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Were mammals originally venomous?

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The extratarsal spur in extant monotremes consists of an os calcaris and a cornu calcaris. A poisonous extratarsal spur occurs only in the platypus (*Ornithorhynchus*); a possibly secondarily non-poisonous spur is present in echidnas (*Tachyglossus* and *Zaglossus*). Some therian mammals (e.g., bats), reptiles (*Chamaeleo*), and amphibians have a spur-like structure in the ankle, but this is not homologous to the extratarsal spur of monotremes. Among fossil mammals, the co-ossified os calcaris and ossified cornu calcaris have been found in the eutriconodontan *Gobiconodon* and in the spalacotheroid 'symmetrodontan' *Zhangheotherium*. Here we describe the os calcaris in several multituberculate mammals from the Late Cretaceous of the Gobi Desert, Mongolia. The multituberculate os calcaris is a large, flat bone, generally similar to that in males of the extant monotreme species, but the cornu calcaris is not ossified. In *Gobiconodon* and *Zhangheotherium* the ossified cornu calcaris is fused to the os calcaris probably to provide the bony support for the keratinous spur. We hypothesize that the os calcaris in these Mesozoic mammal groups is homologous to that of monotremes. However, the extratarsal spur has not been found in non-mammalian cynodonts nor in other synapsids. A platypus-like os calcaris might be an apomorphic characteristic of basal Mesozoic mammals and is secondarily lost in crown therians; the os calcaris is confirmed to be absent in well-preserved tarsal structures of the earliest known crown therian mammals. We speculate that the os calcaris, the cornu calcaris, and its associated venom gland might have served the function of a defensive structure during the 'dark ages' of mammalian history, when dinosaurs ruled the Earth. This structure is a plesiomorphic character retained in extant monotremes and cannot be used as an autapomorphy of Monotremata.

Key words: Multituberculata, Monotremata, *Gobiconodon*, *Zhangheotherium*, os calcaris, cornu calcaris, extratarsal spur

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