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Limb posture in early mammals: Sprawling or parasagittal

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The limb posture in early mammals is a matter of controversy. Kielan-Jaworowska and Gambaryan presented arguments for a sprawling posture in multituberculates, based mainly on three characters of the hind limbs (deep pelvis, mediolateral diameter of the tibia larger than the craniocaudal, and position of MtV, which fits the peroneal groove on the calcaneus and is not aligned with the axis of tuber calcanei). Here we present two more arguments for sprawling hind limbs in early mammals. One is the presence of an os calcaris, supporting the probably venomous spur in hind legs of docodontans, multituberculates, eutriconodontans, and 'symmetrodontans', similar to those of extant monotremes. We argue that early mammals (except for boreosphenidans) had sprawling limb posture and venomous spur; acquisition of the parasagittal stance was apparently characteristic only of boreosphenidans, in which the spur has not been found. The second argument is based on taphonomic evidence from lacustrine conditions (e.g., Early Cretaceous Jehol Biota), in which the mammalian skeletons, except for boreosphenidans (*Sinodelphys* and *Eomaia*), have been preserved compressed dorso-ventrally, suggesting sprawling stance. In similar conditions of the Eocene Messel Biota the skeletons of boreosphenidan mammals (except for bats and pangolins) are preserved lying on flanks, suggesting parasagittal stance. Sereno argued that forelimbs in multituberculates were parasagittal, based on the stated presence of a ventrally facing glenoid, a mobile shoulder joint, and an elbow joint with enhanced flexion-extension capability. However, these characters are not unequivocally indicative of parasagittalism. We demonstrate that the structure of the distal end of the multituberculate humerus is condylar, with no tendency for developing a trochlea. We reconstruct multituberculates and other early mammals with sprawling stance in resting position as plantigrade.

Key words: Mammalia, Multituberculata, Monotremata, os calcaris, spur, venomous mammals, sprawling posture, parasagittalism, Mesozoic.

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