Reports

Pterosaur from the Latest Cretaceous of West Texas: Discovery of the Largest Flying Creature

Abstract. *Three partial skeletons of a large pterosaur have been found in the latest Cretaceous nonmarine rock of West Texas. This flying reptile had thin, elongate, perhaps toothless jaws and a long neck similar to* Pterodaustro *and* Pterodactylus. *With an estimated wingspan of 15.5 meters, it is undoubtedly the largest flying creature presently known.*

During the last 3 years, partial remains of three large Late Cretaceous pterosaurs have been discovered in the Big Bend National Park, Brewster County, Texas. These specimens include the remains of four wings, a neck, the hind legs, and mandibles found 110 to 140 m above the base of the Tornillo Group. Although the larger of the specimens was separated from the others by 40 km, all can be referred to a single species because of the similarity of their humeri, proximal carpals, and second phalanges. This material adds to the growing list of pterosaur remains from North America, which includes discoveries from the Morrison (Late Jurassic) (*1*) and the Lance (Maastrichtian) (*2*) of Wyoming, the Pierre Shale (Campanian) of South Dakota (*3*), the Oldman (Campanian) of Alberta (*4*), the Hudspeth (Albian) of Oregon (*5*), the Niobrara (Santonian) (*6*) and Kiowa (Albian) (*7*) of Kansas, the Mooreville (Campanian) of Alabama (*8*), and the Eagle Ford (Turonian) (*9*) and Buda (Cenomanian) (*10*) of Texas and Arizona (*11*). The pterosaur from the Lance Formation, which is represented by a cervical vertebra only, is certainly closely related to the Big Bend pterosaur. Outside of North America the only species positively shown to be of comparable age is *Titanopteryx philadelphiae*, based on a cervical from the Maastrichtian of Jordan (*12*). *Titanopteryx philadelphiae* differs from the West Texas specimens in having three low ridges on the dorsal surface of the neural arch, where none occur on the latter.

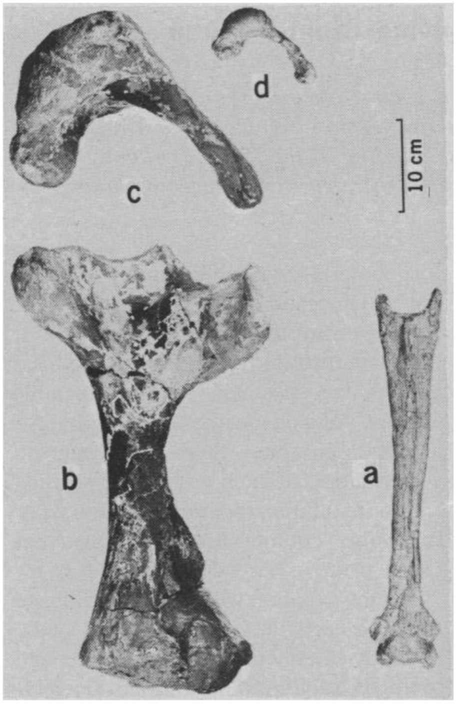

Fig. 1. Texas pterosaur. (a) Dorsal view of cervical vertebra of small specimen, (b) ventral view of left humerus of large specimen, (c) proximal view of left humerus of large specimen, and (d) proximal view of left humerus of small specimen. Scale, × ⅛.

Unlike most pterosaurs, the Big Bend flying reptiles were found in nonmarine sediment. Two of the specimens were found in a clayey floodplain siltstone associated with conglomeratic sandstone lenses deposited as flood splays or small reoccupied stream channels. The other, large specimen, which includes only parts of the left wing, was found in a sandstone deposited by a fine-grained braided stream. All of these specimens were buried more than 400 km inland from the Late Cretaceous nearshore deposits (Olmos and Escondido formations). The habitat and niche of this animal is not easily determined. The abundance of pterosaur bone fragments and the presence of Lower Cretaceous limestone cobble lenses in the Tornillo Group indicate that they may have frequented the hills directly to the west (*13*). The lack of perennial lake deposits, the small size and braided nature of the streams, the large size of the pterosaurs, the structure of their cervicals, and their close association with sauropod remains argue against a primarily piscivorous habit and may indicate a carrion-feeding mode of life. The soaring capacity of large pterosaurs (*14*) was probably similar to that of vultures (*15*), and this pterosaur had a neck long enough to probe a dinosaur carcass.

The Big Bend pterosaur as well as the Cretaceous pterosaurs from Wyoming and Jordan are noteworthy in the slenderness of the cervical vertebrae (Fig. 1a). In the Texas specimens the vertebrae range from 16 to 40 cm in length for the small specimens. Except for their great slenderness, they are similar in shape to the cervicals of *Deratorhynchus validus* (*16*), *Ornithocheirus* (*17*), *Pterodaustro guinazui* (*18*), *Dsungaripterus weii* (*19*), and *Pterodactylus longicollum* (*20*). The posterior end of the cervicals in these creatures possesses postzygapophyses that overhang the bulbous end of the centrum which in turn gives rise ventrolaterally to short posthypapophyses. The

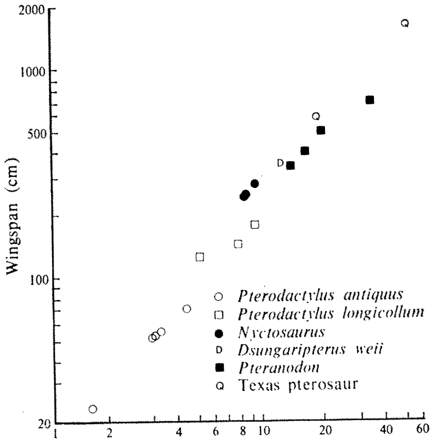

Fig. 2. Calculated wingspan against length of humerus for six pterosaurs, based on published measurements for *Pterodactylus antiquus*, *P. longicollum* (*20*), *Nyctosaurus*, *Pteranodon* (*21*), and *Dsungaripterus weii* (*19*) with estimated values for Texas specimens.

anterior end possesses stout prezygapophyses that extend far beyond the recessed procoelous centrum and the weakly developed prehypapophyses. In the Big Bend specimens the anterior end of the cervicals is composed of two large prezygapophyses forming a yoke that would surround, and a dorsoanteriorly extended procoelous centrum that would rest upon, the bulbous end of the preceding vertebra. This articular arrangement apparently allowed great lateral movement and significant upward movement but restricted downward movement.

The mandibles are long and slender, probably a meter in length. Although the anteriormost part of the dentary is missing, what is preserved indicates that the jaw expanded anteriorly, became triangular toward the tip, and bore no teeth. The strangely elongated jaw would seem to indicate an animal similar to *Pterodaustro guinazui* of Argentina (*18*) or *Pterodactylus antiquus* of Germany (*20*), but unlike *Dsungaripterus weii* of China (*19*) and *Ornithocheirus* of England (*17*), both of which possess extensively toothed, deep, short jaws.

The most distinctive feature of this Big Bend pterosaur is its immense size, for it is without doubt the largest flying creature presently known. The largest specimen from Big Bend has a humerus 52 cm long (Fig. 1, b and c), over twice that of *Pteranodon*. The deltopectoral crest is about half the length of the humerus, making it proportionally longer than in other pterosaurs. The expanded distal end of the humerus is equaled in proportion only by that of the Oregon pterosaur (*5*). Since this large specimen consists of a humerus and partial radius, proximal carpal, distal carpal, metacarpal, first phalanx, and second phalanx, an estimate of the wingspan can be made. Plotting the estimated wingspan against length of the humerus of *Pterodactylus antiquus*, *P. longicollum* (*20*), *Dsungaripterus* (*19*), *Nyctosaurus*, and *Pteranodon* (*21*) shows that for the pterodactyloids the wingspan increased more rapidly than the length of the humerus (Fig. 2), but within any one taxon the ratio of wingspan to length of humerus is constant. Therefore, if one uses the humerus as a standard and increases *Pterodactylus antiquus*—one of the most closely related forms with completely preserved wings—to an appropriate size, a wingspan of only 11 m is obtained. However, if one takes the dimensions of the wing bones preserved in the smaller Texas specimens and applies an allometric increase to these bones and to complementary wing bones in *Dsungaripterus* and *Pteranodon*, a wingspan estimate of 15.5 m results. Following the general trend for pterodactyloids from small to large taxa and extending it to the appropriate humerus length gives a wingspan of 21 m. The intermediate wingspan is accepted at this time.

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Immunofluorescence of Mitotic Spindles by Using Monospecific Antibody against Bovine Brain Tubulin

Abstract. *Monospecific antibody directed against bovine brain tubulin has been purified by affinity chromatography and tested against soluble tubulin and intact microtubules of brain and mitotic apparatus. Binding of the tubulin antibody to the mitotic spindle of rat kangaroo cells was demonstrated in all stages of mitosis by indirect immunofluorescence.*

Within the past 5 years, considerable interest has been directed toward elucidating the molecular structure, mode of assembly, and drug-binding capability of the protein tubulin (*1–3*). Revised methods of purification (*4, 5*) have permitted the isolation of a relatively large amount of tubulin which is nearly electrophoretically homogeneous and retains the capacity to assemble into microtubules. Production of antibody directed against tubulin has been reported (*6, 7*); however, the monospecificity of the antiserum (homogeneity of the antigen tubulin) has not been confirmed. Previous methods of tubulin purification for antibody production involved the formation of paracrystals of tubulin by using high concentrations of vinblastine (*7*). Although a large amount of the crystalline material was undoubtedly tubulin, the presence of other proteins was not ruled out in the preparation, since it was demonstrated that the resolubilized paracrystals possessed an appreciable amount of adenosine triphosphatase activity. To date, there has been no confirmation of such activity in purified 6*S* brain tubulin. A radioimmunoassay for outer doublet tubulin from *Naeglaria gruberi* has been reported (*8*).

In this report we present evidence for the production of monospecific antibody directed against pure bovine brain 6*S* tubulin. The antibody is relatively simple to produce and purify, and it has the ability to bind with microtubules as well as soluble tubulin. Studies using the indirect immunofluorescence technique demonstrate specific fluorescence of mitotic spindles during