The Linton, Ohio Anthracodromeus: World's Oldest Facultative Biped?

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Abstract

The history of vertebrate bipedialism, once thought to have begun with the Mid-Permian *Eudibamis cursoris* (Berman, et al. 2000) may have started even earlier in the Upper Carboniferous. Evidence suggests the Westphalian reptile *Anthracodromeus longipes*, found rarely and exclusively at the Linton lagerstatte in south eastern Ohio, may have possessed facultative bipedal capabilities. *Anthracodromeus* was originally described by Edward Drinker Cope in 1874 as an amphibian and later correctly diagnosed as reptile by Donald Baird in 1958. Only two partial skeletons and a few disarticulated remains, all without a complete skull, are currently known. This study recognizes the potential adaptations for facultative bipedialism as shown in the second, recently recovered partial skeleton which is well articulated showing limb element lengths, foot morphology, spine proportions and pelvic details allowing us to predict the animal's ability to run on two limbs in a manner similar to modern lizards including the widely known *Basiliscus plumifrons* of South America.

General Site Information

The Linton laggerstatten; first discovered in the mid 1800s by John Strong Newberry and other later researchers to preserve a variety of palaeoniscoids ,a single species of coelacanth, three lungfish and orthacanthid sharks. In addition to the fish there are a host of amphibian taxa ranging from primitive individuals to large, more derived taxa with some reaching the size of a small crocodile, although the limited size of the blocks of cannel mean that most are found as fragments. Arthropods including "estheria" syncarids, uncommon pygocephalomorphs and many different millipede genera, including ones not yet reported from the site; are occasionally discovered. The topic of this research is one of the absolute rarest fossils at the site: an early anapsid reptile. *Anthracodromeus longipes* was originally described as an amphibian by famed paleontologist Edward Drinker Cope. Later Princeton's Donald Baird recognized the reptile affinities of the single known fossil at the time, and it was assigned to the family Protorothyrididae. The specimen now in the American Museum of Natural History in New York, NY. A few partial remains of *A. longipes* have been found by Richard Lund and other researchers, all failed to preserve any elements beyond the shoulder girdle. A recent discovery by Scott Mckenzie has potential to be first known skull from the animal.

Despite being a cannel coal deposit identifiable plant fossils are rare. Few lycopods are known to exist at Linton, otherwise little is known of Linton's plants. The locality is known to bew unforgiving to collectors hoping to find reptile and amphibian fossils as most arte exceedingly rare and often far from complete. At present, the locality is privately owned and as such, access is strictly controlled.

Materials and Methods

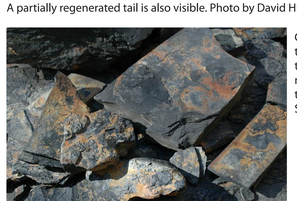
Materials:
CM 81532: A partially preserved post-cranial skeleton of *Anthracodromeus longipes.* The individual preserved here is likely juvenile. CM 81532 includes a well-preserved vertebral column from the shoulder girdle to the sacrum. The caudal portion is damaged and has been regenerated. In addition to the spine, both hindlimbs are present and elements from both forelimbs included as well. Several pairs of ribs and a complete set of gastralia can be noted here. This specimen is completely and unequivocally the best preserved fossil of A. longipes that is known to science. Discovered by Scott McKenzie, this fossil is now in the Carnegie Museum of Natural History.

CM 25282a and CM 25282b: Another fossil from the Carnegie, this is a poorly preserved posterior section of *A. longipes* discovered and donated by Richard Lund and consists of two halves each projecting the same fossil as either a cast or mold. It includes portions of the rear limbs and peds, however the latter is scattered and incomplete. In addition to elements of the limbs, there are several pre- and post-sacral vertebrae as well as numerous scattered gastralia.

Methods:
The basis for this research was author Scott McKenzie's thirty year history of working with fossils collected from Linton. Specimens from Linton are collected in blocks of cannel coal. These blocks are then split in bright light to reveal the fossils within. Once a fossil is identified it is then cleaned with a soft brush and warm water to reveal the details. Further preparation with a small sized pick and magnification can be done if necessary.

Arriving at *Anthracodromeus'* apparent bipedality was done through comparative anatomy and morphology between the specimens and known taxa with bipedal abilites. The main points of comparison were the tarsal bones, pelvis, tail, and limb proportions. Bipedal lepidosaurs, such as *Basiliscus plumifrons,* have noteably elongated trasals. This feature has a biomechanical function that allows the animal to gain greater push when taking a stride. Pelvic proportions in transitional bipeds are similar to those of modern quadrupedal squamates. They differ from those of bipedal reptiles, such as the dinosaurs, in the region of the pubis and the ischium. Both of these bones are short to allow for quadrupedal movement in close proximity to the ground. Tail and limb proportions are of note in bipeds. The caudal proportion of the vertebral column is generally elongate to provide stability during movement. Limb proportions consist of robust hindlimbs with noteworthy greater proportions than those of the forelimbs.

CM 81532: *A. longipes* showing unique preservation of elements of the hindlimbs, trunk, and forelimbs. A partially regenerated tail is also visible. Photo by David Hurey.

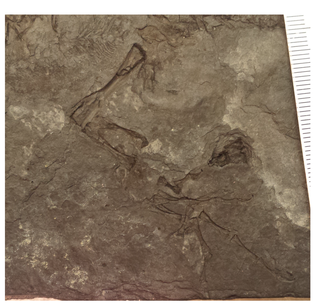


Cannel coal: This is the primary type of coal that was mined at Linton. It is a hardened type of bituminous coal. It was primarily mined for use in glass manufacture during the nineteenth century. Photo courtesy of Swisher Concrete Supplies.

CM 25282a: This is the cast portion of the fossil discovered by Richard Lund. Photo by David Hurey.

Illustration by Jacob Stokes

Site Photo by Scott McKenzie



Left hindlimb of CM 81532 showing a sprawled posture and elongated metatarsal bones in the foot. Hooked claws for climbing club moss are present. Photo by David Hurey

Discussion

In the late 1990's a fossil of particular note was found by Scott McKenzie. The piece in question is a juvenile protorothyrid *Anthracodromeus longipes*. The issue of *Anthracodromeus* is a curious one. The animal possesses many characteristics of a bipedal lepidosaur however, it is not a derived form. It could be possible that this particular specimen represents a transitional form of locomotion. Transitional forms represent a significant scientific value as they allow the scientific community to add new insight into questions about evolution. CM 81532 answers some of these questions. The individual shows appendicular skeletal differentiation. There is a definitive size disparity in the length and robustness of the individual's limbs. The forelimbs are significantly shorter than those in the posterior. The feet are positioned with a widespread posture consisting of five elongate phalanges radiating in an asymmetrical pattern. Asymmetry in the phalangeal elements is a diagnostic marker in bipedal lepidosaurs. Modern taxa such as *Basiliscus pulmifrons* and *Chlamydosaurus kingii* display this characteristic. This type of positioning in the feet allows for greater stability and strength to be added to the stride. This pattern is not repeated in the manus indicating a lesser use in locomotion. In addition to the positioning of the phalanges, there are unusual proportions in the femur and lower leg. While not observable in CM 81532, due to the immaturity of the preserved individual, these proportions are present in CM 25282. CM 25282 is a mature individual with elongated femurs that have an unusually developed proximal epiphysis. This development allows for a free-range movement between the acetabulum and the femoral head. These exclusive traits displayed by *A. longipes* illustrate a biomechanical ability that predates accepted history of vertebrate bipedalism by nearly twenty million years.

Conclusions

A survey of modern lizard taxa finds that a surprising number are able to run on their hind limbs on occasion. The limb proportions on some of the modern genera are similar to *Anthracodromeus.* The spine length, hip structure and front limb size disparity, as far as preservation allows, are also similar. Available evidence indicates a strong likelihood that this Linton reptile was a facultative biped. A very early adaptation to run in this fashion may have application to understanding the evolution of later biped taxa including birds and dinosaurs.

Acknowledgements

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