width through the middle of the carapace instead of between the orbital angles, in the shape of the anterolateral teeth, in the greater length/width ratio, and in having the front broad instead of narrow and constricted at its

base. It differs from *M. dentatus* in having a broad instead of narrow front, the first anterolateral tooth subquadrate instead of pointed, and a length/width ratio of about 1/1.2 instead of 1/1.67. Both *M. guamensis* and *M. dentatus*, however, have similar teeth on the male chela. The new species resembles *M. quadratus* A. Milne-Edwards in having a subquadrate carapace narrowed anteriorly, the first two anterolateral teeth of about the same shape, a broad front not constricted between the orbits, similar dentition on the chela, and in lacking longitudinal rows of tubercles on the branchial regions. It differs from that species in having four anterolateral teeth instead of three, the fixed finger of the male chela straight instead of deflected, and an obtuse instead of acute orbital angle.

Both *M. guamensis* and *M. erato* De Man have subquadrate carapaces, broad fronts, chelae of the same proportions, and a narrow rectangular tooth near the base of the male dactyl. The two differ, however, in that *M. guamensis* has four lateral teeth instead of three, as in *M. erato*, and has its greatest width near the middle of the carapace instead of anterior. Like *M. latifrons* Haswell, *M. guamensis* has a broad front and the carapace narrow anteriorly, but it is distinct in having four lateral teeth, the fixed finger of the chela straight, and a greater length/width ratio. Certain of the characters of the new species are like those of *M. tomentosus* Eydoux and Souleyet, but the latter has only three anterolateral teeth and a length/width ratio of 1/1.36 (according to measurements of Eydoux and Souleyet, 1841, p. 244).

Undoubtedly, the species most similar to *M. guamensis* is *M. pacificus* Dana. Comparing descriptions, the characters of *M. pacificus* match those in *M. guamensis* remarkably well with three exceptions: (1) the fixed finger of the male chela in *M. pacificus* "has no larger tooth, but is crenulated throughout" (Tesch, 1915, p. 192); (2) *M. pacificus* has only three anterolateral teeth, whereas *M. guamensis* has four; and (3) no longitudinal rows of tubercles on the branchial regions of *M. guamensis*, as described for *M. pacificus* by De Man (1890, p. 79). Rathbun (1910a, p. 307) did say of these tubercles, however, that they are "scarcely distinguishable" in the specimens of *M. pacificus* from Amboyna.

ABBREVIATED SYNONYMIES OF CLOSELY RELATED SPECIES:

*Macrophthalmus dentatus* Stimpson

*M. dentatus* Stimpson, 1858, p. 97. Stimpson, 1907, pp. 96-97, Pl. 15, Figs. 1a-c. Tesch, 1915, pp. 184-85.

*Macrophthalmus erato* De Man

*M. Erato* De Man, 1887-1888, pp. 125-29, Pl. 8, Figs. 12-14. De Man, 1895, p. 579. *M. erato* Alcock, 1900, pp. 381-82. Tesch, 1915, pp. 179-81, Pl. 8, Fig. 9. Tweedie, 1937, pp. 163-64. Tweedie, 1954, p. 122.

*Macrophthalmus latifrons* Haswell

*M. latifrons* Haswell, 1882a, p. 549. Haswell, 1882b, p. 90. Tesch, 1915, p. 189.

*Hemiplax latifrons* Etheridge and McClulloch, 1916, pp. 13-14, Pl. 4, Figs. 4-5; Pl. 6, Figs. 3-4.

*Macrophthalmus pacificus* Dana

*M. pacificus* Dana, 1851a, p. 248. Stimpson, 1858, p. 97. De Man, 1890, pp. 79-83, Pl. 4, Fig. 10. Ortmann, 1897, p. 342. Rathbun, 1910a, p. 307, Pl. 1, Fig. 3. Tesch, 1915, pp. 190-92, Pl. 8, Fig. 11.

*M. bicarinatus* Heller, 1868, p. 36, Pl. 4, Fig. 2. De Man, 1902, p. 496.

?*M. pacificus* De Man, 1895, pp. 579-80. Tweedie, 1954, p. 124.

*Macrophthalmus quadratus* A. Milne-Edwards

*M. quadratus* A. Milne-Edwards, 1873, pp. 280-81, Pl. 12, Fig. 6. Tesch, 1915, pp. 185-87, Pl. 8, Fig. 10. Boone, 1934, pp. 204-06, Pls. 107-09. Tweedie, 1954, p. 122.

*Macrophthalmus tomentosus* Eydoux and Souleyet<sup>3</sup>

*M. tomentosus* Eydoux and Souleyet, 1841, pp. 243-44, Pl. 3, Fig. 8. A. Milne-Edwards, 1873, p. 279. Alcock, 1900, pp. 382-83, Tesch, 1915, pp. 193-95, Pl. 9, Fig. 12. Tweedie, 1937, p. 163.

*Types*.—Holotype, a male carapace with chelae attached, UMMP 34620. Paratypes, a male carapace, UMMP 34304, a male carapace with one complete chela, UMMP 34689, a part of a male carapace, UMMP 34690, and part of a male carapace, UMMP 34696.

*Macrophthalmus* sp.

(Pl. V, Fig. 5)

*Description*.—A small female with the dorsal half of the carapace missing. Abdomen nearly covering the plastron, subcircular to suboval except for protrusion of distal pleonite.

*Remarks*.—The shape of the abdomen is that of a nearly mature female. Unfortunately, the dorsal half of the carapace is missing so that specific assignment is impossible. This specimen is about the size of those of *Macrophthalmus guamensis*, sp. nov., and it may belong to that species.

*Illustrated specimen*.—A female plastron and abdomen, UMMP 34314.

## Family Portunidae Dana, 1851b

## Subfamily Podophthalminae Dana, 1851b

Insofar as I have been able to determine from a search of literature, the taxon should be credited to J. D. Dana (1851b, p. 130), who first used the stem of the generic name in "Podophthalmidae." Later, Ortmann

<sup>3</sup> Many authors have credited this species to Souleyet alone, because he wrote in the foreword (Eydoux and Souleyet, 1841, p. ii) that Dr. Eydoux died July 6, 1841, a victim of the yellow fever which ravaged Martinique. Because both authors are entered on the title page and, I assume, shared the authorship of the book, I have credited them both with this species.

(1894, pp. 67, 87), apparently unaware of Dana's prior use of the name, described "Podophthalmidae, nov. fam." Some workers have considered the author to be Rathbun (1930, p. 143), who referred to the "subfamily Podophthalminae." According to present interpretation of the *International Rules of Zoological Nomenclature*, Dana is the author of any and all suprageneric taxa utilizing the stem of *Podophthalmus*.

Genus *Podophthalmus* Lamarck, 1801

*Type species*.—*Portunus vigil* Fabricius, 1798, p. 363.

*Podophthalmus vigil* (Fabricius)

(Pl. IV, Figs. 7-8; Pl. VI, Figs. 9-12; Pl. IX, Figs. 18-19;  
Pl. X, Figs. 1-9; Pl. XII, Figs. 1-17)

*Portunus vigil* Fabricius, 1798, pp. 363-64.

*Portunus Vigil* Latreille, 1817, p. 13. Levrault, 1823, p. 225.

*Podophthalmus spinosus* Lamarck, 1801, p. 152. Latreille, 1803, pp. 54-55, Pl. 46, Figs. 1-2. Lamarck, 1818, p. 257. Levrault, 1823, p. 225. Latreille, 1829, p. 33.

*Podophthalmus vigil* Leach, 1815, p. 149, Pl. 118. Levrault, 1823, p. 225. Cuvier, Griffith, and Pidgeon, 1833, Pl. 12, Fig. 3. H. Milne-Edwards, 1834, pp. 467-68. Lucas, 1839b, p. 179. Randall, 1839, p. 118. Lucas, 1847, p. 300. Gray, 1847, p. 29. Streets, 1877, p. 113. Hoffman, 1874, pp. 5, 39. Nauck, 1880, p. 60. Miers, 1880, p. 238. Martin, 1883, p. 32, Pl. 2, Fig. 28. Miers, 1884, p. 10. Miers, 1886, pp. 207-08. Cano, 1889, p. 91. Ortmann, 1894, p. 87. De Elera, 1895, p. 553. Nobili, 1899, p. 255. Nobili, 1900, p. 498. Lenz, 1901, pp. 458, 480. Nobili, 1903, p. 32. De Man, 1904, pp. 274-76. Nobili, 1906, p. 213. Rathbun, 1906, p. 875. Rathbun, 1910b, p. 366. Klunzinger, 1913, pp. 375-76. Laurie, 1915, pp. 412, 442. Etheridge and McCulloch, 1916, p. 9, Pl. 4, Fig. 3, Pl. 5, Fig. 3. Martin, 1919, pp. 104, 124. Balss, 1922, p. 112. Edmondson, 1923, p. 23. Delsman and De Man, 1925, pp. 314-15, 318, Pl. 15, Figs. b, c. Glaessner, 1929, p. 331. Boone, 1934, pp. 81-85, Pls. 37-38. Sakai, 1936, p. 163. Shen, 1937, p. 137, Fig. 20. Leene, 1938, pp. 12-13. Sakai, 1939, pp. 426-27, 711, Pl. 48, Fig. 2. Edmondson, 1946, p. 283. Lin, 1949, p. 20. Suvatti, 1950, p. 12. Van Weel, Randall, and Takata, 1954, pp. 209, 216-17. Edmondson, 1954, pp. 271-72, Figs. 43d-e, 44.

*Portunus (Podophthalmus) vigil* De Haan, 1835, p. 44, Pl. A.

*Podophthalmus vical* [sic] Suvatti, 1938, p. 70.

*Podophthalmus vigill* [sic] Lin, 1949, p. 10.

*Podophthalmus Vigil* Brewster, 1830, p. 390.

*Podophthalme épineux* Latreille, 1803, p. 54. Lamarck, 1818, p. 257. Levrault, 1823, p. 225. Desmarest, 1816-1830 (1823?), Pl. 6, Fig. 1.

? *Podophthalmus Defrancii* Leach, 1815, pp. 149-50. Levrault, 1826, p. 66. Geinitz, 1845, p. 213. Lucas, 1847, p. 300. Reuss, 1859, p. 82.

*Podophthalme vigil* H. Milne-Edwards, 1851, p. 258.

*Podophthalmus* [sic] *vigil* Guérin-Méneville, 1828, Pl. I, Fig. 3.

*Podophthalmus* [sic] *spinosus* Lamarck, 1835, p. 471.

*Podophthalmus* [sic] *Vigil* Lamarck, 1835, p. 472.

? *Podophthalmus* [sic] *Defrancii* Lamarck, 1835, p. 472.

Radjungan angin Delsman and De Man, 1925, pp. 314-15, 318.

*Description.*—Carapace laterally attenuated, broadly subtrapezoidal. Dorsal surface relatively flat in the anterior half, laterally beveled in the posterior half. Greatest width between the tips of the first anterolateral spines, about  $2\frac{1}{2}$  times the length of the carapace. Front an extremely narrow interocular septum. Anterior border gently arcuate, composed of the very long upper orbital borders separated by the very narrow front; each upper orbital border “beaded” with small spinules (Pl. IV, Fig. 7). Orbital grooves deep, extending the full length of the anterior border. Lower orbital border projecting forward beyond the upper orbital border throughout most of its length, particularly in the proximal one-third.

First anterolateral tooth long, acute, concave forward, set distinctly behind the anterior border (Pl. IV, Fig. 7; Pl. IX, Fig. 18). Second anterolateral tooth much smaller than the rest, set closely behind and separated from it by a sharp V-shaped cleft; very sharp and anteriorly concave in young specimens (Pl. IX, Fig. 18) but blunter and shorter in older crabs (Pl. IV, Fig. 7). Posterolateral borders strongly convergent; each posterolateral border divided into two segments separated by a blunt, short projection, the anterior segment long and straight and the posterior segment distinctly concave, lying above the fourth and fifth pereopods. A sharp but obtuse ridge parallel to the posterior segment of the posterolateral border for most of its length but recurved around the posterior corner of the carapace and continuing along the posterior border. Posterior border straight, less than half as wide as the anterior border.

Cervical groove shallow but distinct, its long outer branches deflected, becoming transverse, and terminating between the anterolateral teeth. Gastric, hepatic, cardiac, and branchial regions fairly well defined by shallow grooves. A transverse groove ahead of and parallel to the outer branch of the cervical groove, shallow but containing a line of pits (Pl. IV, Fig. 7; Pl. X, Fig. 1). A low ridge extending inward from the second anterolateral tooth. Areas where outer layer of shell has been broken off showing a finely papillose layer of shell material (Pl. X, Figs. 1, 3, 5).

Plastron somewhat hexagonal, with straight posterior and anterior borders and convex sides. Anterior segment large, broad, subpentagonal, posteriorly obtusely acuminate; two intersecting grooves; the median groove extending the full length of the segment, its posterior half deep and forming a channel to accommodate the end of the abdomen and its anterior half very shallow; the transverse groove curved, extending between the anterior corners of the segment (Pl. IV, Fig. 8; Pl. VI, Fig. 11; Pl. X, Figs. 4, 6, 9). Each of first four segments of plastron with long, narrow, crescentic episterna extending back alongside the next sternum, anteriorly bounding the socket for the pereopodal coxa of its own somite and pos-

teriorly bounding the socket for the coxa of the next somite. Second, third, and fourth segments of the plastron about equal; rear segment smaller.

Abdomen of the male triangular, posteriorly broad, anteriorly long and attenuated, confined to the accommodating channel in the plastron; the pleonite formed by the fused third, fourth, and fifth abdominal somites very large, crossed by a low ridge (Pl. IX, Fig. 19; Pl. X, Fig. 2); the telson very small.

Meri of first three pereopods large, thick, particularly those of the chelipeds (Pl. IV, Fig. 8; Pl. X, Fig. 2). Chelae of the male long and slender. Propus of each cheliped subhexagonal in cross section, vertically elongate, with a sharp outer ridge and a distinct inner ridge on the palm; a short spine on the dorsoproximal edge at the junction with the carpus (Pl. XII, Fig. 1); the slightly convex lower side ornamented with coarse low tubercles (Pl. XII, Fig. 14); the fixed finger in line with the lower edge of the palm in some specimens (Pl. XII, Figs. 7, 16) and turned up at a slight angle in others (Pl. XII, Figs. 3, 10), long and tapering, armed with coarse, irregular teeth molariform in the proximal part (Pl. XII, Figs. 1, 10–11). Cutting edges of propus and dactyl closely opposed (Pl. XII, Figs. 10–11, 16).

Buccal cavity wide and narrow. Outer maxillipeds with quadrate basi-ischia and tubular, tapering exopods (Pl. IV, Fig. 8; Pl. VI, Fig. 11). Mandibles large, each sharply constricted a short distance behind its sharp cutting edge; cutting edge lying along the proximal edge of a convex part of the mandible (Pl. VI, Fig. 12).

*Illustrated specimens.*—Two incomplete female carapaces, UMMP 34329 and USNM 562484; six incomplete male carapaces, UMMP 34333, UMMP 34622, USNM 562483, USNM 562485–562486, and UMMP 34619; two incomplete carapaces of unknown sex, UMMP 34330 and UMMP 34332; and five chelipeds, UMMP 34691–34695.

#### Family Goneplacidae Dana, 1851*b*

*Remarks.*—The crabs established here as a new genus and a new species are rather enigmatic, in that they have certain features which closely resemble those in crabs of several unrelated families. Their carapaces are neither distinctly subquadrate nor distinctly subelliptical, but rather intermediate between the two. Their anterolateral borders are round, with no anterolateral teeth. The front is broad and straight, without a furrow. The eye sockets are oval, not elongate, so that the distance between the outer orbital angles is considerably less than the greatest width of the carapace. The posterior border is long and straight. One male specimen retains on its ventral side a large piece of shell material (see Pl.

XII, Fig. 21), which is interpreted as a long pleonite of the abdomen. If this piece is actually a long pleonite, then some of the abdominal segments are fused and the male probably has only five pleonites instead of seven.

Smooth crabs such as these with broad, straight fronts, curved antero-lateral borders without teeth, and straight posterior borders are found in several genera of different families. The combination of characters occurs, for example, in the following groups:

Gecarcinidae (land crabs)

*Cardisoma* Latreille

*Ucides* Rathbun

*Gecarcinus* Leach

*Gecarcoidea* Milne-Edwards

Grapsidae (marine crabs)

*Acmaeopleura* Stimpson

*Cyclograpsus* Milne-Edwards

Pinnotheridae (marine, many parasitic crabs)

*Pinnixia* White

*Pinnaxodes* Heller

*Pinnotherelia* Milne-Edwards and Lucas

*Parapinnixia* Holmes

Xanthidae (marine crabs)

*Acidops* Stimpson

*Liagore* De Haan

*Galenopsis* Milne-Edwards

Portunidae, subfamily Catoptrinae (marine crabs)

*Libystes* Milne-Edwards

Potamonidae (freshwater crabs)

Goneplacidae (marine crabs)

*Cryptolutea* Ward

Furthermore, some species of *Carcinoplax* Milne-Edwards (family Goneplacidae) have only faint and inconspicuous anterolateral teeth, which scarcely interrupt the curved anterolateral borders.

In spite of such resemblances certain features in the crabs exclude them from some of these families: (1) The buccal cavity is not as high and the basi-ischia of the outer maxillipeds are smaller than those in members of the Gecarcinidae. (2) The shell material is thicker and harder than that in most species of Pinnotheridae. Moreover, the eye sockets are larger than in the pinnotherid crabs, many of which are parasitic and have very small eyes. (3) The branchial regions are even with the rest of the carapace, not swollen like those in the freshwater crabs of the Potamonidae. (4) The front has no median groove, as in known species of the unusual portunid genus *Libystes*.

Omitting these four leaves only the families Grapsidae, Xanthidae, and Goneplacidae for consideration. The Grapsidae are separated from the Xanthidae and Goneplacidae by the articulation of the carpus with the merus of the outer maxillipeds, which in the Grapsidae is at the distal end of the merus and in the other two families is at the antero-internal angle (Rathbun, 1917, pp. 14-15). According to Rathbun (1917, p. 14), the

Xanthidae and Goneplacidae are "not sharply separated"; the former are "usually transversely oval" and the latter are "usually square or squarish." In most species of the Xanthidae the male ducts are coxal, whereas those of the Goneplacidae are sternal, but there are exceptions in each family.

In the Guam crabs, neither the carpus of the outer maxilliped nor the opening of the male ducts are preserved. Definite familial assignment, therefore, cannot be made on characteristics now regarded as diagnostic, but certain features not usually considered in the classification, strongly indicate that the crabs belong to the family Goneplacidae. In the Xanthidae the carapace is subelliptical with a relatively short posterior border; in addition, the plastron is small in comparison to the dorsal surface, and, since its posterior border is short, has a more or less circular outline. In the Grapsidae, on the other hand, the carapace is nearly square, although the sides may be convex; the carapace is never much wider than long; and, if the front is deflected, it is invariably more than one-third as wide as the carapace and the distance between the outer orbital angles is nearly equal to the greatest width of the carapace. In contrast to these families, in the Goneplacidae the carapace is subquadrate with a long posterior border, the plastron (broad at the posterior edge) is more or less semicircular, most species are noticeably wider than long, and the front in many is about one-third as wide as the carapace. Since the characteristics of the crabs of the new genus and species agree with those of the Goneplacidae they are here assigned to that family.

#### Subfamily Carcinoplacinae Miers, 1886

*Remarks.*—The following abbreviated key to the subfamilies of the Goneplacidae is based on characteristics which can be seen in the specimens under consideration:

- A. Only four pairs of pereopods, the fifth pair absent ..... Hexapodinae
- B. Five pairs of pereopods
  - 1. Orbits very long, forming narrow trenches ..... Goneplacinae
  - 2. Orbits somewhat elongate, oval ..... Carcinoplacinae
  - 3. Orbits circular ..... Rhizopinae

Rathbun (1917, p. 17) described the subfamily Carcinoplacinae (the subfamily Prionoplacinae or Pseudorhombilinae of authors) as follows:

Carapace xanthoid, the regions seldom well defined; front usually of good breadth and square cut, often little deflexed; eyes and orbits usually of normal size and form, the eyes well pigmented and the eyestalks normally movable except in certain deep-sea genera; the antennules fold transversely; antennal flagella of medium length. Epistome well defined; buccal cavern square-cut and usually completely closed by the external maxillipeds, which have a subquadrate merus. The base of the third segment of the male abdomen covers the whole space between the last pair of legs. Male openings not sternal.

**Carcinoplacoides**, gen. nov.

*Type species.*—*Carcinoplacoides flottei*, sp. nov.

*Description.*—Carapace xanthoid, but with a rather long posterior border. Regions poorly defined. Carapace smooth. Front straight, deflected, about one-third as wide as the carapace, no central furrow. Orbits oval. Anterolateral borders round, no anterolateral teeth. Posterolateral borders curved, slightly convergent. Concave indentations of lateral border above the insertion of the posterior pereopods.

Plastron nearly semicircular. Abdomen of male subtriangular, tapering abruptly and sharply acuminate, composed of five pleonites. Abdomen of female broad, nearly covering the plastron, composed of seven pleonites.

Buccal cavity oblong, about half as wide as carapace. Basi-ischia of outer maxillipeds very broad. Articular cavities of antennae narrow, vertically elongate, proximal to eye sockets. Sockets of antennules large, transversely elongate, oval.

*Remarks.*—This genus closely resembles *Carcinoplax* Milne-Edwards, whence the name is derived, but differs from it in having no traces of anterolateral teeth. *Carcinoplacoides* is also very similar to *Cryptolutea* Ward (1939, p. 1), described as: "The carapace is moderately convex longitudinally; transversely flat. The fronto-orbital width is more than half the width of the carapace. The antero-lateral margins are arcuate but unarmed . . ." It is unlike *Cryptolutea* in that it has the carapace strongly convex transversely and five instead of seven pleonites in the male abdomen. Ward reported (1939, p. 2) that *Cryptolutea lindemanensis*, the type and only known species of the genus, lives near the strandline in Queensland, where it "excavates intricate burrows under the stones, extending from one to the other at an inch or two below the surface of the mud."

**Carcinoplacoides flottei**, sp. nov.

(Pl. III, Figs. 1-4; Pl. V, Fig. 8; Pl. VII, Figs. 4-5; Pl. XII, Figs. 19-23)

*Description.*—Carapace small, smooth, subovoid, rather truncate at the front and rear. Dorsal surface strongly arched from front to rear (Pl. V, Fig. 8), very gently arched from side to side (Pl. III, Fig. 4; Pl. XII, Fig. 22). Length/width ratio approximately 1/1.6. Greatest width located about one-third the length behind the front.

Front straight, broad, deflected, slightly less than one-third the greatest width of the carapace, no furrow (Pl. III, Figs. 1, 4). Each eye socket oval, with a low C-shaped ridge around its dorsal, outer, and ventral borders, forming a shallow concavity as seen in dorsal view. Distance

between the outer orbital angles about three-fifths the greatest width of the carapace. Ophthalmic foramina located at the inner edges of the eye sockets (Pl. III, Fig. 4). Two very small, vertically elongate, narrow openings, one at the inner edge of each eye socket and about on the same level with the rim around the socket (Pl. III, Fig. 4; Pl. XII, Fig. 22), presumably the articular cavities of the antennae. Two large, transversely elongate, oval sockets between the narrow openings just mentioned, one on each side of a median septum (Pl. XII, Fig. 22), presumably the sockets of the antennules.

No anterolateral spines; the anterolateral borders round. Lateral borders gently convex, except for a distinct concave indentation on each side at the junction of the lateral and posterior borders, just above the insertion of the posterior pereopod. Posterior border straight, about  $9/16$  the greatest width of the carapace. A distinct rim along the edge of the posterior and posterolateral borders, becoming indistinct near the middle of the lateral borders.

Very little relief or demarcation of the regions on the smooth dorsal surface. Low, curved angulation extending obliquely forward from each end of the posterior border, becoming indistinct in the branchial region. Faint, slightly depressed, more or less H-shaped marking in the central posterior part of the carapace, the front part probably the cervical groove and the rear part probably bounding the cardiac and intestinal regions (Pl. III, Fig. 1). In a specimen with the shell exfoliated from the central region, steinkern showing this marking as two distinct, slightly curved, transverse grooves, set close together and parallel, both very faint in the median parts; the anterior groove with two very small pits, one on each side of the midline, and divergent, short, anterolateral extensions; the posterior groove with strongly divergent posterolateral extensions (Pl. XII, Fig. 20).

Two long, slender, cylindrical processes visible through the eye sockets of the hollow holotype, hanging down inside the carapace at the position of the pits on the steinkern (Pl. XII, Fig. 20) and of small indentations on the exterior of the cervical groove (Pl. III, Fig. 1), presumed to be for attachment of the internal adductor muscles of the mandibles.

Each pterygostomian region convex, its junction with the dorsal surface marked by an irregular row of small tubercles and by a low ridge near and joined to the rim around the eye socket (Pl. III, Fig. 4; Pl. XII, Fig. 22). Pterygostomian region ornamented with small, pointed tubercles, becoming small and indistinct on the suborbital extensions. Buccal cavity oblong, apparently almost half as wide as the entire carapace (Pl. XII, Fig. 23).

Of the outer maxillipeds, only parts of the exopods and basi-ischia preserved; exopod well developed, slightly curved, proximally convex; basi-ischium very broad, posteriorly acuminate, its proximal half raised and thicker than the distal half and anteriorly extending a little farther forward with a rounded tip (Pl. XII, Fig. 23).

Plastron nearly semicircular (Pl. XII, Figs. 22-23). The fused sterna of the postoral cephalic and the first four thoracic somites (the anterior segment of the plastron) large, in the shape of a quadrant of a circle, the curved side anterior; a deep V-shaped median channel (to accommodate the abdomen) extending about three-fifths of the distance toward the anterior end of the segment, its front part becoming narrow and shallow and terminating with very short lateral extensions. Arrangement of episterna in this crab very unusual, the ventral spur of the coxa on the cheliped articulating with a notch entirely within the episternum of the terminal segment, and the spurs of the coxae on the next three pereopods articulating with notches between adjacent episterna; contrary to the arrangement in most crabs, the coxae of the anterior four pereopods in this species not touching the sterna of their corresponding somites. Sterna of the fifth, sixth, and seventh thoracic somites (the second, third, and fourth segments of the plastron) of about the same width, radiating from the posterocentral part of the plastron. Median channel accommodating the abdomen deep, flaring greatly behind the anterior segment, occupying nearly all the space between the posterior pereopods (Pl. XII, Fig. 23). Sternum of the eighth thoracic somite (the rear segment of the plastron) with only small sections at the sides of the extremely wide median channel.

Each episternum of the anterior segment large, set off from the fused sterna by a broad groove; episternum more or less bluntly E-shaped, consisting of two connected lateral lobes lying ahead of the posterior border of the fused sterna and bounding the notch articulating with the coxa of the cheliped, a posterior extension lying entirely alongside the episternum of the next somite (not in contact with the sternum of the next somite), and a lateral terminal lobe forming the anterior side of the notch articulating with the spur of the second pereopod (Pl. XII, Figs. 19, 21). A small semicircular lobe, considered to be part of the sternum instead of the episternum, lying ahead of each episternum of the anterior plastral segment but not connected to it, set off from the rest of the sternum by a narrow groove (Pl. XII, Figs. 21, 23). Episternum of the fifth thoracic somite lying along the entire side of the corresponding sternum but divided from it by a faint groove; episternum more or less b-shaped, consisting of a narrow anterior strip alongside the inner edge of the episternum of the preceding plastral segment, a small, shallow

central notch articulating with the coxal spur of the second pereopod, and a very large semicircular posterior lobe extending from the middle of the sternum of its own somite almost to the middle of the sternum of the next somite, its posterior half lying along the outer edge of the episternum of the next somite (Pl. XII, Fig. 19). The notch articulating with the coxal spur of the second pereopod formed by two episterna, that of its own (the fifth thoracic) somite and that of the preceding fused somites.

Episternum of the sixth thoracic somite similar in size and shape to that of the preceding somite, but the posterior part of its lobe lying alongside the next sternum instead of episternum (Pl. XII, Fig. 19). The notch articulating with the coxal spur of the third pereopod formed by two episterna, that of its own (the sixth thoracic) somite and that of the preceding (the fifth thoracic) somite. Episternum of the seventh thoracic somite about the same shape as the two preceding episterna but much smaller and shorter; its narrow anterior strip extending only to the front edge of the articulating notch of the fourth pereopod, delimited from the adjacent sternum by a very faint, inconspicuous groove and distally bounded by the rear extension of the preceding episternum (Pl. XII, Fig. 19); its rear lobe small, projecting backward along the edge of the last thoracic sternum to the articulating notch of the posterior pereopod. No episternum on the last thoracic somite; the sternum of this somite indented at the middle of its edge to form the rear half of the articulating notch of the posterior pereopod.

Abdomen incomplete in each specimen. Abdomen of female very broad but probably not covering the entire plastron except, perhaps, at its base between the rear pereopods; a short linguiform telson preceded by two pleonites of about the same length; other pleonites apparently shorter but crushed and disarticulated (Pl. XII, Fig. 19). Abdomen of male apparently confined to the accommodation channel in the plastron, wide at its base and nearly filling the space between the rear pereopods, tapering very abruptly and sharply acuminate; the first preserved pleonite (apparently the fused third, fourth, and fifth abdominal somites) very large, the next pleonite (apparently the sixth abdominal somite) incomplete, and the telson entirely missing (Pl. XII, Fig. 21).

Pereopods very incomplete. Coxa of the cheliped with a much greater diameter than that of the other coxae (Pl. XII, Figs. 19, 21, 23).

*Remarks.*—The larger male, UMMP 34698, has a more subquadrate and less xanthoid carapace than the smaller UMMP 34303. The same ontogenetic change in shape occurs in *Carcinoplax longimanus* (De Haan), as is shown in figures by De Haan (1833, Pl. 6, Figs. 1a-c) and by Sakai (1939, Pl. 101, Figs. 2-4).

The species is named in honor of Dr. C. T. Flotte, who discovered the specimens.

*Types*.—Holotype, a male carapace, UMMP 34303. Paratypes, a male carapace, UMMP 34698, an incomplete female carapace, UMMP 34697, an incomplete male carapace, USNM 562477, and an incomplete female carapace, USNM 562478.

**?*Carcinoplacoides flottei*, sp. nov.**

(Pl. XI, Figs. 1-3)

*Description*.—One specimen, consisting of only a small segment of the carapace, parts of the plastron and abdomen, and incomplete pereopods of the right side, and closely resembling *Carcinoplacoides flottei*, sp. nov., in the shape of the posterolateral border and the plastron. Apparently an immature female, but the abdomen not as large as that of the paratype female, UMMP 34697, of *C. flottei*. The pereopods more nearly complete than those in any of the specimens of that species.

Merus of cheliped massive, subtriangular in cross section, with a slightly concave frontal face and convex posterodorsal and posteroventral faces; as seen from the front (Pl. XI, Fig. 1), the upper edge curved rather sharply downward to its junction with the basi-ischium, and the lower edge straight. Distal end of merus very large, its posterodorsal margin bearing a curved fissure extending to the end, giving the terminus a crimped or buckled appearance (Pl. XI, Fig. 2).

Coxae and basi-ischia of walking legs small. Meri of walking legs long and very slender, that of the posterior pereopod slightly wider and shorter than in the preceding pereopods, with a terminal constriction and narrow collar. Carpus of posterior pereopod less than half as long as merus, small, very narrow at its base, distally flaring.

*Remarks*.—The strong similarity between the plastron of this crab and that in the specimens classified as *Carcinoplacoides flottei*, particularly in the episterna, leads me to believe they are one species. If this be true, the pereopods of *C. flottei* are much like those in species of *Carcinoplax*, such as *Carcinoplax longimanus* (De Haan), in which only the merus of the cheliped is large and massive, and the meri of the walking legs are very slender.

*Illustrated specimen*.—Part of right side of a carapace with attached meri of pereopods, UMMP 34688.

PALEOECOLOGY

The two crabs still living in the Pacific region, *Macrophthalmus latreillei* and *Podophthalmus vigil*, serve as reliable indicators for the paleoecology of the fossil fauna, for it may logically be assumed that the

species formerly lived in the same kind of environment as that in which they are now found. As in other aspects of paleontology, the present is the key to the past. *Macrophthalmus latreillei*, as do other species of the genus, lives on flat muddy bottoms near the shore. When disturbed, the crabs bury themselves in the mud with only the tips of their long stalked eyes projecting above its surface. In Remy's (1952a, p. 34) words, the crabs of this genus inhabit "les flaques de boue; le long de la mer, dans la zone de balancement des marées." He studied reports of fossil occurrences and concluded (p. 34) that the extinct crabs lived in and on the sediment in which they were entombed. Moreover, he found no evidence that the habits of *Macrophthalmus* have changed since the genus appeared in the Miocene. At the present time species of *Macrophthalmus* are found throughout the Indian and Pacific Ocean regions, from Japan to Australia, and from the Red Sea eastward to Singapore, Hawaii, and the west coast of the United States. Wherever they occur, they live near shore, in bays, in estuaries, and in marine swamps.

The other indicator species, *Podophthalmus vigil*, also lives on muddy bottoms in shallow water. Van Weel, Randall, and Takata (1954, p. 209) described it as "a swimming crab found in large numbers on and in muddy flats rich in organic matter," and remarked further (p. 217), that "The crab, which swims surprisingly little and remains buried in the mud during the day, lives in a habitat decidedly poor in oxygen." From this, one concludes that *P. vigil* differs markedly from other crabs of the family Portunidae, some species of which swim so actively near the surface of the sea that they catch mackerel. The crabs of this species probably swim nocturnally, or at least move about actively at night, for Edmondson (1954, pp. 219-20) states, "Such larger swimming crabs as *Portunus sanguinolentus*, *Podophthalmus vigil*, and *Scylla serrata*—which frequent bays, harbors, and sheltered situations about the islands [in Hawaii]—are often taken in trips and baited nets. These larger forms are valued as food, and quantities of them are sold at the fish markets." Delsman and De Man (1925, pp. 314-15, 318) also list *P. vigil* as one of the commercial species in Batavia, but Tweedie (1937, p. 163) remarks that at Singapore, "Their presence in the market was exceptional; they are not regularly sold as food."

The fossil crabs from Guam lived in the sublittoral zone. One assumes that the water in Apra Harbor was about the same depth when they were alive as it was before dredging operations began. The harbor was quite likely a polyhaline bay, extending a little way to the north between the mainland and connected to the sea by a channel lying offshore from the Orote Peninsula. Fresh water from small streams emptying into the bay

may have diluted the marine water, but only slightly. The calcareous mud on the bottom must have received a considerable quantity of weathered volcanic debris, carried out from the land by streams and surface wash. In other words, at that time the physical geography differed little from that of today. Because *Macrophthalmus latreillei* and *Podophthalmus vigil* have such a wide geographic range, one can only express the opinion that the fossil specimens inhabited waters no colder than those in southern Japan today and probably no warmer than those in the equatorial regions. The many fossil crabs point to an abundant supply of organic matter, which is indicative of a teeming community in the bay.

One might speculate on the manner in which these crabs died in such great numbers. Over two hundred specimens have been found, and undoubtedly, a more thorough search would uncover many times that number. That the crabs were buried alive seems certain, for the collection of *Macrophthalmus latreillei* includes old females, adult males, young females, and very young crabs. The fossils are not exuviae, but complete skeletons. Perhaps the crabs perished in some catastrophe, buried alive in calcareous mud.

Typhoons are now common in the region of the western Pacific, but it is doubtful that a tropical storm was responsible for wiping out this fauna. Malaysians include *Podophthalmus vigil* in the bottom-dwelling, paddle-footed commercial crabs, which they call "radjungans." Delsman and De Man (1925, p. 318) wrote, "According to fishermen the radjungans are found a little distance above the bottom when the weather is rough. Evidently they are swimming then, perhaps the water is troubled near the bottom which is quite possible as the radjungans live in depths varying from two or three to ten fathoms only." It seems likely that a typhoon, which gradually increases in intensity, would have alerted most of the *Podophthalmus vigil* and caused them to swim above the disturbed, roiled zone.

The island arcs are noted as regions of crustal unrest. Earthquakes are frequent, some of them violent. An earthquake is the logical cataclysmic force that could dislodge the unconsolidated sediments from near to shore, starting a submarine slide that buried the crab community completely. *Podophthalmus vigil* is brought up by Batavian fishermen from about 15 fathoms (Delsman and De Man, 1925, p. 315), a depth that allows ample slope shoreward on which such a slide might have developed. The bay may have been repopulated several times, with successive thriving communities meeting a common fate.

Dr. Tracey wrote (letter dated January 20, 1958):

Since 1825 there have been 19 moderately severe earthquakes recorded on Guam, and two, in 1849 and 1902, very destructive (intensity IX on the old Rossi-Forel scale). The latter [1902] was observed by Cox, who described the damage in some detail and mentioned among other things the occurrence of many landslides in the mountains.

The enclosed nature of the inner harbor would suggest that a relatively minor slide, caused either by a quake or a heavy rain in the drainage basin of the harbor, could pump a lot of material into the harbor. I would not be surprised, then, if at some later time when it is possible to get good complete cores from the harbor, a good many catastrophes will be recorded.

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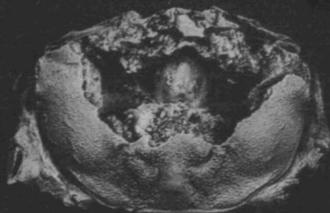
**PLATES**

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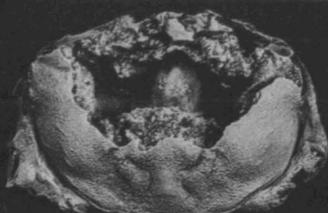
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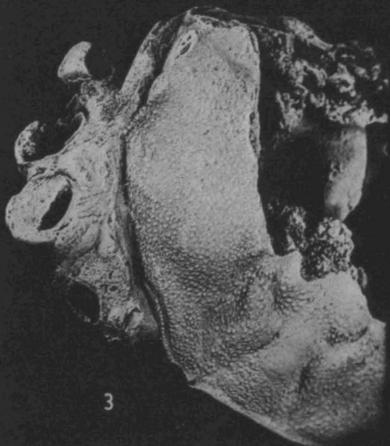
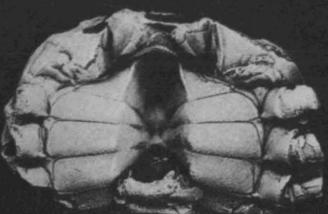
PLATE I



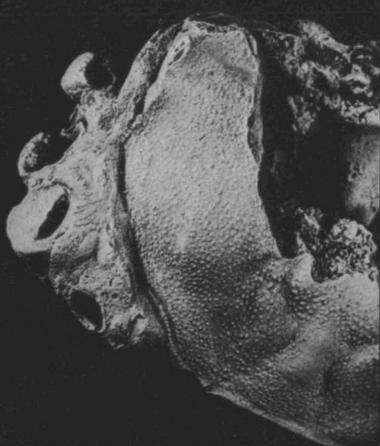
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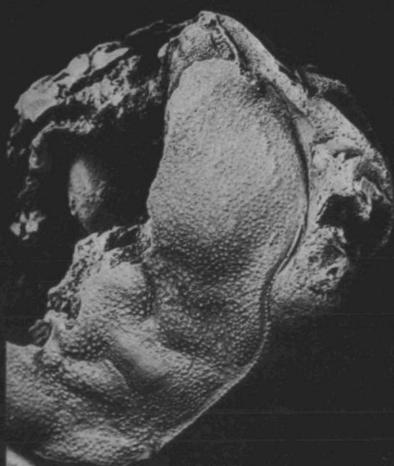
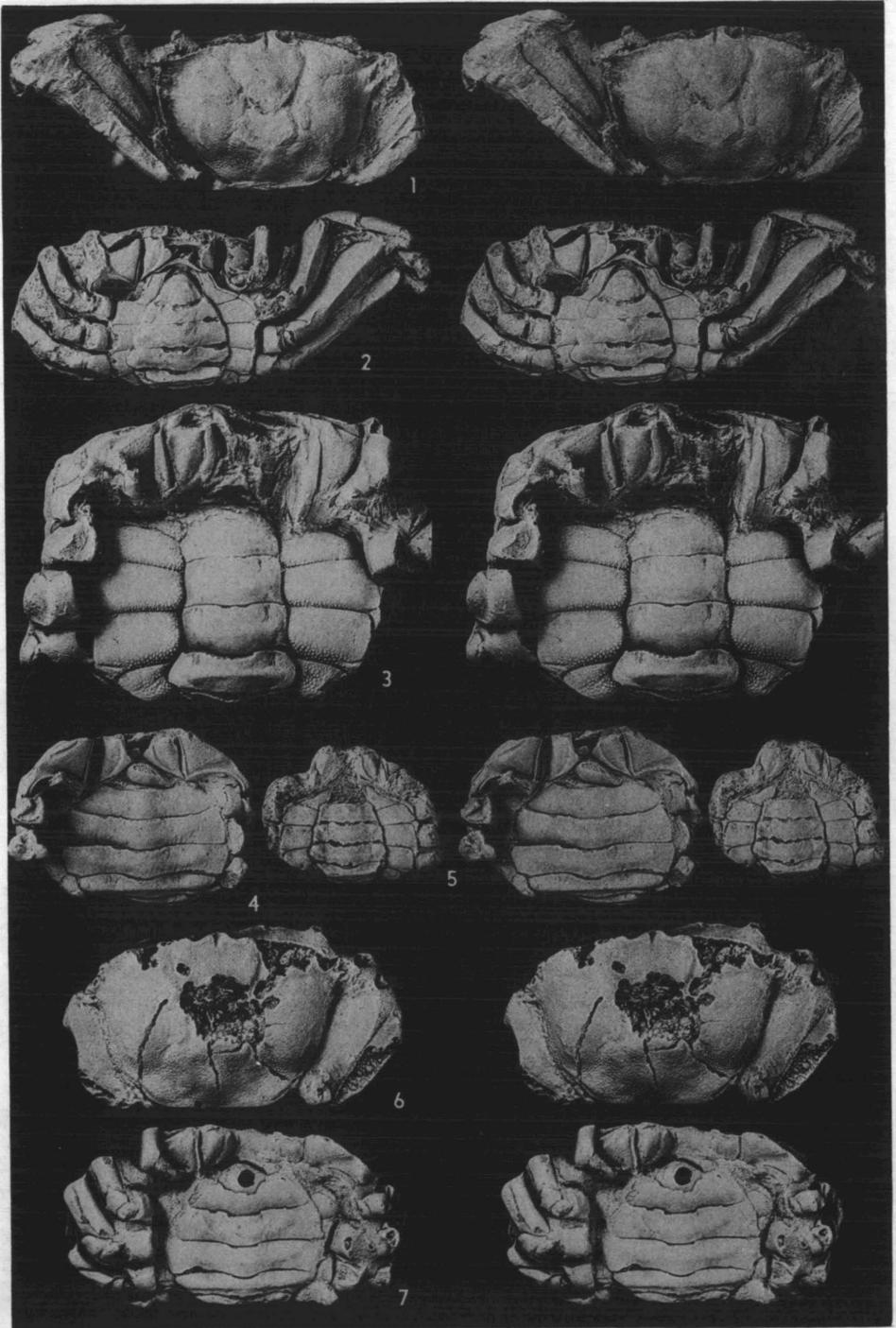


PLATE II



## EXPLANATION OF PLATE II

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PLATE III

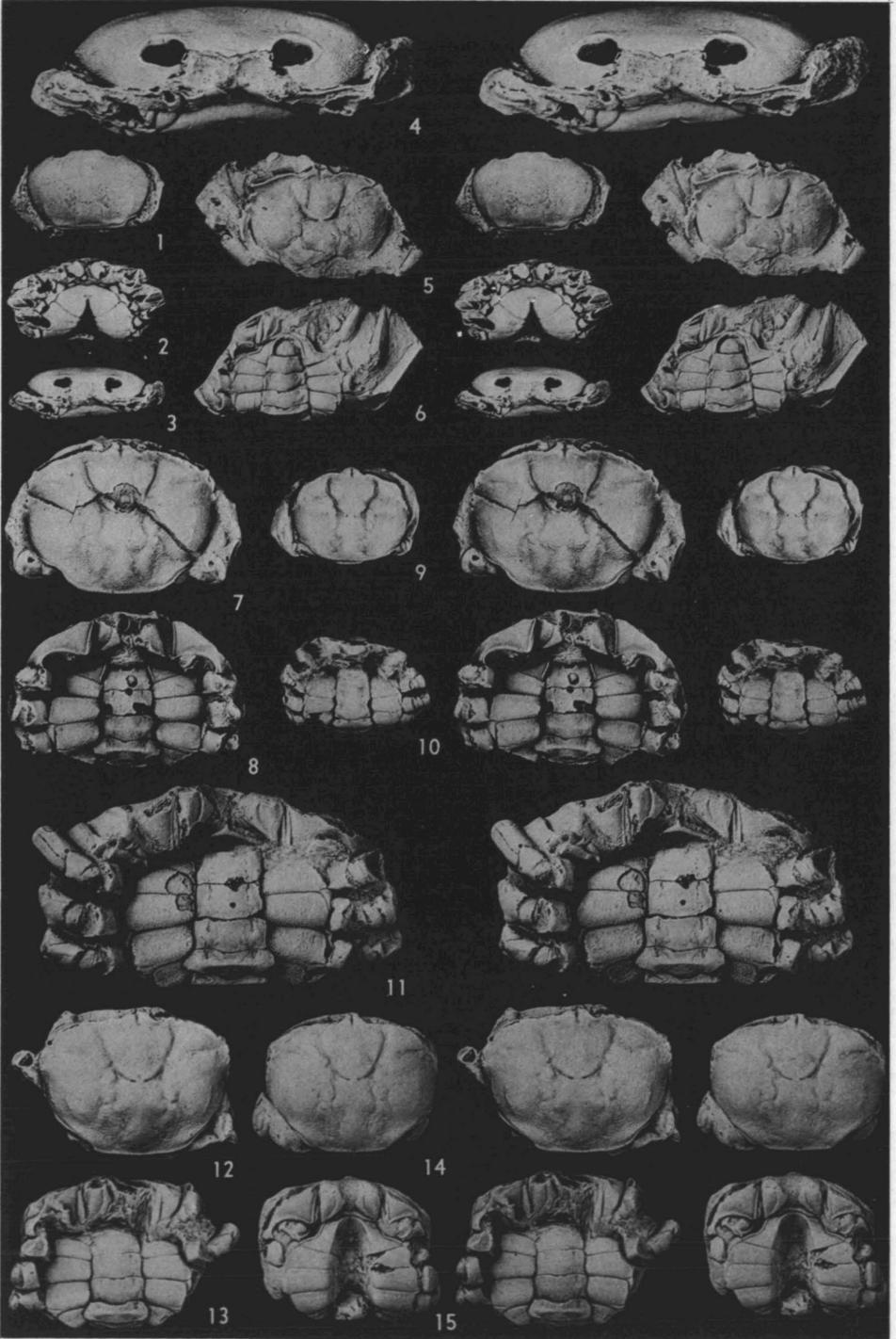
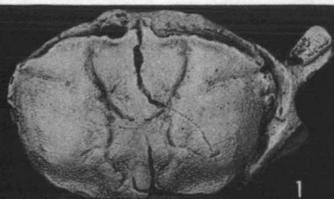
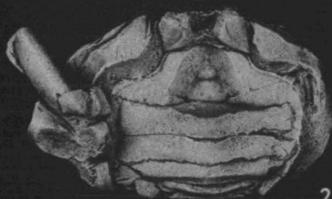


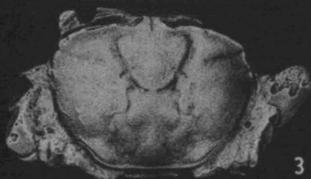
PLATE IV



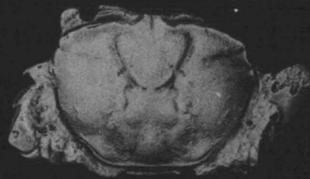
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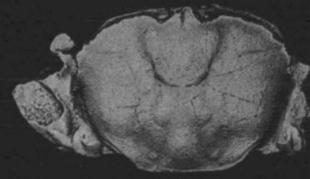
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PLATE V

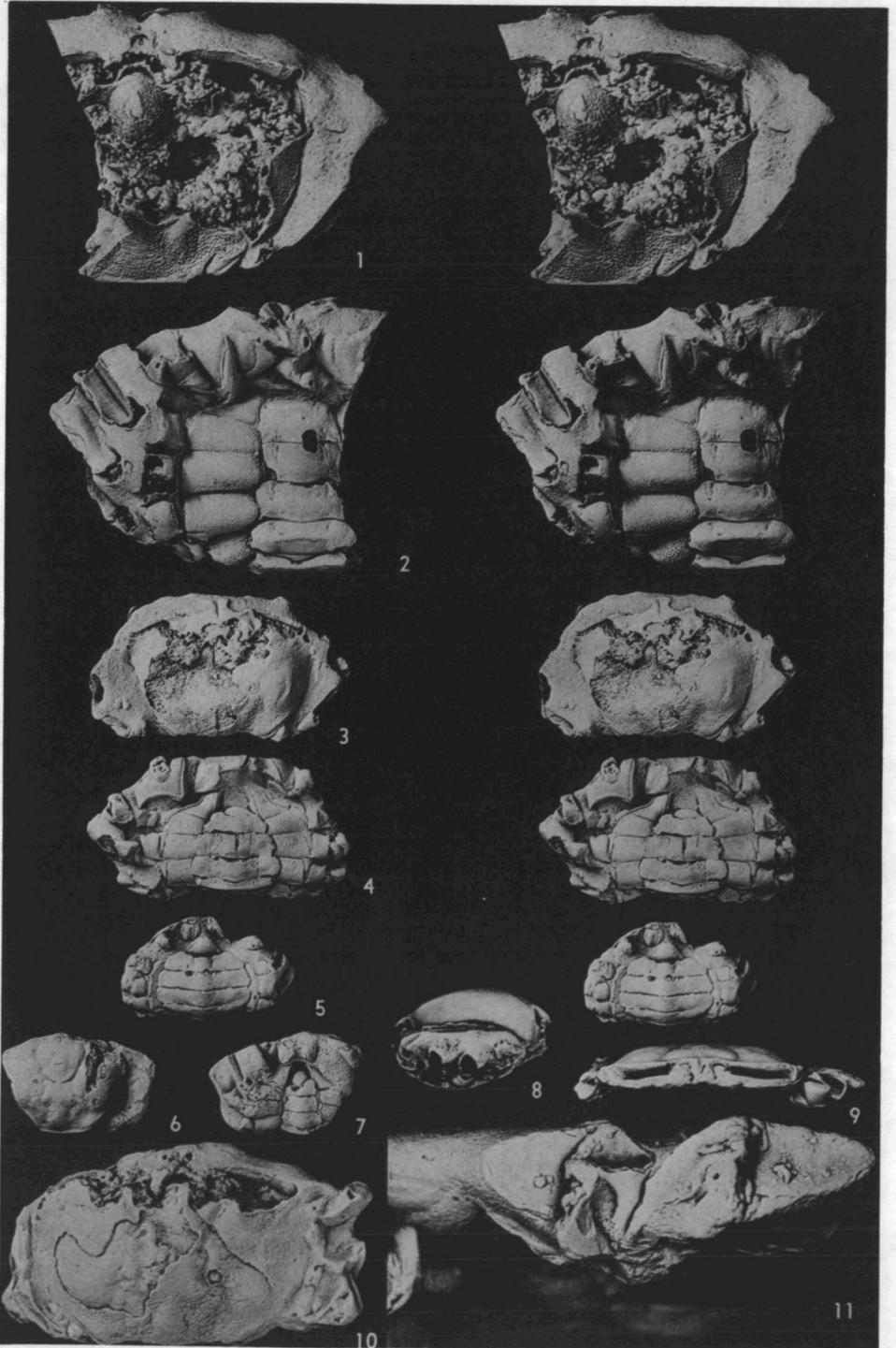
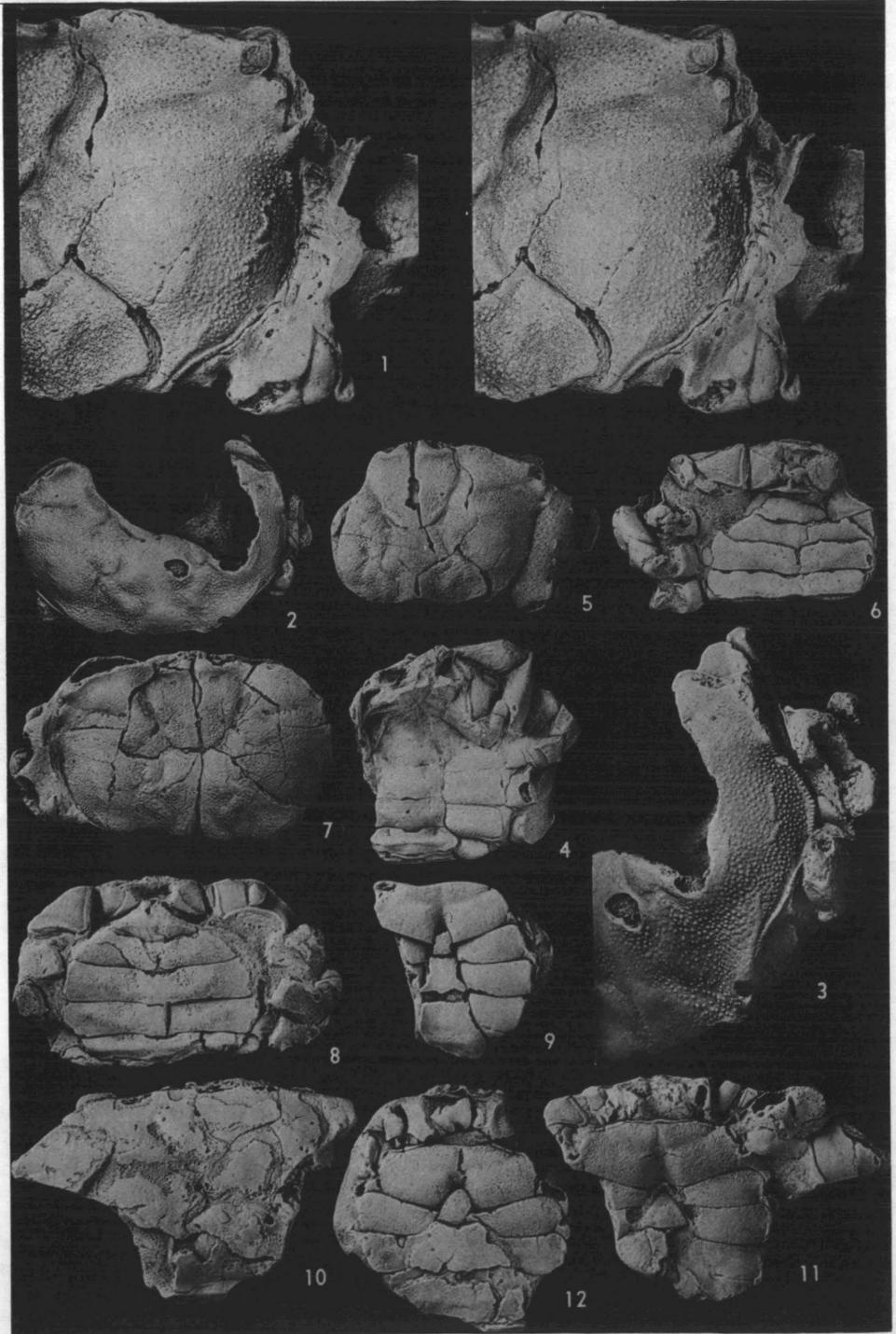


PLATE VI



## EXPLANATION OF PLATE VI

(All figures, except as noted,  $\times 1$ )

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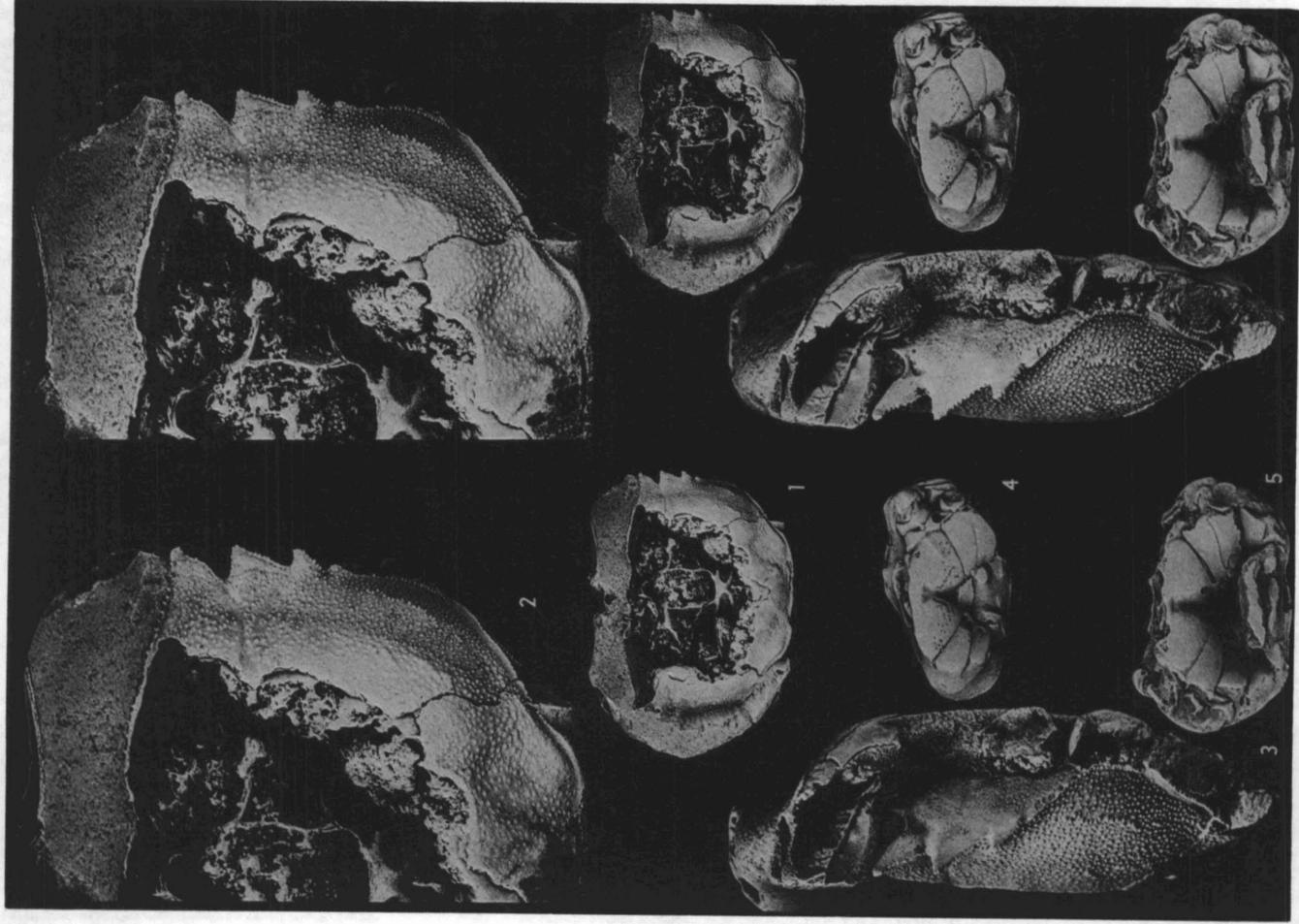
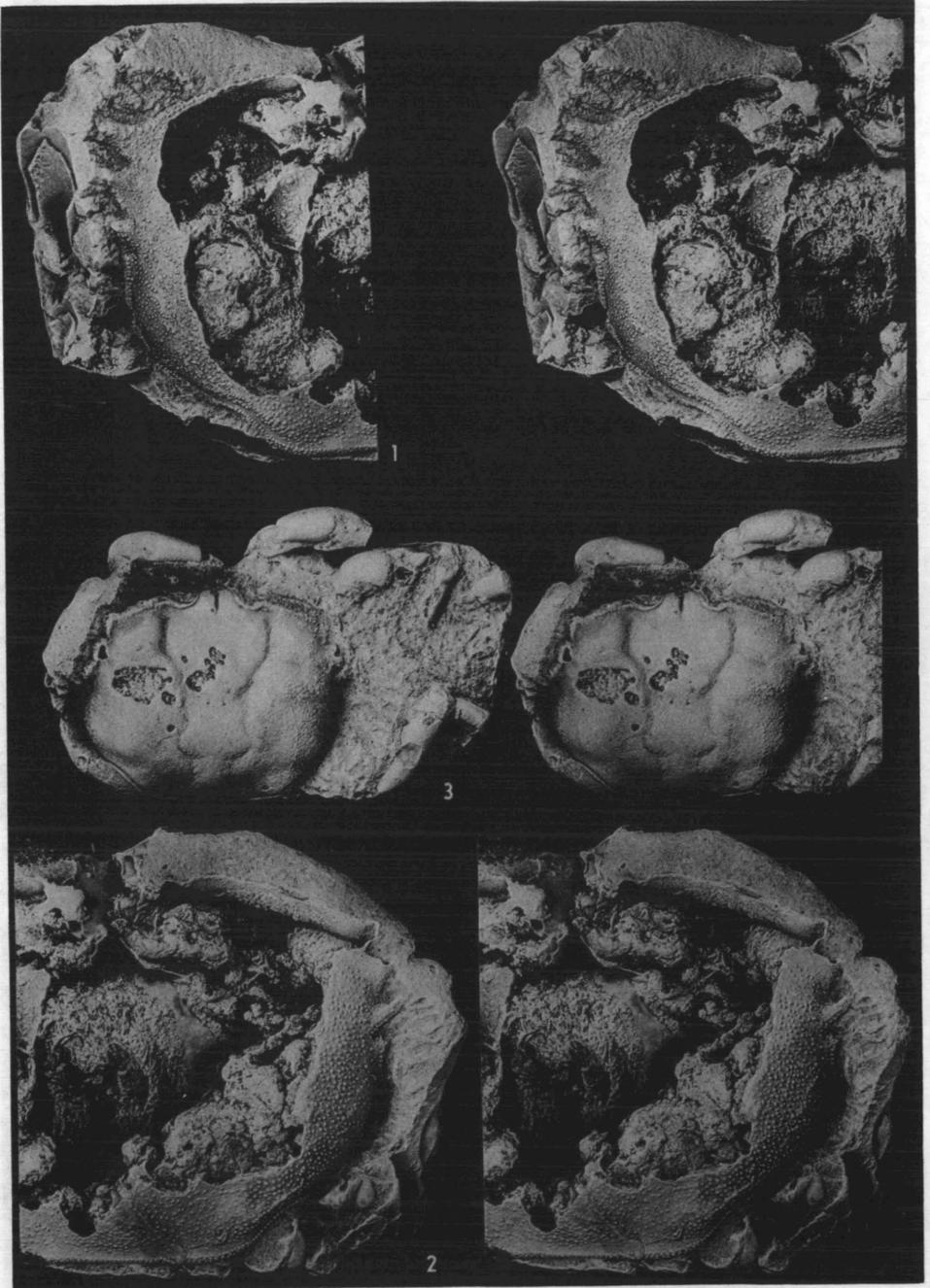


PLATE VIII



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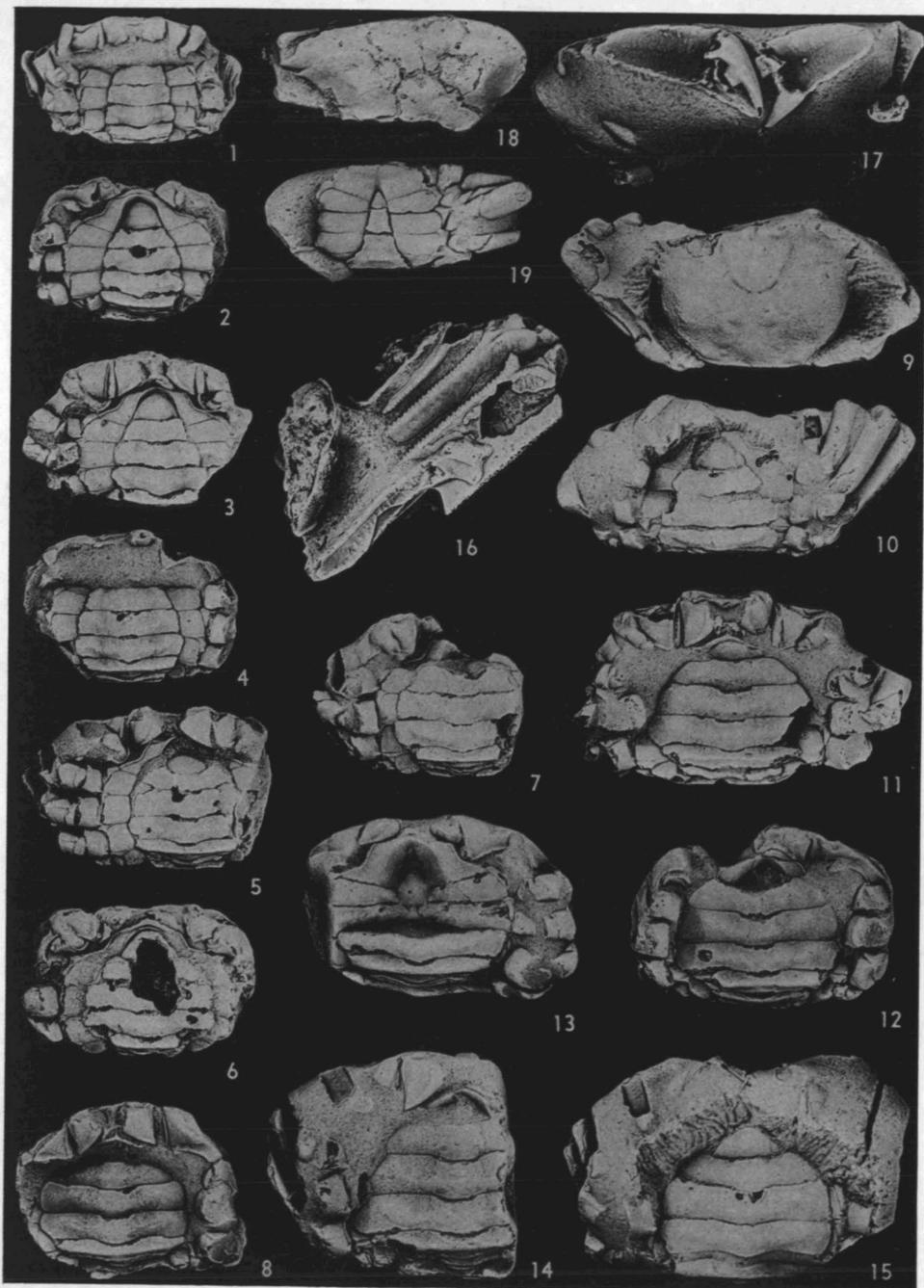
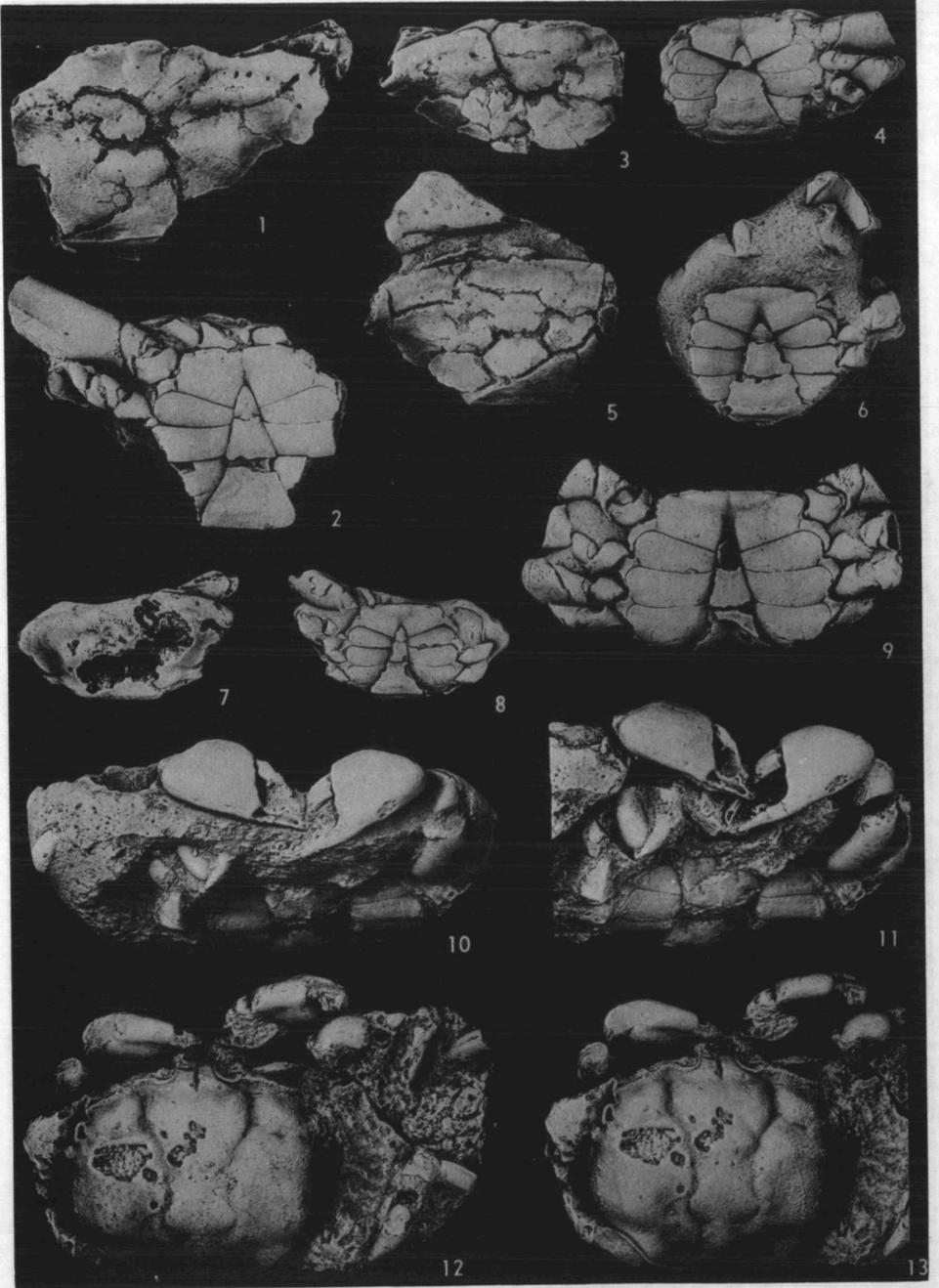


PLATE X



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PLATE XI

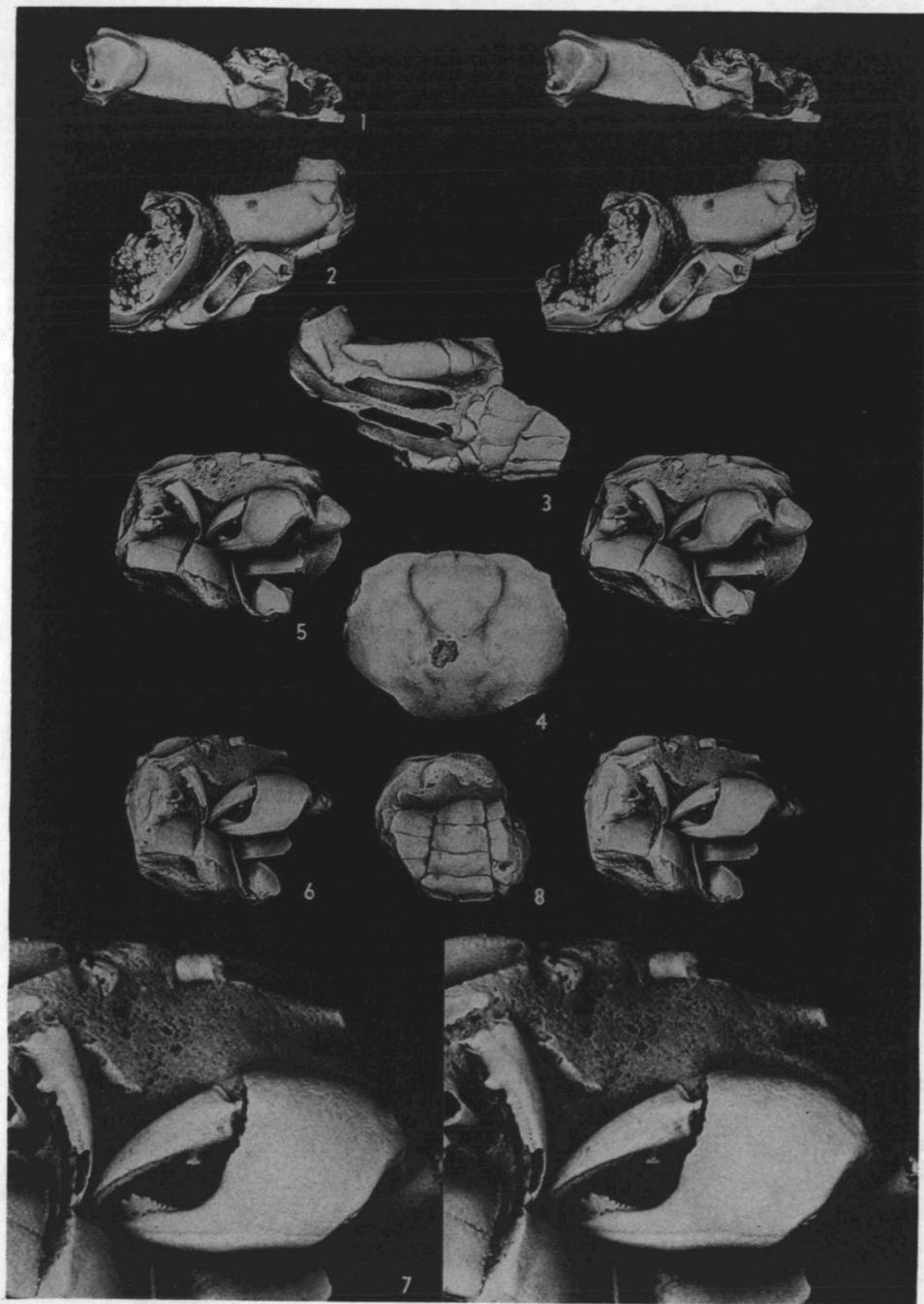
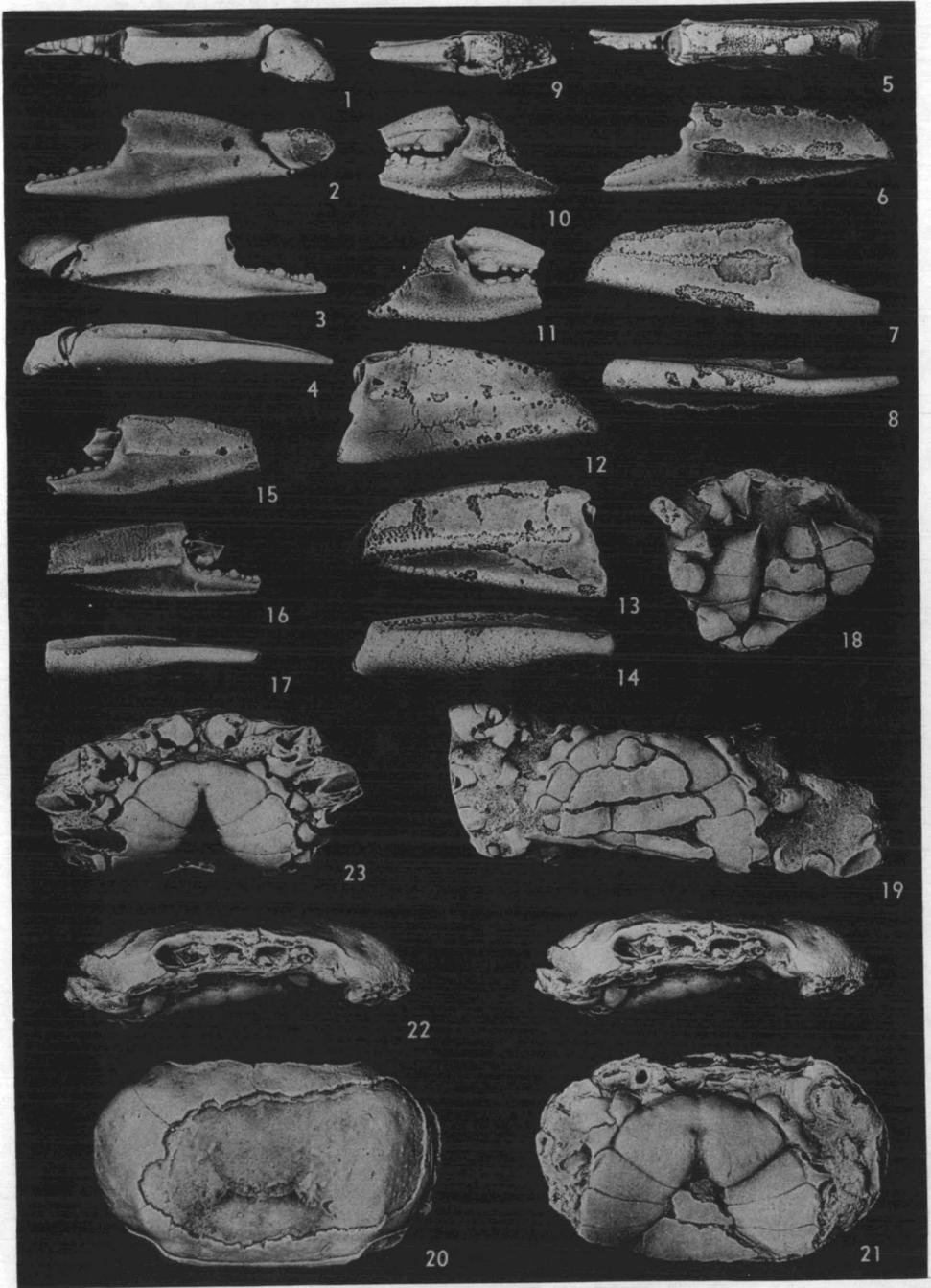


PLATE XII



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FIG. 19. Ventral view ( $\times 2$ ) of an incomplete female carapace which does not have any part of the dorsal side preserved, paratype, UMMP 34697.	
FIGS. 20-22. Dorsal and ventral views and anterior stereogram ( $\times 2$ ) of a male carapace, paratype, UMMP 34698.	
FIG. 23. Ventral view ( $\times 2$ ) of male, holotype, UMMP 34303. Other views in Plate III, Figures 1-4 and Plate V, Figure 8.	

