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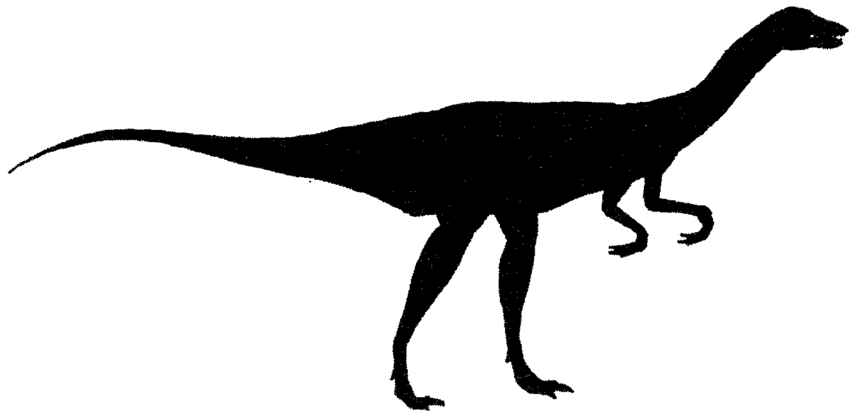

Elmisauridae

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INTRODUCTION

Elmisaurids are small, lightly built theropods (estimated weight 35–65 kg) of the Late Cretaceous characterized by large feet and gracile hands. The skull is at present unknown, but raptorial claws and elongate limbs suggest that they were quick and agile predators.

Chirostenotes pergracilis was described by Gilmore (1924*a*) on the basis of two nearly complete hands of a single individual collected from the Judith River Formation of Alberta (figs. 9.1, 9.2). A slender pair of dentaries was tentatively assigned to the species in the same paper, but there is no justification for this assignment. An isolated, articulated foot (fig. 9.2) became the type specimen of *Macrophalangia canadensis* (Sternberg 1932*a*). The same location produced a metatarsus that Parks (1933) described as *Ornithomimus elegans*. Various authors speculated on the possible synonomy of these three species, but until the recent discovery of a partial skeleton of *Chirostenotes pergracilis* (Currie and Russell 1988), this could not be confirmed.

Elmisaurus rarus (figs. 9.1, 9.2) was described on the basis of partial skeletons from the Nemegt Formation of the Mongolian People's Republic (Osmólska 1981). In most respects, it is very similar to *Chirostenotes pergracilis*, although the tarsals and metatarsals are coossified in the Asian form. These two species were different enough from other theropods that Osmólska (1981) established the Elmisauridae (table 9.1).

A coossified tarsometatarsus discovered recently in Alberta is close enough in morphology to suggest that *Elmisaurus* was also found in Alberta and that the type specimen *Ornithomimus elegans* is an immature specimen of *Elmisaurus* (Currie in prep.).

The skull and axial skeleton, with the exception of the sacrum, are at present unknown for the Elmisauridae. Currie and Russell (1988) speculate that *Chirostenotes* may turn out to be a caenagnathid when more complete specimens are found, whereas Ostrom (this vol.) feels that *Chirostenotes* may be synonymous with *Dromaeosaurus*.

DIAGNOSIS

The Elmisauridae is diagnosed on the basis of metatarsal III being pinched proximally between the second and fourth metatarsals but with only the proximal tip excluded from the extensor surface of the metatarsus; the second to fourth distal tarsals and metatarsals are tightly associated and tend to coossify into a tarsometatarsus; the back of the metatarsus is deeply emarginated.

Elmisaurids are also characterized by a unique suite of characters that collectively help define the family. The third digit of the manus is longer than the first digit. There is a proximodorsal "lip" on the manual unguals. The postacetabular blade of the ilium is shorter than the preacetabular blade.

TABLE 9.1 Elmisauridae

	Occurrence	Age	Material
Theropoda Marsh, 1881b			
Elmisauridae Osmólska, 1981			
Chirostenotes Gilmore, 1924a			
C. pergracilis Gilmore, 1924a (including *Macrophalangia canadensis* Sternberg, 1932a)	Judith River Formation, Horseshoe Canyon Formation, Alberta, Canada	middle Campanian-early Maastrichtian	Partial skeleton, pes, 2 manus, sacrum, isolated elements
Elmisaurus Osmólska, 1981			
E. rarus Osmólska, 1981	Nemegt Formation, Omnogov, Mongolian People's Republic	?late Campanian or early Maastrichtian	3 pedes, manus
E. elegans (Parks, 1933) (= *Ornithomimus elegans* Parks, 1933)	Judith River Formation, Alberta, Canada	middle Campanian	3 pedes

ANATOMY

Six coossified vertebrae form the sacrum in *Chirostenotes,* which is a higher number than in theropods other than troodontids, oviraptorosaurians, some ornithomimids, and birds. Sacral vertebrae are pierced by pleurocoels.

The coracoid of *Chirostenotes* is the only known element of the pectoral girdle of elmisaurids. It had a more extensive contact with the scapula than in the dromaeosaurid *Deinonychus* but is otherwise very similar in size and shape.

Metacarpal I in elmisaurids is a straight, slender bone, in contrast with the shorter, stouter version seen in oviraptorids, *Deinonychus, Ornitholestes, Dilophosaurus,* and tyrannosaurids or the longer, stouter metacarpal I of ornithomimids. *Microvenator* has a similar metacarpal I. Metacarpal II is the largest metacarpal element, whereas metacarpal III was probably very slender.

The third digit is 30 percent longer than digit I but 30 percent shorter than digit II. The longest phalanx in the hand is the second one of digit II, which is about 5 percent longer than II-1. In contrast, the first phalanx of digit I in ornithomimids and oviraptorids is longest, and the second finger is only slightly longer than the third.

The first digit is not opposable to the other fingers in elmisaurids. Digit III is very slender, and it is conceivable that the outer fingers (II, III) were syndactylous. This would only flex properly if there was some alignment between joint mcII/II-1 and mcIII/III-1 and between II-1/II-2 and III-2/III-3.

The manual unguals are strongly laterally compressed and have large, well-developed flexor tubercles. The dorsal edge of the articulation forms a prominent "lip" for the attachment of the extensor tendons.

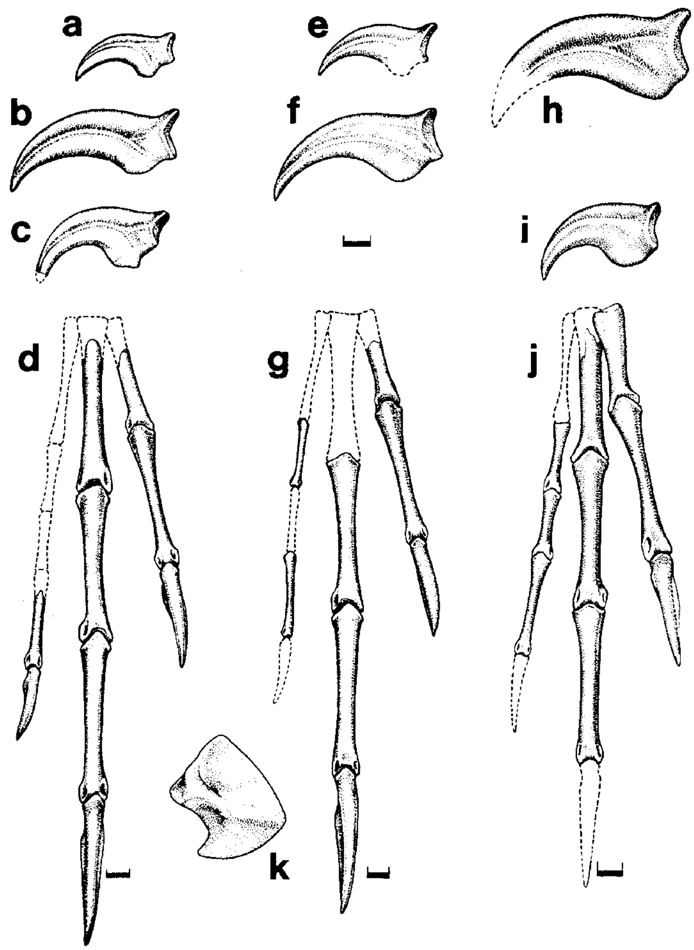

Fig. 9.1. Comparison of elmisaurid manus. a, b, c, d, manual unguals III, II, and I and reconstruction of the manus of *Chirostenotes pergracilis;* e, f, manual unguals of *Chirostenotes pergracilis* (after Currie and Russell 1988); g, reconstruction of *Chirostenotes pergracilis* manus (after Currie and Russell 1988); h, manual ungual II; i, j, manual ungual I and reconstruction of the manus of *Elmisaurus rarus* (after Osmólska 1981); k, coracoid of *Chirostenotes pergracilis* (after Currie and Russell 1988). Scale = 1 cm.

The only other theropod genera with similar unguals are *Microvenator* and *Oviraptor*.

Like most theropods, the elmisaurid ilium is dolichoiliac, having an elongate preacetabular blade that is squared off cranially. The postacetabular blade is less than 70 percent as long as the preacetabular portion of the ilium. Similar proportions are only seen in the opisthopubic dromaeosaurids, although the elmisaurid pelves are propubic.

The ischium of *Chirostenotes* is shorter than in any other known theropod and is only about 45 percent as long as the femur. There is a strong obturator process that is well separated from the pubic contact.

The hindlimb of *Chirostenotes* is long and slender. The ratio of tibia to femur is 1.2, which compares favorably with the more cursorial theropods. The femur is similar to those of other theropods. However, the base of the lesser trochanter is more distally located than in other known forms. Some of the specializations in the pelvis and femur suggest that the tail was relatively short in comparison with other theropods (Currie and Russell 1988).

In *Chirostenotes*, the cnemial crest of the tibia did not extend far along the shaft of the bone. A ridge extending distally along a third the length of the shaft clearly indicates the region of contact with the fibula, a bone that is otherwise unknown in elmisaurids.

The astragalus of *Chirostenotes* completely covered the distal end of the tibia. Its ascending process extended at least a sixth the distance up the flexor surface of the tibia. There is no pronounced horizontal groove separating the distal condyles from the ascending process. As reconstructed, the calcaneum is a small but discrete element. The distal tarsals tend to fuse to the metatarsus. Distal tarsal IV has a distinctive proximolateral projection in *Elmisaurus* specimens from Mongolia and Alberta.

The metatarsus is elongate and similar to *Ornithomimus edmontonensis* in relative length. Fusion or close association of the proximal ends of the second, third, and fourth metatarsals with the distal tarsals is the most diagnostic characteristic of elmisaurids. The lines of fusion are still visible in the type specimen of *Elmisaurus rarus* but are obliterated in other specimens from Mongolia and Alberta.

As in most theropods, the first metatarsal is divided into proximal and distal segments as the intervening shaft failed to ossify. Only the distal segment is known, and it was closely appressed to the shaft of metatarsal II. The shaft of the second metatarsal is only slightly more slender than that of the fourth. The proximal end of metatarsal II contacts metatarsal IV for a short distance on its extensor surface. Metatarsal III is

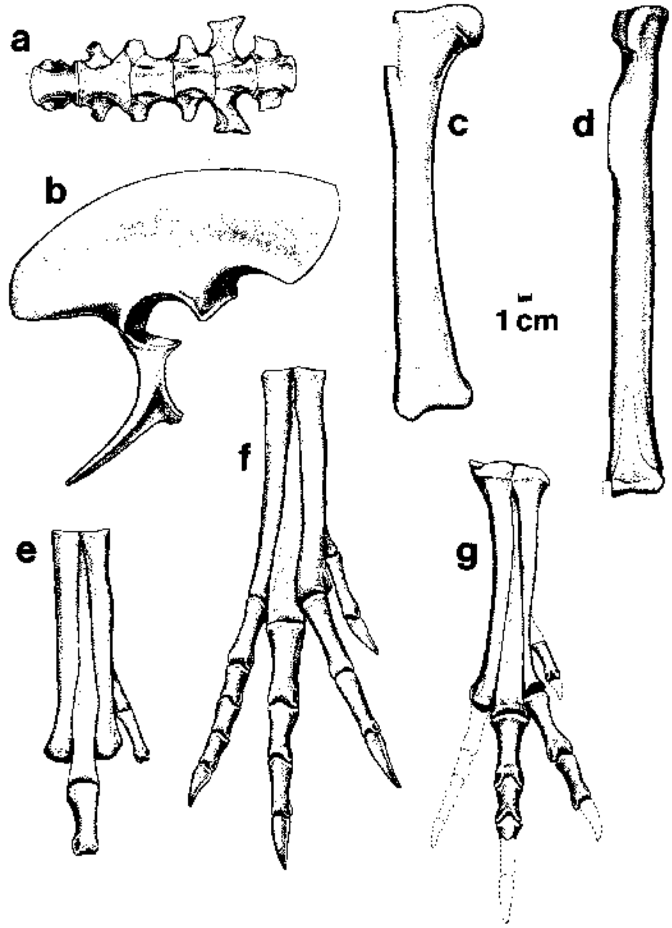

Fig. 9.2. Pelvic and hindlimb elements of elmisaurids. a, ventral view of sacrum of *Chirostenotes pergracilis* (after Currie and Russell 1988); b, ilium and ischium of *Chirostenotes pergracilis* in right lateral view, (after Currie and Russell 1988); c, d, reconstruction of right femur and tibia of *Chirostenotes pergracilis*, cranial views (after Currie and Russell 1988); e, metatarsals and phalanges of *Chirostenotes pergracilis* (after Currie and Russell 1988); f, reconstruction of pes of *Chirostenotes pergracilis* (type of "*Macrophalangia*"); g, reconstruction of pes of *Elmisaurus rarus* (after Osmólska 1981). Scale = 1 cm.

proximally pinched between the adjacent metatarsals, as in troodontids, ornithomimids, and tyrannosaurids. In *Chirostenotes*, the proximal end is diamond shaped in section, whereas it is triangular in *Elmisaurus*. The distal end of metatarsal IV is well separated from the distal end of the second metatarsal on the caudal surface, in contrast with *Troodon*, in which they almost touch (Wilson and Currie 1985). Metatarsal V is a small, boomerang-shaped bone in *Chirostenotes*.

At midlength, the flexor surface of the metatarsus is strongly arched in section, the shafts of the second and fourth metatarsals extending farther caudally than that of the third.

The phalanges of the pedal digits are more slender than those of ornithomimids, and the unguals are laterally compressed and recurved. Digits II and IV are subequal in length, and digits II, III, and IV are almost as long as their corresponding metatarsals. Phalanges II-1 and III-1 are the longest ones in the pes, III-1 being slightly shorter in *Chirostenotes.* Pedal unguals are sharply pointed but are not as trenchant as those of dromaeosaurids.

In summary, three species of elmisaurids can be easily distinguished from each other. Metatarsals II, III, and IV of *Chirostenotes pergracilis* are tightly bound proximally and may fuse in large individuals. The proximal end of metatarsal III is diamond shaped in section, and phalanx III-1 is marginally shorter than phalanx II-1. The linear dimensions of mature specimens of *Elmisaurus rarus* are about one-third smaller than *Chirostenotes pergracilis.* The distal tarsals have coossified with the proximal ends of metatarsals II, III, and IV to form a tarsometatarsus. Distal tarsal IV has a proximolateral projection, and the proximal end of metatarsal III is triangular in section. The proximal phalanges of digits II and III are subequal. *Elmisaurus elegans* is the same size as *Elmisaurus rarus* but is more gracile. A ridge along the caudolateral margin of metatarsal IV is not as strongly developed, and metatarsal II has a relatively more slender shaft in the species from Alberta.

PHYLOGENY AND EVOLUTION

Elmisaurids have been established as a separate family of theropods on the basis of incomplete but distinctive skeletons. Currie and Russell (1988) speculate on the possibility of synonymizing *Chirostenotes* and *Caenagnathus.* There are many similarities in the postcranial skeletons of the elmisaurids and *Oviraptor,* including the relative proportions of manual digits I and III, the presence of a proximodorsal "lip" on the manual unguals, the shape of the ilium, and the six sacral vertebrae with pleurocoels. These similarities suggest that the Elmisauridae is at least a sister taxon to the Oviraptorosauria. *Microvenator* (see Norman, this vol.) may be an early representative of this lineage.

PALEOECOLOGY AND BIOGEOGRAPHY

At present, elmisaurids are known only from the Late Campanian and/or Early Maastrichtian of the Northern Hemisphere. Nine articulated, partial skeletons have been collected (two of which were recovered from channel sandstones), as well as identifiable isolated bones. The sediments of the Judith River, Horseshoe Canyon, and Nemegt formations represent predominantly fluvial deposition, which favors the preservation of only large animals as articulated specimens. Small animals, such as elmisaurids, tended to be destroyed or disarticulated by the action of high energy fluvial environments or by scavengers. No cranial material can be associated with identifiable elmisaurid postcrania.

Elmisaurids are found in regions that are thought to have been warm temperate to subtropical and seasonally dry (Gradzinski 1970; Jarzen 1982).

The length of the hindlimb and its proportions suggest that *Chirostenotes* was a quick, agile animal. The manual claws were laterally compressed and recurved, indicating that elmisaurids were probably active predators. Their small size and gracility suggests that prey species were small. This is difficult to confirm without cranial material, however. The outer digit of the hand is so slender that it may have been useful for prying insects from the bark of trees if it was free or for grooming if it was syndactylous.