An azhdarchid pterosaur cervical vertebra from the Hell Creek Formation (Maastrichtian) of southeastern Montana

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In July, 2002 field crews from the Burpee Museum of Natural History collected a partially articulated tyrannosaur skeleton from the Hell Creek Formation of Carter County, Montana. During preparation of the tyrannosaur, an isolated cervical vertebra of a large azhdarchid pterosaur was discovered in one of the field jackets. The Azhdarchidae are a family of large to giant pterodactyloid pterosaurs, known principally from fragmentary remains, found in Cretaceous rocks around the globe. This family contains some of the latest, and largest, pterosaurs. Quetzalcoatlus nordrøp() from the Javelina Formation (Maastrichtian) of the Big Bend National Park in Texas, for example, had an estimated wingspan of 11–12 meters (Langston, 1981). Arambourgenia philadelphiae (Nesov, 1984) with its estimated wingspan of over 12 meters (Frey and Martill, 1996; Martill, et al., 1998) and Hatzegopteryx thambema from the late Cretaceous Hateg Basin of western Romania (Buffetaut, et al. 2002; 2003) may have been even larger.

The only published records of pterosaur remains from the Hell Creek Formation are two indeterminate specimens, which have been recorded from North Dakota, but not described (Johnson et al., 2000; Pearson et al., 2002). Due to the rarity of pterosaur remains, found in Cretaceous rocks around the globe. This family contains some of the latest, and largest, pterosaurs. Quetzalcoatlus nordrøp() from the Javelina Formation (Maastrichtian) of the Big Bend National Park in Texas, for example, had an estimated wingspan of 11–12 meters (Langston, 1981). Arambourgenia philadelphiae (Nesov, 1984) with its estimated wingspan of over 12 meters (Frey and Martill, 1996; Martill, et al., 1998) and Hatzegopteryx thambema from the late Cretaceous Hateg Basin of western Romania (Buffetaut, et al. 2002; 2003) may have been even larger.

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is well developed and wider than high. It is flanked ventrally by the postexapophysis.

A large part of the right postzygapophysis has broken away, leaving only the base. The left postzygapophysis is present and exhibits a well-developed articular facet on its ventro-medial surface. The neural canal, seen from its caudal end, is flanked by a small, vertical, slit-like foramen on each side. A shallow, ovate excavation, possibly the recess for the elastic ligament, occurs above the neural canal. A reconstruction of BMR P2002.2 in dorsal and lateral view is presented in Figure 3.

Based on its preserved characters, BMR P2002.2 can be identified as a mid-series cervical vertebra from a pterosaur of the family Azhdarchidae. This assignment is based on the totality of traits preserved in the vertebra, including its extreme length, greatly reduced neural spine, and a tubular neural canal suspended within the lumen of the centrum (except at the ends of the neural arch). The stratigraphic position of the vertebra is consistent with its identification as that of an azhdarchid pterodactyl.

Comparisons and Discussion—Because azhdarchid cervical vertebrae are hollow, they commonly suffer from varying degrees of diagenetic distortion. Typically, such vertebrae are crushed (flattened) dorso-ventrally. The lateral crushing of BMR P2002.2 is unusual and complicates comparison with other specimens. Several examples of azhdarchid cervical vertebrae have been described. One of us (MDH) recently had the opportunity to examine six composite cervical series of *Quetzalcoatlus* sp. in the collections of the Texas Memorial Museum, Austin. These vertebrae were collected in the 1970s and 1980s by Dr. Wann Langston Jr. and his students in Big Bend National Park, Brewster County, Texas (Lawson, 1975; Kellner and Langston, 1996). The neck of pterodactyls is generally conceded as comprising nine vertebrae, some of which are very long and tube-like (Howse, 1986). The mid-series cervicals, C-3 thru C-7, have long vertebral bodies of which those of C-5 and C-6 are distinctly longer and more slender than the others. BMR P2002.2 resembles a putative fifth cervical of *Quetzalcoatlus* sp. from the Maastrichtian Jal-elina Formation in Texas (TMM 42180-2), although BMR P2002.2 possesses an apparently more robust hypapophyseal process (which restricted ventral deflection of the neck) at its anterior end. We do not attribute much importance to this difference, however, owing to the substantial deformation suffered by both specimens. However, BMR P2002.2 is relatively gracile by comparison with the Texas material. BMR P2002.2 is 348 mm in length (exapophyses to caudal condyle) whereas the cervical of *Quetzalcoatlus* sp. is 394 mm long. BMR P2002.2 is severely crushed transversely and at midlength is only 5 mm thick. The corresponding measurement of the dorsoventrally crushed TMM 42180-2 is 34 mm. The distortion complicates comparison, but assuming a near circular cross section of both vertebrae, the diameter of the uncrushed Burpee Museum vertebra would have been about 18.25 mm at midlength whereas that of TMM 42180-2 was about 30.5 mm. The slenderess of BMR P2002.1 is also reflected by a transverse diameter across the prezygapophyses of 22.25 mm compared to an estimated width of ~38 mm in the cervical of *Quetzalcoatlus* sp. (only one zygapophysis is preserved in the specimen, and the anterior end of the vertebra has been expanded transversely by crushing, preventing precise measurement of its width). A comparable disparity in width exists at the posterior ends of the specimens, but distortion precludes accurate measurements. It seems unlikely that the difference in width between the two vertebrae would have been eliminated by an increase in length of the BMR P2002.2 specimen to equal that of the fifth cervical of *Quetzalcoatlus* sp.

BMR P2002.1 does seem similar to the fifth cervical of *Quetzalcoatlus* sp. However, the distorted condition of the specimen precludes its referral to any known azhdarchid species. We therefore assign it to the Azhdarchidae incertae sedis. Langston (1981) has estimated the wing-span of *Quetzalcoatlus* sp. from Texas at 5.5 m. In light of the correspon-
dence in size and morphology between the Texas specimens of *Quetzalcoatlus* sp. and BMR P2002.2, an estimate of 5.0 to 5.5 m for the wingspan of the Burpee azhdarchid is probably appropriate.

Theropod dinosaurs may have occasionally preyed upon, or scavenged, the cadavers of pterosaurs. Currie and Jacobson (1995) report a specimen of an azhdarchid pterosaur from Dinosaur Provincial Park, Canada, that shows evidence of having been eaten by a member of the theropod dinosaur genus *Saurornitholestes*. As well, Buffetaut et al.

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**FIGURE 2.** Drawings of mid series cervical vertebra (BMR P2002.2) of cf. *Quetzalcoatlus* sp. in A, ventral aspect; B, right lateral aspect; C, left lateral aspect; D, dorsal aspect; E, cranial aspect; F, caudal aspect. **Abbreviations:** anc, anterior cotyle; bp, blind pocket; hyp, hypapophysis; nc, neural canal; ns, neural spine; pc, posterior condyle; pex, postexapophysis; pnf, pneumatic foramen; poz, postzygapophysis; prz, prezygapophysis; tc, transverse canal.

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**FIGURE 3.** Drawing of reconstructed mid series cervical vertebra (BMR P2002.2) of cf. *Quetzalcoatlus* sp. in A, dorsal aspect; B, right lateral aspect. Abbreviations as in figure 2.
(2004) report an ornithocheirid pterosaur vertebra from the Lower Cretaceous Santana Formation of Brazil with a broken tooth of a spinosaurid theropod embedded in the bone. Although BMR P2002.2 was found immediately beneath the skeleton of a tyrannosaur, all damage to the specimen appears to be attributable to diagenetic causes. The presence of the two fossils in the same field jacket was a result of the accidental juxtaposition of the remains. As it is unlikely that a fragile, elongate azhdarchid cervical could survive much transport in a fluvial environment without sustaining significant injury; its completeness indicates that it was transported only a short distance before coming to rest on the point bar sands.

While azhdarchid remains have not been described previously from the Hell Creek Formation, an azhdarchid cervical has been reported from the Lance Formation of Niobrara County, Wyoming (Estes, 1964). The specimen consists of the anterior half of a fifth or sixth cervical. We estimate that the complete bone would have been approximately 240–260 mm long, and thus somewhat smaller than BMR P2002.2. The Lance Formation consists of laterally equivalent sediments of the same age and made up of the same types of floodplain deposits as the Hell Creek. The Javelina Formation of Texas is also composed chiefly of rocks formed in continental floodplain environments (Lehman, 1987). Azhdarchid remains have also been reported from continental deposits of the Two Medicine Formation (Campanian) in Montana (Padian, 1984; Padian and Smith, 1992; McGowan et al., 2002) and the Oldman Formation (Campanian) of Alberta (Currie and Russell, 1982). The occurrence of this group in continental sediments of the Hell Creek Formation is, therefore, not surprising.

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LITERATURE CITED


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