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THE LITTORAL ANOMURAN DECAPOD CRUSTACEAN FAUNA OF THE PUNTA PEÑASCO-BAHÍA LA CHOLLA AREA IN SONORA, MEXICO.

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# THE LITTORAL ANOMURAN DECAPOD CRUSTACEAN FAUNA OF THE PUNTA PEÑASCO-BAHÍA LA CHOLLA AREA IN SONORA, MEXICO

by

Clinton Albert Westervelt, Jr.

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A Dissertation Submitted to the Faculty of the

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In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

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THE UNIVERSITY OF ARIZONA

GRADUATE COLLEGE

I hereby recommend that this dissertation prepared under my direction by Clinton A. Westervelt, Jr.

entitled THE LITTORAL ANOMURAN DECAPOD CRUSTACEAN FAUNA OF THE PUNTA PEÑASCO-BAHÍA LA CHOLLA AREA IN SONORA, MEXICO

be accepted as fulfilling the dissertation requirement of the degree of DOCTOR OF PHILOSOPHY

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SIGNED: Clinton A. Weatherford Jr.

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ABSTRACT

The Anomuran crabs have often received little attention in contrast to the Brachyuran and Macruran Decapods in various survey studies. This is an especially pronounced fact in the northern part of the Gulf of California. With the exception of the excellent monograph on Eastern Pacific Porcellanids, there are no thorough studies on the Anomurans in this area. A few scattered papers have been published, but many of these are based on small, incomplete collections from shipborne expeditions.

The Gulf of California is the northernmost extension of the Panamic Marine Province and exhibits important phenomena that influence the zoogeographical and ecological distribution of its marine life forms. Particularly interesting in this littoral study is the remarkable tide range in the collecting area, amounting to about 20 to 22 feet during some new and full moon periods.

The littoral Anomuran fauna in this collecting area consists of a total of 26 species exclusive of the Callianassidae. This total number may be divided systematically into the following families: (1) Porcellanidae, with 15 species; (2) Paguridae with 9 species, some of which have been illustrated by the author for the first time; (3) Axiidae with one species; and (4) Albuneidae,

also with one species. Keys and illustrations for the identification of these 26 species are included.

The ranges of 6 species are extended farther north into the Gulf of California, as follows: Axius (Neaxius) vivesi is extended about 500 miles from La Paz, Baja California; Pagurus lepidus and Pagurus albus are extended about 300 miles from Bahía de Santa Inez, Baja California; Petrolisthes crenulatus is extended 130 miles from Angel de la Guarda Island; Petrolisthes tiburonensis and P. schmitti are extended to the north and east about 60 miles from San Felipe. A new combination is made for the pagurid Pylopagurus roseus (Benedict) (=Pagurus roseus (Benedict)).

Comparison studies of the distribution and affinities of the 26 Anomurans collected in this study show that 11 (42 per cent) appear to be endemic, including 4 porcellanids, 6 pagurids and one axiid. Twelve species (46 per cent) are Panamic in distribution and also occur throughout the Gulf. These Panamic species are represented by 8 porcellanids, 3 pagurids and one albuneid. Three species of Petrolisthes (12 per cent) occur throughout the Gulf and have also been collected at Bahía de la Magdalena on the Pacific side of Baja California. These figures agree rather closely with the distribution studies of other authors.

Some behavior notes on several of the species collected are indicated and special reference is given to

observations on Pylopagurus roseus and Petrochirus californiensis. The feeding methods of several species are discussed and the second known reference to antennary feeding in hermit crabs is described for Isocheles pacificus and for a new species of Paguristes from the sand flats of Bahía la Cholla.

# INTRODUCTION

This study was undertaken to increase our knowledge of the littoral Anomuran Decapod Crustaceans in the northern part of the Gulf of California. This area is one of the northernmost extensions of the Panamic Marine Province (Dall 1909) and exhibits some important phenomena that influence the zoogeographical and ecological distribution of its marine life forms.

The marine animals, with a few exceptions, such as the mollusks, are not well known and have received only cursory study as is characteristic of shipborne collecting expeditions. Early collections often resulted in short species descriptions, and in inaccurate type localities. Many of the Anomuran species collected in this study have received only token attention in the amount of one or two published references since the original description.

Almost nothing has been published on the ecology, feeding methods or behavior of these Gulf species. An example of this is Axius (Neaxius) vivesi, originally described in 1895 in seven lines of text with a type locality of "Lower California." Until 1941, with the publication of the very useful Sea of Cortez, by Steinbeck and Ricketts, nothing was known of the ecology of this species. Also, many distribution ranges were not fully

known as to their northernmost limit in this desert-modified marine environment. Ranges have been extended in a few cases almost throughout the length of the Gulf of California.

The reasons, then, for this study are multiple in nature. Primarily, it has been the author's mission to determine the littoral Anomuran fauna in the Puerto Peñasco-Bahía la Cholla area. In addition to identification of the fauna, other information has accumulated on the ecology and distribution of the several species.

Some of these Anomurans have been taken to the laboratory where they were maintained for observation. Because of the fact that they will do well and apparently thrive at room temperature, it has been possible to take preliminary notes on their behavior, including feeding methods, and on the interesting shell-changing conduct of some hermit crab species.

In all, 29 species of littoral Anomurans have been collected in this limited coastline area of about five or six miles. This includes 15 species of the family Porcellanidae, the flattened porcelain crabs, 9 species of hermit crabs or Paguridae, one each of the families Axiidae and Albuneidae. In addition, three species of the family Callianassidae were collected and will be determined in another study. This brings the total to 29 species in only

one section of the Decapod Crustaceans that occur in this limited, intertidal area.

New range extensions northward are indicated for six species. Axius (Neaxius) vivesi is extended 500 miles to the north. Two species of hermit crabs in the genus Pagurus, P. lepidus and P. albus, are extended 300 miles to the north. Petrolisthes crenulatus is extended 130 miles, while P. tiburonensis and P. schmitti are now established about 60 miles to the north and east of San Felipe.

Comparison studies of zoogeographical distribution and affinities show that of 26 species in the author's collections, 11 (42 per cent) appear to be endemic, including 4 porcellanids, 6 pagurids and one axiid. Twelve species (46 per cent) are Panamic in distribution, and also occur in the Gulf from Puerto Peñasco southward; this group can be subdivided into eight porcellanids, three pagurids and one albuneid. Three species of Petrolisthes (12 per cent) occur throughout the Gulf and have also been collected at Bahía de la Magdelena on the Pacific side of Baja California. These figures appear to agree with previous studies on the distributions of Brachyuran Decapods (Garth 1960, Glassell 1934) and other studies on various invertebrate phyla.

## COLLECTING AND EXPEDITIONS IN THE GULF OF CALIFORNIA

The Gulf of California has received relatively little attention from marine zoologists compared to other coastal areas located in close proximity to the United States. This is due primarily to the fact that the Gulf is located in a comparatively hostile, sparsely settled, desert environment. Roads to the Gulf were almost non-existant 100 years or so ago, and even at the present time few roads reach the shores of this very rich collecting area. This is especially true on the Baja California side where the roads still remain in a primitive condition. The west coast highway of Mexico has been of great importance in opening up the eastern shores of the Gulf to collecting, and such areas as Puerto Peñasco, Guaymas, Kino Bay, San Felipe and Mazatlan are now easily reached by automobile.

At the present time two marine stations are established on the shores of the Gulf of California. The Vermilion Sea Field Station is located at Bahía de los Angeles on the east coast of Baja California. This station is operated by the San Diego Natural History Society with financial support from the National Science Foundation. This station, the first really productive station scientifically speaking, has produced several publications, especially in the fields of Ichthyology and Malacology

(McLean 1961). Besides the studies of the marine life of that area of the Gulf, herpetological studies on the off-shore islands are in progress by several scientists at the University of California at Los Angeles.

The University of Sonora and the University of Arizona have been negotiating for the past nine years to build a marine station in the Puerto Peñasco area. Four years ago the hopes for such a project were increased when the Institute of Atmospheric Physics of the University of Arizona and the Office of Saline Water of the U. S. Department of the Interior established a solar salt water conversion plant at Puerto Peñasco. This gave impetus to the efforts of our Department of Zoology to effect the establishment of a marine station, with the Sonoran authorities furnishing the buildings and the University of Arizona providing the scientists and instructors. These plans were accomplished in 1965 with the construction of a station consisting of a laboratory building and a residence hall.

Three other small marine stations are located on the shores of the Gulf of California. One, located at Las Cruces, near the southern tip of Baja California is operated by Immaculate Heart College in Los Angeles, California, and the other two are small stations of the Mexican Fisheries Authorities located at Guaymas and Mazatlán.

Many of the older collecting records were made by shipborne expeditions; however, a few, including some of the earliest, were made by individuals collecting in the intertidal zone. Among the oldest collecting records that included Decapod Crustaceans are those made by John Xantus during a two-year (1859-1861) residence at Cabo de San Lucas. While engaged by the U. S. Coast Survey to establish and maintain a tide gauge, he made a number of collections in the Cape region. These collections were later described by Stimpson (1860, 1871). A second collection by W. J. Fisher and H. Edwards made in the vicinity of Mazatlán was reported on by Lockington (1877, 1878). Another shallow-water collector was Diguet whose specimens were described by Bouvier (1895).

Two of the earliest expeditions by ship into this area were those made by the U. S. Fish Commission steamer Albatross in 1891 and 1904-1905.. These biological collecting expeditions were under the direction of Alexander Agassiz, and large numbers of deep-water invertebrates were collected. The results of the 1891 and 1904-1905 expeditions along with maps and data on stations were published by Townsend (1901, 1916).

A later expedition including more emphasis on shore collecting was made by the California Academy of Sciences in 1921. The studies on the crustaceans collected were

published by Rathbun (1924) on the Brachyura and by Schmitt (1924) on the Anomura and Macrura.

Another expedition obtaining its collections primarily by dredging was the Templeton Crocker from March, 1936 to May of the same year. Mr. Templeton Crocker's ship, the Zaca, departed from San Diego and stopped at various stations in the southern and middle Gulf. The Anomurans were reported upon by Glassell (1937a & b).

The Allan Hancock Foundation at the University of Southern California has supported an outstanding program of biological investigation in the Eastern Pacific. Much of this study has included marine investigations in the Gulf of California aboard the Foundation's ships, Velero I, III, and IV. These Velero cruises have traversed much of the Gulf and on a few trips have collected at Puerto Peñasco and other points along the Sonoran coast (Fraser 1943).

The E. W. Scripps cruise in 1939-1940, was sponsored by the Scripps Institute of Oceanography, and Anderson (1950) reported that much important data on the geology and oceanography of the Gulf were collected.

A more recent collecting cruise in the Gulf was the three-month Puritan expedition in 1957, sponsored by the American Museum of Natural History. This expedition began its Gulf collecting at Mazatlán and Bahía los Frailes, near the tip of Baja California, then proceeded north along the Peninsula shoreline from island to island,

including various points on Baja California, to terminate at San Felipe. The expedition was concerned with the study of the effects of insular isolation on mammals, reptiles, and amphibians, and the comparing of present and past distributions of littoral marine invertebrate faunas, especially the mollusks, corals and bryozoans (Emerson 1958).

Several independent collectors have made important discoveries, including H. N. Lowe, whose anomurans were described by Glassell (1935), and E. F. Ricketts (Steinbeck and Ricketts 1941), whose studies have been of great importance in furthering our knowledge of the Gulf fauna.

Some of the most recent cruises into the Gulf of California include several sponsored by Scripps Institute of Oceanography, and three sponsored by the Advanced Systems Development Division of Pneumodynamics Corporation (Parker 1963).

## PHYSIOGRAPHY OF COLLECTING AREA

The collecting carried out in preparation of this paper on Anomuran Decapods was made at the Puerto Peñasco-Bahía la Cholla area in Sonora, Mexico. This part of the Sonoran coast receives very little rainfall, in general, from winter rain moving eastward from the Pacific coast. It is therefore a very dry desert region, which coupled with certain edaphic characteristics produces a sparce vegetation. This is especially true in the area immediately surrounding the shore line. In driving south from the border, a marked decrease in vegetation forms can be observed from a point beginning 15 to 20 miles south of the town of Sonoyta. H. N. Lowe (1934) noticed this phenomenon as indicated in his paper describing an early field trip to Puerto Peñasco:

> Just below the border, the sleepy little town of Sonoyta lies in a green oasis formed by the Sonoyta River. It is practically self-supporting save for a few imported American clothes and sundries . . . .
>
> Along this part of the road was quite a vigorous growth of mesquite, ironwood, paloverde, and numerous "saguaros" or giant cacti, rarely branched.
>
> As the road ran southwestward toward the Gulf, the vegetation grew sparser until nothing but creosote bush remained.

The native flora in the immediate Punta Peñasco-Bahía la Cholla area consists of small stunted cholla

cactus with some ocotillo and several smaller herbaceous plants.

The rocky outcroppings in the area, so necessary for rich intertidal collecting, are made up of a granitic rock in most instances. This is the case in the vicinity of Bahía la Cholla, Pelican Point and Norse Beach. Also the highest peak in this vicinity, Cholla Peak, 408 feet in elevation, is of this same type of rock. The other main rock type in this collecting area is a darker colored basalt which makes up the bulk of Punta Peñasco. This basalt may have been associated with the basalt flows in and around Cerro Pinacate in the geological past (Scholefield 1965).

On approaching the rocky intertidal area, one familiar with the Pacific coast of the United States immediately notices the absence of the larger algal species or kelps, and that very few animals occur on exposed surfaces of the rocks. This may be due in part to the heat of the desert sun, and a lack of surf and spray. Small brown algal species about 2-8 inches in length are present, however at lower tide levels.

The rocky intertidal zone where the author collected was located in two main areas, the first being at Norse Beach and the second along the south shore of Bahía la Cholla (see map, page 143). Most of the rocky intertidal Anomurans came from the Norse Beach area and several were

collected only in this locale. Norse Beach is perhaps best defined as that area between Puerto Peñasco and the granite mountain called Cholla Peak. At its west end the intertidal zone of Norse Beach steepens and consists of larger rocks and boulders. A shallow sandstone, and sandstone conglomerate reef-like area is present between the points where the two Norse Beach roads approach the beach area (see map, page 143). This reef is impressive in that it contains a large number of recent fossil shells. This rocky expanse, which includes some large intertidal pools, dips downward toward a subtidal position at the eastern end of the beach, i.e., in the direction of Puerto Peñasco. The upper intertidal area consists of a sandy beach made up of a rather coarse shelly sand of a light color. This is backed by a dune-like rise of sand. A dirt road parallels the beach behind this dune a short distance toward Puerto Peñasco.

Bahía la Cholla, lying to the north of Norse Beach and east of Pelican Point, is a large open sand flat expanse. On the south shore is a small settlement with a few stores, cantinas, gasoline stations and small houses. These latter serve as part time residences for fishermen and others who come from Arizona and California on weekends.

The sand flats of the bay are bordered by a rocky area on the south shore, extending from the eastern border

of the settlement out to and including Pelican Point. The eastern shore or "Back Bay" area is a shallowly sloping mud flat with an open spreading estero and Salicornia marsh. Numerous tide return channels run, in some cases, several miles into the lowlands behind the bay. An accurate description of this bay has been made by S. Stillman Berry (1956):

> Cholla Cove, the southern indentation of the great Bahía de Adair in northern Sonora, is to one interested in marine natural history, a remarkable bit of shore indeed, its fauna rich and varied far beyond the experience of one familiar only with the ordinary mud flat of less favored climes. . . . At extreme high tide the silent rise crept (within a few feet of the camp); at low tide one had to tramp across the mud flat perhaps a mile and a half or two miles to reach the outer reefs. The outgoing water fades away at the end before one's eyes; the incoming flows like a river, and one is wise . . . not to be overtaken by it.
>
> In the upper stretches, what we may call the shallow backwater of the playa with the shortest period of submersion, is a region of flat sloughs. . . . These are covered with a fairly heavy growth of haline plants such as Salicornia, and everywhere are to be seen the empty shells of the small semi-terrestrial ellobiid pulmonate, Melampus.

The northern shore, which gradually becomes confluent with the general shoreline of much larger Adair Bay, is made up variously of sand and mud flat areas, with some small rocky reef-like areas. The roads skirting around Bahía la Cholla and leading to this north shore area are frequently flooded at times of new and full moon tides, making driving in the area rather hazardous. In the bay flats there are a few rocky outcrops and at the lower tide

levels a rocky reef outcrop is exposed. This reef has many tide pools and is the home of the giant hermit Petrochirus. The rocks are covered with many small algal species. The large sand dollar Encope grandis, and a slightly smaller, but no less common species E. micropora, inhabit the lower intertidal sand flats in large numbers. These sand dollars are so numerous as to give one the feeling of walking on a tile floor in some places.

Almost every marine habitat with the exception of mangrove and coral is available within a few miles of Puerto Peñasco and the new marine station. With this variety of habitats it is to be expected that a very rich fauna would result, and this appears to be the case in the vicinity of Puerto Peñasco.

This collecting area, just described, and the new marine station at Puerto Peñasco may be reached rather easily by automobile from Tucson or Phoenix. The distances are about the same from either of these Arizona cities. It is also possible to fly by small aircraft to Puerto Peñasco, as an adequate landing field of moderate length is located just north of the town. A plane landing is a signal for a taxi to arrive at the airport.

## ANOMURAN FAUNA

The Anomuran crustaceans have been singled out for special study because of the limited amount of available information about their occurrence in the northern part of the Panamic Province. Often in checking records of Anomurans, as well as other groups of invertebrate animals, one finds that the species are best known in the more southerly regions of the Panamic Marine Province. Furthermore, those species known or recorded from the Gulf are in many instances representative of rather superficial collecting. Soule (1960), particularly emphasized the lack of bryozoan collections along the Sonoran and Sinaloan coasts in Mexico.

It is intended, therefore, that this study will provide useful knowledge of this group of decapod crustaceans; and perhaps through the proper taxonomic identification of the species, this work will be of assistance to ecologists, physiologists and others who may be concerned with further investigations on the Anomurans.

The name "Anomura" as herein applied is used as a Section name having equal status with the Brachyura or true crabs and Macrura, the "tailed" shrimp-like forms.

The Anomurans are peculiar, when compared with other decapods, in that they exhibit three distinct body

forms. These are the straight abdomen form, resembling that of a shrimp or crayfish, the curved, often asymmetrical abdomen of the hermit crabs, and short, reflexed abdomen of the porcellanid crabs. These structural variations have given rise to several problems in decapod classification.

The earliest of the published decapod classifications, according to Borradaile (1907), was that written by Latreille in 1806. In his paper he divided the decapods into the Macrura (tailed forms) and the Brachyura (short tailed crabs). In this classification then, the Anomurans, including such diverse forms as the sand crabs, the hermit crabs and the porcelain crabs, instead of being placed with the Macrura to which they all are most closely related, could in fact be placed in either one of the two, depending on abdomen form. The second important stage in decapod classification began in 1834 with the publication of a paper by H. Milne-Edwards (1834) wherein he established a third group name, the Anomura. This third group was intermediate between Latreille's Brachyura and Macrura. In the Anomura he placed the Paguridae, Hippidae, Porcellanidae, and also some of the more primitive true crabs, the Dromiidae, Homolidae and Raninidae (Borradaile 1907). Since the publication of Milne-Edwards' paper the Anomura has been diversely used and abused by authors for various decapod families. The third important concept on decapod

classification was that introduced by Boas (1880). He proposed a division of the decapods into two primary groups, the Natantia and Reptantia. The Natantia included primarily the forms that swim during their adult stage by using the pleopods. This group then would include the shrimp-like forms. The Reptantia, on the other hand, contained the decapods primarily adapted to a crawling existance. Some of the Reptantia may be able to swim, but if so, appendages other than the pleopods are used.

The name "Anomura" is usually designated as a tribe or section name in more recent crustacean papers. Throughout this study it will be used as a section name.

The Anomura are characterized by the following morphological characteristics: carapace not fused with epistome (area ventral to cavities of antennules and dorsal to the mouth area). Abdomen modified or reduced in size. Last thoracic sternum (posteriormost) is free, with its pair of periopods differing in size, function or position. Antennae, in most species, insert lateral to attachment of the eye stalk.

## Systematics, General Comments

The section Anomura is herein divided into the superfamilies Galatheidea, Paguridea, Hippidea and Thalassinidea. These four superfamilies encompass all of

the intertidal members of the section in the collecting areas included in this study.

The classification follows that of Borradaile (1907) and Borradaile and Potts (1935) as outlined below, although certain higher categories are elevated:

Phylum Arthropoda
Superclass Crustacea
Class Malacostraca
Subclass Eucarida
Order Decapoda
Suborder Reptantia
Section Anomura

Listing of Superfamilies and Families

Galatheidea: Abdomen bent upon itself, symmetrical; body depressed or flattened; rostrum often well developed; first legs chelate.

Family Porcellanidae

Paguridea: Abdomen nearly always asymmetrical, either soft and twisted or bent under thorax; rostrum usually small or absent; first legs chelate; uropods modified to hold body in hollow objects such as snail shells.

Family Paguridae

Thalassinidea: Abdomen extended, symmetrical; body laterally compressed; rostrum sometimes well developed; first legs chelate, or subchelate; tail fan well developed.

Families Axiidae and Callianassidae

Hippidea: Abdomen bent under thorax, symmetrical; rostrum small or wanting; first legs styliform or subchelate; tail-fan not adapted for swimming.

Family Albuneidae

## Organization of Systematic Catalog of Puerto Peñasco Anomurans

Family. Listing of family name.

Generic Name. Listing of generic name followed by author of the name and date of first publication.

Scientific Name. Listing of the presently accepted scientific name.

Synonymy. Includes reference to original description, type locality, and published references of the names that have been used to refer to the species indicated.

Previous Records. Previously published records showing collecting locale, author and date. The name following the citation is that of the expedition or of the collector (except when identical to author of the publication), and date in parentheses refers to the author of the record. With the exception of the localities published in Appendix I "Tables of Material Examined," Haig (1960) all other previously published records in other publications have been included in this section, in so far as it has been possible to discover them.

New Records. New collecting records by the author and others that are reported for the first time in the present study are located in the Appendix.

Color. Notes on the colors of live or preserved material, where available, on Anomuran specimens collected by the author and in some cases including notes from other publications. The names of colors that appear capitalized are based on Ridgway (1912). The colors are recorded for the dorsal surfaces of the carapace and legs.

Measurements. Taken from smallest and largest specimens in the author's collections where available. Measurements in millimeters are for the length of the carapace.

Ecology. Information as to where specimens were collected in the intertidal with reference to apparent preference of habitat and substratum; notes regarding their symbiotic associations; incidence of ovigerous females; and records of the months in which these females were collected.

Behavior. Certain behavioral characteristics of several of the Anomuran species have been observed while keeping specimens in a 10-gallon aquarium in the laboratory during a part of this study. This aquarium, measuring 12 inches high by 20 inches long by 11 inches wide, was equipped with a Miracle undergravel filter along with a three-gang valve block to allow attachment of an extra air stone for water circulation. The air supply used was the compressed air of the Biological Sciences Building. This system was used without any special means of filtering and it appeared to be satisfactory. Food used during this observation period was Clark's New Age dry trout pellets containing about 50 per cent protein. This brand food is manufactured in Salt Lake City, Utah.

The water for this marine aquarium was taken from the Gulf of California, brought back to the laboratory and placed directly into the aquarium without any filtering. Distilled water was added occasionally to maintain salinity by bringing the level up to a predetermined mark on the glass. About eight gallons of water were used to provide a better surface to volume ratio. The bottom gravel material was collected from the intertidal pools at Norse Beach. Special heating or cooling devices were not required in the aquarium, as the specimens responded well in the laboratory where the air temperature ranged from 17.8 to 28.0° C.

General Remarks. Information not included in the above subheadings.

Range. Range from north to south based on published records (see Table 25).

## Systematic Catalog

ANOMURA: Galatheidea

Porcellanidae

*Euceramus* Stimpson 1860

*Euceramus transversilineatus* (Lockington) Fig. 1

*Porcellana transversilineata* Lockington 1878, pp. 396, 405, Type Locality, Boca de Las Piedras, Sinaloa and Bahía de Los Angeles, Gulf of California.

*Euceramus transversilineatus* (Lockington) Glassell 1938, p. 426, pl. 30. Neotype designated with localities at: off N. end of Tiburon Island and Punta Peñasco, Sonora, Mexico. Haig 1960, p. 190, pl. 36, fig. 2, text-fig. 7(2). Parker 1963, p. 163.

Previous Records.

Gulf of California: off north end of Tiburon Island, Punta Peñasco, San Felipe, Mexico (Glassell 1938). Boca de las Piedras, Sinaloa, Mexico (Lockington 1878). Curray-Orca Cruise, 26 meters 28° 31.0' N x 112° 04.2' W; 24 meters 28° 45.8' x 112° 04.0' W (Parker 1963).

New Records. See Table 1.

Color.

"Carapace dark pinkish buff and striated longitudinally with reddish brown. Chelae yellow cream but with a large brown spot on merus and carpus. Fingers with a

broad dark brown band around center. Ambulatory legs greenish white with touches of brilliant orange. Ventral side pinkish buff. A dark brown band runs from eye socket across center portion of maxillipeds" (Petersen, of a live specimen from the Gulf of California, Haig 1960).

Measurements.

Largest specimen, a female measured 6.8 mm; the smallest specimen, a male measured 5.3 mm.

Ecology.

The author's specimens were collected from the tube of Pachycerianthus insignis the burrowing anemone, which is referred to as "Sloppy-guts" on p. 200 in Steinbeck and Ricketts (1941). Sometimes associated with gorgonid corals at extreme low tide on sand and shell material (Glassell 1938). Also dredged in deeper water (Haig 1960), and sand and sandy mud (Parker 1963).

Behavior.

The feeding position was observed for this species. The specimen was in a small jar about two inches in diameter and one and a half inches high with about one half inch of shelly sand in the bottom. This jar was on the bottom of a 10 gallon aquarium. The animal was positioned with its eye stalks, antennae and mouth parts out of the sand with the more posterior portions of the

body embedded in the sand. When uncovered from the sand substratum in its jar, this specimen would tend to burrow backward slowly into the sand.

General Remarks.

This species is quite small and was not collected by the author. It could be rather common in the collecting area, but because of its small size and tendency to remain in the lowest intertidal zone, it is not commonly collected.

Range.

Bahía de Santa María and Bahía de la Magdalena, Baja California; Punta Peñasco and San Felipe Gulf of California, south to Isla Taboga, Panama. Shore to 34 fathoms (Haig 1960).

## Pachycheles Stimpson 1858

### Pachycheles setimanus (Lockington) Fig. 2

Petrolisthes (Pisosoma) setimanus Lockington 1878, pp. 396, 402, Type Localities, Bahía Mulegé and Isla San Jose, Gulf of California.

Pachycheles panamensis? Schmitt 1924, p. 385.

[not] Pachycheles panamensis Faxon 1893, p. 175.

Pachycheles setimanus (Lockington) Glassell 1936, p. 292; 1938, p. 444. Steinbeck and Ricketts 1941, p. 456. Haig 1960, p. 139, pl. 31, fig. 2.

Previous Records.

Gulf of California: Bahía de Tepoca, F. Baker (W. Schmitt 1924). Bahía Mulege and Isla San Jose (Lockington 1878). Bahía Concepción and Pulmo Reef (Steinbeck and Ricketts 1941).

New Records. See Table 2.

Color.

The general ground color is tan in life.

Measurements.

Largest specimen, a male measured 8.0 mm; the smallest specimen, also a male, measured 5.3 mm.

Ecology.

Most of the author's specimens were collected on the undersides of rocks in the lower intertidal zone. Several specimens were also associated with sponges. Steinbeck and Ricketts (1941) found it in coral interstices at Pulmo Reef near the tip of Baja California. Ovigerous females were taken by the author in January, February, March, April, July, and November, possibly indicating that this species breeds throughout the entire year.

General Remarks.

It should be indicated that this species is the only member of the large genus Pachycheles to occur in the

intertidal at Puerto Peñasco. It is very common, however, in the author's collecting area.

Range.

Throughout the Gulf of California from Puerto Peñasco and San Felipe to Pulmo Reef.

## Petrolisthes Stimpson 1858

### Petrolisthes tiburonensis Glassell Figs. 3 and 4

Petrolisthes tiburonensis Glassell 1936, p. 284, Type Locality, at south end of Isla Tiburon, Gulf of California; 1938, p. 444. Haig 1960, p. 70, pl. 25, figs. 1, 3.

Previous Records.

Gulf of California: Puerto Refugio, Isla Angel de la Guarda, Bahía de los Angeles, S. end of Isla Tiburon (Glassell 1936, 1938).

New Records. See Table 3.

Color.

The general ground color in life is dark brown.

Measurements.

Largest specimen, a male measured 10.5 mm; the smallest specimen, a female measured 1.9 mm.

Ecology.

All of the author's specimens were taken from under rocks in the lower intertidal, particularly where the intertidal slope was steeper and the rocks were of larger size.

Behavior.

The author maintained specimens in the aquarium and observed the function of the large brush of setae on the ends of the propodus of the chelipeds. It is used in a scraping motion and is drawn over the surface of objects toward the mouth and then is cleaned by the third maxillipeds. Also the brush of setae may be whipped through the water, especially when a large amount of suspended particulate matter is present. At times when only a low concentration of suspended matter is present, this species may extend and hold its third maxillipeds straight out from the body for up to 8 to 10 seconds before bringing them in to be cleaned by the second maxillipeds.

General Remarks.

This species and Petrolisthes crenulatus are the largest species of the genus occurring at Puerto Peñasco. The long legs and chelae add much to the size. An interesting case of sexual dimorphism is exhibited by P. tiburonensis. The male is larger and the chelipeds have a much elongated carpus without spines on the anterior edge. The female possesses a much shortened carpus which is armed

with short spines on the anterior edge. The propodus is also armed with these short spines on the outer border.

Range.

Gulf of California from San Felipe to Punta Trinidad.

Petrolisthes hirtipes Lockington Fig. 5

Petrolisthes hirtipes Lockington 1878, pp. 395, 397, Type Locality, Bahía Mulegé and Puerto Escondido, Gulf of California. A. Milne-Edwards and E. L. Bouvier 1894, p. 291. Schmitt 1924, p. 383. Glassell 1936, p. 284; 1938, p. 443. Steinbeck and Rickets 1941, p. 457, pl. 29, fig. 3. Haig 1960, p. 60, pl. 24, fig. 3.

Petrolisthes hispidus Lockington, A. Milne-Edwards and E. Bouvier 1894, p. 293, footnote.

Previous Records.

Baja California: Bahía de Magdalena (Glassell 1936). Gulf of California: Bahía de Tepoca, Sonora, F. Baker (W. Schmitt 1924). Puerto Refugio, Isla Angel de la Guarda, Bahía de los Angeles, Bahía de San Carlos, Punta Marcial Reef, Bahía San Gabriel, Isla Espíritu Santo (Steinbeck and Ricketts 1941). Bahía Mulegé and Puerto Escondido (Lockington 1878).

New Records. See Table 4.

Color.

The general ground color in life is tan with red on the dactylus of the chelipeds and on the tubercles of the surfaces of the chelipeds. The outer parts of the third maxillipeds are a medium blue.

Measurements.

Largest specimen, a male measured 11.5 mm; the smallest specimen, a female measured 2.5 mm.

Ecology.

From under rocks in lower intertidal zone, occasionally in middle intertidal.

Behavior.

The author has observed that Petrolisthes hirtipes feeds at times of low concentration of suspended food material by extending its third maxillipeds, holding them out for 3 or 4 seconds and then pulling them in to be cleaned by the second maxillipeds, either together or separately. Also, this species can hold both of its third maxillipeds up so particles fall on open surfaces, as when the crab is positioned on the side of a rock.

General Remarks.

A common intertidal porcellanid in the author's collecting area.

Range.

Bahía de la Magdalena, Baja California, Entire Gulf of California from Bahía la Cholla south to Cabo de San Lucas (Haig 1960).

Petrolisthes crenulatus Lockington Fig. 6

Petrolisthes crenulatus Lockington 1878, pp. 395, 398, Type Locality, Puerto Escondido, Gulf of California. Glassell 1936, p. 286; 1937a, p. 80; 1938, p. 444. Haig 1960, p. 110, pl. 23, fig. 4.

Previous Records.

Gulf of California: Puerto Escondido (Lockington 1878). Puerto Escondido (Glassell 1936, 1937a). Off Arena Bank, W. Beebe on Zaca (Glassell 1937a).

New Records. See Table 5.

Color.

The general ground color is medium brown speckled with white, and with dark brown on the distal part of propodus and dactylus of the chilipeds.

Measurements.

Largest specimen, a male measured 16.0 mm; the smallest specimen, also a male, measured 2.9 mm.

Ecology.

Found under rocks in lowest intertidal, sometimes associated with sponges. Once dredged in 10-15 fathoms along with corallines and gorgonids by Velero III (Haig 1960).

Behavior.

A specimen of P. crenulatus after feeding for a while, came out from under its rock, began to scrape its third maxillipeds across the sand, and then proceeded to work over this material with its second maxillipeds.

Range.

Bahía Magdalena, Baja California. Gulf of California, from Isla Angel de la Guarda to Mazatlán; Isabel and Tres Marías Islands (Haig 1960). The author's collecting at Puerto Peñasco and Bahía la Cholla extends the range about 130 miles to the north.

Petrolisthes gracilis Stimpson Fig. 7

> Petrolisthes gracilis Stimpson 1858, p. 227, a listing only in latin, Type Locality, "Sinu Californico" (= Gulf of California). 1859, p. 74 (description; Type Locality restricted to Guaymas). Lockington 1878, listing only, pp. 395, 396. Rathbun 1910, p. 599, Guaymas, Mexico and Ecuador. Schmitt 1921, p. 181, name and Guaymas Type Locality only apply; 1924, p. 383. Glassell 1938, p. 443. Steinbeck and Ricketts 1941, p. 456, pl. 29, fig. 4. Haig 1960, p. 79, pl. 27, fig. 2.

Petrolistes gracilis Stimpson Sivertsen 1933, pl. 3, fig. 31.

Previous Records.

Gulf of California: Guaymas, Sonora, C. P. Stone (Stimpson 1859). Bahía de Tepoca, Bahía de San Carlos, F. Baker (Schmitt 1924). Bahía de los Angeles, Bahía de San Carlos, Puerto San Carlos, Sonora; Bahía San Gabriel, Isla Espíritu Santo (Steinbeck and Ricketts 1941).

New Records. See Table 6.

Color.

The general ground color is dark brown with minute speckles of white. A black stripe is present on the posterior side of the propodus of the fourth and sometimes the third peripod.

Measurements.

Largest specimen, a male measured 9.0 mm; the smallest specimen, a female measured 2.7 mm.

Ecology.

This species is one of two commonly found in the upper midlittoral zone. Ovigerous females were collected in February, March, and April by this author. Ovigerous females have been collected from January to June according to Haig (1960). Specimens were dredged by Velero III on

two occasions in 10 fathoms from sand and rock bottom, and in 18-25 fathoms from a sandy bottom (Haig 1960).

General Remarks.

A very common, widely distributed porcellanid in this area.

Range.

Bahía de Santa María, Baja California; Gulf of California from Puerto Peñasco and San Felipe south to La Paz. Islas Las Tres Marías. Extralimital: Bahía Tangola-Tangola, Mexico (Haig 1960).

Petrolisthes schmitti Glassell Fig. 8

> Petrolisthes schmitti Glassell 1936, p. 280, Type Locality, San Felipe, Gulf of California; 1938, p. 444. Haig 1960, p. 104, pl. 29, fig. 1.

Previous Records.

Gulf of California: San Felipe (Glassell 1936).

New Records. See Table 7.

Color.

In alcohol, a red-brown mottled with white.

Measurements.

Largest specimen, an ovigerous female measured 3.5 mm; the smallest specimen, a male measured 2.0 mm.

Ecology.

Found in the lower intertidal under rocks and among sponges. The author collected ovigerous females in July. Haig (1960) found ovigerous females in April and June.

General Remarks.

This is a small species; it did not seem to be common at any point in the study area.

Range.

Gulf of California from San Felipe south to Isla San Francisco. The author's collecting has extended the range about 30 miles north and east to Puerto Peñasco-Bahía la Cholla.

Petrolisthes sanfelipensis Glassell Fig. 9

Petrolisthes sanfelipensis Glassell 1936, p. 281, Type Locality, San Felipe, Gulf of California; 1938, p. 443. Haig 1960, p. 30, pl. 20, fig. 3.

Petrolisthes felipensis Glassell 1937a, p. 82.

Previous Records.

Gulf of California: Punta Peñasco, Sonora, San Felipe, (Glassell 1936, 1937a).

New Records. See Table 8.

Color.

A dark purplish red or maroon color in life; light pink in alcohol.

Measurements.

Largest specimen, a female measured 10.6 mm; the smallest specimen, also a female, measured 2.9 mm.

Ecology.

The author's specimens were collected in the lowest intertidal zone either under rocks or associated with sponges. Three specimens collected by Dr. Pickens were associated with a piece of Pedina, a brown alga floating free at low water mark in Bahía la Cholla. Glassell (1937a) reports some specimens taken from among sponges and gorgonids. The Allan Hancock Foundation ships, Velero III and IV, took specimens by dredging in 3 to 25 fathoms, with bottom material of rock, sand, shell and mud. Ovigerous females were taken in March by Velero III, and in June by Glassell (Haig 1960). The author's material included one ovigerous female taken in March, two in June, and one in August.

Range.

Bahía de San Juanico and Bahía de Magdalena, Baja California. Gulf of California; from Punta Peñasco south to Guaymas, shore to 25 fathoms (Haig 1960).

Petrolisthes armatus (Gibbes), Restricted synonymy, after Haig (1960) Fig. 10

Porcellana armata Gibbes 1850, p. 190, Type Locality, Florida; 1851, p. 128.

[not] Porcellana armata Dana 1852, p. 426.

Porcellana gundlachii Gibbes Guerin 1855, pl. 2, fig. 6, Type Locality, Cuba.

Petrolisthes armatus (Gibbes) Stimpson 1858, p. 227; 1859, p. 73. Streets 1871, p. 240. Lockington 1878, pp. 396, 399. Bouvier 1895, p. 8. Ortmann 1897, p. 280. Rathbun 1910, pp. 558, 559, pl. 41, fig. 3. Boone 1931, p. 151, text fig. 6 (part); 1932, p. 35, text fig. 9. Glassell 1938, p. 444. Steinbeck and Ricketts 1941, p. 456. Holthuis 1954a, p. 15; 1954b, p. 161. Bott 1955, p. 52. Garth and Haig 1956, p. 4. Haig 1956, p. 19; 1957, p. 9; 1960, p. 50; 1962, p. 178.

Porcellana leporina Gibbes Heller 1862, p. 523, Type Locality, Rio de Janeiro, Brazil.

Petrolisthes leporinus (Gibbes) Smith 1869, p. 38.

Ptrolisthes armatus (Gibbes) Smith 1871, p. 92.

Petrolisthes similis (Gibbes) Henderson 1888, p. 108 (fide Faxon 1895, p. 70, footnote).

Petrolisthes iheringi (Gibbes) Ortmann 1897, p. 286, pl. 17, fig. 3, Type Locality, Sao Sebastião, Brazil.

Petrolisthes lamarcki var. asiaticus (Gibbes) Borradaile 1898, p. 464 (part).

[not] Petrolisthes lamarckii (Leach) 1820, pp. 49-56.

[not] Petrolisthes asiaticus (Leach) 1820, pp. 49-56.

Petrolisthes armatus (Gibbes) Nobili 1901, p. 11.

Petrolisthes armatus var. pallidus (Gibbes) Verrill 1908, p. 291, Type Locality, Bermuda.

Previous Records.

Gulf of California: "Lower California" (Probably Gulf, Haig 1960), Diguet (Bouvier 1895). Bahía Mulegé (Lockington 1878), Bahía Concepción, El Mogote (Steinbeck and Ricketts 1941). El Salvador: Puerto El Triunfo, H. Peters (Bott 1955). Near La Unión, Bahía de la Unión, M. Breseman (Holthuis 1954a, 1954b). Honduras: Golfo de Fonseca, J. A. McNeil (Smith 1871). Panama: probably Pacific side Sternbergh and Rowell (Stimpson 1859). Isthmus of Panama, J. McNeil (Streets 1871b). Bellavista, Panama City, Askoy (Haig 1957). Punta Patillo, Fortified Island, W. G. Van Name (Boone 1931). Isla Flamenco, E. Festa (Nobili 1901). Colombia: Buenaventura, H. Brattström and E. Dahl (Garth and Haig 1956). Ecuador: 01° 07' N x 79° 53' W, Askoy (Haig 1957). Bahía and Punta Santa Elena, E. Festa (Nobili 1901). Galápagos Islands: Isla Edén, Harrison Williams Expedition (Boone 1932). Peru: Matapalo and Las Vacas near Capon, R. E. Coker (Rathbun 1910). Bermudas: Mortensen (Haig 1962). Virgin Islands: St. Thomas, Eggers (Haig 1962). Brazil: Cotinguiba, Hygom (Haig 1962); Rio de Janeiro, Warming

(Haig 1962); Sepetiba, Boving-Petersen (Haig 1962); Cuba: Havana? Hygom (Haig 1962).

New Records. See Table 9.

Color.

A medium brown color with cream designs on upper surfaces.

Measurements.

Largest specimen, a male measured 14.5 mm; the smallest specimen, a female measured 4.5 mm.

Ecology.

All specimens collected by the author were taken from under rocks at various tide levels. This species ranges into the upper mid-littoral zone along with P. gracilis. Some specimens were taken at depths of 14 to 16.5 fathoms by Chace (1956) in West Africa. The dredged specimens were taken on bottom material of rock, sand, and shell (Haig 1960). Ovigerous females were taken in every month of the year (Haig 1960).

General Remarks.

Judging from its wide distribution and ability to live rather high in the intertidal zone, this must be a very adaptive species. It can be kept in the laboratory

aquarium very easily, and would probably make good experimental material for a wide variety of investigations.

Range.

Eastern Pacific: Puerto Peñasco and San Felipe, Gulf of California, south to Bahía de la Independencia, Peru. Galápagos Islands. Western Atlantic: Connecticut, Gulf Coast of Florida to Santa Catharina, Brazil. Bermudas. Eastern Atlantic: Gibralter, Senegal to Angola. Ascension Island (Haig 1960).

## Minyocerus Stimpson 1858

### Minyocerus kirki Glassell Fig. 11

Minyocerus kirki Glassell 1938, p. 430, pl. 31, Type Locality, San Felipe, Gulf of California. Haig 1960, p. 193, pl. 37, fig. 1, text fig. 8. Haig 1962, p. 185. Parker 1963, p. 163.

Previous Records.

Gulf of California: San Felipe (Glassell 1938). Curray-Orca Cruise, 26 meters, 28° 31.0' N x 112° 04.2' W; 110 meters, 29° 54.3' N x 113° 03.2' W (Parker 1963). Nicaragua: Realejo, Orsted (Haig 1962).

New Records. See Table 10.

Color.

Carapace with median longitudinal area white with a yellow cast, branchial areas brown with a greenish cast. Antennules blue, flagelum yellow. Chelipeds and ambulatory legs with a whitish ground color banded with brown (Glassell 1938, from notes on a live specimen by W. A. Kirk).

Measurements.

The single specimen collected by the author was a male and had a carapace length of 3.0 mm.

Ecology.

Most records published on this species indicate that it is a commensal with various species of the starfish Luidia and occasionally brittle stars. Parker (1963) reports specimens taken with a shell dredge in deeper water in the Gulf from 13 to 110 meters on sand and sandy mud. He does not indicate any association with other organisms. Ovigerous females have been taken in May and December.

Range.

San Felipe and Puerto Peñasco in the Gulf of California to Punta Monypenny and Realejo, Nicaragua, shore to 110 meters (Haig 1962).

## Porcellana Lamarck 1801

### Porcellana cancrisocialis Glassell Fig. 12

Porcellana cancrisocialis Glassell 1936, p. 292, Type Locality, Punta Peñasco, Sonora, Gulf of California; 1937a, p. 86. Steinbeck and Ricketts 1941, p. 458. Haig 1957, p. 13; 1960, p. 200, pl. 38, fig. 2, text fig. 9(2); 1962, p. 187. Parker 1963, p. 163.

Previous Records.

Gulf of California: Punta Peñasco, San Felipe (Glassell 1936). Estero de la Luna (Steinbeck and Ricketts 1941). Arena Bank, Zaca (Glassell 1937a). Vermilion Sea Expedition I, 48 meters, 23° 35.2' N x 106° 53.5' W; Curray-Orca Cruise, 61 meters, 22° 09.0' N x 106° 08.0' W; 35 meters, 28° 41.0' N x 112° 06.0' W; 24 meters, 28° 45.8' N x 112° 04.0' W (Parker 1963). Panama Area: Taboga Island, 4.5 fathoms; Taboguillo Island, 2-5 fathoms; Taboguillo Island from gorgonids at 3 fathoms, Isla San Jose; Perlas Islands, 25 fathoms; Southwest of S. Point of Isla Rey, Perlas Islands, 15 fathoms; South of Isla San Jose, 26 fathoms, Mortensen (Haig 1962).

New Records. See Table 11.

Color.

Ground color in life an ivory yellow, overcast with lavender and blood-red spots. Protogastric regions

lighter. Chelipeds same colors as carapace. Ambulatory legs banded with white on propodus (Glassell 1936).

Measurements.

Largest specimen, a female measured 7.0 mm; the smallest specimen, also a female, measured 6.5 mm.

Ecology.

The author's specimens were all associated with the large hermit crab Petrochirus. Haig (1960) reports that the species may often occur free-living. Ovigerous females have been collected in the months from December through May, and in August (Haig 1960). This species may be associated with gorgonids (Haig 1962).

Range.

Baja California: Bahía de Santa María and Punta Tosco. Gulf of California: Punta Peñasco south to Bahía de Santa Elena in Ecuador; Isla Isabel off the coast of Mexico. Shore to 54 fathoms (Haig 1960).

Porcellana paguriconviva Glassell Fig. 13

Porcellana paguriconviva Glassell 1936, p. 293, Type Locality, Punta Peñasco, Sonora, Gulf of California; 1937a, p. 87. Steinbeck and Ricketts 1941, p. 458. Haig 1960, p. 203, pl. 38, fig. 9(3); 1962, p. 185.

Previous Records.

Gulf of California: Punta Peñasco, Sonora (Glassell 1936). Bahía de Santa Inez, Zaca (Glassell 1937a). Bahia Concepción (Steinbeck and Ricketts 1941). Panama Area: Taboga Island, 4-5 fathoms; Taboguilla Is. 3 fathoms from gorgonids; Taboguilla Island 3 fathoms, Mortensen (Haig 1962).

New Records. See Table 12.

Color.

Ground color light brown, with four longitudinal blue stripes on carapace, some broken by ground color. Legs with blue spots, some of which are outlined with red.

Measurements.

Largest specimen, a male measured 5.8 mm; the smallest specimen, also a male, measured 3.5 mm.

Ecology.

The author's specimens were associated with Petrochirus the giant hermit crab, in the lower intertidal zone. Deep water collections indicate that this species may occur in a free living state, and also that it may be associated with gorgonids (Haig 1962).

Range.

Baja California: Bahía de la Magdalena. Punta Peñasco, Gulf of California south to Bahía Cocos, Costa Rica. Shore to 50 fathoms (Haig 1960).

## Megalobrachium Stimpson 1858

### Megalobrachium smithi (Glassell) Fig. 14

Pisosoma smithi Glassell 1936, p. 286, Type Locality, Miramar Beach near Guaymas, Sonora, Gulf of California.

Pisonella smithi Glassell 1938, pp. 437, 442.

Megalobrachium smithi (Glassell) Chace 1942, p. 100.

Previous Records.

Gulf of California: Punta Peñasco, Sonora; Punta Sargent, Sonora; Isla del Carmen, Isla Espíritu Santo (Glassell 1936).

New Records. See Table 13.

Color.

In alcohol, carapace cream; ambulatory legs light pink; abdomen and sternum iridescent (Glassell 1936).

Measurements.

The single specimen collected was a female and had a carapace length of 4.5 mm.

Ecology.

The author's single specimen was taken from under a rock. A few specimens were taken from coral by the Allan Hancock Expeditions (Haig 1960).

Range.

Gulf of California, from Punta Peñasco south to Isla Espíritu Santo (Haig 1960).

Megalobrachium tuberculipes (Lockington) Fig. 15

Pachycheles tuberculipes Lockington 1878, pp. 396, 404, Type Locality, La Paz, Gulf of California.

Polyonyx tuberculipes (Lockington) Nobili 1901, p. 21. Rathbun 1910, p. 601.

Pisonella tuberculipes (Lockington) Glassell 1938, pp. 437, 440, pl. 34, fig. 1, Neotype designated, Neotype Locality, Punta Peñasco, Sonora, Gulf of California. Steinbeck and Ricketts 1941, p. 457.

Porcellanopsis tuberculipes (Lockington) Chace 1942, p. 100. Haig 1957, p. 15.

Megalobrachium tuberculipes (Lockington) Haig 1960, p. 227, pl. 16, fig. 11, pl. 40, fig. 4., new combination.

Previous Records.

Gulf of California: Punta Peñasco, San Felipe, Sonora (Glassell 1938). Isla Coronado, West end of Tiburon (Steinbeck and Ricketts 1941). La Paz (Lockington

1878). Panama: Isla Saboga, Islas de Las Perlas, Askoy (Haig 1957). Colombia: Bahía Humboldt, Askoy (Haig 1957). Ecuador: Bahía de Santa Elena, E. Festa (Nobili 1901).

New Records. See Table 14.

Color.

In life, muddy gray with a dark patch on the central regions; in alcohol, light pink (Glassell 1938).

Measurements.

Largest specimen, a female measured 3.5 mm; the smallest specimen, also a female, measured 1.9 mm.

Ecology.

The author's specimens were collected from under rocks and on sponges in the lower mid-littoral zone.

General Remarks.

This species is by far the most common species of Megalobrachium in the collecting area.

Range.

Punta Peñasco and San Felipe, Gulf of California south to Bahía de Santa Elena, Ecuador. Shore to 10 fathoms (Haig 1960).

## Ulloaia Glassell 1938 Fig. 16

### Ulloaia perpusillia Glassell

Ulloaia perpusillia Glassell 1938, p. 434, pl. 33, fig. 1, Type Locality, Punta Peñasco, Sonora, Gulf of California. Haig 1960, p. 230, pl. 37, fig. 2, text fig. 11; 1962, p. 191.

Previous Records.

Gulf of California: Punta Peñasco, Sonora (Glassell 1938). Panama Area: Taboga Island, washed from sponge, 3 fathoms, Contadora Island, Islas de Las Perlas, 8-10 fathoms, Mortensen (Haig 1962).

New Records. (Not collected during this study)

Color.

In alcohol, cream, tipped with orange red (Glassell 1938).

Measurements.

Male holotype 3.5 mm. long, 3.1 mm. wide. "The only other specimen seen, a female is 2.9 mm long" (Haig 1960).

Ecology.

Found among gorgonid corals, sponges and bryozoans at extreme low tide (Glassell 1938).

General Remarks.

A very small species and rare in collections. There are only five specimens known from four localities.

Range.

Punta Peñasco, Gulf of California to Islas de Las Perlas, Panama.

ANOMURA: Paguridea

Paguridae

Paguristes Dana 1852

Paguristes sanguinimanus Glassell Fig. 17

Paguristes sanguinimanus Glassell 1938, p. 419, Type Locality, Punta Peñasco, Sonora, Gulf of California. Gordan 1956, p. 324.

Previous Records.

Gulf of California: Punta Peñasco, Sonora (Glassell 1938).

New Records. See Table 15.

Color.

General ground color red, with many minute orange spots; eyes a medium blue color.

Measurements.

Largest specimen, a male measured 19.5 mm; the smallest specimen also a male, measured 17.0 mm.

Ecology.

The specimens obtained during this study were collected on the sand flats of Bahía la Cholla in the lower intertidal. Glassell (1938) reports that his specimens were collected on 2 May 1935 at low tide at Punta Peñasco. The Types were taken from this series. He collected another series in the same place on 12 April 1937. He reports the carcinoecia (gastropod shell) was a species of Turritella. The carcinoecia noted by this author was the pink mouth murex, Hexaplex erythrostomus.

Range.

Known only from the head of the Gulf at Punta Peñasco and Bahía la Cholla.

Paguristes anhuacus Glassell Fig. 18

Paguristes anhuacus Glassell 1938, p. 421, Type Locality, Punta Peñasco, Sonora, Gulf of California. Gordan 1956, p. 321.

?Paguristes perrieri Glassell Bouvier 1895, p. 7 (according to Haig in litt.). Alcock 1905, p. 156. Gordan 1956, p. 323.

Previous Records.

Gulf of California: Punta Peñasco, Sonora (Glassell 1938). ?Lower California, Diguet (Bouvier 1895).

New Records. See Table 16.

Color.

China blue on distal third of eye stalk; eye black and ringed with white at base. Antennules and antennae China Blue, ringed with white at joints of segments. Color names based on Ridgway (1912).

Measurements.

Largest specimen, a male measured 9.0 mm; the smallest specimen, an ovigerous female measured 2.4 mm.

Ecology.

The author's specimens were taken under rocks and also out on the sand flats of Bahía la Cholla in the lower intertidal and middle intertidal zones. Ovigerous females were collected in the month of July. Glassell (1938) reports the species as occurring from extreme low water to a depth of 10 fathoms.

The carcinoecia reported by Glassell was a species of Turritella. The author's specimens were usually living in the shells of Cerithium.

Range.

Known only from the upper end of the Gulf (Glassell 1938).

## Pagurus* Fabricius 1775

### Pagurus albus (Benedict) Fig. 19

Eupagurus albus Benedict 1892, p. 6, Type Locality, Gulf of California. Alcock 1905, p. 179.

Pagurus albus (Benedict) Glassell 1937b, pp. 256, 258. Steinbeck and Ricketts 1941, p. 454. Gordan 1956, p. 325.

Previous Records.

Gulf of California: Bahía de Santa Inez, Turner Island, Zaca (Glassell 1937b). San Lucas Cove, Estero de la Luna (Steinbeck and Ricketts 1941).

New Records. See Table 17.

Color.

General ground color white or tan; eyes black.

Measurements.

Largest specimen, a male measured 12.0 mm; the smallest specimen, a female measured 2.9 mm.

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*The generic name Pagurus is used to replace Eupagurus according to the decision of the International Commission on Zoological Nomenclature, Opinion 472 (1957).

Ecology.

Glassell (1937b) reports a specimen from 3 fathoms at Bahía de Santa Inez in the Gulf. Ricketts and Steinbeck (1941) report taking specimens at San Lucas Cove and at Estero de la Luna "as slender, yellow, medium-sized hermits in Polinices shells." This author's specimens were also in Polinices shells and were collected from the intertidal zone of Bahía la Cholla on sand flats, along with Paguristes anhuacus and Paguristes sp. nov. (blue dot hermit crab).

General Remarks.

This species, as pointed out by Glassell (1937b) is very active and quick of movement. Specimens kept in an aquarium were able to jump one fourth to one half an inch above the substrate when the glass was tapped or when a shadow was passed over them.

Range.

Previously known only from the middle and southern parts of the Gulf. The range in this study has been extended 300 miles northward to Bahía la Cholla.

Pagurus lepidus (Bouvier) Fig. 20

Eupagurus lepidus Bouvier 1898, p. 381, Type Locality, La Paz Bay, Lower California. Alcock 1905, p. 180.

Pagurus lepidus (Bouvier) Glassell 1937b, p. 256. Steinbeck and Ricketts 1941, p. 455. Gordan 1956, p. 331. ?Chace 1962, p. 623.

Previous Records.

Gulf of California: La Paz Bay, Diguet (Bouvier 1898). Bahía de Santa Inez, Zaca (Glassell 1937b). El Mogote (Steinbeck and Ricketts 1941). ?Clipperton Island, Limbaugh, Chess and Hambly (Chace 1962).

New Records. See Table 18.

Color.

In alcohol, a light tan color.

Measurements.

Largest specimen, a male measured 6.0 mm; the smallest specimen, an ovigerous female measured 1.9 mm.

Ecology.

Glassell (1937b) reports that specimens taken by the Zaca were at one fathom near shore. Steinbeck and Ricketts (1941) collected their specimens at El Mogote but did not give any ecological information. The specimens collected for this study were found both under rocks in the rocky intertidal and on the sand flats of Bahía la Cholla in the lower and middle intertidal zones.

Ovigerous specimens were collected by the author in March and July.

Behavior.

Several specimens of P. lepidus were kept in the aquarium for observation. It was noted that during periods of high concentration of particulate food matter this species would wave its antennae two or three strokes through the water and then bring them in to be wiped by the third maxillipeds. At other times, under similar conditions specimens would exhibit a rapid motion with their third maxillipeds, perhaps best described as a pawing motion. These mouth parts were then occasionally cleaned by the second maxillipeds.

Range.

Previously known from La Paz, Bahía de Santa Inez and El Mogote in the Gulf of California, and from Clipperton Island. The Range in this study has been extended 300 miles northward to Norse Beach and Bahía la Cholla.

Pylopagurus Milne-Edwards and Bouvier 1891

Pylopagurus roseus (Benedict), new combination* Fig. 21

*Based on a comparison of structural characteristics of specimens of Pylopagurus and the outline of generic characteristics by Walton (1954), the author, with the concurring support of Miss Janet Haig (in litt.), and under the authority of Articles 48 and 51 of the International Code of Zoological Nomenclature adopted by the XV International Congress of Zoology, makes a new combination of this taxon. The species is hereby taken out of Pagurus and placed in Pylopagurus.

Eupagurus roseus Benedict 1892, p. 22, Type Locality, Gulf of California. Alcock 1905, p. 180.

Pagurus roseus (Benedict) Gordan 1956, p. 335.

Previous Records.

Gulf of California: Albatross (Benedict 1892).

New Records. See Table 19.

Color.

In life, dark brown, speckled with tan; eyes red.

Measurements.

Largest specimen, an ovigerous female measured 10.5 mm; the smallest specimen, a female measured 8.0 mm.

Ecology.

Common in rocky intertidal at lowest tide levels. Often seen crawling on shelly white sand deposited in pools and depressions still filled with water at low tide. The carcinoecia is usually Cerithium and Turbo flutuosus (=Callopoma).

Ovigerous females were collected in January and March.

Behavior.

Molting Behavior: Early in the morning on 9 January 1964, a Pylopagurus specimen molted and remained out of its shell for two to three hours. Apparently its

body was still soft and unable to support the weight of the shell, or it may have been prevented from entering its shell by other hermit crabs in the aquarium. It was later observed that when this newly-molted specimen did try to get into a shell, another hermit crab of the same species pulled off a walking leg. The following morning, the newly-molted hermit crab was observed to have lost both chelae, and was then placed in a separate glass culture jar for protection and observation of regeneration of the lost appendages. This specimen was able to use its first pair of walking legs to scoop up gravel and food material, and to transfer these substances to the third maxillipeds for feeding.

On the 25th of January all of the Pylopagurus specimens were fed, and it was noted that the specimen indicated in the preceding paragraph had not been active for several days. This was apparently a sign of the impending molting process, since the specimen molted the following day. During this period of 17 days, the specimen was kept at an average temperature of 20.6° C. Changes observed after this period of time were: (1) the regenerated major cheliped was about 1/2 to 2/3 the size expected for an adult specimen, and somewhat lighter in color, (2) the newly-formed antenna was about 2/3 to 3/4 the length of the normal right-hand one, (3) the regenerated minor cheliped was about normal size, (4) both

the regenerated minor cheliped and the antenna were of a normal color, (5) the integument was darker in color one or two days prior to molting, (6) the specimen became quiescent, (7) the specimen about to molt refused to feed and tended to hide under available objects, and (8) the molting specimen awaited the hardening of the exoskeleton for several hours before entering a shell, moving around, or feeding. During these several molting sequences recorded here for Pylopagurus, the author never observed the eating of the exuviae as Held (1963) observed in the aberrant form Birgus latro, the coconut crab.

A final note regarding molting behavior in Pylopagurus roseus is the manner in which individuals react after a hermit crab of like species has molted. In this behavior pattern, a recently molted individual would be followed and not infrequently attacked by others of the same species. There appears to be some means by which the other hermit crabs are alerted to the fact that molting has taken place. This could be a chemical substance, such as a hormone, or something released into the water by the newly formed integument. Then too, it could be a visual cue of inactivity, or of simply being out of the shell. On occasion, the author purposely placed active specimens at the opposite end of the aquarium from a recently molted individual, and each time the active specimen would go directly back to the molted specimen.

Changing of Shells: The changing of shells by this species was observed many times. A confrontation would occur at which the larger specimen would grab the shell of the smaller specimen, and in most instances, would place the smaller specimen on its back, aperture up. The larger hermit crab would then grasp the shell of the smaller and vibrate it. There would be much flailing of the legs, but no actual grabbing of each other's appendages. After several seconds of this tactile signalling of vibrations, the smaller hermit crab, now placed with the aperture of its shell up, would suddenly come out of its shell and jump behind it or on top of it. As this occurred, the larger hermit crab would enter the now vacated shell, and would either remain in it or would leave it after a few seconds and re-enter its former shell. Often the larger hermit crab would keep the smaller specimen out of both shells while trying them out. In one case, the same two hermit crabs exchanged shells twice in an hour and a half.

An interesting variation of this shell-changing behavior was noted in one instance when the larger and smaller Pylopagurus specimens confronted each other. The smaller hermit crab was placed so the aperture of its shell was up and the crab itself was drawn deeply into its shell. The larger specimen then proceeded to shake and vibrate the smaller hermit, upon which the smaller of the two suddenly came up to the aperture of the shell and

caused the larger specimen to snap backward quickly. As this occurred, the smaller specimen came out of its shell quickly and walked away without going up on its shell.

When a Pylopagurus specimen changed shells, it would quickly go into the new shell all the way to the apex, and then would return to the aperature area again. Sometimes this process would be repeated, apparently indicating a checking-out procedure of the new shell and the hooking of the uropods in the shell.

Another interesting shell-changing incident occurred after a larger hermit crab took over a smaller hermit crab's shell. The larger, having taken almost half a minute to check the shell, and at the same time keeping the resident hermit crab out of its own shell, finally came out and went back into its original shell. The smaller individual then went around the far side of his own shell and entered it quickly. Immediately, thereupon, the larger hermit crab hit it with its major cheliped and walked off.

In one instance when the author lifted a Pylopagurus specimen from the aquarium with forceps, the hermit crab left its shell and fell back into the water, where it wandered until it came by chance upon a Polinices shell. Turning the shell aperature up, the hermit crab began to clean it with its minor cheliped for just a few seconds. With a quick motion, the hermit crab uncurled its abdomen, backed into the shell and jerked partially in and

out until the abdomen was well ensconced in the shell. Once in the shell, it began to walk about. Hermits were never observed to be forcibly removed from their shells by other hermit crabs as reported by Allee and Douglis (1945) in their study on Pagurus longicarpus from the Atlantic coast.

Copulating Behavior: Only one observation of what must be considered copulatory behavior was recorded. One specimen with its shell aperture up was facing an upright specimen. There was then active touching of antennae, and rubbing and stroking of legs and chelipeds. Especially noteworthy was a mutual rubbing of the major cheliped of each individual by the minor cheliped of the other individual. After about two minutes of this activity, the hermits lined up venter to venter with their anterior ends elevated. They were positioned with their bodies out of the shell to a point where one could just see the base of the abdomen. The body of each was flexed at the joint of the abdomen and thorax so both could line up the ventral sides of the thorax. This behavior sequence of copulation was observed just once in the Anomurans kept in the aquarium and only in Pylopagurus roseus.

Range.

Unknown. Type locality is "Gulf of California." Only other records are those in this study for Norse Beach at the head of the Gulf.

## Clibanarius Dana 1852

### Clibanarius digueti Bouvier Fig. 22

Clibanarius digueti Bouvier 1898, p. 379, Type Locality, La Paz, Gulf of California. Alcock 1905, p. 160. Schmitt 1924, p. 382. Steinbeck and Ricketts 1941, p. 453. Gordan 1956.

Previous Records.

Gulf of California: La Paz, Diguet (Bouvier 1898). San Carlos Bay, Sonora, F. Baker (Schmitt 1924). Amortajada Bay, Puerto Escondido, Pt. Marcial Reef, Coronado Island, Concepción Bay, San Lucas Cove, San Francisquito Bay, Angeles Bay, south end of Tiburon Island, Port San Carlos in Sonora and at Gabriel Bay on Espíritu Santo Island (Steinbeck and Ricketts 1941). Vermilion Sea Expedition-Shepard, 28° 55' N x 113° 31' W intertidal (Parker 1963).

New Records. See Table 20.

Color.

Scarlet Red to Scarlet with light tan tubercles on the chelipeds and ambulatory legs. Antennae Scarlet Red. Color names based on Ridgway (1912).

Measurements.

Largest specimen, a male measured 15.0 mm; the smallest specimen, also a male, measured 5.0 mm.

Ecology.

This is the most common hermit crab in the Puerto Peñasco area. It is found under rocks in the rocky intertidal of Norse Beach, and on the open sand flats of Bahía la Cholla. This species also occurs higher in the intertidal than any other hermit crab in the area.

The carcinoecia of this species varies considerably, but it is commonly Cerithium.

Range.

Gulf of California from Puerto Peñasco to La Paz.

## Petrochirus Stimpson 1859

### Petrochirus californiensis Bouvier Fig. 23

Petrochirus californiensis Bouvier 1895, p. 6, Type Locality, Lower California. Nobili 1901, p. 24. Prizibram 1905, p. 198. Rathbun 1910, p. 597. Glassell 1937b, p. 251. Steinbeck and Ricketts 1941, p. 454, pl. 12, fig. 1. Gordan 1956, p. 339. Parker 1963, p. 163. Taylor 1966.

Petrochirus granulatus californiensis Bouvier Bott 1955, p. 53, pl. 5, fig. 7 a & b.

Previous Records.

Gulf of California: Monument Beach, Bahía de Santa Inez, Zaca (Glassell 1937b). Punta Peñasco, Sonora (Glassell 1937b). El Mogote, Concepción Bay, and at entrance to Agiobampo Estuary (Steinbeck and Ricketts

1941). Vermilion Sea Expedition I, 44-48 meters, 23° 35.2' N x 106° 53.5' W; Curray-Orca Cruise, 16 meters, 28° 30.0' N x 111° 59.5' W, 24 meters, 28° 45.8' N x 112° 4.0' W (Parker 1963). El Salvador: La Libertad, Schuster (Bott 1955). Ecuador: Santa Elena Bay, E. Festa (Nobili 1901).

New Records. See Table 21.

Color.

In alcohol, ground color is tan with many large areas of dark brown to black. A dark brown spot at the outer distal edge of the merus of the chelipeds remains after much of the other brown pigment spots have faded away.

Measurements.

Largest specimen, a male measured 40 mm; the smallest specimen, a female measured 25 mm.

Ecology.

Found in pools and on rocks in the lowest intertidal area of Bahía la Cholla. Taylor (1966) who studied this species claims that it is much more common and easier to collect in the intertidal zone during the winter months. The carcinoecia of this species in the author's collecting area is the black murex, Muricanthus nigritus, and less

commonly, and perhaps better suited for smaller specimens, Hexaplex erythrostomus, the pink mouthed murex.

General Remarks.

This is the largest hermit crab occurring in the collecting area covered by this study.

Behavior.

On several occasions while specimens were kept in the aquarium, the behavior of Petrochirus was observed during shell changing. Usually the larger specimen would grab the shell of a smaller crab and tap it or shake it against its own, whereupon the smaller individual would emerge from its shell. The smaller crab would go behind its shell after leaving it. Then the larger crab would investigate the shell, at times remaining in it or more often returning to its own shell. Seemingly, neither specimen was harmed during this process. On several occasions when a newly-collected specimen was placed in an aquarium with specimens collected at an earlier date, it would be immediately set upon, if smaller in size, and then shell-changing would take place. The author never observed one Petrochirus pulling another forcibly from its shell.

When Petrochirus specimens were first introduced into the laboratory aquarium, they were frequently observed to molt within three or four days. The reason for this is

not known, but it could be due to the different environmental factors of the new surroundings, or to the severe stress introduced during the trip to the laboratory after collecting.

Range.

Puerto Peñasco, throughout the Gulf of California, south to Santa Elena Bay, Ecuador.

## Isocheles Stimpson 1859

### Isocheles pacificus (Bouvier) Fig. 24

Isocheles wurdemanni, var. pacificus Bouvier 1907, p. 115, Type Locality, Payta, Peru. Forest 1952, p. 809.

Isocheles wurdemanni pacificus Bouvier Rathbun 1910, p. 596.

Isocheles pacificus Bouvier Forest 1964, p. 291.

Previous Records.

Peru: Payta, M. Rivet (Bouvier 1907).

New Records. See Table 22.

Color.

In alcohol, general ground color is tan or white, with two dark brown stripes on dorsal sides of eye stalks.

commonly, and perhaps better suited for smaller specimens, Hexaplex erythrostomus, the pink mouthed murex.

General Remarks.

This is the largest hermit crab occurring in the collecting area covered by this study.

Behavior.

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Puerto Peñasco, throughout the Gulf of California, south to Santa Elena Bay, Ecuador.

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Isocheles pacificus Bouvier Forest 1964, p. 291.

Previous Records.

Peru: Payta, M. Rivet (Bouvier 1907).

New Records. See Table 22.

Color.

In alcohol, general ground color is tan or white, with two dark brown stripes on dorsal sides of eye stalks.

Measurements.

Largest specimen, a male measured 11.0 mm; the smallest specimen, a female measured 4.5 mm.

Ecology.

All of the author's specimens were collected on the sand flats of Bahía la Cholla in the infra-littoral zone.

Range.

Known only from the Type Locality, Payta, Peru. Due to the fact that this species has been collected only once prior to the present collections of the author, a range extention will not be indicated.

Paguristes sp. undescribed

A new species of Paguristes, in manuscript by Miss Janet Haig, is very common on the sand flats of Bahía la Cholla. This small species, usually occurring in Cerithium shells, may be recognized by the two rows of plumose setae on the antennae and by the blue circle of color or "blue dot" on the inner side of the merus of both chelipeds. General coloration is tan, with light pink on the eye stalks.

ANOMURA: Hippidea

Albuneidae

Lepidopa Stimpson 1858

Lepidopa mearnsi? Benedict Fig. 25

Lepidopa mearnsi? Benedict 1903, p. 895, Type Locality, "West Coast of Central America."

Previous Records.

West Coast of Central America.

New Records. See Table 23.

Color.

General overall ground color is white, with a dark brown spot at the posterior end of the thorax, and at the anterior end of abdomen in a mid dorsal position. Some light iridescent pink color is present on the propodus of the chelipeds.

Measurements.

Largest specimen, a female measured 10.2 mm; the smallest specimen, a male measured 7.3 mm.

Ecology.

Collected in fine sand, two to three inches below the surface at lowest tide levels.

General Remarks.

This species was first described from one specimen in very poor condition. The single type in the USNM #26171 is probably the only one in existence (Haig in litt.). The author's specimens have been tentatively identified by Miss Janet Haig of the Allan Hancock Foundation.

Range.

Known only from the type locality of West Coast of Central America (Benedict 1903).

ANOMURA: Thalassinidea

Axiidae

Axius Leach 1815

Axius (Neaxius) vivesi (Bouvier)

Eiconaxius vivesi Bouvier 1895, p. 7, Type Locality, Lower California.

Axius (Neaxius) vivesi (Bouvier) De Man 1925a, p. 56. De Man 1925b, p. 14. Steinbeck and Ricketts 1941, p. 450.

Previous Records.

Lower California: Diguet (Bouvier 1895). La Paz (Steinbeck and Ricketts 1941).

New Records. See Table 24.

Color.

In life, general body color Eosine Pink to Begonia Rose, with small white areas. Faded to white in alcohol. Color names based on Ridgway (1912).

Measurements.

Carapace length in the single male specimen collected was 21.5 mm.

Ecology.

The author's specimen was collected under a rock. However other specimens in the area were in tunnels that opened in sandy areas between embedded rocks, making it almost impossible to dig them out. Concerning its ecology, Steinbeck and Ricketts (1941) say:

> Taken abundantly east of La Paz, in burrows in the gravelly mud flats, under and around the (mostly) dead heads of the coral Porites. One of the commonest animals of the region, presumably very important in the littoral economy, since it is both large and active. Difficult to collect, wary, and fast . . . .

General Remarks.

This species was first described by Bouvier in 1895 from a unique specimen collected by M. Diguet in Lower California. The description by Bouvier is very short, consisting of only seven lines. This species which was further detailed by J. G. De Man (1925a) included figures of the posterior abdominal segment, telson, and the major

cheliped. There was no mention of the ecology of this species in either of these papers.

Range.

Previously known only from La Paz. The range has been extended northward ca. 500 miles in the present study.

## Callianassidae

Two species of Callianassa and one species of Upogebia were collected from the sand flats of Bahía la Cholla during the interim of this study. The efforts which were made to identify these three species were unsuccessful due to the fact that there is no specialist on Panamic callianassids. Identifications will require a comparative study of type specimens located in several eastern museums, and further collection in more southern locations of the Panamic Province.

### Key to the Families of Intertidal Anomuran* Decapod Crustaceans in the Puerto Penasco-Bahia la Cholla Area

1 Abdomen soft, curved, unprotected, with reduced number of appendages, living in abandoned gastropod shells - - - - - - - - - - Paguridae (p.73)

1' Abdomen large, straight, protected, with segmental appendages, crayfish-like in general body form - - - - - - - - - Axiidae (p. 66) Axius (Neaxius) vivesi

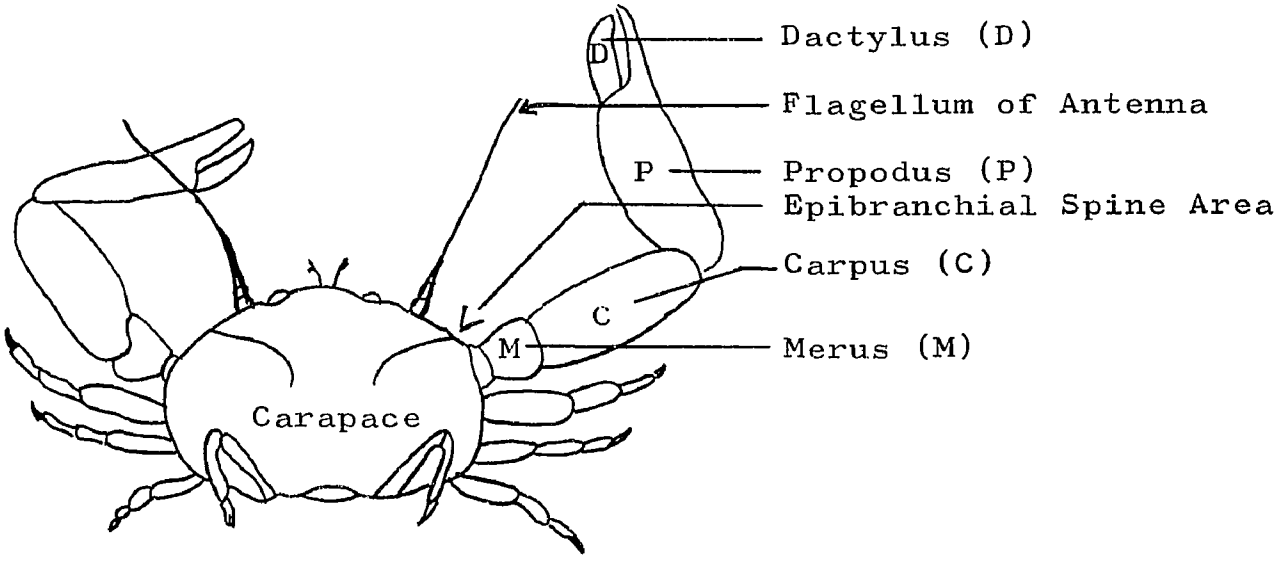
*See characteristics of Section Anomura on p. 16.

1" Abdomen short, and reflexed under thorax, animal crab-like in general appearance - - - - - 2

2 Antennules as long or longer than body, and bearing two rows of plumose setae, legs flattened and blade-like in appearance, adapted for life in sand - - - - Albuneidae (p. 65)
Lepidopa mearnsi?

2' Antennules very short, not bearing two rows of plumose setae, legs normal, not flattened, with sharp claws, adapted for living on rocks - - - - - - Porcellanidae (p. 71)

## Glossary of Terms Used in the Keys




Front: Area ventral to cavities of antennules and dorsal to mouth area.

Cheliped or Chela: The claw or claw-like first walking leg.

Periopod: A walking leg originating on the ventral side of the thorax.

Piliferous striations: Raised ridges on carapace having short setae projecting from them.

Epibranchial spine: A spine projecting from epibranchial area (see above).

Pectinate: Comb-like in general form.

Ocular scales: Small scale-like processes at the base of the eye stalk of hermit crabs, often spine-like or armed with teeth.

Rostrum: A spine-like process projecting from the median, anterior point of carapace.

## Key to the Intertidal Species of Porcellanidae

1 Carapace one and one-half times as long as wide; a large cavity on epibranhial margin - - - - - - - - - *Euceramus transversilineatus*

1' Carapace not as above, never as much as one and a half times as long as broad - - - - - - - - 2

2 Basal segment of antennae not produced forward to meet anterior margin of carapace; antennae originating close to outer margin of eye - - - - - - - - - - - - - - - - - 3

2' Basal segment of antennae produced forward and in contact with carapace; antennae far removed from eye - - - - - - - - - - - - - - - - 10

3 Posterior portion of side walls of carapace consisting of one or more pieces separated by membranous interspaces; chelipeds thick, robust, one distinctly larger than the other - - - - - - - - - - *Pachycheles setimanus*

3' Posterior portion of side walls of carapace without separate pieces; chelipeds not thick or robust - - - - - - - - - *Petrolisthes* - - 4

4 Epibranchial spine absent - - - - - - - - - - - - - - - 5

4' Epibranchial spine present - - - - - - - - - - - - - - 9

5 Anterior margin of merus of walking legs nodulate on anterior margin - - - - - - - - - - - - - - - - - *Petrolisthes-tiburonensis*

5' Anterior margin of merus of walking legs unarmed - - - - - - - - - - - - - - - - - - - - - - - - 6

6 Carpus of chelipeds armed with spines on anterior margin - - - - - - - - - - - - - - - - - - - 7

6' Carpus of chelipeds unarmed on anterior margin - - - - - - - - - - - - - - - - - - - - - - - - - 8

7 Carpus with wide set conical tubercle on anterior margin; manus with a thick fringe of setae on outer margin; tubercles of chelipeds tipped with red, tip of dactylus of cheliped red; distal parts of 3rd maxillipeds dark blue in color - - - - - - - - - - - - - Petrolisthes hirtipes

7' Carpus with strong teeth on anterior margin; carapace white or cream, dactylus of walking legs and chelipeds dark brown in color - - - - - - - - - - Petrolisthes crenulatus

8 Carpus over twice as long as wide, legs and chelipeds smooth, without spines; general color over dorsal surface of legs and carapace dark brown - - - - Petrolisthes gracilis

8' Carpus twice as long as wide or less, with 2-3 small pointed teeth at proximal anterior edge of carpus, 2 ridges on upper surface; color dark brown splotched on white; a small rocky intertidal species - - - - - - - - - - - Petrolisthes schmitti

9 Carapace with distinct piliferous striations; chelae with marked alternation of ridges and grooves, fringe of setae on outer edge of manus, 4 or 5 sharp teeth on anterior edge of carpus of cheliped; dark red in color - - - - - - - - - - Petrolisthes sanfelipensis

9' Carapace without distinct piliferous striations; chelae without alternations of ridges and grooves, 3 sharp teeth on proximal anterior edge of carpus of cheliped; brown in color - - - Petrolisthes armatus

10 Movable segments of antennae minute and flagellum rudimentary, their length scarcely exceeding width of eye; 3 rostral spines present, and epibranchial spine also present; may be commensal on sea stars - - - - - - - - - - - - - - Minyoceras kirki

10' Movable segments of antennae larger, easily visible, flagellum about as long as carapace - - - - - - - - - - - - - - - - - - - - - - 11

11 Front prominant, strongly tridentate or trilobate in dorsal view - - - - - Porcellana - 12

11' Front deflexed, appearing rounded or faintly trilobate in dorsal view - - - - - - - - - - - - - 13

12 Epibranchial angle with two or three spinules, frontal teeth pointed at tips, median one spinulate on margins; a fringe of setae present on the outer border of chelipeds; often commensal with Petrochirus, the "giant hermit crab" - - - - - - - Porcellana cancrisocialis

12' Epibranchial angle unarmed, frontal teeth rounded at tips, median one not spinulate; fringe of setae absent on the outer border of chelipeds; often commensal with Petrochirus, the "giant hermit crab" - Porcellana paguriconviva

13 Carapace about as broad as long, front trilobate to strongly tridentate in frontal view; basal segment of antennules very small, recessed behind front, the latter projecting over them like a shelf - - - - Megalobrachium - 14

13' Carapace longer than broad, front with a broad rectangular rostral process, visible only in frontal view; basal segment of antennules large, produced anteriorly to fill notches between rostral process and inner orbital angle - - - - - Ulloaia perpusillia

14 Telson of abdomen composed of 5 plates; tubercules and setae over most of body and upper surfaces of chelipeds - - - - - - - - - - - - - - - Megalobrachium tuberculipes

14' Telson of abdomen composed of 7 plates; without setae and tubercules - - - - Megalobrachium smithi

## Key to the Intertidal Species of Paguridae

1 Chelae of distinctly different size, right larger than left - - - - - - - - - - - - - - - - - - - 2

1' Chelae approximately equal or subequal in size - - - - - - - - - - - - - - - - - - - - - - - - - 4

2 Inner edge of carpus of major cheliped armed with spines, otherwise surface of carpus smooth, color in life dark brown with tan or white bands, antennae long, thin, setiform, eye stalks brown with 2 encircling white rings, eyes red, in rocky areas, "red eyed hermit crab" - - - - - - - - Pylopagurus roseus

2' Inner edge of carpus of major cheliped armed with spines and with rows of spines and tubercules present on surface - - - - - - - - - - 3

3 Carpus of major cheliped with 3 rows of spines, inner edge, and 2 other rows on anterior side; very small tubercles between rows; color white or light tan over general body surface and appendages; found on sand flats of Bahía la Cholla, "white hermit crab" - - - - - - - - - Pagurus albus

3' Carpus of major cheliped with 3 rows of spines, but roughly tuberculate on the anterior surface between spine rows, legs and chelae tuberculate; general body and leg color brown; eye stalks with pointed tuft of setae at apex; with color pattern in the form of a brown arrow pointing to it; largest species in area, and is strongly built, "giant hermit crab" - - - - - - - - - - - - - - - - - - - - Petrochirus californiensis

4 Definite rostral spine present between eye stalks - - - - - - - - - - - - - - - - - - - - - - - - 5

4' Rostrum a short truncate lobe or absent, not spine shaped - - - - - - - - - - - - - - - - - - - - 7

5 Ocular scales terminating anteriorly in one spine-like tooth; chelae and walking legs covered with light colored tubercles on a light reddish colored background, eye stalk light red, eye light blue, "blue eyed hermit crab" - - - - - - - - Paguristes sanguinimanus

5' Ocular scales with 4 or 5 spines at anterior edge - - - - - - - - - - - - - - - - - - - - - - - - 6

6 Ocular scales with 2 spines and sometimes a small 3rd spine; both pairs of antennae, 2nd and 3rd maxillipeds, and eye stalks dark blue with white ring-like markings; chelae and walking legs covered with thick brown hair-like setae, "hairy hermit crab" - - - - - - - - - - - - - - - - Pagurista anhuacus

6' Ocular scales with 3 to 5 spines and broadly truncate in form; 2nd pair of antennae and setiferous tip of antennule red, chelae and walking legs dark reddish brown with light blue or white tubercles; very common in rocky intertidal area - - - - - - - - - - - - - - - - - - - - - - - - Clibanarius digueti

7 Antennae pectinate, with 2 rows of long setae; general body color white, with setae on body surface - - - - - - - - - - - - - - - - 8

7' Antennae filiform without rows of long setae; right cheliped slightly larger than left; a general mottled brown in color; found on sand flats and in rocky areas - - - - - - - - - - - - - - - - - - Pagurus lepidus

8 With a circular spot of blue color on the inner edge of the merus of both chelipeds, eye stalks a light pink color in life, "blue dot hermit crab" - - - - - - - - - - - - - - - - - - - - - - Pagurista sp. nov.

8' Without circular spot of blue color on inner edge of merus, but with two brown stripes running lengthwise on eye stalks - - - - - - - - - - - - - - - - - - - - - - - - Isocheles pacificus

## Observations on Feeding Methods

Feeding methods in the porcellanids and pagurids have been observed for a few species in aquaria. The porcellanids exhibit cast-net feeding action, utilizing the third maxillipeds, as briefly indicated in papers by Calman (1911), Orton (1927), Yonge (1928), and Boltt (1961). All

of these references were to species of the genus Porcellana and none of the authors elaborated on this feeding action.

Cast-net feeding has been observed in the present study in 11 species of the 15 total collected. When specimens are feeding by this method, the somewhat enlarged and strongly setose third maxillipeds are waved through the water and then brought in to be cleaned off by the second pair of maxillipeds. The actual movement of these third maxillipeds provides an interesting study in itself. Orton (1927) observed that Porcellana longicornis extends its third maxillipeds "like whips or rackets, throwing out the left and right one alternately." In six of the porcellanid species observed by the author, the third maxillipeds are also brought in to be cleaned in an alternate manner. This is a fairly rapid movement at times, but tends to vary according to the concentration of particulate matter in the water. In the five other species of porcellanids the third maxillipeds are brought in simultaneously. In the present study, there appears to be no special taxonomic significance with regard to these two methods of maxilliped use.

The feeding action could usually be induced either by stirring up the bottom sediment or by sprinkling in some of the pellet fish food. In a brief note Borradaile (1921) comments on the feeding of Porcellana platycheles:

> This animal is not a commensal, and gathers for itself suspended food, taking it by means of long fringes upon the third maxillipeds, but is

> provided with well developed inner mouthparts. Possibly it feeds, not, as Haplocarcinus does, only upon the very minute organisms which make up the nannoplankton, but also upon suspended particles of greater size and toughness. Or it may be that it uses the chelae for seizing food, though I have not seen it do this.

Borradaile had not observed the seizing of food particles by the chelae in these species. However, in the present study small pieces of liver have been seized by the chelae in three species, Petrolisthes hirtipes, P. gracilis, and P. armatus. Also, with reference to the chelae, certain species of Petrolisthes have a patch of setae which plays a part in the feeding action. The crab will use this brush of setae to scrape across flat surfaces to catch particulate food matter and then bring it to the third maxillipeds.

The hermit crabs are primarily scavengers of the substratum in various habitats. Much of the work that has been done on the feeding of hermits has been carried out with experiments on Atlantic coast species (Orton 1927). More has been done on Pagurus bernhardus than any other species.

The chelae are used primarily for picking up larger particles, but are also used for breaking up particles. In the case of those species with chelipeds of equal size, such as Clibanarius, either chela may be used without preference for food handling. In species where one chela is larger than the other, the smaller one is used for feeding by transferring particles to the third maxillipeds.

In some species such as Petrochirus californiensis and Pylopagurus roseus the periopods are used to lift sand from the bottom, sift it, and clean it of food items by means of the third maxillipeds. This action was also observed by Thompson (1904) for Pagurus longicarpus on the East Coast and by Orton (1927) for P. bernhardus in England.

Although apparently not recorded in the literature, the author has observed another variation in the use of pagurid maxillipeds. This action takes place during periods in which the water contains high concentrations of particulate food matter, and is perhaps best described as a pawing motion with the third maxillipeds. This is a quick motion, in which the comparatively short third maxillipeds literally "paw" the water, and are frequently and very quickly brought back to be cleaned by the second maxillipeds. Occasionally, during this observation, the antennae and antennules are wiped by the third maxillipeds. This method of feeding has been noted for Pylopagurus roseus, Pagurus lepidus, and P. albus.

One more feeding method utilized by a few hermit crabs and recorded only once in the literature has been termed "antennary cast-net feeding." This term, first applied by Boltt (1961) for this type of feeding was discovered in Diogenes brevirostris, a South African hermit crab. In this type of feeding the antennae are specialized in that they possess two rows of plumose setae, and are

swept through the water to catch particulate material. During each sweep the antennae are twisted so the shafts of the setae are facing forward as the sweep is made. After each antenna has made three or four sweeps it is brought in and cleaned by the third maxillipeds. On certain occasions when the particulate food matter in the water is high, these antennae may be held vertically in the water without moving, and then just brought in to be cleaned. Further, it was observed that when feeding by this method, the hermits would tend to seek out some high point in the aquarium, such as on top of a rock. Often they would be on the back of another hermit crab. The two species in the author's collections observed to utilize this feeding method, Isocheles pacificus and Paguristes sp. nov., also feed in the normal way of using chelae to transfer food to the third maxillipeds.

## ZOOGEOGRAPHICAL REMARKS

The Gulf of California is about 650 miles long, yet only 60 to 130 miles in width and is therefore an extremely long, narrow, inland extension of the Eastern Pacific Ocean. It is located in one of the great desert regions of the world, and for this reason its characteristics tend to be primarily continental. This is true with regard to water temperatures, and the general lack of steady wind-driven surf, especially in the northern latitudes. Certain other physical characteristics of this long arm of the ocean, primarily the tides and currents, are further intensified by the fact that the Gulf narrows above its middle latitude and its waters are even further restricted due to the two large islands of Tiburon and Angel de la Guarda. These combined effects of restriction have a profound effect on the tides in the Puerto Peñasco area. Here in the comparatively shallow north end, the tides may reach 20 to 22 feet on some full and new moon series, and at low tide one can walk out for miles on the exposed flats. The intertidal area is therefore subjected to severe desiccation, high light intensity and a poorly developed surf. Dawson (1960) states the following about this area: "These remarkable conditions of surf, tide, temperature, and circulation, operating on an extremely

diverse shore type, from mudflats, to rocky cliffs, provide for a flora and fauna as distinctive as for any region of similar size in the world."

At the head of the Gulf in the Puerto Peñasco-Bahía la Cholla area, the author has collected 29 species of Anomurans. This figure is extremely high considering the fact that this group constitutes only one section of the order Decapoda. In addition, the collecting area encompasses only about five miles of coastline and is moreover limited to the littoral zone.

In order to give some idea of the richness of this part of the Gulf, several separate studies will be cited wherein the authors list numbers of species. A study by H. N. Lowe (1935) included 105 species of bivalves and 168 species of gastropods. This study makes an interesting comparison with his mollusk collections from La Paz in the southern part of the Gulf (Pilsbry and Lowe 1932) which included 90 species of bivalves and 110 species of gastropods. McLean (1961), who studied the marine mollusks from Los Angeles Bay on the west coast of the Gulf, listed a total of 405 mollusks, including 135 bivalves, 248 gastropods, 3 scaphopods and 19 chitons. Nearly 50 species of Echinoderms have been collected or reported from the head of the Gulf in a soon-to-be-published report on this important marine group. This study by J. A. Beatty will include some of the sublittoral species, however. Another

report, still in preparation, includes 40 to 50 species of Opisthobranch mollusks and will be published by E. Marcus. Some of these figures may include a few deep-water species, but they should serve to point out the fact that the collecting is extremely rich and varied, and that this phenomenon probably extends to most of the marine invertebrate groups.

The above figures on the richness of the Puerto Peñasco-Bahía la Cholla and general Gulf areas are given added importance in view of studies made in certain other coastal areas in the world. L. Holthuis (1959), who made a study of the Decapod Crustaceans of Surinam (Dutch Guiana), includes 13 species of Anomurans all from offshore at an average depth of 20 to 30 meters. Ten are hermit crabs and three are porcellanid crabs.

O. Paul'son (sic) (1875), who studied and described the collections of Professor Kovalevskii from the Red Sea, records 15 species of Anomurans. Six of these are porcellanids, five are pagurids, three are galatheids and one a hippid.

Bott (1955), who published a study on a comparatively incomplete collection of crustaceans collected in El Salvador, listed eight species of Anomurans, four of which were pagurids, one a porcellanid, one a callianassid, and two of which were hippids. In another study on the porcellanid crustaceans from Madagascar and the Comores

Islands (Haig 1965) there is a total of 14 species for an area of considerable shoreline.

A final listing of interest (as it deals with Clipperton Island off the west coast of Mexico) is a paper by Fenner Chace, Jr. (1962). In his survey, eight Anomurans were cited as occurring on this small coral island.

The affinities of this northern Gulf Anomuran fauna seem to lie entirely with the Panamic marine province. This province has been defined by Dall (1909) as extending from Lower California, including the Gulf, south to the Bay of Guayaquil, Ecuador. Additional studies, including one by Rathbun (1910), strongly suggest that the northern limit of the Peruvian Province (southern limit of the Panamic) is much more gradual in species change, which indicates that a sharp line cannot easily be drawn at that point. It appears, however, that the limits to be drawn for the Panamic Province will vary considerably, depending on new collecting records in the vicinity of the boundary lines indicated above. For the present purposes then, it seems best to limit the southern end of the Panamic at about the boundary of Ecuador and Peru. The northern boundary is even more nebulous, because of scattered collections to the north along the Lower California coast. In addition, species in most groups tend to drop out rather slowly as one travels northward along this coast. The best "limit"

appears to be between Magdelena Bay and the vicinity of Cedros Islands for most of the species. It should be borne in mind, however, that Panamic species drop out all the way along this coast even to Point Conception in California, and that much intertidal collecting should be carried out along the western Baja California Coast. The Gulf of California, according to Garth (1960), presents a special problem due to the fact that it extends far northward, enclosing a body of water that is temperate at its northern end and tropical at its southern end.

In studying the zoogeographic affinities of the Puerto Peñasco-Bahía la Cholla fauna, the author finds that out of 26 species of Anomurans, 11 (42 per cent) are endemic species found only in the Gulf of California. These 11 can be broken down to include 4 porcellanids, 6 pagurids, and one axiid. Twelve species (46 per cent) are Panamic in distribution and also occur in the Gulf from Puerto Peñasco southward. This Panamic group can be subdivided into 8 porcellanids, 3 pagurids and one albuneid. Three species of Petrolisthes (12 per cent) occur throughout the Gulf and have also been collected at Bahía Magdelena on the Pacific side of Baja California (see Table 25, p. 115).

Three papers have been published on the Gulf of California Decapods and their affinities. The most recent is a study of three groups of Brachyuran, or short-tailed crabs, made by Garth (1960). He made a study of 230

species and concluded that 80 (35 per cent) were endemic to the Gulf of California, 131 (57 per cent) were Panamic and 19 (8 per cent) were northern in distribution. In a similar publication on Brachyuran crabs, Glassell (1934) studied 197 species of which 75 (40 per cent) were endemic, 96 (48 per cent) were Panamic, and 24 (12 per cent) were north-temperate species.

Steinbeck and Ricketts (1941) also included an analysis of the Anomuran fauna. They collected 32 species of littoral Anomurans in the Gulf, exclusive of the thallassinids. Nine of these were hermit crabs, 20 were porcellanids, 2 were hippids and one was a galatheid. They concluded that the Gulf Anomura as a group are rather strictly Panamic, and also endemic.

Based on these reports of faunistic surveys in the Gulf and associated Panamic regions, it seems rather apparent that this Puerto Peñasco-Bahía la Cholla area is definitely related to the Panamic Marine Province and that there seems to be a pronounced development of endemism in the Gulf. This is indicated by the collections and studies of Steinbeck and Ricketts (1941), based on a large tabulation of invertebrate animals. In their study, including a compilation of ranges for 415 species, they find that 72 (17.5 per cent) are endemic, 160 (38.5 per cent) are Panamic, 42 (10.1 per cent) range northward, 68 (16.3 per cent) are distributed both to the north and south of the

Gulf, 39 (9.6 per cent) are tropicopolitan or cosmopolitan, 20 (4.8 per cent) are West Indian and only 14 (3.3 per cent) are Indo-Pacific in origin. We have seen then, from the above figures that the fauna at Puerto Peñasco is very definitely Panamic in origin with many indigenous species.

What then is the original derivation of the Panamic species? It appears, from published studies available up to the present time, that most of these coastal warm-water Eastern Pacific elements are most closely related to the warm-water Western Atlantic marine fauna. This may seem somewhat improbable in light of the present physiographical barriers, and is probably best answered from geological and paleontological evidence. One would think upon examination of a map that our Eastern Pacific fauna should be most closely related to the Pacific Ocean or Indo-Pacific area because no continent is present as a barrier. This apparent paradox was elucidated by Ekman (1953) who reasoned that the large expanse of open ocean of deep water along with the general lack of land masses and islands does create a very real barrier to distribution, which barrier he has called the "Eastern Pacific Barrier."

A detailed study and comparison of Eastern Pacific and Western Atlantic warm-water fauna will reveal a great similarity between many species in the same genera. The species that are definitely similar are termed analogous species, and sometimes, even for the specialist, they are

difficult to distinguish. This Western Atlantic fauna, then, even earlier in geological history, has been derived from the old Tethys Sea fauna via the equatorial Atlantic, the Mediterranean Sea, and the Indian Ocean. Therefore, it is in all likelihood, derived originally, geologically speaking, from the Indo-Pacific area. This faunal history is related in greater detail by Keen (1958).

# APPENDIX

Table 1. Euceramus transversilineatus

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | in sand of lower intertidal | 13 Mar 1965 | 1 | 1 | | 2 | D. Casky |

Table 2. Pachycheles setimanus

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Pelican Point | under rocks | 25 Nov 1961 | 1 | | 2 | 3 | Author |
| Norse Beach | under rocks, lower mid-littoral | 31 Jan 1962 | | 1 | 1 | 2 | Author |
| Norse Beach | under rocks on reef minus tide level | 31 Jan 1962 | 3 | 2 | 1 | 6 | Author |
| Norse Beach | under rocks, mid-littoral | 24 Nov 1962 | | 1 | 4 | 5 | Author |
| Norse Beach | under rock, lower mid-littoral | 2 Feb 1963 | 6 | 4 | 2 | 12 | Author |
| Norse Beach | under rock, lower mid-littoral | 2 Feb 1963 | 5 | 4 | 4 | 13 | Author |
| Norse Beach | under rock, mid-littoral | 9 Mar 1963 | 1 | | | 1 | Author |
| Norse Beach | under rocks, infra-littoral | 23 Mar 1963 | | 1 | | 1 | Author |
| Norse Beach | under rocks, mid-littoral | 23 Mar 1963 | 1 | 1 | 1 | 3 | Author |

Table 2.--Continued

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Norse Beach | under rock, mid-littoral | 26 Apr 1963 | | | 1 | 1 | Author |
| Norse Beach | under rocks, mid-littoral | 5 Jul 1963 | | | 3 | 3 | Author |
| Norse Beach | on sponges, mid-littoral | 6 Jul 1963 | | 1 | | 1 | Author |
| Norse Beach | underside of rock, lower mid-littoral | 6 Jul 1963 | 1 | 1 | 1 | 3 | Author |
| Norse Beach | among sponges, lower mid-littoral | 6 Jul 1963 | | | 2 | 2 | Author |
| Bahía la Cholla | underside of rock, on south shore mid-littoral | 7 Jul 1963 | 1 | | 3 | 4 | Author |
| Norse Beach | around sponges, lower mid-littoral | 20 Jul 1963 | 3 | 1 | | 4 | Author |
| Bahía la Cholla | under rock, mid-littoral, north shore | 29 Nov 1963 | 1 | | | 1 | Author |
| | | TOTALS | 23 | 17 | 25 | 65 | |

Table 3. Petrolisthes tiburonensis

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Norse Beach | under rock, mid-littoral, NW end | 10 Mar 1962 | 1 | | | 1 | Author |
| Puerto Libertad | under rock, south shore, Cirio Point | 1 Apr 1962 | | 1 | | 1 | Author |
| Norse Beach | under rock, mid-littoral tide pool | 2 Mar 1963 | | | 1 | 1 | Author |
| Norse Beach | under rock, mid-littoral, NW end | 24 Mar 1963 | | 2 | | 2 | Author |
| Norse Beach | underside of rock, mid-littoral | 5 Jul 1963 | | 1 | | 1 | Author |
| Bahía la Cholla | underside of rock, south shore, lower mid-littoral | 7 Jul 1963 | | 3 | | 3 | Author |
| Norse Beach | underside of rock, lower mid-littoral | 14 Mar 1964 | | | 1 | 1 | Author |

Table 3.--Continued

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Norse Beach | under rock | 14 Mar 1964 | 1 | | | 1 | Author |
| Norse Beach | under rock, on reef | 19 Feb 1965 | | 1 | | 1 | Author |
| | | TOTALS | 2 | 8 | 2 | 12 | |

Table 4.--*Petrolisthes hirtipes*

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | under rock, upper mid-littoral, south shore | 13 Dec 1959 | (not preserved) | | | | Author |
| Norse Beach | under rock, infra-littoral | 31 Jan 1962 | 1 | 2 | | 3 | Author |
| Norse Beach | under rock | 6 May 1962 | 1 | | | 1 | Author |
| Norse Beach | underside of rock, lower mid-littoral | 2 Feb 1963 | (not preserved) | | | | Author |
| Norse Beach | under rocks, lower mid-littoral | 23 Mar 1963 | 2 | | | 2 | Author |
| Norse Beach | under rocks, NW end | 24 Mar 1963 | 2 | 4 | 2 | 8 | Author |
| Norse Beach | under rocks, mid-littoral, NW end | 24 Mar 1963 | 7 | 5 | | 12 | Author |
| Norse Beach | underside of rock, lower mid-littoral | 20 Jul 1963 | 1 | | | 1 | Author |

Table 4.--Continued

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Norse Beach | under rock, on reef | 19 Feb 1965 | | 1 | | 1 | Author |
| Norse Beach | under rock, at ca. 0 tide level | 9 Mar 1963 | | 1 | | 1 | Author |
| | | TOTALS | 14 | 13 | 2 | 29 | |

Table 5. *Petrolisthes crenulatus*

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Norse Beach | under rocks at ca. minus tide | 31 Jan 1962 | | 2 | | 2 | Author |
| Norse Beach | tide pool, on reef | 20 Jan 1962 | | 1 | | 1 | Author |
| Norse Beach | under rock | 6 May 1962 | 1 | 1 | | 2 | Author |
| Norse Beach | on reef | 26 Apr 1963 | 1 | 1 | | 2 | P. E. Pickens |
| Norse Beach | around sponges, lower mid-littoral | 20 Jul 1963 | 1 | | | 1 | Author |
| Norse Beach | underside of rock | 30 Nov 1963 | 1 | | | 1 | Author |
| Norse Beach | lower inter-tidal | 26 Jun 1965 | 1 | | | 1 | P. E. Pickens |
| Estuary, SE of Puerto Peñasco | under rocks | ? Jun 1965 | 1 | | 1 | 2 | R. Pardy |
| | | TOTALS | 6 | 5 | 1 | 12 | |

Table 6. Petrolisthes gracilis

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | upper mid-littoral under rocks, south shore | 13 Dec 1959 | 2 | 4 | | 6 | Author |
| Norse Beach | under rock in upper mid-littoral, NW end | 20 Jan 1962 | 7 | 4 | | 11 | Author |
| Norse Beach | under rocks on reef at ca. 0 tide level | 31 Jan 1962 | 1 | 1 | 1 | 3 | Author |
| Norse Beach | on reef | 17 Mar 1962 | 2 | 3 | | 5 | Author |
| Puerto Libertad | under rock on south shore of Cirio Point | 1 Apr 1962 | 1 | 1 | | 2 | Author |
| Norse Beach | under rocks, lower mid-littoral | 24 Nov 1962 | 2 | 1 | | 3 | Author |
| Bahía la Cholla | under rocks, upper mid-littoral, south shore | 25 Nov 1962 | 10 | 4 | | 14 | Author |

Table 6.--Continued

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | under rocks, south shore | 25 Nov 1962 | 3 | 4 | | 7 | Author |
| Norse Beach | underside of rock, lower mid-littoral | 3 Feb 1963 | 6 | 1 | 1 | 8 | Author |
| Bahía la Cholla | underside of rocks, south shore, lower mid-littoral | 3 Feb 1963 | 9 | 20 | | 29 | Author |
| Norse Beach | under rock in mid-littoral tide pool | 2 Mar 1963 | 1 | 1 | 1 | 3 | Author |
| Norse Beach | under rocks in mid-littoral | 9 Mar 1963 | 3 | 2 | | 5 | Author |
| Norse Beach | under rocks, NW end | 10 Mar 1963 | 1 | 1 | | 2 | Author |
| Norse Beach | under rocks, NW end | 10 Mar 1963 | | (not preserved) | | | Author |
| Norse Beach | under rocks, upper mid-littoral | 23 Mar 1963 | 4 | 4 | | 8 | Author |
| Norse Beach | under rocks, infra-littoral | 23 Mar 1963 | 1 | | | 1 | Author |

Table 6.--Continued

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Norse Beach | under rock, NW end | 24 Mar 1963 | | 1 | | 1 | Author |
| Bahía la Cholla | upper intertidal, in back slough | 1 Jul 1965 | 2 | 3 | 4 | 9 | P. E. Pickens |
| | | TOTALS | 55 | 55 | 7 | 117 | |

Table 7. Petrolisthes schmitti

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | underside of rock, lower mid-littoral, south shore | 3 Feb 1963 | 1 | 2 | | 3 | Author |
| Norse Beach | among sponges, lower mid-littoral | 6 Jul 1963 | | | 1 | 1 | Author |
| Norse Beach | among sponges, lower mid-littoral | 6 Jul 1963 | | | 1 | 1 | Author |
| | | TOTALS | 1 | 2 | 2 | 5 | |

Table 8. Petrolisthes sanfelipensis

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Pelican Point | under rock in tide pool | 24 Nov 1961 | | 1 | | 1 | Author |
| Norse Beach | under rocks at minus tide level | 31 Jan 1962 | 2 | | | 2 | Author |
| Norse Beach | under rocks | 6 May 1962 | | | 2 | 2 | Author |
| Norse Beach | under rocks, mid-littoral | 23 Mar 1963 | 1 | 1 | | 2 | Author |
| Norse Beach | under rocks, infra-littoral | 23 Mar 1963 | 1 | 1 | 1 | 3 | Author |
| Bahía la Cholla | on snail shell with small octopus in it | 5 Aug 1963 | | | 1 | 1 | J. A. Beatty |
| Bahía la Cholla | on sponges and under rocks, infra-littoral | 29 Nov 1963 | 7 | 5 | | 12 | Author |
| Norse Beach | under rocks on reef | 19 Feb 1965 | 1 | 1 | | 2 | Author |

Table 8.--Continued

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | on Pedina, a brown alga floating in infra-littoral | 12 Mar 1965 | 2 | 1 | | 3 | P. E. Pickens |
| Estuary, SE of Puerto Peñasco | under rocks, lower mid-littoral | 27 Jun 1965 | 2 | | 2 | 4 | R. Pardy |
| | | TOTALS | 16 | 9 | 6 | 31 | |

Table 9. Petrolisthes armatus

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | under rocks, upper mid-littoral | 13 Dec 1959 | 1 | | | 1 | Author |
| Pelican Point | under rock in tide pool, mid-littoral | 25 Nov 1961 | | 1 | | 1 | Author |
| Norse Beach | under rock in upper mid-littoral, NW end | 20 Jan 1962 | | 1 | | 1 | Author |
| Norse Beach | on reef | 6 May 1962 | 2 | 1 | | 3 | Author |
| Norse Beach | on reef, lower mid-littoral | 24 Nov 1962 | | 2 | | 2 | Author |
| Norse Beach | under rock, mid-littoral | 24 Nov 1962 | | 2 | 1 | 3 | Author |
| Bahía la Cholla | under rocks, south shore, mid-littoral | 25 Nov 1962 | 2 | 3 | | 5 | Author |
| Bahía la Cholla | under rocks, upper mid-littoral | 25 Nov 1962 | 2 | | | 2 | Author |

Table 9.--Continued

| | | | | | | |
|---|---|---|---|---|---|---|
| Norse Beach | under rock, lower mid-littoral | 2 Feb 1963 | 1 | | 1 | Author |
| Bahía la Cholla | underside of rock, south shore, lower mid-littoral | 3 Feb 1963 | 2 | 3 | 5 | Author |
| Norse Beach | underside of rock, lower mid-littoral | 3 Feb 1963 | 3 | 3 | 6 | Author |
| Norse Beach | under rock in tide pool, mid-littoral | 2 Mar 1963 | 2 | 3 | 5 | Author |
| Norse Beach | under rock, lower mid-littoral, NW end | 10 Mar 1963 | | (not preserved) | | Author |
| Norse Beach | under rock, upper mid-littoral | 23 Mar 1963 | 1 | | 1 | Author |
| Norse Beach | under rock, mid-littoral | 5 Jul 1963 | 1 | | 1 | Author |

Table 9.--Continued

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | under side of rock, south shore | 7 Jul 1963 | 1 | | | 1 | Author |
| | | TOTALS | 18 | 19 | 1 | 38 | |

Table 10. *Minyoceras kirki*

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | from surface of starfish, both *Astropecten* and *Luidia* were in jar | 13 Feb 1965 | 1 | | | 1 | P. E. Pickens |

Table 11. *Porcellana cancrisocialis*

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | shell of *Petrochirus californiensis*, lower mid-littoral | (unknown) | 1 | | | 1 | P. E. Pickens |

Table 12. *Porcellana paguriconviva*

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | shell of *Petrochirus californiensis*, infra-littoral | 15 Jan 1965 | 1 | | | 1 | P. E. Pickens |

Table 13. *Megalobrachium smithi*

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Norse Beach | under rock, lower mid-littoral | 9 Mar 1963 | | 1 | | 1 | Author |

Table 14. Megalobrachium tuberculipes

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Norse Beach | under rock | 24 Nov 1962 | 1 | | | 1 | Author |
| Norse Beach | underside of rock, lower mid-littoral | 2 Feb 1963 | 3 | 2 | | 5 | Author |
| Norse Beach | under rocks, mid-littoral | 23 Mar 1963 | | 1 | | 1 | Author |
| Norse Beach | under rocks, NW end | 24 Mar 1963 | | 1 | | 1 | Author |
| Norse Beach | among sponges, lower mid-littoral | 6 Jul 1963 | 2 | | 4 | 6 | Author |
| Norse Beach | under rocks, mid-littoral | 19 Feb 1965 | | 1 | | 1 | Author |
| Norse Beach | base of sponge, lower mid-littoral | 20 Jul 1963 | | | 1 | 1 | Author |
| | | TOTALS | 6 | 5 | 5 | 16 | |

Table 15. Pagurist*es* sanguinimanus

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | sand flat, lower mid-littoral | 5 Aug 1963 | 1 | | | 1 | J. A. Beatty |
| Bahía la Cholla | sand flat, lower mid-littoral | 21 Nov 1964 | 1 | | | 1 | P. E. Pickens |
| | | TOTALS | 2 | | | 2 | |

Table 16. Paguristes anhuacus

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Norse Beach | under rock, at 0 tide level | 9 Mar 1963 | | 1 | | 1 | Author |
| Norse Beach | under and on rocks, mid-littoral | 5 Jul 1963 | 2 | | | 2 | Author |
| Norse Beach | on rocks, in small pools at lower mid-littoral level | 6 Jul 1963 | 7 | 3 | 8 | 18 | Author |
| Bahía la Cholla | on rocks, south shore lower mid-littoral | 7 Jul 1963 | | (not preserved) | | | Author |
| Bahía la Cholla | on sand, mid-littoral, near south shore | 15 Mar 1964 | 1 | | | 1 | Author |
| | | TOTALS | 10 | 4 | 8 | 22 | |

Table 17. Pagurus albus

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | sandsurface, lower mid-littoral | 7 Jul 1963 | 12 | 3 | | 15 | Author |
| Bahía la Cholla | sand surface, mid-littoral | 19 Jul 1963 | 12 | 10 | | 22 | Author |
| Bahía la Cholla | sand surface | 15 Mar 1964 | 2 | | | 2 | Author |
| | | TOTALS | 26 | 13 | | 39 | |

Table 18. Pagurus lepidus

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Norse Beach | tide pool | 20 Jan 1962 | 1 | | | 1 | Author |
| Norse Beach | under rocks, mid-littoral | 24 Nov 1962 | 2 | 1 | | 3 | Author |
| Norse Beach | under rocks, in tide pools, lower mid-littoral | 6 Jul 1963 | | (not preserved) | | | Author |
| Bahía la Cholla | on rocks, lower mid-littoral, south shore | 7 Jul 1963 | 2 | | 5 | 7 | Author |
| Bahía la Cholla | on sand, mid-littoral, near south shore | 30 Nov 1963 | 1 | 1 | | 2 | Author |
| Bahía la Cholla | on sand, near south shore | 15 Mar 1964 | 27 | 1 | 5 | 33 | Author |
| | | TOTALS | 33 | 3 | 10 | 46 | |

Table 19. Pylopagurus roseus

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Norse Beach | tide pool, lower mid-littoral | 20 Jan 1962 | | | 1 | 1 | Author |
| Norse Beach | under rocks, on reef, lower mid-littoral | 31 Jan 1962 | | | 1 | 1 | Author |
| Norse Beach | tide pool, lower mid-littoral | 6 May 1962 | 2 | | | 2 | Author |
| Norse Beach | under rocks, in tide pool, mid-littoral | 2 Mar 1963 | | | 1 | 1 | Author |
| | | TOTALS | 2 | | 3 | 5 | |

Table 20. Clibanarius digueti

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | on rocks, mid-littoral | 12 Dec 1959 | 10 | 5 | | 15 | Author |
| Norse Beach | on rocks, mid-littoral | 17 Mar 1962 | 3 | | | 3 | Author |
| Puerto Libertad | tide pools | 1 Apr 1962 | 12 | 1 | | 13 | P. E. Pickens |
| Puerto Libertad | under rocks, south shore of Cirio Point | 1 Apr 1962 | 4 | | | 4 | Author |
| Norse Beach | under rocks, on reef, lower mid-littoral | 24 Nov 1962 | 5 | | | 5 | Author |
| Norse Beach | under rocks, mid-littoral | 2 Mar 1963 | 6 | 1 | | 7 | Author |
| Norse Beach | tide pool, mid-littoral | 9 Mar 1963 | 4 | | | 4 | Author |
| Norse Beach | under rocks, upper mid-littoral | 23 Mar 1963 | 1 | | | 1 | Author |
| | | TOTALS | 45 | 7 | | 52 | |

Table 21. Petrochirus californiensis

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | pool in infra-littoral | 21 Nov 1964 | 1 | | | 1 | P. E. Pickens |
| Guaymas | washed up on beach, San Carlos Bay | 25 Jan 1961 | 1 | | | 1 | J. H. Gerdes |
| Bahía la Cholla | infra-littoral | 13 Feb 1964 | | 1 | | 1 | P. E. Pickens |
| Desalting Plant | infra-littoral | 10 Jun 1964 | | 1 | | 1 | P. E. Pickens |
| | | TOTALS | 2 | 2 | | 4 | |

Table 22. Isocheles pacificus

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | on sand flats, in infra-littoral zone, north shore | 29 Nov 1963 | 3 | | | 3 | Author |
| Bahía la Cholla | from rock and sand, south shore | 21 Nov 1964 | 2 | | | 2 | P. E. Pickens |
| | | TOTALS | 5 | | | 5 | |

Table 23. *Lepidopa mearnsi*

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Norse Beach | in sand, about 2 or 3 inches below surface | 13 Feb 1965 | (specimen incomplete) | | | 1 | P. E. Pickens |
| Norse Beach | in sand, infra-littoral, 2 or 3 inches below surface | 18 Jul 1966 | 1 | 1 | | 2 | Mary Anne Hill |
| | | TOTALS | 1 | 1 | | 3 | |

Table 24. *Axius* (*Neaxius*) *vivesi*

| Locality | Habitat | Date | Males | Females | Ovigerous Females | Total | Collector |
|---|---|---|---|---|---|---|---|
| Bahía la Cholla | under rock, lower mid-littoral, south shore | 1 Nov 1959 | 1 | | | 1 | Author |

Table 25. Distribution of Twenty-five Species of Anomurans from Puerto Peñasco

| Clipperton and Galápagos Islands | Gulf of Calif., Central and South America | Gulf of Calif., West Coast of Mexico and Central America | Gulf of California and outer Baja California Coast | Entire Gulf of California | Northern and Middle Gulf of California | Northern Shore of Gulf of California and Northern Coast only | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | Petrolisthes armatus |
| | | --- | --- | --- | --- | --- | P. gracilis |
| | | | --- | --- | --- | --- | P. crenulatus |
| | | | --- | --- | --- | --- | P. hirtipes |
| | | | --- | | --- | --- | P. sanfelipensis |
| | | | | | --- | --- | P. schmitti |
| | | | | | --- | --- | P. tiburonensis |
| | | | | --- | --- | --- | Pachycheles setimanus |
| | | | | --- | --- | --- | Megalobrachium smithi |
| | --- | --- | | --- | --- | --- | M. tuberculipes |
| | | --- | --- | --- | --- | --- | Porcellana paguriconviva |
| | --- | --- | --- | --- | --- | --- | P. cancrisocialis |
| | | --- | | --- | --- | --- | Minyoceras kirki |
| | | --- | --- | --- | --- | --- | Euceramus transversilineatus |
| | | --- | | --- | --- | --- | Ulloaia perpusillia |
| | | | | --- | --- | --- | Clibanarius digueti |
| | | | | --- | --- | --- | Pagurus albus |
| | | | | --- | --- | --- | P. lepidus |
| | | --- | | | | --- | Paguristes sp. nov. |
| | | | | | | --- | P. sanguinimanus |
| | | | | | | --- | P. anhuacus |
| | | | | | | --- | Pylopagurus roseus |
| | --- | --- | | --- | --- | --- | Petrochirus californiensis |
| | --- | | | | | --- | Isocheles pacificus |
| | | | | --- | ? | --- | Axius vivesi |

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Fig. 1 Euceramus transversilineatus


Fig. 2 Pachycheles setimanus

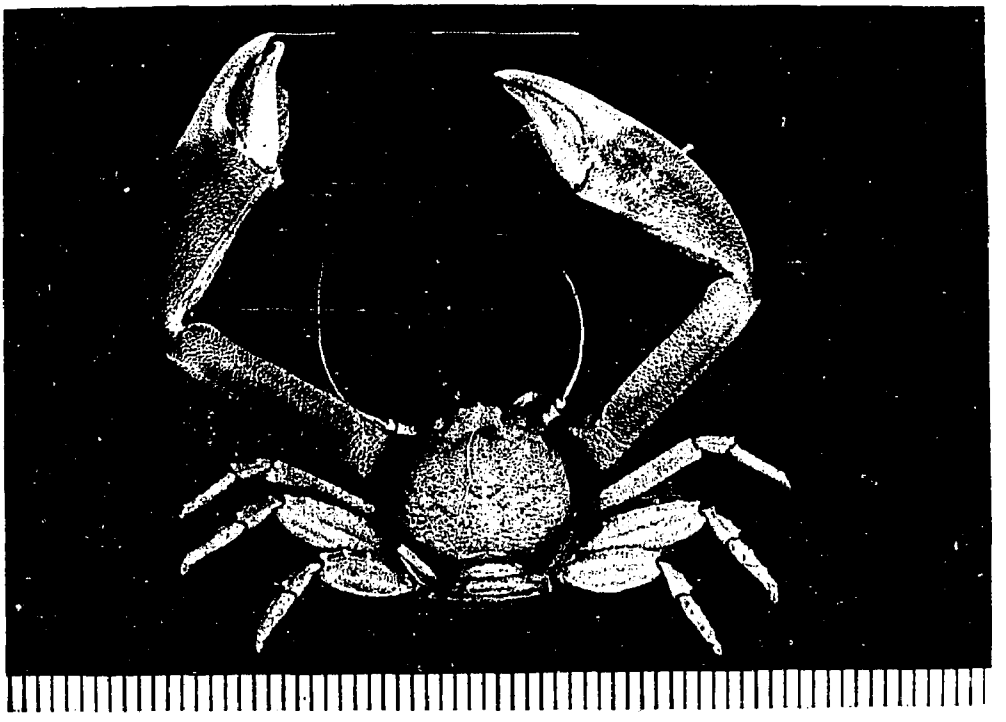


Fig. 3 Petrolisthes tiburonensis (male)

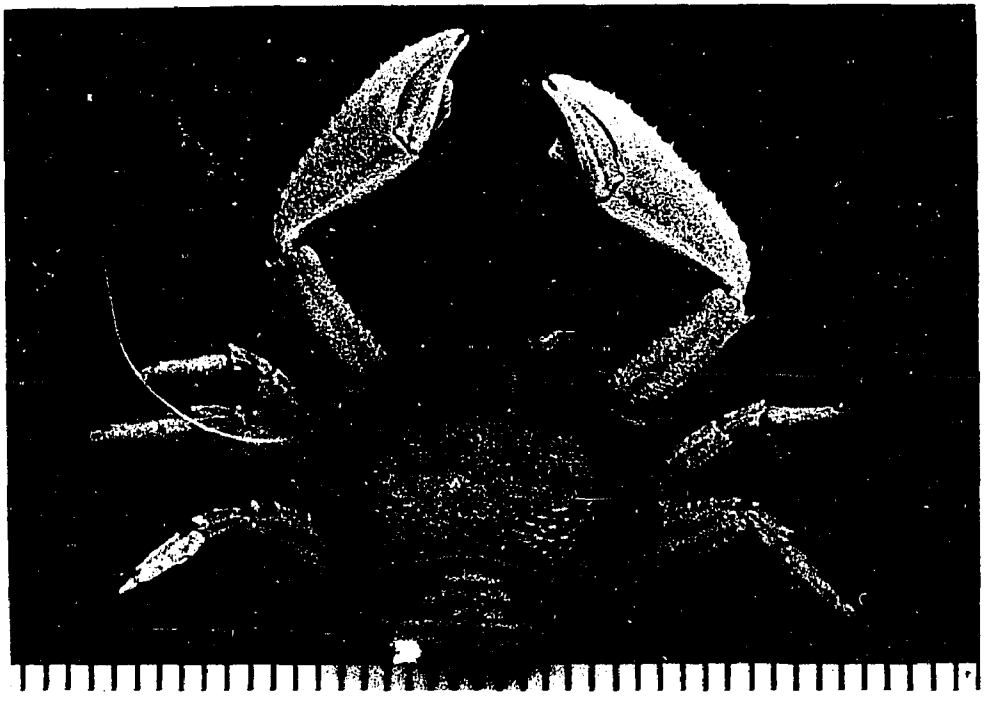


Fig. 4 Petrolisthes tiburonensis (female)

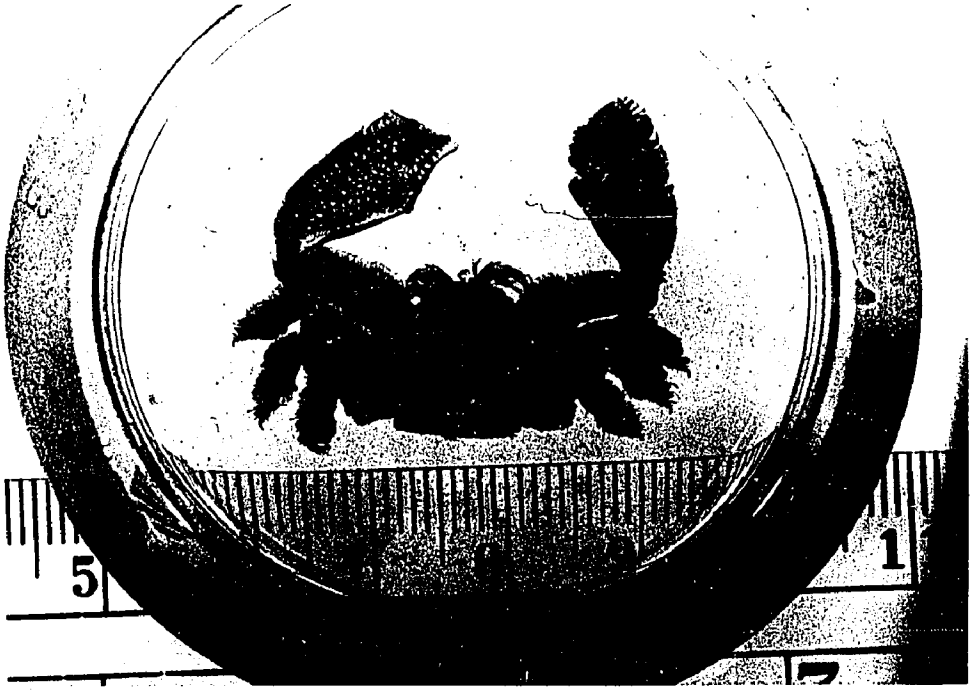


Fig. 5 Petrolisthes hirtipes

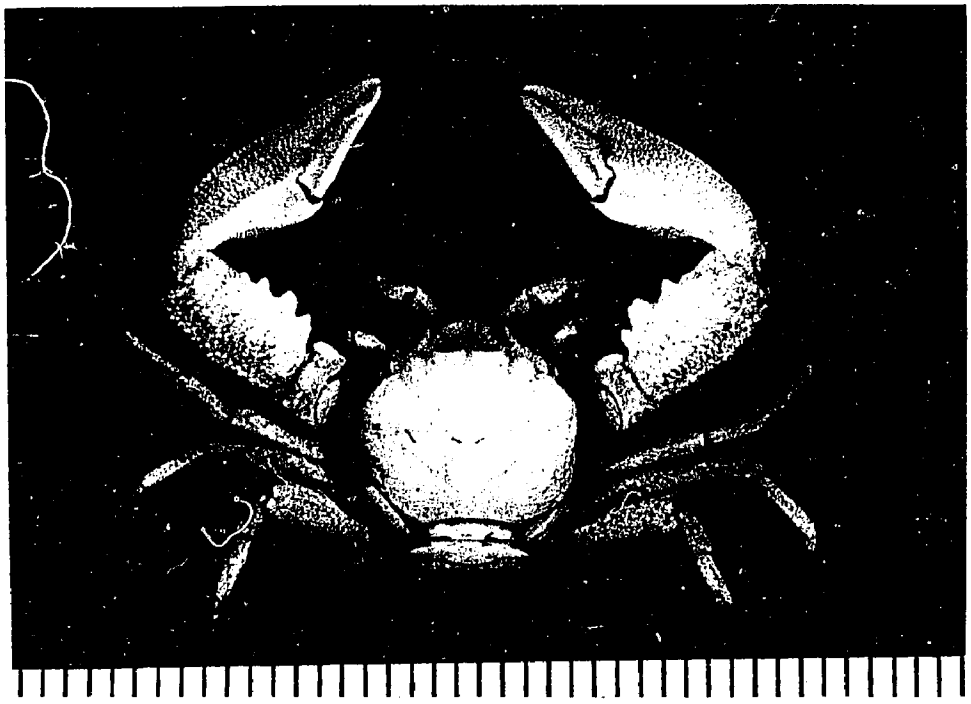


Fig. 6 Petrolisthes crenulatus

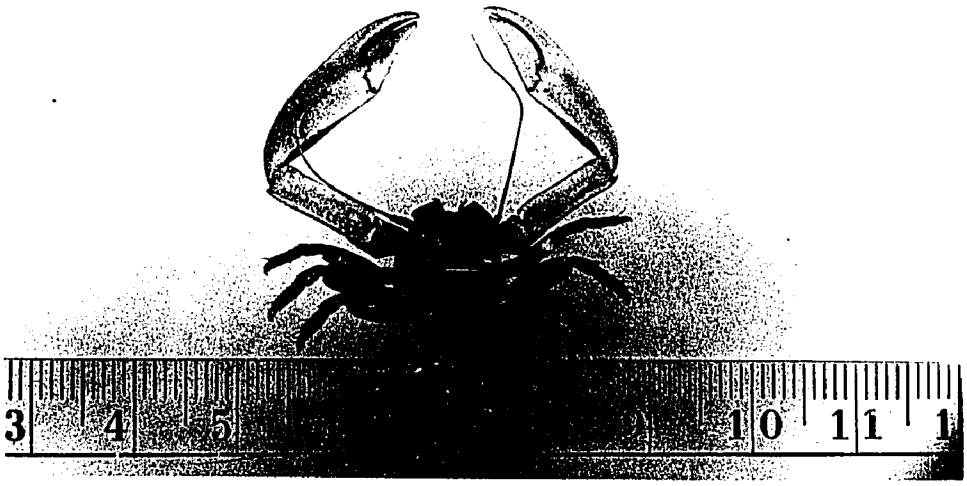



Fig. 7 Petrolisthes gracilis

Fig. 8 Petrolisthes schmitti

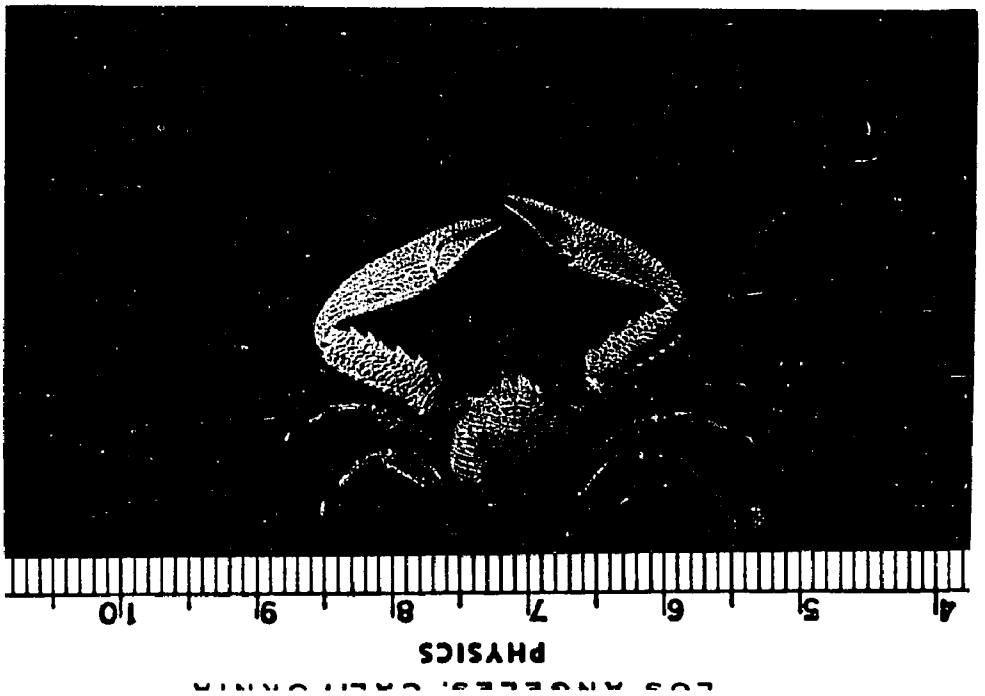


Fig. 9 Petrolisthes sanfelipensis

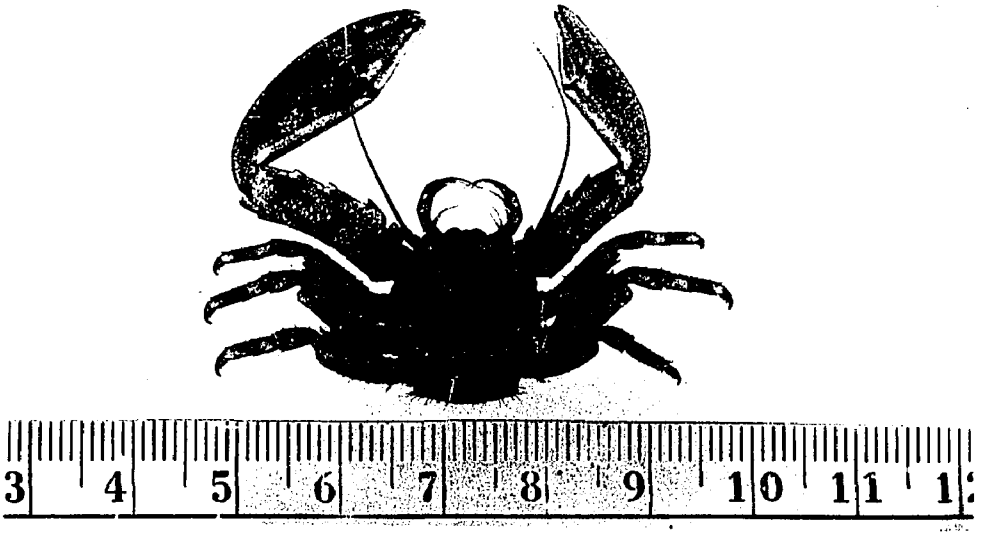


Fig. 10 Petrolisthes armatus

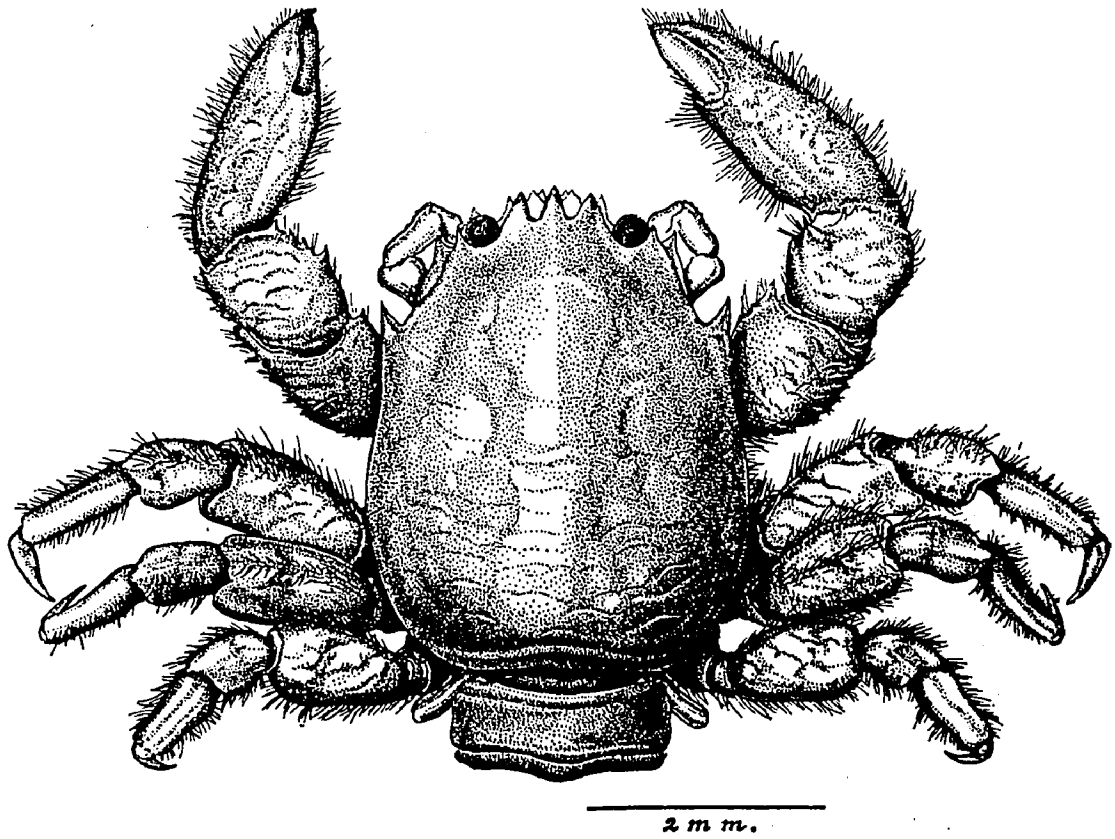



Fig. 11 Minyocerus kirki

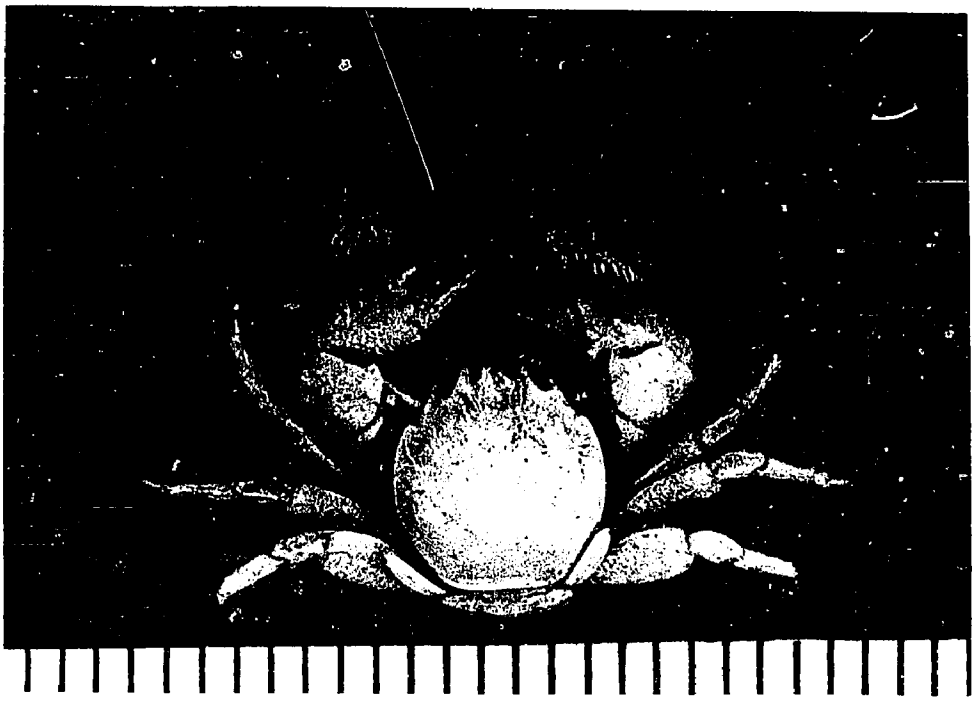


Fig. 12 Porcellana cancrisocialis

Fig. 13 Porcellana paguriconviva

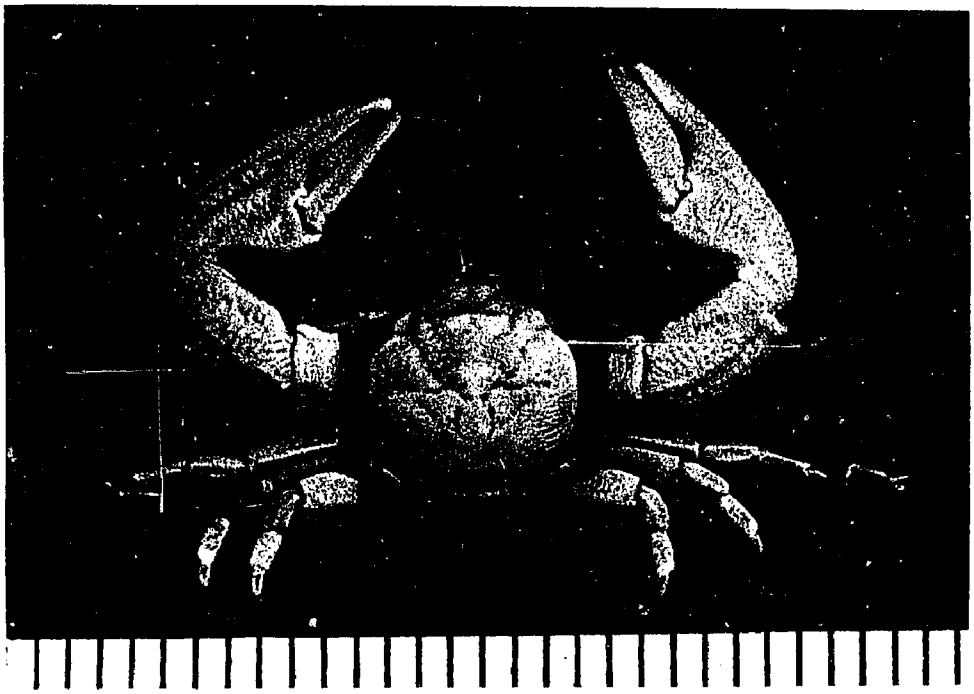


Fig. 14 Megalobrachium smithi

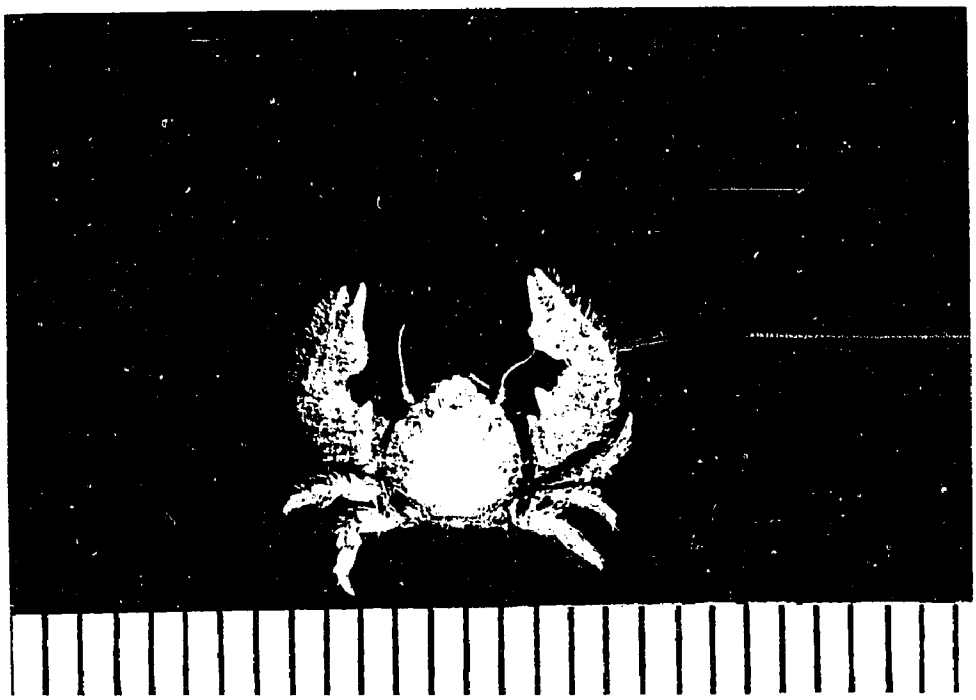


Fig. 15 Megalobrachium tuberculipes

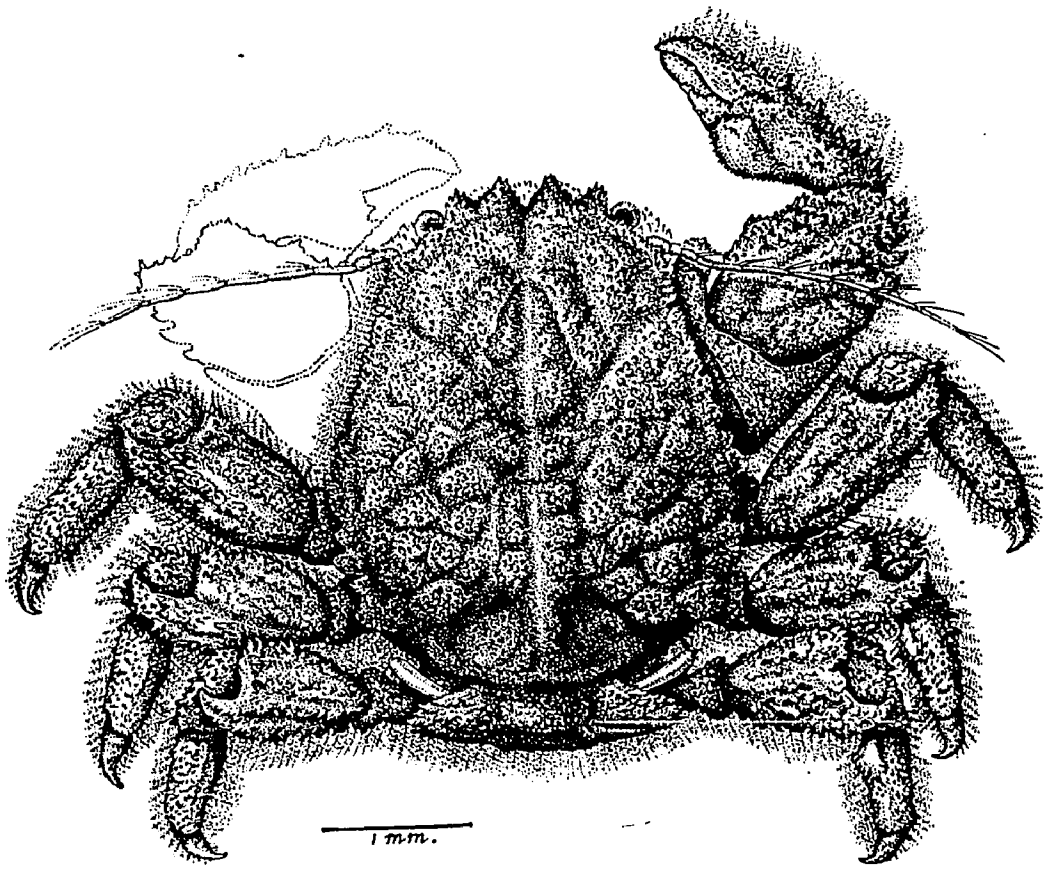



Fig. 16 Ulloaia perpusillia

Photographs have been made available through the courtesy of Miss Janet Haig and the Allan Hancock Foundation.

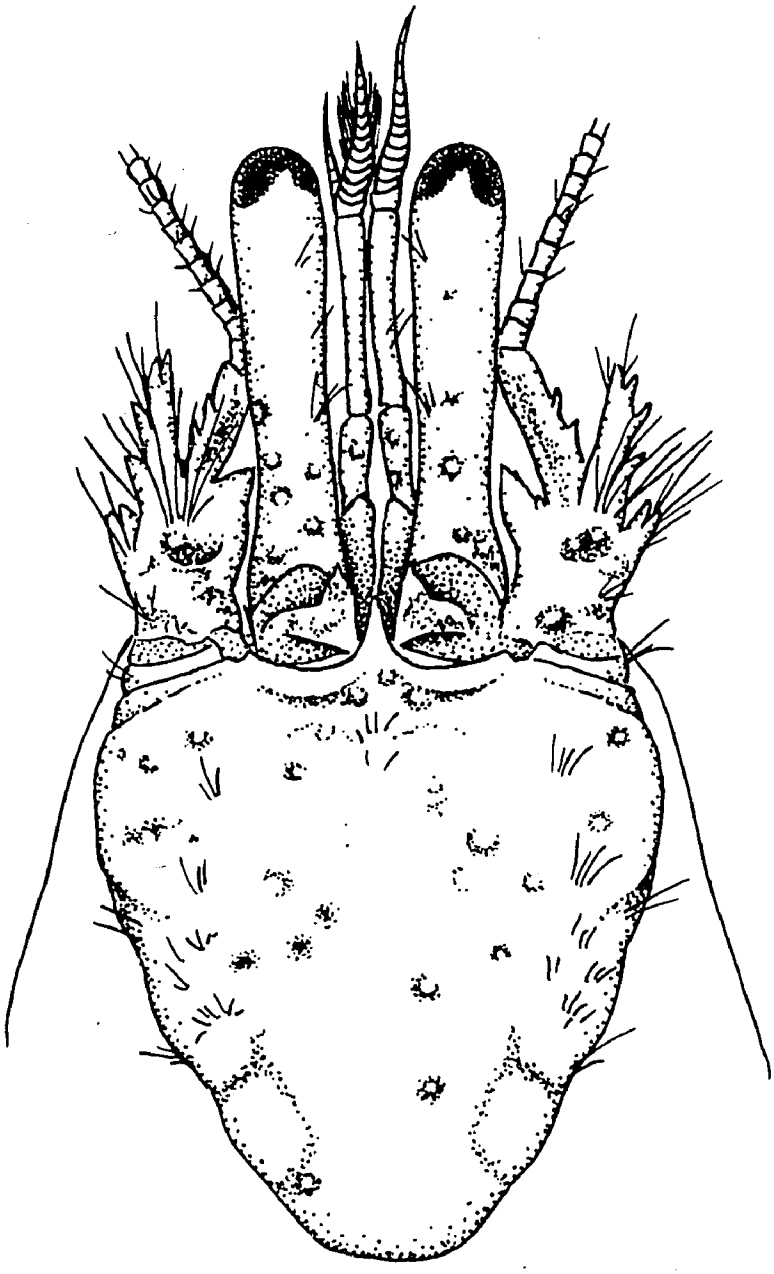


Fig. 17 Paguristes sanguinimanus male x 7

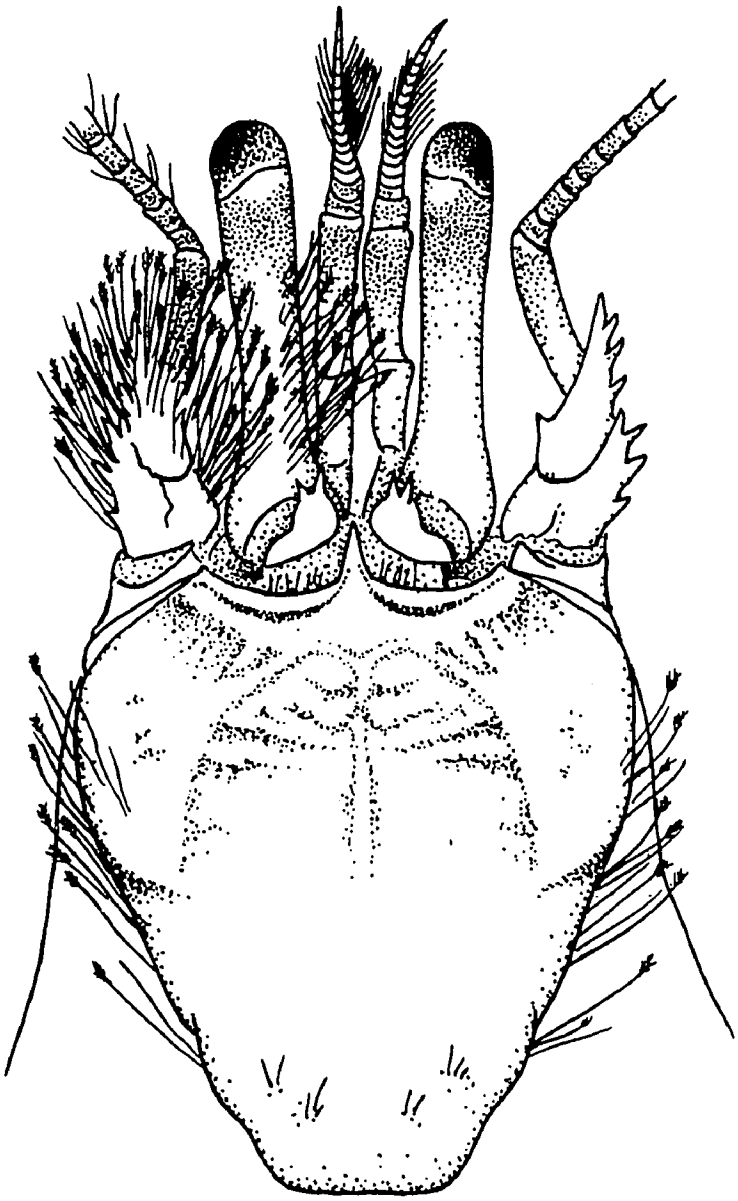


Fig. 18 Pagurista anhuacus male x 15

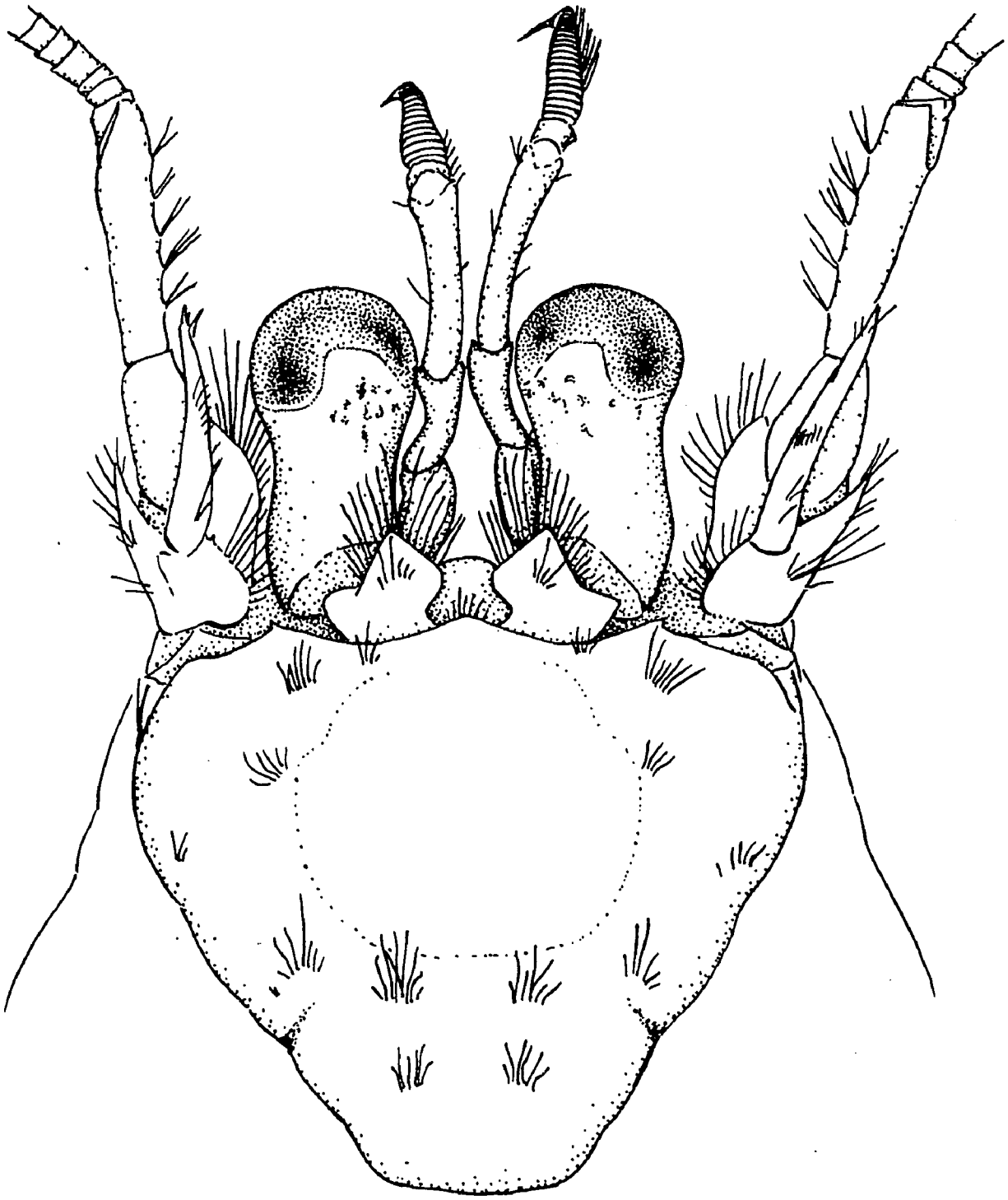


Fig. 19 Pagurus albus male x 15

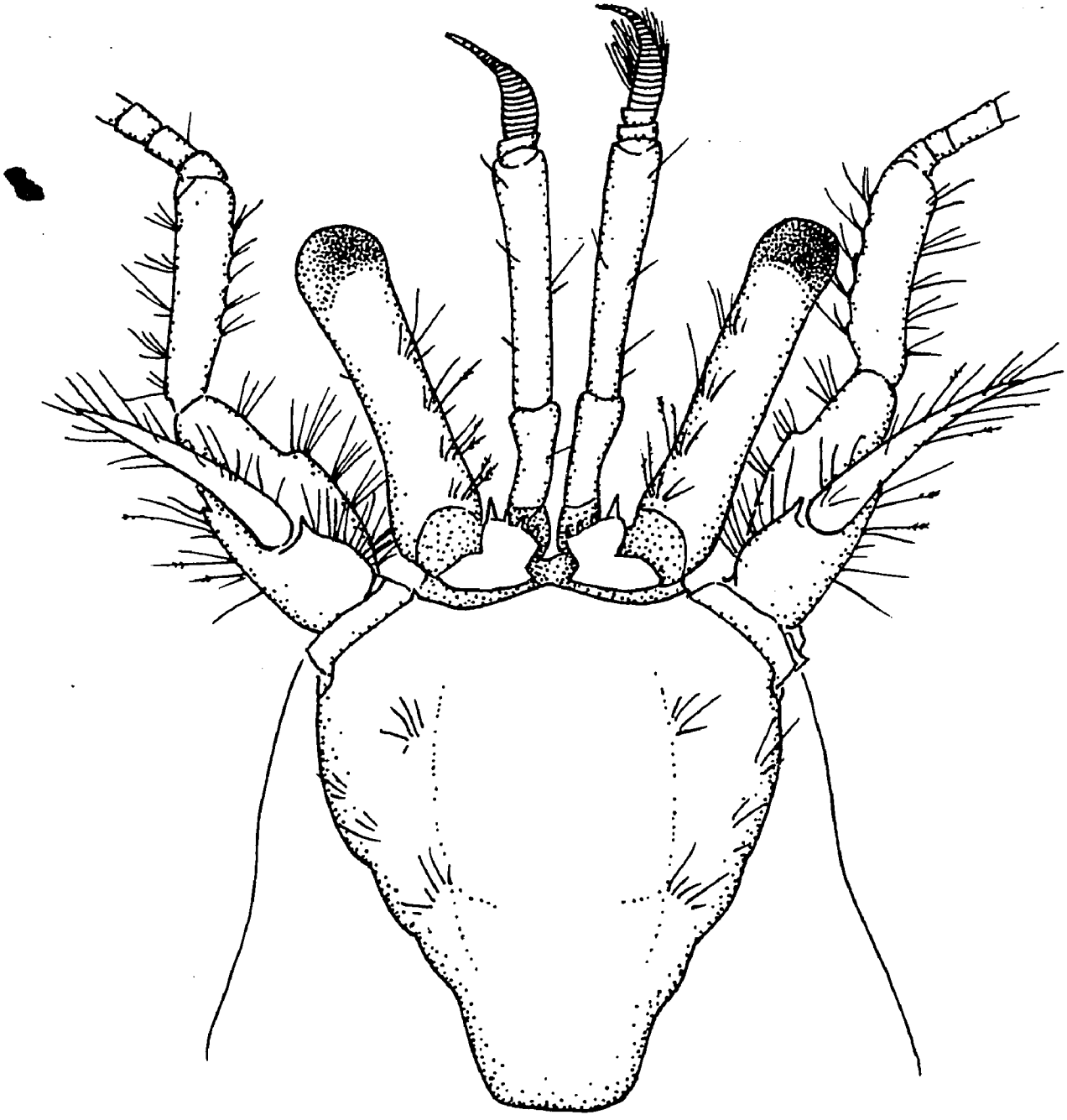


Fig. 20 Pagurus lepidus male x 22

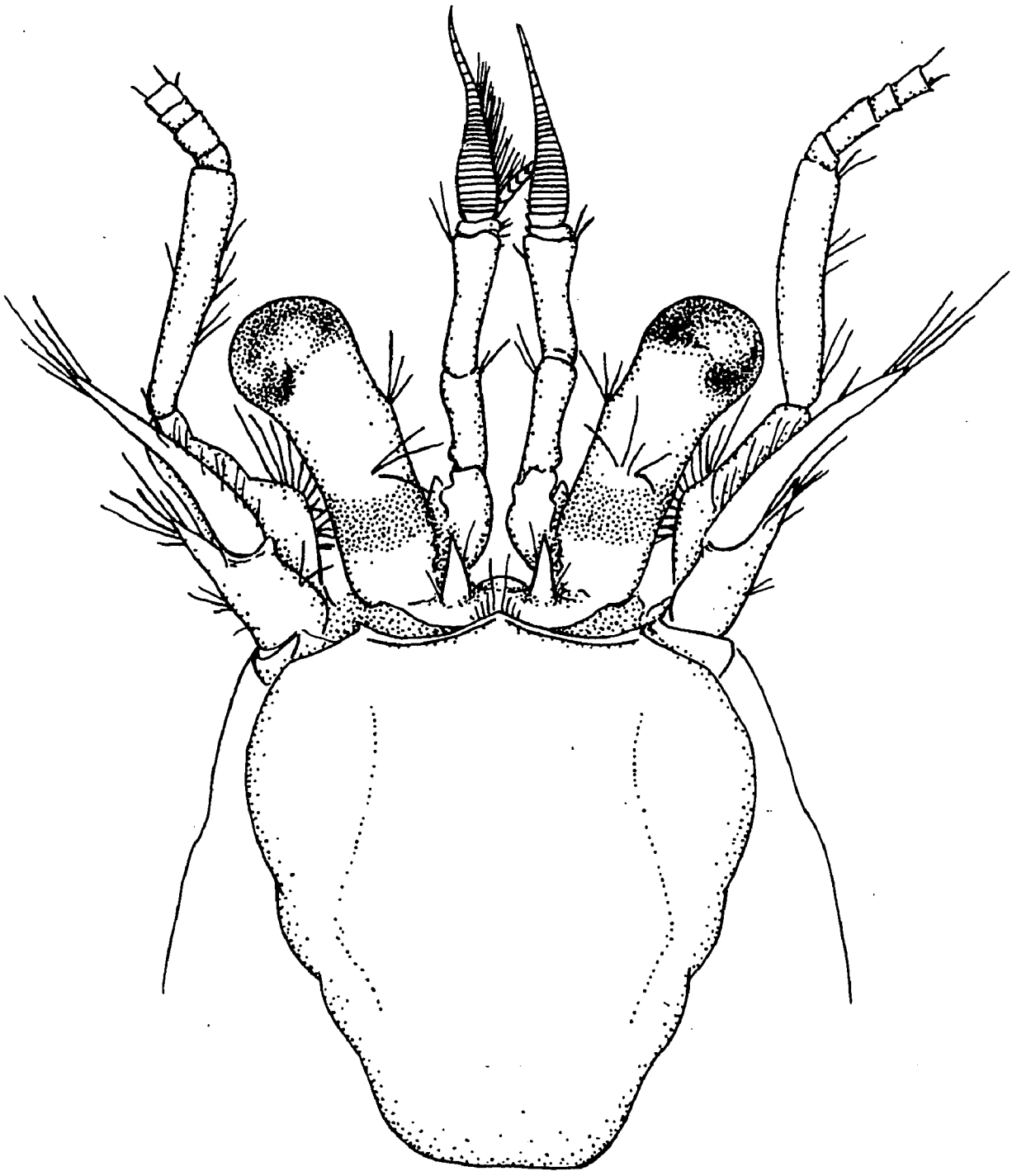


Fig. 21 Pylopagurus roseus female x 15

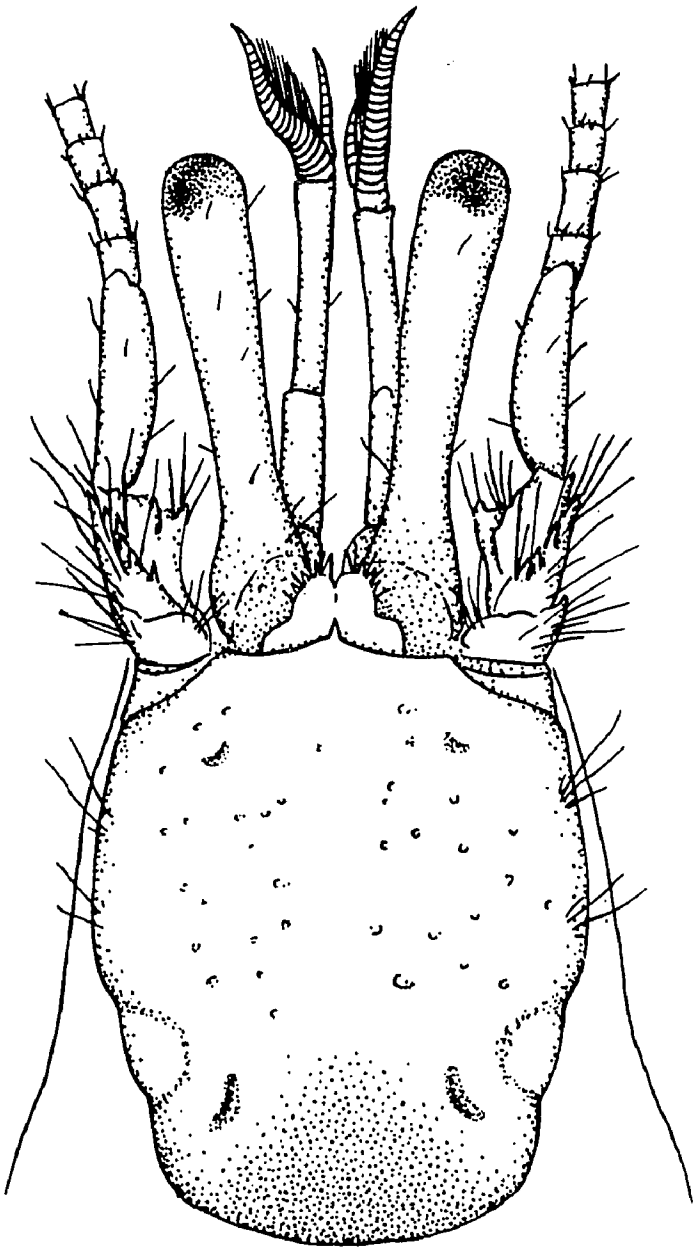


Fig. 22 Clibanarius digueti male x 12

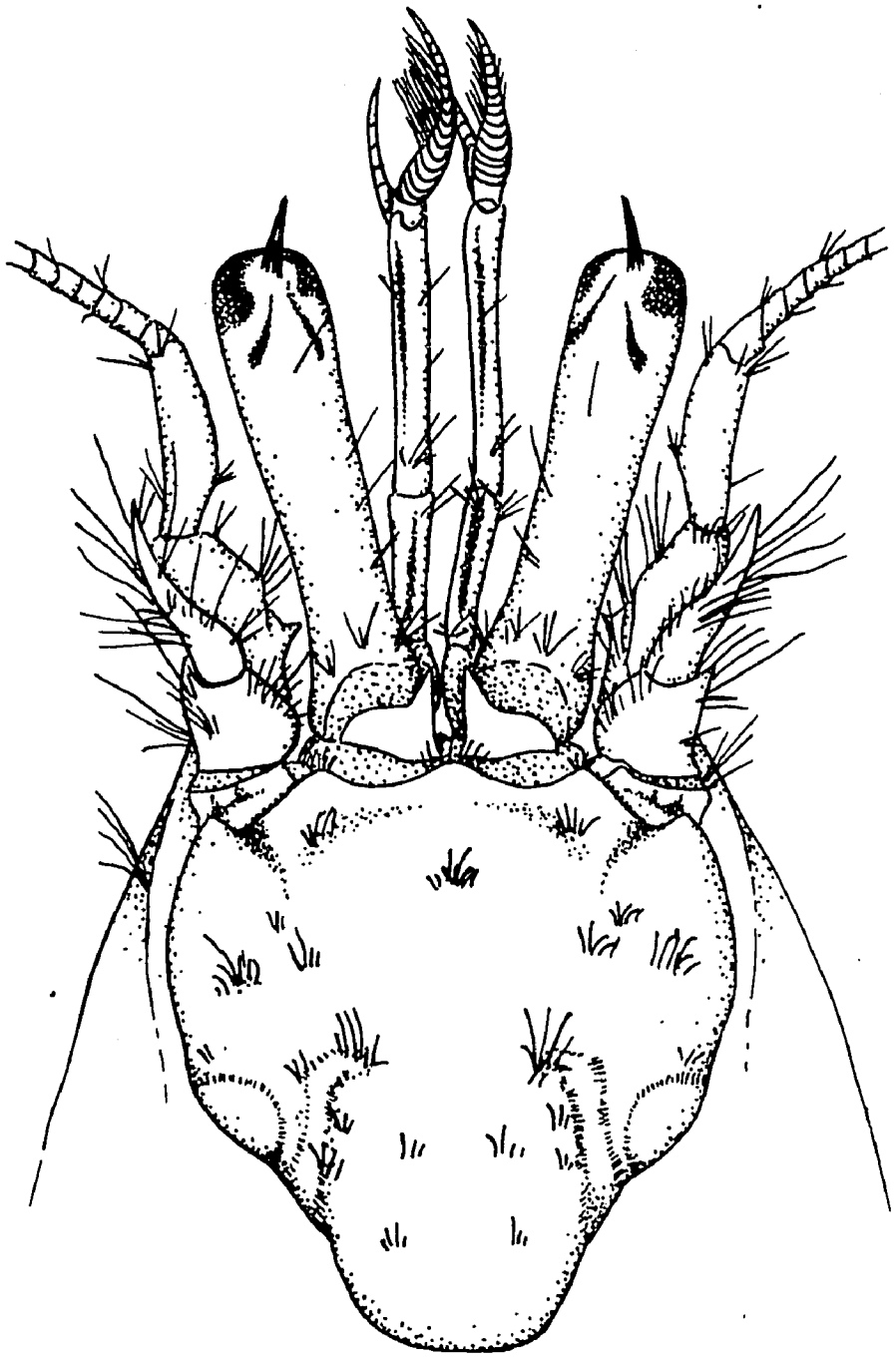


Fig. 23 Petrochirus californiensis female x 5

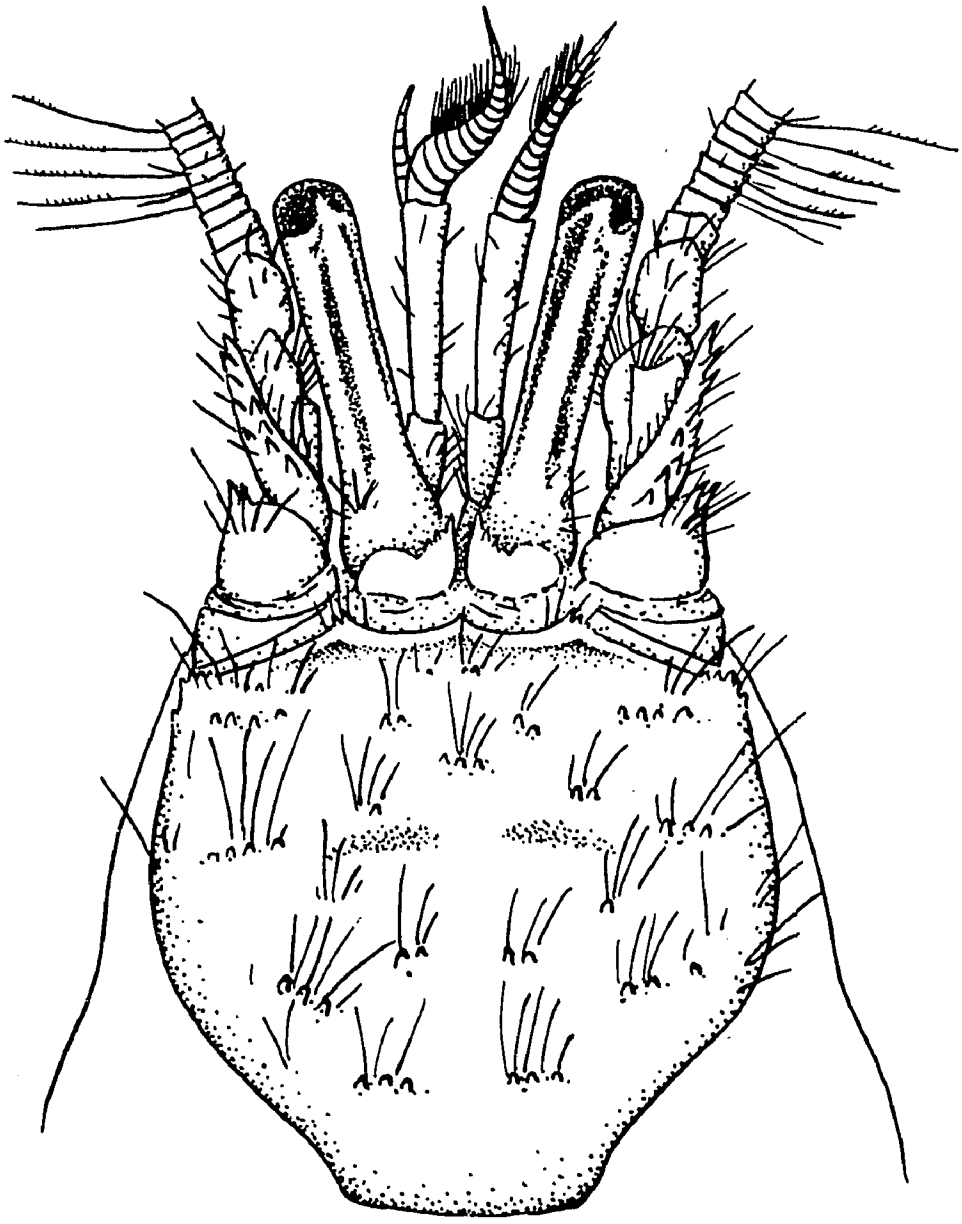


Fig. 24 Isocheles pacificus male x 14

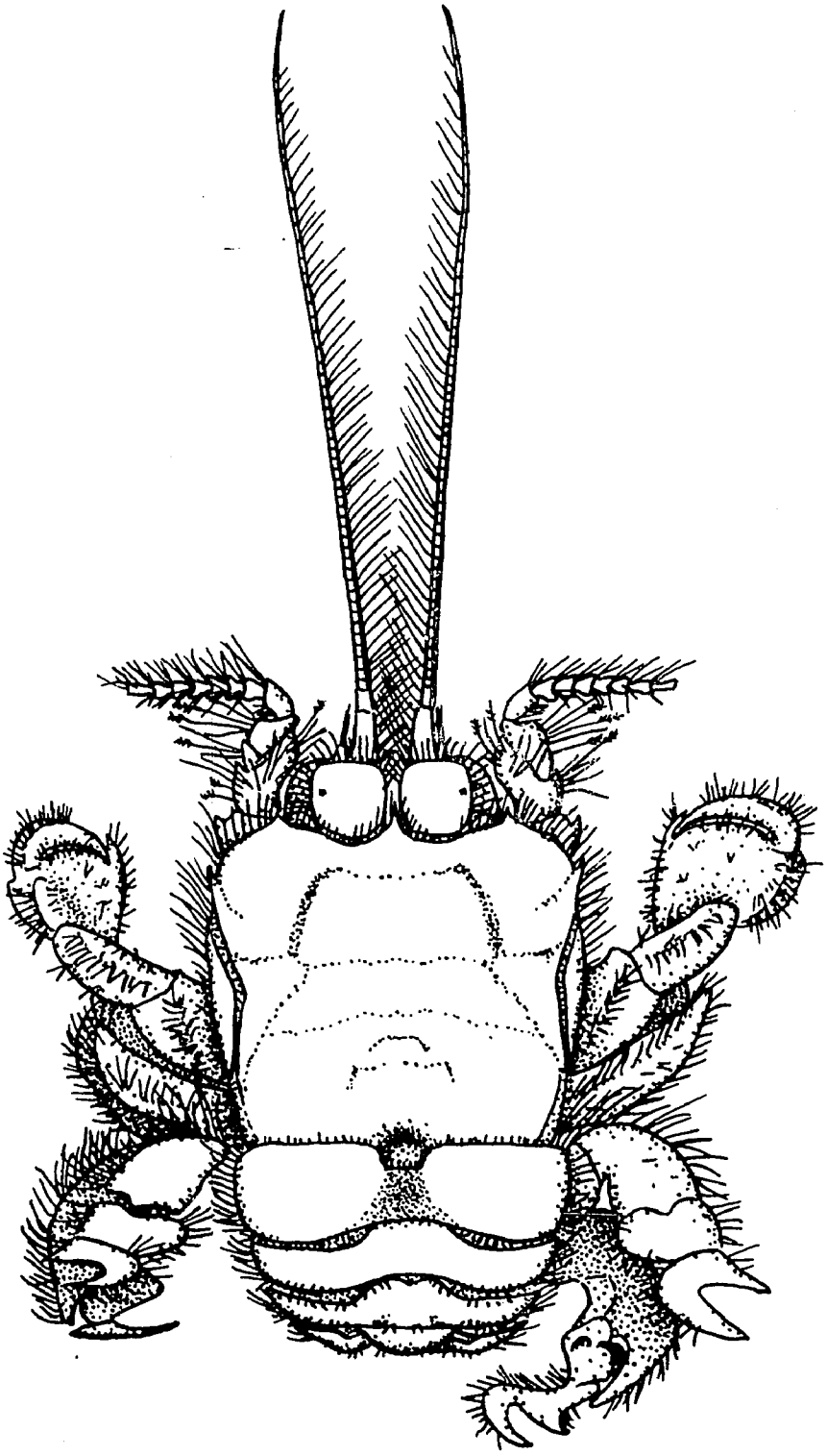
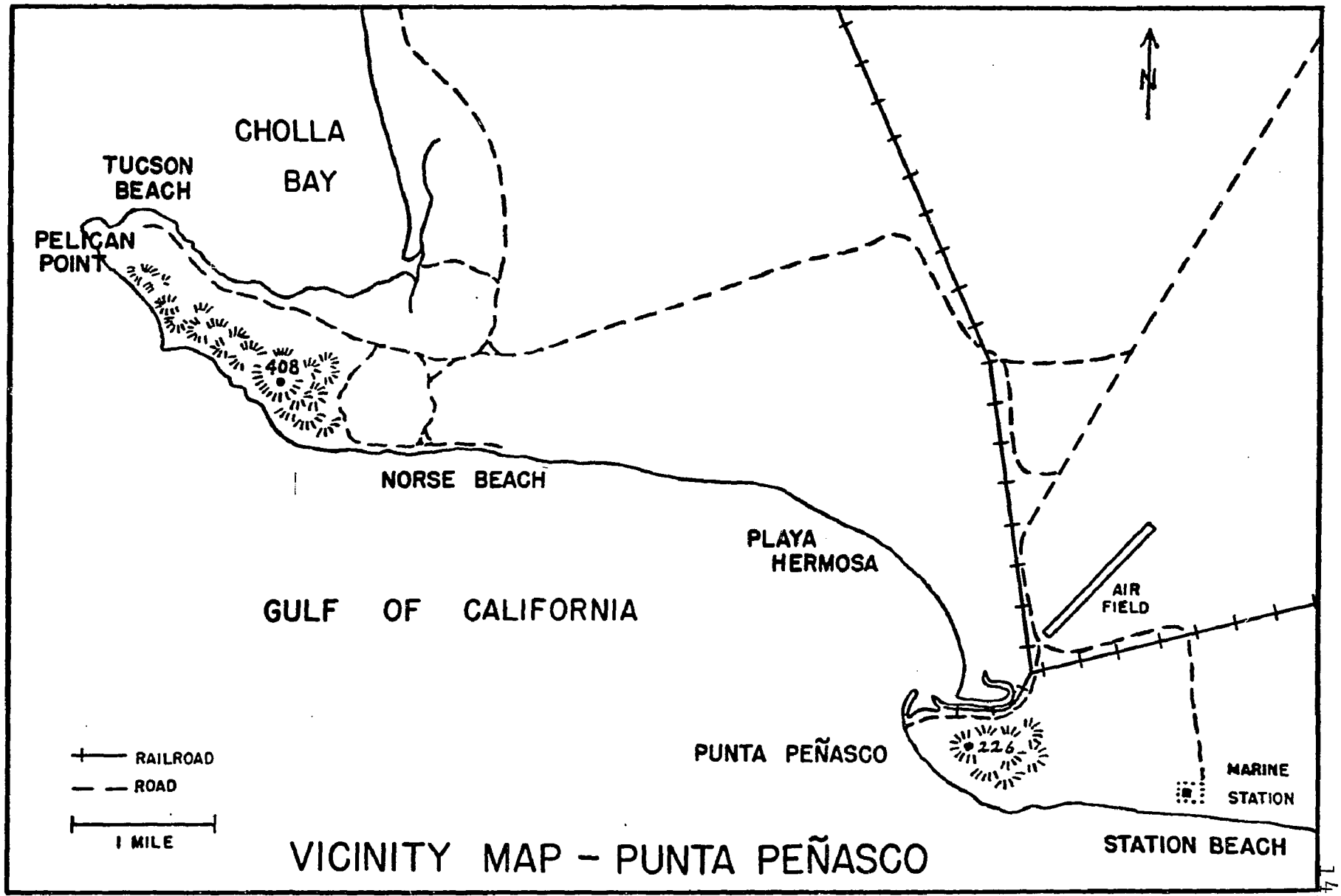


Fig. 25 Lepidopa mearnsi male x 4




VICINITY MAP - PUNTA PEÑASCO