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THE MOLLUSCAN FAUNA OF THE FLORIDA MIDDLE GROUNDS WITH COMMENTS ON ITS ZOOGEOGRAPHICAL AFFINITIES¹

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ABSTRACT: Recent studies have indicated that the Gulf of Mexico is bounded by a discontinual series of hard substrates which support faunal and floral assemblages of both temperate and tropical origins. This substrate distribution has had a significant impact on molluscan fauna in the Gulf of Mexico. An investigation of the molluscan fauna of the Florida Middle Grounds has produced 75 species associated with this high relief substrate which is also characterized by hermatypic corals. Although the molluscan fauna is comprised of forms which are predominantly "Caribbean eurythermic" and "Caribbean Restricted" (76%) which is similar in composition to the West Flower Garden Bank of Texas, their species composition is quite dissimilar (only 23% similarity). For these and other reasons, it is proposed that the zoogeographic status of the Gulf of Mexico should be seriously reconsidered by specialists in other faunal groups.

INTRODUCTION

The Gulf of Mexico is bounded by a discontinual series of hard, sometimes moderately high relief rocky substrates which bear faunal and floral assemblages of both temperate and tropical origins (Figure 1). Bright and Pequegnat (1974), and Bright and Rezak (1976) have reviewed both biological and geological aspects of these topographical features on the western gulf continental shelf. Brooks (1973) has dealt with topographic features in the eastern Gulf.

The zoogeography of bivalve molluscs and of mollusks in general, in the Gulf of Mexico has been discussed by Pulley (1952) and Rehder (1954) respectively. Collard and D'Asaro (1973) have discussed zoogeographic relationships of benthic invertebrate communities in the eastern Gulf of Mexico, and Hedgpeth (1953, P. 201-205) and Briggs (1974, p. 214-221) have given their views on the status of provinces and zones in the Gulf of Mexico.

The molluscan faunas of Lobos Reef

¹Contribution number 012, Dauphin Island Sea Lab.

(21°08'N, 097°13'W) and Enmedio Reef (19°06'N, 095°56'W) which are 100 km southeast of Tampico and 15 km southeast of Veracruz respectively have been studied by Tunnel (1974). Lipka (1974) investigated the reef associated molluscan fauna of the West Flower Garden Bank (WFGB) located at 27°52'N, 093°48'W which is 172 km south of Galveston, Texas. The molluscan fauna reported herein is associated with the hermatypic reef community briefly described by Hopkins (1974) at the Florida Middle Grounds (28°35'N, 084°29'W) approximately 137 km southeast of Apalachicola, Florida. See Figure 1 for spatial relations for the various topographic structures. Hopkins (*op. cit.*) has established the the FMG hermatypes are dominated by *Millepora* along with *Madracis* and *Dichocoenia* in contrast to the *Diplora-Monastrea* formations of the WFGB. For this reason as well as the significant spatial separations of these reef areas, a comparative characterization of their molluscan faunas should be of value in gaining a better understanding of these deep reef communities. The only known previous report on the

Fig. 1. Map of the Gulf of Mexico showing locations of known coral reefs. (After Bright & Pequegnat, 1974)

molluscan fauna from the Florida Middle Grounds is that of Lyons (1976).

METHODS

Because of the depth and topography of the Florida Middle Grounds (23-36m), open circuit SCUBA (non-recirculating self contained underwater breathing apparatus) was used for specimen collection at six sampling sites during June and September 1975 and February - March, 1976. Each sampling site encompassed a rectangular area of the approximate dimensions 15 x 75 meters. Representative specimens of the materials described herein are currently in residence at the Dauphin Island Sea Lab.

Routine temperature measurements were recorded (uncorrected) with mercury

stem thermometers, and these data are in agreement with the mean monthly temperatures published by Cheney and Dyer (1974).

RESULTS

The present study reports 75 species from the FMG which includes 42 species of gastropods, 24 species of pelecypods, three species of cephalopods, two species of chitons and of particular, note four species of opisthobranch gastropods one of which just recently has been described by Marcus and Gallagher (1976) from shallow water. The molluscan species encountered on the Florida Middle Grounds are displayed along with their noted occurrence by Lipka (*op. cit.*) or Tunnel (*op. cit.*) in Table 1.

Tunnel (*op. cit.*) reported 290 molluscs (211 gastropods, 73 bivalves, 4 chitons, and 2 cephalopods) in his study which ranged from supratidal to 23 M. the dominant gastropod genera were: *Triphora* (12 species), *Caecum* (11 species), *Cerithiopsis* (10 species), *Turbanilla* (7 species) and *Cymatium* (6 species). The dominant bivalve genera were *Lithophaga* and *Lima* (4 species each) and *Barbatia*, *Chama* and *Tellina* with 3 species each. Lipka (*op. cit.*) collected 65 species of molluscs from the (WFGB) and included 41 species of gastropods, 21 species of pelecypods, two species of cephalopod and one species of chiton.

The molluscan assemblage of the Florida Middle Ground is quite dissimilar to the WFGB as measured by the Bray-Curtis similarity index (1957) where:

$$\% S = \frac{2a \times 100}{b + c}$$

where a is the number of species common to two sites; b and c are the total number of species at each site. In comparing the similarity of these data to Lipka (*op. cit.*) a value of 24% was obtained.

Of the specimens presently identified, only eight species of gastropods collected from the Middle Ground also occurred from the Flower Garden (Table 2). One WFGB species of *Calliostoma* was a juvenile and not identified to determine if it occurred on the Middle Ground. *Cerithium litteratum* was the most abundant gastropod surveyed *in situ* from both the Flower Garden (Lipka, *op. cit.*) and the Florida Middle Ground.

Of the 24 Florida Middle Ground species of pelecypods collected, only seven were found to be common to both reefs (Table 1). Some specimens of *Barbatia* collected from the Middle Ground have tentatively been identified

as *B. cancellaria* a species which was collected by Lipka (*op. cit.*) from the West Flower Garden. *Lithophaga bisulcata* was found in abundance in both reef ecosystems, although *L. aristata* was more abundant from the Middle Ground. *Malleus candeanus* collected from the Flower Garden was found only attached to hard substrates, not in sponges (Lipka, *op. cit.*) while some of the Middle Ground specimens were collected from sponges. *M. candeanus* was abundant from the Florida Middle Grounds as was *Chlamys benedicti*, *Spondylus americanus*, *Pteria colymbus*, *chama macerophylla*, and *Lopha frons*.

Two species of the genus *Octopus* comprised two of the three cephalopods collected from the Florida Middle Grounds (Table 1). The only specimen collected from the Flower Garden was a juvenile and could not be identified beyond the genus *Octopus*. Only one species of squid, *Loligo pealei*, was collected from the water column over both of the two reefs studied.

Lipka (1974) did not mention the collection or identification of any opisthobranchs from the West Flower Garden; four species were collected from the Florida Middle Grounds (Table 1).

DISCUSSION

For the purposes of the ensuing discussion, we think it is important to review pertinent information from Hedgpeth (1953), Briggs (1974), and Valentine (1973). Hedgpeth (*op. cit.* p. 195-205) is a comprehensive treatment of "Biogeographical and Ecological Considerations" based on the knowledge available to him at that time. Our interpretation of this effort leads us to conclude that Hedgpeth's conclusions concerning the Gulf fauna were influenced the greatest by (a) littoral and sub-

Table 1. Comparison of the Molluscan fauna of the Florida Middle Ground with the data of Lipka (1974) and Tunnel (1974). A = alive; D = shell only; * indicates a new record for the eastern Gulf of Mexico.

	Florida Middle Grounds	West Flower Gardens Bank	Lobos	Enmedio
CLASS GASTROPODA				
Family FISSURELIDAE (Fleming)				
<i>Emarginula pumila</i> (A. Adams)	A*		A	D
<i>Hemitoma octoradiata</i> (Gmelin)	A			
<i>Diodora cayenensis</i> (Lamark)	A		A	A
<i>Diodora dysoni</i> (Reeve)	A			
<i>Lucapina suffusa</i> (Reeve)	A*		D	A
<i>Lucapina aegis</i> (Reeve)	A		D	A
Family TROCHIDAE (Rafinesque)				
<i>Calliostoma roseolum</i> (Dall)	A			
<i>Calliostoma barbouri</i> (Clench & Aguayo)	A*			
<i>Calliostoma jujubinum</i> (Gmelin)	A			
Family TURBINIDAE (Rafinesque)				
<i>Astraea phoebia</i> (Röding)	A	A		
<i>Astraea tecta americana</i> (Gmelin)	A*	A	A	A
<i>Astraea cf. tuber</i> (Linné)	A			
Family CYCLOSTREMAIDAE (Fisher)				
<i>Arene cruentata</i> (Mühlfeld)	A	A		
Family TURRITELLIDAE (Clarke)				
<i>Turritella exoleta</i> (Linné)	A*			
<i>Vermicularia knorrii</i> (Deshayes)	A			
Family CERITHIDAE (Fleming)				
<i>Cerithium atratum</i> (Born)	A			
<i>Cerithium litteratum</i> (Born)	A	A	A	A
Family TRIPHORIDAE (Gray)				
<i>Triphora turrithomae</i> (Holten)	A*	A	A	A
Family CREPIDULIDAE (Fleming)				
<i>Crepidula aculeata</i> (Gmelin)	A			
<i>Crepidula plana</i> (Say)	A			
Family ERATOIDAE (Gill)				
<i>Trivia pediculus</i> (Linné)	A			
Family CYPRAEIDAE (Rafinesque)				
<i>Cypraea spurca acicularis</i> (Gmelin)	A	A	A	A
Family OVULIDAE (Fleming)				
<i>Simnia uniplicata</i> (Sowerby)	A			
<i>Cyphoma macgintyi</i> (Pilsbry)	A			
Family MURICIDAE (de Costa)				
<i>Murex florifer dilectus</i> (A. Adams)	A*			
<i>Urosalpinx cf. cinerea</i> (Say)	A			
<i>Ocenebra minirosea</i> (Abbott)	A*			
<i>Muricopsis oxytatus</i> (M. Smith)	A		D	D
<i>Calotrophon ostrearum</i> Conrad	A			
Family CORALLIOPHILIDAE (Chenu)				
<i>Coralliophila abbreviata</i> (Lamarck)	A	A		A
<i>Coralliophila caribaea</i> (Abbott)	A*		A	A
Family COLUMBELLIDAE (Swainson)				
<i>Anachis floridana</i> (Rehder)	A			
Family BUCCINIDAE (Rafinesque)				
<i>Bailya intricata</i> (Dall)	A*		A	A
<i>Bailya parva</i> (C. B. Adams)	A			
<i>Engina corinnae</i> (Grovo)	A*			
<i>Engina turbinella</i> (Kiener)	A*		A	A
<i>Pisania tincta</i> (Conrad)	A	A	A	A
<i>Antillophos adelus</i> (Schwengel)	A			
Family FASCIOLARIIDAE (Gray)				
<i>Leucozonia nassa</i> (Gmelin)	A		D	A
<i>Leucozonia ocellata</i> (Gmelin)	A*			
<i>Latirus cariniferus</i> (Lamarck)	A			

Table 1 (cont.)

	Florida Middle Grounds	West Flower Gardens Bank	Lobos	Enmedio
<i>Fasciolaria tulipa</i> (Linné)	A		A	A
Family APLYSIIDAE (Rafinesque)				
<i>Aplysia parvula</i> (Mörch)	A			
Family DORIDIDAE (Rafinesque)				
<i>Hypselodoris edenticulata</i> (White)	A			
<i>Chromodoris clenchi</i> (Russell)	A			
Family DENDRODORIDIDAE (Pruvot-Fol)				
<i>Dendrodoris warta</i> Marcus & Gallagher	A*			
CLASS PLOYPLOCOPHORA				
Family ISCHNOCHITONIDAE (Dall)				
<i>Stenoplax floridana</i> (Pilsbry)	A			
Family CHITONIDAE (Rafinesque)				
<i>Tonicia schrammi</i> (Shuttleworth)	A			A
CLASS PELECYPODA				
Family ARCIDAE (Lamarck)				
<i>Arca zabra</i> (Swainson)	A	D	A	A
<i>Arca imbricata</i> (Bruguière)	A		A	A
<i>Barbatia cf. cancellaria</i> (Lamarck)	A	A		
<i>Barbatia domingensis</i> (Lamarck)	A	A	A	A
<i>Arcopsis adamsi</i> (Dall)	A		A	A
Family MYTILIDAE (Rafinesque)				
<i>Musculus lateralis</i> (Say)	A			A
<i>Lithophaga nigra</i> (Orbigny)	A*		A	A
<i>Lithophaga antillarum</i> (Orbigny)	A		A	
<i>Lithophaga bisulcata</i> (Orbigny)	A	A	A	A
<i>Lithophaga aristata</i> (Dillwyn)	A	A	A	A
<i>Botula fusca</i> (Gmelin)	A			A
Family PTERIDAE (Gray)				
<i>Pteria columbus</i> (Röding)	A		A	
<i>Pinctada imbricata</i> (Röding)	A			
Family MALLEIDAE (Lamarck)				
<i>Malleus candeanus</i> (Orbigny)	A	A	A	A
Family PECTINIDAE (Rafinesque)				
<i>Chlamys benedicti</i> (Verrill & Bush)	A	A		
<i>Argopecten gibbus</i> (Linné)	A			
Family SPONDYLIDAE (Gray)				
<i>Spondylus americanus</i> (Hermann)	A	A		
Family OSTREIDAE (Rafinesque)				
<i>Lopha frons</i> (Linné)	A		A	A
Family CHAMIDAE (Lamarck)				
<i>Chama macerophylla</i> (Gmelin)	A		A	A
Family TRAPEZIIDAE (Lamy)				
<i>Coralliphaga coralliphaga</i> (Gmelin)	A		A	D
Family VENERIDAE (Rafinesque)				
<i>Ventricolaria rugatina</i> (Heilprin)	A*			
Family GASTROCHAENIDAE (Gray)				
<i>Gastrochaena hians</i> (Gmelin)	A			
<i>Spengleria rostrata</i> (Spengler)	A*			A
Family HIATELLIDAE (Gray)				
<i>Hiatella arctica</i> (Linné)	A*			
CLASS CEPHALOPODA				
Family LOLIGINIDAE (Lesueur)				
<i>Loligo pealei</i> (Lesueur)	A	A		
Family OCTOPODIDAE (Rafinesque)				
<i>Octopus vulgaris</i> (Cuvier)	A	A	A	A
<i>Octopus joubini</i> (Robson)	A			

littoral collections, (b) the large degree of disjunct distributions which he attributed in part to insufficient sampling effort, and (c) his evaluation and conclusions concerning the amounts and validity of endemism reported. Of particular consequence, his treatment did not consider the more recently investigated hard-substrate communities ringing the Gulf on the coastal shelf. The question of provincial definitions has been reviewed by Briggs (*op. cit.*, p 16) who asks the question "_____ how much does a local fauna have to differ from the parent in order to merit formal recognition as a province?" He goes on to admit an "arbitrary" value of 10 per cent endemism for designation as a separate province. He further makes a case for using "shelf animals" in developing provinces, an admitted shortcoming in Hedgpeth's treatment. Valentine's (1973) treatment of the "province" question has an entirely different approach, e.g. "it is in fact theoretically possible that a province could possess no endemic species at all and yet have distinctive communities". Thus Valentine (*op. cit.*, p. 337) defines provinces "as regions in which communities maintain characteristic taxonomic compositions". Furthermore, "since communities are polythetic units, it is necessary that only enough of the species differ so as to form distinctive characterizing sets of species in each province".

Rehder (1954) has provided a summary review of the molluscan literature for the Gulf and provides some zoogeographic implications. This work generally outlines the Caribbean Province as including the northwest coast of Cuba from Cabo San Antonio to Habana, the west coast of Florida from the Dry Tortugas and Key West north to probably Tampa Bay (the northern limit of this province is somewhat doubtful here but lies somewhere between Sanibel

Island and Cedar Keys), and "the coast of Mexico from Cabo Catoche to the vicinity of Port Isabel, Texas and possibly beyond to Corpus Christi Bay". He further observed that the mollusks of the area described "show an obvious relationship with those of the West Indies and the entire Caribbean region." In dealing with the Carolinian Province he states:

"This area extends from Cape Hatteras, North Carolina, south to about Cape Canaveral on the east coast of Florida, and from about Tampa Bay on the Florida west coast northward and westward along the shore of the Gulf to about Corpus Christi Bay, Texas."

Lastly and of importance to this discussion, Rehder *op. cit.* calls attention to the fact that the fauna of deeper water shows relationships with topical elements of the Caribbean and of even more pertinence, there are species which appear to be peculiar to the Gulf.

The often cited contribution by Work (1969) updates the efforts cited above, but further opens the question of the validity of conclusions about provincial boundaries based on shallower water observations. For example, the work of Merrill and Petit, 1965; Cerame-Vivas and Gray, 1966; Menzies *et. al.* 1966, are all cited as examples that indicated West Indian species have invaded the Carolinian Province. Work (*op. cit.*) should also be credited with observing that the area off-shore from Clearwater to near St. Marks on the upper big-bend coast of Florida has an extraordinary tropical assemblage, and he refers to it as the "disjunct *Astraea* zone" because of the apparent abundance of *Astraea phoebia* and *A. tecta* ssp. His observations and hypothesis have been verified hydrographically by Austin and Jones (1974) and biologically by Hopkins (1974) and Smith and Ogen (1974). Furthermore, the existence of West Indian species in deeper areas of the western Gulf has

been more than substantiated by Bright and Pequegnat (1974).

Tunnel (1974) developed a terminology and an approach not unlike that of Hedgpeth (1953) in order to numerically characterize the molluscan fauna. Granted there are aspects of the classification that may be regarded as arbitrary, we feel that their use herein will help expose them to the kind of critical review necessary to either have them stand the scrutiny of our peers, or pass from the scene because they were indefensibly arbitrary. We use the following terms defined accordingly:

Carolinian Restricted -organisms whose range is limited to north of mid-Florida either side of peninsular Florida.

Carolinian Eurythermic -organisms whose range extends from the eastern seaboard southward to Brazil and with possible occurrence in Bermuda along with the northern Gulf of Mexico.

Caribbean Eurythermic -organisms whose major distribution center involves Mexico, the Bahamas, Cuba, the West Indies; but with extensions into the Gulf of Mexico and up the eastern seaboard to North and South Carolina.

Caribbean Restricted -organisms whose ranges are limited to south of mid-Florida.

Gulf Restricted -organisms endermic to the Gulf of Mexico.

Using range data from Abbott (1974) and Andrews (1971) we can summarize our molluscan fauna as follows:

	Carolinian Restricted	Carolinian Eurythermic
No. of Species	2	15
Caribbean Eurythermic	Caribbean Restricted	Gulf Restricted
31	25	2

As a result of the preceeding discussion, the findings herein and supported by the conclusions of Smith (1976), we have arrived at a point where we can best support a contention that as regards the molluscan fauna, the Gulf of Mexico can best be delineated as the Gulf Province. We have examined the evidence for con-

sidering it as Carolinian because of its shallow temperate fauna along the upper Gulf Coast, found that it is easily off-set by tropical occurrences even in embayments (Work, 1969). It can be seen that the Middle Grounds molluscan fauna has a predominantly Caribbean heritage as we might expect based on the work of Collard and D'Asaro (1973). We are puzzled by Briggs (*op. cit.*, p. 218-221) who in placing the northern Gulf of Mexico in the Carolinian Province presents clear evidence for numerous examples of papers emphasizing tropical or Caribbean biota and even concludes that the probable overall level of endemism for fishes and invertebrates is in the vicinity of 10 per cent. (Recall that Briggs *op. cit.*, p. 16 established an admittedly arbitrary 10% endemism for considering provincial areas). However, we agree that the presence of West Indian forms does not necessarily make it a Caribbean Province. However, we do feel that the two major current systems operating, e.g. the Loop Current (Maul, 1974) and the Mexican Current (Sturges and Blaha, 1976) coupled with the vagaries of river and embayment discharges are providing oportunities for the development of a unique molluscan faunal assemblage in the Gulf of Mexico. We believe there is an insurmountable amount of evidence that indicates that the Gulf of Mexico contains a number of communities with remarkable dissimilarity, but still contain some common characteristic lineage other than "Carolinian".

This position is in agreement with Valentine (1973), and we predict it will be further supported by other work on the Florida Middle Ground and from dredging/trawling and box-coring in the eastern Gulf. Consequently, we urge other faunal investigators to carefully examine their speciality and determine whether their faunal assemblages do not better fit the category of a Gulf Province

rather than the uncertainties of such titles as "relict West Indian fauna", "impoverished West Indian fauna", and "fauna of mixed Carolinian West Indian affinities".

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