A PLIOCENE VERTEBRATE FAUNA FROM LOW ELEVATION IN MANATEE COUNTY, FLORIDA

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ABSTRACT. Excavations at the Manatee County Dam Site yield the first representative in-place collection of the classic Bone Valley Fauna. The fauna is unified in age, none of it being reworked from older beds. It is unequivocally Hemphillian (Middle Pliocene) in age.

The fossil vertebrates lived in three adjacent habitats (savannah, freshwater stream, and estuary). The two most abundant elements in the fauna are sharks (*Carcharhinus leucas* and *Negaprion brevirostris*) which today range extensively into estuarine and fresh waters. If, as the evidence suggests, the area has been tectonically stable since at least Miocene time, the sea dropped at least as low as the level of the Manatee County site. 6 feet above present mean sea level. Evidence of eustatic fluctuations in sea level of over 90 feet during Hemphillian time is presented.

The equid genus *Griphippus* and a tortoise near *Geochelone turgida* are recorded for the first time in eastern United States. A peculiar ridge-toothed crocodylid may be related to *Characodus* from the Late Miocene of Colombia, South America. A skull and mandible of *Rhynchotherium* from the Manatee County site are referred to *R. euhypodon* (Cope), and *R. simpsoni* Olsen from the Bone Valley District is synonymized with the same species. The Honduranium genera *Blekitherium* and *Abyelodon* are synonymized with *Rhynchotherium*, and their respective genotypic species are synonymized as *R. bicki* (Frick).

INTRODUCTION

The fauna described below is essentially a local sample of the classic Bone Valley vertebrate fauna from central peninsular Florida. However, this new local fauna in Manatee County distinguishes itself by the following circumstances: (1) it is the first good sample of Bone Valley vertebrates collected in place from a known stratigraphic horizon; (2) it lies west of the Bone Valley Phosphate Mining District proper; and (3) it is from a low elevation only a few feet above present sea level.

The classic Bone Valley vertebrate fauna is a composite fauna based almost entirely on small collections donated by private collectors to various museums in the eastern United States. Only a few of the specimens in these collections have accurate geographic data, and none have stratigraphic data. There is no basis for the common assumption that the Bone Valley fauna is a unified fauna. Indeed, the obvious complexity of the sequence exposed in the phosphate districts is a powerful warning against making such an assumption. Against this background the importance of a collection of vertebrates from a single known stratigraphic unit can be appreciated.

The terrestrial and marine vertebrates described below were collected in place from a westward extension of the Bone Valley Formation, in particular from the upper conglomeratic member of that formation. Within the Bone Valley Phosphate Mining District this member generally occurs at an elevation of from 100 to 120 feet above present sea level. At the Manatee County Dam Sites, however, the same member occurs at an elevation of 6 to 10 feet above sea level. The most probable explanations for this difference are either that sea level fluctuated con-
siderably during Middle Pliocene time or that the peninsula of Florida was tectonically active during this time. As shown below, the former is more probable.

ACKNOWLEDGMENTS

The rapid development of land in Florida is inevitably destroying vast stores of material fascinating to natural historians, professional and amateur alike. Paradoxically, the same process is stimulating a great stir of interest in natural historical subjects as excavations expose unique items at an accelerating rate. With the great abundance of pressing problems to be investigated, it is especially gratifying to paleontologists when amateurs independently develop an interest in the subject and provide essential cooperation. This certainly has been the case in the present project. We wish particularly to thank Mr. William Winton and Mr. Jack Steinhelper, who, while overseeing the construction of a dam at this site, provided invaluable assistance and showed us every courtesy. We would also like to thank Mr. Don Moore for drawing our attention to the site.

Through their stimulating discussions colleagues Walter Auffenberg, Pierce Brodkorb, H. K. Brooks, E. G. Pirkle, and Thomas H. Patton aided us considerably in understanding these problems. Likewise, Cliff Townsend, Director of Marineland, Marineland, Florida, shared freely his extensive knowledge of the habits of living sharks, and Richard H. Tedford, American Museum of Natural History, provided many helpful comments. This work was supported by grants from the Frick Corporation and the National Science Foundation (GB 3862).

GEOGRAPHIC AND STRATIGRAPHIC SETTING

The vertebrate fauna described below was obtained from an area about 300 meters square on the eastern side of the southern wing of the Manatee County Dam. The dam is to feed a water treatment plant which will serve Manatee County. Its geographic position is illustrated in figure 1.

Nearly all the collections were made in the more southerly borrow pit which was dug to supply clay for construction of the dam. This pit is just south of the Manatee River in sec. 30, T. 34 S., R. 20 E., Manatee County, Florida.

A stratigraphic section taken at the south corner of this borrow pit is presented in table 1.

The greenish clay members of the Hawthorne Formation contain abundant molds of Balanis and Merceneria shells. In the upper part of this unit, large numbers of articulated ribs and vertebrae of two individuals of Halianassa, an extinct dugong, were excavated.

The sand and gravel unit represents the upper part of the Bone Valley Formation. It varies considerably in thickness in the area studied, the maximum observed thickness being about 4 feet. This unit consists predominately of phosphate pebbles with occasional flat rounded quartz
pebbles of a few centimeters diameter. This bed is generally well sorted. The pebbles and many of the contained fossils are considerably water worn.

Despite the considerable water wear on many, the fossils in this bed are not derived from older deposits. All taxa appear to be Pliocene in age, and most groups are represented by some unworn specimens. An outstanding example of material that was certainly not transported is a skull and jaw of *Rhynchotherium* discussed below. This specimen occurred in the base of the gravel and in fact had settled about three inches into the top of the green clay unit below. There are also certain fragile mammal teeth and some finely denticulated shark teeth that could not have undergone significant transport.

In this area the accumulation of the Bone Valley Formation is probably localized. In a nearby borrow pit north of the Manatee River the unit is totally absent, although the section is otherwise similar.
Section in southwest corner Borrow Pit #1, Manatee County Water Treatment Plant, about 100 years southwest of Little Manatee River near Boggy Creek (altitude 21 feet)

<table>
<thead>
<tr>
<th>Quaternary</th>
<th>Thickness in ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Surficial sand; lower 3 ft with pebbles of phosphate and quartz.</td>
<td>13'</td>
</tr>
<tr>
<td><strong>Unconformity</strong></td>
<td></td>
</tr>
<tr>
<td>Bone Valley Formation:</td>
<td></td>
</tr>
<tr>
<td>2. Gravel, phosphate pebbles of white, green, tan and black color. rare quartzite; pebbles rounded; matrix, tan to cream, medium to coarse clayey sand with numerous fine phosphate pebbles; terrestrial and marine vertebrates common, often water-worn.</td>
<td>1'-3'</td>
</tr>
<tr>
<td><strong>Unconformity</strong></td>
<td></td>
</tr>
<tr>
<td>3. Clay, grayish green, sandy, 20 percent phosphorite particles, massive, or with very thin partings, relatively unconsolidated; basal 1 ft conglomeratic with phosphate and quartzite pebbles.</td>
<td>9'-11'</td>
</tr>
<tr>
<td><strong>Unconformity</strong></td>
<td></td>
</tr>
<tr>
<td>Middle Miocene:</td>
<td></td>
</tr>
<tr>
<td>Hawthorne Formation:</td>
<td></td>
</tr>
<tr>
<td>4. Silt, greenish gray to yellowish green, argillaceous fine to coarse sandy, with gray and black phosphate granules, five or six massive graded beds, well consolidated especially near top of each bed, Callinassa and mollusk burrows and bioturbation especially near top of each bed, marine fossils include Balanus sp., Mercenaria nannodes, and two partial skeletons of Halicarnass</td>
<td>17'</td>
</tr>
<tr>
<td>5. Sand and clay, thin to very thin interbedded units, dark gray fine phosphatic sand, olive green clay.</td>
<td>14'</td>
</tr>
<tr>
<td>6. Limestone (not seen but logged in cores just below exposed surface).</td>
<td></td>
</tr>
</tbody>
</table>

The upper unit in this section consists predominantly of Pleistocene sands. An upper molar of a horse of the genus *Equus* was collected in this unit.

A detailed study of this section, accompanied by heavy mineral and grain size analyses, is in preparation by Drs. Pirkle and Yoho of the University of Florida.

**PALEOECOLOGY**

All the fossils from the Bone Valley Formation at the Manatee County Dam Site represent vertebrate animals. They compare closely with similar materials found in the Bone Valley Phosphate District. The few Bone Valley taxa that are absent from the Manatee Site, such as antilocaprids and certain carnivores, are rare groups that could have been missed simply by chance.

The Manatee terrestrial fauna cannot be taken as a representative sample of the total vertebrate community that once lived in that area. Only the large herbivores are adequately represented. Medium to large-sized carnivores are meagerly sampled, while the diversity of small reptiles, amphibians, insectivores, bats, rodents, and rabbits that surely belonged to the terrestrial communities are totally unrecorded. The bias
is in favor of the larger terrestrial vertebrates. In the Manatee Site there also appears to have been rigorous selection against light materials, including many bones. An overwhelming majority of the preserved vertebrate remains are teeth.

The nature of the sediments clearly points to the explanation for this bias. Such coarse, well sorted deposits imply high competence in the mode of aquatic transport. The complex depositional history of these deposits precluded the preservation of the smaller, lighter, and less durable vertebrate remains.

The Manatee vertebrates include groups of species from two distinct habitats: an estuarine marine community, on the one hand, and a terrestrial savannah community, on the other. The site of deposition coincides with the locus of the estuarine community as shown by abundant small marine vertebrate specimens. The terrestrial suite of fossils was more stringently sorted for durable elements. Along with the quartz pebbles and other coarse clasts they were transported from a short distance inland.

The terrestrial fauna occupied a wet savannah situation near the mouth of a major river. The most abundant ungulates in this fauna are the horses. All of them are hipparionine types with extremely hypsodont dentitions, highly specialized for grazing. They retained well-developed side toes which may have provided maneuverability on soft substrates (Shotwell, 1961). The tortoises and camels were also specially adapted to grassland feeding.

Access to a fresh-water aquatic situation is implied by the short-legged presumably amphibious rhinoceros Teleoceros. Tapiravus closely resembles the modern tapirs, which usually frequent swamps and major water courses.

Further indication of a partially aquatic situation is provided by the occurrence of the mastodon Rhyncotherium at the Manatee County Dam Site. The unusual flattened and enamelled lower tusks of Rhyncotherium evidently worked with the uppers to provide a scissor-like grasp for gathering lush vegetation. This arrangement along with the downturned symphysis was interpreted by Frick (1933, p. 515) to show that: "Rhyncotherium may have subsisted largely on the vegetation of marshes and ponds, its shear-like incisors and depressed mandibular symphysis possibly being adapted to the quick severing of the slimy roots of succulent water plants". Probable fresh-water aquatics are the Chrysemys turtles and the alligators. A ridge-toothed crocodylid is also present and probably was an estuarine type.

Near the Pliocene coast at Manatee there were complex interrelationships between the lowland savannahs, freshwater streams, and estuaries as sea level underwent minor fluctuations. All these habitats were sampled, and animals from adjacent sites were deposited together, with rapid but not extensive transport.
Table 2

Sharks from Manatee County and habitats of Recent congeners

<table>
<thead>
<tr>
<th>Fossil species</th>
<th>Percent of elasmo-branch fauna</th>
<th>Recent Florida congeners</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Odontaspis cuspidata</em></td>
<td>0.3</td>
<td><em>Odontaspis taurus</em></td>
<td>Coastal</td>
</tr>
<tr>
<td><em>Odontaspis macrole</em></td>
<td>8.8</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td><em>Isurus hastalis</em></td>
<td>4.5</td>
<td><em>Isurus oxyrinchus</em></td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>Carcharodon megalodon</em></td>
<td>3.2</td>
<td><em>Carcharodon</em></td>
<td>Pelagic but occasionally coastal</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>carcharias</strong></td>
<td></td>
</tr>
<tr>
<td><em>Galeocerdo cuvieri</em></td>
<td>2.6</td>
<td><em>Galeocerdo cuvier</em></td>
<td>Coastal or estuarine</td>
</tr>
<tr>
<td><em>Galeocerdo aduncus</em></td>
<td>0.7</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td><em>Rhizoprionodon</em></td>
<td>0.9</td>
<td><em>Rhizoprionodon</em></td>
<td>Coastal or estuarine</td>
</tr>
<tr>
<td><em>terrae-novae</em></td>
<td></td>
<td><strong>terrae-novae</strong></td>
<td></td>
</tr>
<tr>
<td><em>Carcharhinus leucas</em></td>
<td>39.9</td>
<td><em>Carcharhinus leucas</em></td>
<td>Coastal, fresh or estuarine</td>
</tr>
<tr>
<td><em>Negaprion brevirostris</em></td>
<td>35.5</td>
<td><em>Negaprion brevirostris</em></td>
<td>Coastal or estuarine</td>
</tr>
<tr>
<td><em>Hemipristis serra</em></td>
<td>4.0</td>
<td>none</td>
<td></td>
</tr>
</tbody>
</table>

The composition of the marine fauna suggests that this community is more fully represented than the terrestrial community at the Manatee County Dam Site. Although many of the teeth and some of the bones representing the marine community have undergone water wear, the bias affecting the marine elements was not as stringent as that against the terrestrials. This is reflected both in the taxonomic diversity of the marine community and in the size range of the elements representing this community. It should be noted particularly that a large number of very small sharks' teeth and certain rather small fish elements were taken by screening.

Further insight into the paleoecology at the Manatee County Dam Site may be gained by analyzing the distribution and habits of the nearest living relatives of the fossil fishes found there. The following is a brief review of such material (table 2).

Recent Congeners of Manatee fossil fishes

*Odontaspis taurus* (Rafinesque)

Congeneric fossil species: *O. cuspidata* (Agassiz) and *O. macrole* (Agassiz)

The single specimen taken by the Cape Haze Marine Lab. (Clark and von Schmidt, 1965) was taken in 6 meters of water. The research unit of Florida Marineland frequently catches this species within 2 miles of shore but never in the nearby intracoastal waterway (Cliff Townsend, personal commun.). This shark is a coastal, shoalwater species usually taken in less than 5 fathoms (Bigelow and Schroeder, 1948) and often coming into 2 to 6 feet of water. It is fairly common on the Florida east coast but apparently rare in the northern Gulf of Mexico. Springer (1963) found adult females of this species to be abundant near shore from the records of the Salerno, Florida gill-net fishery.
Isurus oxyrinchus (Agassiz)

Congeneric fossil species: *I. hastalis*

*I. oxyrinchus* is pelagic, typically near-surface, and fast swimming. The Cape Haze Marine Lab. catch from 1955 to 1964 (Clark and von Schmidt, 1965) did not include *I. oxyrinchus*. However, it occurs in the Atlantic Gulf Stream and is taken occasionally by sport fishermen. Bigelow and Schroeder (1948) note that *I. oxyrinchus* is frequently reported from estuaries in tropical West Africa.

Carcharodon carcharias (Linnaeus)

Congeneric fossil species: *C. megalodon* Agassiz

Little is known of the habitats of this species. It is apparently cosmopolitan, as Bigelow and Schroeder (1948) report a specimen taken in 700 fathoms off Cuba as well as several captures made in shallow water. Clark and von Schmidt (1965) figure a specimen captured in 30 meters of water, and Springer (1939) reports one from 8 miles off Englewood, Florida, which would indicate a depth of about 50 feet. Three specimens have been captured by crews from Florida Marineland within 2 miles of St. Augustine (Cliff Townsend, personal commun.). Scattergood (1962) lists 12 captures from the coast of Maine, and Bachus (1957) records a specimen from 2 miles off Dennis, Massachusetts. In 1916 human remains were taken from a shark of this species following four fatalities in New Jersey, two on bathing beaches and two well up a brackish creek. It is probable that this shark is pelagic but occasionally strays into near-shore and estuarine waters.

Galeocerdo cuvier (Lesueur)

Congeneric fossil species: *G. aduncus* Agassiz

*G. cuvier* is a common shark on both coasts of Florida. It is caught occasionally far from land but more usually in shallow, coastwise water. It is reported to enter bays and river mouths (Bigelow and Schroeder, 1948) and is occasionally taken in the mouth of the St. Augustine inlet (Cliff Townsend, personal commun.).

Rhizoprionodon terraenovae (Richardson)

The *Rhizoprionodon* from the Manatee County Dam Site probably represents this same species. This small shark is found today only in shallow water in inshore areas. It is reported from brackish water of the Pascagoula River in Mississippi (Bigelow and Schroeder, 1948). The junior author has taken several sharks of this species from the shallow waters (4 to 15 ft) around Cedar Key, Florida.

Negaprion brevirostris (Poey)

The fossil *Negaprion* teeth collected at the Manatee County Dam Site were of this same species. This shark is strictly an inshore form and is quite common on both coasts of Florida. Florida Marineland commonly catches these sharks in 60 feet of water within 2 miles of shore but gets its largest specimens on the Nine Mile Reef at about 72 feet (Cliff
Townsend, personal commun.). *Negaprion* ascends into estuaries and euryhaline creeks and is reported from fresh water in Brazil (Bigelow and Schroeder, 1948). Springer (1950) cites the small eye size of the Lemon Shark as evidence of its shallow water affinities but notes that apparently transient specimens have been caught over deep water. It was the third most prominent species (10 percent of the total number) in the Cape Haze Marine Lab. catch (Clark and von Schmidt, 1965). This is one of two species of large shark inhabiting Lake Worth, a saltwater estuary in southeastern Florida (Vorelberg, 1962).

*Carcharhinus leucas* (Muller and Henle)

As mentioned previously, this species was the most abundant shark in the Manatee Dam Site fauna.

Like *Negaprion brevirostris*, this shark is never found far from land. It often enters the larger Florida rivers, going well into brackish water and occasionally into completely fresh water. It is the second species of large shark caught in Lake Worth, Florida (Vorelberg, 1962). *C. leucas* is the freshwater shark found in Lake Nicaragua under the synonym *C. nicaraguensis* (Thorson, Watson, and Cowan, 1966). Bigelow and Schroeder (1948) report other examples of this species in fresh, or brackish to fresh, water from Lake Yzabal, Guatemala; the Atchafalaya River, Louisiana; and 180 miles up the Patuca River in Honduras. This is a very common shark along both Florida coasts and was the most abundant single species captured by the Cape Haze Marine Lab. from 1955 to 1963 (Clark and von Schmidt, 1965).

*Hemipristis*

No recent members of the genus *Hemipristis* are known from Florida waters.

*Order Rajiformes*

*Aetobatus* (Blainville)

The recent spotted Eagle Ray, *Aetobatus narinari*, is a coastal species. It is seldom (if ever) taken more than a mile or two from shore (Bigelow and Schroeder, 1954).

*Genus Myliobatus cuvier*

Recent rays of this genus do travel across the open seas but are most often encountered in coastal waters.

*Class Osteichthyes*
*Order Tetradontiformes*
*Genus Diodon Linnaeus*

Two recent species occur in Florida waters, *D. hystrix*, the porcupine fish, and *D. holocanthus*, the balloonfish. Both these fish occur in shallow inshore waters, particularly bays and inlets.

From the preceding discussion and table 2 the following conclusions can be drawn. Of the shark specimens found at the Manatee Dam Site, 89.3 percent represent species that occur close inshore. If one considers
that the recent *Carcharodon* occasionally enters quite shallow water and that the habitat of *Hemipterus* is unknown, it leaves only the genus *Isurus* as a pelagic, deep-water species. The fossil *Isurus hastalis* differs from the recent *I. oxyrinchus* most obviously in having much wider teeth. It may very well be that its habitat differed also; one might speculate that the broader teeth indicate a less strictly piscivorous diet and perhaps a more inshore habitat. It should also be noted that the recent *I. oxyrinchus*, which is strictly piscivorous (Bigelow and Schroeder, 1954), occasionally does come close inshore in pursuit of mackerel schools.

The presence of *Carcharhinus leucas* and *Negaprion brevirostris* in large number (75 percent of the shark tooth collection) is particularly significant. These two species are the most thoroughly euryhaline of those listed, and both tend to occur in coastal to brackish waters.

In summary, an analysis of the shark species collected at the Manatee County Dam Site indicates a shallow coastal sea or estuary at the time of deposition. The presence of the bony "puffer fish", *Diodon*, the ray *Aetobatus*, and the sharks *Carcharhinus leucas*, *Negaprion brevirostris*, and *Rhizoprionodon terraenovae* add critical evidence to this conclusion. None of the other fishes contradict this conclusion, and recent congers of *Odontaspis* and *Galeocerdo* add weight to it.

**AGE AND CORRELATION**

The Manatee Dam fauna is found in phosphatic gravels exposed at a low elevation near the Little Manatee River. It is common to find Pliocene land vertebrates deposited at low elevations in stream valleys outside the Bone Valley District, such as in the Peace River. Usually it is assumed that they are washed out of the Bone Valley Formation in the phosphate mining district and redeposited in younger fluvial (river pebble) sediments. Clearly this is the correct interpretation in most such instances, as evidenced by the water worn dissociated condition of such Pliocene specimens and by their occurrence alongside unworn Pleistocene specimens. Nevertheless, other possibilities exist.

In the present instance the Pliocene deposits (and the contained fossils) are primary and not redeposited at a later time, as shown by the following evidence:

1. All the fossil material is Middle Pliocene (Hemphillian) in age; no younger or older materials are included.
2. The deposits include certain delicate materials that could have undergone little or no transport. These specimens include numerous shark and ray teeth with delicate denticles, two cementless juvenile horse teeth, and a bird bone. The nearly complete skull, jaw, and tusks of a mastodon are not reworked either.
3. The type of preservation of all the fossil materials is uniform and consistent with a single time and area of deposition.
4. None of the invertebrate fossils characteristic of the underlying deposits are found in the Pliocene gravel unit.
All elements of the vertebrate fauna of the Manatee County Dam Site, excluding the two \textit{Halianassa} skeletons from the underlying Hawthorne Formation, occur in association within a single stratum of coarse clastic materials. Presumably all the materials were deposited within a very short span of time. All the taxa studied yield consistent results with respect to their age. While no single taxon is totally reliable, the several good age indicators taken together, constitute evidence that would be difficult to doubt.

The most reliable single indicator of Hemphillian age in this fauna is the large hipparionine horse \textit{Neohipparion}. Though the species cannot be determined with certainty, it is very close to \textit{Neohipparion phosphorum} Simpson from the classical Bone Valley District and surely belongs in the \textit{N. euryystyle} species group. Members of this group are restricted to deposits of Hemphillian age and are distinctly advanced over members of the \textit{N. occidentale} group of Clarendonian age.

\textit{Nannippus minor} (Sellards) and \textit{Hipparion ingenuum} (Leidy) are little known outside of southeastern United States. Until they can be more closely tied into known evolutionary lineages, their significance as age indicators must remain somewhat dubious. Nevertheless, the stage of evolution within hipparionine horses generally, indicated by the degree of hypsodonty in both species, the small size of \textit{N. minor}, and the enamel complexity in \textit{H. ingenuum}, strongly suggests Hemphillian age.

The rhinocerotid teeth (genus \textit{Teleoceras}) from the Manatee Site are among the most hypsodont known from North America. Presumably they pertain to the final chapter of New World rhinocerotid history which is fixed by numerous records as Hemphillian.

\textit{Geochelone turgida} (Cope) was hitherto known only from Hemphillian faunas of the southern Great Plains. Its occurrence at the Manatee Dam Site further confirms the Hemphillian age of this fauna. Likewise, the extinct pond turtle, \textit{Chrysemys inflata} (Weaver and Robertson), is known only from Hemphillian deposits (Rose and Weaver, 1966) and is more primitive than its nearest relatives from Blancon deposits.

Other mammalian taxa in this fauna indicate an age of Hemphillian or older but cannot be relied upon for greater refinement. These include the horse, \textit{Griphippus}, and the tapir, \textit{Tapirus}. On the other hand the presence of \textit{Tanupolama} indicates an age of Hemphillian or younger. The overlap of ranges in these genera further indicates a Hemphillian age.

In summary, many elements of this fauna point to the same age and none contradict it. The combined evidence of many taxa deposited contemporaneously leads surely to the conclusion that this fauna of the Manatee County Dam Site is Hemphillian (Middle Pliocene) in age. It is probably younger than the early Hemphillian McGehee Site in Alachua County, Florida, and may be as young as the typical Bone Valley fauna. Potassium-argon dates from fossiliferous volcanic sequences in western
United States show that the Hemphillian extended from about 10 to about 4 m.y. before the present (Evernden and others, 1964).

STRUCTURAL RELATIONSHIPS

The elevation of the Bone Valley Formation at the Manatee County Dam Site is less than 10 feet above present mean sea level. This is considerably lower (about 100 ft) than typical levels in the Bone Valley District and is considerably lower than any occurrence of this formation previously described. The low elevation of those deposits might be explained in either of two general ways:

1. The original depositional surface of the Bone Valley gravel moved rapidly downward to the west. Since this occurrence is on the far western edge of previously described outcrops, it would be expected to be considerably lower than the rest, or

2. Westward tilting or other structural deformation subsequent to the time of deposition of Bone Valley Gravel lowered this site.

It is highly probable that the first explanation (original depositional surface) is the correct one. Wherever the structure of the Bone Valley has been carefully studied it exhibits little or no deformation. For example, Cathcart (1968a) showed in the Plant City Quadrangle that whereas the underlying Hawthorne Formation is arched up over the Hillsborough High, the Bone Valley Formation thins out on its flanks. Similarly, in the northern part of the same quadrangle, the Hawthorne and older formations dip rather steeply to the southeast in conformity with the plunge of the Ocala Arch, whereas the overlying Bone Valley Formation dips gently northward in what is presumably its original altitude. In the area east of Bartow, Ketner and McGreevey (1959, p. 75) point out that the Citronelle Formation of probable late Miocene age was not involved in structures associated with the Ocala Uplift which produced in the same area vertical displacements of several hundred feet.

These observations apply to local sections within some of the most deformed parts of the Bone Valley District. They strongly suggest that post-Hawthorne sediments in the area have not been affected appreciably by structural changes.

Similar views prevail regarding the overall structural history of Florida. Cooke (1945), Vernon (1951), Carr and Alverson (1959), among other students of Florida geology, conclude that the major Cenozoic orogenic episodes preceded the deposition of the Hawthorne Formation, that some final activities did involve the formation, but that no younger sediments were affected. These conclusions are in accord with the above observations in the Bone Valley District.

Further evidence of the stability of peninsular Florida during the Late Cenozoic may be provided by the marine terraces (see discussion below). Clearly no significant warping has affected the uniformity of elevation of these terraces (MacNeill, 1950; White, 1958; and Alt and Brooks, 1964). However, the ages of these terraces are subject to con-
siderable controversy. Current opinions on the age of the oldest clearly recognizable shoreline (Okefenokee) range from Late Miocene (Alt and Brooks, 1964), to preglacial (Doering, 1958) to Yarmouthian (MacNeill, 1950). As implied below, we favor Tertiary antiquity for at least the two oldest terraces. But until this matter is settled, it is unclear whether the horizontal shorelines prove peninsular stability since Late Miocene time or only since the Yarmouthian.

Cooke (1945, p. 5-6, 198) suggested that the Gulf Coast of the Florida Peninsula was downwarped at about the end of the Pliocene. He cited possible evidence of this near Tampa Bay and from there north. However, south of Tampa Bay, particularly in Manatee County, there is convincing evidence that no such warping occurred. Cathcart (1962, 1963a, 1963b, and 1963c) drew contours on the limestone member of the Hawthorne Formation and found, besides an ancient drainage pattern incised into the limestone surface, only a gentle southerly dip. Even on the Ocala Limestone of Late Eocene age, Vernon (1951) found only a slight southward dip in Manatee County. No examples of faulting or limestone collapse have been observed in the area. Thus, there is no reason to doubt that the Manatee deposits have been structurally stable since before the Bone Valley Gravels were deposited.

The simplest and most probable explanation for the low elevation of the Bone Valley Gravel at the Manatee Site is the initial depositional slope of the formation. It tends to thin away from the Ocala Arch. At the Manatee Site one finds the southwestern feather-edge of the formation. This pattern suggests that one would expect the original surface of the Bone Valley Formation to slope off of the Ocala Arch. Moreover, since that formation is predominantly fluvial and estuarine, one might expect it to exhibit greater irregularities and in many places steeper slopes than the underlying marine deposits.

**Pliocene Sea Levels**

The Bone Valley gravels at the Manatee County Dam Site accumulated under estuarine conditions and therefore must have been at about mean sea level. Since these gravels now lie 6 to 10 feet above mean sea level, the sea then stood only slightly above its present elevation. This is considerably below the level generally postulated for Pliocene seas (Cooke, 1945; Alt and Brooks, 1964; Alt, 1967). It is necessary, therefore, briefly to review the evidence in Florida bearing on Pliocene sea levels.

**Shorelines.**—The sequence of shorelines in peninsular Florida has been thoroughly mapped and analyzed by Cooke (1945) and MacNeill (1950). Cooke discussed seven such shorelines, but MacNeill, applying more rigorous criteria, recognized only four. The shorelines he recognized are the following:

| Okefenokee | 150 feet above present sea level |
| Wicomico | 100 |
| Pamlico | 30 |
| Silver Bluff | 10 |
fauna from low elevation in Manatee County, Florida

Some intermediate stands of the sea also were noted between the Pamlico and the Wicomico shorelines.

Recently Altschuler and Young (1960) and Altschuler, Cathcart, and Young (1964) have suggested that even the Okefenokee and Wicomico shorelines are more apparent than real, and that they are merely residual sand blankets derived irregularly from underlying deposits. Although their observations are surely correct in several local sections, this view seems unduly skeptical as a regional generalization. The problem is discussed further by Pirkle, Yoho, and Webb (1967).

The origin of these shorelines generally has been attributed to high Pleistocene seas resulting from interglacial melting of continental ice sheets. More recently, however, Alt and Brooks (1964) and Alt (1967) have suggested that only the Pamlico shoreline is of Pleistocene interglacial origin, and that the higher shorelines mark the stands of successively older Tertiary seas.

Of particular interest here is their suggestion that the Wicomico shoreline at approximately 100 feet above present sea level is Pliocene in age. As evidence of this age they point out that “the youngest fossiliferous marine deposits immediately underlying the terrace associated with the 90-100 foot shoreline are the Caloosahatchie Marl, Charlton Formation, and the Waccamaw Formation”, which generally have been dated by invertebrate paleontologists as Pliocene. They also note that a number of Pliocene land vertebrate sites occur just landward from the Wicomico shoreline. More recently Brooks (personal commun.) has suggested that the major Pliocene stand was at 120 to 140 feet in elevation.

Distribution of Pliocene land vertebrate localities.—The places in Florida that contain Pliocene land vertebrates are indicated in figure 1. The only other such sites east of the Mississippi River are near the mouth of the Ashley River in South Carolina and near Mobile, Alabama. The localities shown in this figure actually represent a much larger number of fossil sites, groups of which have been clustered on this map. In particular, the Bone Valley District contains a large number of land vertebrate sites that are treated here as a unit.

The distribution of most of these sites approximates the mapped area of outcrop of the Bone Valley and Alachua Formations (Vernon and Puri, 1964). Three surface extensions of terrestrial Pliocene deposits beyond presently mapped areas should be noted. One is the Manatee Site, a westward extension of the Bone Valley Formation. The second is the long northern tract that runs through Columbia, Suwanee, and northern Gilchrist counties and connects the mapped deposits of southern Gilchrist County to those of Hamilton County. And the third (southward) extension consists of scattered undescibed collections from thin lowland deposits along the Caloosahatchie and Kissimmee Rivers.

The sediments containing these terrestrial vertebrates of Pliocene age are of two fundamental types: coarse clastics with dark phosphatic pebbles and sandy montmorillonitic clays. Unreworked Pliocene land
vertebrates have been found in no other kinds of sediments in eastern United States.

The best examples of the clay deposits are Mixson's Bone Bed, 1½ miles northeast of Williston in Levy County, and Withlacoochee 4a, a new site 8 miles southeast of Dunnellon in Marion County. The Mixson's locality is also the type of Sellards Alachua Clay (later broadened to the Alachua Formation of diverse and inconsistent usage; see Webb, 1964). The clay, orange or red when oxidized but blue-green in an unweathered state, fills sinkholes in the Ocala Limestone of late Eocene age. Presumably the abundant mastodonts, ground sloths, turtles, alligators, bone-crushing dogs, and several kinds each of rhinoceroses, horses, and camels including several articulated specimens, were trapped in sinkhole ponds. There is no evidence of any marine or estuarine influence at either Mixson's or the Withlacoochee site.

Such clay deposits, especially fossiliferous ones, are not nearly as common as the phosphatic coarse clastics. Both types of sediments occur together at the McGehee Site, a few miles north of Newberry in Alachua County. The Alachua clays are interbedded with coarse phosphatic sands, and both kinds of sediments produce Pliocene terrestrial and aquatic vertebrates. The vertebrate fauna also includes a major estuarine component. The geometry and texture of the sediments further indicate a fluvio-estuarine situation (Webb, 1964; Hirschfeld and Webb, 1968).

In the Bone Valley District, Pliocene land vertebrates occur in two different units within the Bone Valley Formation (Webb, Tessman, and Waldrop, ms). In the lower unit of predominantly fine phosphatic montmorillonitic clays and sands, the terrestrial vertebrates are rare. The shallow marine fauna, including a diversity of sharks, rays, some bony fishes, articulated remains of crocodilians, dugongids, and cetaceans, and occasional lenses of oysters, predominates. The upper unit, the Bone Valley Gravel (sensu stricto), is developed as a coarse clastic deposit filling channels cut into the lower unit of the Bone Valley Formation (sensu lato). This gravel unit produces the bulk of the Pliocene land vertebrates known from the Bone Valley District. However, at most localities, it also includes an estuarine component represented by unworn teeth of most of the sharks and many of the other marine taxa that occur in the subjacent unit.

Northward from the Bone Valley District occurrences of the Pliocene phosphatic gravels are spotty. This is evidently a function of their position with respect to the Ocala Arch. Instead of resting on the embayed surface of the Hawthorne Formation as they do in the Bone Valley District, they fill declivities in the karst surface developed during Oligocene and Miocene time on Eocene and Oligocene limestones. These more northerly Pliocene phosphatic coarse clastics accumulated predominantly in irregular depositional basins and straths under fluvialte or estuarine conditions. This situation is exemplified by the Occidental Mine near White Springs in Hamilton County (Brooks, 1966).
Fauna from low elevation in Manatee County, Florida

Refined ages of the Florida Pliocene sites.—It is a curious fact that all the Florida Pliocene land vertebrate sites that can be accurately dated are Middle Pliocene (Hemphillian sensu, Wood and others, 1941). Some of the sites included in figure 1 cannot be assigned with full confidence to a subepoch within the Pliocene; however, even in these instances the probability is that they are Hemphillian.

It is just becoming possible to resolve the age determinations of several Hemphillian sites even further. For example, it is clear that the McGehee Site is early Hemphillian (Hirschfeld and Webb, 1968), whereas the Upper Bone Valley terrestrial vertebrate fauna (at all sites where dating is possible) appears to be late Hemphillian. The new Withlacoochee 4a site appears to be earlier than the Upper Bone Valley fauna on the basis of the less advanced characters of the various equidae and of a new species of Osteoborus therein (Webb, ms). Unfortunately the fauna from the Manatee Site cannot be aged so accurately, except to note that it is not as early as the McGehee fauna.

Pliocene sea level fluctuations.—Deposits containing Hemphillian land vertebrates occur at three principal elevations in Florida. A few occurrences are “high deposits” from about 110 to over 150 feet above present sea level. Such localities occur, for example, around Gainesville in Alachua County in the form of fluviatile deposits of gray phosphatic sands and gravels. In Florida wherever these high level deposits are found they are either fluviatile coarse clastics or sinkhole clays; no estuarine or marine deposits are known. Where fragmentary marine vertebrates are associated they can be shown to be reworked from nearby outcrops of the Hawthorne Formation of Miocene age.

A second group of localities occurs at elevations between 70 and 120 feet. The best known are the McGehee Site in Alachua County, Mixson’s Bone Bed in Levy County, and the Bone Valley sites in the central part of the phosphate district. While Mixson’s and McGehee both occur at the same elevation, the McGehee Site clearly reflects an estuarine influence, whereas the Mixson’s Site does not (Webb, 1964). The Hemphillian Bone Valley sites include shallow marine, estuarine, fluviatile, and intermediate situations.

A third most interesting group of Hemphillian land vertebrate localities occurs at lower elevations. The Manatee Site is the lowest of these that definitely occurs in place. The new Withlacoochee 4a Site is also indicative of a low sea level. The rich vertebrate fauna from this site includes no estuarine or marine component but does include representation of a probable forest community not sampled in the McGehee or Bone Valley faunas (Webb, 1967). The site extends about 30 feet downward from the surface of the Withlacoochee River, which itself is 40 feet above present sea level. Hence it represents a forested inland situation at an elevation of less than 10 feet above present sea level.

Conclusions regarding Pliocene sea levels.—The physiographic evidence in Florida indicates a probable Pliocene sea stand at an elevation
of 100 feet or more (Alt and Brooks, 1964; Alt, 1967). Moreover, the McGehee and Bone Valley vertebrate faunas occur at elevations of 70 to 120 feet and contain significant estuarine components. Taken together these independent lines of evidence provide a strong argument for a stand of the sea at 100 or more feet in the Hemphillian (Middle Pliocene).

Physiographic evidence of lower sea levels in the Pliocene cannot be obtained because subsequent Pleistocene eustatic events have destroyed and covered them. However, the vertebrate evidence particularly at the Manatee Site and at Withlacoочee 4a provides substantial evidence that the sea reached about as low as its present level, if not lower, sometime during the Hemphillian (Middle Pliocene).

Clearly, then, sea level moved more than 90 feet vertically within Hemphillian time. Which direction did it move at which time? The answer depends upon refined correlations between the Hemphillian vertebrate faunas of Florida. The McGehee fauna is distinctly earlier than the other adequately known faunas. The Withlacoочee 4a and the Bone Valley faunas are clearly later Hemphillian, and, tentatively, the former is regarded as older than the latter. Unfortunately the age of the fauna from the Manatee Dam Site is not subject to such refinement (see above section on "age and correlation"), except that it is younger than the McGehee fauna.

If the refined correlations of these four faunas are considered in relation to the sea level indicated by each, the simplest relationship that emerges is indicated in figure 2. The Manatee Site might be related to the fluctuation of unknown latitude marked by the major unconformity within the Bone Valley Formation, or it might be related to the low sea

![Fig. 2. Eustatic fluctuations of sea level during Hemphillian (Middle Pliocene) time.](image-url)
indicated for the Withlacoochee Site. The simplest picture is the latter. Sea level stood at about 100 feet near the beginning of the Hemphillian time interval. It dropped to near its present level or lower near the middle of the Hemphillian. The Hemphillian sea attained its maximum height late in that stage during deposition of the lower part of the Bone Valley Formation. A lowering of unknown vertical extent, but evidently of short duration, preceded the final stage of Bone Valley deposition, represented by the Bone Valley Gravel of very late Hemphillian age. The highest stand of the Hemphillian sea is represented physiographically by either the Wicomico or the Okefenokee shoreline (see map in McNeill, 1950).

Evidence from other regions.—Similar complexity in the evidence bearing on Pliocene sea levels occurs in the Charleston phosphate district. The situation there in South Carolina is of considerable interest because there too, the sediments occupy a structurally stable area. Malde (1959, p. 83) summarizes his findings there as follows: “During the Pliocene the relations of land and sea were about as today, but for a time the sea covered a narrow belt along the present coast and left thin beds of shells mixed with sand the Waccamaw Formation. Fluctuations of sea level may have been greater than those shell deposits near the coast indicate, because marine mollusks which seem related to Pliocene forms are found further inland 65 feet above present sea level and also nearer the coast 83 feet below present sea level”. Of course the last site does not indicate a drop of sea level to 83 feet but provides only a lower limit to how far the shoreline may have dropped. These data indicate fluctuation of Pliocene seas between a low stand near present sea level or lower and a high stand at or above 65 feet. The relevance of these data to the Bone Valley situation is obvious. The ages of Charleston Pliocene deposits have not been determined precisely. Hence, one cannot be sure how the Pliocene chronology of fluctuations there relates to evidence in peninsular Florida. It is possible that both areas reflect the same cycle of changes.

Since peninsular Florida and Charleston, South Carolina, were structurally stable areas, the observed fluctuations in sea level presumably represent worldwide eustatic events. Confirmatory evidence is found in the stable region north of the Red Sea (Souaya, 1963). Also, in the European sequence, the Pontian regression might reflect the same eustatic drop observed in Manatee County.

Recent work in polar regions of the world provides increasing evidence of pre-Quaternary glacial phenomena (Donn and Ewing, 1966; Rutford and others, 1967). Such polar glaciation may have been the primary cause of the Middle Pliocene drop in sea level described here.

It would be expected that if glacial activity in polar regions is correlated with regressions of Tertiary seas, there would also be evidence of cooler water during or a little later than the episodes of lowered sea levels. In this connection, Bandy’s (1966 and 1967) description of the spread of cold-water Foraminifera in the Middle Pliocene is of great
interest. The time of a major temperature drop in Pliocene seas, according to Bandy's evidence, was about 10 m.y. before the present. This accords well with the Hemphillian age indicated for the low sea level stand at the Manatee Site.

Vertebrate paleontologists have long recognized that the Hemphillian was an age of extensive faunal interchange between North America and Eurasia. And, more recently, it has been shown that intermingling of the continental faunas of North and South America also was established during the Hemphillian (Olson and McGrew, 1941; Webb, 1964; Hirschfeld and Webb, 1968). Eustatically established corridors may be the principal condition favoring the interchange of these continental faunas during Hemphillian time.

**SYSTEMATIC PALEONTOLOGY**

The fossils from the Manatee Dam Site are exclusively vertebrates. A complete list of taxa is presented in table 3.

**CLASS ELASBOBRANCHII**

**ORDER SELACHII**

Shark teeth were by far the most abundant specimens at the Manatee County Dam Site. Over 870 were identified. A somewhat smaller number of teeth were too worn or fragmentary to work with. Even very small shark teeth were obtained by sorting through fine window screen, thus reducing size bias in collecting.

The tooth terminology used here follows Applegate (1965 and 1967). A shark’s tooth consists of two basic parts, the enamel covered *crown* and the osteodentine *root*. Subdivisions of the crown are called *crownlets* (example *Ginglymostoma*). A *flange* is a fingerlike projection bringing the enamel down onto the root (example *Ginglymostoma*). Tooth *denticles* may occur lateral to the crown (example * Odontaspis*) and are smaller and more pointed than crownlets. A tooth blade may occur posterior to the crown (example *Galeocerdo*). The *anterior* edge of a tooth is that toward the symphysis, and the *posterior* edge is that toward the jaw hinge. *Lingual* and *labial* face inward toward the tongue and outward away from the tongue respectively.

The relative abundance of each of the ten species of shark is presented in table 2. The present habitat of each species or that of its nearest Recent relative is shown in the same table. The probable habitat at the site of deposition is discussed earlier in this paper.

Family Odontaspidae

*Odontaspis macrota* (Agassiz)

(UF 11907)

Teeth of this species are notably more robust than those of the Recent *O. taurus* Muller and Henle. The root is heavily triradiate, and the
TABLE 3
The vertebrate fauna of the Manatee County Dam Site

Elasmobranchii

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
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<tbody>
<tr>
<td>Odontaspidae:</td>
<td><em>Odontaspis macrota</em> (Agassiz)</td>
</tr>
<tr>
<td></td>
<td><em>Odontaspis cuspidata</em> (Agassiz)</td>
</tr>
<tr>
<td>Isuridae:</td>
<td><em>Carcharodon megalodon</em> Agassiz</td>
</tr>
<tr>
<td></td>
<td><em>Isurus hastalis</em> Agassiz</td>
</tr>
<tr>
<td>Carcharhinidae:</td>
<td><em>Carcharhinus leucas</em> (Muller and Henle)</td>
</tr>
<tr>
<td></td>
<td><em>Negaprion brevirostris</em> (Poey)</td>
</tr>
<tr>
<td></td>
<td><em>Hemipristis serra</em> Agassiz</td>
</tr>
<tr>
<td></td>
<td><em>Galeocerdo cuvieri</em> (Peron and Le Sueur)</td>
</tr>
<tr>
<td></td>
<td><em>Galeocerdo aduncus</em> Agassiz</td>
</tr>
<tr>
<td></td>
<td><em>Rhizoprionodon cf. terrae-novae</em> (Richardson)</td>
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</table>

Rajiformes

<table>
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<tr>
<th>Family</th>
<th>Species</th>
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<tbody>
<tr>
<td>Myliobatidae:</td>
<td><em>Actobatus</em> sp.</td>
</tr>
<tr>
<td></td>
<td><em>Myliobatus</em> sp.</td>
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<tr>
<td>Pristidae:</td>
<td><em>Pristis</em> sp.</td>
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Osteichthyes

Tetradontiformes

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Perciformes

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Reptilia

Chelonia

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<tr>
<td>Testudinidae:</td>
<td><em>Chrysemys inflata</em> Weaver and Robertson</td>
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<td></td>
<td><em>Geochelone cf. turgida</em> (Cope)</td>
</tr>
<tr>
<td>Cheloniidae:</td>
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<tr>
<td>Trionychidae:</td>
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<td></td>
<td><em>Trionyx</em> sp.</td>
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Crocodilia

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<tr>
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<td><em>cf. Characostusthus</em> Langston</td>
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<td>Alligatoridae:</td>
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Aves

Pelicaniformes

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Mammalia

Carnivora

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<td>Proboscidea:</td>
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<td>Gomphotheriidae:</td>
<td><em>Rhynochotherium cf. euhypodon</em> (Cope)</td>
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Perissodactyla

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<td>Tapiridae:</td>
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<tr>
<td>Rhinocerotidae:</td>
<td><em>Teleoceras</em> sp.</td>
</tr>
<tr>
<td>Equidae:</td>
<td><em>Gnophippus</em> sp.</td>
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<tr>
<td></td>
<td><em>Neohipparion cf. phosphorum</em> Simpson</td>
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<tr>
<td></td>
<td><em>Nannippus minor</em> (Sellards)</td>
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<tr>
<td></td>
<td><em>Hipparion ingenuum</em> Leidy</td>
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Artiodactyla

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<th>Family</th>
<th>Species</th>
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</thead>
<tbody>
<tr>
<td>Camelidae:</td>
<td><em>cf. Tanupolama</em></td>
</tr>
</tbody>
</table>

Mammalia
crown is narrow and recurved. The tooth denticles are curved and spur-like and lie at the point of junction with the root. More than one pair of denticles may be present.

*Odontaspis cuspidata* (Agassiz)

These teeth (UF 11908) are apparently identical to those of the extant sand shark, *Odontaspis taurus* Muller and Henle. Long recurved slender crowns and acutely angled roots characterize this form. All but posterior teeth bear a single pair of lateral tooth denticles.

**Family Isuridae**

*Carcharodon megalodon* Agassiz

The teeth of this species are large and robustly triangular. Both anterior and posterior margins of the crown bear coarse serrations. Lower teeth are more narrow than uppers and have more concave margins. The broad, serrate lateral denticles that characterize *C. auriculatus* Agassiz of the Paleogene formations of Florida are absent in *C. megalodon*. Follett (1966) figures such denticles on a very young shark of the recent species *C. carcharias* Linnaeus, so it is possible that very small teeth of *C. megalodon* might also exhibit this character. The Manatee fossil teeth differ from the extant species *C. carcharias* Linnaeus by having broader, more convex crowns in both upper and lower teeth. It appears that very large specimens of *C. carcharias* resemble *C. megalodon* much more in tooth form than do smaller individuals. It is possible that these species are identical.

*Iurus hastalis* (Agassiz)

This species is quite different from the extant *Iurus oxyrinchus* Rafinesque. The fossil teeth (UF 11909) have much broader crowns anterioposteriorly than does *I. oxyrinchus*. The anterior teeth of *I. hastalis* do not show the heavily triradiate “root” pattern of the anterior teeth of *I. oxyrinchus*. Teeth of this genus consistently lack serration and lateral denticles.

**Family Carcharhinidae**

*Carcharhinus leucas* (Muller and Henle)

Upper teeth of this species are broadly triangular with moderately coarse serrations. The lower teeth are slimmer and less coarsely serrated. This was the most abundant shark in the Manatee Dam Fauna (UF 11910).

Bigelow and Schroeder list 12 recent species of *Carcharhinus* as possibly occurring in Florida water and Clark and von Schmidt (1965) report six of these species in the recent Gulf of Mexico fauna of Florida. Of these only *C. leucas* has been identified in the Manatee Fauna. Artificial tooth sets constructed of Manatee fossil teeth compare closely with recent *C. leucas* dentitions. The fossil tooth sets differ from other recent species as follows: The fossil teeth are entirely serrate on both crown and base; this eliminates *C. falciformis* and *C. maculipinnis*, in which the lower teeth are smooth-marginated, and *C. limbatus*, *C. longimanus*, *C.*
milberti, and *C. oxyrhynchus* which have smooth-based lowers. The fossil teeth are quite regularly serrate, whereas the uppers of *C. obscurus* and *C. springeri* have stronger serration on the outer base than on the crown. The upper teeth in the fossil series are more broadly triangular than those of *C. acronotus, C. romotus*, and *C. porosus.*

*Negaprion brevirostris* (Poey)

The teeth of this shark (UF 11911) are nearly as common in the Manatee Dam Site as those of *Carcharinus leucas.* Upper teeth of this species may be identified by the narrowly triangular, smooth-edged crowns and irregularly crenulate bases. Lower teeth are a little slimmer than uppers and are entirely smooth. Both uppers and lowers become increasingly oblique toward the corners of the jaw. Fossil *Negaprion* have been referred to such extinct species as *N. gibbesi* (Woodward) and *N. magnus* (Cope). However, the close similarity between the Manatee *Negaprion* teeth and *N. brevirostris* precludes referring them to anything other than the extant species.

*Hemipristis serra* Agassiz

The genus *Hemipristis* is no longer extant in American waters but is reported from the Red Sea as *H. elongatus* (Klunzinger) by Fowler (1941) and from the Philippine Sea (Carter Gilbert, personal commun.).

The roots of the upper teeth of *H. serra* (UF 11912) are characteristically “gull-winged” in cross section. The anterior margins of the upper teeth are convex, and the rear are concave, causing the tooth to curve toward the corner of the jaw. Both margins of the upper teeth are coarsely serrate, with the serrations ending abruptly short of the tip. The lower teeth are similar but straighter and more slender with serrations ending midway above the root.

*Galeocerdo cuvieri* (Peron and LeSueur)

Teeth of this species (UF 11913) are asymmetrical, with the crown rounding on the posterior margin to a notch about halfway to the tip. By contrast, the anterior margin curves quite smoothly to the tip. The serrations are coarse, becoming finer near the tip and on the extreme bases. Upper and lower teeth are nearly identical in form.

*Galeocerdo aduncus* Agassiz

These teeth (UF 11914) occur sparsely in the Manatee Dam fauna. They differ from *G. cuvieri* in bearing more elongate and slender crowns. The serrations of the crown are less coarse than those of *G. cuvieri.*

*Rhizoprionodon cf. terrae-novae* (Richardson)

These teeth (UF 11915) are smooth crowned, with wavy posterior bases. The crown slopes obliquely toward the posterior of the jaw. The fossil teeth are closely similar to teeth in four Recent dentitions of *R. terrae-novae,* but they appear to be slightly broader crowned.
ORDER RAJIFORMES
   Family Myliobatidae
   Genus Aetobatus Blainville

   Lower and upper tooth bands of an eagle ray similar to those of the
   extant Aetobatus narinari (Euphrasen) were collected at the Manatee
   County Dam Site. The acute posterior angle of the lower tooth bands
   of this genus make it readily identifiable.

   Tail spines characteristic of this genus were also collected, although
   the close similarity of the tail spines of Aetobatus to those of Dasyatis
   and Myliobatus make these a less definite character than the tooth bands.

   Genus Myliobatus Cuvier

   The median tooth bands of this genus are more arched at the ends
   than in the middle with the general effect being a slow curve rather than
   the angle of Aetobatus. Tooth bands of rays of the genus Myliobatus oc-
   curred in about the same frequency as did those of Aetobatus. As noted
   above, it is difficult to separate tail spines of the Myliobatidae from those
   of the Dasyatidae.

CLASS OSTEICHTHYES
ORDER TETRAODONTIFORMES
   Family Diodontidae

   Beak elements of Diodontid fish were collected at the Manatee Dam.
   Comparison with recent forms showed affinity to the genus Diodon and
   probably to a form quite like the extant Balloonfish, Diodon holocanthus
   Linnaeus.

ORDER PERCIFORMES
   Family Sciaenidae

   Numerous crushing teeth of Sciaenid fishes were included in the
   Manatee Dam sample. Some of these are similar to those of the extant
   Black drum, Pogonias cromis (Linnaeus). No concentrated effort at
generic identification of these teeth was attempted.

CLASS REPTILIA
ORDER CHELONIA
   Family Testudinidae

   Chrysemys inflata Weaver and Robertson

   This new species was based on materials from the central part of the
   Bone Valley phosphate district. As usual, the stratigraphic origin was
   not known; it was considered possibly of Pleistocene age. However, the
   present occurrence of the same taxon in Hemphillian age sediments
   confirms previous opinion that the age is Pliocene.

   This is the most common turtle in the Manatee Dam Site. A thick,
deeply grooved, strongly bifurcate peripheral element, UF 11581, has
   been described and figured by Weaver and Robertson (1967). A hypo-
   plastral element, including the right rear part of the bridge, exhibits the
   smooth ventral surface, very thick bone, and widely flaring lateral surface
overlapped by the femoral scute, all characteristic of the *Pseudemys scripta* group.

**Geochelone (Hespero?testudo) cf. turgida** (Cope)

The *turgida* group of tortoises (Auffenberg, 1962; Oelrich, 1957) is represented by a pygal element, UF 11935. It is the largest pygal known from that group; the next larger specimens are positively referred to *Geochelone turgida*. The estimated dorsal width of the Manatee County specimen is 66 mm, the length is 41 mm, and the ventral width is 18 mm. This pygal is strongly triangular. The ratio of dorsal to ventral width (3.7) falls within the range of *G. turgida* specimens and is higher than in *G. johnstoni* (Auffenberg, 1962, p. 632). The element is very thick for its size, with a maximum diameter of 20.9 mm.

In side view the pygal is seen to be strongly arched as is often true of male *turgida* specimens, but is unknown in either sex in the subgenus *Caudochelys* (Auffenberg, 1963). That the suprapygal element was not fused to the pygal is shown by the distinct sutural surface of the pygal. The external surface of this element is slightly irregular but unsculptured. The supracaudal sulcus coincides with the suture between pygal and suprapygal, and there is no trace of longitudinal median sulcus on the surface of the pygal. The midventral pygal notch is broadly rounded and attains a depth of 3.3 mm. On the ventral surface a distinct transverse groove represents the ligamentary attachment of the supracaudal buckler, showing that this specimen definitely represents the subgenus *Hespero?testudo*.

The Manatee County pygal represents a tortoise quite distinct from either of the other two tortoises previously described from the Pliocene of Florida. *Geochelone hayi* Sellards from the Bone Valley District is not included in the *turgida* group due to its relatively thin, flat shell, nearly parallel-sided pygal, and its size, about three times greater than large *G. turgida*. The Manatee County tortoise has a much thicker shell than *G. allenii* (Auffenberg, 1966) from McGehee Farm and is nearly twice the size of the largest specimens of that species, although the latter does also pertain to the *G. turgida* group. The Manatee pygal agrees most closely with specimens referred to *G. turgida* from the Buis Ranch Fauna of Kansas and Oklahoma and from the Axtel Fauna of Oklahoma, both Hemphillian in age. This is the first evidence that the same taxon also occurs in a Pliocene (Hemphillian) fauna of Florida.

**Family Cheloniidae**

Two carapaceal fragments of sea turtles, UF 11936, were collected in the main borrow pit locality. One specimen, a first costal, reveals very distinctly the characteristic punctate structure of a sea turtle shell.

**Family Trionychidae**

*Trionyx* sp.

Softshell turtles are represented by two elements in the collection, UF 11937.
ORDER CROCODILIA

Family Crocodylidae
cf. Charactosuchus Langston

In the Pliocene estuarine deposits of Florida, the common crocodylid (excluding alligatorids) is Gavialosuchus. It is characterized by its long narrow snout, Tomistoma-like skull, unkeeled, imbricating dermal plates, and smooth-surfaced teeth. In addition, however, there is, in the same deposits tantalizing recurrent evidence of another crocodylid characterized by its multiple-ribbed (or fluted) teeth. In the present instance, this group is represented by a single tooth, UF 11938. The tooth is long and slender, the enamelled crown attaining a height of 25.5 mm while the maximum (basal) diameter is only 9.0 mm. The presumed anterior and posterior faces are marked by weak carinae. In anterior (or posterior) view the tooth is seen to be curved gently, the concave side presumably facing lingually. Smooth but generally distinct flutings run the full vertical length of the crown. There are seven flutes on the presumed lingual side and eight or nine on the labial side. The grooves on the presumed lingual side are the more distinct. These flutings are broadly incised and are not to be confused with the vertical cracks occasionally observed in weathered teeth of most fossil crocodilians. The flutings could more easily be confused with the corrugated surface of the inner layers of dentine in various crocodilian teeth, but the pattern in question here is definitely developed on the outer enamel surface of the tooth.

Fluted crocodylid teeth are also known from the Bone Valley District and from Pliocene sands in various creeks in Gainesville, Florida. Auffenberg (1954) has pointed out that similar ribbing occurs among Recent crocodylians in Crocodylus cataphractus, a narrow snouted, fish-eating form from Africa. He also notes (1957) that “Pliogonodon priscus” Leidy, from New Jersey, has similar fluted teeth.

The only cranial material known to be associated with such teeth in southeastern United States is a maxillary fragment in the Charleston Museum (ChM 41.188.45) described by Auffenberg (1954). He notes that “the shape of the maxillary suggests that of Gavialosuchus, i.e., a long narrow snouted crocodilian”. The single fluted tooth in this jaw is “approximately 10 mm. long, and thus considerably smaller than those in available skulls of Gavialosuchus americanus (Auffenberg, 1954)”.

More recently, Langston (1965) has described Charactosuchus, a new crocodylid from the Late Miocene La Venta fauna of Colombia, South America. This genus is characterized by, among other features, long delicately fluted teeth set in high alveolar “collars” in long slender jaws. The details of the teeth compare closely with those from the Pliocene of Florida. Moreover the proportions of the jaws do not separate this form from the fragmentary maxillary from the Mio-Pliocene of South Carolina. Obviously, this comparison is tentative pending more complete material.
Family Alligatoridae

*Alligator* sp.

Several alligator teeth and dermal scutes, UF 11939, were collected at the Manatee site. Most of the material represents alligators of moderate to large size.

CLASS AVES
ORDER PELICANIFORMES
Family Phalacrocoracidae

*Phalacrocorax* cf. *wetmorei* Brodkorb

The only avian specimen from this site, the distal end of a humerus, UF 11916, has been identified by Dr. Pierce Brodkorb. It compares well with extensive material of the cormorant that predominates in the Bone Valley avifauna (Brodkorb, 1955).

CLASS MAMMALIA
ORDER CARNIVORA
Family Canidae

A third lower molar of a small canid UF 11917 was recovered by screening at the Manatee Dam Site. This tooth is only about half the size of *M*<sub>3</sub>’s in *Osteoborus cynoideus* from the Hemphill Fauna in Texas.

No other canids have been described from the Pliocene of eastern United States, and it is impossible to make a sound generic determination on the evidence of this tooth alone. The tooth is about 5 mm long by 4 mm wide, with low but distinct trignoid and talonid, and two long, nearly fused, roots.

ORDER PROBOSCIDEA
Family Gomphotheriidae

Numerous broken cusps and enamel chips indicate the presence of gomphotheres at the Manatee Dam Site. There is no indication among these specimens of a zygodont type of mastodon, such as *Pliomastodon*; presumably all of the materials pertain to *Gomphotherium* or *Rhychocitherium*.

The lateral portion of a cervical vertebra is well preserved. The fact that so fragile a piece was not broken indicates the material could not have been transported far.

*Rhychocitherium* cf. *euhyodon* (Cope)

*Rhychocitherium simpsoni* Olsen (1960)

A canal dug through the Bone Valley Formation at the Manatee Dam Site exposed the skull and jaws, UF 11930, of this remarkable mastodon. Unfortunately, however, the anterior part of the skull was destroyed by the dragline and washed down the canal. The parts that were recovered include the posterior parts of the mandible bearing both third molars and the posterior half of the cranium. Also from the canal bottom nearby the anterior tip of the right inferior tusk and parts of the upper molars of the same individual were collected.
Description: The lower third molars of the Manatee Dam Rhynchotherium are only slightly worn and reveal clearly the characteristics of Rhynchotherium molars. The enamel is quite thick. The maximum crown height (47 mm) is relatively low. The cusps are arranged in an extremely simple bunodont pattern with simple pretre and no posttretre trefoils. There are no cingula. The lophids number four and a half, the last partial lophid consisting of four or five conulids. This pattern is developed in similar fashion in both lower third molars.

The measurements of the lower molars are presented in table 4 and compared with those of other rhynchotheres. It is clear that this is the smallest mature specimen of Rhynchotherium described.

<table>
<thead>
<tr>
<th>Table 4</th>
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<tr>
<td>Measurements of M₃ in various Rhynchotherium specimens</td>
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<tr>
<td>Length</td>
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<tr>
<td>Manatee County specimens &amp; 153 &amp; 66 &amp; 42 &amp; 47</td>
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<tr>
<td>R. simpsoni Olsen &amp; 194 &amp; 83 &amp; 43 &amp; —</td>
</tr>
<tr>
<td>R. edense Frick &amp; 160 &amp; 68 &amp; 42 &amp; 50</td>
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<tr>
<td>R. cf. shepardi Leidy (Contra Costa Co., Calif.) &amp; 163 &amp; 73 &amp; 45 &amp; 45</td>
</tr>
<tr>
<td>R. hondurensis (Frick) &amp; 173 &amp; 76 &amp; 44 &amp; —</td>
</tr>
<tr>
<td>R. falconeri Osborn &amp; 173 &amp; 80 &amp; 46 &amp; —</td>
</tr>
<tr>
<td>R. browni Osborn &amp; 176 &amp; 96 &amp; 55 &amp; —</td>
</tr>
<tr>
<td>R. tlaclae Osborn &amp; 180 &amp; 99 &amp; 55 &amp; —</td>
</tr>
<tr>
<td>R. cuwypodon (Cope) &amp; 182 &amp; 78 &amp; 43 &amp; —</td>
</tr>
<tr>
<td>R. chinjiensis Osborn &amp; 200 &amp; 92 &amp; 46 &amp; —</td>
</tr>
<tr>
<td>R. anguirivale Osborn &amp; 214 &amp; 98 &amp; 46 &amp; —</td>
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The lower tusk tip presents a heavy wide enamel band on the lateral surface. The band is 29 mm wide dorso-ventrally at a point 300 mm behind the tip of the tusk. This is probably its maximum width. In side view the tusk is seen to curve upward gently toward the symphysis, more sharply near the tip. In top view a very slight lateral curvature is also evident. This cross section of the tusk is ovate ventrally but strongly compressed dorsally, so that it has a sharp triangular peak. The enamel band covers the upper two-thirds of the lateral side of the tusk and faces lateral and slightly dorsad. The enamel is heavily worn throughout the 10 inch length preserved, the wear being most conspicuous near the tip.

The posterior part of the skull presents no unusual features.

Comparisons: The molar teeth of the Manatee Rhynchotherium are the smallest known in any rhynchothere, although teeth referred to R. edense from the Mount Eden locality fauna of California approach the Manatee County specimens in size. The width/length index (42) is at the low end of the range characteristics of Rhynchotherium. However, the only species that do not have approximately this same index in the lowers are the two Mexican species of Rhynchotherium, R. browni Osborn, and the species R. tlaclae Osborn with indices of 55 (see table 4).

The development of the posterior lophid (pentolophid) of the third molars agrees most nearly with those of R. edense and R. anguirivale
from the Upper Snake Creek fauna of western Nebraska. In these specimens the pentalophid consists of a number of conulids forming a relatively broad row. By contrast, in R. falconeri from the Blanco local fauna of Texas, R. euhypodon from Driftwood Creek, Nebraska, and R. hondurensis from Tapasuma, Honduras, there are only two conulids in the last lophid of M₃; and in R. tlaescalae and R. browni from Mexico, R. chinjienis from India, and a specimen from Contra Costa County, California referred by Leidy to R. shepardi, there is in the last lophid only one conid of sufficient size to be counted.

The compressed, enamel-banded, lower tusk is, along with the downturned symphysis, the outstanding diagnostic feature of Rhynchotherium; however, a surprising number of specimens lacking the enamel band have been described. In the type of R. simpsoni Osborn, also from the Bone Valley Formation of Florida, the enamel bands are absent from upper and lower tusks. In their place a set of deep grooves runs longitudinally along the tusk (Olsen, 1960). Clearly these grooves are not the normal surface of the tusk but rather the internal fluting exposed when the outer layer, including the enamel band, was stripped away. There is no reason to doubt that enamel bands were originally present on the outer surfaces of these tusks. Since this is the only feature that could be interpreted as specifically diagnostic and it is quite doubtful, R. simpsoni cannot stand as a distinct species. It should be regarded as a synonym of R. euhypodon.

The absence of enamel on the lower tusks of the type specimen of Aybelodon hondurensis Frick was given considerable weight in the generic diagnosis. However, the tusks are represented only by parts of the bases rooted in the symphyseal bone. The enamel band, when present in a mature animal, does not carry back even to the base of the exposed part of the tusks; thus, the absence of enamel in Aybelodon is probably an artifact of preservation rather than a generic distinction. The tusk roots in Aybelodon exhibit the lateral compression characteristic of Rhynchotherium. This important clue suggests with high probability that the rhynchothere sample from the Gracias Formation in Honduras represents a single species referable to Rhynchotherium.

Other examples of Rhynchotherium tusks lacking enamel have been reported, but fortunately they have been recognized as abnormal instances without taxonomic significance. Osborn (1936, p. 495) pointed out that the tusks of R. falconeri had lost their enamel through abrasion, and Olson and McGrew (1941) noted that a tusk from Honduras has no enamel because of its advanced wear stage and incomplete preservation.

The type and only specimen previously referred to R. euhypodon was described by Cope (1884). There is considerable doubt as to the proper association of the six tusks found with the type jaw. However, the arrangement of tusks indicated by Cope, with the lower tusks larger than the uppers, seems more reasonable than the rearrangement suggested by
Osborn. The lower tusks appear less compressed than most Rhynchotherium lowers, but this may well be a matter of individual variation.

In naming the Honduran genus Blickotherium Frick (1933) attempted to distinguish it by the following features:

A. Mode of wear of tusks.
B. Presence of 3.
C. "Elongation and relatively but moderate depression of the symphysis".

These points are reviewed seriatim.

A. The shape and wear of the tusks in the immature genotypic specimen from Honduras (see Frick, p. 521) indicate a slight malocclusion but otherwise a mode of tusk manipulation exactly as Frick described for Rhynchotherium edense (p. 514). The heavy dorsal wear on the left lower tusk indicates that this individual was somewhat "left-handed", but the primary area of impact or shear on the lower tusks are still, as is typical, dorsolateral at the upper edge of the enamel band.

B. There is no question that "Blickotherium" does have a permanent ("replacement") 3. However, there is considerable doubt as to whether the contrary is true of Rhynchotherium. Frick (1930, p. 141) inferred that the permanent premolars were never developed in Rhynchotherium, basing this on a single juvenile specimen of R. edense in which no remnants of successional teeth were found. In this early work Frick properly held reservations regarding the interpretation of this single specimen. It may be noted, further, that Osborn (1936, p. 492) figures an upper 3 of R. anguirivale. It is more probable that the presence of a well-developed 3 in "Blickotherium" casts doubt on Frick's interpretation of the succession in the juvenile R. edense jaw than that it provides the diagnosis for a new genus.

Downs (1952) presents an alternative interpretation of the tooth homologies in the juvenile jaw of R. edense, but it does not appear to be correct. If the middle tooth were 3 (rather than d3) it would be round, bilobed, and less worn than the following tooth (which he would suppose was M3).

C. The symphysial configuration varies over a considerable range in known specimens of Rhynchotherium. The slender symphysis in "Blickotherium" is not uncommon among advanced rhynchotheres: in particular it is seen in R. euhyodon, R. (=Aybelodon) hondurensis and R. edense. Thus there does not appear to be any substantial basis for distinguishing "Blickotherium" from Rhynchotherium.

It should be evident from this discussion that the Honduranian rhynchotheres are taxonomically oversplit. We regard Aybelodon and Blickotherium as synonyms of Rhynchotherium and further suggest that R. ("A.") hondurensis (Frick, 1933) is a synonym of R. ("B.") blicki (Frick, 1933). Both species were collected in the same deposits of limited geographic and temporal span, one being represented by an aged specimen, the other by an adolescent specimen.
Much work remains to be done before the taxonomy of advanced rhynchotheres can be adequately sorted out. At this point, however, it seems clear that taxonomic multiplication has gone too far and that probably one genus and at most two or three species are represented in the New World. It may be noted in the present study that within the Bone Valley Formation two relatively complete specimens have been found and in most features resemble one another closely, yet in size they span nearly the whole range observed in the genus *Rhynchotherium*. We suggest that a considerable range of natural variation must be included in our concepts of proboscidean species.

**ORDER PERISSODACTYLA**

**Family Tapiridae**

*Tapiravus* cf. *polkensis* Olsen

A rather large Pliocene tapir is represented by a well-preserved left M², UF 11919. Evidently this tooth had not yet erupted, as the roots are not fully formed, and the tooth is unworn. It is clearly M² because the transverse diameter of the anterior moiety is much greater than that of the posterior moiety as in M² and M³ of late Cenozoic tapirs generally, and it has a strong posterior cingulum unlike M³'s.

Since this is the only upper molar of a tapir described from the Pliocene of eastern United States, relevant comparisons are limited. The size of this molar is appropriate for an upper molar of *Tapiravus polkensis* Olsen, and it is on this basis, and the geographic and stratigraphic proximity, that this reference is suggested. The anter-posterior diameter of the molar is 24.0 mm. The type P⁴ of *T. polkensis* measures 17 by 22 mm.

*Tapiravus* cf. *validus*, described by Gazin and Collins (1950) from the Calvert Formation of Maryland, is considerably smaller than *T. polkensis*, the dimensions of M¹ being 15.0 mm by 16.0 mm. The molar from the Manatee Site is also higher crowned than the Calvert specimen and has a squarer outline due to its straighter, stronger anterior, posterior, and anterolingu al cingula. In the Manatee molar, there is no angle or change in the thickness in the enamel crest from the metaloph to the crista on the anterior slope of the metacone, as there is in the Calvert specimen. The mesostyle is very weak in the molar from Manatee.

Comparison with other Pliocene tapirs of North America is limited by the fact that few have been described (Macdonald, 1960). A broken right upper molar (M² and M³) from Brady Pocket in Nevada (Macdonald, 1956) is comparable in size and character with the Bone Valley tapir.

**Family Rhinocerotidae**

An abundance of rhinoceroses living in the Manatee area during Pliocene time is suggested by the numerous fragments of enamel from rhinocerotid teeth collected in this local fauna. It is probable that the fragments pertain to *Aphelops* as well as to *Teleoceras*. Unfortunately, only two generically identifiable specimens were recovered.
Teleoceras sp.

The presence of Teleoceras is indicated by two fragmentary teeth. The trigonid of a right lower molar, UF 11918, is fairly well worn, yet the crown measures 38 mm high. The ectoloph of a worn upper molar (UF 11931) measures 61 mm anteroposteriorly and 60 mm in height. The anterior rib is well-developed and near the base becomes much stronger than the mesostylar convexity.

Family Equidae

Horses are the most abundantly represented terrestrial vertebrates at the Manatee County Dam Site. Of a sample of some forty cheek teeth about half are generically identifiable. Only three of these show no signs of water wear. The only non-dental element of an equid is the proximal phalanx of an animal the size of Neohipparion, UF 11920.

It is a curious fact that to date all the Pliocene equids described from eastern United States are hipparionine types, in the broad sense. The present fauna is no exception.

Neohipparion cf. phosphorum Simpson

Figure 3

A well-preserved second upper premolar, UF 11940 (fig. 3), an unworn lower molar, UF 11921, and the anterior part of an upper premolar, UF 11922, represent the genus Neohipparion. The fragmentary premolar which is at least moderately worn, has a crown height of nearly 50 mm. The well-preserved P3 has the characteristic strong stylar cups and considerable folding of the enamel of the fosette borders. The lower molar exhibits the very broadly spread metaconid and metastylid and the flattened labial cusps also characteristic of the Neohipparion eurystyle group.

Fig. 3. Neohipparion cf. phosphorum P3, UF 11940, × 1.

Griphippus sp.

Figure 4

Griphippus is here recognized for the first time in eastern United States. However, studies now in progress indicate that the genus is more common in the Pliocene of Florida than published records suggest. In several collections Griphippus teeth have been mixed with those of Nannippus minor.
fauna from low elevation in Manatee County, Florida

Fig. 4. *Griphippus* sp. LP, UF 11923, × 1.

A single upper premolar of *Griphippus*, UF 11923 (fig. 4), was collected at the Manatee Dam Site. It had reached a late wear stage, the crown measuring only 10 mm high. At this height the protocone is fully connected to the protoloph. That this tooth does not represent *Calippus* is indicated by the retention of several enamel plications in this late stage of wear. There is a strong pli-caballin; a pli-protoconule and a pli-prefossette also remain. The retention of a small round hypofossette is also characteristic of *Griphippus*. And finally, the protocone in this premolar is orientated anteroposteriorly, not quasi-transversely as in premolars of *Calippus*.

*Nannippus minor* (Sellards)

This diminutive hippocrinine horse is represented by two lower cheek teeth, UF 11924-25, an unworn upper third molar, UF number 11932, and a deciduous upper premolar, UF 11933.

*Hipparion ingenuum* Leidy

Figure 5

At the Manatee Site, as in the Bone Valley Fauna, the most common horse is this middle-sized hippocrinine (Simpson, 1930). A dozen complete or nearly complete teeth, UF numbers 11926 through 11929, are included in the present sample.

The protocone is usually large and elliptical; in early wear it tends to be lenticular. The pli-caballin is usually single, sometimes double, except in late stages of wear. The fossette borders are complexly folded in early wear, with a persistent pli-protoloph, a pli-protoconule, two to five pli-prefossettes, two to four pli-postfossettes, and a double pli-hypoyle. The hypoconal groove is broadly open in all stages of wear.

The lower cheek teeth are characterized by their well-rounded, nearly equal metaconid and metastylid with a broad shallow groove between them. There is no parastylid in the premolars or molars. The labial cusps are well rounded, not flat. The entoconid is retracted from the lingual side of the tooth. No pli-caballinid is observed in the present sample. Minor plications in the protolophid and metalophid are common. No specimens in the present sample give an adequate indication of the unworn height of the crown.

Fig. 5. *Hipparion ingenuum* (Leidy). a) LM³, UF 11929. b) LM₁, UF 11926. × 1.
ORDER ARTIODACTYLA
Family Camelidae
cf. Tanupolama

Llamine camelids are represented in this faunule by a well-preserved second right upper molar, UF 11934, and a few tooth fragments. The basal dimensions of the molar are 22.7 mm anteroposterior and 20.9 mm transverse. The styles and ribs are very strongly developed and lingually there is a distinct inflection on the posterior wall of the protocone. This tooth is evidently moderately well worn; a less worn fragmentary specimen has a protocone 21 mm high.

SUMMARY

1. A thin bed of Bone Valley Gravel at the Manatee County Dam Site yields a vertebrate faunule similar in composition to the classic Bone Valley fauna.

2. This is the first representative Bone Valley faunule collected in place.

3. The vertebrates were not reworked. Although some specimens are heavily water worn, others of the same species are too fragile or too heavy to have undergone much transport or reworking.

4. The vertebrates were derived from three contiguous habitats (savannah, freshwater stream, and estuary) and deposited together. The marine part of the fauna is dominated by the sharks, Carcharhinus leucas and Negaprion brevirostris, both of which range extensively into estuarine and fresh waters today.

5. Several of the included taxa, particularly the horses, indicate a Hemphillian (Middle Pliocene) age, and none contradict this conclusion.

6. There is no evidence for (and considerable against) any local or regional tectonism affecting this site since the Miocene.

7. If (6) is correct, sea level at one time during the Hemphillian reached the level of the Manatee County vertebrate site, 6 feet above present sea level, or lower. Evidence of high stands of more than 90 feet above present sea level is also presented.

8. The equid genus Gripphippus and a tortoise very close to Geochelone turgida are recognized for the first time in eastern United States.

9. Ribbed crocodylid teeth which occur in many Pliocene deposits of Florida may be related to Characotosuchus Langston from the Late Miocene of Colombia, South America.

10. Rhynchotherium simpsoni Olsen from the Bone Valley District is synonymized with R. euhypodon (Cope). A partial skull and mandible from the Manatee County site are referred to the same species. The Honduranian rhynchothere genera, Blickotherium and Aybelodon, are synonymized with Rhynchotherium and their respective genotypic species are synonymized as Rhynchotherium blicki (Frick).
fauna from low elevation in Manatee County, Florida 809

References


