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**THE OCCURRENCE OF *Rhopilema verrilli*
(CNIDARIA: SCYPHOZOA: RHIZOSTOMEAE)
ON GALVESTON ISLAND, TEXAS
AND A DISCUSSION ON ITS DISTRIBUTION IN U.S. WATERS**

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ABSTRACT: A specimen of the rhizostome scyphomedusa *Rhopilema verrilli* was stranded on the beach at Galveston Island, Texas, in the spring of 1985. Two young specimens have since been collected in the marshes on the north side of Galveston bordering West Galveston Bay. This species is relatively rare throughout most of its range and has only been reported once before in the western Gulf of Mexico.

Seasonal and geographic distributions from literature records are discussed in relation to temperature, salinity, currents, and life history. Occurrences along the U.S. East Coast indicate progressively later seasonal appearances and decreased abundances from Georgia to New England. Occurrences in the Gulf of Mexico are almost all limited to the Mississippi Sound area. Collection records suggest that *R. verrilli* has two centers of distribution, one in southern U.S. East Coast waters and one in the northeastern Gulf of Mexico, and that occurrences outside these centers are due to transport by currents. We believe that *R. verrilli*'s apparent rarity in the western Gulf of Mexico results primarily from a combination of wind-driven current patterns, timing of volume of Mississippi-Aatchafalaya River discharge, and temperature-salinity tolerances of the species acting against transport into, and survival in, the western Gulf.

On 26 March 1985, we were informed by the Galveston Beach Patrol that a "giant" jellyfish had washed ashore on East Beach, Galveston Island, Texas. When we located the stranded specimen (which was quite large compared to the usual beached jellyfish), we were unable to make a field identification and returned the organism to our laboratory. We subsequently identified the jellyfish as *Rhopilema verrilli* (Fewkes 1887), a member of the rhizostome order to which the locally very abundant "cannonball" or "cabbagehead" jellyfish (*Stomolophus meleagris* L. Agassiz 1860) also belongs. Although it appears formidable because of its large size, *R. verrilli* does not present a stinging threat to humans (Calder 1972a:214).

Examination of the literature and information from Dr. Dale Calder, Royal Ontario Museum (personal communication) indicated that this was the second specimen reported from the Gulf of Mexico west of the Mississippi Delta. Two juvenile specimens which appear to be *R. verrilli* were collected in the marshes bordering West Bay (part of the Galveston Bay complex) in 1986 and 1987.

Rhopilema verrilli is known only from New England to Georgia on the U.S. East Coast and the northern Gulf of Mexico (Gosner 1971, Calder 1972a, 1973, Phillips 1972, Kraeuter and Setzler 1975, Larson 1976). Apparently the species is rare to uncommon throughout most of its range and is limited to the coast and the mouths of estuaries (Larson 1976, Calder

1977). In the Gulf of Mexico, prior to 1953, specimens of *R. verrilli* had been collected in Mobile Bay, and a single specimen had been collected at Port Aransas (although the species was considered common in Chandeleur Sound by Martin Burkenroad) (Hedgpeth 1954:277). Subsequent records in the Gulf of Mexico are all from the Mississippi Sound area, east of the Mississippi Delta (Phillips 1972, Burke 1975a, b). Specimens were not collected during oceanographic cruises in the eastern Gulf of Mexico (Collard 1977) or from the central and western Gulf of Mexico (Phillips 1972, Berkowitz 1976, Park and Turk 1980, Wormuth, McEachran and Pequegnat 1980). A number of checklists and reports from various coastal regions of the Gulf of Mexico were reviewed and found not to mention *R. verrilli* (Cross and Parks 1937, Behre 1950, Walker 1953, Humm 1953, Tabb and Manning 1961, Richmond 1962, 1968, Dawson 1966, Gillespie 1971, Perret 1971, Christmas 1973, Fotheringham, 1980).

Life history studies of *Rhopilema verrilli* indicate that development is accelerated at higher temperatures (20 C vs. 10-12 C) (Cargo 1972, Calder 1973, Burke 1975b). Planulae swam actively when liberated, settled within 7-10 days and produced scyphistomae (Calder 1973). However, swimming planulae may be suppressed, with polyps budding directly from gonadal tissue (Cargo 1972). Scyphistomae typically produce monodiscous strobilae, although 2 or 3 ephyrae sometimes develop. Ephyrae were liberated within 7 days of first indication of strobilization when cultures were kept at 20 C (Calder 1973). Calder's (1973) work indicated that development to the medusa stage may occur in less than a month, whereas Burke (1975b) indicated development required 90 days. Polyps of *R. verrilli* and *Stomolophus meleagris* are very similar (Calder 1982:

156) as are the ephyrae, and the most reliable method of distinguishing between the stages of these two species is examination of the nematocysts (Calder 1977, 1983).

Burke (1975b) conducted substrate preference tests and found that polyps did not develop normally on particles smaller than silt-size (250 μ). He also reported that polyps were not found on fouling plates or artificial reefs placed in the Mississippi Sound area. Calder *et al.* (1977:30) reported polyps of *R. verrilli* from oyster dredge collections in Little River Inlet, South Carolina. No report of podocysts was found.

MATERIAL EXAMINED

Identification of the stranded medusa as *Rhopilema verrilli* was based on several morphological features which combine to make the species quite distinctive, viz: 1) 6 large marginal lappets per octant separated by a pair of much smaller lappets flanking a rhopalium; 2) a complex anastomosing canal system in the lower 6 cm of the bell margin; 3) eight thick mouth arms with numerous oral openings; and 4) long terminal appendages hanging down from the mouth arms. The bell diameter of the specimen lying on its aboral surface in preservative was 35 cm, which is about half the maximum reported size of 60 cm (Phillips 1972). The medusa had apparently been on the beach only a short time because it appeared fairly fresh. However, it had numerous rips in the bell margin and may have been tumbled about in the surf prior to collection. We did not determine the sex or reproductive state.

Smaller (2.5 - 4 cm) medusae, whose characteristics conform to those of *R. verrilli*, were collected from marshes on Galveston Island in the spring of 1986 and 1987. Salinities in West Galveston

Bay during that period ranged from 25 to 30 ppt (A. Tirpak, unpublished data).

SEASONAL AND
GEOGRAPHIC DISTRIBUTIONS

As noted previously, *Rhopilema verrilli* appears to be restricted to near-shore habitats in the eastern United States, i.e. the East Coast and the northern Gulf of Mexico. Literature records were examined to determine patterns of seasonal and geographic distribution.

Gulf of Mexico

Rhopilema verrilli is apparently very rare west of the Mississippi Delta and uncommon to rare east of the Delta. All records of *R. verrilli*, except the one from Port Aransas (Hedgpeth 1954) and ours from Galveston, are from the Mississippi Sound area in the eastern Gulf of Mexico. Burke's (1975a,b) long-term study of pelagic Cnidaria in Mississippi Sound provided the most data on occurrences and seasonality of *R. verrilli*. In that study, specimens were obtained by trawling, towing a plankton net, and walking the beach adjacent to trawling stations. About 1000 samples were collected by all methods combined. The data indicate a

very irregular occurrence pattern (Fig. 1). Abundances were greatest in 1968 and 1971. No specimens were recorded in 1969 (Hurricane Camille destroyed all backlogged samples and curated specimens) and only one occurrence was recorded in 1972. With one exception (July 1971) all specimens were collected in winter through spring (December - May).

Burke's (1975b) hydrographic data indicate that, while specimens were collected over a temperature range of 8-29 C, most were associated with temperatures above 20 C (Table 1). All but two records were associated with 20 ppt or higher salinity, and no specimens were collected at any station where salinities approached zero at least once during the study.

Burke's (1975b) collecting locality data indicate an interesting distributional pattern. All specimens were recorded from the central part of the isles and passes of the Mississippi Sound barrier island chain (Fig. 2). None were collected at stations in the bay systems bordering Mississippi Sound (low salinity) or the extreme western islands in the barrier island chain or from the Alabama-Florida coasts. Specimens obtained in April-December 1971 were collected from Horn Island, Petit Bois Island or the pass between them, all in the eastern half of the Sound (Fig. 2, Table 1). In December 1972 and January 1973, all specimens were collected from the western half of the Sound (Cat Island, Ship Island and the pass between Ship and Horn Islands). Temperatures and salinities were similar at all stations along the entire island chain during each sampling period in 1971 and 1972-73.

Figure 1. Occurrence of *Rhopilema verrilli* in trawl tows (30 minutes) and on beaches in the Mississippi Sound area. Beached and trawled totals have been combined. I = start or end of project phase. X = beached specimens (8 total); occurrences recorded only.

U.S. East Coast

Rhopilema verrilli has been reported from many more localities along the U.S. East Coast than in the Gulf of Mexico

Table 1. Comparison of dates and sites of collection of *Rhopilema verrilli* in the Mississippi Sound area with associated temperatures, salinities and mode of collection (trawled vs. beached) (from Burke 1975b).

Date	Station	Temp	Sal	# Spec	Mode
1971					
Apr 10	Horn Island	22	28	1	Beach
Apr 11	Horn Island	21	28	1	Trawl
Apr 13	Petit Bois Island	24	27	2	Beach
Apr 14	Petit Bois Island	24	27	4	Beach
Apr 14	Petit Bois Island	24	27	4	Trawl
May 11	Horn Island	26	33	1	Beach
Jul 13	Petit Bois Island	29	30	1	Trawl
Dec 12	Horn Is.-Petit Bois Is. Pass	14	29	1	Trawl
1972					
Dec 9	Ship Is.-Horn Is. Pass	15	28	1	Trawl
1973					
Jan 4	Cat Island	12	17	1	Beach
Jan 6	Ship Island	8	25	1	Beach
Jan 7	Ship Island	12	26	2	Beach
Mar 14	Petit Bois Island	16	10	1	Beach

(Table 2). Records from the East Coast indicate that abundances decrease, and appearances are progressively later in the year, from south to north (Table 2), which suggests transport by currents from a southern area. Mayer (1910:707) believed, based on periodic collections and oral reports of fishermen, the jellyfish was a southern species that was carried into northern waters and “occasionally establishes itself in Long Island Sound.” No records were found from Florida.

The only locality from which *R. verrilli* polyps have been reported is in Little River Inlet, which straddles the North

Carolina-South Carolina border (Calder *et al.* 1977). Calder (personal communication) believes the life cycle is completed in South Carolina. It is possible the life cycle may also be completed in Georgia.

DISCUSSION

The seasonal and geographic distributions of *Rhopilema verrilli* pose some interesting questions. If the species is restricted to eastern North America, is there more than one center of distribution? Is there a Caribbean source that is supplying specimens to both the Gulf

Figure 2. Map of the Mississippi Sound area and adjacent coastline showing locations of Burke's (1975b) sampling stations and the stations at which *Rhopilema verrilli* was collected.

Table 2. Reported occurrences of *Rhopilema verrilli* along the east coast of the United States.

Locality	Date	# Spec.	Temp.	Sal.	Reference
Connecticut					
New Haven Harbor	Sept 1886	1	—	—	Fewkes 1887
Branford Harbor	Sept & Oct 1909	— — —	—	—	Mayer 1910
Thimble Ids., Long Island Sound	Aug & Sept 1889	Common	—	—	Mayer 1910
Thimble Ids., Long Island Sound					
Delaware Bay	— — — —	— — —	—	—	Watling & Maurer 1973
Maryland					
Patuxut River, Solomons	12 Oct 1965	1	—	—	Cargo 1971
Solomons	1967	Several	—	—	Cargo 1971
Virginia					
Chesapeake Bay	Early winter	— — —	—	—	Wass 1965
Chesapeake Bay	Late summer & fall	Occasional	—	—	Cargo 1972
Chesapeake Bay	— — — —	Rare	—	—	Calder 1972b
Virginia waters	Fall & winter 1970-1971	Several	—	—	Calder 1972a
Wachapreague	24 Dec 1970	1	—	—	Calder 1973, 1977
North Carolina					
Pamlico Sound	Nov 1904	1	—	—	Mayer 1910
Pamlico Sound	Autumn	Frequent	—	—	Mayer 1910
South Carolina					
South Carolina	Winter & spring	Fairly common	—	—	Calder & Prigden 1977
Little River Inlet	April 1976	Polyps	22	33	Calder <i>et al.</i> 1977
South Carolina	— — — —	Common	—	—	Calder (pers. comm.)
South Carolina	Autumn & spring	Freq. common	—	—	Zingmark 1978
Georgia					
Dean Creek, Sapelo Id.	17 Jan 1963	1	—	—	Kraeuter & Setzer 1975
Big Hole, Sapelo Id.	17 Feb 1966	1	—	—	Kraeuter & Setzer 1975
Sapelo Id. (beached)	March 1972	Mod. large num.	13-16	22-23	Kraeuter & Setzer 1975
East Coast					
Connecticut to N. Carolina	— — — —	Uncommon	—	—	Larson 1976
Bay of Fundy to Cape Hatteras	Summer & fall	— — —	—	—	Gosner 1971
New England to N. Carolina	— — — —	— — —	—	—	Bigelow 1914

and the East Coast? Why are there so few records from the western Gulf of Mexico?

No stages of *R. verrilli* have been reported from the Caribbean or Florida, and if it did inhabit the tropics and medusae were being transported into U.S. waters via currents, one would expect records from some region of the Florida peninsula.

Occurrence data suggest there are two centers of distribution in the Carolinian Zoogeographic Province, one in the northeastern Gulf of Mexico and one along the southeast Atlantic coast. If so, this disjunct distribution may be a remnant of a continuous distribution during a higher sea stand. It is also possible that the northern Gulf may supply occasional specimens to the southeast U.S. coast, *i.e.* individuals that are entrained in the Loop Current and carried into the

Gulf Stream (although one would then expect some strandings on the Florida east coast).

Whether or not the species “establishes” itself as Mayer (1910) believed, completes its life cycle, or even survives in northern waters along the East Coast is questionable. Cold winter temperatures in northern latitudes may be lethal to adults and any larvae produced. Culture of planulae stripped from sexually mature medusae has shown that larvae can survive temperatures as low as 5 C, and that development into strobilae is retarded at 12 C, but is expedited at 20 C (Cargo 1971, 1972; Calder 1973). Temperature had a similar effect in the related *R. esculenta*; 12-16 C caused abnormal strobilization, but complete strobilization was induced in two weeks by temperatures up to 22 C (Chen and Ding 1983). If *R. verrilli* larvae or polyps are not killed

by low temperatures, their development may be retarded to the point that viable strobilae are not produced.

Possible explanations for the scarcity of records in the western Gulf are: 1) it really does not occur often, 2) numbers are being reduced by predation, 3) it occurs more frequently but is not observed/recognized. The latter is possible, but given the number of biologists who collect or otherwise spend time on the beaches or sample in estuaries and offshore, and who would notice a 30-60 cm diameter jellyfish, we believe it is unlikely. It is also possible some are being consumed by predators, *i.e.* turtles, but it is unlikely that all or nearly all specimens would be eaten. We suggest that the species is rare in the western Gulf because some physical/chemical condition(s) of the environment: a) prevent dispersion, and/or b) do not meet the requirement(s) necessary for survival, strobilization or sexual reproduction.

Currents may play a major role in determining if *R. verrilli* is found in the western Gulf of Mexico. It is known that objects floating in the eastern Gulf can be transported to Texas and Mexico; Chew, Drennan and Demoran (1962), Tolbert and Salsman (1964) and Williams *et al.* (1977) determined, using drift bottles released in various areas of the eastern Gulf, that surface currents changed seasonally with shifts in dominant wind direction. In general, bottles released in late spring and summer were recovered on northern Gulf beaches and those released in winter were recovered along the east coast of Florida, whereas bottles recovered in the western Gulf were mostly released in August-October.

Predominant currents over the continental shelf of the northern Gulf of Mexico, both east and west of the Mississippi Delta, are westward nearshore and eastward offshore (Cochrane and Kelly 1986,

Schroeder *et al.* 1987), suggesting large semi-permanent cyclonic gyres. Schroeder *et al.* (1985) observed extensive estuarine-shelf exchange forced by winter and spring cold fronts which could transport medusae seaward from Mississippi Sound into the semi-permanent current regime. Once in the westward-moving nearshore current, *Rhopilema* could be transported from the Mississippi Sound area into the western Gulf, if it is able to get around the Mississippi Delta.

Bottle releases by Chew *et al.* (1962) at four localities off the Mississippi Delta indicated two trends. First, the closer to the Delta the release occurred, the greater the tendency for the bottles to move westward, and second, bottle recoveries from the western Gulf were greater in late summer-fall than in winter-spring. Recent current meter records obtained by Wiseman and Dinnel (1988) indicated a net, although weak, westward flow around the Delta during summer-fall. This current provides a mechanism for moving a floating object from the northeastern Gulf into the western Gulf. Once west of the Delta, transport of the water mass and any organisms contained therein is generally westward along the Louisiana and Texas coasts (Cochrane and Kelly 1986).

Thus, a number of physical-chemical factors may be operating to prevent transport of *Rhopilema* into the western Gulf. Greatest abundances in the eastern Gulf appear to occur in winter-spring, the time when winds are onshore. This would concentrate medusae nearshore and away from the semi-permanent current regime. The time of strongest westward currents off the Mississippi Delta coincides not only with the time of lowest average Mississippi River discharge (Cochrane and Kelly 1986), and thus potentially higher salinities (July-November), but also with the time when

fewer specimens appear to be available to be transported. Once past the Delta, salinity conditions may not be favorable for survival or reproduction. Much of the Mississippi-Atchafalaya discharge flows westward as a coastal band of brackish water (Cochrane and Kelly 1986). The salinity of this water may be below the tolerance level of *R. verrilli* most of the time and act against survival in the western Gulf. The young specimens collected in West Galveston Bay in 1986-1987 were obtained during a period when salinities in much of the Galveston Bay system (usually <25 ppt) had increased into the 25-30 ppt range.

From the above information, we predict that the probability of collecting *R. verrilli* in the western Gulf of Mexico will increase when climatic conditions approach a drought, *i.e.* reduced Mississippi-Atchafalaya and local discharge results in higher salinities and there is less of a barrier to transport and survival in the western Gulf.

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