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Another Sternberg "fish-within-a-fish" discovery: First report of *Ichthyodectes ctenodon* (Teleostei; Ichthyodectiformes) with stomach contents

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George F. Sternberg is well remembered for collecting the famous "Fish-within-a-fish" specimen, a 2 m *Gillicus* preserved inside a 4 m *Xiphactinus* specimen, from the Late Cretaceous Smoky Hill Chalk of Gove County, Kansas in 1952. Another, much earlier collected "fish-within-a-fish" specimen was rediscovered recently in storage at Park University, Parkville, Missouri. It was collected by G.F. Sternberg's father, Charles H. Sternberg, who sold it and other specimens to the university from his laboratory in Lawrence, Kansas. A letter dated March 24, 1919 accompanying the materials confirmed that the sale occurred just prior to the elder Sternberg moving to his retirement in California. Most importantly, this specimen is the only known example of *Ichthyodectes ctenodon* Cope 1870 with stomach contents. Although most of the prey fish was lost due to erosion prior to discovery, it has been tentatively identified as *Enchodus petrosus* from the characteristics of the caudal fin, vertebrae, and overall size. Due to the posterior location of the prey, it appears that the larger *Ichthyodectes* died after some digestion of the prey had taken place. Although *I. ctenodon* has long been assumed to be one of the major mid-sized predators in the Western Interior Sea, this specimen provides the first evidence of a piscivorous diet and adds to our knowledge of the ecology of the Late Cretaceous ocean that covered much the North American Midwest.

Key words: Niobrara, Smoky Hill Chalk, Western Interior Sea, Ichthyodectidae, predator, prey, piscivory

INTRODUCTION

The Family Ichthyodectidae includes *Xiphactinus audax* Leidy 1870, the largest predatory teleost known in the Late Cretaceous seas, as well as the smaller *Ichthyodectes ctenodon* Cope 1870, and *Gillicus arcuatus* Hay 1898. All three species were common inhabitants of the Western Interior Sea that covered the Midwestern portions of North America. Although *Gillicus* was a large (2 m) Tarpon-sized predator itself, it is probably best known for being the prey of the much larger *Xiphactinus audax* (e.g. the extensively photographed "Fish-within-a-fish" specimen at the Sternberg Museum of Natural History, Hays, Kansas; Walker 2006).

Relatively little has been written specifically about *Ichthyodectes* since it was first described by E.D. Cope (1870) on the basis of fragmentary specimens collected from the upper Smoky Hill Chalk near Sheridan, Kansas by B.F. Mudge. Although a large predatory fish (~2 m) in its own right, *Ichthyodectes ctenodon* was easily eclipsed in size by *Xiphactinus audax*. While the classification and phylogeny of ichthyodectids has been addressed by

various authors, (Patterson and Rowen 1977; Stewart 1999; Blanco and Alvarado, 2007; Taverne 2008), other than Bardack (1965), *Ichthyodectes ctenodon* has been largely ignored as a species by paleontologists since its discovery, and the subsequent brief descriptions by Cope (1875, pl. VLVI), Crook (1892), Hay (1898, 1903) and Stewart (1900).

Ichthyodectes was initially placed within the family Saurodontidae by Cope (1870). Crook (1892) then established the Family Ichthyodectidae to include *Ichthyodectes*, *Xiphactinus* and *Saurodon*. Later Stewart (1900 p. 262-263) separated *Ichthyodectes* from *Saurodon*, and established the families of Ichthyodectidae, including *Ichthyodectes*, *Xiphactinus* and *Gillicus*, and Saurodontidae, including *Saurodon* and *Saurocephalus*. Woodward (1901) created the Family Chirocentridae to include all ichthyodectids and saurodontids, as well as other fossil groups (see also Loomis, 1900).

Forty years later, Berg (1940) suggested that the saurodontids differed significantly from other fossil and recent chirocentrids (wolf-herrings), and placed them within a new version of the Family Ichthyodectidae. Cavender (1966) agreed and also concluded that *Xiphactinus*, *Ichthyodectes* and *Gillicus* should not be included in the Chirocentridae or the Clupeiformes. Berg's (1940) suggestion was generally accepted by other authors until Bardack (1965) reviewed the Family Chirocentridae.

Romer (1966) included the families Saurocephalidae (=Saurodontidae) and Ichthyodectidae within the Suborder Ichthyoidectoidei as part of the Osteoglossomorphs. Following that, Bardack and Sprinkle (1969) erected the order Ichthyodectiformes, including the Romer´s suborder Ichthyodectoidei. Patterson and Rosen (1977) supported the inclusion of *Xiphactinus*, *Ichthyodectes* and *Gillicus* within a larger version of the Family Ichthyodectoidei that had been proposed initially by Berg (1940).

Maisey (1991) created the Family Cladocyclidae and included some of the ichthyodectids from Berg´s (1940) family, and thus placed *Xiphactinus*, *Ichthyodectes* and *Gillicus* in the Family Ichthyodectidae again, as Stewart had suggested in 1900. According to Stewart (1999), however, the relationships of the Order Ichthyodectiformes proposed by Maisey (1991) were not supported by his phylogenetic analysis of the group. More recently Blanco-Piñón and Alvarado-Ortega (2007) included a new genus *Vallecillichthys* within the latest version of the Family Ichthyodectidae, but did not find enough evidence to include *Gillicus*. Taverne (2008) described the genus *Gillicus* as the sister group of Chirocentrites. A subsequent discovery of *Gillicus* in the Turonian limestone of northern Mexico resulted in the inclusion of the genus within Ichthyodectidae by Alvarado-Ortega and Porras-Múzquiz (2009).

Ichthyodectes ctenodon was a common inhabitant of the Late Cretaceous Western Interior Sea, with a fossil record that extends from the Cenomanian through the early Campanian (Bardak, 1965; Stewart, 1990; Everhart, et al. 2004; Everhart, 2005). Complete specimens are rare, and only a few are known to be in museum collections. One of these was collected by George Sternberg and Myrl V. Walker from Logan County in 1931 (Fig 1-A) and sold to the United States National Museum (USNM 12358). According to Bardak (1965, p. 55), this specimen is 155 cm in standard length (tip of jaw to base of tail) and has the dorsal, pelvic, anal and caudal fins restored (Fig. 1-B). A second, nearly complete specimen of a young individual (FHSM VP-706) was collected in Logan County and is 110 cm in length (Bardack, 1965). The large specimen (KUVP 104) on exhibit at the University of Kansas Museum of Natural History is a composite of two fish (Bardack 1965).

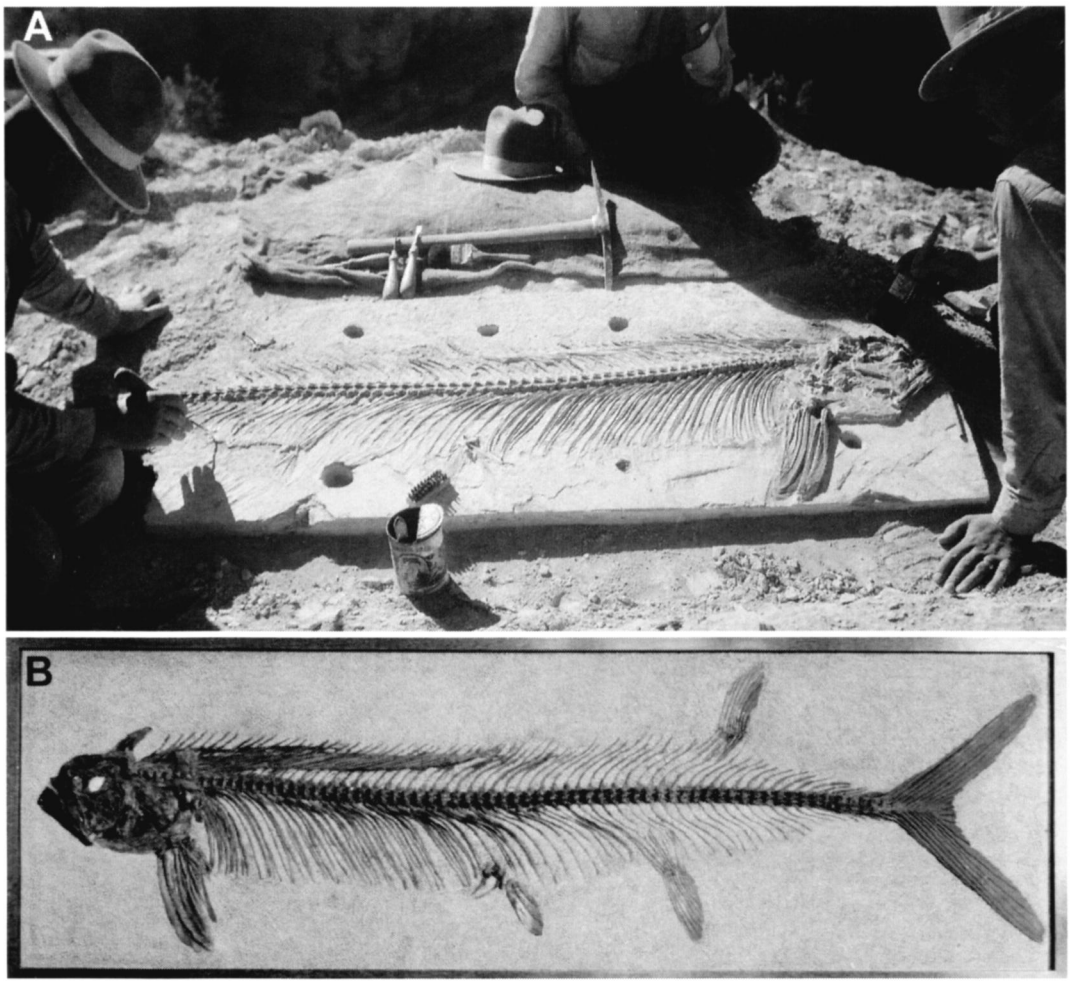

Figure 1-A. A field photo from 1931 showing George F. Sternberg (left) and Myrl V. Walker (right) in the process of collecting one the best known specimens of *Ichthyodectes ctenodon* (USNM 12358). The specimen is 155 cm in length from the tip of the jaw to the base of the tail; 1-B. The specimen as mounted and sold to the United States National Museum. (Photos used with permission of the Forsyth Library, Fort Hays State University, Hays, Kansas.)

The specimen reported here (PUPC 1001; Fig 2) is curated in the paleontology collection of Park University, Parkville, Missouri. Based on a count of the remaining vertebrae, the specimen includes the anterior 40% of an adult *Ichthyodectes ctenodon* that would have measured about 1.6 m when alive. The probable *Enchodus* specimen inside is comprised of a complete caudal fin and at least 14 articulated caudal vertebrae. Additional vertebrae may be present but are presently obscured due to debris near the edge of the mount.

Systematic Paleontology

Class Osteichthyes, Huxley 1880
Division Teleostei, Müller 1846
Order Ichthyodectiformes, Bardack and Sprinkle 1969
Family Ichthyodectidae, Crook 1892
Ichthyodectes ctenodon, Cope 1870

Material

The PUPC 1001 specimen was collected in a typical Sternberg field mount by building a

Figure 2. Specimen of *Ichthyodectes ctenodon* (PUPC 1001) containing the remains of a probable *Enchodus petrosus* as stomach contents collected by Charles H. Sternberg from Logan County, Kansas about 1918. (Scale bar = 10 cm)

frame of "2x4" framing lumber around the exposed bones of the *Ichthyodectes* in the field and then pouring plaster directly on the bones until it was level with the top of the frame. Once the plaster hardened, additional boards were nailed or screwed to the frame, forming a permanent bottom for what is essentially a wooden box enclosing the plaster covered specimen. Then the specimen was undercut and turned over. Excess chalk was probably removed in the field to reduce weight, but the final preparation of the specimen most likely was done in Sternberg's laboratory in Lawrence, Kansas. Nearly all of the remaining chalk was removed at that time and the bones were given a coating of shellac, based on the visible discoloration of the coating. At some point, additional batter boards were attached to the original frame with screws (Fig. 2) to provide a space between the fossil and a lid that would have been attached for shipping.

The exterior dimensions of the original frame are 68 cm long, 35 cm wide and 15 cm deep. It is almost completely filled with plaster. The anterior portion of the left side of the *Ichthyodectes* and posterior right side of the *Enchodus* are exposed in the plaster mount. The *Ichthyodectes* specimen is 62 cm in length, from the tip of the upper jaw to the last of the exposed vertebrae, and 24 cm in maximum height. The remaining caudal portion of the *Enchodus* measures about 14 cm in length, and 7.7 cm in the depth of the caudal fin.

There are two identification tags affixed to the specimen. One note is typewritten and says, "ICTHYOCDECTES [sic], Niobrara Fm., Logan Co., Kansas. C. H. Sternberg," with "#7" handwritten in the upper left corner. The second note is handwritten and has partially crumbled away with age: "No. 7, Niobrara Group Cretaceous, Icthyodectes [sic] anaides, Butte [Creek], Log[an County]." Note that *I. anaides* is a junior synonym of *I. ctenodon* (Bardack, 1965, p. 60).

Locality/ Stratigraphy – The information provided with the specimen indicates that it was collected on [Twin] Butte Creek in southern Logan County. This is consistent with the many other specimens that were

being collected by the Sternberg family at that time (Sternberg, 1922). The exposures of the Niobrara Formation along Twin Butte Creek are mostly upper Smoky Hill Chalk, Late Santonian-Early Campanian in age (Bennett 2000, fig. 6).

Specimen History – The PUPC 1001 *Ichthyodectes* is part of the Park University Sternberg Collection, including 157 specimens purchased from Charles H. Sternberg in 1919. The collection is 66% dinosaur bones (dominated by hadrosaur material) from his freelance 1917 field season in Alberta, Canada and 34% marine fossils from western Kansas. In addition to PUPC 1001, the 53 specimens from Kansas include the plaster mounted skulls of *Xiphactinus audax*, *Gillicus arcuatus, Pentanogmius evolutus,* and *Saurodon leanus* (Dowdy and Hageman 2007). The only known documentation of the transfer of the specimens comes from a letter and a packing list of the contents shipped. The letter was written by C.H. Sternberg to Dr. Merlin C. Findlay, a biology professor at Park College from 1892-1945, for whom the current Findlay-Wakefield Science Hall on campus is named. The letter thanks Dr. Findlay for the visit to the college and to his house in Parkville, Missouri.

At the time of the sale, Sternberg's laboratory was located at 918 Vermont Street in Lawrence, Kansas. The house has been torn down and the property is currently included in a parking lot. A glimpse into Charles H. Sternberg's passion for collecting is represented by his 1919 business letterhead which reads:

> "My Fossils Have Been Sent to: The U.S. National Museum where are thousands of my plants [fossil leaves from the Dakota Fm]. To the British Museum of Natural History. The Paleontological Museum of Munich where I have 85 species of vertebrates. The American Museum of Natural History, New York, where are the results also of 8 years service in the field as assistant of the late Prof. E. D. Cope. The National Museum of France at Paris. The National Museum of Germany at Berlin. Senckenburg, Natural History Museum, Frankfurt-on-the-Main. The Museums of the Universities of Tubingen, Roemer at Hildersheim, Yale, Harvard, Chicago, Toronto, Princeton, California, Minnesota, Iowa, Ohio, Michigan, Cornell, Poukeepsie, Massachusetts Institute of Technology, Kans. and many other Museums and Universities throughout the world."

Discussion

Skull – PUPC 1001 appears to conform closely to the description of *Ichthyodectes* provided by Bardack (1965). The specimen is exposed in left lateral view in the plaster mount. Most noticeably, the teeth that are visible are more or less uniform in size, especially in comparison to *Xiphactinus audax*. Also, the supraoccipital crest rises more sharply, relative to the frontal than in *Xiphactinus*. Bardack (1965) notes that the angle is 35-40 degrees from the horizontal axis of the body in four specimens of *Ichthyodectes* that he measured. The angle is about 35 degrees in PUPC 1001.

As preserved (Fig. 3A, B), the head is about 26 cm in length from the tip of the lower jaw to the back of the operculum. The lower jaw is in a normal closed position, with the teeth obscured beneath the maxillae. The ventral portion is damaged and may have been lost during preparation. The length of the lower jaw is 12 cm, which compares favorably to the average length of 13.7 cm (14 specimens) reported by Bardak (1965, p. 57). A single row of uniformly-sized (~5 mm), closely set teeth are visible on the left maxilla. Bardack (1965) reported an average of 48 teeth in the maxilla of *Ichthyodectes*. Although the left premaxilla is completely exposed, most of the teeth are broken or missing. Both halves of the scleral ring are visible within the orbit of the left eye.

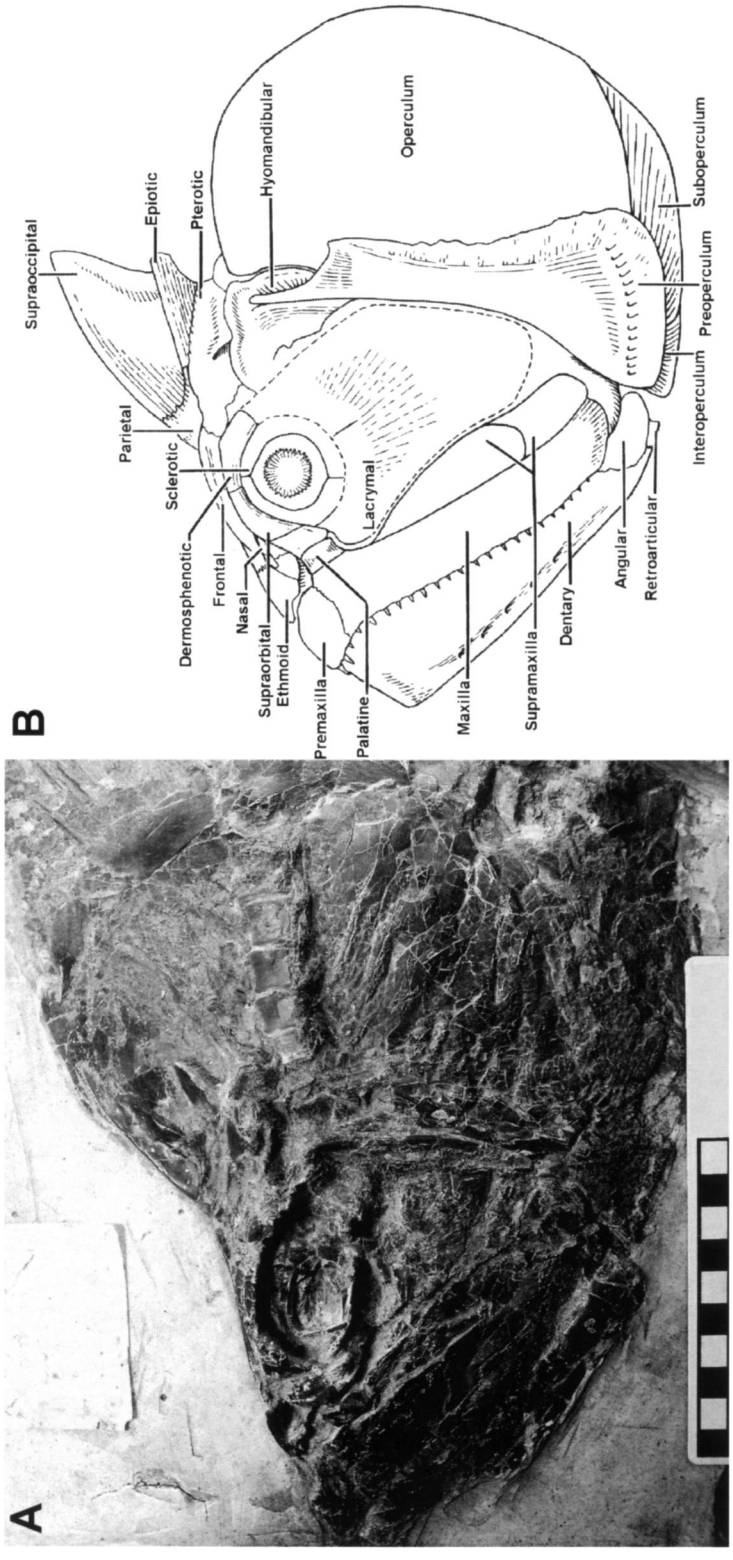

Figure 3-A. The anterior portion of PUPC 1001, including the skull, as prepared by C.H. Sternberg. Note the complete scleral ring and large supraoccipito-parietal crest. (Scale bar = 10 cm); 3-B. Line drawing of the skull of *Ichthyodectes ctenodon* (Adapted from Bardack, 1965, fig. 16).

At 5.5 cm, the prominent supraoccipito-parietal crest on the cranium is more than 25% of the total height of the skull.

Opercular series – The left operculum is crushed against about 10 of the vertebrae immediately posterior to the cranium. The left preoperculum and subopercular are visible ahead of and below the operculum, respectively. The interoperculum is damaged and difficult to discern.

Post-cranial – The base of the left pectoral fin is visible but most of the fin is missing. Additional portions appear to have been present originally, but may have been damaged during preparation or subsequent handling. The remains preserve a total of about 30 articulated vertebrae from the back of the cranium to the point where the specimen had eroded out of the chalk. The vertebral series ends just ahead of where the pelvic fins would have been located. Bardack (1965) reported a range of 68-72 vertebrae in the specimens he examined. All of the ribs appear to be in their natural positions and there is no evidence of scavenging or significant disarticulation due to decomposition. Although Sternberg apparently removed some of the rib elements that were laying on top of the caudal fin of the prey fish, there is no doubt that it is contained within the abdomen of the *Ichthyodectes*. No complete scales are visible, but it appears that a layer of material consisting of partially decomposed scales is present in various areas of the remains.

Enchodus petrosus Cope 1874 was a common but somewhat smaller predator species in the Western Interior Sea. It has been characterized as the "saber-toothed salmon" for its large, fang-like teeth (see Stewart 1900, pl. LXX, figs. 11-14; Green 1913, pl. III, figs. 1-2; Goody 1976, Text-fig. 7). While there are numerous skulls and jaws in museum collections, the fish is seldom preserved intact and few caudal fins are available for comparison with PUPC 1001. Green (1913, pl. VI, fig.1) and Goody (1976, text-figs. 5-6) published the best examples.

Figure 4. The caudal fin of the prey discovered as gut contents of PUPC 1001. Note that some portions of the ribs overlying the caudal fin were removed by Sternberg during preparation of the specimen. (Scale bar = 10 cm)

Comparison of the caudal fin within the larger fish in PUPC 1001 with these figures does not show any features which are inconsistent with our identification of the prey as being *Enchodus* sp. Goody (1976, p. 98) notes that 45 vertebrae are present in *E. petrosus*, and that the centra are "well ossified, longer than deep and mesially constricted." Three of the vertebrae of the prey fish that are visible just anterior to the caudal fin fit this description. In PUPC 1001, most of the *Enchodus* specimen (Fig. 4) was apparently lost to erosion prior to the collection of the larger fish. It had been swallowed headfirst, which is the normal feeding practice in most fishes, and may have been partially digested at the time that the *Ichthyodectes* died. It is likely that the digestion of large prey in these fish proceeds in a linear fashion, and not all at once. In a similar specimen reported by Everhart (2005, p. 87) where an *Enchodus* (FHSM VP-14025) had been swallowed by a *Cimolichthys* (FHSM VP-14024), most of anterior portion of the

prey was partially digested and generally unrecognizable while the posterior portion of the body, including the caudal fin, was still intact, although the caudal fin was damaged by weathering. In this specimen the prey was identified as *Enchodus* by the presence of the pair of distinctive palatine bones located near the cloaca of the larger fish. A relatively undigested *Enchodus* (FHSM VP-15066) of similar size was discovered inside another *Cimolichthys* (FHSM VP-15065), but only the prey specimen includes the anterior portion of the fish, not the caudal fin.

Conclusion

PUPC 1001 is the first known specimen of *Ichthyodectes* with gut contents. The prey fish in this case was most likely *Enchodus petrosus*. While it is not surprising that a large predatory fish like *Ichthyodectes* had a piscivorous diet in a sea full of fish, it had not been confirmed until the re-discovery of this classic Sternberg specimen. As such, this specimen adds to our knowledge for the ecology of the Late Cretaceous Western Interior Sea that covered much of the North American Midwest for more than 35 million years.

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