A Small Coelacanth (Sarcopterygii: Actinistia) from the Upper Cretaceous of Monmouth County, New Jersey

Conference Paper · June 2020

CITATIONS
0

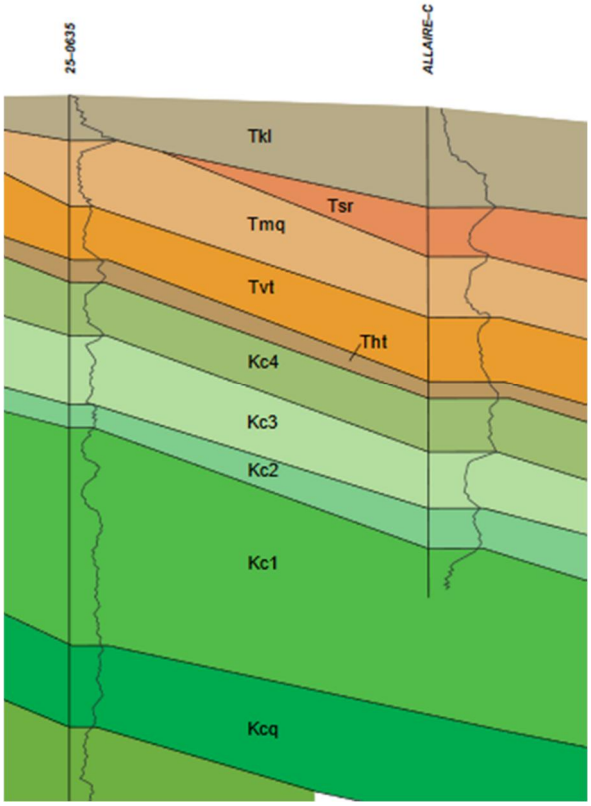
READS
381

2 authors:

Wayne Callahan
New Jersey State Museum
14 PUBLICATIONS **25** CITATIONS
SEE PROFILE

Carl Mehling
American Museum of Natural History
41 PUBLICATIONS **71** CITATIONS
SEE PROFILE

Geology and Paleontology of Monmouth County, New Jersey



2019 Conference proceedings for the 36th annual meeting of the Geological Association of New Jersey

Edited by James Brown and Tim Macaluso

Hosted by Brookdale Community College

A Small Coelacanth (Sarcopterygii: Actinistia) from the Upper Cretaceous of Monmouth County, New Jersey

Wayne Callahan[1] and Carl Mehling[2]
[1]*New Jersey State Museum, Trenton, NJ, USA;*
[2]*American Museum of Natural History, New York, NY, USA.*

ABSTRACT

The Late Cretaceous vertebrate scrap faunas of the New Jersey coastal plain have been the source of many major paleontological discoveries since the early 19th century. Even today, in spite of urban sprawl and the steady loss of classic collecting localities, new discoveries are made with relative frequency. Recently a partial quadrate of a small coelacanth was collected in situ at the Holmdel Park Site, a cooperative venture between the New Jersey State Museum and the Monmouth County Park Service. This site exposes a transgressive lag deposit from the Late Campanian, basal Navesink Formation. This is the second coelacanth fossil ever reported from the Cretaceous of New Jersey and, since it was collected directly from matrix, is the only New Jersey Cretaceous coelacanth that can be confidently dated. The specimen, though not complete, is well preserved with moderate to strongly ornamented bone above and on the sides of the condyles. The condyles themselves are approximately one quarter the size of those from the smallest quadrate assigned to *Megalocoelacanthus dobiei*. Since the newly found quadrate is quite robust in cross-section it does not appear to be from a juvenile and so does not likely belong to *M. dobiei*. The new specimen is from younger strata than the freshwater Cretaceous Gondwanan forms *Mawsonia* and *Axelrodichthys* and is considerably smaller than *Mawsonia*. We compare the new fossil quadrate to fragments of several small unidentified coelacanth specimens from the Late Cretaceous of Kansas and speculate as to the relationship of the new specimen to the European Cretaceous coelacanth *Macropoma.* Until additional material is found the exact status of the new fossil coelacanth is equivocal, however it does appear to represent a new small coelacanth in the Late Campanian of the Atlantic Coastal Plain.

INTRODUCTION

The state of New Jersey has played a key role in the history of vertebrate paleontology in America ever since the discovery of dinosaur bones on the John E. Hopkins farm in Haddonfield in 1838 and the subsequent description and naming of *Hadrosaurus foulkii* Leidy in 1856 (Weishampel and Young 1996). E. D. Cope and O. C. Marsh began their long productive paleontological careers, and their infamous feud, with the exploration and study of vertebrate fossils from the Late Cretaceous greensands and clays of the New Jersey coastal plain. Although most of the original localities collected by these early pioneers have long been abandoned and lost to urban development, super highways and the demise of greensand mining, important fossil finds are still being made in the state on a fairly regular basis (for example: Grandstaff et al., 2000; Parris et al., 2001; Landman et al., 2004).

The fossil record of coelacanth fishes from New Jersey includes the diminutive coelacanth *Diplurus (Osteopleurus) newarki* and the much larger *Diplurus longicaudatus* which are both known from rocks of the Late Triassic Newark Supergroup (Schaeffer 1952; Rizzo 1999). The coelacanth trail then disappears in North America for approximately 135 million years when the giant coelacanth *Megalocoelacanthus*

dobiei makes its appearance in late Santonian and early Campanian marine sediments from Alabama, Georgia and (a coronoid assigned to *M. dobiei*) New Jersey (Schwimmer et al., 1994). The quadrate described here is the second coelacanth fossil from the Late Cretaceous of New Jersey and appears to be from a much smaller adult fish then *M. dobiei*.

The following institutional abbreviations are used: **AMNH,** American Museum of Natural History, New York City, NY, USA; **NJSM**, New Jersey State Museum, Trenton, NJ. USA.

DISCOVERY AND GEOLOGICAL SETTING

The coelacanth quadrate, NJSM 22481, was collected by the authors in April of 2008 at the Holmdel Park Site in Monmouth County, New Jersey. This site (hereafter referred to as the HP Site) is protected by a joint agreement between the Monmouth County Park System and the New Jersey State Museum and is an active research locality.

The site exposes a ≈1.5-meter-thick fossiliferous, highly bioturbated, poorly sorted, pebbly, slightly glauconitic quartz sand which is separated by a marked erosional disconformity from the subadjacent Campanian Wenonah Formation. This layer is a distinct but variable feature throughout much of northeastern Monmouth County and it has led to much confusion as to its proper place in the sequence. It has been variously referred to the upper part of the Mt. Laurel Formation by Krinsley and Schneck (1964) and as a lag related to the Navesink transgression by Owens and Sohl (1969). Olsson (1987) included it as part of the basal Navesink Formation, a procedure followed by Martino and Curran (1990) and Callahan et al., (2014). Gallagher (2014), following Miller et al. (1999), considers this layer to be a regressive unit in the uppermost Mt. Laurel Formation.

The problem of the exact nature of this unit is compounded by changes in the nature of its fauna from place to place. At the Marlboro Manse site, Gallagher (2014) reports an extensive invertebrate fauna in addition to common vertebrate remains, whereas Callahan et al., (2014) report an extensive vertebrate fauna with only a very few, poorly preserved invertebrate fossils.

The stratigraphic nature of this layer is discussed in some detail elsewhere in this volume.

The associated vertebrate fauna at the Holmdel Park Site is a mixed assemblage of predominately eurytopic marine taxon with a preference for shallow water. This fauna also includes some deep-water distal elements and a significant number of taxa of brackish, freshwater and terrestrial origin. Near-shore forms include, but are not limited to: abundant teeth of the lamnid shark *Scapanorhynchus*, the salmoniform teleost fish *Enchodus petrosis* several near shore rays including *Ptychotrygon vermiculata* and *Rhombodus laevis*, and the squamate *Mosasaurus conodon.* Distal deepwater forms include very rare teeth of the paleoniscid shark *Synchodus*, teeth of various Lamnid sharks, and rare teeth from the large predaceous teleost *Xiphactinus vetus.* Brackish and freshwater taxa are represented by the small hybodont *Lonchidion babulski*, an unnamed myleodaphid ray, the bonefish *Paralbula casei*, ganoid scales probably assignable to *Lepisosteus*, fairly abundant trionychid turtle bones, and crocodilian teeth and osteoderms. Entirely terrestrial taxa include abundant bits of petrified conifer wood (some exhibiting bivalve borings), common hadrosaurine dinosaur remains and a single theropod tooth. For a complete list of the fauna from this site see Callahan et al. (2014). The preservation of the vertebrate fossils in this fauna ranges from very well preserved to taphonomically very mature. This is not surprising considering that the fossils are found in a time averaged, transgressive lag deposit.

SYSTEMATIC PALEONTOLOGY

Class Osteichthyes HUXLEY, 1880
Subclass Sarcopterygii ROMER, 1955
Order Actinistia COPE, 1871
Family Coelacanthidae AGASSIZ, 1844

Genus and species indeterminate

Referred material: NJSM 22481**,** left quadrate, well preserved and almost complete; Late Cretaceous (late Campanian), basal Navesink Formation, Holmdel Township, Monmouth County, New Jersey, U.S.A. Figure 1.

Description: Quadrates, which are an element of the endoskeletal portion of the palate, are often well preserved in fossil coelacanths (Forey 1998). NJSM 22481 is an almost complete isolated left quadrate from a relatively small coelacanth. The bone measures approximately 10 mm across the condyles in the anteroposterior direction. The medial condyle measures slightly less then 10 mm in diameter while the lateral condyle measures 6 mm in diameter. The total height of the quadrate is 17.5 mm.

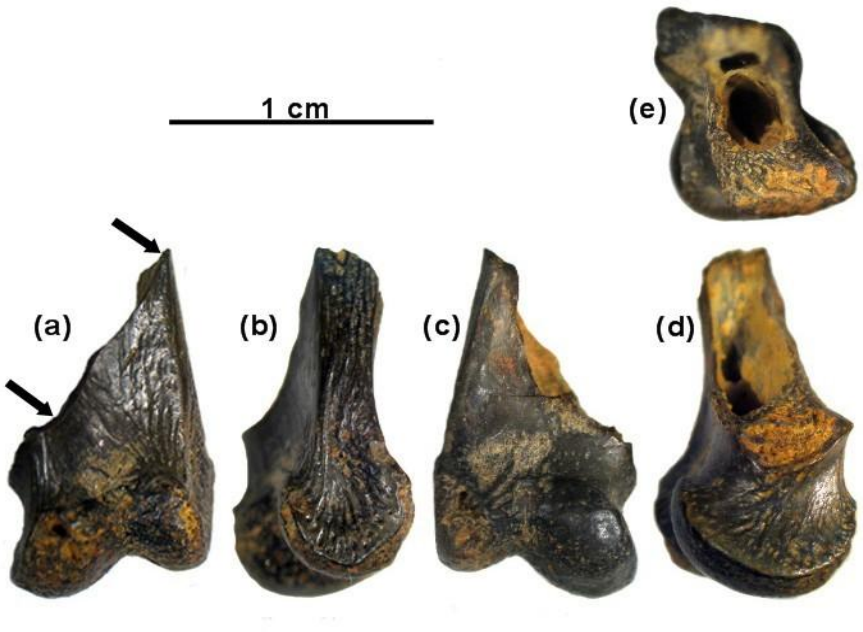


Figure 1. NJSM 22481, Left quadrate of a small coelacanth in (a) anterior view, (b) lateral view, (c) posterior view, (d) medial view and (e) dorsal view. Arrows indicate sutural surface of quadrate with pterygoid.

The anterior (Fig. 1a) and lateral (Fig. 1b) surfaces are strongly ornamented; having branching ridges which are separated by pronounced grooves. In medial view (Fig. 1d) the condyle displays more subdued ornamentation with fine radiating shallow ridges. In posterior view (Fig. 1c) there is no discernable ornamentation. Both condyles have a strong ridge along the margin of the bi-convex articular surfaces with the lateral condyle having a radial groove between the marginal ridge and another ridge marking the ventral limit of the ornamentation.

The medial condyle extends ventrally 2 mm below the lateral condyle. The shaft of the quadrate is compressed anteroposteriorly and has a central cavity that is approximately 2.5-3 mm in diameter. Another smaller, rectangular shaped cavity extends into the lateral condyle (Fig. 1e). One of the distinct

features of the specimen is the almost complete, well preserved sutural surface which delineates the attachment of the quadrate to the pterygoid. The suture line extends from the dorsolateral tip of the shaft and terminates just above the medial condyle.

DISCUSSION

Coelacanths are rather rare in the Late Cretaceous with the latimeriid *Megalocoelacanthus* in North America, and indeterminate mawsoniids found in Europe and Madagascar (Cavin et al. 2005; Lionel Cavin pers comm. 2008). The giant coelacanth *Mawsonia* is known from the late Early Cretaceous (Apto-Albian) of Africa and South America (Forey 1998), and the smaller mawsoniid *Axelrodichthys* is known from the Apto-Albian Santana Formation of Brazil (Maisey 1991). Both of these predominately Gondwanan mawsoniids are interpreted to have inhabited freshwater environments. *Mawsonia* has also recently been reported from the Cenomanian (early Late Cretaceous) Bahariya Formation of Egypt (Grandstaff et al. 2002).

Macropoma, a marine coelacanth closely related to the extent *Latimeria*, is known from the Turonian of England and the Czech Republic (Forey 1998). Even though *Macropoma* and *Latimeria* show a close cladistic relationship they are found in environments that are very different, with *Macropoma* coming from shallow water deposits and *Latimeria* inhabiting water depths of 150 to 700 m.

Prior to the discovery of NJSM 22481 the only fossil coelacanth known from the Late Cretaceous of New Jersey was a single coronoid tentatively assigned to *Megalocoelacanthus dobiei* (Fig. 2). That specimen (AMNH FF 6643) was found as float among the stream lags at Big Brook in Marlboro, New Jersey (Schwimmer et al., 1994). Along its course of several miles, Big Brook transverses several fossil bearing formations and so the exact age of AMNH FF 6643 cannot be ascertained with certainty (Schwimmer et al. 1994). NJSM 22481 was found in-situ and can be confidently dated to mid-late to latest Campanian in age.

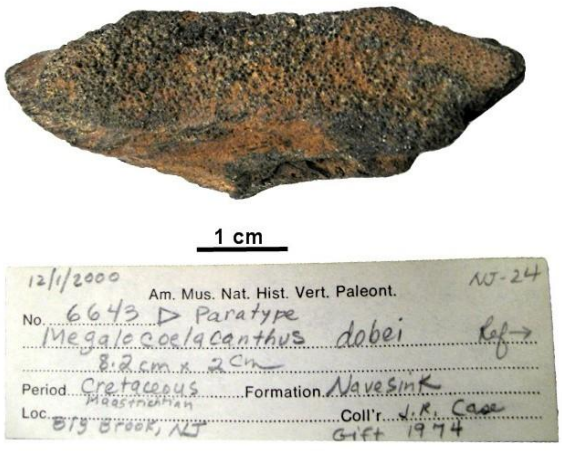


Figure 2. Medial view of stream worn left coronoid fragment (AMNH FF 6643) of a large coelacanth, possibly assignable to *Megalocoelacanthus dobiei*. The specimen was recovered as float along Big Brook in Marlboro, NJ by Gerard Case.

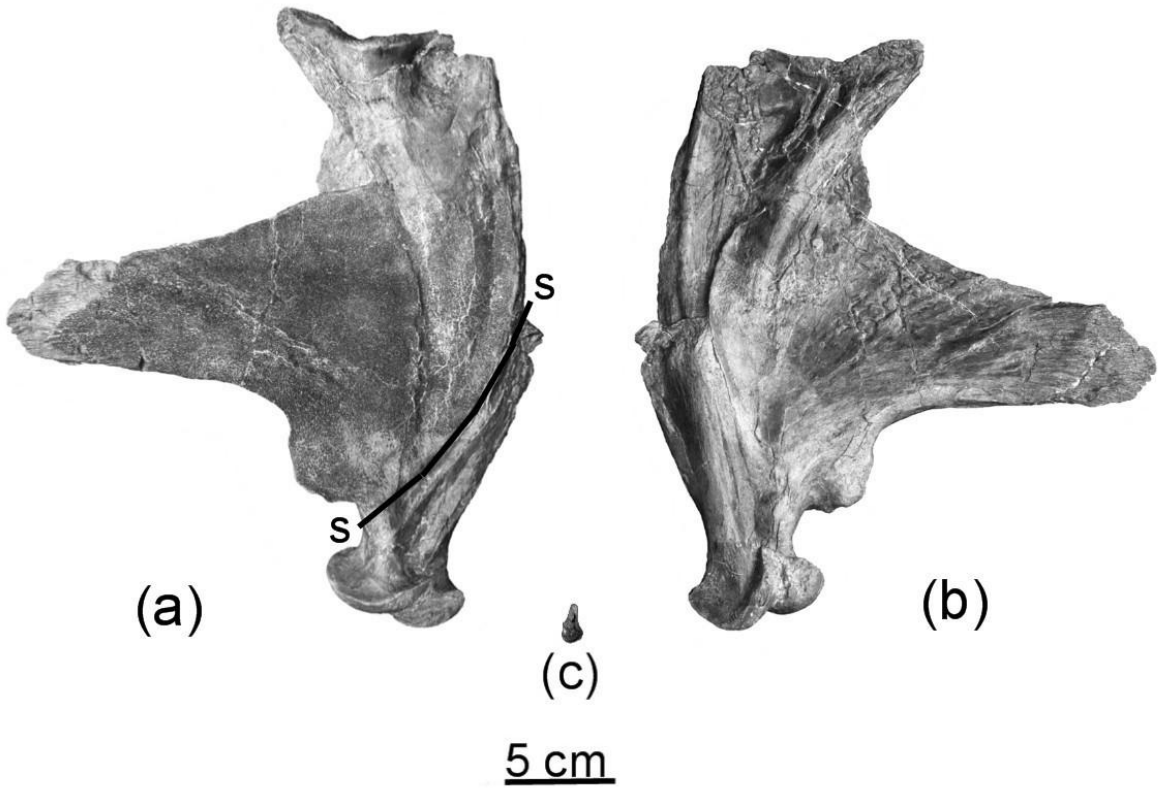


Figure 3. Right Palatoquadrate of *Megalocoelacanthus dobiei* (AMNH FF 20267) from the early Campanian Niobrara Formation, Lane County, Kansas, (a) medial view and (b) lateral view. NJSM 22481 (c) shown for size comparison. Line s-s delineates the suture between the quadrate and pterygoid. (Modified from Dutel et al., 2012)

We compared NJSM 22481 to quadrate specimens of *Mawsonia* (AMNH FF 11758) and *Axelrodichthys* (AMNH FF 11760, AMNH FF 12220 and AMNH FF 14026R) and to figured specimens of *Macropoma* and *Megalocoelacanthus* (Dutel et al., 2012; Woodward 1905; Forey 1998; Schwimmer et al., 1994). Although quadrates in general are not particularly diagnostic certain inferences could be made.

Carvalho and Maisey (2008) have estimated the overall length of specimens of *Mawsonia gigas* from the Areado Group of Brazil to be between 630 mm to 1.8 m. The largest known *Mawsonia* quadrate from Brazil with a condylar head length of 110 mm would represent a fish of 6.3 m in length. The overall lengths of *Axelrodichthys* specimens from Brazil reach 1-2 m (Maisey 1991). Schwimmer et al. (1994) estimate the overall length of *Megalocoelacanthus dobiei* to reach 3.5 m. Specimens of the European latimeriid Macropoma measure less then 600 mm long while the extent Latimeria reach a length of 1.5-2 m. Based on the condylar length of NJSM 22481 the fish would have been about 58-60 cm long which would place it in the smallest range for any of the known Cretaceous to recent coelacanths.

NJSM 22481 does not appear to represent *Mawsonia* or *Axelrodichthys* which, except for the recent discovery in southern France (Cavin et al. 2005), are restricted to fresh water deposits from South America, Africa and Madagascar. The quadrates of these coelacanths lack the ornamentation on our specimen and have a different geometry in the shapes of the condyles when viewed in posterior and anterior aspect. Fossil remains of *Megalocoelacanthus dobiei* (excluding AMNH FF 6643) have been recovered from marine sediments of late Santonian to early Campanian in Alabama, Georgia and Kansas. This makes them only marginally older than NJSM 22481 and from a similar environment. It is tempting

and would be expedient to assign the new quadrate to *M. dobiei* considering the similarity in age and paleoenvironment. The great disparity in size could be explained by assigning NJSM 22481 to a juvenile. Comparisons of the New Jersey specimens to figured photographs of the quadrate of *M. dobiei* however show that the quadrate of *M. dobiei* does not display the type of ornamentation seen on the new specimen and there is a greater disparity in size between the two condyles of *M. dobiei* then are seen in NJSM 22481. Although these differences may be just artifacts of preservation or the result of ontogeny, it has been noted that in cross-section the shaft of NJSM 22481 is quite robust and not what would be expected in a juvenile (David Schwimmer pers comm. 2008). Several species of the genus *Macropoma* have been described form the Albien-Turonian of Europe (Forey 1998). These are very close in size to the New Jersey specimen and, like the NJ specimen, are found in sediments indicating a shallow marine environment (Maisey 1991). Unfortunately, published accounts of this genus are insufficient to make direct comparisons.

Additional small unidentified coelacanths have been reported from the mid-Turonian and Coniacian of Kansas (Stewart et al. 1991; Everhart et al. 1995). The quadrates associated with these finds are a close match in size and shape to the New Jersey specimen but are not as well preserved. These may represent additional material from the same or similar small coelacanth form North America. Another small coelacanth quadrate was found in Late Campanian sediments from Mississippi (David Schwimmer pers comm. 2008). This particular specimen is about the same size as NJSM 22481 but is very poorly preserved.

Until additional material is found the exact status of NJSM 22481 remains equivocal. It may represent a new small Late Campanian coelacanth from the Atlantic Coastal Plain or a relative of *Macropoma* that bridged the early Atlantic Ocean.

CONCLUSIONS

NJSM 22481 is the left quadrate of a small coelacanth from the Late Cretaceous (late Campanian) of Monmouth County. It was found in a transgressive lag deposit that represents a mix of shallow marine, brackish/freshwater and terrestrial environments. Since it is very well preserved it was likely not transported far from the place where it was buried and probably represents a shallow water marine fish, very unlike the preferred habitat of extent coelacanth *Latimeria*. Comparison to known fossil coelacanth remains is equivocal insofar as identification beyond Family is concerned although indications are that the new specimen shows closer affinities to the latimeriids then the mawsoniids. This discovery should encourage the search of existing museum and private collections from the Late Cretaceous of the Atlantic Coastal Plain for additional material that may have escaped notice by those looking for large shark bony fish and marine reptile teeth in the fossil bearing brooks, occasional construction sites and rare mining operations that expose Late Cretaceous sediments in Southern New Jersey.

ACKNOWLEDGEMENTS

We would like to thank Lionel Cavin, Barbara Grandstaff, David Schwimmer, David Parris and Mike Everhart for their encouragement, comments, photographs and copies of papers that greatly improved our understanding of anatomy of coelacanth quadrates. We thank Ralph Johnson and Matt Garb for help in unraveling the stratigraphy at the discovery site. We especially thank John Maisey for examining the specimen and offering his expertise on the subject of coelacanth fishes,

Jim Brown for inviting us to participate in the 2019 GANJ conference, and Sterling Nesbitt who originally identified the bone as a coelacanth quadrate. Barbara Grandstaff also reviewed an early draft and the paper was greatly improved by her suggestions.

LITERATURE CITED

Callahan, W. R., C. M. Mehling, R. K. Denton, and D. C. Parris. 2014. Vertebrate paleontology and Stratigraphy of the Late Cretaceous Holmdel Park Site, Monmouth County, New Jersey. *in* Santucci, V. L., G. A. Liggett, B. B., Beasley, H. G, McDonald, J. Tweet, J. Chilstrom, S. Foss and S. Y. Shelton (eds.) Proceedings of the 10th Conference on Fossil Resources, Dakoterra 6: 163-169.

Carvalho, M. S. S., and J. G. Maisey. 2008. New occurrence of Mawsonia (Sarcopterygii: Actinistia) form the Early Cretaceous of the Sanfranciscana Basin, Minas Gerais, southeastern Brazil. *In* Cavin, L., A. Longbottom and M. Richter (eds.), Fishes and the breakup of Pangaea. Geological Society, London, Special Publication, 295: 109-144.

Cavin, L., P. L. Forey, E. Buffetaut, and H. Tong. 2005. Latest European coelacanth shows Gondwanan affinities. Biology Letters 2005: 17-177.

Dutel H., J.G. Maisey., D. R. Schwimmer., P. Janvier., M. Herbin and G. Clément (2012) – The giant cretaceous coelacanth (Actinistia, Sarcopterygii) *Megalocoelacanthus dobiei* Schwimmer, Stewart & Williams, 1994, and its bearing on Latimerioidei interrelationships. Plos One 7(11): e49911. [online article]

Everhart, M. J., P. A. Everhart, and J. D. Stewart. 1995. Notes on the biostratigraphy of a small coelacanth from the Smoky Hill Chalk Member of the Niobrara Chalk (Upper Cretaceous) of western Kansas. Kansas academy of Sciences, Transactions 14 (Abstracts): 20.

Forey, P. L. 1998. History of the coelacanth fishes. London, Chapman & Hall. 419 pp.

Gallagher, W. B., 2014. Taphonomy of a Late Campanian fossil assemblage at Marlboro, Monmouth County, New Jersey. The Mosasaur VII: 53-68.

Grandstaff, B. S., Y. Attia, and J. Smith. 2002. New specimens of Mawsonia (Actinistia: Coelacanthiformes) from the Cenomanian (Late Cretaceous) of Bahariya Oasis, Western Dessert Egypt. Journal of Vertebrate Paleontology, Abstracts of Papers 22(3): 60A.

Grandstaff, B. S., W. B. Gallagher, K. Shannon, and D. C. Parris. 2000. New discoveries of Late Cretaceous mammals in eastern North America. Journal of Vertebrate Paleontology, Abstracts of Papers 20(3): 44A.

Krinsley, D. and M. Schneck, 1964. The Paleoecology of a Transition Zone Across an Upper Cretaceous Boundary in New Jersey. Paleontology 7(2): 266-280.

Landman, N. H., R. O. Johnson, and L. E. Edwards. 2004. Cephalopods from the Cretaceous/Tertiary boundary interval on the Atlantic Coastal Plain, with a description of the highest ammonite zones in North America. Part 2. Northeastern Monmouth County, New Jersey. Bulletin of the American Museum of Natural History 287: 1-107.

Martino, R. and H. Curran, 1990. Sedimentology, Ichnology and Paleoenvironments of the Upper Cretaceous, Wenonah and Mt. Laurel Formations, New Jersey. Journal of Sedimentary Petrology 60: 125-144

Maisey, J. G. (ed.) 1991. Santana fossils: an illustrated atlas. Neptune, New Jersey. TFH Publications. 459 pp.

Miller, K. G., E. Barrera, R. K. Olsson, P. S. Sugarman, and S. M. Savin, 1999. Does ice drive early Maastrichtian eustacy? Geology, 27: 783-786.

Olsson, R. K. 1987. Cretaceous stratigraphy of the Atlantic Coastal Plain, Atlantic Highlands of New Jersey, *in* Roy D. C., ed., Northeastern Section, Geological Society of America, Centennial Field Guide. 5: 87-90.

Owens, J. P. and N. F. Sohl, 1969. Shelf and Deltaic Paleoenvironments in the Cretaceous-Tertiary Formations of the New Jersey Coastal Plain. *In* Subitzky, ed., Geology of Selected Areas in New Jersey and Eastern Pennsylvania and Guidebook to Excursions. Rutgers University Press: New Brunswick, New Jersey, pp. 235-278

Parris, D. C., B. S. Grandstaff, and W. B. Gallagher. 2001. A lungfish from the Upper Cretaceous of New Jersey. Journal of Vertebrate Paleontology, Abstracts of Papers 21(3): 87A.

Rizzo, C. A. 1999. A large coelacanth c.f. Diplurus (Pariostegus) longicaudatus, from the Late Triassic Lockatong Formation, Granton Quarry, New Jersey. The Mosasaur 6: 85-90.

Schwimmer, D. R., J. D. Stewart, and G. D. Williams. 1994. Giant fossil coelacanths of the Late Cretaceous in the eastern United States. Geology 22: 503-506.

Schaeffer, B. 1952. The Triassic coelacanth fish *Diplurus* with observations on the evolution of the Coelacanthini. Bulletin of the American Museum of Natural History 99(2): 25-78.

Stewart, J. D., P. A. Everhart and M. J. Everhart. 1991. Small coelacanths from Upper Cretaceous rocks of Kansas. Journal of Vertebrate Paleontology, Abstracts of Papers 11(3): 56A.

Weishampel, D. B., and L. Young. 1996. Dinosaurs of the East Coast. Baltimore, Maryland. The Johns Hopkins Press. 274 pp.