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THE LATE CRETACEOUS LAMNIFORM SHARK, *SERRATOLAMNA SERRATA* (AGASSIZ), FROM THE MOOREVILLE CHALK OF ALABAMA

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ABSTRACT

Serratolamna serrata (Agassiz) is a Late Cretaceous lamniform shark typically found in Maastrichtian marine deposits. Here we describe seven isolated teeth of *S. serrata* from the Lower Campanian portion of the Mooreville Chalk in Alabama, and this report constitutes the first documentation of the species from this stratigraphic unit. The described teeth are significant because they represent the oldest (ca. 80 Ma) record of *S. serrata* in the world, and possibly suggest a North American origin for the taxon. *Serratolamna serrata* may have evolved from another lamniform, *Cretalamna appendiculata* (Agassiz).

INTRODUCTION

Serratolamna serrata is an extinct shark taxon represented only by isolated teeth, which are found in Late Cretaceous marine deposits in different parts of the world (Cappetta, 1987). The taxon has been reported from Europe (e.g., France and Spain: Cappetta, 1970; Landemaine, 1991; Cappetta and Corral, 1999), Africa (Morocco and Nigeria: Arambourg, 1952; Cappetta, 1972), Madagascar (Gottfried et al., 2001), Jamaica (Underwood and Mitchell, 2000), and North America (Figure 1). The North American records (Figure 1) consist of localities in Maryland (Hartstein and Decina, 1986; Kent, 1994; Hartstein et al., 1999), New Jersey (Case et al., 2001; Robb, 2004), North Carolina (Case, 1979), Arkansas (Becker et al., 2006), North Dakota (Hoganson et al., 1995; Hoganson and Murphy, 2002), South Dakota (Becker et al., 2004), Texas (Welton and Farish, 1993; Case and Cappetta, 1997), and Mexico (Gonzalez-Barba et al., 2001; Kirkland and Aguillon-Martinez, 2002).

The Mooreville Chalk (Upper Santonian – Middle Campanian) is an Upper Cretaceous marine deposit exposed primarily in Alabama (Puckett, 1994; Mancini et al., 1995: triangle pointed by arrow in Figure 1). Although various shark taxa occur in the Mooreville Chalk (Russell, 1988), *Serratolamna serrata* has never been reported from the formation to date. The senior author (KS) recently examined several teeth of *S. serrata* from the Mooreville Chalk of Alabama housed in the McWane Science Center, Birmingham (which manages the collection of the Red Mountain Museum [RMM] no longer in operation) and the University of Alabama Museum of Natural History (UAMNH), Tuscaloosa. The primary purpose of this paper is to formally describe those *S. serrata* specimens and review the geographic and stratigraphic distributions of this species.

SYSTEMATIC PALEONTOLOGY

Class CHONDRICHTHYES Huxley, 1880
Subclass ELASMOBRANCHII Bonaparte, 1838
Cohort EUSELACHII Hay, 1902
Subcohort NEOSELACHII Compagno, 1977
Superorder GALEOMORPHII Compagno, 1973
Order LAMNIFORMES Berg, 1958
Family CRETOXYRHINIDAE(?) Glickman, 1958
Genus *SERRATOLAMNA* Landemaine, 1991
SERRATOLAMNA SERRATA (Agassiz, 1843)
(Figure 2)

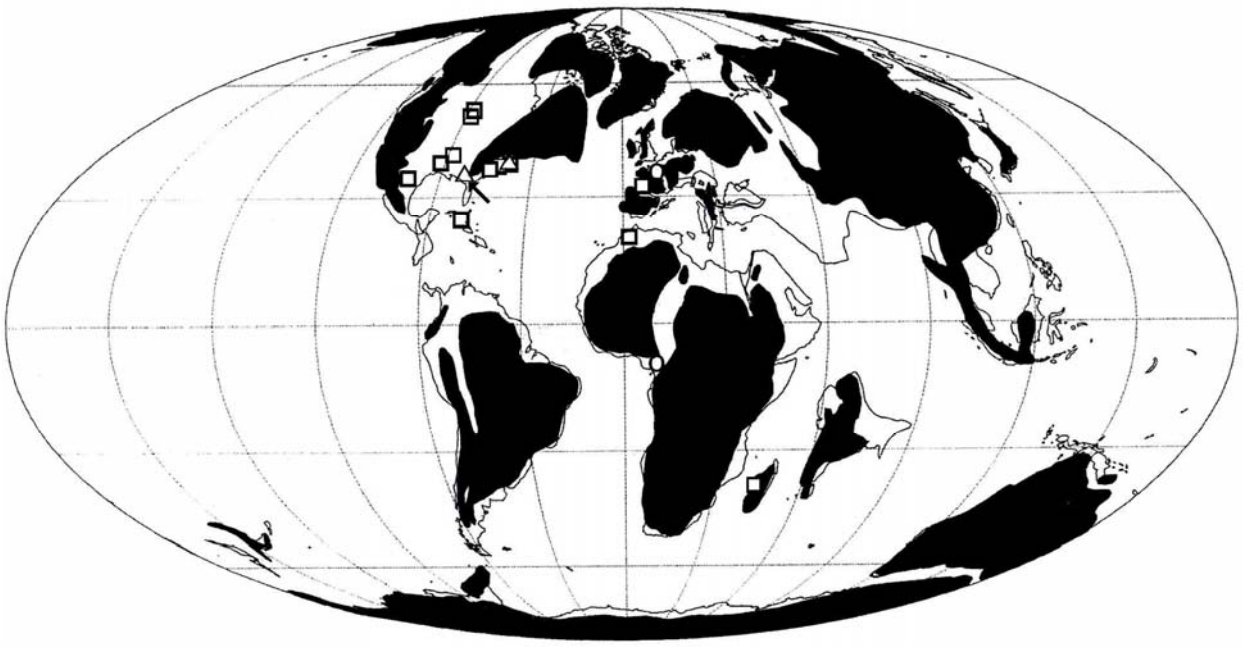

FIGURE 1. Paleogeographic map showing localities of *Serratolamna serrata* (map depicts Maastrichtian coastlines: after Smith et al., 1994:33). Symbols: triangle = Campanain record (Robb, 2004; arrow indicates Alabama record of this report); square = Maastrichtian record (Arambourg, 1952; Case, 1979; Hartstein and Decina, 1986; Welton and Farish, 1993; Kent, 1994; Hoganson et al., 1995; Cappetta and Corral, 1999; Hartstein et al., 1999; Underwood and Mitchell, 2000; Case et al., 2001; Gonzalez-Barba et al., 2001; Gottfried et al., 2001; Hoganson and Murphy, 2002; Kirkland and Aguillon-Martinez, 2002; Becker et al., 2004, 2006); circle = "Campanian–Maastrichtian" record (i.e., with poor stratigraphic control; Cappetta, 1970, 1972; Landemaine, 1991; Case and Cappetta, 1997).

Lamna cuspidata Agassiz, 1843, p. 290, pl. 37a, figs. 43–50.

Lamna serrata (Agassiz): Arambourg, 1952, p. 98, pl. 16, figs. 1–41.

Odontaspis substriata (Agassiz): Cappetta, 1970, p. 358; Cappetta, 1972, p. 187, pl. 2, figs. 1–10.

Otodus serratus Agassiz: Case, 1979, p. 84, pl. 32, figs. 27–28.

Cretolamna serrata (Agassiz): Harstein and Decina, 1986, p. 93, pl. 1, fig. 4.

Serratolamna serrata (Agassiz): Landemaine, 1991, p. 14, fig. 5; Welton and Farish, 1993, p. 112, figs. 1–5; Hoganson, Erickson, and Holland, 1995, p. 60; Case and Cappetta, 1997, p. 164, pl. 3, figs. 5–8; Cappetta and Corral, 1999, p. 349, pl. 4, figs. 4–6; Harstein, Decina, and Keil, 1999, p. 20, pl. 1, fig. 3; Underwood and Mitchell, 2000, pp. 25–30, fig. 4A–E; Case, Schwimmer, Borodin, and Liggett, 2001, p. 126, pl. 2, figs. 29–30; Gonzalez-Barba, Coutiño-Jose, Ovalles-Damian, and Vega-Vera, 2001, p. 33; Gottfried, Rabarison, and Randriamiarimanana, 2001, p. 493, pl. 1, fig. 2; Becker, Chamberlain, and Terry, 2004, p. 285, fig. 4M–N; Robb, 2004, p. 80, fig. 1E; Becker, Chamberlain, and Wolf, 2006, p. 705, fig. 3.20–21.

Materials—RMM 1615.1, one tooth from Green County, Alabama (Figure 2A); RMM 2984.1, one tooth from Dallas County, Alabama (Figure 2B); RMM 5698, one tooth from Green County, Alabama (Figure 2C); RMM 5706, one tooth from Dallas County, Alabama (Figure 2D); RMM 5768, one tooth from Dallas County, Alabama (Figure 2E); UAMNH PV988.0020.0073.004, one tooth from Dallas County, Alabama (Figure 2F); UAMNH PV988.0020.0322.001, one of three catalogued teeth from Dallas County, Alabama (Figure 2G).

Occurrence—The seven teeth described here come from three different localities in Alabama: two localities in Green County and one locality in Dallas County. The exact locality data for each specimen are on file at the McWane Center and UAMNH. Stratigraphically, all those teeth occurred in the lower portion of the Mooreville Chalk, which is Early Campanian (ca. 80 Ma) in age (S. M. Keller, pers. comm., 2005).

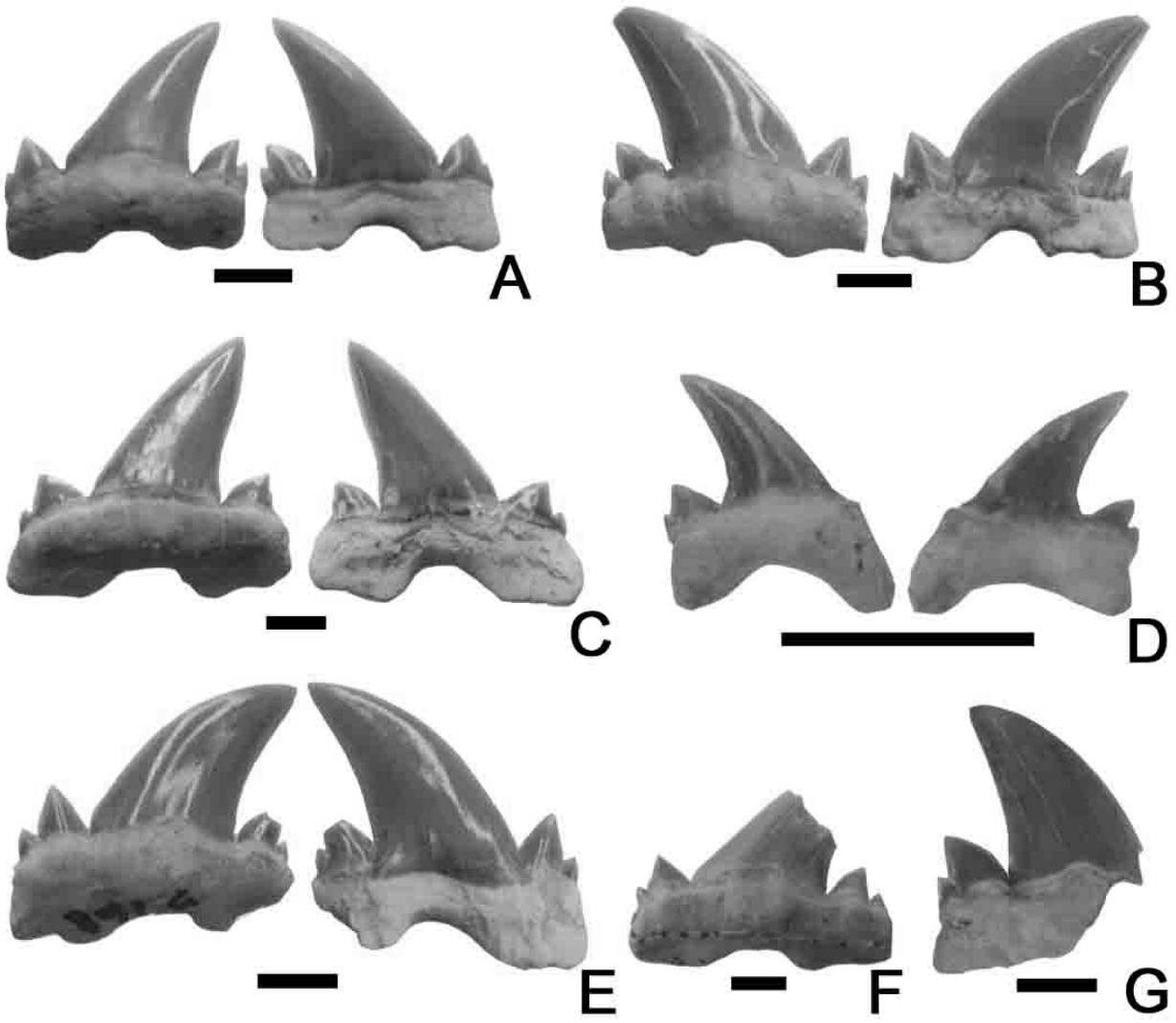

FIGURE 2. Teeth of *Serratolamna serrata* from Upper Cretaceous Mooreville Chalk of Alabama. **A**, RMM 1615.1; **B**, RMM 2984.1; **C**, RMM 5698; **D**, RMM 5706; **E**, RMM 5768; **F**, UAMNH PV988.0020.0073.004; **G**, one of three shark teeth catalogued as UAMNH PV988.0020.0322.001. Orientation: A–E, left side = lingual view, right side = labial view; F and G, lingual view. Scale bars equal 5 mm.

Description—Each tooth of *Serratolamna serrata* consists of a crown composed of a large asymmetrical central cusp, commonly two pairs of diverging lateral cusplets, and a bilobed root. Complete teeth in our sample measure from 4.5 mm to 22 mm in total height. The central cusp is triangular with a broad base and a sharply tapering apex that tends to strongly curve distally. It is slightly compressed labiolingually with a gently convex lingual face, that tends to be particularly thin near its mesial and distal corners, and a flat labial face . The lateral cusplets also have a flat labial face and a gently convex lingual face. The ones closest to the central cusp are much larger than the ones located laterally. The central cusp and lateral cusplets have cutting edges that are smooth (= unserrated) and razor-like. A narrow lingual tooth neck is located between the crown and the root. The root is broad with a weakly raised lingual protuberance, which may show a very shallow, short nutrient groove with zero to a few small nutritive pores. The root lobes are short, sub-rectangular, and their basal margin is broad and commonly shows a shallow indentation. The basal interlobe concavity of the root tends to be shallow.

Remarks—The seven teeth of *Serratolamna serrata* described here exhibit some morphological and size differences. The smallest tooth (RMM 5706:

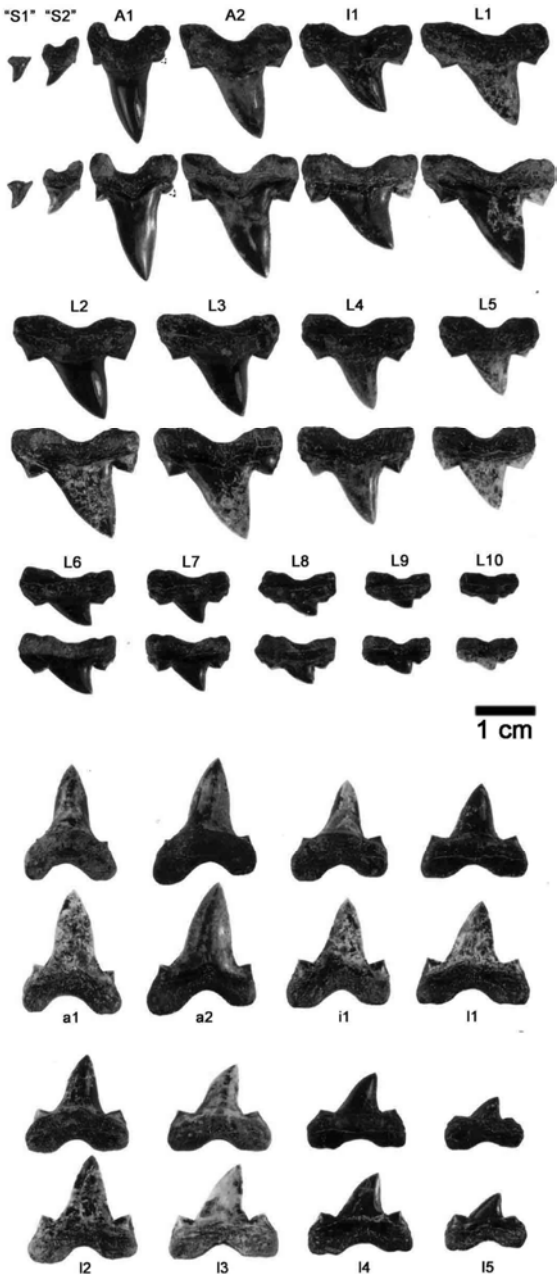

FIGURE 3. Upper and lower teeth from one individual of *Cretalamna appendiculata* from Early Campanian portion of Niobrara Chalk of western Kansas (modified from Shimada [in press, figs. 8, 9]). Top row = lingual view; bottom row = labial view (images reversed). Abbreviations: A, upper anterior tooth; a, lower anterior tooth; I, upper intermediate tooth; i, lower intermediate tooth; L, upper lateral tooth; l, lower lateral tooth; P, upper posterior tooth; p, lower posterior tooth; S, upper symphysial tooth; s, lower symphysial tooth.

Figure 2D) may have come from a small individual, but it likely represents a tooth from near the distal end of the dentition because it has a strongly inclined principle cusp and a broad basal root concavity. Based on the dentition of modern and extinct lamniforms (e.g., Shimada, 2002, in press), tall teeth with a highly curved central cusp (e.g., RMM 2984.1 and RMM 5768: Figure 2B, E) probably come from the middle of the dentition (i.e., mesially located lateral teeth), whereas tall teeth with a more erect central cusp (e.g., RMM 1615.1 and RMM 5698: Figure 2A, C) probably have come from the mesial end of the dentition (e.g., anterior teeth or teeth adjacent to them). Therefore, *Serratolamna serrata* is interpreted to show a moderate heterodonty (e.g., also see Welton and Farish, 1993).

DISCUSSION

Siverson (1999) pointed out that the family Cretoxyrhinidae has been used as a taxonomic waste basket for several Cretaceous and Paleogene lamniform taxa. Although he suggested that Cretoxyrhinidae should be restricted to the type genus *Cretoxyrhina*, he did not propose familial placements for most of the other lamniform genera traditionally classified into Cretoxyrhinidae, including *Serratolamna*. Although cretoxyrhinid taxonomy may be in need of revision, we have chosen to keep *Serratolamna* within Cretoxyrhinidae in order to minimize confusion.

Serratolamna serrata was previously known from 15 localities (Figure 1), and except for an Early Campanian specimen reported from New Jersey (Robb, 2004), all of the material is derived from Maastrichtian strata. The collection of Alabama teeth described here is significant because it represents some of the oldest *S. serrata* material in the world. The fact that the oldest *S. serrata* (Early Campanian) localities are located in North America suggests that the species evolved in North America and became widely dispersed during the Maastrichtian.

Based on Applegate (1970), Meyer (1974), and Thurmond and Jones's (1981) work, Russell (1988) previously listed the following 14 or 15 shark (= non-batoid elasmobranch) taxa from the Mooreville Chalk of Alabama: *Ptychodus mortoni*, *P. polygyrus* (Ptychodontidae), *Chiloscyllium greeni* (Hemiscyllidae), *Cantioscyllium* sp. (Ginglymostomatidae), *Rhincodon* sp. (Rhincodontidae), cf. *Odontaspis tenuis* (Odontaspididae), *Scapanorhynchus texanus* (Mitsukurinidae), cf. *Anomotodon angustidens* (Alopiidae), *Pseudocorax laevis*, *Squalicorax kaupi*, *S. pristodontus* (Anacoracidae), *Cretalamna* (=*Cretolamna*) *appendiculata*, *Cretoxyrhina mantelli* (Cretoxyrhinidae), and cf. *Mustelus* and/or *Triakis* sp. (Triakidae). Among these shark taxa, teeth of *Cretalamna appendiculata* (Figure 3) resemble particularly close to those of *Serratolamna serrata* in having a large broad-based triangular central cusp and paired lateral cusplets (e.g., see Welton and Farish, 1993; Kent, 1994). We also note that the lingual root protuberance of our *S. serrata* material is relatively

smooth or shows one or more nutritive pores. Such a root feature is reminiscent of *Cretalamna appendiculata* teeth (Figure 3) and is unlike most previously described *S. serrata* teeth (see synonymy list above) which are characterized by the presence of a short, but distinct, nutrient groove on the lingual root protuberance. However, *S. serrata* teeth, including our material (Figure 2), differ from *C. appendiculata* teeth (e.g., Figure 3) in four aspects. First, there are generally at least two pairs of lateral cusplets in the former, whereas only one pair is usually present in the latter. Second, the central cusp in the former tends to show a strong distal curvature compared to that in the latter species. Third, the central cusp of *S. serrata* teeth is more compressed labiolingually compared to that of *C. appendiculata* teeth. Fourth, the central cusp of *S. serrata* teeth tends to be particularly thin near the mesial and distal corners on the lingual face, whereas *C. appendiculata* teeth do not show such a tendency. The third and fourth aspects make *C. appendiculata* teeth to look more robust than *S. serrata* teeth.

Although the *Serratolamna serrata* teeth described here can be distinguished from *C. appendiculata* teeth as discussed above, the observed similarities between them (see also above) warrant the possibility that they are sister species. *Cretalamna appendiculata* is another "cretoxyrhinid" taxon known from Albian (Early Cretaceous) to Ypresian (Eocene) marine deposits nearly worldwide (Shimada, in press). If they are indeed sister taxa, the fact that *C. appendiculata* was in existence before the emergence of *S. serrata* (i.e., by Early Campanian as demonstrated in this paper) indicates a phylogenetic origin of *S. serrata* from the *C. appendiculata* clade.

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