A STUDY OF THE UPPER EOCENE OTOLITHS OF THE YAZOO CLAY IN CALDWELL PARISH, LOUISIANA

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ABSTRACT

An extensive and detailed study of the otoliths from three localities of the Tullos Member of the Yazoo Clay in Caldwell Parish, was undertaken in order to classify and describe the upper Eocene otoliths. The classification of the otoliths was based mainly on Recent forms when extant genera were available for comparison. Eleven families and sixteen genera were identified and described through a systematic study of approximately 1600 otoliths from the Tullos Member of the Yazoo Clay.

LOCATION OF STUDY AREA AND COLLECTION PROCEDURES

The study area is located in the southeastern portion of Caldwell Parish, Louisiana, approximately in the central part of northern Louisiana. The study area is bounded by the Ouachita River on the east, by the Caldwell-Catahoula Parish boundary on the south, by Louisiana State Highway 126 on the west, and by the community of Copenhagen on the north. Although collections were made at many exposures of the Yazoo Clay in the study area, only three exposures were selected for study. The three localities were chosen because they were stratigraphically equal, extensive, and yielded the most vertebrate material.

Collection procedures for this study included unit volume collections and extensive surface collections over a four year period. Unit volume samples were processed in an ultrasonic cleaner using tap water (no additives or cleaning solutions). The samples were wet-sieved through a U.S. Standard No. 40 sieve (opening-420 microns), and all material that was retained in the sieve was kept for study.

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STRATIGRAPHY

All otolith specimens in this study were collected from the Tullos Member of the Yazoo Clay (Jackson Group). Otoliths were collected from essentially the same stratigraphic horizon at all three localities. Specimens from Locality I were collected approximately 20 feet (6 meters) to 80 feet (24 meters) above the Moodys Branch-Yazoo Clay contact. Specimens from Locality II and III were approximately 50 feet (15 meters) to 90 feet (27 meters) above the Moodys Branch-Yazoo Clay contact. The specimens from Locality I were collected mainly from the lower strata of the Tullos Member, while specimens from Locality III were collected from the upper portion of the Tullos Member.

PHYSIOLOGY OF THE OTOLITHS AND RELATED STRUCTURES

A majority of vertebrate remains can be classified as parts of or related to the skeletal system. Various bones, spines, vertebrae, teeth, and scales are common vertebrate fossils that represent parts of the skeletal system. Otoliths are unique in that they are not parts of the skeletal system, but integral and specialized parts of the acoustico-lateralis system.

Otoliths are located in the two auditory labyrinths of the teleost fish. The deeply buried labyrinths are located posterior to the brain and anterior to the first vertebra in the skull of the fish. The location of the labyrinth and its relation to other structures in the braincase is shown in Figure 1.

The utriculus, sacculus, and lagena represent cavities in the labyrinth (Figure 2).

In each of these cavities, there is a single "stone" or body composed of calcium carbonate. These are the "earstones" known as otoliths or statoliths, which are secreted by the walls of the labyrinth (Norman 1931). The otoliths increase in size by the deposition of calcium carbonate in layers on the outer surface. Yapp (1965), as well as many other workers, states that otoliths show annual growth lines. These lines are visible under the microscope as alternating light and dark concentric rings, which are a result of the varying rates at which the calcium carbonate was secreted and probably corresponds with various seasons.

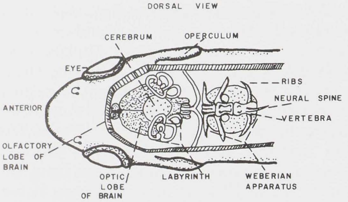

FIGURE 1. Location of the labyrinth and related structures.

The otoliths in each cavity of the labyrinth are given a name. The sacculus contains the sagitta, the lagena contains the asteriscus, and the utriculus contains the lapillus. Thus, there are three otoliths in each labyrinth and six otoliths for each fish.

According to Lowenstein (1957), the labyrinth has four chief functions. The labyrinth is concerned with the maintenance and regulation of muscle tone and is a receptor for angular accelerations, gravity, and sound. Many of these functions are related to one another. Norman (1931) emphasized that the purpose of the labyrinth was mainly to maintain equilibrium and to perceive sound. Lagler *et al.* (1962) stated that the labyrinth and its associated structures maintain the equilibrium and orientation of the fish, receive vibrations, and perceive sound frequencies.

MORPHOLOGY OF THE OTOLITHS

The bony fishes usually contain three otoliths or statoliths in each labyrinth. Koken (1884) originally named the otoliths as the sagitta, lapillus, and the asteriscus. These names were based on their shape in the carps: sagitta (an arrow), lapillus (a stone), and asteriscus (a parenthesis sign). As discussed earlier, these otoliths are located in the sacculus, utriculus, and the lagena, respectively. Sagitta, lapillus, and asteriscus are used by many workers: Dante (1953), Frizzell (1965), Frizzell and Lamber (1961), and Frizzell and Dante (1965). Some workers use the terms sacculith, utriculith, and lagenalith. These terms relate the otoliths to their sites within the labyrinth and are considered to be more descriptive than the terms of Koken (Stinton 1975).

The sagitta is the largest of the three otoliths found in the bony fishes with the lapillus and the asteriscus being much smaller. However, one exception to this is the Order Ostariophysi. In the ostariophysians, the sagitta is the smallest with the lapillus and the asteriscus being larger. In most ostariophysians, the asteriscus is the largest. One exception that occurs in the ostariophysians is the Family Ariidae. In the Ariidae, the lapillus is very large and can be useful in identification.

In most studies, the sagittae are examined because of the characteristic pattern that is found on the inner face. This pattern is indicative of genus and species. Different species of a genus can be discerned by small differences in the sagittae. The sulcus usually remains the same in the different species within a genus. Specific differences are usually found on the periphery of the sagittae, especially the anterodorsal area (Stinton 1975).

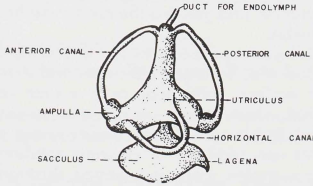

FIGURE 2. Structures of the labyrinth.

Morphologic features of the inner face of the sagitta are shown in Figure 3. The inner face is the side that is connected to nerve endings and usually has a characteristic pattern on it. The terms in Figure 3 are fairly standard in otolith studies and are the terms used by Frizzell and Dante (1965).

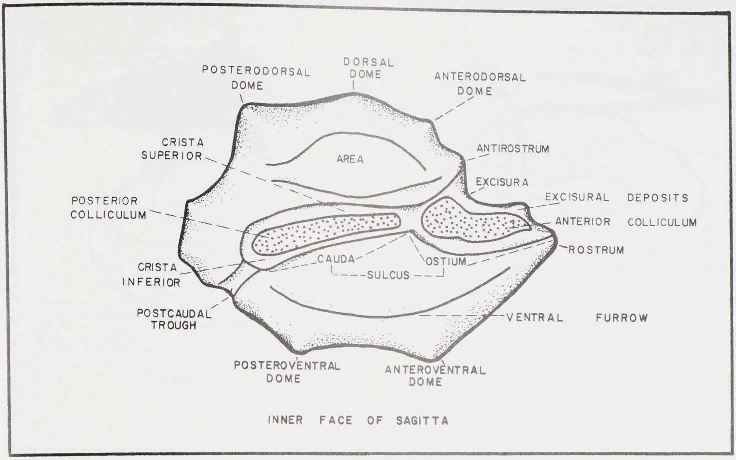

FIGURE 3. Morphologic features of the inner face.

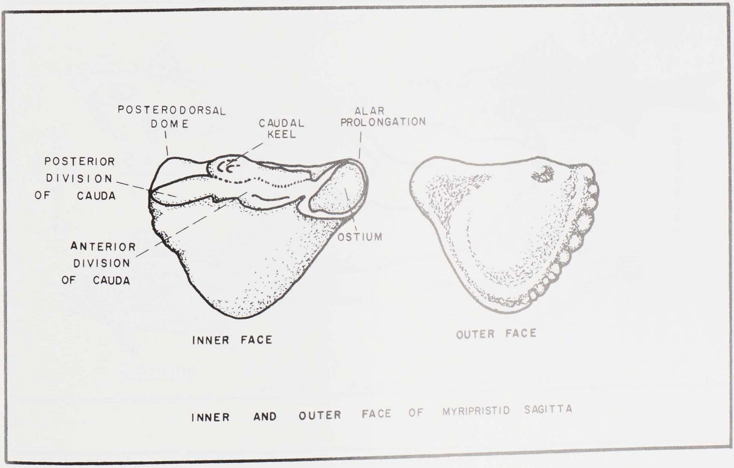

FIGURE 4. Morphologic features of the myripristid sagitta.

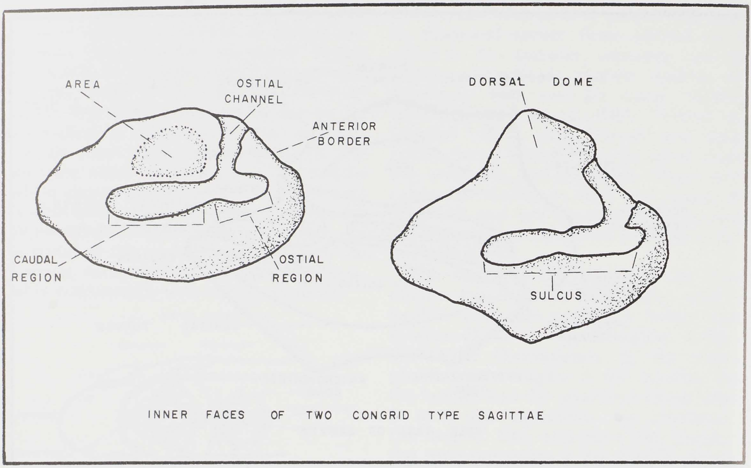

FIGURE 5. Morphologic features of the congrid type sagitta.

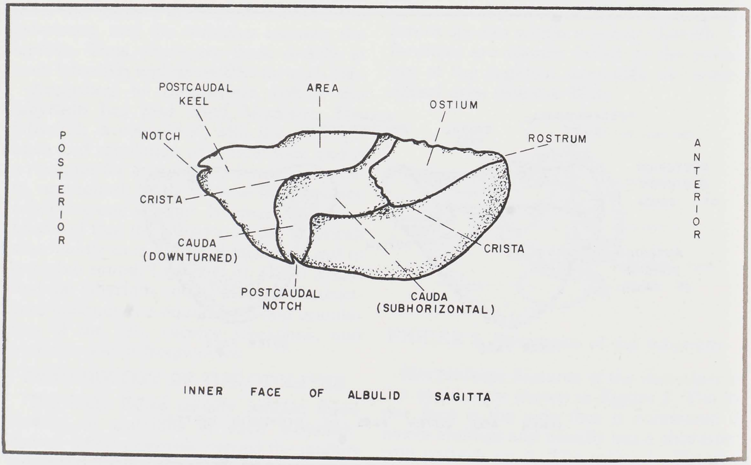

FIGURE 6. Morphologic features of the albulid type sagitta.

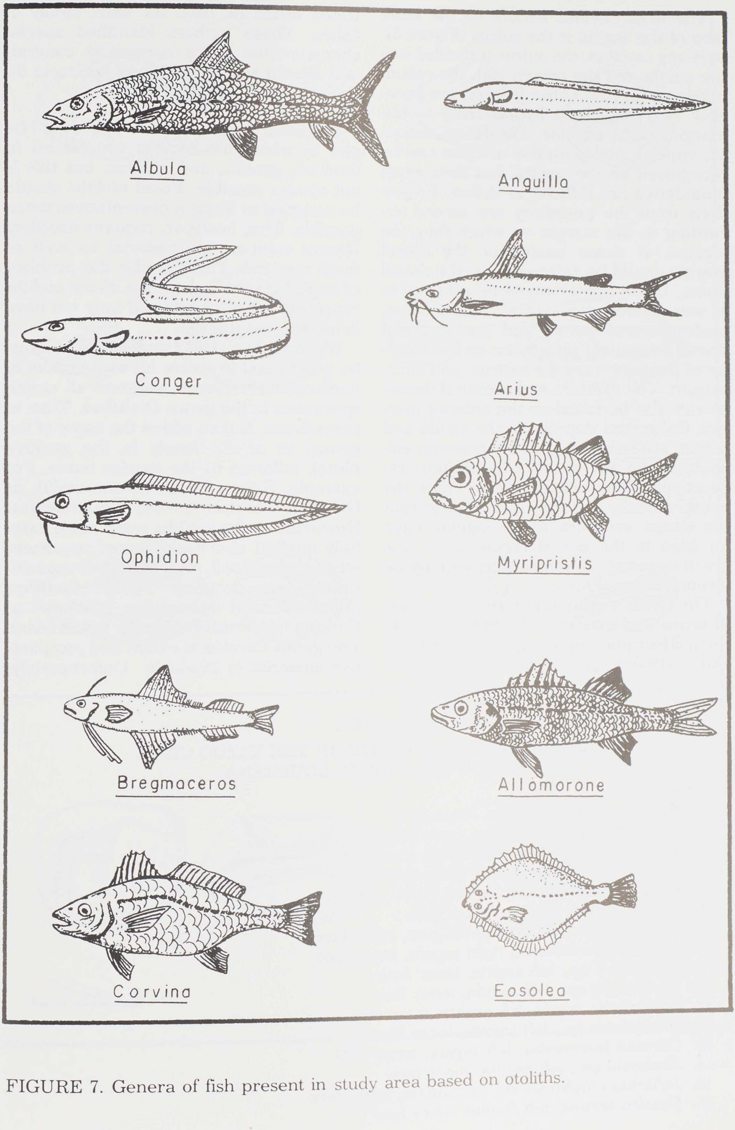

FIGURE 7. Genera of fish present in study area based on otoliths.

The most obvious feature on the inner face of the sagitta is the sulcus (Figure 3). In many sagittae, the sulcus is divided into the cauda and the ostium with the collum between the two. Other features are probably best described by referring to the margins of the sagittae. The dorsal, anterior, ventral, and posterior margins can be recognized on the sagitta, but their exact boundaries are difficult to define. Projections from the periphery are named according to the margin on which they are located. A dome located on the dorsal margin would be referred to as the dorsal dome. Other domes would be referred to as anterodorsal dome, anteroventral dome, posteroventral dome, and posterodorsal dome. Prominent projections on the anterior of the sagitta are the rostrum and antirostrum. The excisura and excisural deposits can also be found on the anterior margin. Colliculum deposits in the cauda and ostium are referred to as the posterior colliculum and the anterior colliculum, respectively. The crista superior rims the cauda dorsally and the crista inferior rims the cauda ventrally. Many sagittae have an area in the dorsal region above the crista superior. A ventral furrow may be located below the sulcus.

The terms shown in Figure 3 are general terms and may not be totally adequate for a description of a sagitta. Frizzell and Dante (1965) suggested that separate illustrated terms be used for each family of fishes. These authors identified special characteristics of the myripristid, congrid, and albulid sagittae (Figures 4, 5, and 6).

TAXONOMY

The ideal system of taxonomy would be one in which the otoliths are placed in families, genera, and species, but this is not always possible. Fossil otoliths should be assigned to living representatives when possible. This, however, requires excellent Recent comparative material as well as fossil material. There is also the problem of extinct genera and species. Some otoliths represent extinct forms and may not have living representatives.

When Koken (1884) studied the otoliths, he was forced to create his own system of nomenclature. Koken assigned all otolith specimens to the genus *Otolithus*. Then in parenthesis, Koken added the name of the genus, or of the family in the genitive plural, followed by the species name. For example, Koken identified one otolith as *Otolithus (Sciaenidarum) intermedius*. However, as the otoliths were more carefully studied and evolutionary sequences were determined, the *Otolithus* nomenclature was dropped. Today, *Otolithus (Sciaenidarum) intermedius* is known as *Corvina intermedia* (Family Sciaenidae). The genus *Corvina* is extant and comparative material is available. Unfortunately,

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PLATE 1

CHARACTERISTIC OTOLITHS IN THE YAZOO CLAY, CALDWELL PARISH, LOUISIANA

Figure

1. *Albula* sp., right sagitta, inner face
2. *Anguilla*? sp., left sagitta, inner face
3. "*Conger*" *dissimilis*, left sagitta, inner face
4. *Ariosoma* sp., left sagitta, inner face
5. *Conger*? *vetustus*, left sagitta, inner face
6. *Arius* sp., left lapillus, outer face
7. *Bregmaceros troelli*?, right sagitta, inner face
8. *Preophidion stintoni*, right sagitta, inner face
9. *Ophidion*? sp., left sagitta, inner face
10. *Brazosiella* sp., left sagitta, inner face
11. *Myripristis creola*, left sagitta, inner face
12. *Allomorone* sp., left sagitta, inner face
13. *Corvina intermedia*, left sagitta, inner face
14. *Ekokenia* sp., left sagitta, inner face
15. *Jefitchia claybornensis*, left sagitta, inner face
16. *Eosolea texana*, left sagitta, inner face

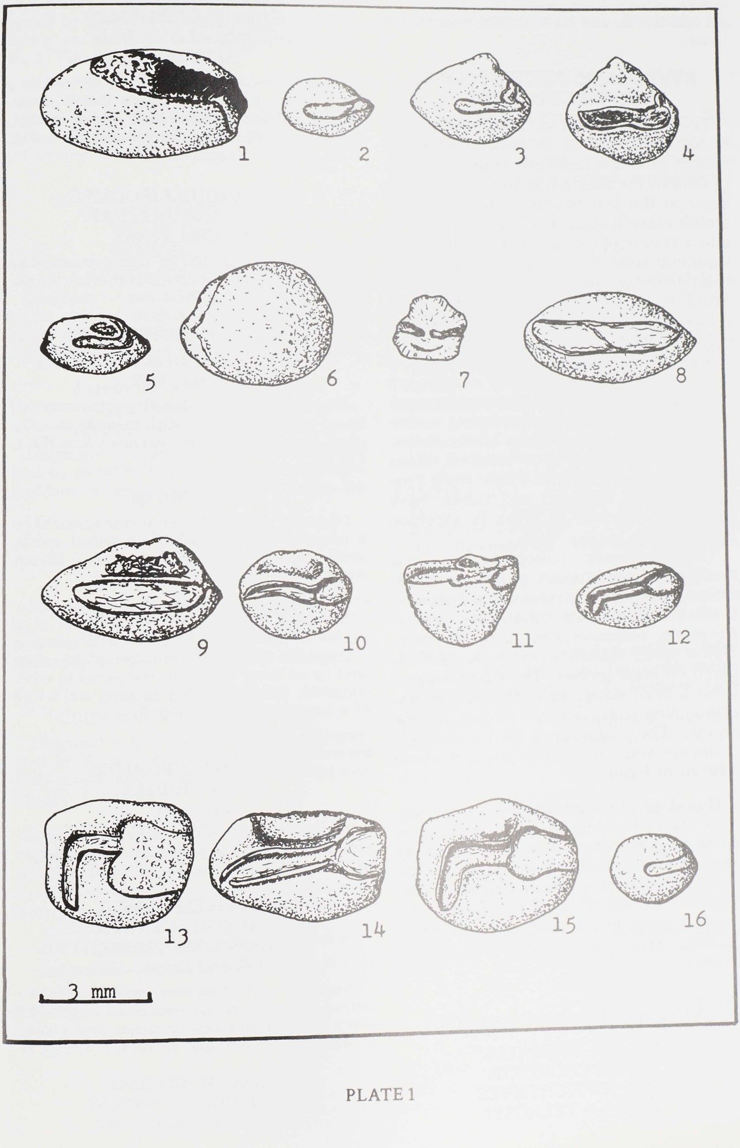

PLATE 1

all otoliths do not have extant representatives.

SYSTEMATIC PALEONTOLOGY OF THE OTOLITHS

The classification of fossil otoliths, or statoliths, is still in its initial stages. Although attempts have been made to classify otoliths for over a hundred years, it has been in the last twenty years or so that otolith classification has begun to develop into a system of classification in which phylogenetic relationships are understood. It is unfortunate that many early taxonomists failed to search for ancestor-descendant relationships. However, workers have become acutely aware of the necessity of searching for Recent representatives of fossil otoliths. As more fossil otoliths are collected, studied, and compared to possible descendants, a more complete understanding of the phylogeny of the fishes, based on otoliths, will be obtained. Many recent workers, such as Fitch, Nolf, Frizzell, Stinton, Lamber, and Dante, have diligently searched in order to ascertain phylogenetic relationships.

The systematic paleontology in this study was based mainly on Romer (1966). Romer's classification was utilized because it was fairly recent, complete, and familiar to many paleontologists and biologists. Below each classification, a diagnosis is given on each species. The diagnosis presents a brief statement of the unique, discriminating characteristics of that specific otolith. The diagnosis is by no means a complete description. All of the otoliths are figured in Plate 1.

Based on the identification of the otoliths, line drawings were prepared for some of the genera found in the study area. These drawings were based on Recent genera or very similar Recent genera. Figure 7 shows some of the genera that were present in the study area based on otoliths and comparisons with extant genera.

SYSTEMATIC PALEONTOLOGY

Kingdom ANIMALIA
Phylum CHORDATA
Class OSTEICHTHYES
Infraclass TELEOSTI

Order ELOPIFORMES
Family ALBULIDAE
ALBULA sp.

Diagnosis — *Albula* sp. is characterized by a long ostium, a posterior cauda that is downturned and deeply excavated, and a twisted, concavo-convex nature of the sagitta (Pl. 1, Fig. 1).

Order ANGUILLIFORMES
Family ANGUILLIDAE
ANGUILLA? sp.

Diagnosis — *Anguilla?* sp. is characterized by a diagonally inclined sulcus that reaches the anterior rim (Pl. 1, Fig. 2).

Family CONGRIDAE
"CONGER" DISSIMILIS Frizzell and Lamber, 1962

Diagnosis — *"C." dissimilis* is characterized by an excavated cauda, thick deposits of colliculum, and a shorter, more narrow sulcus (Pl. 1, Fig. 3).

ARIOSOMA sp.

Diagnosis — *Ariosoma* sp. is characterized by a non-excavated to slightly excavated cauda, small deposits of colliculum, and a longer, wider sulcus (Pl. 1, Fig. 4).

CONGER? VETUSTUS Frizzell and Lamber, 1962

Diagnosis — *Conger? vetustus* is characterized by its lower height (as compared to other congrids), a deeply impressed area, and a lack of a dorsal dome (Pl. 1, Fig. 5).

Order SILURIFORMES
Family ARIIDAE
ARIUS sp.

Diagnosis — The lapillus of *Arius* sp. is characterized by a sulcus on the outer face and an umbo on the inner face (Pl. 1, Fig. 6).

Order GADIFORMES
Family BREGMACEROTIDAE
BREGMACEROS TROELLI? Frizzell and Dante, 1965

Diagnosis — *Bregmaceros troelli*? is characterized by its minute size (maximum length—2.0 mm), an inverted scutiform shape, and a widely separately ostium and cauda (Pl. 1, Fig. 7).

Family OPHIDIIDAE
PREOPHIDION STINTONI Frizzell and Dante, 1965

Diagnosis — *Preophidion stintoni* is characterized by its biconvex, seed-like shape, a completely enclosed sulcus, and a divided sulcus (Pl. 1, Fig. 8).

OPHIDION? sp.

Diagnosis — *Ophidion?* sp. is characterized by its very obvious, almost completely enclosed sulcus and subpyriform shape (Pl. 1, Fig. 9).

Order BERYCIFORMES
Family Unknown
BRAZOSIELLA sp.
Frizzell and Dante, 1965

Diagnosis — *Brazosiella* sp. is characterized by its obvious, slightly recurved sulcus, elongated area, prominent crista superior, and slightly upward directed ostium (Pl. 1, Fig. 10).

Family HOLOCENTRIDAE
MYRIPRISTIS CREOLA
(Frizzell and Lamber, 1961)

Diagnosis — *Myripristis creola* is characterized by its sulcus located on the dorsal margin, scutiform shape, and caudal keel (Pl. 1, Fig. 11).

Order PERCIFORMES
Family SERRANIDAE
ALLOMORONE sp.

Diagnosis — *Allomorone* sp. is characterized by its long, narrow, straight cauda with only the posterior downturned, narrow, elliptical ostium, and subelliptical shape (Pl. 1, Fig. 12).

Family SCIAENIDAE
CORVINA INTERMEDIA (Koken)

Diagnosis — *Corvina intermedia* is characterized by its wide ostium, a sharply downward bent cauda, and a rounded anteroventral margin (Pl. 1, Fig. 13).

EKOKENIA sp.

Diagnosis — *Ekokenia* sp. is characterized by its slightly downward flexed cauda, a rectangular-shaped, very obvious depressed area, and a very prominent crista superior (Pl. 1, Fig. 14).

JEFITCHIA CLAYBORNENSIS (Koken)

Diagnosis — *Jefitchia claybornensis* is characterized by its downturned cauda, narrow ostium, and subquadrate shape (Pl. 1, Fig. 15).

Order PLEURONECTIFORMES
Family SOLEIDAE
ESOLEA TEXANA Frizzell and Dante, 1965

Diagnosis — *Eosolea texana* is characterized by its subcircular shape, small size (maximum length-2.2 mm.), and a sinuous, undivided sulcus (Pl. 1, Fig. 16).

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