Muscular Reconstruction of the Forelimb of the Theropod Dinosaur *Mononykus olecranus*

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ABSTRACT

Mononykus olecranus was a small, nonavian predatory theropod that exhibited unusual forelimb size in comparison to other theropods. The forelimbs were distinctly stunted in size with only one finger and claw on each hand. The perplexity of these forelimbs has prompted many to study the function of the *Mononykus* forelimbs. This study uses phylogenetic muscle reconstruction methods along with previous reconstructions of theropods such as *Tawa* and *Majungasaurus* to help us better understand what *Mononykus* may have been capable of. Overall, there are several modifications in the forelimb that improve the leverage of the shoulder flexors and elbow extensors. An improved lever arm for shoulder flexors like Supracoracoideus would be provided by the enlarged posteroventral process of the scapulocoracoid and the projecting deltopectoral crest of the humerus. Improved leverage for elbow extensors like Triceps brachii would be shown by the massive olecranon process of the ulna and enlargement of the ectepicondyle of the humerus. The humerus also shows an enlargement of internal tuberosity related to the shoulder adductors. These reconstructions, along with the rest of the forelimb, are consistent with the hypothesis that *Mononykus* used its unusually small forelimbs for digging or scratching, perhaps when foraging for insects.

MATERIALS AND METHODS

The holotype of Mononykus olecranus (MPC 107/6; Perle et al., 1994) preserves a complete forelimb including a scapulocoracoid, humerus, radius, ulna, manus. Our reconstruction of the musculature utilizes both phylogenetic muscle reconstruction methods and information from previous reconstructions of theropods such as Tawa and Majungasaurus (Burch, 2014; 2017). These previous theropod reconstructions provided the foundation for the muscle attachment sites that were reconstructed in Mononykus olecranus. We used Adobe Illustrator to accurately trace a photo of the bone that could then be used in conjunction with the previous theropod reconstructions to identify possible muscle attachment sites. The musculature of Mononykus was then compared to that of other theropod dinosaurs, allowing for assessment of previously hypothesized functions such as digging.

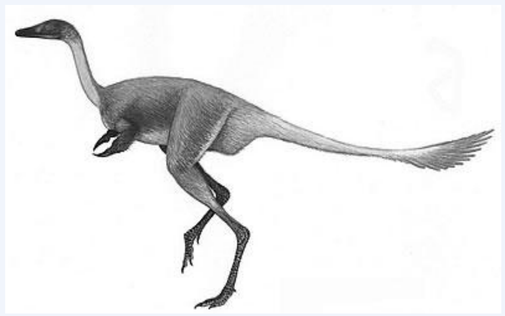

Figure 1. Life reconstruction of *Mononykus olecranus* displaying its stunted forelimb with only one claw on each hand (Atuchin A., Natural History Museum).

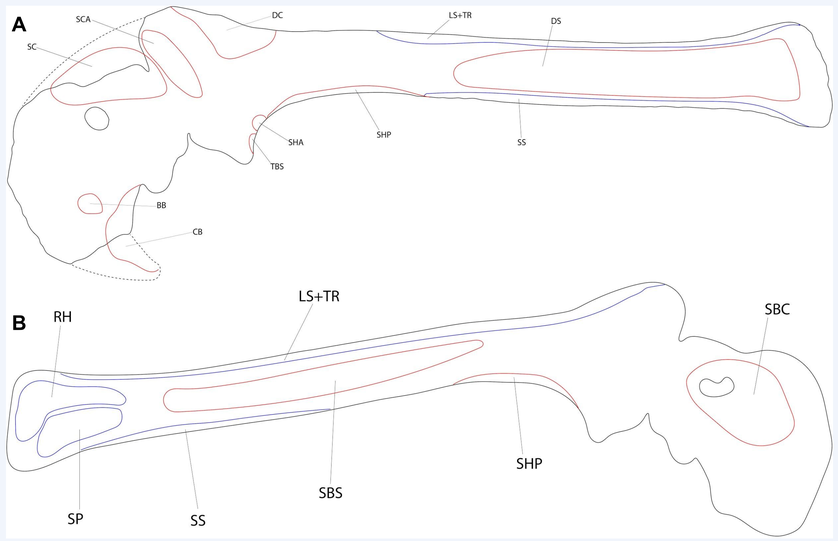

Figure 2. The left scapulocoracoid showing proposed muscle origins (red) and insertions (blue) in the lateral (A) and medial (B) views. BB, Biceps brachii; CB, Coracobrachialis; DS, Deltoideus scapularis; DC, Deltoideus clavicularis; LS, Levator scapulae; RH, Rhomboideus; SC, Supracoracoideus; SCA, Supracoracoideus accessorius; SS, Serratus superficialis; SHP, Scapulohumeralis posterior; SHA, Scapulohumeralis anterior; SP, Serratus profundus; SBS, Subscapularis; SBC, Subcoracoideus; TR, Trapezius; TBS, Triceps brachii scapularis.

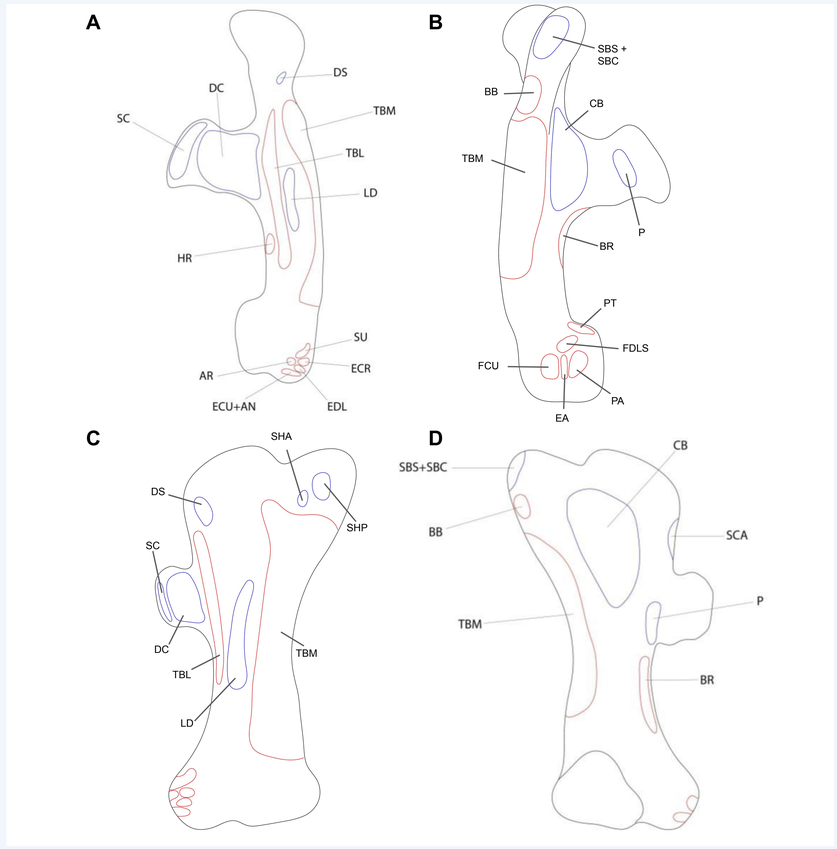

Figure 3. The left humerus showing proposed muscle origins (red) and insertions (blue) in the lateral (A), medial (B), posterior (C), and anterior (D) views. AN, Anconeus; AR, Abductor radialis; BR, Brachialis; BB, Biceps brachii; CB, Coracobrachialis; DC, Deltoideus clavicularis; DS, Deltoideus scapularis; ECR, Extensor carpi radialis; EDL, Extensor digitorum longus; ECU, Extensor carpi ulnaris; EA, Epitrochleoanconeus; FDLS, Flexor digitorum longus superficialis; FCU, Flexor carpi ulnaris; HR, Humeroradialis; LD, Latissimus dorsi; PT, Pronator teres; P, Pectoralis; PA, Pronator accessorius; SC, Supracoracoideus; SU, Supinator; SBS, Subscapularis; SBC, Subcoracoideus; SCA, Supracoracoideus accessorius; SHA, Scapulohumeralis anterior; SHP, Scapulohumeralis posterior; TBM, Triceps brachii medialis; TBL, Triceps brachii longus.

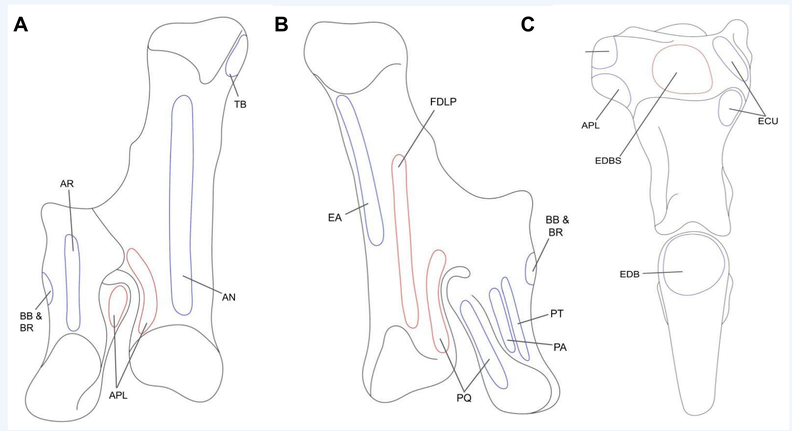

Figure 4. The left antebrachium (A and B) and manus (C) showing proposed muscle origins (red) and insertions (blue) in the lateral (A), medial (B), and dorsal (C) views. AN, Anconeus; APL, Abductor pollicis longus; AR, Abductor Radialis; BB, Biceps brachii; BR, Brachialis; ECR, Extensor carpi radialis; EDBS, Extensor digitorum brevis superficialis; ECU, Extensor carpi ulnaris; EDB, Extensor digitorum brevis; EA, Epitrochleoanconeus; FDLP, Flexor digitorum longus profundus; PT, Pronator teres; PA, Pronator accessorius; PQ, Pronator quadratus; TB, Triceps brachii.

CONCLUSIONS

The forelimb of Mononykus olecranus was reconstructed based on a phylogenetic muscle reconstruction method along with previous information obtained from past reconstructions of the theropods Tawa and Majungasaurus. The reconstruction of a forelimb as distinctly stunted in size as Mononykus with only one finger on each claw leaves a lot of ambiguity. However, the ability to compare this forelimb to past reconstructions gives way to a more unequivocal reconstruction of the muscle attachment sites in the forelimb of Mononykus. Our results suggest that Mononykus used this strange forelimb to dig or scratch perhaps in an attempt to forage for insects. Evidence of this includes an enlarged posteroventral process located on the scapulocoracoid, a large olecranon process of the ulna along with an enlargement of the ectepicondyle located on the humerus. The massive size of these allows for improved leverage of the shoulder flexors (supracoracoideus) and elbow extensors (triceps brachii). The improved leverage of these muscles would allow for forceful digging motions.. Further studies and reconstructions on the forelimbs of theropods similar to Mononykus will add more data to this reconstruction that may help resolve some ambiguity found within this reconstruction.

ACKNOWLEDGMENTS

Thank you to Dr. Burch for her guidance throughout the process of this reconstruction along with her vast knowledge and experience. Collections access provided by Chinzorig Tsogbaatar, Mongolia Paleontological Center.

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