FLORIDA FOSSIL INVERTEBRATES

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OLIGOCENE AND MIOCENE ECHINOIDS

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Florida Fossil Invertebrates is a publication of the Florida Paleontological Society, Inc., and is intended as a guide for identification of the many, common, invertebrate fossils found around the state. It will deal solely with named species; no new taxonomic work will be included. Two parts per year will be completed with the first three parts discussing echinoids. Part 1 (published June 2001) covered Eocene echinoids, Part 2 (January 2002 publication) is about Oligocene and Miocene echinoids, and Part 3 (June 2002 publication) will be on Pliocene and Pleistocene echinoids. Each issue will be image-rich and, whenever possible, specimen images will be at natural size (1x). Some of the specimens figured in this series soon will be on display at Powell Hall, the museum's Exhibit and Education Center. Each part of the series will deal with a specific taxonomic group (e.g., echinoids) and contain a brief discussion of that group's life history along with the pertinent geological setting. **This publication is possible through the generous financial support of James and Lori Toomey.**

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INTRODUCTION

The interval of time from the Oligocene through Miocene epochs (from approximately 34 to 5 million years ago) is quite interesting with respect to species diversity of echinoids in Florida rocks. The Oligocene limestones contain only 11 species, a significant decrease from the 40 taxa in the Eocene, while the Miocene formations have 16 echinoid species (Figure 1). The moderate increase in number of species from the Oligocene to the Miocene also is important because this pattern has only recently been determined, and it differs from earlier interpretations. Prior to our work (Oyen and Portell, 2001), the published data regarding echinoid species in Florida indicated diversity continued to decrease over this time interval. One of the reasons for this increase, not decrease, in diversity is a function of fossil preservation, not necessarily a change in the biological or ecological systems of the ocean realm. Most of the new or additional species we record from the Miocene are found as fragments or as casts and molds rather than complete specimens. Such fragments may simply have been disregarded in the past, but we believe important discoveries have been made, and will continue to be made, as fragments are collected and examined. Readers should be aware, however, that not all of the echinoid species found in the Oligocene and Miocene are formally described yet and therefore not included in this publication. Our work is continuing to describe the new species collected from rocks of both epochs.

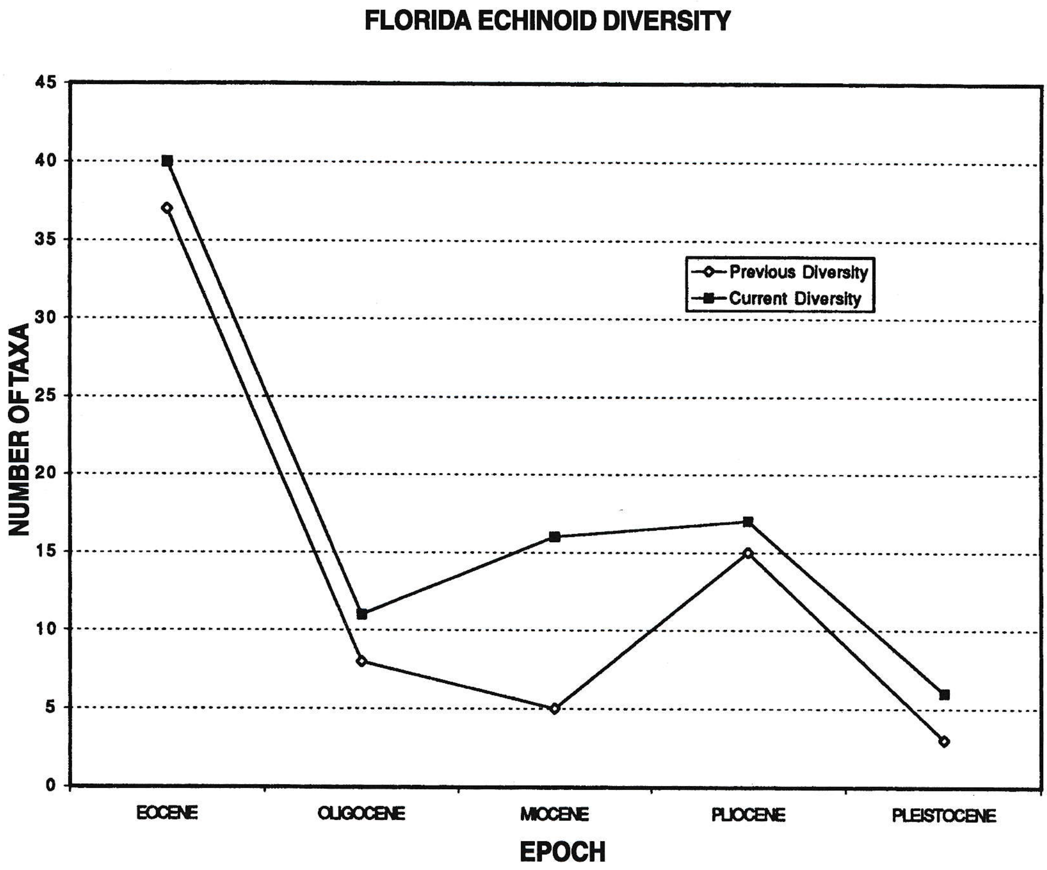

Figure 1. Fossil echinoid diversity curves for Florida. Open diamonds represent previously published taxonomic records (prior to Oyen and Portell, 2001) while the black squares show current diversity values. Note the distinct change in the diversity trend from the Oligocene to the Miocene (now an increase in diversity, in contrast to a former decrease).

GEOLOGICAL SETTING

Exposures of echinoderm-bearing Oligocene rocks in Florida are distributed from the west-central peninsular region north and west into the panhandle of the state (Figure 2). Stratigraphic units containing echinoids include the Suwannee Limestone, the Marianna Limestone, and the Bridgeboro Limestone (Figure 3). These three formations are similar to the Eocene limestones in their carbonate-rich composition, although the non-carbonate mineral content may exceed 10% slightly more frequently

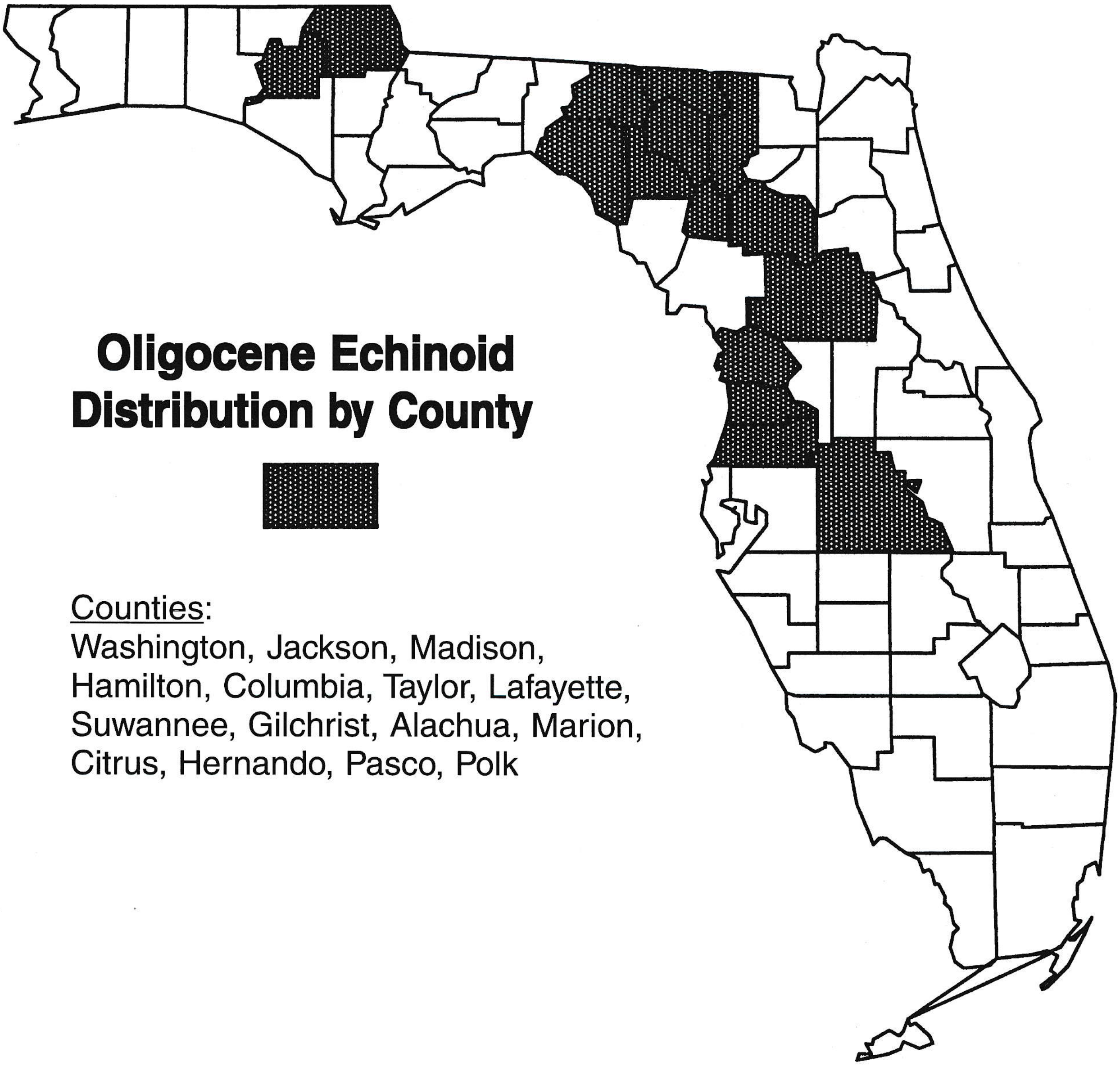

Figure 2. Shaded counties have records of echinoids from surface exposures, quarries (mined above groundwater or below groundwater levels), and along rivers or streams (either above or below water level). Data are from the Invertebrate Paleontology collection in the Florida Museum of Natural History in Gainesville, Florida.

than is true for the older strata. Lithologies of the strata range across the spectrum from mudstones to grainstones, and also vary from poorly lithified facies to very well-cemented or partially silicified zones. The most pervasive stratigraphic unit is the Suwannee Limestone, and all known or described echinoderms from the Oligocene are present in this formation. The Suwannee Limestone is also the thickest unit of the three Oligocene limestones, reaching a maximum of approximately 46 m (151 ft) in northern Florida and southern Georgia along the Gulf Trough.

EPOCH	STRATIGRAPHIC UNITS
OLIGOCENE	Bridgeboro Limestone
	Marianna Limestone
	Suwannee Limestone

Figure 3. Oligocene stratigraphic units containing echinoids.

Most of the research completed in recent years regarding Miocene lithostratigraphy for Florida was published by Dr. Thomas Scott (Florida Geological Survey). Scott produced a detailed bulletin in 1988, reviewing the history and current status of Miocene stratigraphy in Florida. Even though his work improved and clarified the use of stratigraphic terminology within the state, some points of debate still continue regarding the revisions he proposed. However, these disputes with stratigraphic unit names or lithologic definitions are not addressed in this paper because the primary focus here is on fossil echinoids, not formation names and their origins.

A total of 10 Miocene formations contain echinoderms within Florida (Figure 4). The general distribution of echinoid-bearing exposures of Miocene rocks is discontinuous from the central portion of the peninsula northward to the Florida-Georgia border and westward into the panhandle of the state (Figure 5). Formation definitions and boundaries used in this paper currently are accepted as valid units by the Florida Geological Survey. The large number of stratigraphic units prevents a detailed discussion of their composition and areal distribution, but several references cited in the suggested readings contain such information. In general, the dominant lithology of the Miocene formations is more strongly siliciclastic in contrast to the older Oligocene and Eocene limestones. Several of the Miocene units contain abundant carbonate beds, while others contain few carbonate-rich zones and primarily consist of grains of quartz, chert, and various clay and phosphate minerals. In most cases, echinoids are found in the predominantly carbonate or shelly beds. The total thickness of Miocene sediments exceeds 100 m (328 ft) in local areas of the subsurface of Florida.

<table>
<tr><th>EPOCH</th><th colspan="3">STRATIGRAPHIC UNITS</th></tr>
<tr><td rowspan="4">MIOCENE</td><td colspan="3">Peace River Formation</td></tr>
<tr><td>Shoal River Formation</td><td>Statenville Formation</td><td>Coosawhatchie Formation</td></tr>
<tr><td>Torreya Formation</td><td>Chipola Formation</td><td>Marks Head Formation</td></tr>
<tr><td>Chattahoochee Formation</td><td>Parachucla Formation</td><td>Arcadia Formation</td></tr>
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Figure 4. Miocene stratigraphic units containing echinoids.

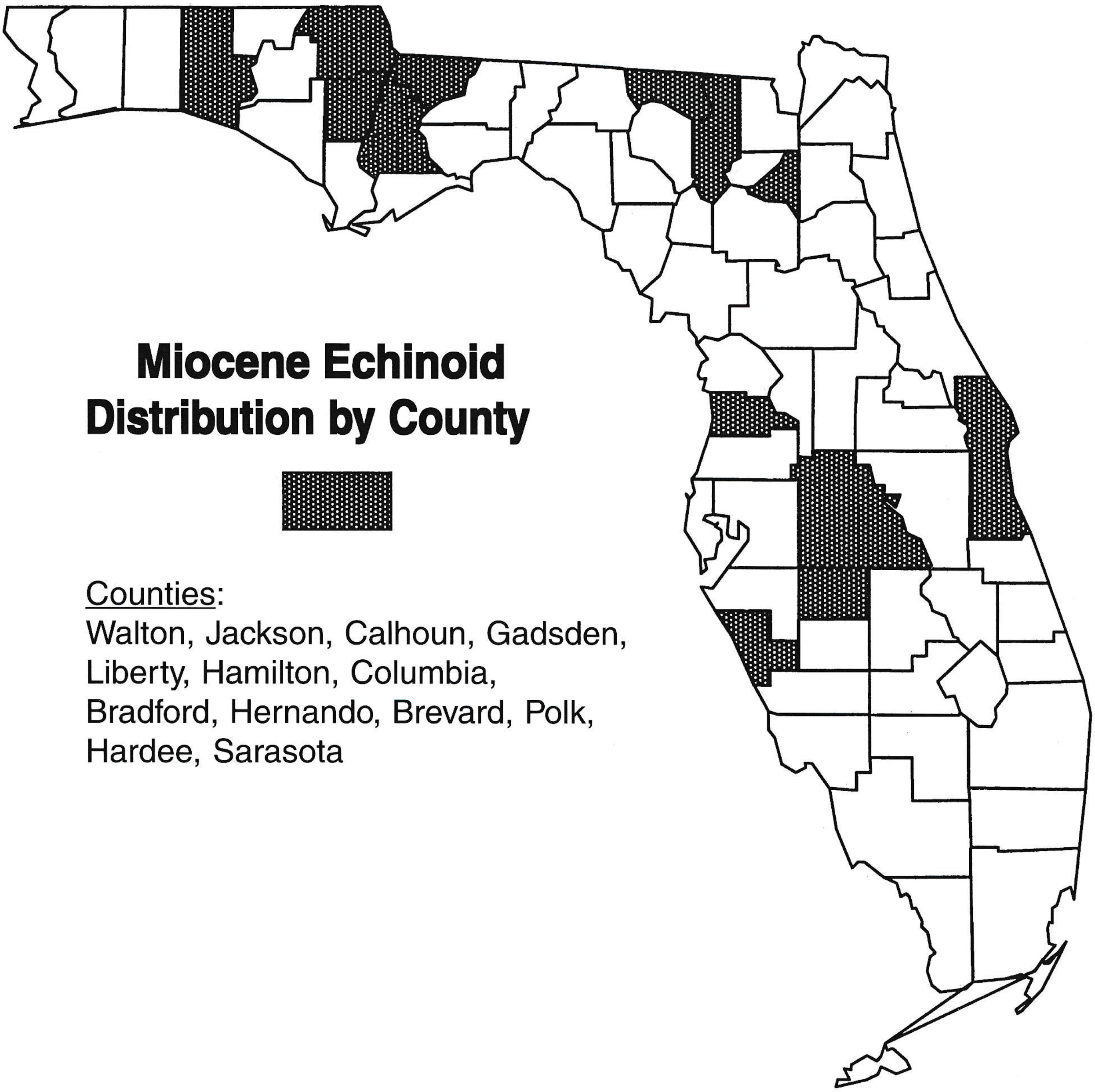

Figure 5. Shaded counties have records of echinoids from surface exposures, quarries (mined above groundwater or below groundwater levels), and along rivers or streams (either above or below water level). Data are from the Invertebrate Paleontology collection in the Florida Museum of Natural History in Gainesville, Florida.

SKELETAL MORPHOLOGY

Echinoids have a skeleton that is reasonably durable and preserves well during fossilization processes. The skeleton is an endoskeleton, meaning it is found beneath the living tissue of the organism. One of the reasons that echinoids are common fossils is (at least in part) due to the mineral composition and structural arrangement of the skeletal plates. The skeletal plates are composed of the mineral calcite ($CaCO_3$), usually as a type called high-magnesium calcite. This mineral compound is fairly stable chemically, and does not dissolve or alter as easily as another variety of calcium carbonate called aragonite. This is evident when looking at other invertebrate fossils in Florida such as some coral and mollusk species that were originally aragonite. Many coral and mollusk species are rare, or are present most often only as molds, because their aragonite skeleton has dissolved away, leaving only an impression of the interior or exterior of the fossil skeleton. A second reason that echinoids are found as complete or nearly complete skeletons, is because the calcite plates are rigidly attached to one another, and therefore normally do not disarticulate quickly upon death of the animal. The primary exception to this statement regarding disarticulation is with respect to the spines of the echinoids. It is uncommon to find fossil echinoids with more than a few spines still attached to the skeleton.

Identification of fossil echinoids is not as difficult as with some other fossil taxa because they tend to be large enough to examine without special equipment such as microscopes, they preserve well, and the diagnostic morphological traits are fairly easy to learn. What are the morphological characteristics that are important in distinguishing echinoid species? Several features are of particular importance and will be described here. First, the general shape of the *test* (i.e., the skeleton) is important. Echinoids sometimes are called sea urchins, sea biscuits, or sand dollars, and each of these names is related to a slightly different skeletal morphology. Sea urchins are *regular* echinoids, in which the test shape is nearly spherical in outline (Figure 6, part A). Also of significance for identification of the regular echinoids is the location of the *periproct* (or the opening in the test for the anus); the periproct of all regular echinoids is found within the *apical system* (i.e., a series of plates on the aboral surface of the test). The sea biscuits and sand dollars are part of a group called the *irregular* echinoids, in which the test shape is elliptical and/or flattened (Figure 6, part B). The periproct of irregular echinoids is located somewhere outside of the apical system, and may be found either on the aboral (the top or dorsal side) or adoral (the bottom or ventral side) surface. The symmetry of echinoids is based on the arrangement of the five petal-like structures (called *ambulacra*) visible on the aboral surface of the test. The ambulacra are separated by plate regions called the *interambulacra* (both are visible in Figure 6; the labels are abbreviated as "amb." and "interamb."). Regular echinoids have true pentameral (five-part) symmetry, while the more elongate or flattened irregular echinoids have bilateral (two-part) symmetry superimposed on the pentameral symmetry. The elongate or flattened test shape of the irregular echinoids is an evolutionary adaptation that facilitates shallow to deep burrowing in the sediment of the ocean floor. Therefore, paleontologists usually describe the length, width, and height of the test in species descriptions because these parameters may be related to the environment the echinoid occupied while alive.

In addition to test shape and symmetry, several other morphological features are used to identify species of fossil echinoids. The size, shape (circular versus elliptical and narrow), and location of the periproct (whether on the top, side, or bottom of test) is important. The size and shape of the *peristoma* (i.e., the opening in the test for the mouth) also is used to define various species. All echinoids have their mouth on the bottom (ocean floor) side of the test because they eat organic matter found on top of or within the sediment on the sea floor. The specific arrangement of the ambulacra, including their width, length, and pore shapes, is used as a diagnostic characteristic of echinoid species too. Pores that make up the ambulacra allow soft-tissue *tube feet* to extend outside the body of the echinoid. These tube feet function to move food particles to the mouth of the animal, act as chemical sensory devices, and allow the

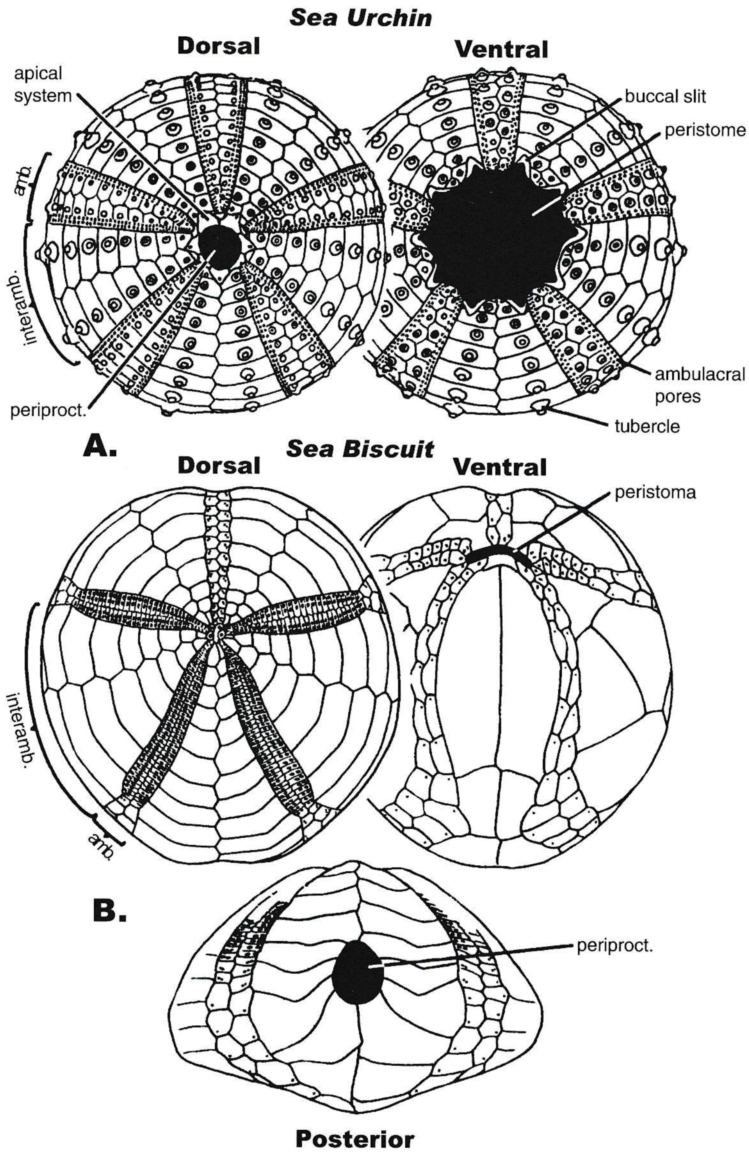

Figure 6. Dorsal and ventral views of tests of a regular echinoid (part A) and an irregular echinoid (part B). Note the difference between test shapes and relative positions of physical features such as the periproct, peristome, ambulacra, and apical system on the sea urchin versus the sea biscuit (modified from Smith, 1984; figure 1.1).

echinoid to "breathe" by passing dissolved oxygen in the water through the tissue of the tube feet. Varying arrangement and size of ambulacra in the skeleton may be useful to interpret environmental conditions in which the echinoid was living, and thereby allows paleontologists to reconstruct the paleoecology of fossil assemblages. *Lunules* are present in some clypeasteroid echinoids (sand dollars) found in Florida, particularly in species of Mellita and Encope from younger Pliocene and Pleistocene formations. Lunules are the slotted openings in the sand dollars that allow food gathered by tube feet and spines on the upper surface of the echinoid (as they burrow) to be passed to the mouth on the bottom surface of the animal. The length, width, and relative position of these lunules on the skeleton are also used to characterize species. None of the Oligocene or Miocene echinoids of Florida have lunules, but this feature will be important when identifying species to be discussed in Part 3 later in 2002.

Other distinctive physical characteristics of the echinoid skeleton include *tubercles* and *radioles*. Radioles (more commonly known as spines) are present on all living echinoids, but are seldom found attached to fossil echinoids. This is because the attachment point of the spine to the test, a bump or knob called a *tubercle*, is very small, and because the attachment is flexible in a ball and socket arrangement. When the animal dies, any rolling or abrasion of the dead animal in the water currents causes the spines to separate from the tubercles easily. Furthermore, living echinoids can lose their spines temporarily as their body reacts to environmental stress, and will grow them back later. Even though the spines are often missing from fossils, the tubercles on the surface of the test remain. The shape, size, and distribution of the tubercles can be used to interpret the size and shape of spines as well as the life habits of the echinoid (e.g., did it burrow deeply into the sediment or live at, or just below, the sediment-water interface?). An example of the specialization of spines for various tasks is illustrated in Figure 7 for both a sand dollar and a sea biscuit.

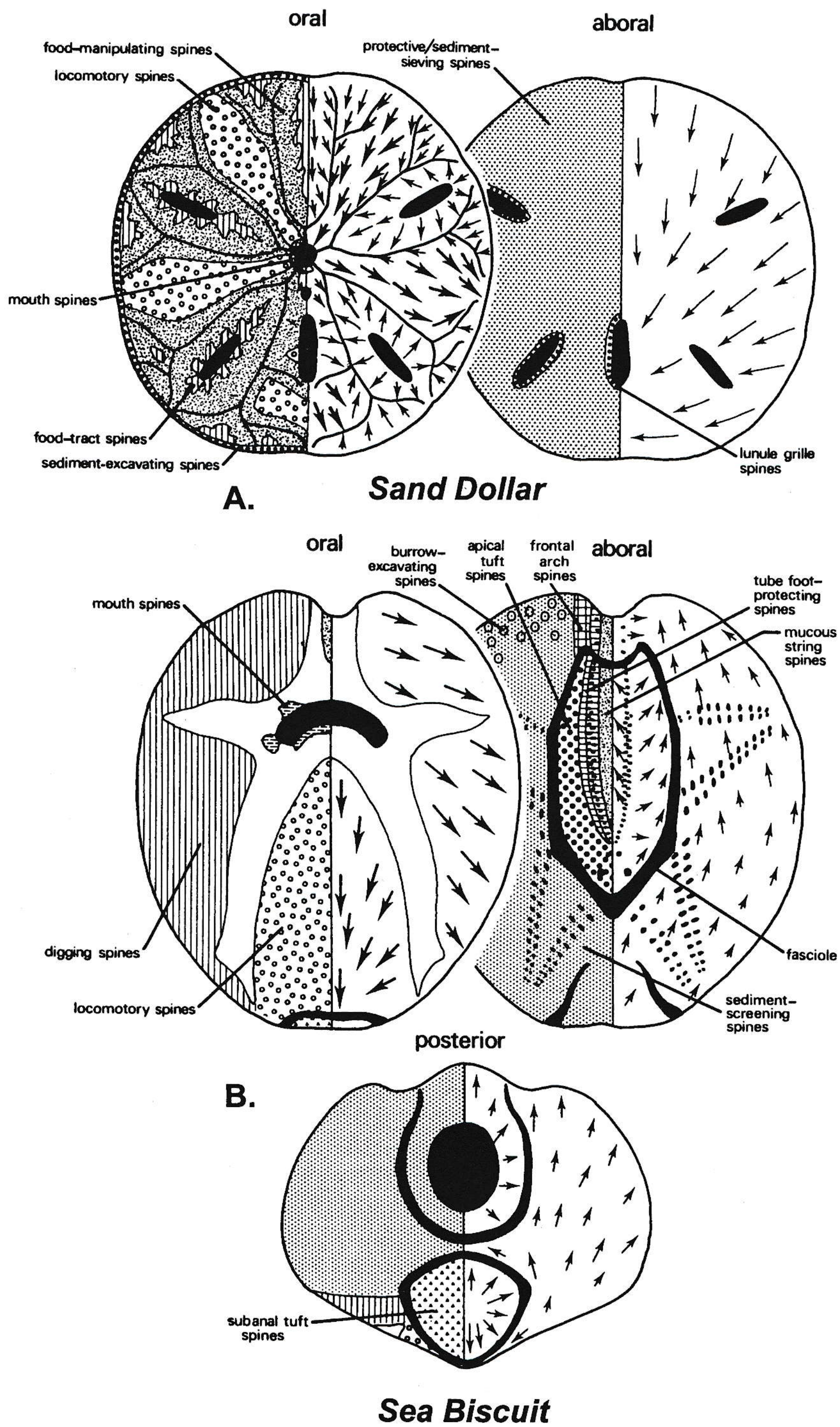

Figure 7. Functions of test spines in echinoids. Note the specialization of spines in various regions of body for life activities such as burrowing, movement, defense, food transfer, etc. Distribution of tubercles reflects spine types and functions, even when spines are not present on fossils (modified from Smith, 1984; figure 3.14).

PLATE 1 (OLIGOCENE ECHINOIDS)

A) Gagaria mossomi (Cooke, 1941); UF 28245; aboral view; 1x.

B) Gagaria mossomi (Cooke, 1941); UF 28245; adoral view; 1x.

C) Phymotaxis mansfieldi Cooke, 1941; UF 3344; aboral view; 1x.

D) Phymotaxis mansfieldi Cooke, 1941; UF 3344; adoral view; 1x.

E) Clypeaster batheri Lambert, 1915; UF 2546; aboral view; 1x.

F) Clypeaster batheri Lambert, 1915; UF 2546; adoral view; 1x.

G) Clypeaster cotteaui Egozue, 1897; UF 54993; aboral view; 1x.

H) Clypeaster cotteaui Egozue, 1897; UF 54993; adoral view; 1x.

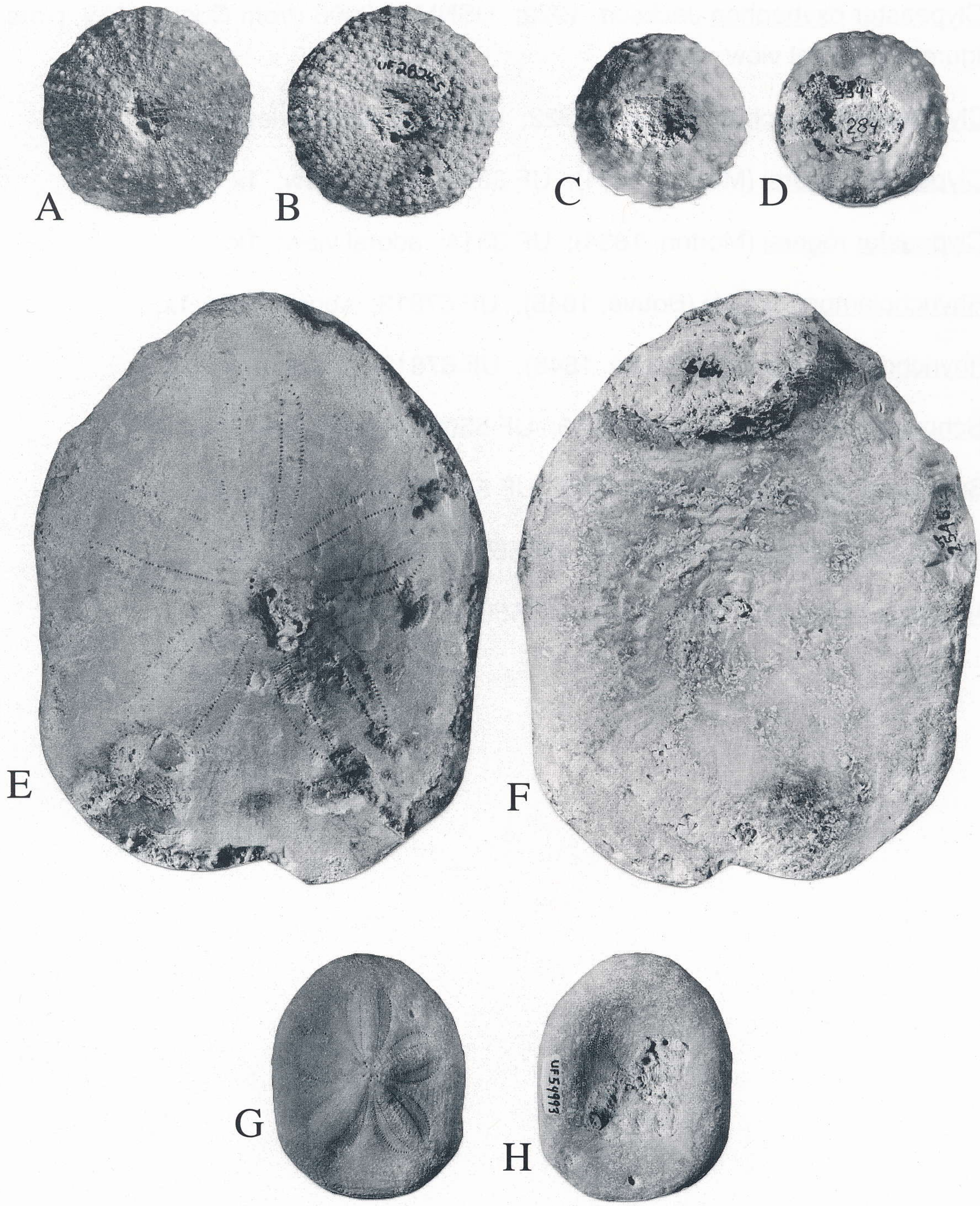
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PLATE 2 (OLIGOCENE ECHINOIDS)

A) Clypeaster oxybaphon Jackson, 1922; USNM 499006 (from Cooke,1959; plate 11, figure 1); aboral view; 1x.

B) Clypeaster oxybaphon Jackson, 1922; UF 4926; aboral view; 1x.

C) Clypeaster rogersi (Morton, 1834); UF 3314; aboral view; 1x.

D) Clypeaster rogersi (Morton, 1834); UF 3314; adoral view; 1x.

E) Rhyncholampas gouldii (Bouvé, 1846); UF 67813; aboral view; 1x.

F) Rhyncholampas gouldii (Bouvé, 1846); UF 67813; adoral view; 1x.

G) Schizaster americanus Clark, 1915; UF 55006; aboral view; 1x.

H) Schizaster americanus Clark, 1915; UF 55006; adoral view; 1x.

I) Agassizia mossomi Cooke, 1942; UF 55007; aboral view; 1x.

J) Agassizia mossomi Cooke, 1942; UF 55007; adoral view; 1x.

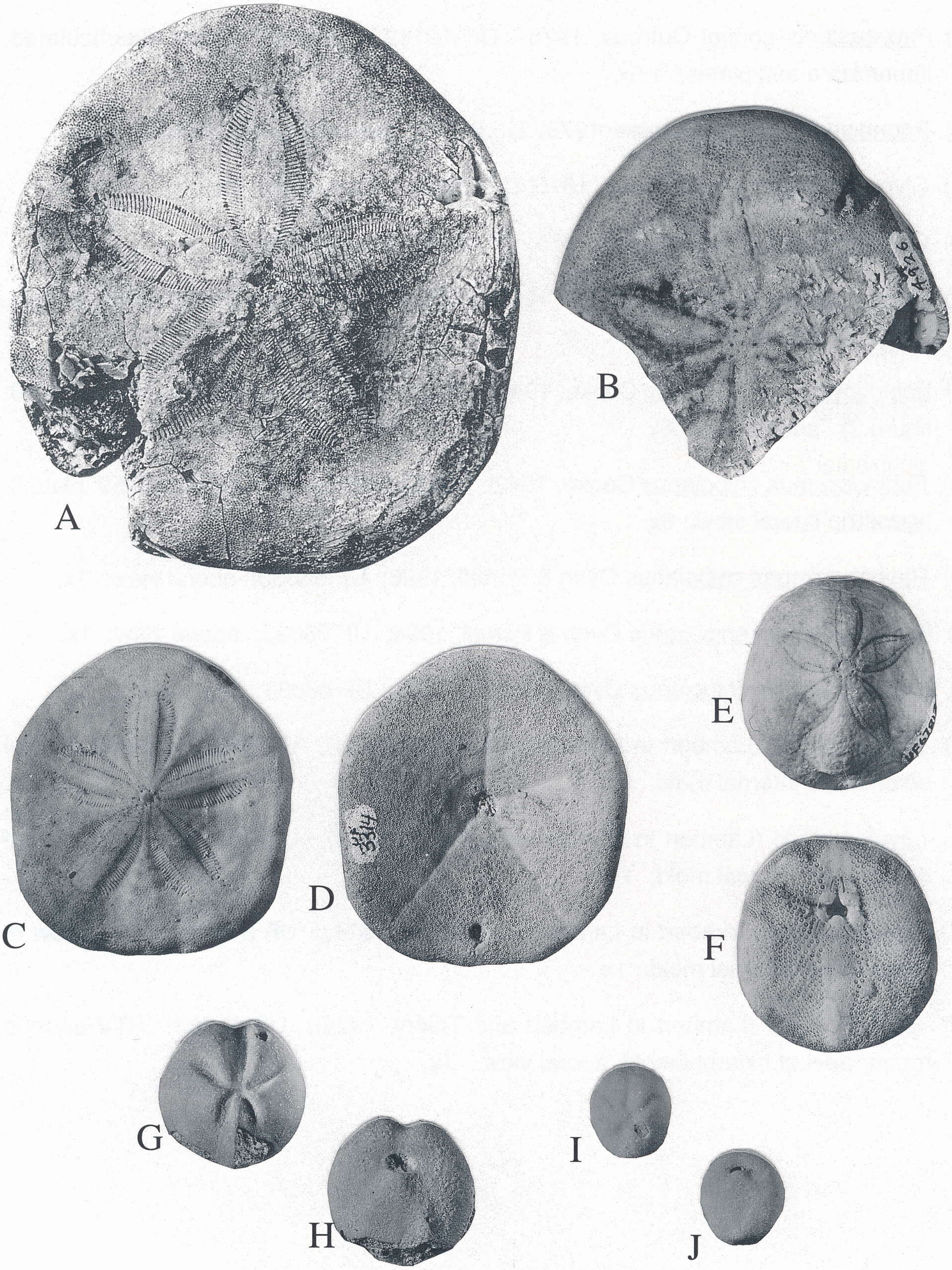
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PLATE 3 (MIOCENE ECHINOIDS)

A) Prionocidaris cookei Cutress, 1976; UF 101422; exterior of two disarticulated, imperforate test plates; 1.5x.

B) Prionocidaris cookei Cutress, 1976; UF 88540; two incomplete radioles; 1.5x.

C) Clypeaster concavus Cotteau, 1875; UF 65864; aboral view; 1x.

D) Clypeaster concavus Cotteau, 1875; UF 65864; adoral view; 1x.

E) Echinocyamus chipolanus Cooke, 1942; USNM 499003 (from Cooke, 1959; plate 9, figure 1); aboral view; 6x.

F) Echinocyamus chipolanus Cooke, 1942; USNM 499003 (from Cooke, 1959; plate 9, figure 2); adoral view; 6x.

G) Echinocyamus chipolanus Cooke, 1942; USNM 499003 (from Cooke, 1959; plate 9, figure 3); lateral view; 6x.

H) Rhyncholampas chipolanus Oyen & Portell, 1996; UF 66633; aboral view; 1x.

I) Rhyncholampas chipolanus Oyen & Portell, 1996; UF 66633; adoral view; 1x.

J) Rhyncholampas chipolanus Oyen & Portell, 1996; UF 66633; lateral view; 1x.

K) Lovenia clarki (Lambert in Lambert and Thiéry, 1924); UF 61083; aboral view of dolomitized internal mold; 1x.

L) Lovenia clarki (Lambert in Lambert and Thiéry, 1924); UF 61083; adoral view of dolomitized internal mold; 1x.

M) Lovenia clarki (Lambert in Lambert and Thiéry, 1924); UF 61083; adoral view of dolomitized external mold; 1x.

N) Lovenia clarki (Lambert in Lambert and Thiéry, 1924); UF 61083; RTV silicone rubber peel of external mold, adoral view.; 1x.

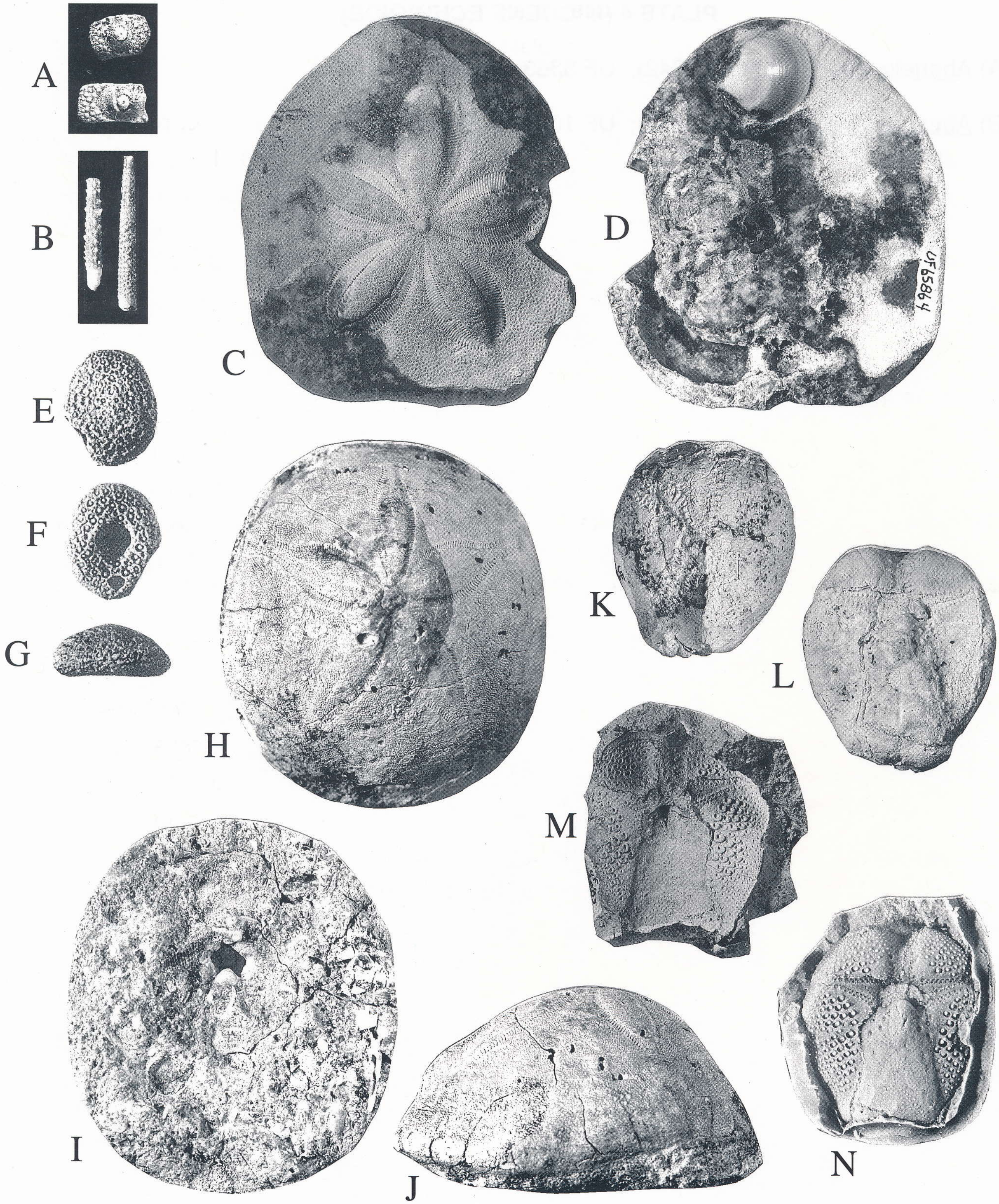
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PLATE 4 (MIOCENE ECHINOIDS)

A) Abertella aberti (Conrad, 1842); UF 5363; aboral view; 1x.

B) Abertella aberti (Conrad, 1842); UF 104444; adoral view; 1x.

A

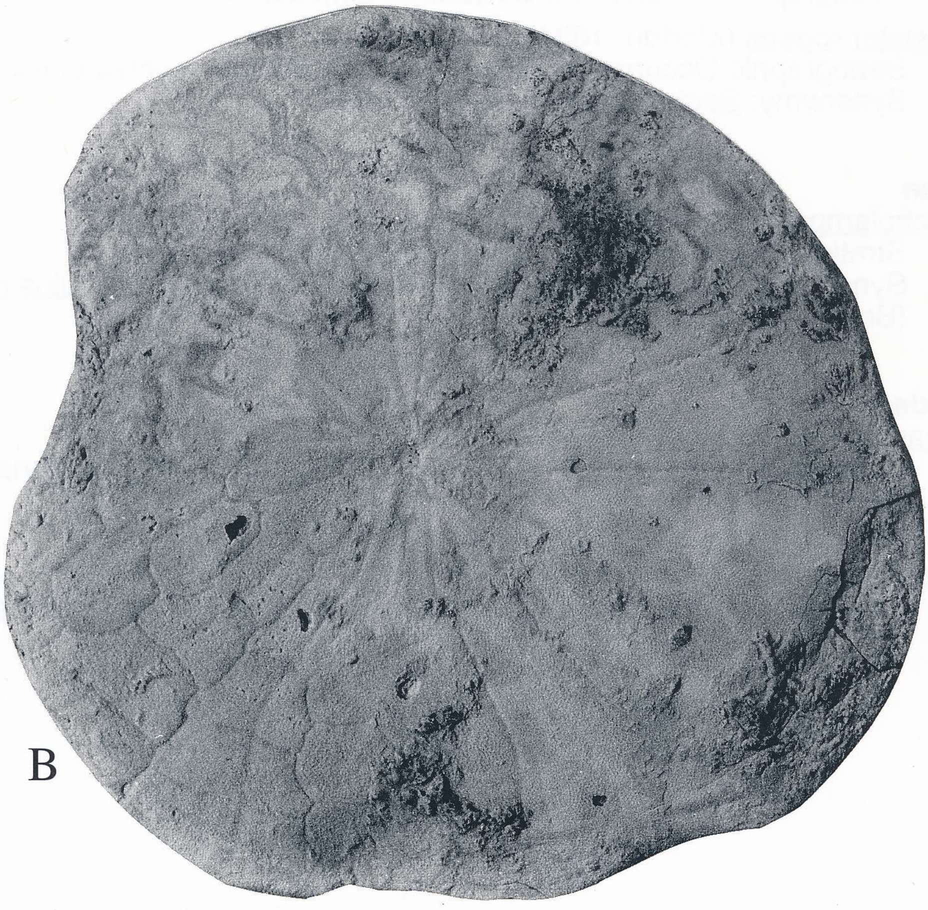

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Table 1. Species list of described Florida Oligocene echinoids with each taxon in systematic order by family (excludes described subspecies). Stratigraphic occurrence for each species is also listed. For some, a brief synonymy (an older name no longer in use) is provided.

?Echinidae

Gagaria mossomi (Cooke, 1941).
Stratigraphic Occurrence: Suwannee Limestone.
Synonymy: Thylechinus mossomi Cooke, 1941.

Stomechinidae

Phymotaxis mansfieldi Cooke, 1941.
Stratigraphic Occurrence: Suwannee Limestone.

Clypeasteridae

Clypeaster batheri Lambert, 1915.
Stratigraphic Occurrence: Suwannee Limestone.

Clypeaster cotteaui Egozcue, 1897.
Stratigraphic Occurrence: Suwannee and Bridgeboro limestones.

Clypeaster oxybaphon Jackson, 1922.
Stratigraphic Occurrence: Suwannee Limestone.

Clypeaster rogersi (Morton, 1834).
Stratigraphic Occurrence: Suwannee and Marianna limestones.
Synonymy: Scutella rogersi Morton, 1834.

Cassidulidae

Rhyncholampas gouldii (Bouvé, 1846).
Stratigraphic Occurrence: Suwannee Limestone.
Synonymy: Pygorhynchus gouldii Bouvé, 1846 and Cassidulus gouldii (Bouvé, 1846).

Schizasteridae

Schizaster americanus Clark, 1915.
Stratigraphic Occurrence: Suwannee, Bridgeboro, and Marianna limestones.
Synonymy: Paraster americanus (Clark, 1915).

Agassizia mossomi Cooke, 1942.
Stratigraphic Occurrence: Suwannee and Bridgeboro limestones.

Table 2. Species list of described Florida Miocene echinoids with each taxon in systematic order by family (excludes described subspecies). Stratigraphic occurrence for each species is also listed. For some, a brief synonymy (an older name no longer in use) is provided.

Cidaridae

Prionocidaris cookei Cutress, 1976.

Stratigraphic Occurrence: Chipola Formation.

Clypeasteridae

Clypeaster concavus Cotteau, 1875.

Stratigraphic Occurrence: Chipola Formation.

Echinocyamidae

Echinocyamus chipolanus Cooke, 1942.

Stratigraphic Occurrence: Chipola Formation.

Abertellidae

Abertella aberti (Conrad, 1842).

Stratigraphic Occurrence: Arcadia, Peace River, Coosawhatchie, Chipola? formations.

Synonymy: Scutella aberti Conrad, 1842 and Scutella floridana? Cooke, 1942.

Cassidulidae

Rhyncholampas chipolanus Oyen & Portell, 1996.

Stratigraphic Occurrence: Chipola Formation.

Loveniidae

Lovenia clarki (Lambert in Lambert and Thiéry, 1924).

Stratigraphic Occurrence: Chattahoochee Formation.

Synonymy: Amphidetus clarki Lambert in Lambert and Thiéry, 1924.

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NOTES