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Teihivenator gen. nov., A new generic name for the Tyrannosauroid Dinosaur *"Laelaps" Macropus* (Cope, 1868; preoccupied by Koch, 1836)

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ABSTRACT

Once referred to the ornithomimosaur 'Coelosaurus' antiquus, 'Laelaps' macropusspecimens from the Navesink Formation (Late Campanian-Early Maastrichtian, Late Cretaceous) of New Jersey, USA was separated as a new species of 'Laelaps' by paleontologist Edward Drinker Cope in 1868. While it was revealed later that 'Laelaps' is preoccupied by laelapidae mite Laelaps agilis and renamed as Dryptosaurus, the taxonomic history of 'Laelaps' macropuswas controversial and sometimes considered as dubious. Here I show 'Laelaps' macropusas a valid taxon of tyrannosauroid based on comparisons with other taxa; there are considerable differences between 'Laelaps' macropusand Dryptosaurus aquilunguis. Therefore, a new generic name for 'Laelaps' macropus,Teihivenatorgen. nov. is erected here.

Key words: Dinosauria; Theropoda; Tyrannosauroidea; *Teihivenator*; *Dryptosaurus*

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INTRODUCTION

It is a well-known fact that an inland sea called the Western Interior Seaway split North America in two landmasses during the Late Cretaceous. The one in the west is called Laramidia, and Appalachia in the east. The geological conditions of Laramidia were generally good for preservation of fossils, making it as one of the most productive dinosaur fossil regions in the world. Appalachia area, however, is not rich in dinosaur fossils as glaciers during the Pleistocene ice age destroyed a lot of fossil beds and exposures are limited. Also, most currently known dinosaur materials are largely fragmentary due to their taphonomic processes and abundance of marine deposits [28]. So, it is an undoubted fact that any new discoveries from this area would be important for understanding dinosaur evolution or diversity from this forgotten continent.

Leidy [19] described the ornithomimosaur *"Coelosaurus" antiquus* based on an isolated tibia ANSP 9222, and assigned several theropod hindlimb elements (AMNH 2550-2553) to syntypes of this taxon. Cope [6-7] separated syntype materials from *"Coelosaurus" antiquus*, based on larger size and the extent of the distal tibia expansion and described them as new species of his genus "*Laelaps*" *macropus*. The genus name *Laelaps* is preoccupied by the mite *Laelaps agilis* [18] so Marsh [21] changed the name to *Dryptosaurus*. However, Matthew & Brown [23] had concluded they probably belong to *"Coelosaurus" antiquus* after all and this conclusion

has received wide acceptance [1], [27]. Although Hay [14] recombined *"Laelaps" macropus* as *Dryptosaurus macropus* and Holtz [16] listed *"Laelaps" macropus* as a dubious tyrannosauroid, they did not provide any comments on this assignment.

Here I review the taxonomic and systematic issues of *"Laelaps" macropus* and show that its syntypes are indeed from a tyrannosauroid, and there are no clear synapomorphies uniting *Dryptosaurus aquilunguis* and *"Laelaps" macropus* as congeneric. Also, it is found that there are considerable differences between *"Laelaps" macropus* and *Dryptosaurus aquilunguis* (Table 1). Therefore, a new generic name is erected here.

MATERIALS AND METHODS

AMNH 2550-2553 are theropod hindlimb materials from the Navesink Formation, New Jersey. They are from a single individual. Comparisons with other tyrannosauroid taxa were based on the other tyrannosauroid publications.
The following abbreviations of organizations and institutions are used in this study: (AMNH) American Museum of Natural History, New York, New York, USA; (ANSP) Academy of Natural Sciences, Philadelphia, Pennsylvania, USA

RESULTS

Systematic Paleontology

Dinosauria
Order Saurischia
Suborder Theropoda
Superfamily Tyrannosauroidea
***Teihivenator* gen. nov.**

***Teihivenator macropus* (Cope 1868) comb. nov.**
Synonyms: *Coelosaurus antiquus* Leidy 1865, the genus is preoccupied by Owen 1854*Laelaps macropus* Cope 1868, the genus is preoccupied by Koch 1836*Dryptosaurus macropus* Hay 1902

Syntypes. AMNH 2550 (partial proximal, distal tibia), 2551 (phalanx II-1, two phalanges III-2), 2552 (distal metatarsal IV), 2553 (proximal metatarsal III).

Etymology: *Teihi* comes from Arapaho native word Teihiihan, which means "strong". *Venator* is a Greek word for "hunter".

Locality and horizon: Navesink Formation, Monmouth County, New Jersey, USA (Late Campanian-Early Maastrichtian).

Diagnosis: Tyrannosauroid theropod diagnosed by following autapomorphies: medial tibial condyle is triangular, whereas lateral tibial condyle is round; medial tibial condyle is positioned higher than lateral tibial condyle; small tubercle is present between the well-separated medial and lateral tibial condyle; intercondylar notch is deep and "I" shaped; cnemial crest can be seen at the posterior view of proximal tibia; lateral malleolus is at same level as medial malleolus; paired ventral processes proximally on all preserved pedal phalanges.

Description and Comparisons
While Leidy [19] and Matthew & Brown [23] identified the syntypes of *Teihivenator* as ornithomimosaur without comment, the material clearly belongs to tyrannosauroid based on the presence of the anterior process on the lateral tibial condyle. Also, preserved pedal phalanges are much more robust than similarly sized ornithomimosaurs and most similar to tyrannosauroids.

AMNH 2550 is composed of proximal and distal ends of a tibia (Fig. 1A, C), about 100 mm wide. Unlike *Dryptosaurus*, the cnemial crest projects above the level of the proximal surface so it is visible in posterior view. Posteriorly, on the proximal end, lateral and medial condyles are well-separated by a deep, "I" shaped intercondylar notch. Although *Dryptosaurus* also has deep intercondylar notch [3], the notch is much more deep and prominent in *Teihivenator*. An unusual feature of the tibia of *Teihivenator* is the presence of a small tubercle in the intercondylar notch. The lateral condyle has an anterior process that is a synapomorphy of derived tyrannosauroids [22]. This process is present in another Appalachian tyrannosauroid *Appalachiosaurus*, but is absent in *Dryptosaurus* [11]. While Brusatte *et al.* [3] argued that the absence of anterior process might be an artifact of erosion, I disagree with that notion since there are no clear indications of that.

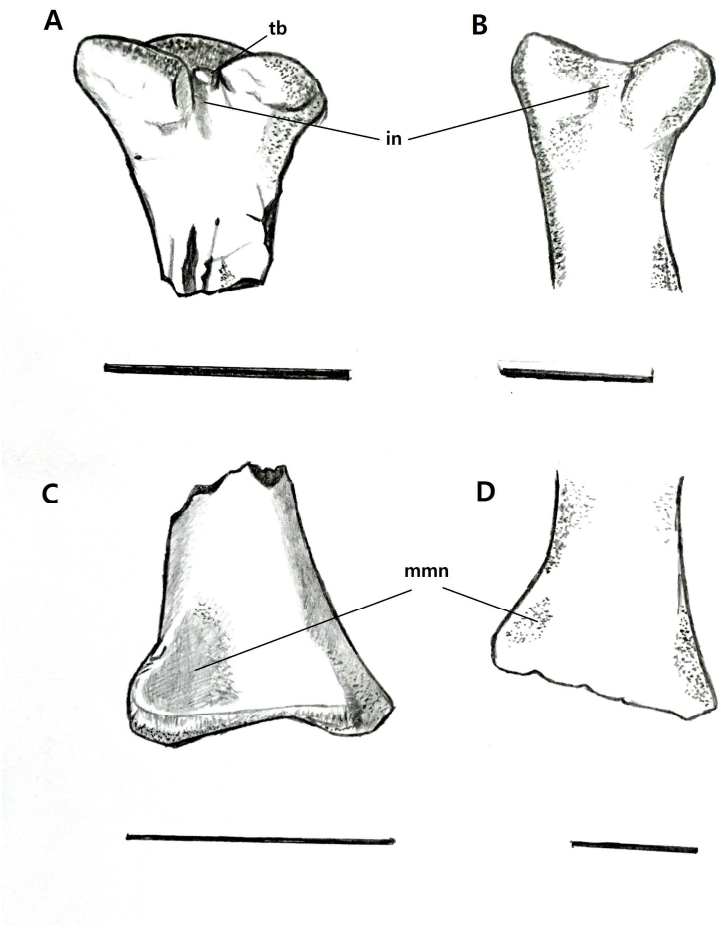

Figure 1: Tibiae of *Teihivenator macropus* and *Dryptosaurus aquilunguis* compared. (A) Proximal part of AMNH 2550 (syntype of *Teihivenator macropus*) in posterior view; (B) Proximal part of left tibia of ANSP 9995 (holotype of *Dryptosaurus aquilunguis*) in posterior view (reversed); (C) Distal part of AMNH 2550 in posterior view; (D) Distal part of left tibia of ANSP 9995 in posterior view (reversed). Abbreviations: in, intercondylar notch; mmn, medial malleolus notch; tb, tubercle in intercondylar notch. Scale bar equals 10 cm.

The medial and lateral condyles are large. The lateral condyle is round in both posterior and proximal view, and appears larger than the medial condyle. The medial condyle has a more triangular shape, and slightly more elevated than the lateral condyle in posterior view. In *Dryptosaurus* both condyles are at the same level (Fig. 1B). The incisura tibialis is shallow. The distal end is expanded mediolaterally. The medial malleolus has a shallow notch on its posterior surface (Fig. 1C). Although *Dryptosaurus* also has a similar, shallow notch on the medial malleolus, it is much shallower (Fig. 1D). In *Teihivenator*, the lateral malleolus is extended at the same level as the medial malleolus, which is more similar to basal coelurosaurs than to tyrannosauroids [10]. In most tyrannosauroids, including *Dryptosaurus* and *Appalachiosaurus*, the lateral malleolus extends significantly farther distally than the medial malleolus [2-3], [11]. However, the lateral malleolus which is at the same level as the medial malleolus, was reported in alioramin tyrannosaurids and *Bistahieversor*[4], [12], [20].

The sizes of the syn type materials for *Teihivenator* indicate a much smaller individual compared to the holotype individual of *Dryptosaurus aquilunguis*.

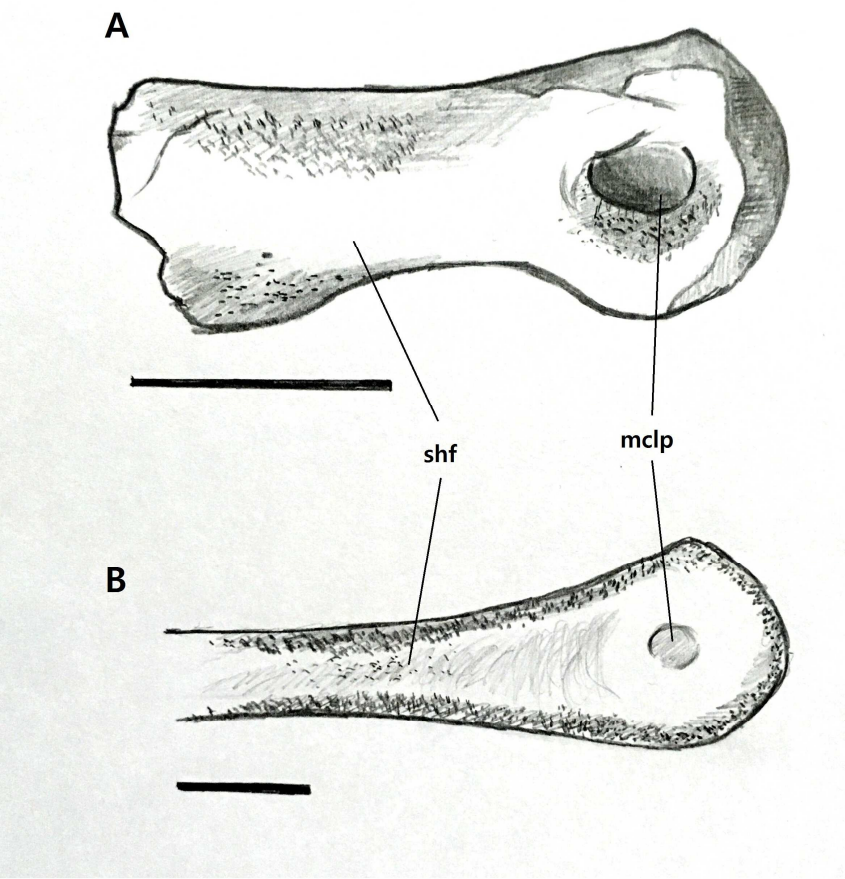

Figure 2: Fourth Metatarsals of *Teihivenator macropus* and *Dryptosaurus aquilunguis* compared. (A) AMNH 2552 (syntype of *Teihivenator macropus*) in medial view; (B) AMNH 2438 (holotype of *Dryptosaurus aquilunguis*) in medial view. Abbreviations: mclp, medial collateral ligament pit; shf, shaft of metatarsal IV. Scale bar equals 5 cm.

Table 1. Comparison of *Teihivenator macropus* and *Dryptosaurus aquilunguis*.

Character	*Teihivenator macropus*	*Dryptosaurus aquilunguis*
Cnemial crest in posterior view	visible	invisible
Intercondylar notch	very deep	deep
Small tubercle in the intercondylar notch	present	absent
Anterior process on the lateral tibial condyle	present	absent
Medial tibial condyle position relative to the lateral tibial condyle	elevated	same level
Medial malleolus notch	shallow	very shallow
Lateral malleolus position relative to medial malleolus	same level	extends much distally
Metatarsal IV shaft	robust	gracile
Medial ligament pit on metatarsal IV	large and deep	small and shallow

However, the relative anteroposterior width of metatarsal IV shaft indicates a much robust metatarsal IV in *Teihivenator* compared to *Dryptosaurus* (Fig. 2). Another possible difference between *Teivenator* and *Dryptosaurus* in metatarsal IV is the depth of medial collateral ligament pit. In *Teihivenator*, the pit is deep and large while in *Dryptosaurus* the pit seems to be

much smaller and shallow. However, Brusatte & Carr [5] suggested the shallow condition of the medial collateral ligament pit of *Dryptosaurus* might be due to its poor preservation. Regardless, the apparent size of pit seems to larger in *Teihivenator*. The proximal end of metatarsal II is D-shaped in proximal view, and the anterior corner is not preserved. The posterior corner is more narrow and triangular compared to other derived tyrannosauroids, and the medial corner is more rounded. The notch for metatarsal III is much shallower than most tyrannosauroids. However, the presence of a notch [15] and the overall similarity of metatarsal II with derived tyrannosauroids indicate the arctometatarsalian condition for *Teihivenator*.

AMNH 2551 is composed of one phalanx II-1 and two phalanges III-2. Phalanx II-1 is about 109 mm long, and each phalanges III-2 are about 93, 96 mm long. Phalanx II-1 is long and thin. The distal condyles and the collateral ligament pits are small. Phalanx III-2 is short and thick. The distal condyles are small, but large and round collateral ligament pits are located centrally placed. The most autapomorphic feature of pedal phalanges of *Teihivenator* is the presence of paired ventral processes proximally. Similar, paired ventral processes are also reported in the basal tyrannosauroid *Guanlong* [29] and coelurosaur *Aorun* [13] but in these cases, they are more prominent and only present in phalanx II-1.

It has been revealed that some dinosaurs underwent dramatic growth changes in morph as they matured [9], [17], and given that syntype individual of *Teihivenator* is fairly a small theropod might suggest the individual is a juvenile, and perhaps even juvenile *Dryptosaurus* even though there are a lot of morphological differences between them. However, while juvenile theropods generally have gracile metatarsals compared to adults [25], the robust metatarsal of *Teihivenator* compared to *Dryptosaurus* strongly suggests their generic distinction. Also, slightly older age of Navesink Formation compared to New Egypt Formation [26] suggests both taxa are not contemporaneous, thus very unlikely to be synonymous.

DISCUSSION

Because *Teihivenator* is only known from fragmentary hindlimb materials, a phylogenetic analysis was not performed here due to the obvious lack of character data. However, based on the available characters in the preserved bones of *Teihivenator*, *Teihivenator* features some characters that suggest a more derived tyrannosauroid position than *Dryptosaurus*. The presence of an anterior process on the lateral tibial condyle is more similar to derived tyrannosauroids like *Appalachiosaurus* and Tyrannosauridae than *Dryptosaurus*. Relatively much more robust metatarsals may also support this position. Another possible character for this phylogenetic position is the lateral malleolus at the same level as the medial malleolus, which is similar to *Bistahieversor* and basal tyrannosaurine Alioramini. However, this could be a more basal coelurosaurian condition as well. *Teihivenator* is probably not a tyrannosaurid as there are currently no evidences for dispersal of tyrannosaurids to Appalachia.

One of the most significant autapomorphies of *Teihivenator* is the presence of paired proximoventral processes on all preserved pedal phalanges. These are probably attachment points for the paired strong flexor tendons, and these are similar to modern predatory birds which grasp their prey with their feet. This suggests that the grasping power of *Teihivenator* feet is stronger than similarly sized theropods, and this might have been related to its predatory or feeding behavior. However, as there are no cranial materials of *Teihivenator*, this assumption should be considered as tentative.

The recognition of *Teihivenator* as a tyrannosauroid calls for a revision of the eastern North American theropod materials to restudy the theropod diversity of Appalachia. Baird [1] referred the incomplete pedal phalanx III-1 from the Eutaw Formation to ornithomimosaur as he considered the material to be identical with "*Coelosaurus*" *antiquus*. However, as the pedal phalanges Baird [1] used for comparison is actually *Teihivenator* specimens, it is probable that his phalanx actually belongs to a tyrannosauroid as Carpenter [8] originally suggested. The absence of proximoventral processes and geologically much older age of Eutaw Formation (Late Coniacian-Early Santonian) suggest this phalanx does not belong to *Teihivenator*, but to an as yet unrecognized tyrannosauroid. Appalachian

tyrannosauroid diversity is clearly underestimated than previously assumed, but discoveries of more complete materials are necessary to clear up this issue.

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