Florida Paleontological Society , Inc.

Newsletter

Volume 8 Number 1 Winter Quarter 1991

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FLORIDA MUSEUM OF NATURAL HISTORY
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Florida Paleontological Society
Spring Meeting

April 20, 1991
9 a.m. to 3 p.m.

De Soto Shell Pit

Bring:
1) Your Lunch
2) Pail & Tools
3) Hat & Sun Lotion

FAMILY FUN DAY

Earth

MAGAZINE

November 1990

Dear Friend:

Kalmbach Publishing Co. is launching a new magazine called EARTH. We thought you'd be interested in sharing this information with your colleagues or including it in a member newsletter.

EARTH magazine will debut January 8, 1991 with 96,000 copies on newsstands worldwide.

EARTH magazine is a response to the public's demand for more factual and scientific information on our planet. We cover a wide range of topics from volcanic eruptions and glaciers to mass extinctions and global warming, presented in a handsomely printed, lavishly produced and compellingly written full-color magazine.

Published by the editors of ASTRONOMY magazine, EARTH is a scientifically accurate and authoritative publication that promotes a deeper understanding of the Earth.

For more information call our editor, Robert Burnham, at (414) 796-8776, extension 572. He is available to answer any questions on the editorial content of EARTH magazine.

Send in the enclosed reply card, and we'll send your complimentary premier issue in January. For subscription information call (800) 446-5489 (weekdays 8:30 - 5:00 CST).

Thank you in advance for any help you can give us in promoting our new magazine.

Sincerely,

Elaine M. Paque

Elaine M. Paque
Public Relations Manager
EARTH magazine

EMP/gt

Enclosures

P.S. We are seeking editorial contributions. If you are interested please call our editor, Robert Burnham, at (414) 796-8776, extension 572.

THE TAMPA BAY FOSSIL CLUB

presents its

FOSSILS

DINO-GAME

ARTIFACTS

GEMS

MINERALS

MINI-MINE

Auction • Displays – featuring fossils, artifacts & minerals
• Dealers • Demonstrations • Refreshments • Raffle
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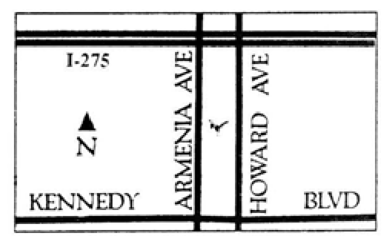


MESSAGE FROM THE EDITOR

As we delve into 1991, we can certainly say, in retrospect, that 1990 was an 'interesting' year. For many of us 1990 was very productive and eventful, for equally as many, we hope '91 will be the year we hit the paleontological lottery and tap into a vein of fossils to make the Rancho La Brea tar pits pale in comparison. Many of you have told me the holidays were tiring but enjoyable; I just want to know who got the remote-controlled life sized Carcharodon megalodon Santa was supposed to have brought me. So much for the fun I had planned in Lake Alice...

On a more serious note, however, Bill Webster, our new FPS President, thanks you all very much for your support in appointing him to that position. Those of us who know Bill know that he will do an excellent job as our leader. In Bill's own words, "I will strive to be an efficient and considerate president." Let's all give him our support and cooperation to ensure that this year is a fruitful one for the FPS.

As for our newsletter, please feel free to write in with suggestions - this is your newsletter, and it's my job to try to see that it reflects what you want to see. Some suggestions I have been given are very promising, including letters to the editor, columns on subjects pertinent to paleontology, a newsletter "photo album" for members to send in interesting pictures of their fossil expeditions and favorite fossils, past and present, and many more. These are all excellent ideas, and I'd like to see them become a reality. So please, if you have anything you'd like to see included in our next newsletter, send it in. So long as the ghosts of paleontologists past, present, and future look favorably upon it, I'll do my best to get it in.

I sign off wishing you the best of luck in your paleontological endeavors. Enjoy your newsletter!

--Jeremy T. Setty
FPS Newsletter Editor

MUSEUM HAPPENINGS

It is once again true that there are no dinosaurs in Florida. (At least at the Florida Museum of Natural History.) Our resident Dino-Mania exhibit's latex lizards have migrated northward as of January 6. Scientists are not sure exactly what caused their disappearance, although there are many theories...

We have had many illustrious visitors here at FMNH since the last newsletter. Among them are STORRS L. OLSON, of the Smithsonian Institution, who is studying fossil birds of the Bahamas; CASTOR CARTELLE, from the Universidade Federal de Minas Gerais in Belo Horizonte, Brazil, who is a specialist on fossil xenarthrans; and GERRY DE IULIIS, from the University of Toronto, a specialist on the megatheriid sloths.

Here on the homefront, otherwise, things have been relatively quiet, with everyone continuing their projects.

DAVID LAMBERT, Ph.D. student, had his paper on shovel-tusked gomphotheres published in November 1990's Journal of Paleontology. He has since been working on material of the vaguely antelope-like ruminant Pediomeryx (family Dromomycidae) from the late Miocene Moss Acres Racetrack site. While apparently not a new species, this material is noteworthy in containing a partial skull preserving both the two frontal horns and the strange occipital horn jutting out behind the head just above the neck (such horns are rare, and when found are usually isolated). GARY MORGAN and ART POYER have settled the newly compactorized VP collections back into accessibility, and ERIKA SIMONS is continuing the large task of computerizing the museum's VP catalog of collections, using a program devised by museum programmer DOUG TURLEY.

ALCEU RANCY, Ph.D. candidate from Acre, Brazil, is readying his thesis on Pleistocene mammals of the Amazon for its final stages. LAURIE WALZ, scientific illustrator, has finished drawings of cetotheriid whale mandible specimens for undergraduate Zoology student JEREMY SETTY's ongoing shark predation project; she is currently completing drawings for Alceu's thesis as well. RUSS McCARTY, chief preparator, is continuing casting work and preparation.

The giant Carcharodon megalodon jaw on which DR. CLIFF JEREMIAH has been working is now at the museum having its finishing touches put on by preparator BOB LEAVY. It will soon be going on display here at the FMNH Fossil Study Center exhibit area.

--Jeremy T. Setty

SHARKS

The shark exhibit at Orlando's SeaWorld is a monument to our misunderstanding of nature. As visitors watch a slide presentation, an authoritative-sounding but invisible narrator reenforces most of the popular myths about sharks - and nature in general - even while he emphasizes how misunderstood "the shark" has been.

And there's the first problem: "the" shark. We don't talk about "the" bird or "the" snake. Why "the" shark? Some 350 species of sharks are known today, from the whale shark, the largest living fish, which reaches 50 feet in length, to the tsuranagakobitozame (literally, "dwarf shark with a long face" in Japanese), which never exceeds 6 inches. Sharks are a single group of organisms, by which we mean that they possess features derived from a common ancestor. But they are not all the same. Yet thinking of sharks as one thing helps perpetuate our common image: from the movie "Jaws" to our first science books to our narrator at Sea-World, we learn that sharks are "perfect killing machines", "relentless", "pitiless", and "fierce". If we then hear that sharks are "misunderstood", we should not wonder. While most sharks are predators, and some are remarkably efficient, active, and aggressive, some sharks also filter plankton; others are scavengers and others eat mollusks and crustaceans off the bottom.

Are they perfect? Again, the term is meaningless if applied to the entire group. Like all groups of organisms that survive, sharks are adequate. They possess morphological, behavioral, and other features that allow them to survive and reproduce. But I'm not sure they're any more "perfect" than koala bears, which are pretty good at what they do too.

Sharks as a group do have a long evolutionary history (which is apparently responsible for the often-heard remark that "sharks have not changed in 300 million years"), but this doesn't mean they're perfect. The oldest known sharks are Devonian in age (around 380 million years ago); the sharks that are familiar to us today, however, did not originate until the Jurassic (around 200 million years ago). There are no species or genera of sharks around today that were around 300 or even 200 million years ago. They are not perfect; they have changed plenty in the dynamic process of turnover that is evolution.

As a group, however, sharks have clearly hit upon a basic design that works very well. But the heterogeneity within this design belies any claim of uniform perfection. Together with their relatives, the skates and rays, sharks have internal skeletons made almost completely of cartilage rather than bone. Most sharks lack heavy scales; their skin is instead filled with many small scales that together form the familiar "sandpaper" feel of sharkskin. This kind of external covering is lightweight and increases hydrodynamic efficiency. Most modern sharks possess large livers filled with oil, which act like the swimbladders of bony fishes. It was once thought that sharks had to keep swimming to force water over their gills and to stay afloat, until the so-called "sleeping sharks" were discovered essentially hibernating from time to time still as could be on the ocean bottom (I have seen nurse sharks "sleeping" under ledges, in 30 feet of water in the Gulf of Mexico 15 miles out from Tampa Bay; at least some scientific theories are easily refuted with simple observations.) All modern sharks, skates, and rays practice internal fertilization and males of all living and most fossil forms possess paired claspers in the pelvic region to facilitate this union. As is the case in many mammals, internal fertilization in cartilaginous fish is associated with production of a small number of eggs, each with a high chance of survival (many sharks give birth to live young). This contrasts with most bony fish, which have external fertilization and produce large numbers of eggs, few of which live to adulthood.

Modern cartilaginous fishes possess several well-developed sensory systems. Sharks, skates, and rays have sensitive olfactory (smell) and visual systems, as well as systems to detect turbulence in the water. Structures located in the lateral line along the length of the body as well as in the snout can detect small electrical impulses, such as those produced by muscular movement. Many sharks have developed these systems to a high degree and use them to detect prey at great distances.

As any beach comber knows, shark teeth are not all alike. Sharks that take bites out of large fish and marine mammals have triangular, blade-like teeth. Sharks that swallow their prey whole have long, thin teeth useful for grasping and holding on before swallowing. All shark teeth are modified scales, and like scales they are continually shed and replaced. Sharks are able to attack and often ingest large prey because of a distinctive, "loose" jaw mechanism that allows their gape to be maximized. Some sharks, it is true, can bite with a force in excess of 15,000 pounds per square inch, but most have much more modest abilities.

All this diversity within "the" shark is fascinating for its own sake, but its larger importance was brought home to me by one of the SeaWorld narrator's final comments: "The shark", he said, "is not an endangered species". In what I can only assume is an awkward attempt to put the icing on the cake of the argument for sharks' "perfection", this narration has made an error that illustrates how we often view life around us, and which in this particular case may have disastrous consequences. By not recognizing and emphasizing the diversity of life, sharks included, we easily come to believe that all species are the same, that preserving one is like preserving another, that saving some arbitrary proportion is a sufficient "success rate".

Many species of sharks appear to be in danger of extinction today, due largely to overfishing. Biologists Charles Manire and Samuel Gruber of the University of Miami have recently reported that recommended United Nations limits on shark mortality have been exceeded consistently for the last ten years. (It's not a matter of catches, only 11% of shark mortality due to commercial fishing is landed. The rest is discarded as bycatch of the swordfish, tuna, shrimp, and squid catches.) Shark fishing tournaments have had to be cancelled for lack of catches. According to the National Marine Fisheries Service, all 72 species of sharks inhabiting U.S. Atlantic waters are in need of some form of protection. Manire and Gruber estimate that we kill around 1 million sharks for each human bitten by a shark every year.

Sharks aren't one thing and they aren't "fierce" or "perfect". They are sharks, in hundreds of different forms evolved for a million reasons over hundreds of millions of years. As long as we persist in identifying the natural world only in terms of our values and emotional perceptions, we inevitably will view it as someting we can use or dispose of at our whim, and we will never grasp fully that its diversity, rather than our perception of its relevance to us, is its only reality.

--Warren D. Allmon
Department of Geology
University of South Florida
Tampa, FL 33620
From Tampa Bay Fossil Chronicles, January 1991

November 1 through 3, WINTER HAVEN, FLORIDA - IMPERIAL POLK COUNTY GEM AND MINERAL SOCIETY, INC., 13th Annual Cypress Gem, Jewelry and Mineral Show. Best Holiday Trav-L-Park and Campground, S.R. 540, Winter Haven, Florida.

Dealers. Show Chairman: Ernie Hitte 225 Denise Lane Auburndale, Florida 33823 (813) 967-8257.

Editor's Note: From time to time, the FPS Newsletter will carry articles on interesting fossil finds or localities in Florida's past. These articles will be illustrated with original photos from the archives of the Florida Geological Survey.

THE VERO BONE BED

Frank R. Rupert
Florida Geological Survey

The year was 1913. Just north of the town of Vero, Florida, a hugh dredge inched forward, cutting a 60 foot wide canal through the gray sands and underlying shelly marl. Designed and excavated by the Indian River Farms Company, the canal would one day drain the extensive citrus lands west and south of Vero.

Five hundred feet west of the Florida East Coast Railroad tracks and the public road (now U.S. 1), the dredge cut through the brown crossed-bedded sands of an ancient stream course. Intent on their forward progress, the machinery operators probably didn't notice the black fossil bone fragments exposed in the organic-rich sand. Later, a local resident, Mr. F.C. Gifford discovered the pocket of bones while exploring the newly-cut canal bank. He described his discovery to a friend, Isaac Weills. Weills, recognizing the potential scientific significance of the find, reported the fossils to then State Geologist Dr. E. H. Sellards at the Florida Geological Survey in Tallahassee. Sellards, and his assistant Herman Gunter, made a number of trips to the site, and assisted in identifying many of the initial fossil finds. The stretch of canal bank intersecting the ancient waterway proved to be a prolific bone bed. It would be another two years, however, before the true significance of Mr. Gifford's discovery would be known.

Fossils found in the fresh canal cuts were donated to the Florida Geological Survey collection by Gifford, Weills, and several other Vero area residents, all newly proclaimed amateur paleontologists. Weills and a friend, Mr. Frank Ayers, checked the canal bank and dredge spoil for more fossils over the next two years. Slumping and erosion of the canal cut continually yielded new fossils. The finds included an abundant variety of Pleistocene mammals, birds, amphibians, reptiles, and insects. Several extinct species and some whose ranges no longer include Florida were unearthed. Some of the more interesting bones came from species of wolf, bear, lynx, horse, sloth, sabercat, elephant, and the extinct armadillo-like *Chlamytherium*. An extinct wolf skull and femur found by Frank Ayers was thought to be a new species, and named *Canis ayersi* in his honor (later work placed this specimen in *Canis dirus*).

In October, 1915, while scouting a freshly-slumped portion of the canal bank containing the cross-bedded sand deposit, Ayers made a discovery which stirred the scientific community and made the Vero bone bed one of the most significant fossil sites of its time. Imbedded in the same strata with the numerous land mammal fossils were what appeared to be human bones. Ayers called Weills, and together they removed the partial skeleton of a young female paleoindian.

This was fascinating news to vertebrate paleontologists. The finding of Pleistocene mammal bones and human fossils in close association was a rare occurrence indeed in the early 1900's. More importantly, this was the first such discovery in the New World. Upon learning of the human bone discovery, Sellards and Gunter organized a dig to look for more human remains. During the year following the initial human discovery, Florida Geological Survey staff worked closely with the local Vero amateurs. The canal bank was excavated back several feet, and other human bones, indian artifacts, and numerous Pleistocene vertebrates were unearthed. Paleoindian remains were discovered in two different sets of strata, both initially considered Pleistocene in age. To all appearances, the deeper human fossil finds were *in situ* with the Pleistocene mammals. If so, this discovery would either move the first appearance of man in Florida back into Pleistocene time, or would suggest that some of the extinct Pleistocene land fauna lingered on into the Recent in Florida. The close association of man and extinct mammals also lent support to those who believed man was, at least in part, instrumental in the demise of the Pleistocene megafauna.

Sellards published his first announcement of the discovery in the July, 1916 issue of the *American Journal of Science*. A follow-up article appeared in the October 27, 1916 *Science*. Further elaboration on the discovery appeared in the Eighth and Ninth Annual Reports of the Florida Geological Survey.

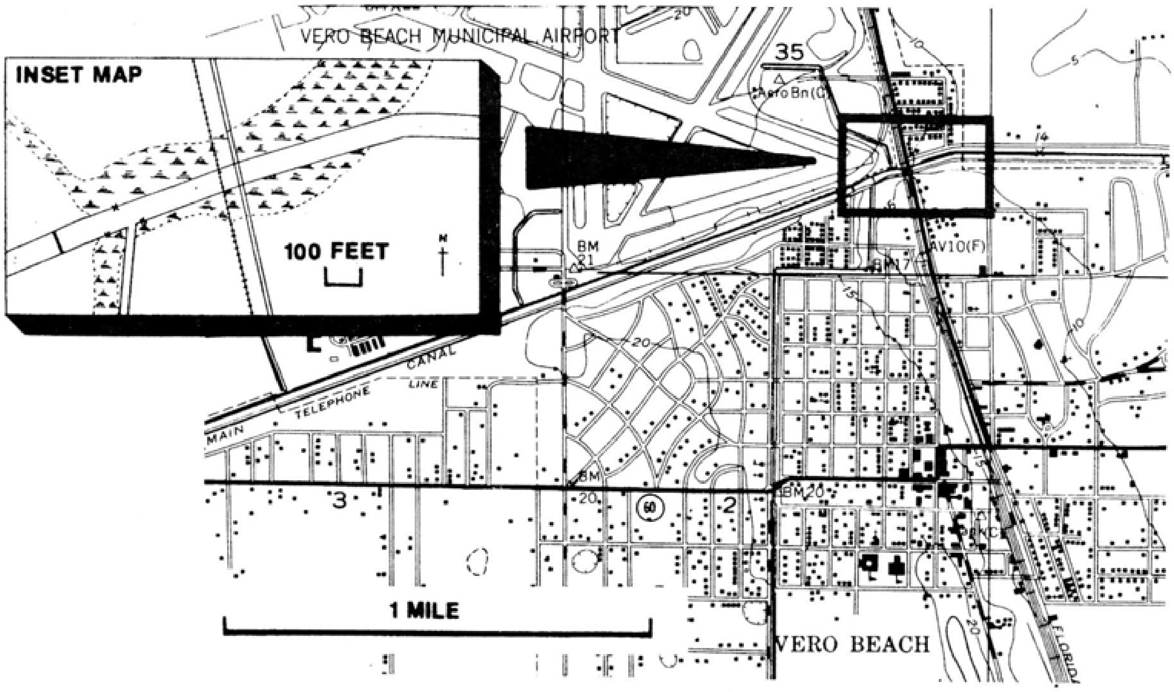
At the invitation of Dr. Sellards, a group of experts assembled at the Vero site during the last week of October, 1916. Each was given a tour of the dig, where they examined the fossiliferous strata and discussed the paleontological finds. Oliver Hay, of the Carnegie Institution, Ales Hrdlicka, of the U.S. National Museum, and George MacCurdy of Yale examined the vertebrate and human fossils. Rollin Chamberlin from the University of Chicago, and Thomas Wayland Vaughn of the U.S. Geological Survey offered their stratigraphic expertise. Later that year, Edward Berry of John Hopkins University studied the numerous plant remains collected at the canal site.

Opinions on the age and contemporaneity of the fossils varied. The 1917 *Journal of Geology* devoted space to papers analyzing the Vero finds. Chamberlin, MacCurdy and Hrdlicka, believed the indian remains represented a secondary deposit, perhaps a Holocene burial site or a reworked fluvial deposit. Hay and Berry sided with Sellards, who steadfastly maintained that the human remains were most likely of Pleistocene age. Vaughn reserved judgement until further evidence could be obtained.

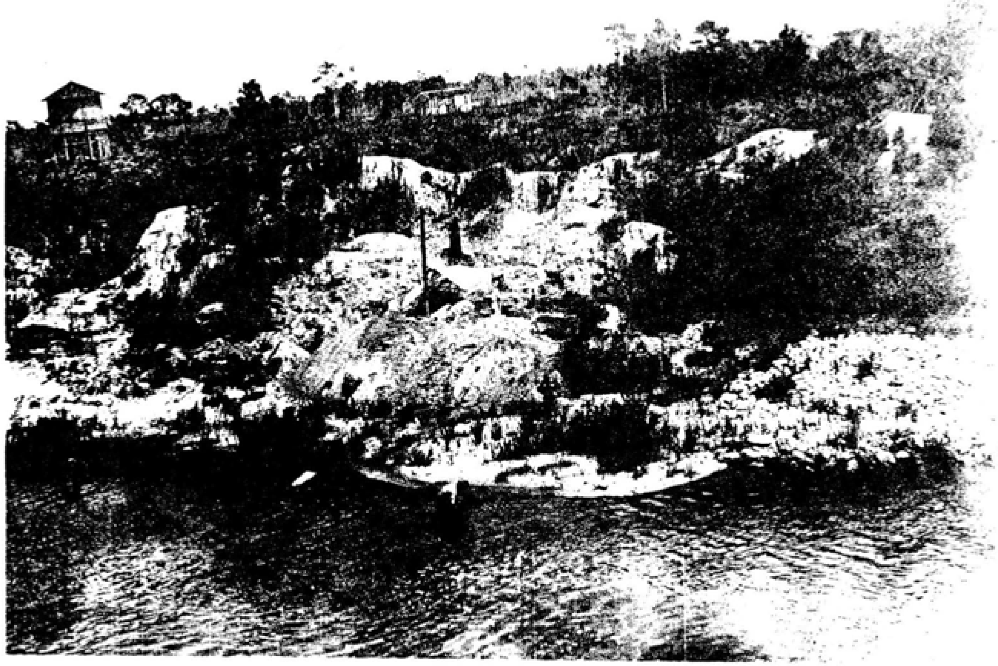
The age debate continued for nearly 10 years, with various authorities publishing summaries and opinions on the Vero finds. In 1924, similar human fossils, also associated with extinct Pleistocene mammals, were found in laterally-equivalent strata at Melbourne, Florida. This temporarily reignited interest in the age relationships of the Vero fauna. The interest gradually waned, and for the next 35 years the Vero bone bed was occasionally studied, without conclusive results, by a few workers. Then, in 1962, Robert Weigel conducted a detailed study of the fossil vertebrates of Vero as his doctoral dissertation at the University of Florida. He included radiocarbon dates on wood and charcoal samples taken from the strata containing the human remains. Weigel concluded that the majority of indian artifacts were of recent origin, probably reworked into the strata during the last 4,000 years. Although radiocarbon dates on the older human intervals were questionable, Weigel believed that the human fossils found in the deeper strata were, most likely, contemporaneous with the Pleistocene animal fossils. Today, archaeologists have, for the most part, rejected the contemporaneity of man and the Pleistocene fauna at both the Vero and Melbourne fossil sites. The consensus is that the human fossils are not in place, and were probably reworked into older beds.

The Vero bone bed has once more faded into obscurity, eclipsed by modern discoveries such as the Windover Farms and Leisey Shell Pit. It will stand out in Florida paleontological history as the first New World association of man and extinct vertebrates. It may perhaps be remembered more for the controversy it raised on the relationship of man and the Pleistocene faunas. The vertebrate fossils recovered at Vero (now Vero Beach), including the early man remains, are now curated as the Florida Geological Survey collection at the Florida Museum of Natural History in Gainesville.

Next Issue: "The Wakulla Spring Mastodon."

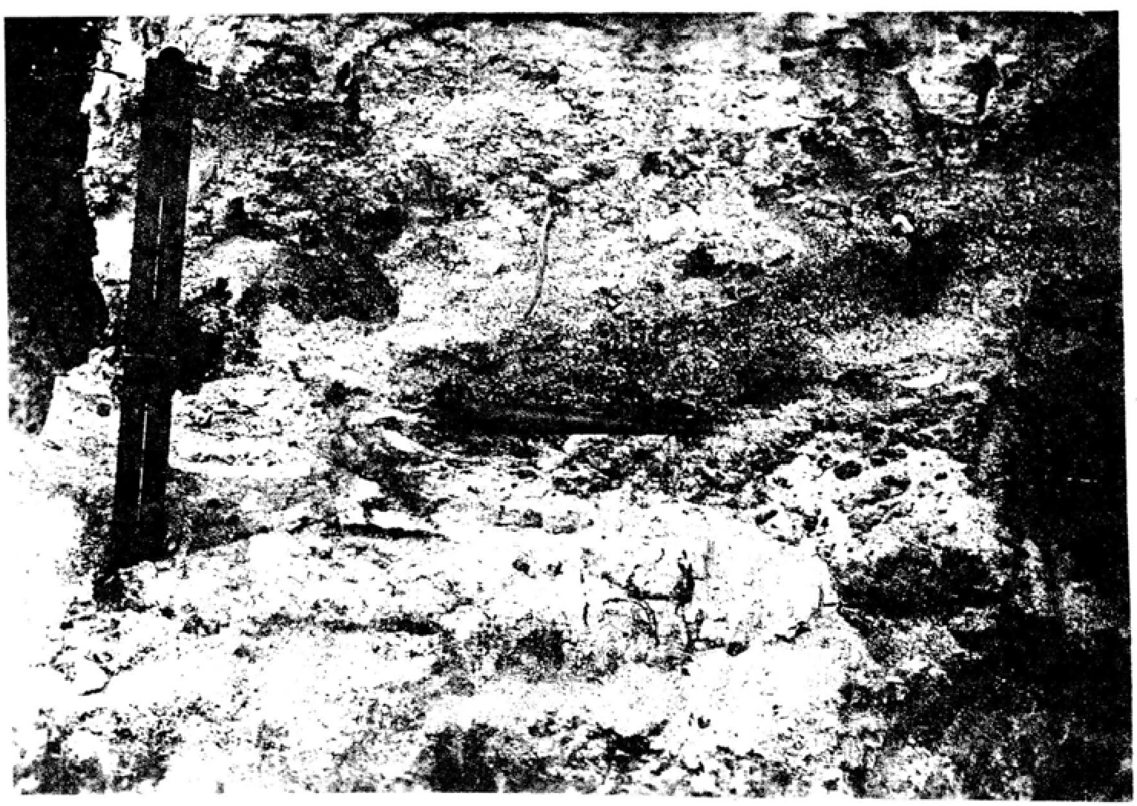


Location of Vero bone bed. Inset map is Sellard's original location figure published in FGS, 8th Annual Report, 1916. Small "x's" indicate human fossil sites. Location of inset is indicated on the portion of U.S.G.S. 7.5 minute topographic quadrangle map, Vero Beach sheet.



Fossil excavations at Vero, 1915. View is to the south, towards the town of Vero. Note the shade canopy over the dig area beyond the dirt heaps. Man in water is screen washing. Photo from FGS photo archives.

Closeup of the south bank of the Vero canal. Lower fossiliferous strata, from which human bones came, is indicated by numbers 1 and 3. Underlying Anastasia Formation coquina is indicated by number 4. Overlying alluvium is indicated by number 5. Photo from FGS photo archives.



Human radius in place in Vero canal bank, 1915. Photo from FGS photo archives.

BOOK REVIEW

DIGGING FOR DINOSAURS. John R. Horner and James Gorman. Workman Publishing, New York. 210 pages. $17.95.

Most science books discuss science in terms of relatively ahistorical facts and ideas; in other words, they rarely discuss the intimate details of how scientific information is discovered and how ideas develop previous to publication. The major exception to this rule that I am aware of lies in books that deal specifically with scientific history, such as for example those books about the great fossil collecting expeditions to Mongolia led by Roy Chapman Andrews in the 1920's. Such books tend to emphasize history rather than science. In the book Digging for Dinosaurs, however, John Horner and James Gorman have done something unusual. They have combined extensive science with historical description to recreate the enthralling modern story of how the now famous dinosaur egg and nest sites in the badlands of Wyoming were first discovered, explored, and interpreted to yield an unprecedented understanding of dinosaur reproductive biology.

For all of its scientific content, Digging for Dinosaurs is first and foremost a story. Despite the fact that this book is written by both John Horner and James Gorman, it is written as an autobiography from the perspective of John Horner. The story begins with John Horner's interest in finding juvenile dinosaurs as a fossil preparator at Princeton, and his unexpected discovery of baby hadrosaur dinosaurs and their nest in the Two Medicine formation in Western Montana. From this point the history of the excavation and exploration of dinosaur nest sites within the Two Medicine over six years of field work is gradually retold over the course of the book. Throughout this retelling the technological and social (including political) logistics of working a continuous paleontological excavation are revealed, providing insight into factors that all field working paleontologists must contend with at some time or other. In parallel the scientific discoveries made at the site are discussed, and how John Horner's ideas about dinosaur biology evolved in response to them.

Scientific information is abundant in this book, extensively covering both biology and geology in the context of paleontology, with emphasis on the reconstruction of paleoecology. In general the science is woven directly into the story, provided when necessary to make what John Horner believed was the significance of certain stories intelligible. However, chapter 3 ("The Good Mother Lizard") is written as a miniature, perhaps overly condensed textbook stuck in the middle of the story. It summarizes the evolutionary history of the dinosaurs and provides a detailed examination of the natural history of the hadrosaurs (e.g. "duck-billed" dinosaurs), some of which struck me as overly speculative. However, despite this one complaint I found the scientific discussion amazingly clear and easy to follow, with such potentially esoteric topics as geological stratigraphy (the science of understanding how and why rock layers are positioned relative to each other) and taphonomy (the study of fossil preser-vation) presented in a manner such that any reasonably educated person can grasp the important poi ynts.

This book is well illustrated, with both color plates and beautiful black and white drawings. However, it should be pointed out that this is not a picture book; its chief value lies in its wonderful exploration of the methods of paleontological inquiry and dinosaur biology. Thus it probably would be on the whole a poor gift for most children, though it certainly could be appreciated by someone at a teenage level.

In summary Digging for Dinosaurs is a book about one aspect of modern scientific history, which unlike most books in this genre places as much emphasis on the science as the history. Through its autobiographical format, it gives the most intimate picture I have ever seen of what it means in practical terms to be a vertebrate paleontologist. Thus, while I would recommend this book to anyone interested in dinosaurs or even just paleontology in general, I would specifically recommend this book to anyone curious about vertebrate paleontology as both a profession and a practiced science.

--W. David Lambert
Department of Zoology, University of Florida

Special Note - When I reviewed David Norman's The Illustrated Encyclopedia of Dinosaurs in the last newsletter, I said that the book had gone out of print. Since then I have discovered that it has been picked up by Random House, and is available through a special distributing division of the company.

NEW FOSSIL STUDY CENTER EXPANDING

The Florida Museum of Natural History's Fossil Study Center, created at approximately the same time as the introduction to Dino-Mania here in mid-September 1990, is continuing to grow.

The Fossil Study Center is supported by a grant from the National Endowment for the Arts and the State of Florida, Department of the State, Division of Cultural Affairs through the Florida Arts Council. Unlike the Dino-Mania exhibit, the Fossil Study Center is both permanent and free to visitors. It is designed to increase the visitor's understanding of scientific methods used by paleontologists to interpret ancient life through the use of specimens from the museum's extensive vertebrate and invertebrate paleontology collections.

Six panel exhibits (What are fossils?, How are Fossils Formed?, What do Fossils Tell Us?, What are Dinosaurs?, Geologic Time Scale, and What Did Florida Look Like 50 million years ago?) and more than thirty specimens introduce the science of paleontology and the diversity of ancient life. Exhibits of Eocene, Oligocene, and early Miocene specimens showcase earlier time periods in Florida's prehistory. The highlight of the Fossil Study Center is the late Miocene exhibit containing articulated skeletons and background paintings that allow the visitor to imagine what North Central Florida was like 7 to 9 million years ago.

The articulated skeletons include Thinobadistes segnis, a ground sloth; Pseudoceros, a primitive relative of the deer family; Barbourfelis lovei, a false sabrecat; Teleoceras proterum, a rhinoceros; and Geochelone hayi, a giant land tortoise similar to modern Galapagos tortoises.

Also included are the skeletons of Gavialosuchus americanus, a fossil crocodile; and Metaxytherium floridanum, a dugong, both exhibited in situ. A fossil dig box allows visitors to explore the world of dinosaurs and the science of paleontology.

Since its beginning last year, the Fossil Study Center has been anticipating still more additions. Currently under way is the task of readying Dr. Cliff Jeremiah's Carcharodon megalodon jaws for final exhibit. The jaws stand more than 2 meters in height and are almost as wide as they are long. They will be on display within the next couple of months, along with other little-known findings about this gigantic specimen. All of the Fossil Study Center's specimens are guaranteed to impress with their unique beauty and extraordinary displays.

--Jeremy T. Setty

FLORIDA PALEONTOLOGICAL SOCIETY 02-13-1991

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Animal-Plant Relationships and Paleobiogeography of an Eocene Seagrass Community from Florida

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Fossil seagrasses are rare in the geologic record. As a result, their patterns of biogeographic distribution and community evolution are poorly understood. Though generally considered to have first appeared in the late Cretaceous, little is known of their subsequent radiation or of the timing of coevolutionary relationships between fauna and flora seen in modern communities. An excellent example of a preserved seagrass community occurs in the late Middle Eocene Avon Park Formation of west-central, peninsular Florida. This fossil assemblage provides some of the first detailed information about the evolutionary development of animal/seagrass interactions, and in addition, documents the pre-Miocene existence of seagrasses in Florida.

The most common seagrasses present are species of Thalassodendron *and* Cymodocea. *As with modern seagrass communities, a diverse assemblage of epibionts, molluscs, and echinoderms is found in association with the blades and rhizomes. Also occurring with the seagrasses and elsewhere in the formation are the remains of some of the oldest dugongs yet known.*

The co-occurrence of numerous juvenile ophiuroids, regular echinoids, and asteroids with the grass blades suggests that the role of the seagrass community as a "nursery" had already been established by the Eocene. This role of providing food and protection for the young of many organisms is well-documented in the modern realm, but has never before been reported from the fossil record.

A strong Tethyan paleobiogeographic connection, previously noted among the Eocene molluscs of Florida, is also supported by the seagrasses and dugongs. We hypothesize that this assemblage of seagrasses was much more widespread in the Neotropics during the Paleogene and into the Neogene. Their absence now can be explained by the changing circulation patterns and cooling initiated by the closing of the Panamanian Isthmus and/or the onset of Plio-Pleistocene glaciation.

INTRODUCTION

Seagrass communities have undoubtedly been integral components of shallow marine ecosystems since their appearance in the late Cretaceous (den Hartog, 1970; Brasier, 1975; Eva, 1980). However, due to their poor preservation potential, marine angiosperms are relatively rare in the fossil record. This paucity of good fossil material makes the study of seagrass paleocommunity relationships and biogeography very difficult.

One of the more spectacular examples of the preservation of a fossil seagrass community occurs in the late Middle Eocene Avon Park Formation of west-central, peninsular Florida. Preserved in these shallow-water, low-energy, marine carbonates is an extensive seagrass bed dominated by the wide-bladed genera *Thalassodendron* and *Cymodocea*.

This exceptional occurrence provides an opportunity for detailed study of animal/seagrass interactions in the Eocene of Florida. Associated with these grasses is a diverse assemblage of epiphytes, epizoans, sediment dwellers, and vagrant epifauna that is comparable to such communities in the modern realm. The relationships of these organisms with the seagrasses are investigated here, as is the importance of numerous juvenile echinoderms associated with the grass blades.

In addition to the paleoecologic significance of this deposit, valuable information is also provided about the patterns of distribution and dispersal of seagrasses during the Cenozoic. Though generally considered to have originated in the Tethys Seaway during the late Cretaceous (den Hartog, 1970; McCoy and Heck, 1976; Larkum and den

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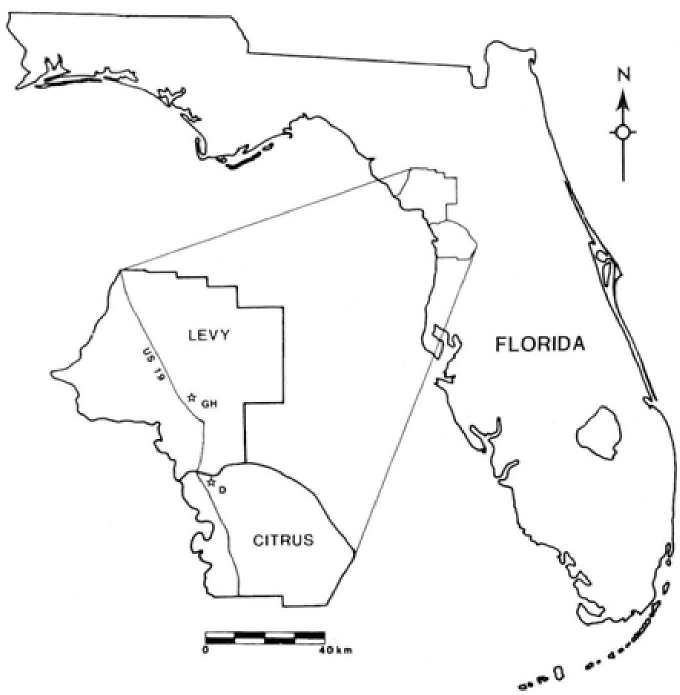

FIGURE 1—Locality map showing Dolime Quarry (D) in Citrus County and Gulf Hammock Quarry (GH) in Levy County, with US 19 included for reference. Scale bar is for county map.

Hartog, 1989), little is known of their subsequent radiation into the Neotropics. This occurrence in the Avon Park Formation conclusively documents the presence of a well-established, diverse community of seagrasses in Florida by the late Middle Eocene, earlier than previously hypothesized by Brasier (1975) and Eva (1980). A strong Tethyan biogeographic connection, previously noted for the molluscan fauna, is also supported by the seagrasses, associated invertebrates, and sirenians.

METHODS

Field work was conducted at four known exposures of the Avon Park Formation in peninsular Florida. Seagrass fossils were recovered only from the Dolime Quarry (SE¼, sec. 11, T17S, R17E, Citrus County, Florida) and the Gulf Hammock Quarry (SE¼, sec. 21, and NE¼, sec. 28, T14S, R16E, Levy County, Florida) (Fig. 1). Material collected primarily from Gulf Hammock by Dixon (1972), housed at the Florida Museum of Natural History (FLaMNH) in Gainesville, FL, was re-examined, as was material collected by Dr. Sheila Brack-Hanes from the same locality and stored at Eckerd College in St. Petersburg, FL. Samples were examined using magnifying lenses and binocular microscopes and associated invertebrates were identified as specifically as possible. Because most remains are present only as internal and/or external molds, silicone rubber peels were made in order to facilitate identifications.

The taxonomy of these fossil seagrasses is not fully understood. Den Hartog recognized six species, two of which he described, from Dixon's Gulf Hammock material (Lumbert et al., 1984). His classifications, however, have been questioned and work is currently being conducted to elucidate the taxonomic affinities of the grasses (for a partial review, see Benzecry and Brack-Hanes, in press). For the purpose of this paper, the classifications of den Hartog (Lumbert et al., 1984) will be followed.

REGIONAL STRATIGRAPHY

The Avon Park Formation is the youngest formation in the Middle Eocene Claiborne Stage of Florida. In the study area it overlies the Lake City Limestone and is separated from the Late Eocene, Jacksonian, Ocala Limestone above by a distinct depositional hiatus (Vernon, 1951; Dixon, 1972). The Avon Park is the oldest rock unit exposed at the surface in Florida and crops out in both Citrus and Levy counties.

The dominant lithology of the Avon Park Formation is a dolomitized biomicrite containing 10 to 30% miliolid foraminifera and some molluscs (Dixon, 1972; Randazzo and Saroop, 1976; Zachos, 1978). The seagrasses at the Dolime Quarry occur about 10 m below the surface, just above water level in the pit. Here the lithology is a light tan/gray, massive to crudely-laminated, dolomitized wackestone to mudstone with light tan, porous, burrows filled with material from the overlying unit quite common throughout. The rock splits along bedding planes where grass blades are present and in cross-section the numerous blades give the appearance of algal laminations.

The extent of the seagrass horizon below water level in the Dolime Quarry cannot be determined. Larger pieces recovered show a distinct grass-containing bed that is at least 20 cm thick, underlain by material similar to that above. Whether this thickness varies laterally, or whether there are additional beds below, is unknown. The zone immediately above is characterized by numerous irregular echinoids identified as *Periarchus lyelli floridanus* Fischer (Randazzo et al., 1990).

Seagrasses recovered from the Gulf Hammock Quarry were found only in spoil piles near the front of the quarry; none were in situ. The lithology of samples containing seagrass is more variable than that at Dolime. Although some are similar, other pieces are lighter tan in color, slightly coarser-grained, poorly-bedded, and often powdery to the touch.

RESULTS

Seagrasses

The most common seagrass found is *Thalassodendron auricula-leporis* den Hartog, a species described in Lumbert et al. (1984) (Fig. 2A–C). This is equivalent to the *Thalassia* sp. mentioned by Dixon (1972). Blades of this species are generally about 2 cm wide, up to 14 cm long, and marked by 27 to 35 parallel, longitudinal ribs, the medial of which is more pronounced. Lumbert et al. (1984)

FIGURE 2—Dominant seagrass species from the late Middle Eocene of Florida: **A**) complete leaf bundle of *Thalassodendron auricula-leporis* den Hartog, showing ligules and attachment to stem: **B**) rhizome, stem, and base of blade from *T. auricula-leporis*; **C**) partial blades of *T. auricula-leporis*, with prominent ligules and venation; **D**) blades of *Cymodocea floridana* den Hartog. Scale bars equal 10 mm.

described the rhizomes as branching, with internodes of variable (5.0–8.0 mm) length, and from 2.0 to 6.0 mm thick. Stems show leaf scars 1.0 to 2.0 mm apart. They also note that groups of relatively long and short internodes are found on the same plant, perhaps indicating some degree of seasonality in the growing conditions. A reconstruction of *Thalassodendron auricula-leporis* is shown in Figure 3. Modern *Thalassodendron* species range from shallow water to depths of about 10 m. They are strictly euhaline, avoiding any source of fresh-water influx (den Hartog, 1970). At the shallow end of its distribution the seagrass grows in circular patches but in deeper water it forms extensive meadows.

Two species of *Cymodocea*, one of which was described

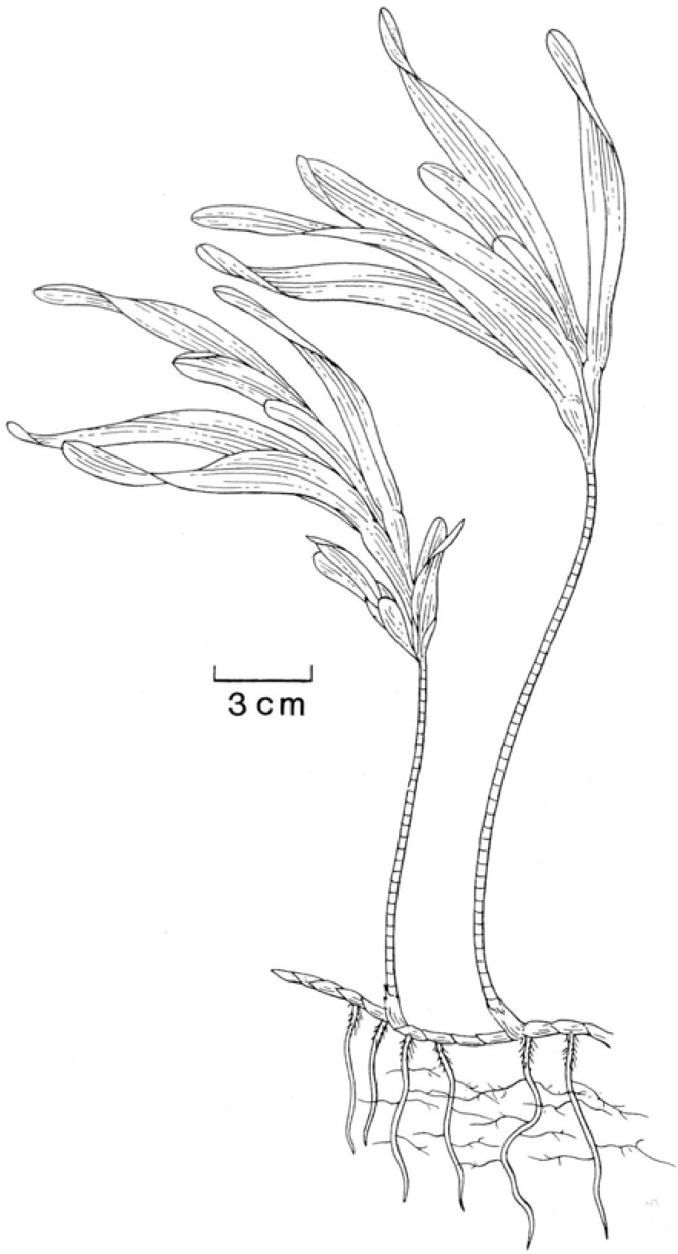

FIGURE 3—Reconstruction of *Thalassodendron auricula-leporis*, based on den Hartog (1970), measurements in Lumbert et al. (1984), FLaMNH specimens UF 548, UF 28031, and UF 28050, and extant *Thalassia*. Stem length is the only dimension that is inferred from modern representatives.

as a new species, *C. floridana* den Hartog, *in* Lumbert et al. (1984), are also present in the fossil seagrass material. The leaf blades are ligulate, at least 6 cm long, 7.0 to 8.0 mm wide, and have 11 to 13 nerves with a prominent midrib (Fig. 2D). This species is similar to the modern *C. nodosa* (Ucria) Aschers., but the blades are roughly twice the width. The other species of *Cymodocea* is not complete enough for specific identification, although the leaf blades strongly resemble those of *C. nodosa* (Lumbert et al., 1984). Den Hartog (1970) describes *C. nodosa* as a typical pioneer species, existing in places that are unfavorable for growth of other genera. It is common in very shallow water and can tolerate wide fluctuations in salinity, temperature, and dissolved oxygen.

A species that Lumbert et al. (1984) have identified as *Thalassia testudinum* Banks ex Konig, the most common species in Florida today, is also present. It is distinguished by longer and wider leaves than *C. nodosa*, with 10 to 15 parallel ribs per blade, cross-veins, and clearly defined tanin cells.

Material representing two other taxa is insufficient for more accurate identification. A very thin-bladed seagrass is relatively common in conjunction with *Cymodocea*, and is perhaps a species of *Halodule* (Dixon 1972; Lumbert et al., 1984). Leaves are 1.0 to 1.5 mm wide, up to 7.0 cm long, and have a single, central nerve. Another unidentifiable seagrass was tentatively classified as a species of *Ruppia* by Dixon (1972), and simply as an unknown zosteroid by Lumbert et al. (1984). Leaves are about 1 mm wide, up to 14 cm long, and strap-shaped, with a pronounced midrib.

Associated Organisms

Epiphytes

Epiphytic algae are integral members of seagrass communities owing to their importance as primary producers, a food source for grazers, and as additional habitat and refuge from predators for smaller invertebrates. Humm (1964), in his study of epiphytes on modern *Thalassia*, delineates two major groups of epiphytes: 1) the year-round, calcareous, Corallinacea, particularly *Melobesia* and *Fosliella*, that encrust the surface of blades and contribute significantly to the sediment (Nelsen and Ginsburg, 1986), and 2) the seasonal annuals, larger macroalgae that can become so prolific during the winter and spring that *Thalassia* is significantly shaded. Epiphytes in both of these categories are found on the Eocene *Thalassodendron*. Coralline algae are recognized as thin films over portions of the blades where they are preserved. Den Hartog (1970) reports that modern *Thalassodendron* is heavily encrusted by algae; therefore, the fossil blades were probably covered more extensively during life. Seasonal annuals are present on several specimens as large, dark, carbonized patches within the seagrass. The patches are non-vascular (therefore considered to be algae) and have epibionts such as *Spirorbis* preserved on their surface (Fig. 4A) indicating that they are marine plants. The margins of these algae are not visible thus identification is impossible. A species similar to the large, flat *Ulva* is possible, as this genus has been reported living epiphytically on *Thalassia* in modern communities (Humm, 1964). If these patches represent seasonal macrophytes, their presence may give insight into the season of burial for this deposit.

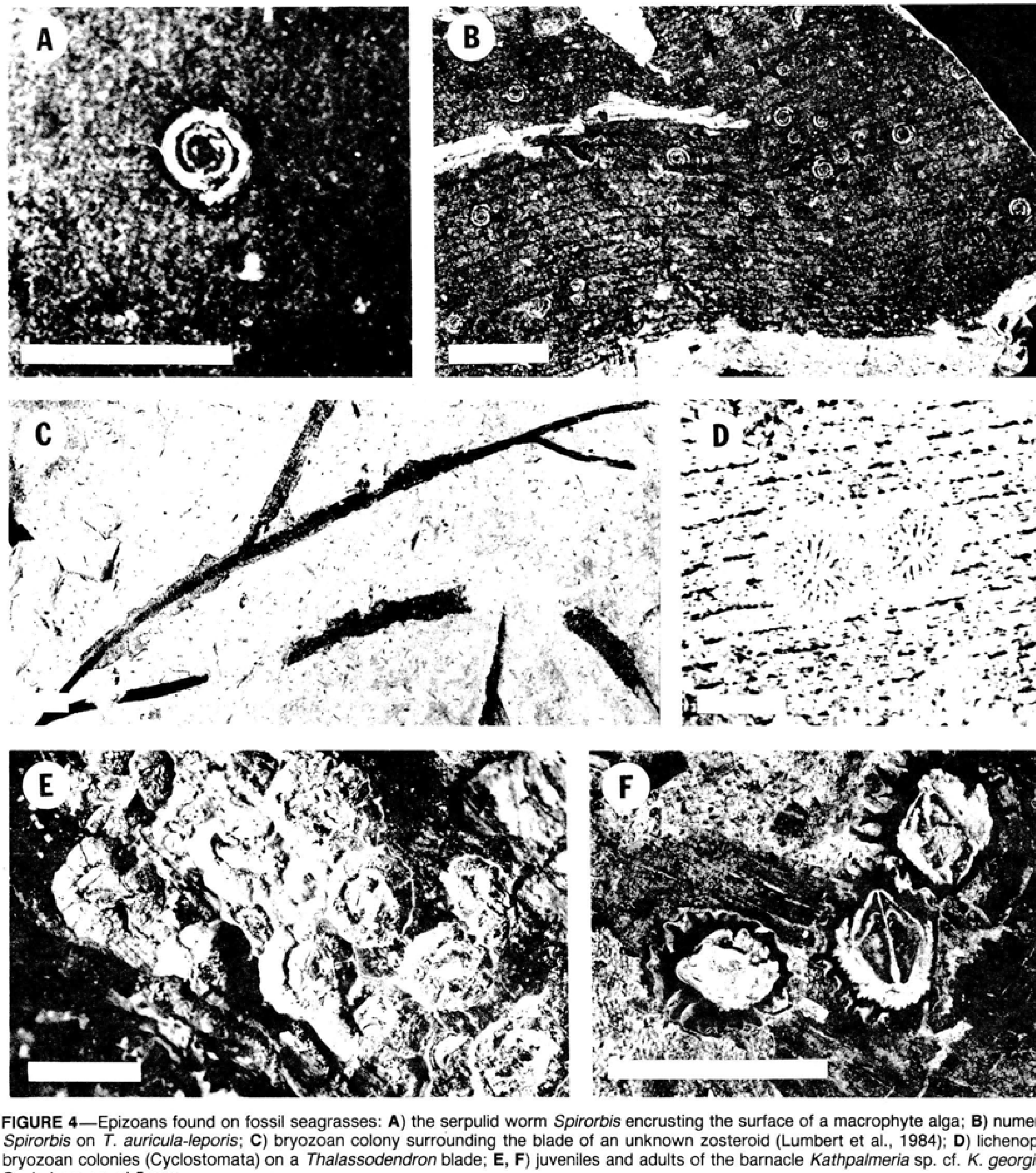

FIGURE 4—Epizoans found on fossil seagrasses: **A**) the serpulid worm *Spirorbis* encrusting the surface of a macrophyte alga; **B**) numerous *Spirorbis* on *T. auricula-leporis*; **C**) bryozoan colony surrounding the blade of an unknown zosteroid (Lumbert et al., 1984); **D**) lichenoporid bryozoan colonies (Cyclostomata) on a *Thalassodendron* blade; **E, F**) juveniles and adults of the barnacle *Kathpalmeria* sp. cf. *K. georgiana*. Scale bars equal 5 mm.

Epizoans

In addition to epiphytic algae, modern seagrass blades are commonly covered with a variety of animal encrusters that make their living filtering food particles from the water column. Few animals actually eat seagrass, living or dead, but many make use of organisms growing on the surface of the grass and its detritus (Moore, 1963); therefore, these epizoans, together with epiphytic algae, form an immensely important food resource for grazing microcarnivores and herbivores.

Evidence for the presence of these organisms in the Eocene community is strong. The aforementioned serpulid worm, *Spirorbis,* is extremely common on preserved seagrasses (Fig. 4A, B). In some cases, the entire coiled tube is preserved, but more often, only the impression or scar is left. Individuals seem to preferentially select the wider blades of *Thalassodendron* or macroalgae over associated, thinner-bladed grass. Perhaps this is due to the protection afforded by living on the underside of a wide blade, as the authors have observed in modern spirorbids, or perhaps it is simply reflective of the greater surface area available for colonization. Another species of polychaete that secretes an uncoiled, randomly wandering tube is also present but is not as common as *Spirorbis.* Both types of polychaete, particularly *Spirorbis,* are common on modern grasses.

Encrusting bryozoans are found on many samples of the fossil material, recognized as patches of meshwork covering portions of the blades. Several specimens distinctly show a colony surrounding an entire grass blade (Fig. 4C). Several varieties of cheilostomate bryozoans have been identified, including species of *Thalamoporella* and cf. *Membranipora,* both of which are common encrusters of modern seagrasses (F. Maturo, pers. comm., 1990). Also very common on some samples are the small, discoidal colonies of lichenoporid bryozoans (Fig. 4D). Specimens may be of the genus *Lichenopora* or *Disporella*; anatomical details necessary for this determination were not preserved. These cyclostomes are found today in normal marine settings. Voigt (1981) has reported numerous cheilostomate and cyclostomate bryozoans associated with seagrasses from the Upper Cretaceous of the Netherlands, thus the relationship between these two groups was initiated early in the evolutionary history of seagrasses and has perpetuated until the present.

Numerous barnacles representing juveniles and adults of a single species are present on one particular sample from the Gulf Hammock Quarry (Fig. 4E, F). These have been identified as *Kathpalmeria* sp. cf. *K. georgiana* Ross (V. Zullo, pers. comm., 1989, 1990). Other less complete individuals are found on the Dolime material. When silicone peels were made of these specimens, minute anatomical details such as the presence of opercular plates within the shells became apparent. The articulated nature of these plates indicates that the barnacles were almost surely alive when they were buried, as opposed to being empty shells washed in from elsewhere. The authors have observed modern barnacles living on the blades and rhizomes of *Thalassia,* thus is is not unusual to find these organisms in the fossil community.

Several disc-shaped benthic foraminifera are also present with seagrasses from Dolime. They have been identified as members of the Family Soritidae by Frank R. Rupert (pers. comm., 1990), but their orientation within the rock does not allow specific identification. Modern foraminiferal genera that live as epizoans on seagrass blades are commonly large and have a discoidal shape (Eva, 1980). Although species of this morphology do not exist exclusively as seagrass epifauna, most are closely associated with grass beds. Several genera from the Eocene of Jamaica have a similar shape and have been used to infer the presence of seagrass beds in the absence of fossil seagrass remains (Eva, 1980). In addition to the soritids observed in this study, Lumbert et al. (1984) report miliolid and rotaliid foraminiferans from the Gulf Hammock seagrass material. These also are commonly associated with seagrass beds today (Martin and Wright, 1988), and thus could be expected in the fossil community.

Soft-bodied organisms are also common epibionts on seagrasses. Sessile particulate-feeders such as hydroids, sponges, tunicates, anemones, and others are common in modern environments (Ogden, 1980) and therefore were probably also present in the Eocene community, although they were not preserved.

Sediment Dwellers and Climbing Epifauna

Other organisms associated with seagrass beds include a diverse assemblage of molluscs, crustaceans, echinoderms, and vertebrates that have adapted to the unique conditions existing there. Detailed discussions of the role of such organisms in modern seagrass communities can be found in Tabb and Manning (1961), O'Gower and Wacasey (1967), Jackson (1972, 1973), Brasier (1975), Kikuchi and Peres (1977), Ogden (1980), Virnstein (1987), and Miller (1988). These groups also occur in the fossil community and will be discussed here.

Numerous small, herbivorous gastropods are especially common in modern ecosystems and are so characteristic of seagrass beds that they may even be used to infer the presence of unpreserved seagrasses in the fossil record (Moulinier and Picard, 1952; Davies, 1970; both *in* Brasier, 1975). Many of these gastropods live as epibionts on grass blades, grazing on epiphytes. Gastropods recovered from the Eocene seagrass beds are nearly impossible to identify due to their poor preservation but the presence of external molds attests to their previous diversity. Most are small (<1.0 cm), suggesting that they may have been epibionts. Surprisingly few individuals were found in the material associated directly with the grasses, although many are present in the sediments above and below. This was unexpected, for they are so abundant in modern communities. Some evidence of rasping on blades by gastropods is suggested by the presence of irregular, lighter patches on some leaves, perhaps due to removal of tissue (Fig. 5A). Strikingly similar traces, made either by gastropods or amphipods (Wolff, 1980), can be found on modern seagrass blades (Fig. 5B).

The bivalve fauna in the Avon Park *Thalassodendron* assemblage is also composed of moldic fossils. Most are very small, unidentifiable, and rarely encountered; however, three species are relatively common and were identified to family, one as a chamid and the other two as ostreids. The chamids are approximately 1.0 cm long, bulbous, and very spiny. They are found clustered around the rhizomes of seagrass, suggesting that perhaps the roots served as a point of attachment for the bivalves in the soft mud. One type of ostreid is also small (approximately 1.0 cm), but very flat and smooth. It is found associated with the blades of the grasses, not the rhizomes, perhaps attaching to the blades in life as the authors have observed with tiny oyster spat. The other ostreid is found only in the Gulf Hammock material and is much larger, up to 7.0 cm. It probably lived nestled among the bases of the plants.

The last molluscan representative found in the seagrass material is a tiny polyplacophoran, about 0.5 cm long. Although it too is preserved as an external mold, enough detail is present to count individual calcareous plates on the shell. This individual must have been alive prior to burial in order to preserve the plates in an articulated manner.

A single brachyuran crustacean was found in the fossil material from the Gulf Hammock Quarry. This is a species of *Portunus,* related to the blue crab *Callinectes sapidus* Rathbun found in seagrass beds today. Like *Callinectes,* it was probably a scavenger. Based on their importance today, other crustaceans such as amphipods and caridean and penaeid shrimp (Mann, 1982; Zieman, 1982, *in* Virnstein, 1987) must have been present in the Eocene community though none have been recovered.

Several asteroid ossicles, some of which are quite large (0.8 cm), are present in the fossil seagrasses. These ossicles may be from the large oreasterid cf. *Goniodiscaster* (D. Blake, pers. comm., 1989), for this genus has been collected from the Ocala Limestone just above the seagrass layer. The modern *Oreaster* is common in thin seagrass beds where it feeds by everting its stomach onto epiphytic algae and digesting them externally (Scheibling, 1980c).

One of the most significant finds in the seagrass material is the presence of numerous juvenile ophiuroids, asteroids, and regular echinoids associated with blades of *Thalassodendron.* Nearly all individuals are less than 2 cm in diameter and many are complete. It is suspected that the asteroids are oreasterids; the ophiuroids and echinoids have not been identified. These echinoderms will be discussed in greater detail in the Discussion section.

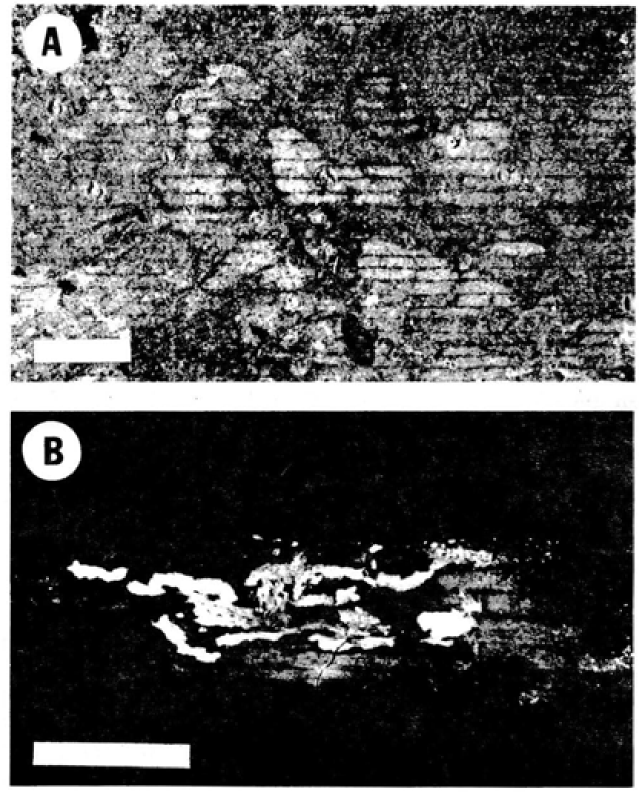

FIGURE 5—Grazing traces probably made by a gastropod on fossil **(A)** and modern **(B)** seagrass blades. Note the irregular, light-colored patches on both that result from removal of organic material. Scale bars equal 5 mm.

Vertebrates

Two large vertebrate species are particularly characteristic of modern seagrass communities: the sirenian *Dugong dugong,* or "sea cow", and the green sea turtle *Chelonia mydas* (McRoy and Helfferich, 1980; Lanyon et al., 1989), both of which are significant grazers on seagrass blades. Fossil representatives of both the sirenians and the cheloniid turtles have been recovered from the Avon Park Formation in these and other localities in Florida.

The dugongs are marine mammals that feed nearly entirely on seagrasses (Domning et al., 1982; Lanyon et al., 1989), and only ingest significant quantities of algae when their preferred food supply is depleted (Spain and Heinsohn, 1973, *in* Domning, 1981, and *in* Lanyon et al., 1989; Marsh, 1981, *in* Domning, 1981). For this reason, the presence of sirenians in a fossil deposit is also strongly indicative of the presence of seagrasses, regardless of whether the latter are preserved. In the Dolime Quarry, we see the direct association of preserved seagrasses with fossil sirenian material. A fragment of pachyostotic bone, probably a dugong rib, is present within the seagrass horizon here, and the authors have collected *Protosiren* remains from elsewhere in the quarry. Domning et al. (1982) have also recorded *Protosiren* and other indeterminate sirenians from the Avon Park Formation in this and other quarries, attesting to their presence at the time. The paleobiogeographic significance of the relationship between dugongs and seagrasses will be discussed in more detail later.

The green sea turtle is also a significant grazer of seagrasses, although not as directly dependent upon them as the dugongs. Sea turtles also consume a variety of algae, depending on what is available in the immediate vicinity (Hirth, 1971; Mortimer, 1981; Garnett et al., 1985; all *in* Lanyon et al., 1989). Fragments of bone from a cheloniid turtle, probably cf. *Syllomus,* have been found in the Dolime mine (G. Morgan, pers. comm., 1990). Although this genus has no modern representatives, its familial relationship with the herbivore *Chelonia* and its presence in the ancient seagrass community suggest that it may have utilized the plants as a food resource.

FIGURE 6—Juvenile asteroids and ophiuroids scattered on blades of *Thalassodendron*, exemplifying the seagrass "nursery". Each is approximately 10 mm in diameter.

DISCUSSION

The Role of Seagrass Beds as "Nursery"

One of the most important functions of modern seagrass beds is the two-part role of "nursery" to a host of associated invertebrates and vertebrates from surrounding communities (Ogden, 1980; Gilmore, 1987; Virnstein, 1987). Seagrass beds provide abundant food in the form of epiphytes and epizoans for grazing juveniles, and in turn the population of grazers provides food for higher consumers. Secondly, refuge from predators is an important aspect of the nursery function, for dense seagrass beds provide shelter from predators for many juveniles that are small enough to hide among the blades.

Although the role of seagrass communities as nursery is well-documented in the modern realm, it has never been described in the fossil record. The Avon Park seagrasses provide the first opportunity to examine this relationship in the Eocene of Florida. Numerous juvenile ophiuroids, asteroids, and echinoids are preserved within the grass bed, none larger than 3.0 cm and many smaller than 1.0 cm in diameter (rays outstretched; Fig. 6). The size of the juveniles indicates that they are almost certainly first year recruits. No adults have been found in the seagrass layer, although several isolated asteroid ossicles were recovered.

The ophiuroids are by far the most common motile invertebrate associated with the fossil seagrasses (Fig. 7A, B). Although these individuals cannot be identified, two species can be distinguished, one of which is probably in the family Amphiuridae (Richard Aronson, pers. comm., 1990). These may be juveniles of species more common outside the seagrass beds as adults, residing in the grasses for food and protection while they are small and thus more vulnerable to predation. No specific mention of juvenile ophiuroids associated with modern seagrasses was found, but Kikuchi and Peres (1977) comment that ophiuroids are particularly abundant in *Thalassodendron* communities off the east coast of Africa, and Tabb and Manning (1961) have found *Ophioderma brevispinum* (Say) associated with *Thalassia* in Florida Bay.

The life habits of the fossil ophiuroids can only be inferred based on comparisons of their morphology with that of modern representatives. Although amphiurids are typically burrowers, these juveniles would likely be too small for this mode of life. The long, flexible arms of some individuals (Fig. 7B) suggest that they may have been climbing the stiff grass blades (Barnes, 1987; F. Maturo, pers. comm., 1989), perhaps to avoid burial in the fine sediment. We postulate that these juveniles were using the blades of *Thalassodendron* as an elevated substrate from which they could filter feed in the water column. This so-called mucus net suspension feeding in ophiuroids has been described by several authors (e.g., Fontaine, 1965; Pentreath, 1970; *in* Jangoux and Lawrence, 1982), and is suggested by the presence of long spines on the arms (Fig. 7B). Mucus is selected and strung in threads between the spines and the arms are waved in the current to trap food particles on the sticky surface. Periodically the mucus is gathered and passed to the mouth as a bolus where it is sorted and ingested. The ophiuroids may also have been grazing on the *Aufwuchs*—the covering of bacteria, epiphytes, and invertebrates encrusting the surface of the blades (W.D. Russell-Hunter, 1970, and pers. comm., 1987). Perhaps, like many organisms, they were more cryptic during daylight hours, hiding under bits of rubble or at the base of plants to avoid predators, then moving up the blades at night to feed.

The small asteroids are oreasterids, perhaps cf. *Goniodiscaster*, also known from the overlying Ocala Limestone (Fig. 7C). Modern adult *Oreaster* is common in thin seagrass beds, but avoids dense meadows of *Thalassia* due to restriction of mobility caused by the stiff leaves. Juveniles, however, are very common in *Thalassia* beds because their small size allows for movement beneath the canopy (Scheibling, 1980a, b). Juveniles are camouflaged by a mottled green and brown color that blends well with seagrass blades; this transforms to light yellow-orange and brown as the individuals mature and move out of the grass bed to a more open, sandy substrate (Scheibling, 1980a). The seagrass habitat provides these juvenile asteroids with abundant food and protection from predators until they reach a size refuge and/or become too large to maneuver in the grass. Modern *Oreaster* thus provides an excellent analogue for these fossil oreasterids.

Partial external molds of tests from at least six regular echinoids, the first regular echinoid fossils reported from the Avon Park Formation, are present in the seagrass material from both quarries. Some specimens are complete with lantern, tubercles, and spines (Fig. 7D). The individuals are no more than 1.0 cm in diameter and thus are undoubtedly juveniles. Moore et al. (1963) conducted a growth study of the urchin *Lytechinus variegatus* (Lamarck) and found that individuals which had settled out of the plankton during the autumn had reached a size of about 10 mm by January. This suggests that the fossil urchins were only several months old when they were entombed. Assuming that spawning and settlement occurred during the same seasons for fossil and modern species and that the growth rates of the two species are comparable, we can speculate that the season of burial for this deposit was the winter. This hypothesis is also supported by the presence of the seasonal macroalgae described earlier.

Ogden (1980) noted two herbivorous urchins common in modern seagrass communities, the abovementioned *Lytechinus variegatus* and *Tripneustes ventricosus* (Lamarck). These echinoids not only graze on epiphytic algae, but are two of the few species that feed directly on the seagrass itself, often ingesting significant quantities of the blades (Camp et al., 1973; Ogden, 1980). The small fossil echinoids may have also grazed on grass blades if they are members of similar taxa. However, a comprehensive survey by Kier and Grant (1965) reported juveniles of both of these species living just outside the seagrass beds; only one was found within. Instead, they found juveniles of *Diadema antillarum* Philippi, an echinoid common in reef habitats as adults, living alone in grass beds far from the preferred habitat of adults. This suggests that these echinoids, like the oreasterids, may represent species more common outside the seagrass system as adults, but which utilize the grass beds as a nursery for juveniles.

Modern *Thalassia* Ecology

Very little has been published concerning the environmental tolerances of the dominant fossil genus, *Thalassodendron*. However, a wealth of information is available about the ecology of modern *Thalassia* communities. Since this species and *Thalassodendron* are very similar in morphology and habitat, much of the knowledge about *Thalassia* will therefore apply to *Thalassodendron*. By using

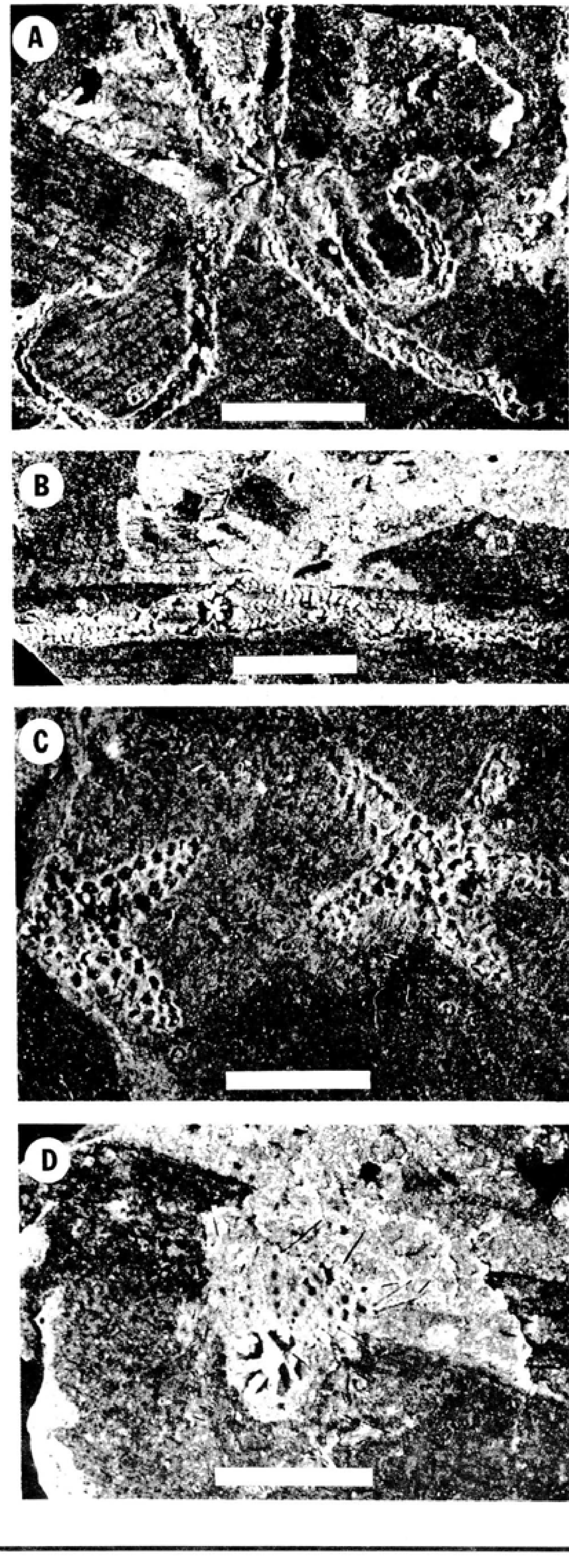

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FIGURE 7—Juvenile echinoderms from the Dolime Quarry: **A, B**) ophiuroids on seagrass blades; note the long, sinuous arms and spines of B, thought to be an amphiurid; **C**) oreasterid asteroids; **D**) regular echinoid, showing tubercles and spines. Scale bars equal 5 mm.

Thalassia as an analogue, the environmental conditions that existed in the Eocene during deposition of the Avon Park may be better understood.

Modern *Thalassia* forms extensive meadows in tropical to subtropical coastal waters on muddy or muddy sand substrates, below low tide to depths of 8 to 10 m (Moore, 1963; den Hartog, 1970). Limiting factors on its distribution, as discussed by Moore (1963), include temperature, salinity, depth, turbidity, and wave action.

Thalassia, like *Thalassodendron,* is a euhaline marine grass. Salinities outside the range of 25 ppt to 40 ppt can be tolerated for short periods, but prolonged exposure is damaging. The depth to which *Thalassia* can survive is largely determined by turbidity. Much solar insolation is needed for growth; therefore, significant expanses of the grass are rarely found in water deeper than 8 m, no matter what the clarity. Plants in very shallow water can tolerate the full intensity of the sun even at low tide, but seem to have shorter blades and sparser foliage than deeper-water plants (Moore, 1963).

Wave action is a significant limiting factor in seagrass distribution. Moore (1963) states that *Thalassia* is only found in offshore settings where wave action is relatively low, otherwise it is coastal. Florida Bay and the Keys have extensive meadows due to the protective functions of Cuba, the Bahamas, reefs, and shallow banks. These geomorphic features, combined with the wide, shallow, continental shelf, help to diffuse the long wavelengths necessary to dislodge the seagrass rhizomes. Shorter wavelength waves from local storms do not affect the rhizome mat significantly, if at all, but only remove blades from the plants. This observation will be important in the interpretation of depositional environment to follow. As an example, Thomas et al. (1961) looked at the effects of Hurricane Donna (Sept. 9–10, 1960) on the *Thalassia* beds in Biscayne Bay. They found that although huge quantities of leaves had been washed ashore by the storm, the beds themselves were relatively undisturbed. The entangled mats of rhizomes, which can be over 25 cm thick (Scoffin, 1970; Jackson, 1973), clearly helped stabilize the sediment and prevent erosion. Furthermore, Thomas et al. (1961) stated that physical damage suffered by the plants would be quickly healed by their rapid growth rate (approximately 25 mm/wk). Modern *Thalassodendron* have a thinner rhizome mat, only 5 to 10 cm (den Hartog, 1970); therefore, the fossil plants may have lived in a quieter, lower-energy environment, perhaps in deeper water, where they were not as likely to be disturbed. The worst effects of storm action on seagrasses are fresh-water influx from storm runoff and increased turbidity due to the resuspension of silt. Moore (1963) found that entire beds can be destroyed by siltation from storms or floods. As discussed below, we hypothesize that this was the case with the Eocene seagrasses.

Paleoenvironmental Reconstruction

Based on information from modern seagrass beds, the Avon Park seagrasses were probably living in shallow (1–10 m), low energy, warm water, either nearshore or on a wide, protected flat. The distribution of Eocene rocks in Florida suggests that marine environments extended substantially further inland, perhaps drowning the entire peninsula; therefore, the latter scenario is more likely. The environment was probably much like Florida Bay today. The existence of a shallow, intertidal zone in the vicinity is suggested by the presence of what appear to be mangrove leaves in the seagrass material.

There is some indication from the preserved flora and fauna that these two seagrass communities existed under slightly different environmental conditions. The flora of the Dolime site is without question dominated by *Thalassodendron auricula-leporis,* with some *Cymodocea floridana* interspersed. At Gulf Hammock, however, these genera are present, but not in the same abundances; instead, *Cymodocea* species and *Halodule* are much more prevalent. The ecological preferences of these genera in modern environments suggest that there may have been more variation in salinity at the Gulf Hammock grass bed, for modern *Halodule* and *Cymodocea* are most common in very shallow water and can tolerate such fluctuations (den Hartog, 1970; C.L. Montague, pers. comm., 1989). In contrast, the abundance of echinoderms at the Dolime pit (all but three were recovered there), which can only exist in waters of normal marine salinity (roughly above 26 ppt), and the stenohaline nature of modern *Thalassodendron* dictates that this community must have existed in a region with little fluctuation in salinity, perhaps in more open, deeper water. Kikuchi and Peres (1977) mention an intriguingly similar situation off the coast of East Africa where ophiuroids today are common in *Thalassodendron* communities but nearly absent from adjacent, shallow-water *Cymodocea* communities.

Additional evidence in support of this hypothesis is afforded by a faunal study of modern seagrass communities. Jackson (1972), in researching an on-shore/off-shore gradient in bivalves associated with modern *Thalassia,* noted that in shallow-water, highly stressed environments, population density is low and overall abundance is high. Individuals also tend to be larger, presumably in order to better isolate themselves from detrimental environmental conditions. With increasing depth, the more stable, predictable conditions result in a less stressful environment. Community diversity is higher, in both species richness and equitability, and overall body size and abundance decreases (Jackson, 1972).

This information suggests that Dolime seagrasses may have existed in water deeper than that at Gulf Hammock. Dolime material contains a more diverse assemblage of invertebrates overall than does Gulf Hammock, and (although material is admittedly scant) the large bivalves (i.e., ostreids), were only recovered from Gulf Hammock. Sedimentologic evidence supports this hypothesis as well. Sediments from Gulf Hammock are lighter in color, suggesting that either there was less organic matter in the sediment or it was better oxygenated, allowing faster decomposition. In addition, grain size was slightly coarser, indicative of more wave action. Both of these properties could be explained by differences in water depth during deposition.

Mode of Preservation

The presence of numerous, intact rhizomes suggests burial in situ, contrary to the opinions of Lumbert et al. (1984) and concurring with those of Randazzo and Saroop (1976). If this had been a wrack deposit, as suggested by the former authors, it would be unlikely that many rhizomes would be present in the material. The stability of the rhizome mat, even under hurricane conditions, has already been related; wrack deposits from a storm event would therefore be composed primarily of leaves, in very large quantities, and probably interspersed with coarser-grained material brought up by high wave energy. Blades would likely be twisted around each other and aligned roughly parallel to the shore by wave action, as can be observed in modern wrack line deposits, but this is not the case here. Grasses are present in abundances that are interpreted as being reflective of the original community, with rhizomes intact, blades laid out flat, in no particular alignment, and with a host of epibionts, molluscs, and echinoderms that were likely present in the original community. As far as can be determined, no invertebrates present were derived from communities outside the seagrass bed, and none show signs of transport or abrasion.

Gradual aggradation of sediment in situ, however, would not account for the presence of the fossil plants. In order to preserve the plant material in such extraordinary condition, the blades must also have been buried very rapidly so that decomposition was inhibited. The presence of numerous, intact ophiuroids, in addition to the seagrass itself, also suggests that this deposit was preserved through rapid sedimentation and not gradual, accretionary deposition. Ophiuroid skeletal elements are joined only by soft tissue and thus are easily disaggregated after death, even with minimal exposure to currents. Schafer (1972) states that ophiuroids can only be preserved intact where there are no bottom currents or where they are buried very quickly. Although wide seagrass blades tend to reduce current energy at the sediment-water interface, resulting in quiet-water conditions and deposition of fine sediments, any organism lying exposed on the surface would likely have been scavenged by roving omnivores (e.g., the crab *Portunus*) long before being sufficiently buried; therefore, rapid burial is much more likely. Brittle stars react to sedimentation by moving upward; however, as little as 5 cm of material rapidly deposited on top of an ophiuroid will immobilize and kill it. Schafer (1972) reports that the period of time after a prolonged gale is especially dangerous because resuspended fine sediments will fall back to the sea floor, entombing the organisms.

This seagrass bed was therefore most probably buried in place by rapid siltation caused by an offshore storm that resuspended large amounts of fine sediment. Scoffin (1970) showed that *Thalassia* is a very effective sediment trap, due to the baffling effect of the blades. Because of their morphologic similarity, the same would be expected of *Thalassodendron*, and this sediment trapping would be enhanced with more suspended material in the water, as after a storm. Rapid fallout of silt in the grass bed would thus explain the unusually good preservation of echinoderms and grass blades.

The thickness of the seagrass layer (at least 20 cm), and the even distribution of grasses and invertebrates throughout this layer, suggested to Dixon (1972) that more than one episode of burial may be represented. Rhizomes buried in the preceding event could have easily sent up new shoots to recolonize the substrate and perpetuate the community as long as the depth of burial was not excessive. However, we find no evidence of multiple graded beds, depositional hiatuses, or other sedimentologic features associated with episodic deposition within the seagrass unit. There is also no bioturbation within the unit itself, which would be expected if time had elapsed between storms. These characters strongly suggest that the seagrass bed represents a single depositional event that took place over a short interval of time; this community was buried during the passing of one storm in the late Middle Eocene.

Galli (1989) describes storm-generated mud layers in modern Florida Bay sediments that are strikingly similar to those seen in the Avon Park Formation. Although his units are only 5 cm thick, he has found evidence for similar layers in the geologic record that are much thicker, corresponding more to the thickness of this seagrass bed. In addition, Poiner et al. (1989) noted that the passage of Cyclone Sandy in March 1985 caused vast areas of deeper-water seagrass beds in northern Australia's Gulf of Carpentaria to be smothered by a thick layer of fine mud which decimated the community. These recent events are analogous to the storm that must have smothered the Eocene community.

Such a scenario is relatively common in the shallow marine realm, but preservation of seagrass communities is rare due to the constant erosion and redeposition of sediments, allowing for disaggregation and decomposition of remains. This occurrence represents one of the rare instances where disturbance of the buried community did not take place. The thickness of the mud layer was also sufficient to sustain anoxic conditions necessary for preservation. Smaller, more typical storm events generally produce thinner sequences (like those described by Galli, 1989) that are more likely to become oxygenated through bioturbation and diffusion.

BIOGEOGRAPHY: THE TETHYAN CONNECTION

Additional Fossil Evidence

Fossil seagrasses are extremely rare in the rock record; therefore, patterns of distribution and dispersal must often be inferred by examining other related factors. Some of the few known occurrences of preserved seagrass material are reviewed by den Hartog (1970), Brasier (1975), Daghlian (1981), Lumbert et al. (1984), and Larkum and den Hartog (1989). These include Cretaceous zosteroids from Japan and cymodoceoids from the Netherlands and Ger-

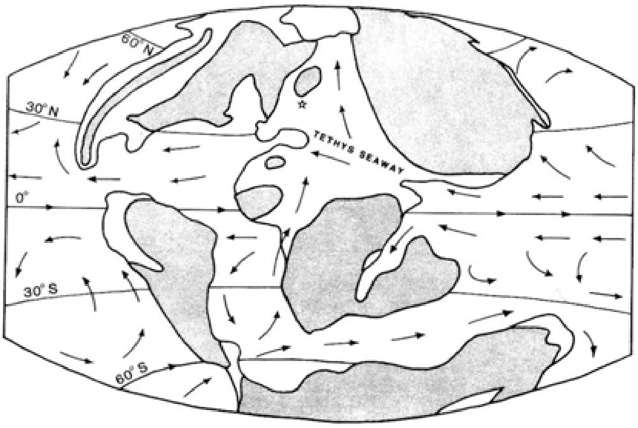

FIGURE 8—Tectonic reconstruction for the Late Cretaceous showing probable exposed land (shaded) and position of Tethys. Arrows indicate inferred paleocurrent directions and star represents Cretaceous cymodoceoids from the Netherlands and Germany. Slightly modified from Brasier (1975), after Cox (1973) and Gordon (1973).

many, species of *Cymodocea* and *Posidonia* from the lower Eocene Paris Basin, species of *Cymodocea* from the Miocene, Pliocene, and Quaternary of Italy, and these Middle Eocene seagrasses from peninsular Florida. Other studies have inferred the presence of seagrasses based on characteristic lithologies (Petta and Gerhard, 1977; Wanless, 1981), invertebrate assemblages (Bretsky, 1978), and associated foraminifera (Brasier, 1975; Eva, 1980).

Modern seagrasses as well as the few known fossil occurrences show distinct Tethyan affinities in their patterns of distribution (den Hartog, 1970). The origin of seagrasses was probably in the Tethys Seaway during the Cretaceous and the present distribution is a result of dispersal, vicariance events, and local extinctions (den Hartog, 1970; McCoy and Heck, 1976; Larkum and den Hartog, 1989). The origin of many organisms closely associated with seagrasses was also probably in the Tethys. Genera characteristic of seagrass communities such as *Codakia, Abra, Ctena, Anodontia, Velates, Venericardia* (molluscs), *Portunus* (brachyuran crab) (McCoy and Heck, 1976), and many foraminiferans (Brasier, 1975; Eva, 1980), arose in the late Crecateous or Paleocene and presumably spread with the dispersal of the seagrasses; thus, their presence in fossil assemblages tends to suggest the concurrent presence of seagrasses, even when plant matter is not preserved.

One of the most reliable indicators of ancient seagrass communities may be the sirenians, some of which feed almost exclusively on the plants and thus have likely been closely associated with them through time. Because the oldest recorded sirenians have been found in Lower Eocene rocks from tropical marine settings (post-dating the arrival of seagrasses), and they, too, are Tethyan in origin, Domning (1981) concludes that it is reasonable to assume the dependence of dugongs (marine sirenians) on seagrass seen in modern communities extends back to the earliest members of this group. He therefore proposes that they provide an excellent example of co-evolution, even more convincing than the previously-mentioned invertebrates (Domning, 1981; Domning et al., 1982). The presence of fossil sirenian remains in the Avon Park Formation was cited in earlier sections of this paper. Because these fossils are not restricted solely to the seagrass horizon, it can be inferred that seagrasses were also present at other times during the deposition of this unit.

Dispersal of Seagrasses

There have been problems in accounting for the spread of seagrasses from the Tethys Seaway to the Neotropics. Based on foraminiferal assemblages, Brasier (1975) concluded that seagrasses did not appear there until the Miocene. This was disproved by Eva (1980), who maintained that seagrasses were present in the Caribbean since the Eocene, but felt they did not reach Florida until later. These authors were apparently unaware of the Middle Eocene seagrasses from Florida reported by Dixon (1972) and Randazzo and Saroop (1976). Questions as to how these seagrass genera arrived in Florida, why they are no longer present, and when they disappeared are considered below.

In the late Cretaceous, an open connection existed between the Indo-Pacific and Atlantic via the Tethys and adjacent sea lanes (Fig. 8; Brasier, 1975; Larkum and den Hartog, 1989). Cymodoceoids were present in northern Europe during this time. Although Brasier (1975) feels that a connection with the New World could not have occurred until the Miocene, it is not unreasonable to hypothesize grasses rafting to the Caribbean on westward-flowing currents much earlier. In support of this, *Thalassodendron* is one of the few genera of seagrass that is viviparous—having floating seeds (den Hartog, 1970; Larkum and den Hartog, 1989). Although the seeds of modern species do not remain buoyant for long (Larkum and den Hartog, 1989), it is conceivable that under the proper conditions, seeds of the fossil plants may have stayed afloat long enough to reach the Neotropics from Europe, especially if the journey occurred in the Late Cretaceous when the continents were much closer together. The possibility also exists that entire plants were dislodged by wave action and rafted to the New World in this manner. The occurrence of the coralline algae *Archaeolithothamnium parisiense* (Gumbel) from the late Middle Eocene of Florida (Johnson and Ferris, 1948) also supports this connection with European assemblages, as this species, like the seagrasses, is reported from the Eocene Paris Basin (Lemoine, 1923; *in* Johnson and Ferris, 1948).

However the connection was made, this assemblage was well-established in Florida by at least the late Middle Eocene. Petta and Gerhard (1977) suggested an even earlier dispersal by inferring the presence of seagrasses in the Late Cretaceous Campanian of Colorado from sedimentologic evidence. Bretsky (1978) supported this idea by noting that bivalves found in those Upper Cretaceous sediments were well-adapted to living in seagrass beds. It is clear from this and other information that dispersal of seagrasses from their Tethyan place of origin occurred

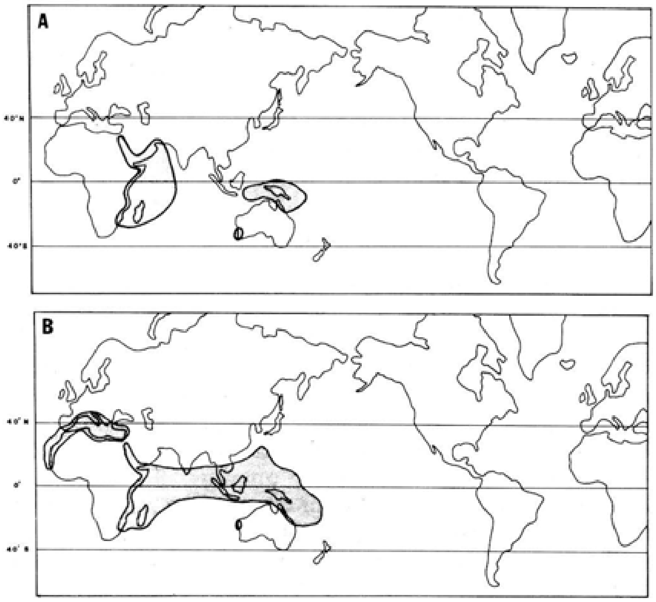

FIGURE 9—Present distribution of A) *Thalassodendron* and B) *Cymodocea* (after den Hartog, 1970).

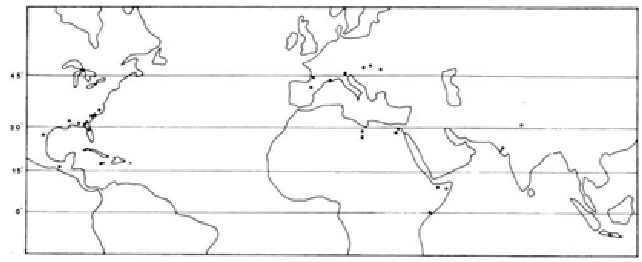

FIGURE 10—Distribution of Eocene sirenian remains, after Domning et al. (1982). Fossil seagrass material could be expected in these areas if preservation were adequate.

rapidly, shortly after their initial appearance, and not only to the Neotropics but also into other parts of the Indo-Pacific (Larkum and den Hartog, 1989).

Past and Present Distribution

Several important questions remain. Why are these seagrass genera not present in the western hemisphere today, and why is there no record of their presence here since the Eocene? *Thalassodendron* and *Cymodocea* are presently restricted to the tropical Indo-Pacific (Fig. 9A, B; den Hartog, 1970). We suggest that seagrasses, particularly *Thalassodendron* and *Cymodocea,* were more widespread in the New World during the Paleogene and perhaps into the Neogene than previously suspected. Larkum and den Hartog (1989) concur, stating: "During the Paleogene, there is definite evidence that *Cymodocea, Thalassodendron, Thalassia,* and *Posidonia* were present and may have been widespread" (p. 127), and "the present distribution of *Thalassodendron* [and, we think, *Cymodocea*] must now be seen as a relic of a much wider previous distribution . . . " (p. 121).

This hypothesis is also supported by the distribution of Eocene sirenian fossils (Fig. 10). The coevolutionary relationship discussed earlier strongly implies the presence of seagrasses in regions where dugongs are found. This suggests that seagrasses existed not only in the Tethys and adjacent waters, but also throughout much of the Neotropics (i.e., from the Gulf of Mexico, into the Caribbean, and along the eastern seaboard of North America as far as North Carolina, a much broader range than that indicated solely by the plant fossils). Unfortunately, because seagrasses are so rarely preserved in the fossil record, it will be difficult to confirm this hypothesis with direct evidence.

The present disjunct distribution of many seagrass species in the Indo-Pacific, as explained by Larkum and den Hartog (1989), is a result of isolation and local extermination of populations caused by changing circulation patterns which brought colder water to the formerly tropical habitats of the plants, and of limited speciation occurring subsequent to the isolation. A similar hypothesis can be drawn for the absence of *Thalassodendron* and *Cymodocea* in the Western Hemisphere today. Perhaps the two species were present until the Pliocene, when the closing of the Panamanian Isthmus altered circulation patterns enough to cause the demise of tropical flora. The closing of the isthmus and consequent drop in temperature and salinity in the Gulf of Mexico had a significant effect on the molluscan fauna of the region (Vermeij, 1978; Jones and Hasson, 1985); thus, it is reasonable to also expect changes in the temperature-sensitive and salinity-sensitive plants of the area. Perhaps *Thalassia,* the existing seagrass, was more tolerant of the cooler waters and lower salinity that resulted and therefore prevailed into modern times. The onset of Plio-Pleistocene glaciation may have had a similar effect (S. Stanley, pers. comm., 1989), as has been shown for the western Atlantic bivalve fauna (Stanley, 1986). Without more detailed information, one can only speculate about the biogeographic history of seagrasses. Careful examination of existing specimens and the discovery of new evidence will be necessary in order to test these hypotheses and better document the distribution of seagrasses in the past.

CONCLUSIONS

This Middle Eocene fossil seagrass occurrence in Florida provides a unique opportunity to examine paleocommunity interrelationships and paleobiogeography. The preservation of plant material and associated faunal elements is sufficient to identify five distinct seagrass genera, dominated by *Thalassodendron* and *Cymodocea,* and a host of epibionts, invertebrates, and vertebrates that in many ways reflects the composition of modern seagrass communities. The role of the seagrass bed as a nursery is represented for the first time in the fossil record by the presence of numerous juvenile echinoderms preserved intact with seagrass blades. Paleoecologic and sedimentologic properties of each quarry studied are detailed enough to infer that water depth at the Dolime site was deeper than that at Gulf Hammock, and that preservation was likely in situ, caused by the resuspension and fallout of mud following a single, large storm.

Paleobiogeographic information provided by this occurrence unquestionably confirms the existence of a diverse community of seagrasses in Florida by the late Middle Eocene. These plants originated in the Tethys Seaway in the late Cretaceous and rapidly became widespread, as suggested by the presence of associated molluscs and dugongs in Eocene rocks of the Neotropics and Indo-Pacific. We hypothesize that the demise of the tropical seagrass flora in the Gulf and Caribbean is a result of changing circulation patterns and cooling caused by the closing of the Panamanian Isthmus and/or the onset of Plio-Pleistocene glaciation.

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PALEONTOLOGICAL SOCIETY INC
FOUNDED 1978

florida paleontological society, inc.

Florida Museum Of Natural History
University Of Florida Gainesville, Florida 32611

FLORIDA PALEONTOLOGICAL SOCIETY ANNUAL MEETING

SATURDAY, OCTOBER 27, 1990

The annual meeting of the FPS was held at 9:00 A.M. in McCarty Auditorium on the campus of the University of Florida, Gainesville, Florida

President Don Lorenzo called the meeting to order at 9:20 A.M. The first order of business was a motion by Eric Taylor that the society purchase tickets to the Dino-Mania Exhibit at the Florida Museum of Natural History for all persons attending the Annual Meeting. These tickets to be instead of a paid speaker such as we have had in the past. The motion was seconded and passed by voice vote.

Roger Portell and Anita Brown were appointed as tellers.

President Lorenzo introduced Dr. Douglas Jones who is the Museum Respresentative to the Florida Paleo Society. Dr. Jones welcomed everyone and went right into the speakers program as published in the Fall Newsletter, Vol. 7, No. 4, 1990.

Following the program, President Lorenzo called the Business meeting to order.

He read the report of the tellers:

President..................Rick Carter
Vice President.............William Webster
President Elect............Jim Pendergraft
Treasurer..................Kevin Schindler
Secretary..................Robert Marsh
Board Members..............Dr. Bruce MacFadden
Ray Robinson
Marilyn Whetzel
Alternate..........Tim Cassady

Portell moved that the ballots be destroyed. The motion was seconded and passed.

President Lorenzo announced that he had received word that Rick Carter was unable to assume the office of the President. In his inability, it was announced that William Webster, Vice President, would fill the office and the Board of Directors would fill the vacant office of the Vice President as instructed by the by-laws of the society.

The minutes of the last meeting were approved as published in the Newsletter, Volumn 7, No.1, Winter Quarter, 1990.

The treasurers report was read and filed for audit. Copy attached.

Dr. Webb reported that the book committee has been hard at work this year. The Plaster Jacket edition being prepared by Richard Hulbert now has the text completed and Hulbert is working on the diagrams and illustrations.

The next scientific publication is ready for printing and two more editions are ready and should be published in the next few months bringing the total volumes of Florida Papers in Paleontology to five.

Dan Bryant was recognized for the good job of editing the newsletter. He has left the University of Florida and is pursuing his career in New York.

The new editors were acknowledged: Jeremy Setty - Editor in Chief
Frank Rupert - Florida Geological Survey
Dave Webb - Scientific Advisor

(Frank Rupert has volunteered to fill a position on the editing staff. His first contributions were in the Fall Newsletter, bringing our members news and current information from the Florida Survey.)

Ben Waller, who was elected as honorary member last year, was introduced to the members.

President Lorenzo announced that due to the on-going construction at the Museum, the ranges would not be open to the members this year, but, Gary Morgan and Roger Portell arranged to be in the fossil display area of the museum to talk to members and to identify their finds.

There being no further business the members were requested to pick up their tickets to the DinoMania display on the way to lunch. The meeting was adjourned for lunch at the Reitz Union.

MEETING OF THE BOARD OF DIRECTORS

The meeting of the Board of Directors was held in the Reitz Union Cafeteria during lunch.

The meeting was called to order by William Webster, President of the Society.

He asked for corrections to the minutes as published in the Newsletter, Volumn 7, No. 1, Winter Quarter, 1990. There were no corrections and they were approved as published.

The treasurers report was accepted and filed for audit. Kevin Schindler requested funds to continue the editing of the Plaster Jacket book. This was approved and there followed a general discussion of methods of raising the funds to pay for the printing of the book which will be costly and should be accomplished during this coming year.

Following this discussion, President Webster appointed the following to serve on a Book Fund Committee: Jeremy Setty, Joyce Webster, Nancy Carry-Chadwick and Don Lorenzo. It was agreed that each would receive a kit with a copy of each of the society publications, order forms and brochures which are available from the society office. These are to be mailed out next week. Tim Cassady volunteered to serve on this committee.

Susan Pendergraft suggested a weekend meeting on the Wekiva River with speakers and an organized program which would be open to members. Following a lively discussion, President Webster appointed the following committee to set up this weekend meeting as a spring meeting, 1991: Susan Pendergraft, Chairman, Joe Latvis and Jim Pendergraft. Susan was given the authority to enlarge the committee from a list of the Society Members in the Orlando area. She will be provided with a list of members.

Susan Pendergraft suggested several fund raising activities which she will research and implement at the spring meeting.

President Webster called for nominations to fill the vacancy of the office of Vice President. Roger Portell and Joe Latvis were nominated. Roger Portell was elected by the Board Members present. Tim Cassady was requested to fill the vacancy on the Board.

President Webster appointed the following committees:

Book Committee:	Roger Portell, Anita Brown
Nominations	Don Lorenzo, Rudi Johnson, Tim Cassady
Finance	Kevin Schindler, Roger Portell, Bruce MacFadden
Spring Meeting	Susan Pendergraft, Joe Latvis, Jim Pendergraft
Fall Meeting	Roger Portell, Jeremy Setty, Anita Brown, Rudi Johnson Gary Morgan and Frank Rupert
Membership	Bob Marsh, Anita Brown, Bruce MacFadden
By-Laws	Anita Brown, Bob Marsh
Honorary Members and Awards	S. David Webb, Jim Pendergraft, Cliff Jeremiah
Historical	Ben Waller, Cliff Jeremiah
Scientific Editor	Gary Morgan
Newsletter Editors	Jeremy Setty, Frank Rupert, S. David Webb (Advisor)
Museum Representative (appointed by Dr. Peter Bennett, Director)	Dr. Douglas Jones
REsident Agent of the Corporation	S. David Webb

Official Location of the Society and the Permanent Address:

FLORIDA MUSEUM OF NATURAL HISTORY
MUSEUM ROAD, UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA 32611

There being no further business the meeting was adjourned at 2:40 P.M.

FLORIDA PALEONTOLOGICAL SOCIETY, INC.
REVENUE AND EXPENSE REPORT
28 OCTOBER 1989 - 27 OCTOBER 1990

REVENUE	
Membership Dues	3029.00
Sales	
Publications	
Beach and Bank Collecting	4002.10
Handbook of Paleo. Prep.	1355.35
Plaster Jacket	345.97
Papers in Fla. Paleo.	524.00
Butvar	404.50
Miscellaneous	
Auction	690.00
T-Shirts	166.00
Donations	350.00
Total Revenue	10866.92
EXPENSES	
Contract Services	1000.00
Publications	
Beach and Bank Collecting	2706.57
Handbook of Paleo. Prep.	2632.50
Newsletter	1168.99
Meetings	
Annual Meeting	648.00
Miscellaneous	
State Filing Fee	35.00
Office Supplies	673.13
T-Shirts	92.45
Other	45.41
Total Expenses	9002.05
Income Over(Under) Expenses	1864.87

FLORIDA PALEONTOLOGICAL SOCIETY, INC.
STATEMENT OF ASSETS
27 OCTOBER 1990

ASSETS		
Cash		
Checking		6674.08
Saving		5520.82
Credit		65.43
	Total Cash and Credit	12260.33
Inventory		
Beach and Bank Collecting (1332 @ $2.50)		3330.00
Handbook of Paleo. Prep. (722 @ $6.50)		4693.00
Papers in Fla. Paleo. (466 @ $3.00)		1398.00
Plaster Jacket (3100 @ $1.00)		3100.00
Butvar (47 lbs. @ $7.50)		352.50
T-Shirts (3 @ $7.00)		21.00
	Total Inventory	12894.50
	Total Assets	25154.83

THE LAST TWO NUMBER IN YOUR MEMBER NUMBER SHOULD BE 91.

PLEASE SEND YOUR DUES IN A PROMPT MANNER.

MEMBERS CARDS WILL BE MAILED WITH YOUR NEWSLETTERS — DUE TO BUDGET CUTS THE POSTAGE WILL BE A SOCIETY EXPENSE. HELP KEEP THE COST DOWN TO NEWSLETTERS.

THANK YOU!

FLORIDA PALEONTOLOGICAL SOCIETY, INC.
MEMBERSHIP REGESTRATION

RENEWAL____

NEW MEMBER____

NAME____

MEMB. NO.(FROM LABEL)__________ PHONE:________/________-__________

ADDRESS:____

CITY_____________________________STATE________ZIP____________

MEMBERSHIP IN THE SOCIETY IS ANNUAL - JANUARY 1 THROUGH DECEMBER 31

CHECK THE APPROPRIATE CATEGORY:

		DUES
[ ]	ACTIVE MEMBER	$10.0
[ ]	ASSOCIATE (UNDER 18 YEARS)	5.0
[ ]	INSTITUTION (NO VOTE)	10.0
[ ]	SUBSCRIBER (PUBLICATIONS ONLY)	10.0

SEND THIS FORM WITH YOUR DUES TO: FLORIDA PALEONTOLOGICAL SOCIETY, IN
FLORIDA MUSEUM OF NATURAL HISTORY
GAINESVILLE, FLORIDA 32611

DATE:__________________ SIGNATURE__________________________