NEOGENE BIVALVE *RANGIA (MIORANGIA) JOHNSONI*; TAXONOMY, DEPOSITIONAL FACIES AND STRATIGRAPHIC RANGE

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I. ABSTRACT

The study of numerous specimens of a fossil bivalve, collected from a Chickasawhay River outcrop in southeastern Mississippi, included statistical tests of valve elongation ratios. Despite their great morphological variety, the molluscan valves were determined to represent only a single species, *Rangia johnsoni*. Valve shape variability appears related to ontogenic development from the young juvenile to adult stages. Diminutive shells, designated previously as *"R. microjohnsoni,"* do not belong to a separate, valid species. The term *Miorangia*, employed by Dall and Gardner, is a valid subgeneric taxon. Further use of the terms *Miorangia microjohnsoni*, *M. johnsoni* and *R. microjohnsoni* is unwarranted. *Rangia johnsoni* inhabited not only reduced salinity, estuarine-lagoonal depositional facies but also extended into inner neritic environments. Although most abundant in the Late Miocene units of the Gulf Coastal Plain, its age range includes the upper Middle Miocene and perhaps even the earliest Pliocene.

II. INTRODUCTION

Just over a century ago (1888-1891), Lawrence C. Johnson of the U.S. Geological Survey first observed Miocene shell concentrates composed of a newly discovered bivalve fossil in southeast Mississippi streambanks and in a Mobile, Alabama water well (Fig. 1). The shell beds occur in a clayey-sandy sequence that Johnson (1892) referred to as "Pascagoula clay" or "Pascagoula Formation." Dall (1892-1894) described the new bivalve species as *Gnathodon johnsoni*, assigning it to a *Miorangia* taxonomic "Section" within the genus *Gnathodon*. Later, the generic name *Rangia* was adopted in the literature. Dall (1894) provided an early taxonomic history of the genus.

On the basis of reversed cardinal teeth in *R. johnsoni*, which correspond to Dall's "Section *Miorangia*" (see Appendix), Gardner (1940) recognized the subgenus *Miorangia*, based, in addition, on the obliquely produced submytiloid outline, with a correspondingly asymmetric hinge (see Appendix). In a number of papers *Miorangia* was substituted incorrectly for the established generic name *Rangia* (e.g., *"Miorangia johnsoni"*).

Gardner (1940) described a new *Rangia* species, different from *R. johnsoni* "apparently only in the much smaller size." She named it *Rangia (Miorangia) microjohnsoni*, maintaining that the diminutive valves (maximum 5 mm length) were not juvenile forms of *R. johnsoni* but instead represent mature life stages of a separate species. The two *Rangia* forms subsequently have been referred to in the literature by a confusing array of designations: *Miorangia microjohnsoni* and *Rangia johnsoni* (Puri, 1953; Murray, 1961); *Rangia (Miorangia) microjohnsoni* and *Rangia microjohnsoni* (Marsh, 1966; Skinner, 1972; Raymond, 1985). Puri (1953, p. 57) regarded *"Miorangia microjohnsoni"* to be the subsurface equivalent of *Rangia johnsoni*. He defined the stratigraphic range of *"Rangia johnsoni-Miorangia microjohnsoni"* as a faunizone (of the Choctawhatchee Stage), fully correlative with

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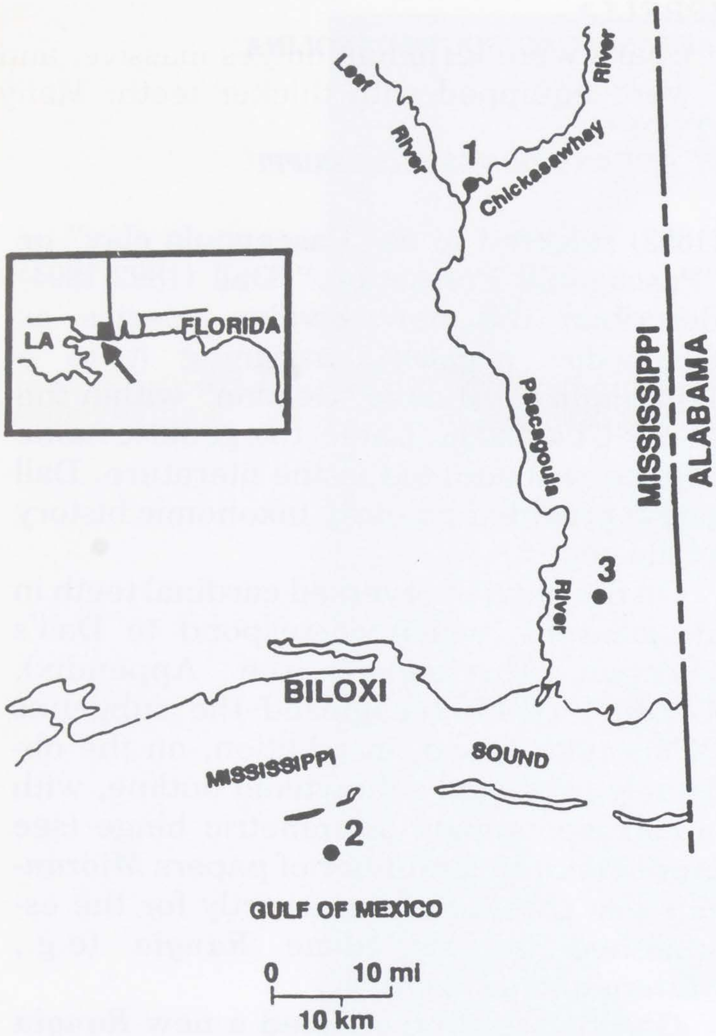

Figure 1. Drillhole and outcrop locations, south Mississippi. Key: 1-Miller Bridge Bluff; 2-Sapphire well; 3-Morton-Thiokol well.

the Pascagoula Formation. Since Gardner's paper, the occurrence of *"M. microjohnsoni"* specimens has been cited in various publications and reports more frequently than *R. johnsoni* has.

A few years ago Jules R. DuBar and David T. Dockery tentatively identified taxa in our southern Mississippi collections as *"Rangia johnsoni/ microjohnsoni."* DuBar (written comm.) pointed out that although Dall's "ovate" and "triangular" valve shapes, as well as oval-elongate and trigonal-elongate types (Figs. 2, 3) commonly coexist in the drill- and outcrop samples, all appear to represent a single species. DuBar suggested further studies to deal with this question.

III. THE *JOHNSONI* VS. *MICROJOHNSONI* QUESTION

Sampled outcrop.

The taxonomic validity of the *Rangia* species was tested using a large sample, collected from the richest, 40-cm interval in a Chickasawhay River bluff (Figs. 4a,b). This outcrop, referred to here as Miller Bridge Bluff (Fig. 1, Location 1), occurs in Greene County, southeastern Mississippi (center of south section line, sec. 29, T1N, R7W; Leakesville SW USGS Quadrangle). First described by Mincher (1941, p.340), it is at the foot of the right river bank, 1 km downstream from the Highway 98 (Miller) bridge. In 1989 it exposed the sequence given in Table 1.

Mincher (1941) also identified estuarine ostracode and foraminifer species from several nearby "Pascagoula Clay" outcrops along the river. Although he described a new bivalve species, *Ostrea westi* only from another location, we did collect this oyster from Unit (b) of the described outcrop.

Valve morphology variations. A total of 303 well-preserved *Rangia* valves collected from Unit (b) were grouped into four size-categories, according to valve length, in order to test the assumption that increasing size is related to morphological differences. Valve length is measured parallel to hinge line and is the distance between anterior and posterior margins at the farthest points. Height is measured normal to length. Ratios of valve length and height, measured at the University of South Carolina by optical microscope with the accuracy of one micron, have been computed for each individual (Tables 2 and 3).

A detailed visual analysis by Campbell of all valves in the four size-groups of valve lengths ‹3.0 mm, 3.1-6.0, 6.1-12.0 and ›12.1 mm indicated that shape differences in *Rangia (Miorangia) johnsoni* were related to allometric growth stages. Valves of Group One (138 specimens) were generally thin-shelled, with high, sharply pointed subterminal beaks, delicate hinges with small teeth. The generally narrow valves (mean length/height ratio: 1.43) often correspond to Dall's "triangular" shapes, although elongated shapes are not rare either. A broad overlap exists between Groups One and Two in terms of valve shape and elongation ratio. The predominance of triangular, "squat" valves in the smallest size-class as well as the abundance of forms, transitional between triangular and ovate, is clearly pointed out by contrasting elongation ratio curves (Fig. 5). Morphological variety and overlap between size categories is also indicated by other valves, sampled from drillholes and not included in the present study (Figs. 2, 3).

Group Two (102 specimens) was represented mostly by thicker, more elongate shells. The mean shape ratio (1.62) reached a maximum value in this group. Beaks were terminal, hinges massive, and were equipped with thicker teeth. Many specimens were virtually identical to Gardner's *"Rangia (M.) microjohnsoni"* illustration (1940, Fig. 1).

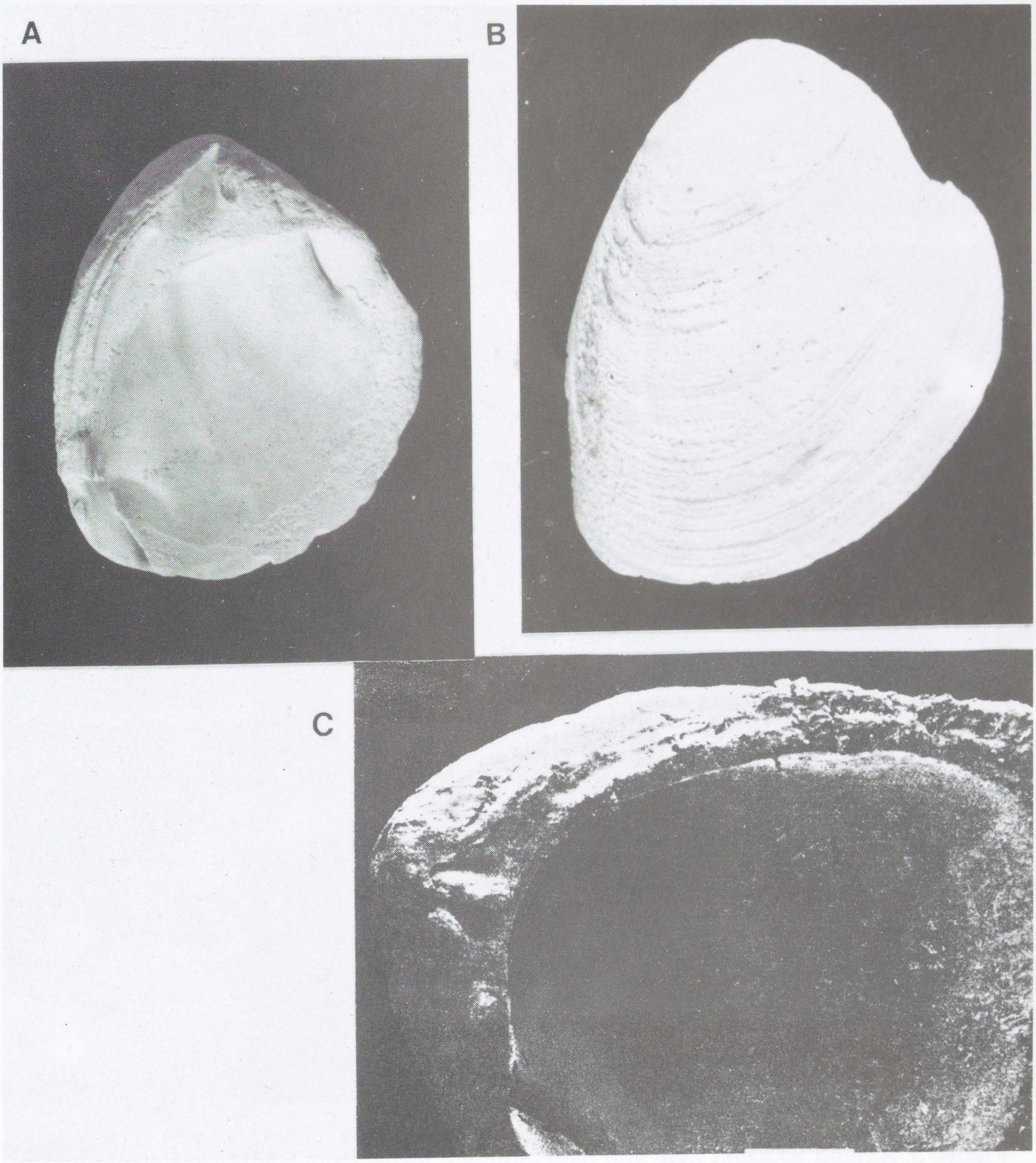

Figure 2. *Rangia johnsoni* trigonal forms from Sapphire Petroleum Co. drillhole (Location 2 on Fig. 1): Binocular microscope photos: (a) left valve interior, length: 16.5 mm, height: 14.3 mm (2730-2760 ft; 832-841 m)); (b) right valve exterior, length: 13.6 mm; height: 12.5 mm (2580-2610 ft; 787-796 m); Morton-Thiokol (Location 3 on Fig. 1) Drillhole: 1929-1960 ft (588-642 m). Length: 3.6 mm, height: 3.5 mm; beak area. SEM image, scale bar: 0.5 mm.

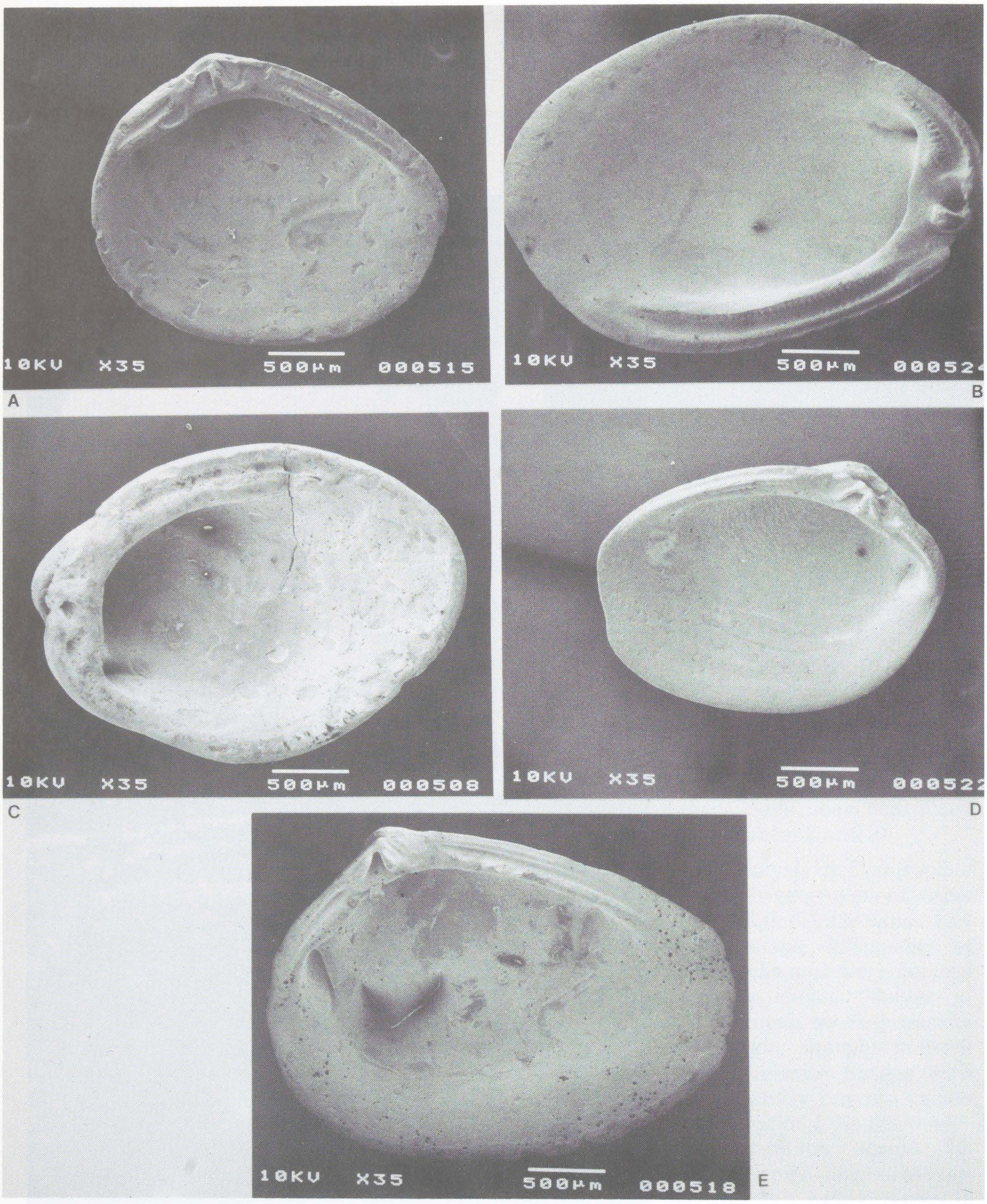

Figure 3. *Rangia johnsoni* oval and oval-elongate forms from Sapphire Petroleum Co. drillhole. (SEM images; scale bar: 0.5 mm.) (a) 3390-3420 ft (1033-1121 m), right valve interior; length: 2.2 mm; height: 1.9 mm (b) 1942-1972 ft (592-601 m) right valve interior, length: 3.3 mm, height: 2.2 mm; (c) 3390-3420 ft (1033-1121 m), right valve interior length: 3.2 mm, height: 1.6 mm; (d) Sapphire 2670-2700 ft (814-823 m), left valve interior, length: 2.4 mm, height: 1.2 mm; (e) Morton-Thiokol, right valve interior 1929-1960 ft (588-642 m); length: 3.1 mm, height: 2.3 mm.

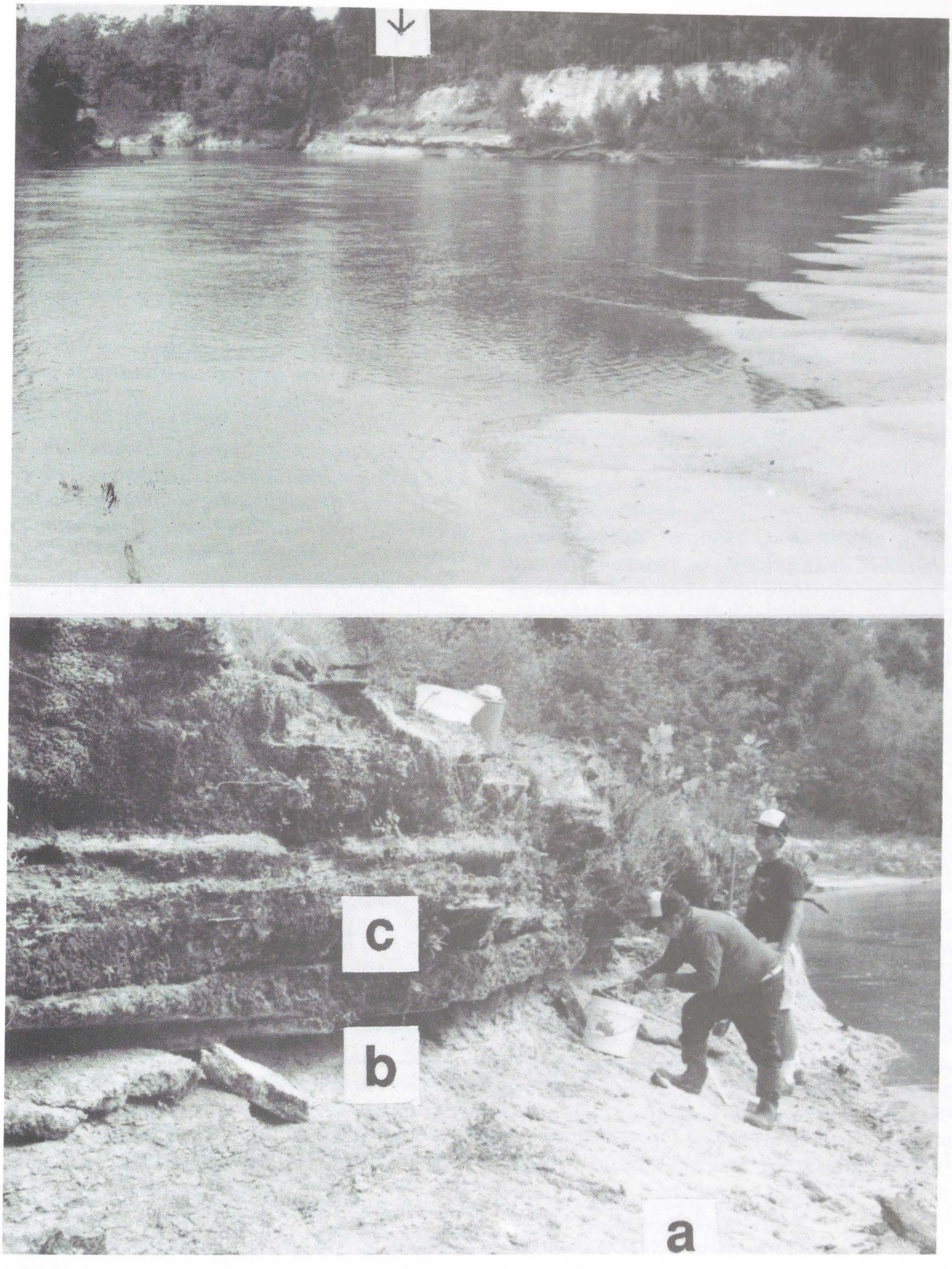

Figure 4. Miller Bridge Bluff; low water stage. (TOP) General downstream view. Outcrop at foot of river bank (arrow). (BOTTOM) Closeup: unconsolidated, thin sampled unit *b;* between units *c* (limestone ledges), and *a* (slope, Messrs. Newby and Howat for scale).

In Group Three (52 specimens) shell walls were thicker but narrower, with massive hinges and low beaks. The mean ratio (1.58) declined slightly from that of Group Two.

Group Four (11 specimens), represented by the largest valves (12-21 mm), had thinner shells. Beaks were relatively higher than in Group Three and terminal. Hinges were less massive and teeth more elongated. The narrow, triangular-shaped valves resembled those that dominated Group One (mean ratio: 1.46).

Species identities: One-way analysis of variance of length/height ratio vs. valve groups.

One-way analysis of variance showed significant differences (alpha <.05) in mean length/height ratios among the four groups. Duncan's Multiple Range Test (Steel and Torrie, 1960, p. 107-114) indicated two distinct subsets, Groups One and Two, significantly different from Groups Three and Two (Table 2).

In contrast, the Scheffe's Procedure (Table 3), which requires larger observed differences for significance (Hicks, 1982, p. 52-53), revealed two overlapping subsets. These subsets, Groups One, Four and Three are not significantly different from each other. There is an overlap between Groups Three and Two. Significant differences exist only between Groups One and Two and Two and Four.

Thus, while both tests showed significant differences within Gardner's "*microjohnsoni*" size-class (combination of Groups One and Two; the dominantly triangular and the dominantly oval-elongate groups, respectively), neither test indicated significant difference between Group Two, those shells were morphologically similar or identical to Gardner's *Rangia microjohnsoni*, and Group Three, those shells that Gardner would have assigned to *Rangia johnsoni*.

Should specimens of two *Rangia* species occur together in the two smaller size-groups, each species would contribute its distinctive values to both groups. Ratio distribution, displayed by a "combined" curve, would then be bimodal, with each species being characterized by a separate ratio frequency curve. But this was not the case. Group One displayed an almost perfect unimodal distribution, with a slight shoulder at ratio 1.1, and the Group Two curve was perfectly unimodal, with a peak value 0.2 greater than in Group One (Fig. 5). In other words, *Rangia johnsoni* juveniles did not coexist with hypothetical "*Rangia microjohnsoni*" adults.

Our analyses, thus, provide no support for the existence of two separate *Rangia* species in the examined material. Instead, morphological differences are attributed to allometric changes. Individual development starts in Group One (young-juvenile ontogenic stage) and continues through Groups Two (older juveniles) and Three (subadults). It culminates in Group Four (fully adult stage). Walls became thicker, progressing from the first to the second group. Typically, this is the sign of maturity among many marine bivalves. However, among species that also inhabit nearshore and inshore environments, this may be an adaptative characteristic to offset corrosive effects of lower salinity waters and organic-rich, slightly acidic substrates.

Table 1. Geologic section, Miller Bridge Outcrop (Location: see Fig. 1).

Pliocene	Citronelle Formation. Yellowish-brown to orange-red, locally cross-stratified alluvial silty sand that forms distinctive high bluff	5 m
U.Miocene	Undifferentiated Neogene paralic-alluvial sequence (earlier: "Pascagoula Formation"):	
	(f) Grayish-green mud, with silty clay, fossil-free (approximate high-water stage, c. 15 m above sea level)	11 cm
	(e) Ironstone ledge, dark grayish-brown to purple-brown, dense, with vertical, limonitized root casts	15-25 cm
	(d) Unconsolidated yellowish-brown sand, abundant shell fragments, dominantly *Rangia* shells and shell fragments	37-65 cm
	(c) Medium light gray-to-bright white, mostly well consolidated, hard coquina-limestone ledges, composed of *Rangia* shells	120 cm
	(b) Moderate greenish-gray clay with *Rangia*-concentrate lenses, shell hash content increases downward (*sampled interval;* Fig. 5)	40 cm
	(a) Sandy-clayey shell hash, gray-to-white, with abundant *Rangia* shells	95 cms
	Extreme low river level	

Table 2. Duncan's Multiple Range Test for *Rangia* valve data in the four size categories (groups).

category	1	4	3	2
size range	‹3 mm	›12 mm	6.001-12 mm	3.001-6 mm
mean ratio	1.4394	1.4604	1.5801	1.6271

Table 3. Scheffe's Test for *Rangia* valve data in the four size categories (groups).

category	1	4	3	2
size range	‹3 mm	›12 mm	6.001-12 mm	3.001-6 mm
mean ratio	1.4394	1.4604	1.5801	1.6271

IV. STRATIGRAPHIC POSITION OF *RANGIA JOHNSONI*- BEARING INTERVALS

Data from south Louisiana and Alabama.

The *Rangia* species has been recognized by Johnson, Dall and several other workers as a key fossil in a number of Miocene Gulf coastal stratigraphic units. These included the Fleming Group, Pascagoula Formation, Miocene coarse clastics, Pensacola Clay (Fig. 6) in a wide belt that extends from southern Texas to northwest Florida. In southern Louisiana, the *"Rangia microjohnsoni"* zone is widely regarded as the "updip" correlative of the Late Miocene neritic facies, similar to the relationship that exists between the nearshore *Potamides matsoni* micromolluscan faunizone and the *Globorotalia fohsi fohsi* planktonic zone in the Middle Miocene (E. B. Picou, Jr., written comm.). Ellisor (1940), as well as Akers and Drooger (1957) considered the *"Rangia johnsoni/microjohnsoni"* biozone of uppermost Late Miocene age.

Raymond (1985) quoted other workers in stating that the two *Rangia* species in Louisiana appeared as early as *Globorotalia fohsi peripheroacuta* (Blow Zone N.10; mid-Middle Miocene). This level corresponds to the *Bigenerina humblei* benthic foram zone. E. B. Picou, Jr. (written comm., 1987), expressed reservations about the Middle Miocene age in view of potential contamination of drill samples in drillholes from higher horizons. Raymond (1985, p. 27) also reported *Rangia johnsoni* from the upper part of the Middle Miocene marine Amos Member (Zones N.9-12) in the Alabama "Pensacola Clay" sequence (Raymond, 1985, p. 27). In southern Alabama, *R. johnsoni* apparently occurs at stratigraphically lower levels than does *Globigerina praebulloides* (range from Middle Miocene through lower Late Miocene Zone N.17) in nearshore drillhole, Exxon/Mobile Bay Block 115 (Otvos, 1988).

Gardner (1940) also noted that, although the bivalve is among the youngest Miocene index fossils, the species extends down the section to the Middle Miocene *Potamides matsoni* and *Uvigerina lirettensis* assemblage zones. In the updip area of southwestern Louisiana, Brunhild (1984) placed the species in the lowermost part of the Late Miocene. Tentative evidence is presented here that *R. johnsoni* first appeared in the Middle Miocene, also in coastal Mississippi. The presence of *Globigerina riveroae* of a dominantly Pliocene range (Blow Zones N.18-19) in a marine sediment lense (Otvos, 1988), in offshore drillhole "Mobile Bay Block 1006" between 373-464 ft (113-141 m), tentatively suggests that the youngest *Rangia johnsoni*- fossils may have been of Pliocene age in Mississippi and Alabama. The lower and upper boundaries of the Pascagoula Formation toward the Hattiesburg and the Graham Ferry "Formations," respectively, had been placed on the appearance/disappearance levels of this *Rangia* species. Because of the regressive character of the overwhelmingly alluvial-paralic Late Miocene-Pliocene sequence and the sporadic, isolated occurrence of *Rangia* valves in the lenticular estuarine lithosomes, the appearance and extinction levels of the faunizone can not be accurately demarcated in the sedimentary sequence. Regionally correlatable lithologic horizons that would mark formation boundaries are absent also.

Mississippi drillhole evidence: age and salinity of depositional facies.

Large numbers of *Rangia* valves were collected from cuttings of two deep drillholes (Fig. 1). Depositional environments and ages of the units that contained the fossils were determined by associated foraminifer assemblages.

(1) *Sapphire Petroleum/ Mississippi Sound Block 90.*

J. DuBar (written comm.) identified 839 "*R. johnsoni/ microjohnsoni*" valves and valve fragments in the 1282-3670 ft (391-1119 m), Late Miocene - Early Pliocene(?) interval. Triangular, oval, oval-elongate, and oval-triangular valves occurred together. Reduced salinity conditions that prevailed from the top of the Neogene section down to 2640 ft (805 m) depth, were reflected by benthic foraminifer species *Ammonia beccarii, Elphidium galvestonense, E. latispatium pontium,* and a few *Nonion depressulum matagordanum.* This interval contained 38.6% of the 839 Rangia valves.

Salinity apparently increased in the 2640-3210 ft (805-979 m) interval that contained 39.9% of *Rangia* valves. The possibly Pliocene age of the higher interval is indicated by two planktonic *Globigerina riveroae* specimens (Blow Zones N.18-19), between 2640-2670 ft (805-814 m). Late Miocene microfossils (*Globorotalia pseudomiocenica, Globigerina praebulloides, Brizalina marginata multicostata,* etc.) occurred between 2670-3900 ft (814-119 m). Nearshore-to-neritic conditions prevailed between 3210-3670 ft (979-1112 m), a core interval that contained 21.4% of the *Rangia* individuals. *Buliminella elegantissima* dominated, along with a variety of other species (*Epistominella pontoni, E. vitrea, Brizalina marginata multicostata, Buliminella* sp. cf. *B. bassendorfensis, Hanzawaia strattoni,* and others.). The abundance of "*Rangia johnsoni/ microjohnsoni*" valves throughout both the lower and the higher salinity intervals, strongly suggests the salinity tolerance of the species and downplays the importance of fall-ins from the higher, brackish horizons.

(2) *Morton-Thikokol, Jackson County, drillhole.*

Rangia johnsoni specimens were abundant in the middle and upper portions of the 904-2493 ft (275-760 m) Late Miocene-

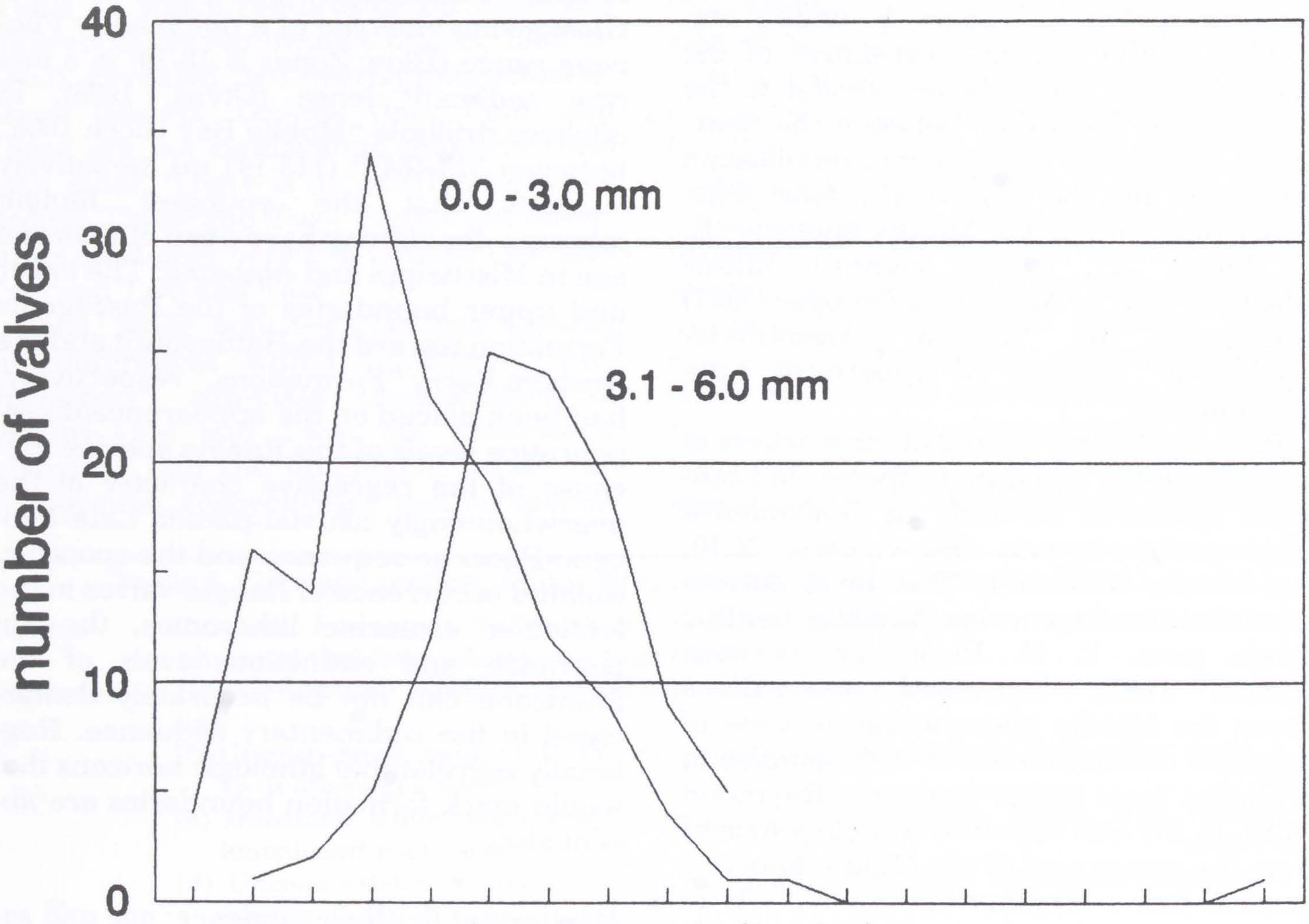

Figure 5. Separation of modes and overlap between *Rangia johnsoni* Group One (0-3.0 mm; dominantly squat, triangular valves) and Group Two (3.1-6.0 mm; dominantly oval-elongate valves).

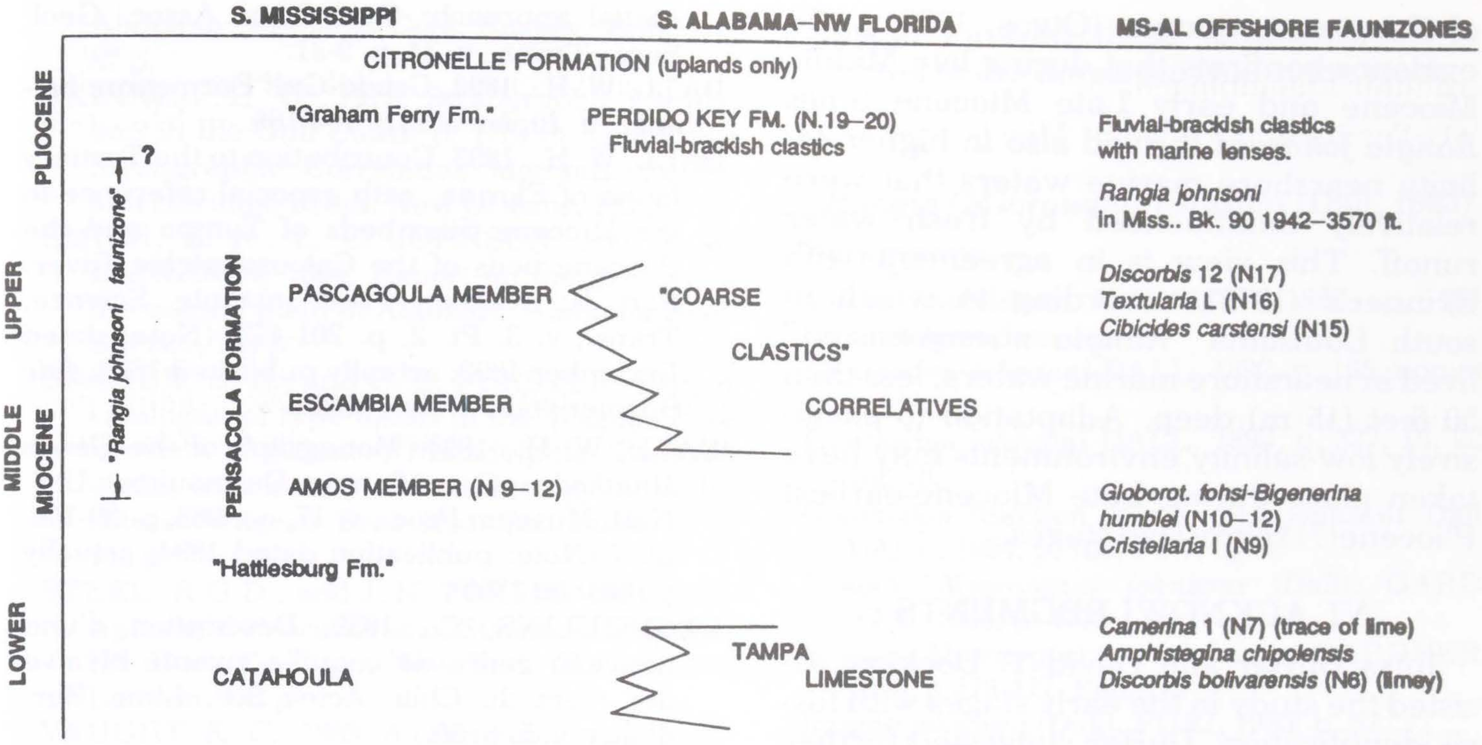

Figure 6. *Rangia johnsoni* faunizone range in updated north-central Gulf coastal plain Neogene stratigraphic sequence (Otvos, 1988 and 1991).

Pliocene? interval. DuBar (written comm.) described the same morphological diversity here as in the other investigated sequences. Low salinity depositional conditions existed between 904-2212 ft (275-674 m), characterized by the dominance of *Ammonia beccarii* and *Elphidium* species, as well as the absence of age-diagnostic planktonic species. Only five specimens of *Rangia johnsoni* occurred below 2243 ft (684 m), in a Middle Miocene (Zone N.9) outer shelf interval with *Globorotalia peripheroronda* (N.4-10), *G. peripheroacuta* (N.9-10), *G. mayeri* (N.9-13), *Globoquadrina dehiscens*, and other planktic taxa. These *Rangia* valves may well have been fall-ins.

V. CONCLUSIONS

Rangia valves from one coastal Mississippi outcrop and two drillholes belong only to one species, *R. (Miorangia) johnsoni*. Differences in the appearance of the valves, expressed in the great variability of length/height ratios, beak position, hinge and teeth structure and shell thickness, appear to be related to ontogenic stages in the development of the individual bivalves. The material at hand provides no evidence to warrant continued use of the terms *Rangia (Miorangia) microjohnsoni*, *Rangia microjohnsoni* or *Miorangia johnsoni*.

Available evidence, still to be supplemented by additional collections from other intervals, suggests a longer stratigraphic range for the species than the commonly accepted Late Miocene interval (Fig. 6). The faunizone ranged from the late Middle Miocene to conceivably into the earliest Pliocene. Due to the lack of precisely datable marine Pliocene lenses, to correlate with adjacent *Rangia*-bearing interval in the alluvial-paralic Neogene sequence, the upper limit of the bivalve's age range can not be firmly established. The absence of regionally correlatable and firmly datable lithologic units that would mark formation boundaries and the spotty appearance of *R. johnsoni*-bearing lenses in the Neogene clayey-sandy sequences are, in addition, among the reasons why Johnson's (1892) "Hattiesburg" and "Pascagoula" – although widely used in the literature – are unacceptable as valid formation designations (Otvos, 1985 and 1991). This is also why horizontal time-lines (e.g., between the Lower and Middle Miocene) would be inappropriate in a stratigraphic table (Fig. 6) to subdivide nondescript alluvial-brackish sequences.

Although its extant "cousin" *Rangia cuneata* (Sowerby, 1832) occupies the very low salinity estuarine niche exclusively (LaSalle and Cruz, 1985), as upper intervals in Mississippi's undifferentiated coastal Neogene sequence (Otvos, 1985, p. 5), evidence confirms that during late Middle Miocene and early Late Miocene times *Rangia johnsoni* thrived also in higher salinity nearshore marine waters that were relatively uninfluenced by fresh water runoff. This view is in agreement with Skinner's (1972), according to which in south Louisiana *"Rangia microjohnsoni"* lived in nearshore marine waters, less than 50 feet (15 m) deep. Adaptation to exclusively low-salinity environments may have taken place during Late Miocene-earliest Pliocene(?) regressive stages.

VI. ACKNOWLEDGMENTS

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Miss Katie Harlan measured the valves in preparation for statistical analysis. The editorial work, comments by Dr. Emily H. Vokes, as well those of Drs. David T. Dockery, William Miller and George C. Flowers were sincerely appreciated.

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APPENDIX: SYSTEMATIC PALEONTOLOGY

Family MACTRIDAE

Genus *Rangia* Desmoulins, 1832

Synonyms (from Vaught, 1989, p. 130 and Abbott, 1974, p. 491)

Gnathodon Gray *in* Sowerby, 1832 (*non* Oken, 1816, *non* Goldfuss, 1820).
Clathrodon Conrad, 1833 (error)
Colombia Blainville *in* Rang, 1834, nomen nudum
Perissodon Conrad, 1863
Columbia Dall, 1898 (error)

Type by monotypy: *Rangia cyrenoides* Desmoulins (= *Gnathodon cuneatus* Gray *in* Sowerby, 1832).

The genus *Gnathodon* Gray apparently predates *Rangia* Desmoulins, but the former is twice preoccupied and therefore unavailable.

Subgenus *Miorangia* Dall, 1894

Type by monotypy: *Gnathodon johnsoni* Dall, 1893.

"*Miorangia* differs from *Rangia* sensu stricto in the smaller size, the obliquely produced, submytiloid outline, the correspondingly asymmetric hinge, and in the detail of the cardinal dentition" (Gardner, 1940, p. 477).

In addition to the differences noted by Gardner, the posterior-lateral tooth of the left valve in *Miorangia* is cross-striated on both its dorsal and ventral surfaces. In *Rangia cuneata* these striations are restricted to the dorsal surface of the tooth.

Rangia (Miorangia) johnsoni (Dall, 1893)

Synonymy:

Venus mobiliana JOHNSON, 1892, p. 151, nomen nudum
Gnathodon Johnsoni DALL, 1892, p. 165, nomen nudum
Gnathodon johnsoni DALL, 1893, p. 337, Pl. 22, fig. 18.
Gnathodon (Section *Miorangia*) *johnsoni* Dall. DALL, 1894, p. 100, Pl. 7, fig. 7
Rangia (Miorangia) johnsoni (Dall). GARDNER, 1940, p. 477
Rangia (Miorangia) microjohnsoni GARDNER, 1940, p.476-477, Figs.1-2
Rangia johnsoni (Dall). PURI, 1953, p. 57
Miorangia microjohnsoni (Gardner). PURI, 1953, p. 57
Rangia johnsoni (Dall). MURRAY, 1961, pp. 411, 413, 418
Miorangia microjohnsoni (Gardner). MURRAY, 1961, pp. 413, 418

DESCRIPTION (Dall, 1894, pp. 100-101):

"Shell small, rather compressed, ovate-triangular to submytiliform in outline, rather thin for the genus, externally smooth or marked only with lines of growth when perfectly normal, but frequently concentrically fluctuate owing to irregularities of growth; beaks prominent, compressed, anterior, close to the hinge line; margin of the shell entire, with no circumscribed lunule or escutcheon; interior smooth, muscular impressions small, distinct; pallial line with a shallow incurvation behind, hinge very asymmetrical, the anterior lateral tooth in the left valve short, ʌ-shaped, received in the right valve into a corresponding sulcus, below which a triangular pustule represents the anterior lateral of that valve; cardinal teeth of the left valve diverging, lamellar, the anterior lamella situated above the anterior lateral tooth, fitting above a triangular cardinal tooth grooved or partly split at the apex, in the right valve; posterior lateral tooth in the left valve long, arched, finely crenate above, received in the right valve between two slender laminae, of which the lower one is most prominent; pit for the ligament and cartilage narrow, oblique, roofed over by a very thin shelly layer generally worn off in rubbed specimens. Length of shell 17.5; height 1.15; double diameter of valve 10 mm. Fragments indicate that the species reached a length of at least 25 mm."

Note: Dall (1894) and all subsequent authors cite the first valid notation of this species as "Dall, 1892 (December)." Spamer and Forster (1988) mention that Dall's second 1892 paper (referred to here as Dall, 1893) was actually published in February, 1893. Dall's 1894 description contained a typographic error for the height value. The corrected value is 11.5 mm; the corresponding length/height ratio for his type specimen, 1.52.

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