CHAPTER XIV

ARTHROPODS: XIPHOSURA, PYCNOGONIDA, AND CRUSTACEA

Blank page retained for pagination

XIPHOSURA

By JOEL W. HEDGPETH, *Scripps Institution of Oceanography, University of California*

The occurrence of *Limulus polyphemus* on the shores of the northern Gulf of Mexico is so limited that few biologists realize that it occurs there at all. To others, the statement of range given in such works as Ekman's Tiergeographie des Meeres, viz., New England to Yucatán, implies widespread occurrence in the Gulf of Mexico. Large populations of the horseshoe crab occur from Long Island to about St. Petersburg, Florida. Although *Limulus* is associated with bays and evidently requires estuarine conditions for optimum populations, its occurrence along the northern shores of the Gulf of Mexico is limited. It appears to be common only in the northeast corner. Cary (1906) reported an abundant population from the Chandeleur Islands, and it may be from this population that the sporadic records for Mississippi and Alabama result. According to records from the Alabama Museum of Natural History, *Limulus* was taken on Dauphin Island in August 1939, and several individuals, both males and females, were observed at night on April 20, 1948, in the same locality. A large male was taken at Wolf River, Baldwin County, on May 13, 1948. A specimen was collected from Santa Rosa Sound near Pensacola on February 20, 1938. The only trans-Mississippi record for this animal is of a specimen collected by C. T. Reed on Padre Island about 1940 or 1941. In view of the widespread occurrence of many invertebrates on both the Middle Atlantic and northern Gulf coasts this erratic distribution of *Limulus* is a curious anomaly. For a recent report on the natural history and breeding habits of *Limulus*, see Shuster (1950). In regions where the horseshoe crab is abundant, it may be a serious predator on soft clam beds, and control measures are being considered in Massachusetts. It is reassuring, however, to learn that control measures are considered costly and of doubtful efficacy as it would be a pity to exterminate one of our greatest zoological curiosities.

LITERATURE CITED

CARY, L. R.
1906. A contribution to the fauna of the coast of Louisiana. Bull. Gulf Biologic Station 6: 50–59.

SHUSTER, CARL N., JR.
1950. Observations on the natural history of the American horseshoe crab, *Limulus polyphemus*. Third Rept., Inv. methods improving shellfish resources, Mass.: 18–23, 2 figs.

Blank page retained for pagination

PYCNOGONIDA

By JOEL W. HEDGPETH, *Scripps Institution of Oceanography, University of California*

Our knowledge of the pycnogonid fauna of the Gulf of Mexico is restricted to a few dredge hauls in the northeast corner of the Gulf and some scattered hauls farther south, the shore and dredge collections at or near Tortugas, and a few shore and buoy collections on the Texas coast. Nevertheless, these records, particularly those from the Tortugas, are of considerable zoogeographical interest. Since the pycnogonids lack an active, free-swimming larval stage, they must rely upon passive means of dispersal. Several instances of pycnogonid larvae in medusae have been reported in the literature, and the occurrence of several species in the sargassum biota suggests an even more convenient vehicle for dispersal (see Hedgpeth, 1947, for discussion and summary of the literature). The distribution pattern of several species along the coasts of America, Europe, and Africa is similar to the occurrence of stranded leguminous seeds, the "sea beans," discussed with exhaustive thoroughness by Guppy (1917).

Another aspect of the fauna of special interest is the occurrence of a ten-legged species, *Pentacolossendeis reticulata*, along the southern edge of the Florida Keys. A cognate octopodous form, similar to the "normal" analogues of other ten-legged species, has not yet been found for *P. reticulata*. Its discovery would be a substantial buttress for the author's theory concerning the origin of ten-legged pycnogonids (1947), and further collections, especially along the 100-fathom line, should be of particular interest. The ten-legged *Pentapycnon geayi* Bouvier, known from French Guiana and north of Puerto Rico, can also be expected in Gulf waters, especially in the Tortugas area.

Aside from the congregation of small, inconspicuous species at Tortugas there are relatively few pycnogonids which are found in the waters of the Gulf of Mexico and which, on the basis of our inadequate information, might be considered characteristic of these waters. These have been indicated on a distribution map (fig. 69). The large prune purple pycnogonid, *Anoplodactylus lentus*, has been collected at several stations in the northeastern part of the Gulf, at Tortugas, and off Yucatán. A smaller form of this species is common along the Atlantic coast from Carolina to Woods Hole. Another species of this typically tropical, warm temperate genus, *A. insignis*, common at Tortugas, is found near Sanibel Island, in the northeast corner off Cedar Keys, and due west of Tortugas. It is common at Bermuda, and there is one record (the type locality) off Bahia, Brazil. Both of these species occur from near shore to moderate depths; *Anoplodactylus lentus*, to 150 fathoms; *A. insignis*, to 48 fathoms. Another large, conspicuous species, *Pallenopsis schmitti*, found in depths from 20 to 155 fathoms, occurs in the Tortugas area and off the coast of Florida near the Bahamas. This species has also been found north of Puerto Rico and the coast of Colombia. The only species of *Nymphon*, a predominantly cold-water genus known to occur in the Gulf, or the entire American tropical area, for that matter, is *Nymphon floridanum* known from Tortugas and off Cedar Keys.

The shore collections from the western Gulf are meager but interesting. *Anoplodactylus pygmaeus* has been found among the fouling growths on buoys near Galveston, and *Ammothella rugulosa* occurs among hydroids at Port Aransas. *Anoplodactylus pygmaeus* is found off the coast of Virginia, along the shore of southern England, and at Naples. *Ammothella rugulosa*, a small easily overlooked species, appears to be common at Tortugas and along the southern coast of Florida. It has been recorded from Brazil and Bermuda.

A conspicuous gap in the distribution of pycnogonids in the western Gulf of Mexico is the absence of *Endeis spinosa*, a situation confirmed by the extensive collections of organisms associated with fouling from New England to Panama

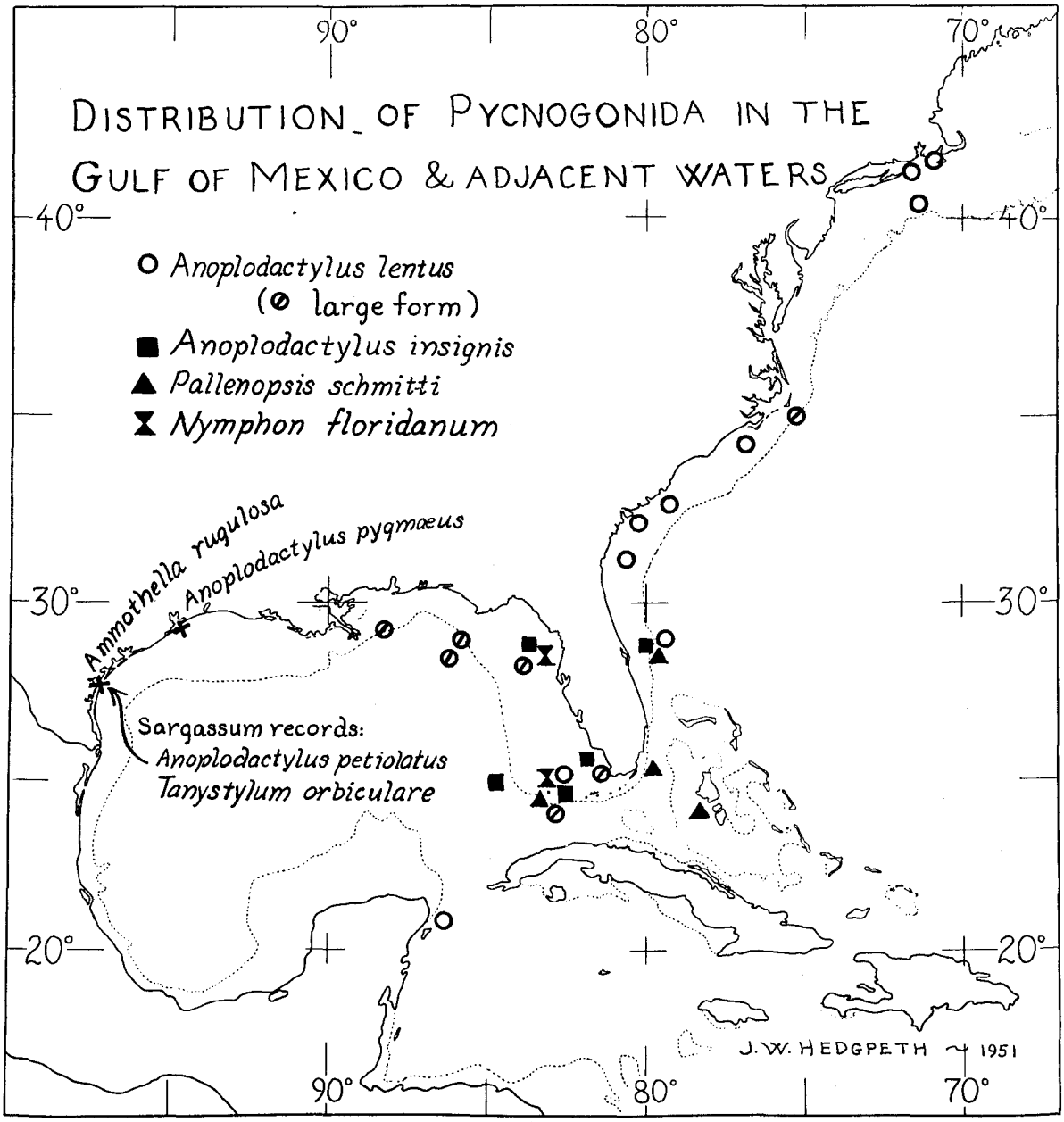

FIGURE 69.—Zoogeographical relationships of pycnogonids occurring in the Gulf of Mexico.

made by the Woods Hole Oceanographic Institution. Common at Tortugas, it occurs also on the shores of various Caribbean islands, the Bahamas, and Bermuda. It is one of the characteristic members of the sargassum fauna of the mid-Atlantic (Timmermann 1932) and occasionally occurs at Woods Hole. But, like the sargassum crab, *Planes minutus*, this pycnogonid has not been found on the sargassum which drifts ashore on the Texas and Louisiana coasts, and Tortugas is the only Gulf of Mexico record for both organisms. *Anoplodactylus petiolatus*, another species of the mid-Atlantic sargassum, has been collected from Texas sargassum. Another species, *Tanystylum orbiculare*, common at Woods Hole, has turned up on Texas sargassum and is the only sargassum record for this species. All other records for *T. orbiculare*, scattered along the Atlantic

coast between Georgia and Rhode Island, are shore or buoy collections. The species is also known from Brazil.

These distributional relationships are best summarized in tabular form. Descriptions and figures of all species included in this table will be found in Hedgpeth (1948). Some corrections in the troublesome genus *Callipallene* have been suggested by Stock (1952).

TABLE 1.—*Distribution of Pycnogonida occurring in the Gulf of Mexico*

Species	Gulf of Mexico	West Indies and Caribbean	Atlantic	Elsewhere	Depth (fathoms)
Nymphon floridanum Hedgpeth	Tortugas, northeast corner.				Surface—5.
Callipallene phantoma (Dohrn)	Tortugas		Norway-Azores	Naples, Black Sea.	
Callipallene brevirostris (Johnston)	Tampa, Fla		Norway; Portugal; Woods Hole; Virginia.		Shore.
Pallenopsis schmitti Hedgpeth	Tortugas	Puerto Rico, Bahamas, Colombia.	East coast, Florida		20–155.
Halosoma robustum (Dohrn)	do		Brazil	Mediterranean	Shore.
Anoplodactylus petiolatus (Krøyer)	Texas coast, sargassum.		Norway-France, Brazil	Naples	To 43.
Anoplodactylus pygmaeus (Hodge)	Texas coast, buoy fouling.		Norfolk, Va., England, Brazil.	do	Shallow water.
Anoplodactylus lentus Wilson	Tortugas, northeast corner.	Yucatán	Florida-Woods Hole		Shore—150.
Anoplodactylus insignis (Hoek)	Tortugas, Sanibel, northeast.		Bermuda, Brazil		3–48.
Anoplodactylus typhlops Sars	Tortugas		Norway, Ireland		To 582.
Anoplodactylus polignaci Bouvier	Sombrero Key		Cape Verde		Shore?.
Anoplodactylus evelinae Marcus	Tortugas		Brazil		Shore.
Anoplodactylus quadratispinosus Hedgpeth	Key West				?.
Anoplodactylus stylirostris Hedgpeth	Tortugas	Bahamas			Shore.
Anoplodactylus pectinus Hedgpeth	do				3–10.
Endeis spinosa (Montagu)	do	Hispaniola, Puerto Rico, Panama.	Florida-Woods Hole; Norway-France; Brazil.	Mediterranean, Black Sea.	Surface—38.
Achelia sawayai Marcus	do	Colombia, Venezuela	Brazil		Shore—25.
Achelia sp.[1]	Texas				
Ammothella rugulosa (Verrill)	Texas, Tortugas		Bermuda, Brazil		Shore.
Ammothella marcusi Hedgpeth	Tortugas				Do.
Nymphopsis duodorsospinosa Hilton	do		North Carolina (Folly River).	Galapagos, Baja Calif.	Shore—10.
Ascorhynchus latipes (Cole)	do	Hispaniola, Bahamas			Shore.
Ascorhynchus colei Hedgpeth	Florida Keys	do			Shore—80.
Eurycyde raphiaster Loman	Tortugas	Hispaniola, Bahamas, Colombia.		Cape Verde	Shore.
Tanystylum orbiculare Wilson	Texas (sargassum)		Virginia-Woods Hole, Brazil.		Shore—15.
Pentacolossendeis reticulata Hedgpeth	Florida Keys				98–100.
Pycnogonum reticulatum Hedgpeth	Tortugas, Key West			El Salvador	Shore.

[1] An immature form, taken with plankton net from the south jetty at Port Aransas, Tex. Cited here because it indicates the occurrence of this genus in the western Gulf.

LITERATURE CITED

GUPPY, H. B.

1917. Plants, seeds and currents in the West Indies and Azores. 531 pp., front., 3 maps. London: Williams and Norgate.

HEDGPETH, JOEL W.

1947. On the evolutionary significance of the Pycnogonida. Smithsonian Misc. Coll. 106 (18): 1–53, 16 figs., 1 pl.

1948. The Pycnogonida of the western North Atlantic and the Caribbean. Proc. U. S. Nat. Mus. 97: 157–342, figs. 4–53, charts 1–3.

STOCK, J. H.

1952. Revision of European representatives of the genus *Callipallene* Flynn, 1929. Beaufortia, No. 13: 1–14, 27 figs.

TIMMERMANN, G.

1932. Biogeographische Untersuchungen über die Lebensgemeinschaft des treibenden Golfkrautes. Zeitschr. Morph. und Oekol. Tiere 25: 288–355, 10 figs.

Blank page retained for pagination

MARINE OSTRACODA

By WILLIS L. TRESSLER, *United States Navy Hydrographic Office*

The marine Ostracoda of the Gulf of Mexico region are very imperfectly known at the present time. George S. Brady, one of the earliest workers in this group to report ostracods from the Gulf region, published a series of papers from 1866 to 1887 and described a number of new species. Some of these descriptions were later incorporated into the report of the *Challenger* expedition, and many of them were published in the Marquis de Folin's work, Fonds de la Mer, which included four volumes published between 1867 and 1887. These volumes are very difficult to obtain, particularly the fourth volume which contains descriptions of several species of Ostracoda from the Gulf region. Unfortunately, almost all of Brady's descriptions are made from the valves alone, and for this reason many of his descriptions cannot be identified definitely with present day, living forms. Although his illustrations are beautifully executed, his descriptions are very brief and give little or no ecological data; not even the depth or exact location is given for most descriptions. Müller (1912), in his masterly compendium of the known species of Ostracoda, both marine and fresh-water, has allowed several of Brady's species, but for the most part his forms have been relegated to the doubtful species category or even to the "dubious genera and species" section of his book.

With the exception of Brady's work, only two other publications which deal with marine ostracods of the Gulf of Mexico are known despite the efforts of several geologists and zoologists who have been working on recent and fossil ostracods from this region. Dr. Henry V. Howe of Louisiana State University and his students, for example, have done considerable work on this group. The two publications referred to above both appeared in 1949 and consist of a preliminary report on ostracods obtained from bottom and core samples taken by the Woods Hole Oceanographic Institution research vessel *Atlantis* in 1947 by W. T. Rothwell, Jr. (1949), and a short report on some marine ostracods from Tortugas by the present author (Tressler 1949).

Rothwell's report was merely an abstract of his findings, but through the kindness of this worker, the present author was able to use his data sheets which give the location and depth of all species which he had taken from the bottom sediment samples. Rothwell distinguished 126 distinct forms but was not able to identify all of these to species. Some 40 of this number, which had been identified to species, were selected as being readily enough identifiable from the valves alone to leave no doubt as to their validity. Only five species were recovered with inner body parts intact, plus three other forms which were not definitely identified to species. The remainder of Rothwell's species were determined from the valves alone. Without these data this report would have been meager indeed. It is to be hoped that Dr. Rothwell will be able to complete his identifications, many of which will undoubtedly turn out to be new species, and publish a report on the complete collection at an early date.

The author has not been able to obtain a copy of Folin and Perier's Fonds de la Mer containing many of Brady's reports, but all species enumerated in volumes 1, 2, and 4 have been evaluated in Müller's (1912) comprehensive report. Also, it has not been possible to go through the paleontological literature which undoubtedly contains references to forms which are living today. One paper (Van den Bold, 1946) is cited in the literature as an example of such reports. Paleontological material is, of course, restricted by its very nature to identifications based upon shell structure alone. The short literature list also includes all other known reports on marine Ostracoda for the whole eastern Atlantic coast, because, while some forms are definitely restricted by temperature conditions, many, which are found at high latitudes, will also be found at

great depths in more southern waters, and for this reason some of the papers cited may be of use in identification of species in the Gulf region. The littoral and very shallow water ostracods of the Gulf of Mexico have scarcely been studied, but judging from the small amount of work which has been done on this ecological realm (Tressler 1940; Tressler and Smith, 1948), the so-called "barren zone" of Rothwell, lying between the strand and about 20 meters depth, should furnish many species.

ECOLOGY

With the limited data available little can be said of the ecological relationships of the species known from this region, and most of this is dependent upon Rothwell's information which he has kindly placed at the author's disposal.

Only 56 species of marine ostracods have been reported from the Gulf of Mexico proper and 19 additional species from the West Indies, Caribbean Sea, and adjacent areas. Most of these species have been reported from the northwest sector of the Gulf.

Rothwell divided the region of the Gulf in which he was working into five zones based upon depth and on the nature of the shelf area, as follows: (1) a Barren Zone between 10 and 24 meters depth, (2) the Marginal Shelf Zone between 24 and 68 meters, (3) the Upper Continental Slope between 68 and 190 meters, (4) the Lower Continental Slope between 190 and 1,250 meters, and (5) the Deep Sea Zone beyond 1,250 meters depth. If we examine the ostracods for which depth data are available, we find that 10 out of the 12 species reported from near Tortugas are in the "Barren Zone." This anomaly may be explained by the fact that Rothwell's samples were all taken with small-diameter punch coring devices or by small bottom samplers; sampling by means of a dredge over a greater area of the bottom would undoubtedly have recovered as many species of ostracods in the shallower water as were found in the beach samples at Beaufort (Tressler 1940) and in shallow water at Solomon's, Maryland (Tressler and Smith, 1948). The species found in the barren zone included *Cytherura lineata, Loxoconcha elegans, Cytherideis silicula* and *Paradoxstoma ensiforme* in the northwest sector and the following from Tortugas: *Cypridina squamosa, Asterope mariae, Asterope elliptica, Cyclasterope tripla, Cyclasterope sphaerica, Pontocypris intermedia, Macrocypris africana, Macrocypris schmitti, Nesidea cushmani, Xestoleberis punctata.*

No species was found exclusively in the Marginal Shelf Zone, but a number of forms were found only in this region and in the adjacent Upper Continental Slope down to 190 meters. These included *Paracytherois flexuosa, Cytherella polita, Macrocypris similis, Paradoxstoma ensiforme,* and *Cythereis silicula.*

Ostracoda which were found in the two preceding zones and in the Lower Continental Slope Zone as well as down to a depth of 1,250 meters included *Argilloecia cylindrica, Macrocypris decora, Cytherella obtusata,* and *Cythereis margaritifera.*

Five species were confined to the Lower Continental Slope and the Deep Sea Zones. These are *Nesidea victrix, Krithe tumida, Pontocypris trigonella, Xestoleberis expansa,* and *Cypridina flatus.* Four species were found only in the Deep Sea area: *Nesidea ovata, Bythocypris bosquetiana, Macrocypris tumida,* and *Pseudocythere caudata.*

The deepest station at which ostracods were collected was 3,630 meters located southeast of Brownsville; two species were found here, *Krithe tumida* and *Xestoleberis expansa.* Several species were, however, found at depths below 3,000 meters. These included, besides the two mentioned above, *Cythereis echinata* (3,157 meters), *Cythereis erica* (3,220 meters), *Cythereis stolonifera* (3,246 meters), *Cythereis dictyon* (3,475 meters), and *Cytheropteron mucronalatum* (3,431 meters).

With the exception of the genus *Conchoecia,* represented by one species, *C. atlantica* from Tortugas, and the males of the genus *Asterope* (*A. mariae* and *A. elliptica*) also from Tortugas, all the ostracods so far reported from the Gulf of Mexico are bottom-dwelling forms. *Conchoecia* is a true pelagic species and one of the very few found among the Ostracoda. The females of the genus *Asterope* keep close to the bottom, whereas the males are active swimmers and ascend to the surface where they are often taken in plankton catches. The nature of the bottom sediments on which the Ostracoda of the Gulf of Mexico are found varies considerably with the area, depth, and the species of ostracod, but unfortunately, for security reasons this subject cannot be discussed within the limits of this report.

Rothwell labels his barren zone as a region of lower salinity situated as it is along the coast where it receives inflow from several large rivers (Rio Grande, Brazos, Atchafalaya, and others). The species found within this zone are mainly forms whose close relatives have also been found in the brackish waters of the Solomons, Md., region at shallow depths.

Some ostracods are restricted by temperature in their world-wide distribution and are found only in northern latitudes or in deep water in other areas. *Bythocypris bosquetiana*, for example, although widely distributed, apparently prefers cold water. Other species, such as *Cythereis echinata*, appear to be widely tolerant of temperature variations and in the Gulf of Mexico, as in other localities, are found at all depths and temperatures. In the Gulf of Mexico Rothwell gives the limits of seasonal variation in bottom temperature as 75 meters which, in the region between Galveston, Tex., and Atchafalaya Bay, La., places its outer limits at the inner portion of the Upper Continental Slope. Beyond this depth bottom temperatures are cold the year round which accounts for the large number of species found beyond 75 meters as compared with the number found in the shallower areas where ostracods and other animals must have wide temperature tolerances.

The section following deals with the individual species which have been reported from the Gulf of Mexico up to the present time. Further details of taxonomy, structure, and individual habits may be obtained for many of these species by consulting references listed, particularly the monumental work of Georg Ossian Sars on the Crustacea of Norway, volume 9, Ostracoda (Sars 1928). Of all the references cited, this work should prove as helpful as any one report in identifying a large majority of the Gulf species. Müller's (1894) Ostracoda of the Gulf of Naples will also be found useful. Brady's papers, if used in connection with Müller's (1912) synopsis, will be of some help, particularly where one must depend upon identification from shells alone.

Suborder MYODOCOPA

Family CYPRIDINIDAE

Cypridina squamosa Müller, 1894

This large active swimmer lives on the bottom and has been reported only from the Tortugas Islands in the Gulf region. It was found at depths of from 20 to 22 meters. It is also known from the Gulf of Naples.

Cypridina flatus Tressler, 1949

A single female was taken at a depth of 1,200 meters near Tortugas. It has not been reported elsewhere in the world.

Asterope mariae (Baird, 1850)

Of all the known ostracods this genus alone possesses gills. Females usually stay close to the bottom; the males, however, may be taken in plankton tows close to the surface. Two females belonging to this species were found in shallow water near the Tortugas Islands. It is known from widely scattered places such as the coasts of Sweden, British Isles, France, Norway, the Mediterranean, North Atlantic, South Atlantic, Pacific, and off Vineyard Sound.

Asterope elliptica Philippi, 1840

This species is similar to *A. mariae* but has a shorter shell. Specimens have been reported from shallow water (4–5 meters) near Tortugas. Its distribution includes the Mediterranean and North Atlantic.

Cyclasterope priacanthus Tressler, 1949

The genus *Cyclasterope*, although closely related to *Asterope*, differs from it in having much higher shells some of which are almost spherical when seen from the side. *C. priacanthus* was reported from the stomach of the glass-eyed snapper, *Priacanthus cruentatus*, near Tortugas.

Cyclasterope sphaerica Tressler, 1949

In water 20 to 22 meters deep near Tortugas. Unknown elsewhere.

Cyclasterope tripla Tressler, 1949

Found in shallow water (on rocks at low tide and 18–20 meters) near Tortugas.

Family HALOCYPRIDAE

Conchoecia atlantica (Lubbock, 1856)

Members of the genus *Conchoecia* are true pelagic ostracods and although often found on the bottom, they are active swimmers. The genus is a large one of nearly 100 species and is widely distributed throughout most of the oceans of the world. One specimen of *C. atlantica* was taken

from the stomach of a fish caught at 160 to 200 meters depth near Tortugas.

Suborder CLADOCOPA

Family POLYCOPIDAE

Polycope orbicularis Sars, 1866

The genus *Polycope* is easily distinguished by the almost completely circular form of the shells which are smooth and glistening, without hairs. Shells of this species were taken in bottom samples at depths of between 128 and 1,867 meters in the northwest portion of the Gulf southeast of Atchafalaya Bay. The distribution of this species includes the coast of Norway, Franz Joseph Land, Cape of Good Hope, and the North Atlantic.

Suborder PLATYCOPA

Family CYTHERELLIDAE

Cytherella lata Brady, 1880

The internal anatomy of species belonging to this genus, which is the only genus in the suborder, is entirely unlike that of any other member of the Ostracoda group. Both pairs of antennae are powerfully developed and can be extended in front but are not used as swimming organs as in other Ostracoda. The posterior antennae are broad and flattened and resemble the appendages of Copepoda. The present species, *C. lata*, was reported from empty shells at depths ranging from 46 to 1,720 meters in various locations in the northwest region of the Gulf, from Brownsville to Atchafalaya Bay. It has also been reported from the West Indies, the Azores, the coast of Brazil, the Banda Sea, and Torres Straits in the East Indies.

Cytherella polita Brady, 1869

This species, first reported from Haiti and Cuba by Brady some 80 years ago, has been recently reported by Rothwell from several locations in the northwest part of the Gulf off Galveston and west of Atchafalaya Bay in comparatively shallow water (29–132 meters). The distribution of this ostracod includes the Arabian Sea, New Zealand, and the coast of South America near the Rio de la Plata.

Cytherella obtusata (Müller, 1912)

Shells of this species were reported in water at depths of from 43 to 198 meters off the coast of the northwest portion of the Gulf from Matagorda Bay to near Atchafalaya Bay. It was originally reported by Brady as *C. truncata* in the Caribbean off Colon (1869) and has since then been taken in Torres Straits.

Suborder PODOCOPA

Family CYPRIDAE

Pontocypris subreniformis Brady, 1880

Shells of this bottom form were taken in 1,600 meters off Brownsville and in 29 meters just west of Atchafalaya Bay. It has also been reported from the coasts of South Africa, Australia, Norway, and from the Arabian Sea.

Pontocypris trigonella Sars, 1866

Shells were found by Rothwell in samples taken at several places in the northwest sector of the Gulf at depths ranging from 190 to 1,417 meters. Its distribution includes the coasts of Norway, England, Haiti, Bermuda, and the Gulf of Guinea.

Pontocypris intermedia Brady, 1868

Five males belonging to this species were taken in an otter trawl in 20 to 22 meters of water off Tortugas. It has been reported from the Mediterranean as well.

Argilloecia cylindrica Sars, 1865

Specimens with internal body parts intact were taken by Rothwell at a depth of 44 meters off Brownsville, and shells were secured in the bottom samples at depths down to 823 meters in the sector of the Gulf between Brownsville and Galveston. This form is also well-known from the Norwegian coast, the North Atlantic, and the Mediterranean.

Macrocypris decora (Brady, 1865)

The large, usually whitish species of the genus *Macrocypris* are strictly bottom dwellers, being entirely devoid of swimming powers. While the actual shape of the shell varies with the species, they all have the characteristic elongated body with white glistening valves. *M. decora* was collected, with body structure intact, by Rothwell at a depth of 155 meters off Trinity Shoal west of Atchafalaya Bay. Shells of this species were taken at several places in the sector between Matagorda and Atchafalaya Bays at depths between 68 and 210 meters. This species appears

to be widely distributed throughout the Southern Hemisphere.

Macrocypris tumida **Brady, 1880**

Shells of this species were taken at between 1,400 and 1,800 meters depth nearly due east of Brownsville. The species is also known from somewhat shallower depths off the Kerguelens (50 meters), New Zealand (357 meters), and the southern coast of Norway.

Macrocypris maculata **(Brady, 1866)**

Shells of this ostracod were recovered from depths of between 57 and 1,720 meters at a number of stations in the northwest region of the Gulf. This species has been reported from the West Indies, the Caribbean, and Ceylon.

Macrocypris similis **Brady, 1880**

Shells were collected from bottom samples, at depths of 33 to 144 meters, taken off Galveston. Distribution includes the east coast of South America, Ascension Island (at a depth of 290–1,235 meters), and the coast of Ceylon.

Macrocypris africana **Müller, 1908**

Three females belonging to this species were collected in an otter trawl haul at depths of between 20 and 22 meters off the Tortugas. This ostracod was originally described from the coast of South Africa.

Macrocypris schmitti **Tressler, 1949**

Eight females were taken from cracked-up rock in shallow water on the west side of Loggerhead Key, Tortugas. This species is unknown except from this region.

Family NESIDEA

Bairdia coronata **Brady, 1870**

This doubtful form was described from specimens obtained off Veracruz in 1870 by G. S. Brady.

Nesidea ovata **(Bosquet, 1853)**

Shells of this bottom-dwelling ostracod were found in bottom samples taken in 1,810 meters of water a little north of due east from Brownsville. It has been reported from South Africa.

Nesidea victrix **(Brady, 1869)**

Shells of this species were collected at various stations in the northwest portion of the Gulf by Rothwell at depths ranging from 190 to 2,395 meters. It has been reported from the West Indies, the Caribbean (off Colon), the coast of north Brazil, and the west coast of North Africa.

Nesidea cushmani **Tressler, 1949**

Several females were collected at depths of from 4 to 22 meters off Tortugas. This is the sole record of this species at the present time.

Nesidea amygdaloides **(Brady, 1866)**

Brady reported this species from the Gulf of Mexico off Veracruz years ago. It is also known from the Australian coast, Cuba, Cocos Islands, New Caledonia, and the southern coast of Norway.

Bythocypris bosquetiana **(Brady, 1866)**

Species of this genus are bottom-dwelling. *B. bosquetiana* has been reported from the presence of shells at depths of 1,253 to 2,523 meters in the region east of Brownsville. Its distribution includes the West Indies, Atlantic Ocean, the Mediterranean, and Bass Straits (1,270 meters depth).

Bythocypris compressa **Brady, 1880**

Shells of this species were taken at depths varying from 66 to 1,920 meters at various locations in the northwest portion of the Gulf from Brownsville, the Sigsbee Deep, and as far as the mouth of the Mississippi River. This species had previously been reported from the South Pacific.

Family CYTHERIDAE

Bythocythere turgida **Sars, 1866**

Shells of this species, which is also bottom-dwelling, were obtained at depths of between 108 and 1,372 meters south of Atchafalaya Bay. It is known from the coast of Norway and the Gulf of Biscay.

Pseudocythere caudata **Sars, 1866**

This easily recognized and widely distributed ostracod was reported present (shells only) by Rothwell in samples taken at between 310 and 1,372 meters in the area south of Atchafalaya Bay. Its distribution includes the North Atlantic, Franz Joseph Land, coast of Norway, Mediterranean, the Kerguelens, and Prince Edward Island.

Cytherura lineata **Brady, 1867**

Numerous shells of this bottom-dwelling species were collected at various stations throughout the

northwest sector of the Gulf at depths ranging from 31 to 1,810 meters. This species had been reported only from the English coast previous to the present time.

***Cytheropteron alatum* Sars, 1866**

As their name implies, species of this genus have prominent wing-like lateral projections from the sides of the valves and are easily distinguishable for this reason. They are strictly bottom-dwelling forms. *C. alatum* shells were recovered from the bottom samples taken at depths between 31 and 1,920 meters at stations widely scattered throughout the whole northwest sector of the Gulf. Its known distribution includes the coast of England, Shetland Islands, the North Atlantic, coast of Norway, and at Funafuti.

***Cytheropteron mucronalatum* Brady, 1880**

Shells of this ostracod were collected in bottom samples at depths of between 174 and 3,431 meters at stations scattered over the northwest area of the Gulf. This species had previously been reported from the Pacific Ocean, between Japan and Patagonia, the Azores (2,515–3,748 meters), the North Atlantic, and between the Azores and the Bay of Biscay at 5,005 meters depth.

***Eucytherura complexa* (Brady, 1867)**

Shells were recovered throughout most of the northwest portion of the Gulf between Brownsville and the mouth of the Mississippi River at depths varying from 42 to 1,400 meters. This ostracod had previously been known only from the English and Norwegian coasts, and the Mediterranean.

***Paradoxstoma ensiforme* Brady, 1867**

These fragile-shelled forms, with their characteristic high posterior valve margins and suctorial mouths, are bottom-dwelling animals usually found near the coast in fairly shallow water. In the Gulf region, Rothwell reported finding their shells along the coast between the Brazos River and Atchafalaya Bay at depths of 16 to 90 meters. This species had been reported previously from the coasts of Norway and England, the Bay of Biscay, and the Mediterranean.

***Paracytherois flexuosa* (Brady, 1867)**

Although these ostracods somewhat resemble *Paradoxstoma* both in shape and in the presence of a suctorial mouth, *Paracytherois* may be distinguished from the other genus by the beak-like, rather than ring-formed shape of the mouth. Rothwell obtained specimens with body parts intact at 66 meters depth off Trinity Shoal near Atchafalaya Bay. Shells of this species were taken at a number of stations in the northwest sector at depths varying from 43 to 190 meters. *P. flexuosa* had previously been reported from the coast of Europe, the North Atlantic, and Franz Joseph Land.

***Xestoleberis minima* (Brady, 1866)**

Members of this genus, like some other groups of ostracods, have a brood pouch in the posterior part of the body for the reception of ripe ova for further development. The species *X. minima* was recorded by Rothwell from a specimen which he obtained with intact body parts at a depth of 88 meters off Galveston. Shells of this species were also found at various stations in the northwest sector of the Gulf at depths ranging from 68 to 210 meters. The species was earlier reported by Brady from shallow water in the West Indies.

***Xestoleberis expansa* Brady, 1880**

Shells were found at many stations in the northwest sector of the Gulf at depths of from 150 to 3,246 meters. This ostracod had been reported previously from off the Rio de la Plata at a depth of 3,473 meters and from the Arabian Sea.

***Xestoleberis curta* (Brady, 1866)**

Shells of this species were taken at depths of between 82 and 265 meters off the coast between Galveston and Atchafalaya Bay. It had been reported previously from many parts of the oceans in depths ranging up to 2,514 meters.

***Xestoleberis punctata* Tressler, 1949**

One female was collected in shallow water from the debris of cracked-up rock west of Loggerhead Key, Tortugas. It is unknown from other regions of the world at the present time.

***Loxoconcha avellana* (Brady, 1866)**

Species belonging to this genus are easily recognized by the short, rhomboid shape of the shell. *L. avellana* shells were found at stations throughout the northwest sector of the Gulf at depths of from 20 to 387 meters. Its known distribution includes the West Indies, Australia, Pacific, and Indian Oceans.

***Loxoconcha elegans* (Brady, 1870)**

Shells of this ostracod were collected at several stations between Matagorda and Atchafalaya Bays in comparatively shallow water at depths of from 16 to 82 meters. It had previously been reported from Cuba and the Straits of Magellan.

***Loxoconcha dorso-tuberculata* (Brady, 1866)**

This ostracod was found at only one station in the northwest sector of the Gulf in 190 meters off Atchafalaya Bay. It is known from the West Indies from which it was originally described by Brady years ago and from Noumea in the New Caledonia group of islands.

***Eucythere declivis* (Norman, 1865)**

This genus contains forms which have a characteristically shaped shell, being much higher anteriorly than posteriorly. *E. declivis* shells were found in widely scattered locations in the northwest sector of the Gulf at depths of between 40 and 1,920 meters. Its distribution includes the coast of Europe, the North Atlantic, and Franz Joseph Land.

***Krithe bartonensis* (Jones, 1856)**

The genus *Krithe* includes species with thin, smooth, and pellucid shells which have a broad marginal zone containing conspicuous pore canals. They are all bottom-dwelling and have poor powers of locomotion. *K. bartonensis* shells were found all over the northwest sector as far as the extent of the *Atlantis* cruises and in depths varying from 40 to 3,367 meters. It is a widely distributed form, being known from the European coast, Norway, Bay of Biscay, Iceland, North Atlantic, and Fiji Islands, at depths down to 3,200 meters.

***Krithe tumida* Brady, 1880**

Shells of this species were collected at depths of from 197 to 3,630 meters in the northwest sector of the Gulf. This species had been reported previously from the North Atlantic, the region of the South Atlantic off the Rio de la Plata in 3,473 meters, and from Funafuti.

***Cythereis dictyon* Brady, 1880**

Species belonging to this large genus all have rough, uneven shells which are often beautifully sculptured or covered with projections or spines. *C. dictyon* shells were found at many stations over the entire northwest sector of the Gulf at depths ranging from 63 to 3,475 meters. It is widely distributed throughout the oceans, being known from such regions as the Kerguelen Islands, Table Bay, Indian Ocean, and New Zealand. In general, it seems to be confined between north latitude 38° and 52° south latitude and has been found at all depths from 87 to 5,080 meters.

***Cythereis echinata* Sars, 1866**

This easily recognized ostracod was reported from shells found at many localities in the northwest sector of the Gulf by Rothwell at depths of between 31 and 3,157 meters. It had been reported previously from the North Atlantic and the Norwegian coast.

***Cythereis erica* (Brady, 1880)**

This species seems to be widely distributed over the northwest sector of the Gulf of Mexico at depths of from 25 to 3,230 meters. Its distribution includes the North Atlantic, the coast of Brazil (1,235 meters depth), and East Indies (915 meters depth), and off the Cape of Good Hope (2,624 meters).

***Cythereis margaritifera* Müller, 1894**

Shells of this species were collected at three stations along the coast from Brownsville to Galveston at comparatively shallow depths which ranged from 29 to 265 meters. It was previously reported from the Gulf of Naples.

***Cythereis pumicosa* (Brady, 1870)**

This species was reported from the waters off Veracruz by Brady. It has also been reported from Turk Island, New Providence, and Cuba in the West Indies.

***Cythereis stolonifera* (Brady, 1880)**

Shells from this species were collected at a number of stations throughout the northwest sector at depths of between 88 and 3,246 meters. It is known elsewhere only from South Africa (Simons Bay).

***Cythereis rastromarginata* (Brady, 1880)**

This ostracod appears to be widely distributed over the whole northwest sector of the Gulf and was reported from shells by Rothwell at depths of

259534 O—54——29

from 150 to 1,902 meters at widely scattered stations. The world-wide distribution includes the Pacific Ocean, Bass Straits, East Indies, Honolulu, and the Indian Ocean.

Cytherideis silicula (Brady, 1870)

The shells of this genus are long and comparatively very low in height. *C. silicula* was collected with body parts intact at depths of 31, 37, and 40 meters by Rothwell off Galveston, and shells of this species were taken along the coast from the Brazos River to Atchafalaya Bay in comparatively shallow water (18 to 174 meters depth). This species had previously been reported by Brady from off Veracruz.

Cytheridea setipunctata Brady, 1869

Brady reported this somewhat doubtful ostracod from the waters off Veracruz. This is the only known record of its distribution.

OSTRACODA REPORTED FROM ADJACENT REGIONS

A number of species of ostracods have been reported from areas immediately adjacent to the Gulf of Mexico. Although these species have not as yet been recorded from the Gulf proper, a list is included for future reference.

Caribbean Sea (Off Colon)

The following species have been reported by Brady for the Colon-Panama region of the Caribbean Sea and have been included by Müller (1912) in his compendium of the Ostracoda:

Paracypris pulchella (Brady, 1886).
Cythere compacta Brady, 1866.
Cythere oblonga Brady, 1866.
Cythereis speyere (Brady, 1868).
Cythereis rectangularis (Brady, 1869).
Cythereis ramdohri Müller, 1912.
Cythereis tuberculata (Sars, 1865).
Cytherella pulchra Brady, 1866.

West Indies

Müller records the following species from the West Indies:

Macrocypris tenuicauda Brady, 1870.
Nesidea subdeltoidea (Sars, 1887).
Nesidea longisetosa (Brady, 1902).
Bythocypris reniformis Brady, 1880.
Cythere duperrei Brady, 1869.
Cythereis tuberculata (Sars, 1865).
Cytheridea curta Brady, 1866.

Cuba

Two species have been described by Brady from the waters off the island of Cuba as follows:

Cythere compacta Brady, 1866.
Cytheridea subquadraregularis Brady, 1870.

Bahama Islands

Two species have also been reported from the Bahamas by Brady:

Xestoleberis angulata Brady, 1870.
Cythereis bahamensis (Brady, 1870).

Conclusions

It will be apparent from the above account that an almost unexplored field awaits the investigator in the taxonomy, ecology, and distribution of the marine Ostracoda of the Gulf of Mexico.

BIBLIOGRAPHY

Blake, C. H.
1929. New Crustacea from the Mt. Desert Region. Biol. Surv. Mt. Desert Region, Part 3: 3–34.
1933. Ostracoda. Biol. Surv. Mt. Desert Region, Part 5: 229–241.

Brady, G. S.
1867. Synopsis of British Ostracoda. Intell. Observ. 12: 110–130.
1868. A monograph of the recent British Ostracoda. Tr. Linn. Soc. London 26 (2): 353–495.
1870. Recent Ostracoda from the Gulf of St. Lawrence. Ann. Mag. Nat. Hist., ser. 4, 6: 450–454.
1880. Ostracoda. Rep. Voy. *Challenger*, Zool., vol. 1, Part 3.

——— and Norman, A. M.
1889. A monograph of the marine and freshwater Ostracoda of the North Atlantic and northwestern Europe. Section 1. Podocopa. Sci. Trans. Roy. Dublin Soc., ser. 2, 5: 621–746.

Cushman, J. A.
1906. Marine Ostracoda of Vineyard Sound and adjacent waters. Proc. Boston Soc. Nat. Hist. 32 (10): 359–385.

Folin, L. de, and Perier, L.
1867–87. Les fonds de la mer. Étude internationale sur les particularités nouvelles des regions sours-marines commencée et dirigée par Berchan. Vols. 1, 2, 4, 1867–72; 1872–74; 1881–87. Bordeaux, Paris.

MÜLLER, G. W.
1894. Die Ostracoda des Golfes von Neapel. Fauna und Flora des Golfes von Neapel. 21 Monographie, 404 pp., 40 pls. Berlin.
1912. Ostracoda. Das Tierreich. 434 pp. Berlin.

ROTHWELL, W. T., JR.
1949. Preliminary report on Ostracoda in bottom samples and cores of northwestern Gulf of Mexico. Bull. Geol. Soc. Am., Pt. 2, 60 (12): 1918.

SARS, G. O.
1928. Crustacea of Norway. Ostracoda. Vol. 9, 277 pp. Bergen Museum.

TRESSLER, W. L.
1939. *Onychocythere*, a new genus of marine ostracod from Florida, with a description of one new species. Jour. Washington Acad. Sci. 29 (8): 336–339.
1940. Ostracoda from Beaufort, North Carolina, sand beaches. Am. Mid. Nat. 24 (2): 365–368.

TRESSLER, W. L.—Continued
1941. Geology and biology of North Atlantic deep-sea cores between Newfoundland and Ireland. Part 4, Ostracoda. U. S. Geol. Surv., Prof. Paper 196–C, pp. 95–105.
1949. Marine Ostracoda from Tortugas, Florida. Jour. Washington Acad. Sci. 39 (10): 335–343.
——— and SMITH, E. M.
1948. An ecological study of seasonal distribution of Ostracoda, Solomons, Maryland, region. Chesapeake Biol. Lab. Publ. 71: 1–50.

VAN DEN BOLD, W. A.
1946. Contribution to the study of Ostracoda with special reference to the Tertiary and Cretaceous microfauna of the Caribbean region. Utrecht Univ. Thesis, 167 pp.

Blank page retained for pagination

COPEPODA

By WALDO L. SCHMITT, *United States National Museum*

In view of the admitted importance of copepods in the economy of the sea it is rather surprising that so little attention has been given the free-swimming forms of the Gulf of Mexico. This may, in great measure, be due to the fact that their systematic study entails much painstaking effort. They are small, and their precise determination requires microscopic dissection and the preparation of slide mounts. Also, the collecting of the specimens needed for an adequate review of the species and a knowledge of their distribution and the conditions of their existence in any large body of water is an expensive undertaking involving the employment of vessels, equipment, and men over a considerable period of time.

Not until the spectacular recurrence of the "red tide" in 1946–1947 had more than casual and localized samplings ever been attempted, but the comprehensive survey initiated at that time seems not as yet to have progressed beyond the list of species and a brief discussion published by King (1950). In his table of plankton distribution there are entered 67 copepods in 50 genera (excluding the pelagic stages of 2 parasitic forms belonging to 2 different genera). Thirteen of these were not accompanied by specific determination, so the number of species could easily be greater if any of these genera were represented by more than one species.

The earliest report enumerating Gulf species consists of Herrick's (1884) work in which he writes, "jottings . . . the result of a few days' stay on Mississippi Sound . . . will give some idea of the [copepod] fauna of the Gulf of Mexico." Of the eight free-swimming species he collected, two represented new species, one, indeed, a new genus. Along with their descriptions he published descriptive notes on five of the six other species.

Three years later Herrick's (1887) paper appeared in which the material on the species of the earlier report was reproduced with emendations and illustrations and two species added; two of the more or less tentatively identified forms of the earlier report were redescribed as new, of which one was referred to a different genus. The number of free-swimming salt and brackish water species recorded by Herrick from Mobile Bay and vicinity thus totals about 10. A few of these are again dealt with by Herrick and Turner (1895) but without particular reference to their occurrence in the salt or brackish waters of Alabama.

No further study of the free-swimming copepods seems to have been made until Foster (1904) prepared his notes on the free-swimming copepods of the waters in the vicinity of the Gulf Biological Station, Louisiana, in which 13 genera were presumably represented by 18 species, though at least 1 species in each of 6 genera was not specifically determined. Foster's specimens were collected 6 to 8 miles out in the Gulf of Mexico, in Calcasieu Pass, and in St. Johns Bayou which connects Lake Calcasieu with the Pass.

A representative of each of two genera not appearing either in King's table or in Foster's list were identified by Herrick also. With these exceptions King seems to have found about everything taken by those authors and, of course, many more genera and species besides. Otherwise, no extensive gatherings of free-swimming copepods have been reported on, though some very remarkable additions resulted from A. S. Pearse's visits to the former Tortugas Laboratory of the Carnegie Institution. In brackish ponds and pools Pearse (1932a) discovered four species of copepods in as many genera of which one genus and three of the species proved to be new records for the Gulf area. From among the numerous inhabitants of certain Tortugas sponges he (Pearse 1932b) sorted 23 different kinds of copepods not identified except as to the 12 genera to which the species belong. Nine of these likewise constituted new records. Finally, in the gill chambers of three species of crabs that he (Pearse

1932c) was examining for parasites he observed three species of free-swimming copepods, one species to a "host." These cannot be regarded as other than accidental guests. Again, two of the genera and perhaps all three species were first records for the Gulf.

Other than King's (1950) very recent preliminary report, little seems to have been done on the free-swimming forms since publication of Pearse's papers. Marsh (1910) remarks that Foster told him he had collected *C. aequoreus* in Lake Pontchartrain and connecting waters and adds, "It seems likely that further collections in brackish waters will show that this is not an uncommon form." Foster seems not to have recorded his observation in print. Davis (1948) netted a marine, a brackish water, and a more or less fresh water type of copepod in Long Lake, Dade County, which is connected with Garfield Bight, a shallow arm of Florida Bay, by a narrow and devious passage 4 miles long. The waters of the lake are distinctly brackish and even in periods of greatest rainfall are believed never to become completely fresh. The brackish water species, *Pseudodiaptomus coronatus*, had earlier been reported by Wright (1936) from the mouth of the Mississippi (Grand Pass and Point Chicot) from which the following year he described *P. americanus*. Mississippi Sound to the eastward is the type locality for Herrick's (1884, 1887, 1895) *P. pelagicus* which, because of its inadequate description, is conceivably identical with *P. coronatus* according to Wright (1937). The marine species proved to be new, while the fresh water form, if it is correctly one, was described as a variety of *Cyclops panamensis*. A newly described species, *Corycaeus americanus*, was added to the fauna by M. Wilson (1949) in part on the basis of material secured in a haul made off [Port] Aransas, Texas. Although the former United States Bureau of Fisheries steamer *Albatross* made one tow net haul in the Gulf of Mexico in 1885, the fact that it added 5 genera, 11 species of marine copepods to the list of those occurring in that body of water did not become known until C. Wilson (1950) reported on the *Albatross* collections.

Summarizing the foregoing information, one can safely say that close to a hundred free-swimming copepods, representative of some 70 genera, have to date been taken in the Gulf of Mexico and in brackish waters adjacent thereto. These, however, are believed to be but a small fraction of the species that an intensive Gulf-wide investigation would reveal.

Though less important economically parasitic copepods from the Gulf of Mexico came to the attention of naturalists at a much earlier date than the free-swimming forms, no doubt because of their association primarily with fish, their generally larger size, and the ease with which they can be collected. Perhaps the first to be recorded from the area was *Argulus funduli* described by Krøyer (1863) from New Orleans and recorded again by Bere (1936) from Lemon Bay, west coast of Florida, and Meehean (1940) from near New Orleans and from a brackish pool at Meveitta, Florida. For the greater part the species parasitizing Gulf fishes have been described principally by Bere and Meehean, just referred to, and, above all, by C. B. Wilson in a series of papers from 1902 through 1944. In all, just about 122 species have been reported from the Gulf after making allowance for duplications: Bere, 70 species; Meehean, 3 or 4 (without salinity readings, it is not always possible to determine whether the water in many localities in Florida may be wholly fresh or brackish); and C. B. Wilson, 48 (mostly in his Tortugas paper of 1935). Though not yet found on fish caught in the Gulf of Mexico, the 25 species of parasitic copepods which Wilson (1913) listed for Jamaican fish, not yet reported from the Gulf, will probably be found to occur there because the host species are common to both areas.

Of equal scientific interest are the parasitic copepods which infest the gills of Crustacea and, in one instance (*Pestifer agilis* Wilson, 1949), were found attached to the skin of an undetermined marine annelid dredged in 380 fathoms south of the Dry Tortugas. There are three species of these parasites of decapod Crustacea in the Gulf of Mexico: *Cancrincola jamaicensis*, originally described from the white land crab in Jamaica (Wilson 1913) and found later at Tortugas in the spider crab, *Microphrys bicornutus*, and the hermit, *Paguristes puncticeps* (Pearse 1932a; Wilson 1935); *Cancrincola plumipes* Humes (1941) described from adult marsh crabs, *Sesarma reticulatum*, at Grand Isle, Louisiana; and *Clausidium tenax* Humes (1949), also from Grand Isle from the mud shrimp, *Callianassa islagrande*.

This brief résumé of the work that has been done in striving for a better understanding and a

more thorough knowledge of the copepod fauna of the Gulf of Mexico, its relation to the other marine life of the area and its physical environment, shows that no more than a beginning has been made so far. Nevertheless, it is an encouraging beginning in view of the potentialities of the problem that it reveals. There is a considerable wealth of Gulf copepod material lying fallow in the collections of the U. S. National Museum that deserves attention in the light of the growing importance of the Gulf fishery resources now being actively developed by the current investigations of the Fish and Wildlife Service.

In Washington there are stored, as yet unstudied but still in good condition, considerable plankton collections made by the former United States Fish Commission and the Bureau of Fisheries steamer *Fish Hawk* in the Gulf of Mexico from as early as 1895 through 1901, 1902, 1903, 1912, 1913, and in 1914 as far to the westward as Lavaca Bay, Texas. These samples should have early attention, a small staff assembled to properly deal with them, and the necessary equipment provided. The U. S. National Museum provides unexcelled facilities for accomplishing these and similar tasks which will inevitably arise as the Gulf is more intensively studied. The student of copepods may have access here to the incomparable copepod library of the late C. B. Wilson that he bequeathed the Smithsonian Institution and to the extensive, authoritatively identified collection of specimens to which he devoted his life and upon which were based his many valuable publications dealing with the free-swimming and parasitic marine copepods of the world.

BIBLIOGRAPHY

Bere, Ruby.

1936. Parasitic copepods from Gulf of Mexico fish. Am. Midland Naturalist 17 (3): 577–625, pls. 1–12.

Davis, Charles C.

1948. Notes on the plankton of Long Lake, Dade County, Florida, with descriptions of two new copepods. Quart. Jour. Florida Acad. Sci. 10 (2–3): 79–88, pls. I–II.

1950. Observations of plankton taken in marine waters of Florida in 1947 and 1948. Quart. Jour. Florida Acad. Sci. 12 (2): 67–103, fig. 1.

Foster, E.

1904. Notes on the free-swimming copepods of the waters in the vicinity of the Gulf Biologic Station, Louisiana. 2d Rept. Gulf Biol. Sta., Bull. No. 2: 69–79.

Herrick, C. L.

1883. A blind copepod of the family Harpacticidae. Am. Naturalist 17: 206.

1884. Final report on the Crustacea of Minnesota, included in the orders Cladocera and Copepoda: together with a synopsis of the described species of North America, and keys to the known species of the more important genera. 12th Ann. Rept. Geol. Nat. Hist. Survey of Minn., Pt. V: 1–192, pls. A–V.

1887. Contribution to the fauna of the Gulf of Mexico and the South. List of the fresh-water and marine Crustacea of Alabama, with descriptions of the new species and synoptical keys for identification. Mem. Denison Sci. Assn., Granville, Ohio, 1 (1): 1–56, pls. 1–9. Also: Geol. Survey Alabama, Bull. No. 1, 5: 1–56, pls. 1–9.

——— and Turner, C. H.

1895. Synopsis of the Entomostraca of Minnesota with descriptions of related species comprising all known forms from the United States included in the orders Copepoda, Cladocera, Ostracoda. Zool. Ser., II, State Geol. and Nat. Hist. Survey of Minnesota, 525 pp., 81 pls.

Humes, A. G.

1941. A new harpacticoid copepod from the gill-chambers of a marsh crab. Proc. U. S. Nat. Mus. 90 (3110): 370–386, fig. 18.

1949. A new copepod (Cyclopoida: Clausidiidae) parasitic on mud shrimps in Louisiana. Trans. Am. Microsc. Soc. 68 (2): 93–103, pls. 1–3.

Illg, Paul L.

1948. Pharodinae, a new subfamily of Chondracanthidae (Crustacea: Copepoda), and a description of *Pharodes biakensis*, n. sp., from New Guinea. Jour. Washington Acad. Sci. 38 (12): 404–412, figs. 1–15.

Jakubisiak, Stanislaw.

1933. Sur les Harpacticoides saumâtres de Cuba. Ann. Musei Zool. Polonici, Warzawa, 10 (9): 93–96, pls. 19–20.

King, Joseph E.

1950. A preliminary report on the plankton of the west coast of Florida. Quart. Jour. Florida Acad. Sci. 12 (2): 109–137.

Krøyer, Henrik.

1863. Bidrag til Kundskab om Snyltekrebsene. Naturhistorisk Tidsskrift, Ser. 3, 2: 74–426, pls. 1–18.

Marsh, C. Dwight.

1910. A revision of the North American species of Cyclops. Trans. Wisconsin Acad, 16 (2): 1067–1134, 10 pls.

1912. Notes on fresh-water Copepoda in the United States National Museum. Proc. U. S. Nat. Mus. 42 (1900): 245–255.

1933. Synopsis of the Calanoid crustaceans, exclusive of the Diaptomidae, found in fresh and brackish waters, chiefly of North America. Proc. U. S. Nat. Mus. 82 (2959): 1–58, pls. 1–24.

Meehean, O. Lloyd.

1940. A review of the parasitic Crustacea of the genus *Argulus* in the collections of the United States National Museum. Proc. U. S. Nat. Mus. 88 (3087): 459–522, figs. 21–47.

PEARSE, A. S.
1932a. Observations on the parasites and commensals found associated with crustaceans and fishes at Dry Tortugas, Florida. Papers Tortugas Lab. Carnegie Inst. Washington Pub. 28 (6): 103–115.
1932b. Inhabitants of certain sponges at Dry Tortugas. Pap. Tortugas Lab. Carnegie Inst. Washington Pub. 28 (7): 117–124, pls. 1–2, fig. 1.
1932c. Animals in brackish ponds and pools at Dry Tortugas. Pap. Tortugas Lab. Carnegie Inst. Washington 28 (8): 125–142, pls. 1–3, fig. 1–2.
1936. Results of survey of the cenotes of Yucatán. Carnegie Inst. Washington Pub. No. 457: 17–28, pls. 1–2.

WILSON, CHARLES B.
1902. North American parasitic copepods of the family Argulidae, with a bibliography of the group and a systematic review of all known species. Proc. U. S. Nat. Mus. 25 (1302): 635–742, pls. 8–27.
1907. North American parasitic copepods belonging to the family Caligidae. Parts III and IV: Revision of Pandarinae and Cecropinae. Proc. U. S. Nat. Mus. 33 (1573): 323–490, 18 figs., pls. 17–43.
1911a. North American parasitic copepods. Description of new genera and species. Proc. U. S. Nat. Mus. 39 (1805): 625–634, pls. 65–68.
1911b. North American parasitic copepods belonging to the family Ergasilidae. Proc. U. S. Nat. Mus. 34 (1788): 263–400, pls. 41–60.
1913. Crustacean parasites of West Indian fishes and land crabs, with descriptions of new genera and species. Proc. U. S. Nat. Mus. 44 (1950): 189–277, pls. 18–53.
1917. North American parasitic copepods belonging to the Lernaeidae, with a revision of the entire family. Proc. U. S. Nat. Mus. 53 (2194): 1–150, pls. 1–21.

WILSON, CHARLES B.—Continued
1932. The copepods of the Woods Hole region, Massachusetts. U. S. Nat. Mus. Bull. 158, xix 635 pp., 316 text figs., 41 pls.
1935. Parasitic copepods from the Dry Tortugas. Pap. Tortugas Lab. Carnegie Inst. Washington 29 (12): 327–347, pls. 1–6.
1936a. Note on a copepod from Cuba. Mem. Soc. Cubana Hist. Nat. 10 (1): p. 32.
1936b. Two new parasitic copepods from Cuban fish. Mem. Soc. Cubana Hist. Nat. 10 (2): 107–112, 15 figs.
1936c. Copepods from the cenotes and caves of the Yucatán Peninsula with notes on cladocerans. Carnegie Inst. Washington Pub. No. 457: 77–88, figs. 1–20.
1944. Parasitic copepods in the United States National Museum. Proc. U. S. Nat. Mus. 94 (3177): 529–582, pls. 20–34.
1950. Copepods gathered by the United States Fisheries steamer *Albatross* from 1887 to 1909, chiefly in the Pacific Ocean. U. S. Nat. Mus. Bull. 100, 14 (4): 1–441, pls. 1–36.

WILSON, MILDRED STRATTON.
1949. A new species of copepod of the genus Corycaeus from the North American Coast. Proc. U. S. Nat. Mus. 99 (3239): 321–326, pl. 18.

WRIGHT, STILLMAN.
1936. A revision of the South American species of *Pseudodiaptomus*. Ann. Acad. Brasileira de Sciencias 8 (1): 1–24, pls. 1–3.
1937. Two new species of *Pseudodiaptomus*. Comm. Tech. Piscicult. Nordeste Publicacão, No. 28, Ann. Acad. Brazil. Sci. 9 (2): 155–162, pls. 1–2.

CIRRIPEDIA: THE BARNACLES OF THE GULF OF MEXICO

By DORA PRIAULX HENRY, *Oceanographic Laboratories, University of Washington*

The following résumé of what is known about the barnacles of the Gulf of Mexico is based on (a) published accounts, the most important of which are the taxonomic studies of Pilsbry (1907, 1916) and the ecological studies of Stephenson and Stephenson (1950), and (b) unpublished data.[1] Pilsbry's material consisted of *Albatross* hauls and isolated shore collections, mainly from the western shores of Florida. Stephenson and Stephenson (1950) studied the Florida Keys area, and several authors have reported barnacles from several localities in the southern part of the Gulf. The unpublished data are based, primarily, on isolated shore collections in which the barnacles of Texas are especially well represented.

Until there is further study of the barnacles of this region, it is possible to draw no more than tentative conclusions concerning their horizontal and vertical distribution, the ecology, and the relationship to the fauna of adjacent areas.

The barnacles of the Gulf may be divided according to habitat into the littoral, the pelagic, and the deep water. Barnacles are probably not an important part of the intertidal fauna on most of the Gulf coast as rocky shores are very scarce, except in southern Florida. Wharfs, piles, and sea walls provide, however, a suitable substratum for several species. These barnacles, as well as some that are found in off-shore waters, also foul ships' bottoms in other parts of their range, and some, at least, may have been introduced into the Gulf in this way. Conditions in the Gulf appear to be much more favorable for the growth of pelagic and deep water barnacles.

A check list of the barnacles known to occur in this region follows (tables 1 and 2). For the sake of brevity, the region has been divided arbitrarily into six coastal areas, i. e., the Dry Tortugas, Florida Keys, west Florida, Mississippi, Louisiana, and Texas, and the deep water of the Gulf of Mexico.

[1] The author is indebted to Dr. Joel Hedgpeth for the opportunity of examining his barnacle collection, as well as that of the Texas Fish and Game Commission, and to Dr. Fenner A. Chace for the chance to study some of the Gulf barnacles acquired by the U. S. National Museum since Pilsbry's monographs were published.

TABLE 1.—*Check list of sessile barnacles in the Gulf of Mexico*

Species	Area	Number of localities	Reported by—[1]
Acasta:			
cyathus Darwin	Dry Tortugas	1	Pilsbry, 1916.
Balanus:			
amphitrite niveus Darwin	Florida Keys	1	Stephenson, T. A. and A., 1950.
Do	West Florida	6	Pilsbry, 1916.
Do	do	1	Kolosováry, 1943.
Do	do	2	Henry.
Do	Texas	1	Do.
amphitrite pallidus Darwin	Louisiana	1	Do.
calidus Pilsbry	West Florida	4	Pilsbry, 1916.
Do	Texas	1	Henry.
? *crenatus* Bruguière	West Florida	1	Kolosováry, 1943.
declivis Darwin	Dry Tortugas	1	Pearse, 1932b.
Do	West Florida	1	Pilsbry, 1916.
eburneus Gould	Florida Keys	1	Stephenson, T. A. and A., 1950.
Do	West Florida	1	Pilsbry, 1916.
Do	Mississippi	1	Do.
Do	do	1	Henry.
Do	Louisiana	3	Do.
Do	Texas	10	Do.
galeatus (Linnaeus)	West Florida	1	Pilsbry, 1916.
Do	do	1	Kolosováry, 1943.
Do	Texas	1	Henry.
improvisus Darwin	West Florida	1	Kolosováry, 1943.
Do	Mississippi	2	Henry.
Do	Texas	3	Do.
stultus Darwin	Dry Tortugas	1	Nilsson-Cantell, 1929.
trigonus Darwin	Gulf of Mexico	1	Henry.

[1] Author's unpublished records are indicated by her name not followed by year.

TABLE 1.—*Check list of sessile barnacles in the Gulf of Mexico*—Continued

Species	Area	Number of localities	Reported by—[1]
Chelonobia:			
manati lobatibasis Pilsbry	West Florida	1	Pilsbry, 1916.
patula (Ranzani)	do	1	Do.
Do	do	1	Henry.
Do	Louisiana	1	Do.
Do	Texas	2	Pilsbry, 1916.
Do	do	1	Do.
testudinaria (Linnaeus)	Florida Keys	1	Henry.
Do	West Florida	2	Pilsbry, 1916.
Do	Texas	4	Henry.
Chthamalus:			
fragilis Darwin	Florida Keys	1	Stephenson, T. A. and A., 1950.
Do	West Florida	1	Pilsbry, 1916.
Do	Texas	2	Henry.
stellatus angustitergum Pilsbry	Florida Keys	1	Pilsbry, 1916.
Do	do	(2)	Stephenson, T. A. and A., 1950.
Platylepas:			
hexastylos (O. Fabricus)	West Florida	1	Pilsbry, 1916.
Do	Texas	1	Henry.
hexastylos ichthyophila Pilsbry	W. Florida	1	Pilsbry, 1916.
Pyrgoma:			
floridanum Pilsbry	do	1	Do.
Stomatolepas:			
praegustator Pilsbry	Dry Tortugas	1	Do.
Tetraclita:			
squamosa stalactifera (Lamarck)	Florida Keys	1	Do.
Do	do	(2)	Stephenson, T. A. and A., 1950.
Verruca:			
alba Pilsbry	Gulf of Mexico	1	Pilsbry, 1916.
floridana Pilsbry	do	1	Do.

[1] Author's unpublished records are indicated by her name not followed by year.
[2] Several.

TABLE 2.—*Check list of pedunculate barnacles in the Gulf of Mexico*

Species	Area	Number of localities	Reported by—[1]
Lepas:			
anatifera Linnaeus	Florida Keys	1	Pilsbry, 1907.
Do	Mississippi	2	Henry.
Do	Louisiana	1	Pilsbry, 1907.
Do	Texas	1	Henry.
anserifera Linnaeus	Florida Keys	1	Pilsbry, 1907.
Do	Mississippi	2	Henry.
Do	Louisiana	1	Pilsbry, 1907.
Do	Texas	1	Henry.
pectinata Spengler	Florida Keys	1	Pilsbry, 1907.
Do	Texas	1	Henry.
Octolasmis:			
forresti Stebbing	Dry Tortugas	1	Do.
Do	Florida Keys	1	Pilsbry, 1907.
Do	do	1	Henry.
Do	Texas	1	Do.
geryonophila Pilsbry	Dry Tortugas	1	Pearse, 1932a.
hoeki Stebbing	do	1	Henry.
Do	Florida Keys	1	Do.
Do	Texas	1	Do.
lowei Darwin	Dry Tortugas	1	Pearse, 1932a.
Do	W. Florida	1	Henry.
Do	Mississippi	2	Do.
Do	Louisiana	1	Pilsbry, 1907.
Do	do	1	Humes, 1941.
Do	do	1	Henry.
Do	Texas	2	Do.
Poecilasma:			
inaequilaterale Pilsbry	Florida Keys	1	Pilsbry, 1907.
inaequilaterale breve Pilsbry	Gulf of Mexico	1	Do.
kaempferi litum Pilsbry	Florida Keys	1	Do.
Scalpellum:			
antillarum Pilsbry	Gulf of Mexico	1	Do.
arietinum Pilsbry	do	1	Do.
diceratum Pilsbry	do	1	Do.
gibbum Pilsbry	do	1	Do.
portoricanum intonsum Pilsbry	do	1	Do.
regina Pilsbry	do	1	Do.
Do	do	3	Henry.
semisculptum Pilsbry	do	1	Pilsbry, 1907.

[1] Author's unpublished records are indicated by her name not followed by year.

The littoral barnacles with the widest distribution in the Gulf are *Balanus eburneus*, *B. amphitrite niveus*, and *Chthamalus fragilis*. In the Florida Keys the common intertidal barnacles of the rocky shore are *Chthamalus stellatus angustitergum* and *Tetraclita squamosa stalactifera*, with the *Chthamalus* occurring at the highest level of the midlittoral zone and the *Tetraclita* at a slightly lower level but overlapping the *Chthamalus* (Stephenson and Stephenson, 1950). The distribution of these two species in the Florida Keys is peculiar; both varied from absent to abundant on the oceanic sides of the keys and from absent to fairly common on the Florida Bay side, and no north-to-south effect could be demonstrated. *T. s. stalactifera* and *C. s. angustitergum* have not been reported from western Florida, although they might be expected to occur in the southern part.

B. eburneus and *B. a. niveus* range from the Florida Keys, where Stephenson and Stephenson (1950) found them commonly on walls, wharfs, and piles but never on the rocky platforms, to the Texas shore. The vertical range for both species is from a little above the low tide line to, at least, 25 fathoms. They are found oftener on wood or shells than on rock, and both are able to live in brackish water.

Chthamalus fragilis also ranges from the Florida Keys, where it is apparently rare, to the Texas shore. It is probably commoner on the northern shores of the Gulf than is indicated by the records, as members of this genus are often overlooked by collectors because of the small size and inconspicuous form. The vertical distribution is unknown for the Gulf, but it occupies a high level of the intertidal zone in other parts of its range.

Below low tide line the most widespread barnacles are *B. galeatus*, situated on gorgonians, and *B. calidus* on shells of all kinds and on dead echinoderms. According to Hedgpeth (personal communications), *B. galeatus* is commonly found on stems of gorgonians which have drifted onto the Texas beach.

The other species of *Balanus* occurring in the littoral zone have been found at only one or two localities so one can only guess at their distribution. *B. improvisus* will probably be found along the northern part of the Gulf, wherever a suitable substratum (wood, shells, and rock) is found, as this species, like *B. eburneus* and *B. a. niveus*, is partial to brackish water. In other areas the vertical distribution of this species is from the low tide line to 150 meters. *B. trigonus*, in other parts of its wide range, occurs from 1 to 3,000 meters on shells, crabs, and sponges. These two species, as well as *B. eburneus* and *B. a. niveus*, are important fouling organisms in other areas, but what part they play in the fouling of ships in the Gulf is unknown.

The barnacles, *B. declivis*, *B. stultus*, and *Acasta cyathus*, which live in sponges have been reported from the southern part of the Gulf, but an examination of the sponges of other parts of the Gulf will no doubt extend the distribution.

In addition to the barnacle-gorgonian and barnacle-sponge associations mentioned above, three other barnacle-associations occur in the Gulf. The barnacle-coral association is practically unknown, as apparently coral has not been examined for barnacles. One species of *Pyrgoma* has been reported by Pilsbry (1931) in coral. Of the turtle barnacles, *Chelonobia testudinaria* is widely distributed in the Gulf as is probably *Platylepas hexastylos* (a subspecies has been found on a fish in western Florida by Pilsbry, 1916). A subspecies of *C. manati* and *Stomatolepas praegustator* are known from only one locality in the Gulf.

The barnacles associated with crabs of the Gulf may be externally on the carapace and internally on the branchiae. *Chelonobia patula* and three species of *Poecilasma*, both of which are mainly on crabs, in addition to four species of *Balanus* (*a. niveus*, *improvisus*, *eburneus*, and *trigonus*) may be found on the carapace. Three species of *Octolasmis* occur on the branchiae. The shallow water crab, *Callinectes sapidus*, is the host of at least the first three species of *Balanus* enumerated above, *C. patula*, *Octolasmis lowei*, *B. trigonus*, *Poecilasma*, and all three species of *Octolasmis* are associated with deep water crabs or palinurids.

Neither the pelagic nor the deep water barnacles are of any assistance in determining the relationship to other faunal areas. The three species of the pelagic genus *Lepas* which occur in the Gulf are nearly cosmopolitan. Conversely, the species of the deep water genera, *Scalpellum* and *Verruca*,

are known from only a few localities and from relatively few specimens in both the Gulf and adjacent areas.

Many tropical species of littoral barnacles are represented in the Gulf. Some of these species, *B. calidus*, *B. declivis*, *B. stultus*, and *C. s. angustitergum*, are limited to the West Indies fauna; *B. galeatus* and *T. s. stalactifera* occur also in the eastern tropical Pacific; and the other species, *C. patula* and *P. hexastylos*, are widespread in tropical waters. The last two species, *B. galeatus*, which has also been found on the Atlantic coast as far north as North Carolina, and *B. calidus* have a wide range in the Gulf, whereas, the other species are limited to the Florida Keys.

The rest of the common littoral barnacles of the Gulf are important components of the littoral fauna of the Atlantic coast where the northern limit varies from Massachusetts (*B. a. niveus* and *B. eburneus*) to New Jersey (*C. fragilis* and *C. testudinaria*) and the southern limit from the Caribbean coast of South America (*B. eburneus* and *C. fragilis*) to southern Brazil (*B. a. niveus* and *C. testudinaria*). With the exception of *B. eburneus* these species occur in one or more other faunal provinces.

The littoral fauna of the Gulf, therefore, consists of a mixture of warm temperate and tropical species. One ubiquitous species, *B. improvisus*, also occurs in the Gulf; the western Atlantic range of this species is from Nova Scotia to southern Patagonia. All of the common littoral barnacles of the temperate waters of the Atlantic coast and none of the common boreal species (*B. balanoides*, *B. crenatus*, *B. balanus*, and *B. hameri*) occur in the Gulf, but many of the tropical species found in the West Indies have not been reported from the Gulf.

BIBLIOGRAPHY

HUMES, A. G.
1941. Notes on *Octolasmis mülleri* (Coker), a barnacle commensal on crabs. Trans. Am. Microsc. Soc. 60: 101–103.

KOLOSOVÁRY, G. v.
1943. Cirripedia Thoracica in der Sammlung des ungarischen National-Museums. Ann. Hist. Nat. Hungarici 36: 67–120, 2 pls.

NILSSON-CANTELL, C. A.
1929. Two species of *Balanus* very little known since the Darwinian monograph of Cirripedia was issued. Ark. Zool. Stockholm 20A, no. 14: 1–7, 3 text figs.

PEARSE, A. S.
1932a. VI. Observations on the parasites and commensals found associated with crustaceans and fishes at Dry Tortugas, Florida. Pap. Tortugas Lab. Carnegie Inst. Washington (Pub. 435) 28: 103–115.
1932b. VII. Inhabitants of certain sponges at Dry Tortugas. Pap. Tortugas Lab. Carnegie Inst. Washington (Pub. 435) 28: 117–124, 2 pls., 1 text fig.

PILSBRY, H. A.
1907. The barnacles (Cirripedia) contained in the collections of the U. S. National Museum. Bull. U. S. Nat. Mus. 60: 122 pp., 11 pls., 36 text figs.
1916. The sessile barnacles (Cirripedia) contained in the collections of the U. S. National Museum, including a monograph of the American species. Bull. U. S. Nat. Mus. 93: 366 pp., 76 pls., 99 text figs.
1931. The cirriped genus *Pyrgoma* in American waters. Proc. Acad. Nat. Sci. Philadelphia 83: 81–83, 1 text fig.

STEPHENSON, T. A., and A.
1950. Life between tide-marks in North America. I. The Florida Keys. Jour. Ecol. 38 (2): 354–402, pls. 9–15, 10 text figs.

THE MYSIDACEA AND EUPHAUSIACEA

By ALBERT H. BANNER, *Department of Zoology and Entomology, University of Hawaii*

Very little is known of the mysid and euphausiid fauna of the Gulf of Mexico. Only three articles deal with the mysids of the region and only one with the euphausiids, together reporting not over a dozen stations mostly occupied before 1900 by the steamer *Albatross*. Tattersall (1951), in his review of the mysids of North America, reports the following species from this region either on the basis of previous records or specimens not previously reported:

Family LOPHOGASTRIDAE

Lophogaster americanus Tattersall.
Lophogaster longirostris Faxon.
Gnathophausia ingens (Dohrn).

Family PETALOPHTHALMIDAE

Petalophthalmus armiger Willemoes-Suhm.

Family MYSIDAE

Gastrosaccus dissimilis Coifmann.
Gastrosaccus mexicanus Tattersall.
Mysidopsis bigelowi Tattersall.
Metamysidopsis munda (Zimmer).
Mysidium integrum Tattersall.

Hansen (1915), in his similar review of the euphausiids of the U. S. National Museum, lists two species collected by the *Albatross* in 1885 and one species collected by the *Grampus* in 1889: *Thysanopoda pectinata* Ortmann, *Thysanopoda orientalis* Hansen, and *Euphausia tenera* Hansen.

All of the species of euphausiids and the species of the first two families of mysids reported are pelagic or bathypelagic forms and were found in the deeper water of the Gulf. The species reported from the family Mysidae are all neritic forms and were collected relatively close to land.

The shortness of this list should not be construed to be indicative of an impoverished fauna either in numbers of species or in numbers of individuals, but rather it should be seen as an indication of insufficient sampling. To catch these relatively large and active planktonts it is necessary to tow for them with large and rather coarse-meshed plankton nets; as many of the species exhibit diurnal migrations it is necessary to tow either at the surface after dark or in deeper water during the day. To capture many of the species of mysids it is necessary to sample the waters immediately above the mud and sand bottoms, for mysids are often hypoplanktonic and spend most of their lives hovering immediately above the bottom. When adequate sampling is carried out the number of species of both mysids and euphausiids can be expected to at least quadruple.

When the fauna of the Gulf is better known the "schizopods" will be found to be divisible into four major ecological groups:

1. *Epipelagic (or epiplanktonic) species.*—This group, living in or near the photic zone of the open sea, will include a few species of mysids but most of the species of euphausiids. The species probably will be found to be relatively widespread in the adjacent regions of the subtropical and tropical Atlantic at least, and possibly will be found to be circumtropical like *Euphausia tenera* listed above.

2. *Bathypelagic species.*—This group will contain both mysids and euphausiids but will be rich neither in number of species nor in number of individuals. Most species that will be found probably will have extremely wide ranges of distribution like *Petalophthalmus armiger* which is also known from off Ireland, the Gulf of Panama, the Gulf of Aden, the Bering Sea, and off Hawaii, to list a few of its localities of capture.

3. *Neritic species.*—This portion of the "schizopod" fauna will be composed mainly of species of mysids with the addition of some species of euphausiids. The distribution ranges of species in this group will be more narrow than those of the pelagic group; some at least will extend for thousands of miles along the coasts. Examples of the type of range are *Mysidopsis bigelowi* which is known to extend from Massachusetts to Louisiana and *Metamysidopsis munda* which extends from Chesapeake Bay to the coast of Brazil. Other species may have a more limited distribution.

4. *Hypoplanktonic species.*—This group, found living hovering above the bottom or temporarily on the bottom in the lower littoral zone and in the deeper waters of the continental shelf, are almost exclusively mysids of rather wide distributional range along the shore lines. As these species often migrate high enough into the water above the bottom to be captured by an ordinary plankton net, in the absence of exact data of capture, it is impossible to determine whether any of the known species of the Gulf are commonly hypoplanktonic.

A more thorough study of the mysids and euphausiids of the Gulf of Mexico probably will show that these rather prominent elements of plankton of the open sea and of inshore waters are essential food intermediates for commercially important fish, as they have been found to be in other regions of the world.

BIBLIOGRAPHY

FAXON, WALTER.
1896. 37. Supplementary notes on the Crustacea. In: Reports on the results of dredging . . . in the Gulf of Mexico and the Caribbean Sea, and on the east coast of the United States, 1877 to 1880, by the U. S. Coast Survey steamer *Blake* . . . Bull. Mus. Comp. Zool., Harvard College, 30 (3): 153–166, 2 pls.

HANSEN, H. J.
1915. The crustacean Euphausiacea of the United States National Museum. Proc. U. S. Nat. Mus. 48 (2065): 59–114, 4 pls.

ORTMANN, ARNOLD E.
1906. Schizopod crustaceans in the U. S. National Museum. The families Lophogastridae and Eucopiidae. Proc. U. S. Nat. Mus. 31: 23–54, 2 pls.

TATTERSALL, WALTER M.
1951. A review of the Mysidacea of the United States National Museum. Bull. U. S. Nat. Mus. 201: x+292, 103 text figs.

STOMATOPODA

By FENNER A. CHACE, JR., *United States National Museum*

The stomatopod fauna of the Gulf of Mexico is very poorly known. There are several records from Key West and the Dry Tortugas, some from the west coast of Florida between Tampa Bay and Sanibel Island, as well as from the northern Gulf between Pensacola and Grand Isle, and a few from Galveston, the Gulf of Campeche, and Campeche Bank. In view of the limited collecting it is surprising to find as many as 13 species of stomatopods from the Gulf recorded in the literature. Preliminary examination of material recently added to the national collections, especially from the dredgings of the M/V *Oregon* of the Fish and Wildlife Service, indicates that several species will be added when the study of this material is finally completed.

The following list of species and the accompanying bibliography have been compiled largely from a manuscript synonymy of the stomatopods prepared and kindly made available by Dr. L. B. Holthuis of the Rijksmuseum van Natuurlijke Historie, Leiden, Holland. Without access to this invaluable summary of stomatopod literature the present survey would undoubtedly be less complete.

STOMATOPODS KNOWN FROM THE GULF OF MEXICO

Gonodactylus oerstedii Hansen, 1892.
Bigelow (1894); Gibbes (1850); McClendon (1911); Pearse (1932); Schmitt (1940); Sharp (1893).
Off Havana; Key West; Dry Tortugas. Also North Carolina and Bermudas to Brazil; Gulf of California to Ecuador.

Lysiosquilla excavatrix Brooks, 1886.
Anonymous (1942); Lunz (1935).
West of Charlotte Harbor, Florida (28 fathoms); Mobile, Alabama; Grand Isle, Louisiana. Also North Carolina.

Lysiosquilla scabricauda (Lamarck, 1818).
Anonymous (1942); Bigelow (1894); Lunz (1937); Sharp (1893).
Key West, Sanibel Island, Johns Pass, and Pensacola, Florida; Grand Isle, Louisiana; Galveston, Texas. Also New England to Brazil; West Africa.

Odontodactylus havanensis (Bigelow, 1893).
Bigelow (1893, 1894); Lunz (1937); Rathbun (1920).
Off Havana, Cuba; Key West; Dry Tortugas; Campeche Bank. Also Bahamas; Curaçao.

Odontodactylus nigricaudatus Chace, 1942.
Chace (1942).
Gulf of Campeche.

Pseudosquilla ciliata (Fabricius, 1787).
Lunz (1937).
Key West. Also Bermudas, Bahamas, and Florida Keys to Brazil; Indo-Pacific.

Squilla edentata (Lunz, 1937).
Lunz (1937).
West-southwest of Pensacola, Florida (120 fathoms).

Squilla empusa Say, 1818.
Anonymous (1942); Bigelow (1893, 1894); Faxon (1896); Lunz (1937); Rathbun (1893); Sharp (1893).
Sanibel Island and Pensacola, Florida; Grand Isle, Louisiana; Galveston Bay, Texas; northern Campeche Bank (84 fathoms). Also New England to Brazil; West Africa.

Squilla intermedia Bigelow, 1893.
Bigelow (1893, 1894).
Off Mississippi Delta (68 fathoms). Also Little Bahama Bank; Puerto Rico.

Squilla neglecta Gibbes, 1850.
Lunz (1937).
Sanibel Island, Florida. Also North and South Carolina.

Squilla rugosa Bigelow, 1893.
Bigelow (1893, 1894).
Off Charlotte Harbor, Florida. Also Isle of Pines, Cuba (subspecies ?).

Squilla, sp. [*S. prasinolineata* Miers, 1880, not Dana, 1852].
Ives (1891).
Silam, Yucatán. Also Brazil.

The present limited knowledge of the distribution of stomatopods, both within the Gulf of Mexico and elsewhere, does not permit any definite zoogeographical conclusions. Five of the thirteen species recorded from the Gulf (*Gonodactylus oerstedii*, *Lysiosquilla glabriuscula*, *L. scabricauda*, *Pseudosquilla ciliata*, and *Squilla empusa*) are known to have extensive ranges, at least from the Carolinas to Brazil. Three of these

which are comparatively common elsewhere have been found thus far in the Gulf area only in the western approaches to the Straits of Florida. It may be of interest that the two species which seem to be most generally distributed in the Gulf (*Lysiosquilla scabricauda* and *Squilla empusa*) are the only ones also recorded from West Africa. Of the species with more restricted ranges, *Lysiosquilla excavatrix* and *Squilla neglecta* are known outside of the Gulf only from the Carolinas; *Odontodactylus havanensis*, *Squilla intermedia*, and *Squilla rugosa* (subspecies ?) have been recorded from the Bahamas-West Indies region; *Squilla prasinolineata* [Miers, not Dana] is a Brazilian species not yet found north of Yucatán; and *Odontodactylus nigricaudatus* is at present represented only by the type specimen from the Gulf of Campeche.

LITERATURE CITED

ANONYMOUS.
1942. Annotated list of the fauna of the Grand Isle region 1928–41. Mar. Lab. Louisiana State Univ., pp. 1–20. Baton Rouge, La.

BIGELOW, ROBERT PAYNE.
1893. Preliminary notes on the Stomatopoda of the *Albatross* collections and on other specimens in the National Museum. Johns Hopkins Univ., Circular 12 (106): 100–102.
1894. Report on the Crustacea of the order Stomatopoda collected by the steamer *Albatross* between 1885 and 1891, and on other specimens in the U. S. National Museum. Proc. U. S. Nat. Mus. 17: 489–550, 28 figs., 3 pls.

CHACE, FENNER ALBERT, JR.
1942. Six new species of decapod and stomatopod Crustacea from the Gulf of Mexico. Proc. New England Zool. Club 19: 79–92, 6 pls.

FAXON, WALTER.
1896. XXXVII. Supplementary notes on the Crustacea. In: Reports on the results of dredging, under the supervision of Alexander Agassiz, in the Gulf of Mexico . . . Bull. Mus. Comp. Zool., Harvard College 30 (3): 153–166, 2 pls.

GIBBES, LEWIS R.
1850. On the carcinological collections of the United States, and an enumeration of species contained in them, with notes on the most remarkable, and descriptions of new species. Proc. Am. Assoc. Adv. Sci., 3d meeting, pp. 167–201.

IVES, J. E.
1891. Crustacea from the northern coast of Yucatán, the harbor of Vera Cruz, the west coast of Florida and the Bermuda Islands. Proc. Acad. Nat. Sci. Philadelphia 43 (1): 176–207, 2 pls.

LUNZ, GEORGE ROBERT, JR.
1935. The stomatopods (mantis shrimps) of the Carolinas. Jour. Elisha Mitchell Sci. Soc. 51 (1): 151–159, 6 figs.
1937. Stomatopoda of the Bingham Oceanographic Collection. Bull. Bingham Oceanogr. Coll., art. 5, 5: 1–19, 10 figs.

MCCLENDON, JESSE FRANCIS.
1911. On adaptations in structure and habits of some marine animals of Tortugas, Florida. Pap. Tortugas Lab., Carnegie Inst. Washington 3: 55–62, 1 fig., 2 pls.

PEARSE, ARTHUR SPERRY.
1932. Inhabitants of certain sponges at Dry Tortugas. Pap. Tortugas Lab., Carnegie Inst. Washington 28: 117–124, 1 fig., 1 pl.

RATHBUN, MARY JANE.
1893. List of Crustacea collected. In: Barton Warren Evermann's A report upon investigations made in Texas in 1891, Bull. U. S. Fish Comm. 11: 61–90, 9 pls.
1920. Stalk-eyed crustaceans of the Dutch West Indies. Rapport betreffende een voorloopig onderzoek naar den toestand van de Visscherij en de Industrie van Zeeproducten in de Kolonie Curaçao, uitgebracht door Prof. Dr. J. Boeke, pt. 2 [1919], pp. 317–349, 5 figs.

SCHMITT, WALDO LASALLE.
1940. The stomatopods of the west coast of America, based on collections made by the Allan Hancock Expeditions, 1933–38. Allan Hancock Pacific Exped. 5 (4): 129–225, 33 figs.

SHARP, BENJAMIN.
1893. Catalogue of the crustaceans in the Museum of the Academy of Natural Sciences of Philadelphia. Proc. Acad. Nat. Sci. Philadelphia, 1893, pp. 104–127.

DECAPODA OF THE GULF OF MEXICO

By ELLINOR H. BEHRE, *Louisiana State University, Baton Rouge, Louisiana*

GENERAL PHYSIOGRAPHIC REGIONS

The decapod Crustacea of the Gulf comprise a division roughly arranged in four, environmentally limited, large groups.

The first of these groups is made up of land forms living more or less on the edge of the salt water and spending part of their life in the sea. This group consists largely of members of the families Gecarcinidae, Grapsidae, and Ocypodidae. Their habitat is conditioned by the nature of the Gulf shores, which in the eastern part of the region under discussion (southern Florida) and on the southern rim are coral shores or limestone, but for the rest mostly sandy or muddy. The genus *Cardisoma*, the commonest representative, becomes in parts of this region a very conspicuous inhabitant of the shores and even of the inland areas. The spot distribution of this particular genus, from Florida to Texas, is a matter of considerable interest. Of its occurrence on the western border of our area, nothing is known. Other widely distributed forms are the family Grapsidae (genus *Sesarma* with subgenera), and the fiddler crabs, ghost crabs, and other Ocypodidae. Some of the genera of this family, such as *Uca minax*, invade brackish and even fresh water shores, though they are seldom found very far from water, even when not breeding.

The second major group is the fauna of the littoral, by far the best known and perhaps the largest segment of the decapod population of the Gulf. The northeastern portion of the northern Mexican coast, especially Yucatán, shows the 1,000-fathom line far off shore, though the shelf from the 100-fathom line is very steep. In the western Gulf (400-foot contour line) the drop is the steepest. The shallows extend farthest out on the north (Louisiana, Mississippi) and east (Florida) and on the northern shore of Yucatán. The littoral therefore comprises a zone of greatly varying width. The spread of the decapods over this area and the ecological niches that may have developed locally are matters of great interest to our general problem.

Roughly, the littoral here is composed of four major habitats, of which two are very similar.[1] There is first (region 1) the shore bordering the mouths of the great rivers. These shore lines are heavily fringed with the muddy deposits of river deltas. The rivers of the southern portion and also of Florida are much shorter, and there is a much lesser volume of deposited material than in the larger northern and western ones, chief among which are the Rio Grande, the rivers of the Mississippi Delta, and the Alabama drainage. The northern shore line appears fairly constant; but some observations would seem to indicate at least two faunal breaks—one at the Mississippi and perhaps a second somewhere between that point and the Texas-Mexico line, which seem to be other than purely climatic. Along the river mouths and up their muddy channels are to be found many mud crabs, definitely the richest single decapod element. Many species of *Panopeus*, *Hexapanopeus* and *Rithropanopeus*, *Eurytium*, and other related genera abound here. In general, we may expect this fauna to differ little from that of the muddy bays to be discussed later (region 3). There is a slightly more active flow of the water and more direct influence of winds, tides, and currents than in the back bays. Probably the single greatest variant is the periodic great alterations in salinity in "high water" years; and this does not seem seriously to affect the decapod population. A very bountiful fauna inhabits the muddy river mouths and tide flats. There is also an additional ecological factor in the slow run-off, which has resulted in man-made artificial microhabitats in the form of jetties, where dwell the rock crabs, along with many other normally rock-dwelling invertebrates that have adopted this territory.

[1] We shall use the rather indefinite term "region" to indicate each of these habitats.

259534 O—54——30

The second region (region 2) of the littoral is composed of the shores of the bars or islands between these run-offs; these areas vary greatly in stability and extent, but appear rather constant in structure and physical nature. But, as mentioned earlier, this apparent constancy is deceptive; a more intensive study of the Brownsville region and the Texas shore line immediately north and east reveals the disappearance of the marsh so characteristic of the Mississippi-Alabama-Louisiana shore line and its replacement by much more sandy shores facing the sea. This can be seen from any topographic map. There have been no comparative faunal studies of this region but such studies might well be expected to reveal an associated faunal break. Intensive studies of a few limited localities show the species of a single genus, such as for example, *Callianassa*, which occur on the ocean side of a bar in the northern Gulf, are definitely more closely related to those in similar habitats in more southern areas than they are to those found along shores with different soil composition in the same climatic zone. Thus it appears that along the northern Gulf, at least, temperature is not a strictly limiting factor.

In general, the common families of region 2 are the Callianassidae, Albuneidae, Hippidae, and some representatives of the Paguridae; the Portunidae represented by the ubiquitous *Callinectes* of many species, and others of that family; a few Pinnotheridae along the sand bars, especially on the open or widely exposed shores; and in slightly sheltered regions and small transient tidal pools, such Palaemonids as *Macrobrachium* and *Palaemonetes*.

The east coast of Mexico is not too well known; although it differs, as we go south, from the Texas shore line. Limestone, coral sands, coral reefs, and actively growing corals, with strips of rocky cliffs of laval origin, prevail. The underlying rock is limestone with much calcareous sand mixed with coral along the shore line. Theoretically, the coral provides the habitat for the crustacean forms which might be expected to replace here the rocky-shore species of other sections. What we might consider the southern rim of the Gulf, namely, the northern shore line of the Yucatán Peninsula, is another region not adequately explored nor described. It may be presumed, however, that such reefs as are present would show a more constant and consistent animal life than is to be found in similar habitats of the northern Gulf, since there is less depositional modification. Here is another key locality for important further study of the Gulf littoral.

Region 3 of the Gulf littoral comprises scattered shallow bays with muddy or occasionally shelly bottoms. This condition is found along the northern and western Gulf. Here there is a typical mud-bottom fauna living at depths of from a few to 20 or 30 feet, and consisting of many Xanthids, some of the family Porcellanidae, especially *Petrolisthes*, species of Inachidae, Palaemonidae, and Crangonidae, and a few of the families Calappidae, Parthenopidae, and Maiidae. Other Xanthids are distributed along the muddy shores of these embayments, where their burrowing often completely riddles large areas of tidal mud flats.

There is a further gap in our knowledge: the fauna of large parts of northern Cuba. From the general topography we would expect a rich fauna on these shores. The forms from the northern shore of Cuba as far as they are known belong more to the Caribbean—more precisely, the West Indian fauna—than to that of the Tortugas and the Florida Keys. But this may be questioned; the picture is not clear-cut, again for lack of records.

Region 4 is the reef fauna of western Florida and the Keys. As suggested above, it may be supposed that we would find here a fauna comparable to that of the West Indies; and as far as the fairly comprehensive studies from the Tortugas show the forms found here are indeed similar to those of the larger islands, such as Puerto Rico, which have been fully studied. They grade into those of northern Cuba. Comparison of this material with that from central and northern South America should show many definitely tropical characters.

The third major group comprises the fauna of the deeper Gulf. On the whole, this fauna is known only from isolated samples of the population since thorough study is wanting. Explorations so far have not been extensive, though in the neighboring West Indies some records have included material from considerable depth. The species found here might presumably be most constant, since temperatures vary less than elsewhere in our general territory except, perhaps, in that part of the Gulf floor which is under

direct influence of the subterranean river deposits. The forms so far described or listed from this region, though not as far as is known limited to it, include the Peneidae which are of considerable economic interest,[2] some of the Porcellanidae, Pagurids of several genera, Inachidae, though not of the same species as those found in the mud flats, and again, Portunids.

The fourth group to be considered is the drift invaders, chiefly from the south, brought in from the south and southeast by winds, tides, and ocean currents either through the Florida Straits or the Yucatán Channel. This group comprises plankton, with larval stages of decapods included, the identification of which has hardly been touched; also, the species that as adults, even egg bearing, are domiciled on the sargassum drift and found in considerable abundance whenever weather conditions in the far and nearer Gulf bring seaweed into the shore. In this category are to be found many of the free-living of the lower crustacean decapods dependent on the plant drift, larvae and adults, especially of the families Portunidae, Parthenopidae, Palaemonidae, and Maiidae.

Thus, examination of our records of the decapod Crustacea of the Gulf of Mexico indicates very clearly large gaps in our knowledge. These gaps are less evident along the northern shore and the Florida Keys than along the eastern part of Mexico and Yucatán. However, since the physical environment falls into the several general types as outlined, we may hope to find a fairly close correlation of the fauna with environments. This correlation will probably go no further than to genera.

COMPARISON OF FAUNAS

Of all the quantitative and intensive studies there are very few which give us a clue as to the general sources or relationships of the Gulf decapod fauna. The big question is: is this fauna largely derived from the tropical forms coming into the Gulf through the Florida and Yucatán Straits, or, on the other hand, does it show more temperate zone characters? Adequate answers are not forthcoming from presently available data, but we may at least glance at the two sets of fairly comparable records: (1) Schmitt's and Rathbun's Puerto Rican material, (2) material from the northern Gulf from the Louisiana State University Laboratory at Grand Isle, Louisiana, and Hedgpeth's Port Aransas, Texas, collection, lumped together. Schmitt's and Rathbun's material is what we may think of as typical West Indian tropical. The fauna of the northern Gulf will be used for comparison, since that area has been worked more intensively than other regions, and since drift from the tropics clearly reaches that shore (sargassum inhabitants).

Schmitt's and Rathbun's collections comprise 40 families, 171 genera, and 315 species. The northern Gulf collections referred to above are represented by 26 families, 66 genera, and 113 species. Of these, 21 families and 41 genera are common to both groups. It may be that some lack of agreement between the two sets of records is due to collecting techniques. However that may be, numbers show that if this comparison is to have any validity the faunal records of the northern Gulf need to be expanded.

It appears from such records as are available that the northern Gulf collections contain two families (one genus in each), usually considered temperate zone families, and not recorded from Puerto Rico. Further, it appears that in those families common to both collections, there are five genera of the shrimp and shrimp-like crabs and one genus of the Brachyura which occur only in the northern Gulf. On the other hand, there are 13 families of Anomura and Macrura and 6 of Brachyura from Puerto Rico which have not been reported from the northern Gulf. (Whether these are all truly tropical families may be questioned.)

The materials reported here indicate a large field for further taxonomic, ecological, and distributional studies on the decapod Crustacea of the Gulf of Mexico.

REFERENCE COLLECTIONS

The specimens serving as a basis for comparison for future students of the Gulf decapods are scattered rather widely. In this country the most important are:

The collections in the U. S. National Museum. Of these may be mentioned those of Schmitt and Shoemaker from the Tortugas, those of Schmitt (on Walter Rathbone Bacon scholarships) from two extended South American explorations, and other smaller ones.

[2] See article on shrimps by M. J. Lindner and W. W. Anderson in this book, pp. 457–461.

The collections from the United States Bureau of Fisheries made at various times by the *Albatross* the *Fish Hawk*, and the *Grampus*. The collections made by the Fish Commission in the Atlantic in 1838–42 and in the North Pacific, 1853–56.

The Pacific coast collections from Mexico, housed at the Allan Hancock Foundation.

The 1933 Johnson Smithsonian Collection to the Puerto Rican Deeps.

The Bingham Oceanographic Collection in the Peabody Museum in New Haven.

Loans now at the U. S. National Museum from various universities and from other limited collections.

PAPERS OF PARTICULAR REFERENCE TO GULF DECAPODS

BOONE, P. L.
1922. An interesting addition to the Florida decapod crustacean fauna. Proc. Biol. Soc. Washington 35: 137–140.

BURKENROAD, M. D.
1934a. Littoral Penaeidae chiefly from the Bingham Oceanographic Collection. Bull. Bingham Oceanogr. Coll. 4 (7): 1–109, 39 figs.
1934b. The Penaeidae of Louisiana, with a discussion of their world relationships. Bull. Am. Mus. Nat. Hist. 68 (2): 61–143.
1936. The Aristaeinae, Solerocerinae and pelagic Penaeinae of the Bingham Oceanographic Collection. Materials for a revision of oceanic Penaeidae. Bull. Bingham Oceanogr. Coll. 5 (2): 1–151, 71 figs.
1939. Further observations on Penaeidae of the northern Gulf of Mexico. Bull. Bingham Oceanogr. Coll. 6 (6): 62 pp., 34 figs.
1949. Occurrence and life histories of commercial shrimp. Science 110 (2869): 688–689.

CARY, L. R.
1906. A contribution to the fauna of the Gulf coast of Louisiana. Bull. Gulf Biol. Sta. 6: 50–59.

CARY, L. R., and SPAULDING, H. M.
1909. Further contribution to the marine fauna of the Louisiana coast. Bull. Gulf Biol. Sta. 12: 1–21.

CHACE, F. A.
1942. Six new species of decapod and stomatopod Crustacea from the Gulf of Mexico. Proc. New England Zool. Club 19: 79–92, 6 pls.

COUTIERE, H.
1910. The snapping shrimps (Alpheidae) of the Dry Tortugas, Florida. U. S. Nat. Mus. Proc. 37 (1716): 485–487.

GLASER, O. C.
1904. An incomplete list of the marine fauna of Cameron. Bull. Gulf Biol. Sta. 2: 41–42.

GOMEZ, M. S.
1933. Una nueva especie de crustaceo Cubano descubierta y clasificada. Sancti-Spiritus Cuba 8: 1–6, 3 figs.

GUNDLACH, J.
1900. Contribucion al estudio do los crustaceos de Cuba. Notas compiladas y completadas por el Dr. J. I. Torralbas. An. Ac. Habana 36: 292–305, 326–332, 362–374; 37: 51–65.

GUNTER, GORDON.
1945. Summary of ecological studies on invertebrates of the Texas coast. Rep. Comm. Mar. Ecol. related to Paleont. Washington, No. 5, pp. 55–56.
1950. Seasonal population changes and distributions as related to salinity, of certain invertebrates of the Texas coast, including the commercial shrimp. Pub. Inst. Mar. Sci. 1 (2): 7–51, 8 figs.

HAY, WILLIAM PERRY.
1903. On a small collection of crustaceans from the island of Cuba. Proc. U. S. Nat. Mus. 26 (1316): 429–435, 3 text figs.

HEDGPETH, JOEL W.
1950. Notes on the marine invertebraté fauna of salt flat areas in the Aransas National Wildlife Refuge, Texas. Pub. Inst. Mar. Sci. 1 (2): 103–119.

HUMES, ARTHUR G.
1941a. A new Harpacticoid copepod from the gill chambers of a marsh crab. Proc. U. S. Nat. Mus. 90 (3110): 379–386.
1941b. Notes on *Octolasmis mulleri* (Coker), a barnacle commensal on crabs. Trans. Am. Microsc. Soc. 40 (1): 101–103.

IVES, J. E.
1891. Crustacea from the northern coast of Yucatán, the harbour of Vera Cruz, the west coast of Florida and the Bermuda Islands. Proc. Acad. Nat. Sci. Philadelphia 43: 176–207, 2 pls.

LINDNER, MILTON J.
1936. Suggestions for the Louisiana shrimp fishery. 12th Biennial Rept. Dept. Conserv., State of Louisiana, 1934–35, pp. 151–167, 3 figs., 1 pl.

LUNZ, G. ROBERT, JR.
1937. Stomatopoda of the Bingham Oceanographic Collection. Bull. Bingham Oceanogr. Coll., Peabody Mus. Nat. Hist. 5 (5): 1–19, 10 figs.

MILNE-EDWARDS, A., and BOUVIER, E. L.
1891. Observations generales sur les paguriens recueillies dans les mers des Antilles et dans le Golfe du Mexique par le *Blake* et al *Hassler*. Bull. Soc. Philom (8) 3: 102–110.
1899. Espèces nouvelles du genre *Palicus*, Phil. (Cympolia, Roux) recueillies par le *Blake* dans la mer des Antilles et le Golfe du Mexique. Bull. Mus. Paris 1899, pp. 122–125.
1909. Les Peneides et Stenopides. In: Reports on the results of dredging, under the supervision of Alexander Agassiz, in the Gulf of Mexico (1877–78) . . . by the U. S. Coast Survey steamer *Blake*. Mem. Mus. Comp. Zool., Harvard College, 27 (3): 177–274, pls. i–ix.

MILNE-EDWARDS, A., and BOUVIER, E. L.—Continued
1923. Les Porcellanides et des Brachyures. In: Reports on the results of dredging, under the supervision of Alexander Agassiz, in the Gulf of Mexico (1877–78) . . . by the U. S. Coast Survey steamer *Blake*. Mem. Mus. Comp. Zool., Harvard College, 47 (4): 283–395, 12 pls., 22 text figs.

PARKS, HAL B.
1940. Descriptive catalogue of the Crustacea of the Gulf coast of Texas. Tech. Bull. of Stephen F. Austin State Teachers College, No. 2, vol. 2, 5 pp., March.

RATHBUN, M. J.
1898. The Brachyura of the biological expedition to the Florida Keys and the Bahamas in 1893. Bull. Lab. Iowa 4: 250–294, pls. i–ix.
1920. New species of spider crabs from the straits of Florida and Caribbean Sea. Proc. Biol. Soc. 33: 23–24. Washington.
1931. Two new crabs from the Gulf of Mexico. Proc. Biol. Soc. 44: 71–72. Washington.
1933. Brachyuran crabs of Porto Rico and the Virgin Islands. Scientific Survey of Porto Rico and the Virgin Islands, Vol. 15, Pt. 1, 121 pp. New York Academy of Sciences Press.
1934. A new crab of the genus *Cyclodorippe*. Smithsonian Misc. Coll. 91 (3): p. 1, 1 pl.

SCHMITT, WALDO.
1930. Some observations on the Crustacea of Tortugas. Carnegie Inst. Washington Year Book 29, pp. 343–346, 10 figs.

SCHMITT, WALDO—Continued
1931. Trawling for crustaceans at Tortugas, Florida. Explorations & Field Work Smithsonian Inst. Washington for 1930–1931, pp. 103–106, 4 photos.
1934. *Coralliocaris pearsei* Schmitt new species. Appendix to: Inhabitants of certain sponges at Dry Tortugas, by A. S. Pearse. Pap. Tortugas Lab. Carnegie Inst. Washington (Pub. 435) 28: 119–124, 2 pls., 1 text fig.

SPAULDING, M. H.
1908. Preliminary report on the life history and habits of the "lake shrimp" (*Penaeus setiferus*). Gulf Biol. Sta. Bull. 11, 29 pp., 6 pls.

WEYMOUTH, F. W.; LINDNER, MILTON; and ANDERSON, W. W.
1932. A summary of the life history of the common shrimp (*Penaeus setiferus*) of the South Atlantic and Gulf coasts of the United States. Trans. Am. Fish. Soc. 62, 3 pp.
1933. Preliminary report on the life history of the common shrimp *Penaeus setiferus* (Linn.). Bull. U. S. Bur. Fish. 48 (14): 1–26.

WHITTEN, H. L.; ROSENE, H. F.; and HEDGPETH, J. W.
1950. The invertebrate fauna of Texas coast jetties; a preliminary survey. Pub. Inst. Mar. Sci. 1 (2): 53–87, 4 figs., 1 pl.

WILLIS, E. R.
1942. Some mud shrimps of the Louisiana coast. Occ. Pap. Mar. Lab., Louisiana State Univ., No. 2, 6 pp.

Blank page retained for pagination

BIOLOGY OF COMMERCIAL SHRIMPS

By MILTON J. LINDNER and WILLIAM W. ANDERSON, *Fishery Research Biologists, Fish and Wildlife Service*

About 140 million pounds of shrimp were taken from the Gulf of Mexico in 1949. In the Gulf there are four commercially important shrimps: the common, white or lake shrimp, *Penaeus setiferus*; the grooved, Brazilian, pink and brown shrimp, *P. duoarum* and *P. aztecus*; and the sea-bob, *Xiphopenaeus kroyeri*. Of these, *P. setiferus*, during the middle 1930's, accounted for about 95 percent of the catch. At that time the fishery in the Gulf proper extended from St. Marks, Florida, with gaps, to Brownsville, Texas. Now, the fishery extends along almost the entire perimeter of the Gulf, and *P. aztecus* and *P. duoarum* have become progressively more important. Probably more than one-third of the 1949 catch was of these two species. Since we know more about *P. setiferus* the remarks that follow pertain to this species only and just for the northern Gulf of Mexico.

P. setiferus is most abundant in areas that are characterized by having an inland, brackish marsh connected by passes with an adjacent shallow offshore area of relatively high salinity and mud or clay bottom. The offshore characteristics seem to be required by the adults and probably also the larvae, while the inland marshes appear to be required by the post-larval pre-adults. The adults are rarely found in abundance in the Gulf of Mexico in depths greater than 30 fathoms. The pre-adults inhabit brackish water and at times are found in water that is almost fresh.

The females do not carry the eggs after fertilization but deposit them directly into the water. Some time prior to the emission of the eggs (time not known) the female has a spermatophore attached to her by the male. The eggs upon emission are fertilized by the sperm contained in the spermatophore. A female will lay about 500,000 eggs at each spawning, and it is probable that there is more than one spawning in a season.

As in other peneids, the first larval stage upon hatching from the egg begins as a nauplius. The larval stages are represented by at least five naupliar, three protozoeal and two mysis stages.

Most, if not all, spawning takes place at sea and not in the estuarine inland waters. Either during or shortly after the larval stages the young shrimp move from the waters of the Gulf to the estuarine waters. Growth is rapid in these estuarine waters. When the young are about 50 mm. in total length (from tip of rostrum to end of telson) they begin to appear in abundance on the estuarine commercial fishing grounds.

The young first appear in the estuarine fishing grounds in June or July, depending upon the area, and by August they have begun to make their appearance in the waters of the Gulf. Generally, in the estuarine waters there is a gradient in size of the shrimp, smaller shrimp occurring in those waters farther inland and larger shrimp in those waters nearest the Gulf. This gradient in size appears to be associated more closely with locality than with salinity.

As the young increase in size they gradually move toward the open waters of the Gulf (fig. 70). The movement of shrimp from the inland waters to the open waters of the Gulf is intensified by the decreasing water temperatures during the fall. As the waters warm in the spring the larger shrimp which are in the open waters of the Gulf mature rapidly and spawn. The smaller shrimp which have wintered in the estuarine waters or in Gulf waters close to shore grow and mature rapidly but spawn later.

Spawning occurs, and appears to be continuous, from at least the latter part of March through September. Apparently there are two major peaks of spawning success. The first peak can be attributed to April in Louisiana and generally June near Aransas Pass, Texas. Growth is rapid and the young from these spawnings produce the fall "run" of shrimp. The spring "run" of shrimp is produced by the second peak of spawning success which appears to result from

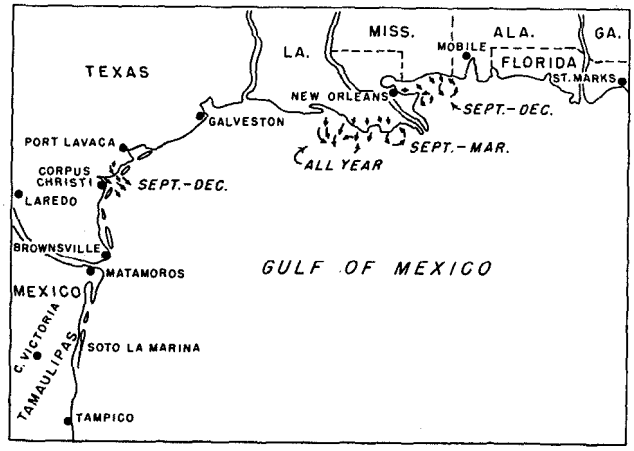

FIGURE 70.—Small shrimp (up to 13 cm.) movements of marked individuals.

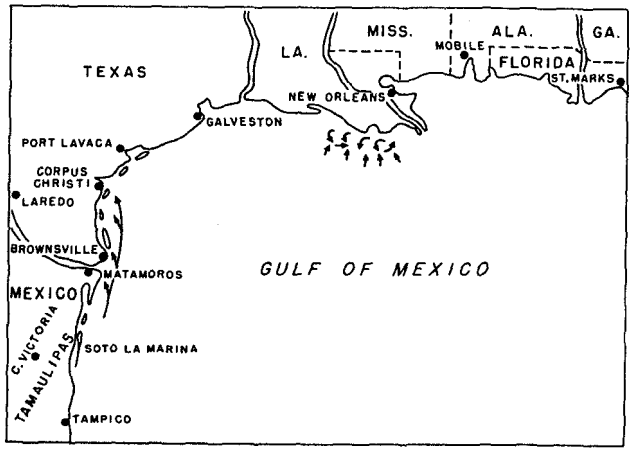

FIGURE 71.—Large shrimp (13 cm. and larger) spring movements of marked individuals.

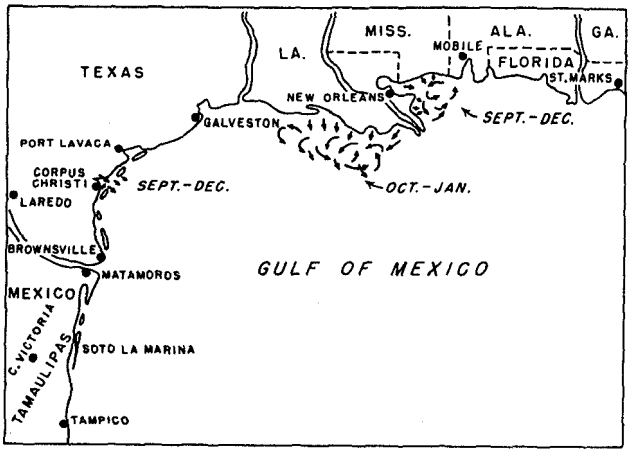

FIGURE 72.—Large shrimp (13 cm. and larger) fall and winter movements of marked individuals.

August or September spawning, both in Louisiana and in Central Texas. The shrimp from the first successful spawning have left the estuarine nursery grounds by midwinter. The young from the second successful spawning generally remain during winter in the estuarine waters and the immediately adjacent inner littoral waters.

The growth of the shrimp is quite rapid during the warm months of the year. From the time of hatching until they reach a length of about 120 mm. the shrimp apparently increase at a rate that averages more than a millimeter each day. This rapid rate continues until about the end of October when growth stops or almost stops, apparently as a result of temperature changes. From about the end of October until the end of February or of March, depending upon the locality, there is little or no growth. In the spring, as the water temperature increases, the shrimp again resume their rapid growth.

From central Texas south there is a definite possibility of migration. In the spring, based upon specimens marked in Mexico, there is a northward movement of shrimp. By inference, and from the time of the first successful spawning, but not based upon marked specimens, it appears highly probable that shrimp from the central and southern part of Texas may move south to the coast of Mexico during the fall and early winter, probably comparable to the movement along the South Atlantic coast of the United States.

In the northern portion of the Gulf of Mexico the wanderings of the shrimp can better be described as movements rather than as migrations (figs. 71, 72). The young gradually move from the estuarine waters to those of the Gulf. Once in the Gulf they appear to mill about like grazing cattle. However, as the temperatures drop during winter the shrimp tend to move a little farther offshore, and as the waters warm in the spring they tend to move back closer toward shore.

The movements of the shrimp are associated with spawning and with temperature. The normal spawning movement is offshore. During winter, in some localities, the movement becomes coastwise because of temperature gradients. Along the northern part of the Gulf of Mexico, warmer winter waters which the shrimp seek are generally found in a belt between the 5- and 30-fathom lines.

In this section of the Gulf, because of the east-west direction of the coast line, there is no appreciable coastwise gradient in temperature. There is, nevertheless, a slight offshore gradient and apparently the shrimp take advantage of this gradient.

Along the western side of the Gulf there is a southward temperature gradient during the winter, and it is probable that there is a southward movement of shrimp from central and southern Texas into Mexico during this season.

The mortality rate is high and although some undoubtedly survive into their second year, for all practical purposes the shrimp can be considered an annual.

In order to manage the shrimp supply properly we must have considerably more knowledge than we have at present. We must know more about the relationship between the abundance of shrimp and their food supply; the effect of thinning or not thinning the population on the nursery grounds; the natural and fishing mortality rates, and the possible competitive action between the white and the grooved shrimps. In addition to these, there is a considerable gap in our knowledge between the time the eggs are laid until the shrimp appear on the nursery grounds. Our present information on this phase of the life history of the shrimp is indeed sketchy. What, for example, causes the apparent peaks in spawning success and what is their significance with respect to the management of this resource? The story of the shrimp is by no means a closed book. Our information has now arrived at the stage where approaches can be made to many important practical problems affecting the relationship between man, the environment, and the shrimp.

BIBLIOGRAPHY

ANDERSON, W. W.

1949. Some problems of the shrimp industry. Proc. Gulf and Caribbean Fish. Inst., Univ. of Miami Mar. Lab., Inaugural Sess.

——— and LINDNER, M. J.

1943. A provisional key to the shrimps of the family Penaeidae with especial reference to American forms. Trans. of the Am. Fish. Soc. 73: 284–319.

——— KING, JOSEPH E.; and LINDNER, MILTON J.

1949. Early stages in the life history of the common shrimp, *Penaeus setiferus* (Linnaeus). Biol. Bull. 96 (2): 168–172.

——— LINDNER, M. J.; and KING, J. E.

1949. The shrimp fishery of the southern United States. Comm. Fish. Rev. 11 (2): 1–17.

BAUGHMAN, J. L.

1946. Discussion of shrimp problems on the Texas coast from the standpoint of conservation. South Texan 15 (12): 7, 15–17.

1947a. Fisheries in Texas. Southern Fisherman 7 (3): 180–181, 254.

1947b. Let's go shrimping. Texas Game and Fish 5 (3): 9–11.

1949. Potentialities of the Gulf of Mexico fisheries and recommendations for their realization. Proc. Gulf and Caribbean Fish. Inst., 2nd Ann. Sess., Univ. of Miami Mar. Lab.

1950. The Texas shrimp fishery and its management. Southern Fisherman 10 (8): 173–174.

BROAD, CARTER.

1949. Identification of the commercial common shrimp species. Comm. Fish. Rev. 11 (12): 1–4.

BURKENROAD, M. D.

1934a. The Penaeidae of Louisiana, with a discussion of their world relationships. Bull. Am. Mus. Nat. Hist. 68 (2): 61–143, 15 figs.

1934b. Littoral Penaeidae, chiefly from the Bingham Oceanographic Collection. Bull. Bingham Oceanog. Coll., vol. 4, art. 7. New Haven.

1939. Further observations on Penaeidae of the northern Gulf of Mexico. Bull. Bingham Oceanog. Coll., vol. 6, art. 6, 62 pp., 34 figs. New Haven.

1949. Occurrence and life histories of commercial shrimp. Science 110 (2869): 688–689.

1951. Measurement of the natural growth-rates of decapod crustaceans. Proc. Gulf and Carib. Fish. Inst., 3rd Ann. Sess., Univ. of Miami Mar. Lab.

CHAPMAN, W. M.

1951. International aspects of the shrimp fishery in the Gulf of Mexico (abstract). Proc. Gulf and Carib. Fish. Inst., 3rd Ann. Sess., Univ. of Miami Mar. Lab.

CHAUVIN, A. B.

1951. The outlook for continued shrimp production in Louisiana. Proc. Gulf and Caribbean Fish. Inst., 3rd Ann. Sess., Univ. of Miami Mar. Lab.

GATES, WM. H.

1910. Shrimp. Fifth Bienn. Rept., Dir. Gulf Biol. Sta., Cameron, La., pp. 8–12. Baton Rouge, La.

GOWANLOCH, JAMES NELSON

1931. The probable cause of "iodine shrimp." La. Conserv. Rev. 2: 31–32. New Orleans.

1933. Fishes and fishing in Louisiana. State of Louisiana, Dept. of Conserv. Bull. 23: 76–81. New Orleans.

1942–43. Report of the Chief Biologist. State of Louisiana, Dept. of Conserv., 16th Bienn. Rep.

1944–45. Report of the Chief Biologist. State of Louisiana, Dept. of Wild Life and Fish., 1st Bienn. Rep.

1946–47. Report of the Chief Biologist. State of Louisiana, Dept. of Wild Life and Fish., 2nd Bienn. Rept.

1948–49. Report of the Chief Biologist. State of Louisiana, Dept. of Wild Life and Fish., 3rd Bienn. Rept.

GUILBEAU, BRAXTON H.

1908. Shrimp. Fourth Bienn. Rep., Dir. Gulf Biol. Sta., Cameron, La., pp. 11–13. Baton Rouge, La.

GUNTER, GORDON.
1943. The Texas shrimp industry. Coastal Div., Texas Game, Fish and Oyster Comm. 1: 9, 19.
1950. Seasonal population changes and distributions as related to salinity, of certain invertebrates of the Texas coast, including the commercial shrimp. Pub. Inst. Mar. Sci., Univ. of Texas, 1 (2): 7–51.

HEDGPETH, JOEL W.
1946. Texas shrimp. Texas Game and Fish 4 (12): 18–19, 7 figs.
1950. Notes on the marine invertebrate fauna of salt flat areas in the Aransas National Wildlife Refuge, Texas. Pub. Inst. Mar. Sci., Univ. of Texas, 1 (2): 103–119.

HIGGINS, ELMER.
1931. Federal Bureau and state governments cooperate in shrimp investigations. La. Conserv. Rev. 1 (7): 3–5. New Orleans.
1934. A story of the shrimp industry. Scientific Monthly, 38: 429–443.

IDYLL, C. P.
1949a. Shrimping in Tampa Bay. Rept. to Fla. State Bd. Conserv. from Univ. of Miami Mar. Lab. (Mimeo.)
1949b. Preliminary report on the effect of bulkheads in the Hillsborough River on the shrimp population. Rept. to Fla. State Bd. Conserv. from Univ. of Miami Mar. Lab. (Mimeo.)
1950a. The commercial shrimp industry of Florida. State of Florida, Bd. of Conserv., Univ. of Miami Mar. Lab. Educ. Ser. No. 6, 31 pp., 4 fig., 2 tab.
1950b. Report on the newly developed Key West shrimp fishery. Rept. of Mar. Lab., Univ. of Miami to Fla. State Bd. of Conserv., Feb. 14.
1950c. Report on the present status of the Franklin County shrimp industry. Rept. of Mar. Lab., Univ. of Miami to Fla. State Bd. of Conserv.
1950d. A new fishery for grooved shrimp in south Florida. Comm. Fish. Rev. 12 (3): 10–16.

JOHNSON, F. F. and LINDNER, M. J.
1934. Shrimp industry of the South Atlantic and Gulf States. U. S. Bur. Fish. Investigational Rept. No. 21, pp. 1–83.

KING, J. E.
1948. A study of the reproductive organs of the common marine shrimp, *Penaeus setiferus* (Linneaus). Biol. Bull. 94 (3): 244–262.

LINDNER, M. J.
1933. Progress in shrimp investigations during the year 1932. La. Conserv. Rev. Apr.: 50–53, 56. New Orleans.
1936a. Suggestions for the Louisiana shrimp fishery. State of Louisiana, Dept. of Conserv., 12th Bienn. Rep.
1936b. A discussion of the shrimp trawl—fish problem. La. Conserv. Rev. Oct.: 12–17, 51.
1938–39. Biennial report, shrimp investigations. State of Louisiana, Dept. of Conserv., 14th Bienn. Rept. pp. 389–399.

LYLES, CHARLES H.
1951. The development of the brown shrimp fishery in Texas. Proc. Gulf and Caribbean Fish. Inst., 3rd Ann. Sess., Univ. of Miami Mar. Lab.

MYERS, HU B., and GOWANLOCH, J. N.
1932. Report of Bureau of Scientific Research and Statistics. La. Conserv. Rev. 2 (9): 7–15. New Orleans.
1934. Cooperative shrimp investigations shed important light on South's most valuable fishery. La. Conserv. Rev. 4 (1): 7–22. New Orleans.

PEARSON, J. C.
1935. Eggs of a peneid shrimp. Science, vol. 82, No. 2121.
1939. The early life histories of some American Penaeidae, chiefly the commercial shrimp, *Penaeus setiferus* (Linneaus). Bull. U. S. Bur. Fish. 49 (30): 1–73.

RATHBUN, RICHARD.
1883. Notes on the shrimp and prawn fisheries of the United States. Bull. U. S. Fish. Comm., 1882, 2: 139–152.
1887. The crab, lobster, crayfish, rock lobster, shrimp, and prawn fisheries. Fishery Industries of the United States, by G. Brown Goode and associates. Sec. 5, 2 (21): 627–810.

SPAULDING, M. HERRICK.
1908. Preliminary report on the life history and habits of the "lake shrimp" *Penaeus setiferus*. Gulf Biol. Sta., Cameron, La., Bull. 11, pp. 1–24, 6 pls. Baton Rouge.

SPRINGER, STEWART.
1951a. Expansion of the shrimp fishery in the Gulf since 1945. Southern Fisherman 11 (10): 28–29, 83–85.
1951b. Operation of the exploratory fishing vessel *Oregon*. Proc. Gulf and Caribbean Fish. Inst., 3rd Ann. Sess., Univ. of Miami Mar. Lab.

SWARTZ, MAX.
1951. The outlook for shrimp production. Proc. Gulf and Caribbean Fish. Inst., 3rd Ann. Sess., Univ. of Miami Mar. Lab.

TRESSLER, D. K.
1923. The American shrimp industry. Marine Products of Commerce, pp. 548–556. Chemical Catalogue Co., New York.

TULIAN, E. A.
1920. Louisiana–greatest in production of shrimp—*Penaeus setiferus*. State of Louisiana, Dept. of Conserv., 4th Bienn. Rep., pp. 106–114.
1923. The present status of the Louisiana shrimp industry. Trans. Am. Fish. Soc. 56: 169–174. Hartford, Conn.

U. S. FISH AND WILDLIFE SERVICE.
1945. Shrimp—Atlantic coast. Fishery Resources of the United States. U. S. Sen. Doc. No. 51. Letter of the Sec. of the Interior, pp. 91–92. Washington.

U. S. FISH AND WILDLIFE SERVICE—Continued
1948. The shrimp and the shrimp industry of the South Atlantic and Gulf of Mexico. Fishery Leaflet No. 319.
1949. Keeping live shrimp for bait. Fishery Leaflet No. 337.
VIOSCA, PERCY.
1920. Report of the Biologist. State of Louisiana, Dept. of Conserv., 4th Bienn. Rep. 1918–20, pp. 120–130. New Orleans.
WEYMOUTH, F. W.; LINDNER, M. J.; and ANDERSON, W. W.
1933a. Preliminary report on the life history of the common shrimp, *Penaeus setiferus* (Linn.). U. S. Bur. Fish. Bull. 48 (14): 1–26. Washington.
1933b. A summary of the life history of the common shrimp (*Penaeus setiferus*) of the South Atlantic and Gulf coasts of the United States. Trans. Am. Fish. Soc., vol. 62. Washington.

Blank page retained for pagination

BIOLOGY OF THE SPINY LOBSTER[1]

By F. G. WALTON SMITH, *Marine Laboratory, University of Miami*

The spiny lobster, or crawfish, of the Gulf of Mexico and the Caribbean belongs to a family of shellfish which is related to the true lobsters and which is to be found in the warmer seas throughout the world. Some members of this family are commercially valuable and support fisheries in South Africa, Australia, California, Hawaii, Japan, and the Caribbean region, including Florida and the Bahamas where they are variously known as rock lobster or spiny lobster, sea crayfish, langouste, and langosta. They are referred to as spiny lobsters because of their similarity to the true or northern lobsters from which they are distinguished by the presence of numerous spines on their bodies and legs and by the absence of large claws. Whereas in the true lobsters the edible meat is mainly taken from the claws, the chief edible portion of the spiny lobster is the tail muscle. Although related, spiny lobsters must not be confused with the smaller fresh-water shellfish utilized commercially in a number of countries under the name of crayfish. For this reason, the term spiny lobster is to be preferred.

Color varies with age and the type of bottom upon which the animals live. Brighter, greenish, or sandy colored animals are usually found on sandy bottom or in shallow water. Darker animals with a greater proportion of blue and brown are found in darker bottom or in deeper water.

The Gulf of Mexico species, *Panulirus argus* (Latreille), is found on the western Atlantic shores from Rio de Janeiro, Brazil, throughout the West Indies to Florida, and rarely as far north as North Carolina. Although occasionally present in other parts of the Gulf of Mexico, they are only abundant in the Florida Keys.

Small numbers of related species are occasionally taken in the commercial catches but usually pass unnoticed. *Panulirus laevicauda* Latreille and *Panulirus guttatus* Latreille are most frequently encountered in this manner in Florida and the West Indies. Others not yet taken in the Florida catch but which are likely to occur rarely are *Palinurellus gundlachi gundlachi* (Von Martens), *Palinustus truncatus* (H. Milne Edwards), and *Justitia longimana longimana* (H. Milne Edwards). Species of the genus *Scyllarides*, belonging to a related family, are taken occasionally in the Gulf of Mexico.

Sexual Characters.—Sexes may readily be distinguished by the following characters. The tips of the fifth pair of walking legs in the male terminate in a single, simple claw similar to those of the other legs. In the female, the fifth leg terminates in a pair of projections which act as pincers used for preening the eggs where they are attached to the under surface of the tail. The male also differs in the presence of swollen sexual openings at the base of the last pair of walking legs. The female openings are much smaller and are at the base of the third pair of legs. A further distinction lies in the swimming legs. In the males these end in a single, leaflike joint, whereas, in the female, they are branched. In the first two pairs these branches are leaflike, while in the following legs the inner branch is a rod-like joint to which the eggs become attached.

Habitat.—The spiny lobster is most active at night when it moves about in search of food. During the daytime, it is usually hidden under rocks, sea grasses, sea fans, large sponges, or other marine growth, with only the whips projecting. There is also a tendency to avoid very strong currents and muddy bottom. Grassy bars with rocky heads and an abundant supply of small shell creatures and worms, especially if protected from excessive wave action, are likely places to find new lobster grounds. While they are usually caught in less than 30 feet of water, it is definitely known that spiny lobsters exist in much greater depths where there is rocky bottom. Movement is usually carried out by walking forward on the

[1] Contribution No. 110 from the Marine Laboratory, University of Miami

legs, but occasionally, by quickly bending the tail, the animal will move backward rapidly to avoid danger.

Food and Enemies.—The spiny lobster has a wide range of food and is frequently a scavenger. Examination of the stomach shows small mollusks, such as young conchs and pelecypods, worms, and occasionally, small Crustacea. Seaweed is frequently found in the stomachs but may not necessarily be of food value. Spiny lobsters will also eat the fresh and dried meat of fish. Food is usually detected by the lobster at some distance by means of a chemical sense in the whips.

In the early stages of development, the spiny lobsters are small, transparent creatures which drift in the water. In these stages they are eaten by a great variety of fish and plankters. After they change into the adult form, but while they are quite small, they crawl among the rocks or grass and are frequently eaten in large numbers by groupers, snappers, and other bottom fish. The older lobsters, even up to a large size, are food for sharks, groupers, and jewfish.

Breeding Habits and Life History.—At some time between February and July, mating occurs at which time the male extrudes a viscous fluid from the swollen openings at the base of the last pair of walking legs. This fluid becomes attached to the under surface of the female between the last three pairs of legs and rapidly hardens on the outside to form a dirty-white or gray-black substance known as the sperm sac.

A short time after the mating act, the females lay their eggs, or berry, which become attached to the paddles under the tail. The eggs are a bright orange-red in color and about 1/32 inch in diameter. They are fertilized by spermatozoa which the female releases from the still soft inside of the sperm sac by scratching with the tips of her legs. The number of eggs varies with the size of the lobster. In the case of a 9-inch animal, the number is about 500,000 forming a berry-like mass.

Most of the females migrate into deeper water while the eggs are incubating and hatch them during the summer months within 3 weeks after laying. The majority of egg-bearing females are found in April. Some females may mate later than others and, as a result, a small number may still be found with eggs as late as November. The old or spent sperm sac is also found in occasional individuals during every month of the year. Most females, however, have completed breeding by the beginning of July. After releasing the eggs, the females begin to return to shallower water.

A small number of females under 7 inches in length, measured from the tip of the telson to a point between the "horns," are found carrying eggs. These have a cape length of under 2 inches and a weight of under ½ pound. The majority, however, do not appear to breed until they reach a body length of 8 inches, corresponding to a cape length of 2½ inches and a weight of ¾ pound (Smith 1951).

The egg of *Panulirus argus* hatches directly into a phyllosoma larva (Lewis 1951). This is a flat leaflike planktonic form with long legs and prominent stalked eyes. Eleven stages of development are recognizable during the planktonic existence which appears to last over a period of as much as 6 months. The larvae grow from about 2 mm. in length to about twice this size. During this period they are carried considerable distances by currents and are sometimes found in plankton hauls taken in the open ocean.

No information is available regarding the behavior of larvae of *Panulirus argus*. It is reported, however, by Von Bonde and Marchand (1935) that the early planktonic stages of the South African species react to light so as to appear at the surface during nighttime and to retire to deeper water during daylight hours. In the Australian species the final stages before metamorphosis are found at the surface.

Migrations.—As a result of tagging experiments in the Bahamas and in Florida, it is known that the spiny lobster is able to migrate over considerable distances. Individuals have been recaptured as much as 100 miles from the point of release after a lapse of a little more than 100 days.

At all times of the year, lobsters may undergo mass movements alongshore, apparently in relation to the food supply. They also tend to move inshore immediately after stormy periods. At times, offshore movements seem to be associated with prolonged calm or warm weather, but mass movements have also been observed with no accompanying change in physical conditions. These may also be related to a scarcity of food.

Although these are insufficient experimental data to draw any definite conclusions, the observations of fishermen upheld general observations regarding seasonal movements associated with breeding habits. (Dawson and Idyll, 1951.)

During the months of February to April, the lobsters tend to collect in certain inshore areas while mating. During April to June, the females move into deeper water where the eggs are laid and return again during July and August. Spiny lobsters also tend to move offshore during the cold months of December and January. There is reason to believe, however, that spiny lobsters are present at all times of the year in deeper water wherever there is protection in the form of rocky heads or marine growth.

Molting.—At intervals, the spiny lobster casts its shell and grows a new one. Molting is evident in some lobsters at all times of the year. Observations made in the Bahamas show that the majority of males and young females are found molting during the months of April to June and again during October to December. The mature females molt during early spring before the start of the breeding cycle, and sometimes during August after they have shed their eggs. Only the smaller, immature females molt during June. Molting probably takes place following periods of abundant food supply and is partially dependent upon temperature.

Prior to molting, the spiny lobster seeks the shelter of rocks and ceases to feed actively. For this reason, the number of molting individuals in the ordinary type of trap does not truly indicate the percentage undergoing molt. After a period varying from a few hours to a few days, the old shell cracks along definite lines and becomes dislodged first from the cape region and then from the tail. The new shell is in place beneath the old one before molting, but it does not harden completely for at least a week.

Immediately after losing the old shell, the lobster has been found to absorb considerable quantities of water. This accounts for the rapid increase in size prior to hardening of the new shell. From the time when cracks first begin to appear in the old shell until the new shell no longer feels soft when compressed in the hand, molting takes a little more than 2 weeks.

Growth Rate.—Studies of growth rate have been based upon the direct measurement of captive individuals, length frequency analyses of the catch, and by a comparison of molting frequency with growth between molts. Although none of these methods have given conclusive results, they indicate that growth of the spiny lobster when about 1 pound in weight is somewhat greater than 1 inch per year.

LITERATURE CITED

Dawson, Charles E., Jr., and Idyll, Clarence P.
1951. Investigations on the Florida spiny lobster, *Panulirus argus* Latreille. Florida State Board of Conservation Tech. Ser. No. 2, Univ. of Miami.

Lewis, John B.
1951. The phyllosoma larvae of the spiny lobster. Bull. Mar. Sci. Gulf and Caribbean 1 (2): 89–103.

Smith, F. G. Walton.
1951. Caribbean spiny lobster investigations. Proc. Gulf and Caribbean Fish. Inst., 1950. Univ. of Miami.

Von Bonde, Cecil, and Marchand, J. M.
1935. The natural history and utilization of the Cape crawfish, Kreef, or spiny lobster. Fishery Bull. No. 1, Dept. Commerce and Industries, Fish and Mar. Biol. Survey Div., Union of South Africa.