Researchers remain divided over 'feathered dinosaurs'

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Feathered dinosaur candidate fossils have drawn huge interest from secularists who have fitted them into a dinosaur-to-bird evolutionary narrative. The same fossils draw interest from biblical creationists who strive to accurately categorize them into Genesis kinds. Some researchers, including creation paleontologists, accept feathered dinosaurs partly on the basis of detailed secular descriptions. Conversely, some creation scientists with expertise in other disciplines remain unconvinced that those secular descriptions have eliminated enough evolutionary bias to legitimize feathered dinosaurs as a Genesis-friendly category. In addition, secular reports fit the feathered dinosaur candidates into conflicting categories, and include disputes about whether certain fossilized structural remnants really represent feathers. Other intractable barriers against evolution from dinosaur to bird, including centres of mass and respiratory systems, should call into question attempts to conflate the categories. Thus, both creation and anti-creation researchers remain divided over how to categorize feathered dinosaur candidates, and even over the legitimacy of 'feathered dinosaurs' as a category.

While a large majority of secular scientists agree that some dinosaurs had feathers, creation scientists remain divided. The very concept of feathered dinosaurs arose only a few decades ago, when new fossils from China began to reveal fossilized fibres and later actual feathers still associated with some dinosaur-like fossils, plus fossilized fibres interpreted as protofeathers on other fossils. New discoveries of hard-to-classify extinct and feathered or fibred fossil forms have prompted some creation researchers to admonish their peers to embrace feathered dinosaurs. The various arguments that each side advocates reveal a healthy ongoing scientific and biblical exchange.

Not game-changing, but important (and fascinating)

Biblical creationists have long noted that Genesis 1 does not specify whether or not God created Day 6 land creatures including dinosaurs with or without feathers.[1] So what's the big deal?

Genesis 1:21 says: "So God created great sea creatures and every living thing that moves, with which the waters abounded, according to their kind, and every winged bird according to its kind. And God saw that it was good." Either God was correct when He asserted that "every winged *ôph* [flying creature, including birds, bats, pterosaurs, and insects]" reproduced "*according to* their kind", or today's secular scientists are correct when they assert the Genesis antithesis: that each winged flying creature evolved by morphing *between* fundamental kinds.

A genuine dinosaur (reptile kind) with *bona-fide* feathers that today characterize various bird kinds might not directly affront Scripture's within-kind demand, but it would fuel evolutionary bias by blurring between-kind lines. "We have clearly defined, anatomy-based categories for 'bird' and 'dinosaur,' but evolution needs a third, bird-dinosaur transition category."[2] Since secularists could more easily construe a feathered dinosaur to fit that third category, biblical scientists should show healthy caution in interpreting feathered dinosaur claims.

Some feathered dinosaur advocates use arguments from authority, which we consider weaker because they point to expert opinions instead of evidential analyses. Expert opinions have value especially for the expert who can pinpoint and explain fact-based supporting evidence to back their conclusions, but we find a lack of backing in some of the arguments put forth. The weakest of two arguments from authority that we have encountered in friendly verbal discussions asserts that creation researchers should trust evolutionary scientists' labels of 'feathered dinosaurs' because the evolutionists have first-hand and thus the most intimate knowledge of the fossils. But does this argument overlook the role of bias in evolutionary assessments? Despite close fossil interaction, secularists can succumb to the temptation to "willfully forget" evidence for creation and the Flood, as per 2 Peter 3:5, as well as to "suppress the truth" that aligns with biblical creation as per Romans 1:18.

Archaeopteryx and authority

This anti-creation bias probably surfaces when evolutionary paleontologists recategorize fossils. Even among evolutionists, one's assessment could depend on whether one believes that birds evolved from dinosaurs or from non-dinosaurian reptiles. For example, Chinese

workers Xu, You, and Han used a cladistics analysis to determine that *Archaeopteryx*, long considered a bird, better fit within the dinosauria.[3] Just a few months later, Australians Lee and Worthy performed a similar analysis, but emphasized different traits with different weights to find that *Archaeopteryx* groups with Aves after all:

> "The reinstatement of *Archaeopteryx* as a basal bird in both likelihood-based analyses contradicts macroevolutionary inferences that relied (at least partly) on the shift of *Archaeopteryx* into deinonychosaurs."[4]

Archaeopteryx certainly has a number of unambiguous bird features, as evolutionists and creationists have pointed out:

- Perching foot.[5] This means that its wings would have needed to be sophisticated enough to produce the special wing turbulences (leading edge vortices) like those of modern birds, so that it could land delicately on a branch.[6]
- Classical elliptical wings like modern woodland birds.[5]
- Fully-formed flying feathers (including asymmetric vanes and ventral, reinforcing furrows as in modern flying birds).[5]
- A large furcula (wishbone) for attachment of strong muscles responsible for the downstroke of the wings. Figure 1 shows the flight-ready *Archaeopteryx* furculum, as reconstructed from fossil comparisons.

Similarly, *Scansoriopteryx* (*Epidendrosaurus*) received happy initiation into the feathered dinosaur category only for a later analysis to settle its identity as 'a non-dinosaurian bird'.[7,8] Which authority should a non-expert trust and why?

A call for clarity on *Caudipteryx*

Caudipteryx is another favourite 'feathered dinosaur' that exemplifies a need for evidence to undergird an authoritative statement. General consensus among uniformitarians holds *Caudipteryx* as a basal form of the clade Oviraptorosauria—a word basically defined as 'feathered dinosaur'. However, a number of evolutionists have argued that it was an extinct bird that had lost its ability to fly, somewhat like today's flightless cormorants. For example, some eminent Polish dinosaur experts argue that birds did not evolve from oviraptorosaurs, but from earlier theropods. One lineage supposedly lost the power of flight to become evolutionary dead-end oviraptorosaurs. Some of their bird-like features include:

> "… extensive pneumatization; enlargement of the parietal portion of the skull roof; double-headed otic process of the quadrate; lateral cotyla on the quadrate for articulation with the quadratojugal; functional loss of contact between the palate and jugal; shallow or rod-like jugal. This set of traits is absent in non-avialan theropods but is present in advanced birds."[9]

We quote this not necessarily to prove that *Caudipteryx* was a bird, but to demonstrate the insufficiency of appealing, either directly or indirectly, to evolutionary expert analysis, since those analyses conflict over each supposed feathered dinosaur.

In other words, certain evolutionists have interpreted these extinct creatures as intermediates that support the evolution of non-flying dinosaurs into flying birds, but others as representing devolution *from* flying birds. While creation researchers disagree over whether or not one should call *Caudipteryx* a bird or dinosaur, we all agree that the 'grandfather paradox'—summarized in Alan Feduccia's quip that you can't be older than your grandfather—erases its evolutionary status. Granting evolutionary dating for the sake of argument, *Archaeopteryx* is allegedly 153 Ma,[10] and the beaked bird *Confuciusornis* is 'dated' to 135 Ma, but their alleged feathered dinosaur ancestors such as *Sinosauropteryx* and *Caudipteryx* are considered younger than their supposed descendants, 'dated' to ~125 Ma.

The definition of dinosaur needed to expand to include odd fossil bird-like forms like *Caudipteryx*. But why force definitions to evolve when not all evolutionists agree that birds evolved from creatures like these? Some evolutionists call this an odd bird with no dinosaur relation at all. Flip-flopping between huge category distinctions reveals root problems in interpretation. More complete data sets would help, as would the reduction of bias. An investigator can select or overemphasize traits that fit evolutionary or creationary narratives. After all, evolution's advocates would love to find feathered dinosaurs. Why should creation scientists uncritically swallow what evolution-believing experts say when they're saying different things?

What about bias?

The argument that biblical creationists should accept uniformitarian assertions of feathered dinosaurs suffers from a lack of control against evolutionary bias. A second argument from authority asserts that creation science skeptics of feathered dinosaurs do not have expertise in paleontology, whereas creation science believers in feathered dinosaurs do. Thus, the former should defer to the experts. But again, an expert should be able to supply factual backup when needed. The creation paleontologist who backs a feathered dinosaur category merely by referencing secular assessments ought first to explain why evolutionary bias played no role in those studies. They should also show why their expertise trumps that of evolutionary *paleornithologist* feathered dinosaur doubters like Alan Feduccia, Storrs Olson, and the late Larry Martin (1943–2013). Specific anatomical reasons to accept feathered dinosaurs would be more convincing than use of *argumentum ad verecundiam*—authority-based arguments.

We propose two anatomical categories as possible anchors for discernment: feathers and femurs, and we tentatively suggest that vertebral spinous processes, lung structure, and quill knobs might also help.

The traditional means of identifying birds was feathers. No living reptile or mammal has feathers. Therefore feathers should identify a fossil as a bird unless it has overtly distinct and virtually undisputed non-avian skeletal characters. But which fossils have real feathers?

Fibres for feathers?

One of the best known 'feathered dinosaurs' is the ~1-m-long *Sinosauropteryx*, a compsognathid dinosaur discovered in 1996. Some filaments ('fuzz') were discovered which have been widely interpreted as feathers or 'protofeathers,' since the filaments do not branch whereas bird feathers do branch. However, the animal was found in the common death pose, with its neck thrown back, which probably occurred during perimortem or postmortem degradation while submerged.[11] This extreme arching back caused the dorsal integument to buckle, and this buckling could be observable most sensibly if these filaments were part of a unified structure like skin, not feathers. Evolutionist and feathered dinosaur doubter Theagarten Lingham-Soliar explains:

> "... compressive and tensile forces acting on a clearly unified structure, i.e. an upright frill or crest overlying the neck, back and tail of *Sinosauropteryx* … as opposed to individual proto-feathers, is considered more reasonable ... . The results include the most controversial issue associated with *Sinosauropteryx* and strongly demonstrate, based on soft tissue analysis and forensic animation, that the dorsal, externally preserved integumental tissue represents a dorsal crest rather than protofeathers … ."[12,13]

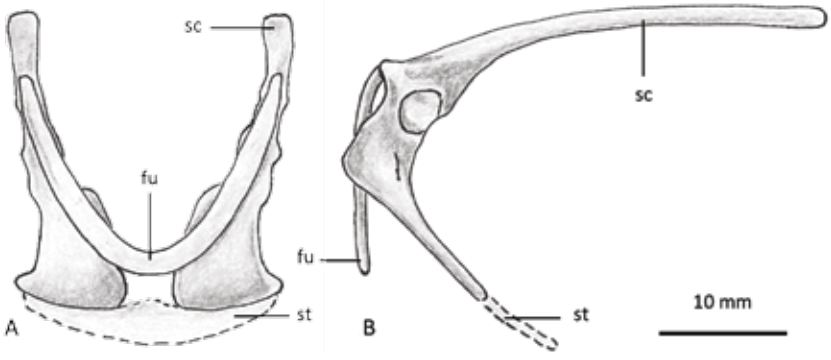

Figure 1. *Archaeopteryx pectoral* girdle, restored on the basis of different specimens. A) Front view. B) Left lateral view. Drawing after Wellnhofer, p. 128. fu: furcula; sc: scapula; st: sternum.

A buckled dorsal skin crest, like that in iguanas, partly decayed, leaving skin fibres, not feathers at all. Figure 2 shows a *Sinosauropteryx* specimen with a darkened halo, also found surrounding many clearly identifiable forms like mosasaurs that may represent organic remnants. The halo dorsal to the spine in this specimen conforms to the Lingham-Soliar explanation of diagenetically altered skin frills. He co-authored a 2005 study that found a very close match between decayed skin fibres and the fossil 'protofeathers'.[14] Also, Lingham-Soliar shows that *Sinosauropteryx's* tail didn't end in a taper, but in a spatula shape with 'fuzz' around it. He suggests that since the fossil is found associated with lacustrine biota, *Sinosauropteryx* was probably semi-aquatic, and a spatulate structure would greatly aid propulsion through water:

> "Finally, it is bewildering that in a lacustrine environment, a crest-like structure on the tail or body or both, useful in swimming, is generally not even contemplated in dinosaurs such as *Psittacosaurus*, *Sinosauropteryx*, *Tianyalong*, and *Beipiaosaurus*."[12,15]

This is a huge contrast from *real* feathers, which Lingham-Soliar analyzed under an electron microscope when he discovered the "biomechanically 'ingenious' and novel architecture of the fibre organization".[16]

His 2016 study of rotting ostrich carcasses found more evidence that supposed protofeathers are actually collagen fibres from decaying skin. First, the ostrich feathers on land scattered into a tangle with no organization in under 100 hours during degradation. In water, feathers detached after just a few days of rotting, then scattered and travelled further from the carcass. Lingham-Soliar contrasts those tangled feathers with the organized fibres in the fossils. Second, after the carcass had completed its five-day rotting and become skeletonized, its skin, bones, and some connective tissue remained largely intact even after its internal organs and muscles were gone. He noted that the skin's persistence—including the ostrich scaly foot skin—matched the skin remnant interpretive scenario for 'protofeathers'. He wrote: "The presence of internal structural fibres protected by skin and scales before ultimate destruction is the parsimonious explanation."[17] Further, he noted that the most pronounced 'opisthotonous' posture occurred under water, "strongly supporting the post-mortem hypothesis of the phenomena".[17] These fibres of possible skin remnants thus seem utterly insufficient to classify *Sinosauropteryx* as a bird rather than a dinosaur.

A 2017 report from senior author Jakob Vinther has disputed some of Lingham-Soliar's work on *Sinosauropteryx*.[18] It uses higher resolution photography to demonstrate that some 'collagen' fibers were actually preparation marks made by air scribes, and others were were actually tiny, linear features of the sedimentary matrix. However, three *Sinosauropteryx* specimens do have very dark fibrous remnants. These may or may not represent collagen, but nor do they likely represent feathers, since feathers are branched and these fibers are not. Without real feathers, the animal would not fit a feathered dinosaur category.

The 2012 description of an estimated one-tonne Chinese tyrannosaurid with 'feathers' fits a similar description.[19] It had non-branching fibres only. They could represent frayed collagen fibres from partially decayed skin. If they were non-branching feathers, as the authors asserted, then they would be unprecedented biological structures, they would be unprecedented in reptiles, and they would have been purely aesthetic since the animal and its fibres were utterly unsuited for flight. Why insist on a feather interpretation when it carries this kind of baggage and when the simpler, albeit less exciting, decayed skin interpretation fits the data just fine?

In contrast, some supposed feathered dinosaurs like *Microraptor* had asymmetrical feathers and gross anatomies outfitted for flight or at least for gliding. What clear non-avian skeletal structures demand a reptilian as opposed to the avian classification for *Microraptor* that its feathers indicate?

Figure 2. *Sinosauropteryx prima*, an Asian compsognathid, displayed at the Hong Kong Science Museum. Specimen shows darkened halo adjacent to body, especially dorsal to the spine. In some specimens, the halo extends over body parts including forelimbs and cheeks and consists of defined fibres interpreted either as protofeathers or diagenetically reduced skin remnants. Image: Laikayiu, *Wikipedia*.

Limb structure and centre of mass

Flying birds have a distinct anatomy for flight, which their very powerful front limbs power. So a flying bird's centre of mass lies quite close to the wings, in contrast to a theropod where the centre of mass rests over its hips. An evolutionary transition would have needed to shift the mass forward for flight. Feduccia argued long ago:

> "'It's biophysically impossible to evolve flight from such large bipeds with foreshortened forelimbs and heavy, balancing tails,' exactly the wrong anatomy for flight."[20]

If the supposed mass shift happened before the wings fully formed, then the resulting dinosaur would obviously not yet fly, but couldn't run either. It would fall on its face figuratively and literally. Similarly, flight or even gliding wings like those on *Archaeopteryx* would get in the way of theropod locomotion enough to label their possessor less fit, ending its line of descent long before it could reach a flying bird stage.

Femur orientation dovetails with body balance, and should help adjudicate between bird and dinosaur. Avian femurs are housed within their bodies, integrate with and stabilize their air sac networks, and move very little. "What seems like its 'knee' is equivalent to our ankle",[1] whereas dinosaur legs hinge at the hip. This is important for their breathing:

> "The thin walled and voluminous abdominal air-sacs are supported laterally and caudally to prevent inward (paradoxical) collapse during generation of negative (inhalatory) pressure: the synsacrum, posteriorly directed, laterally open pubes and specialized femoral-thigh complex provide requisite support and largely prevent inhalatory collapse."[21–23]

Ground-dwelling birds like cassowaries and roadrunners resemble the candidate feathered dinosaurs more closely than powerful flying birds do. Even these ground-bound birds use the fixed-thigh structure of strong flying birds. Preliminary reconstructions of *Microraptor* skeletons seem to show that if its thigh pointed down like dinosaurs (i.e. its legs hinged at the hips and not the knees), then its centre of gravity would have been too far forward. It would have fallen on its face. But by orienting its femurs forward to maintain anteroposterior balance, its centre of gravity would have hinged over its 'knee', as in birds. Creationary advocates of feathered dinosaurs might more easily persuade peers if they could construct digital or physical models of the fossils in question to test where the centre of gravity lies over the wings (i.e. bird) versus hips (i.e. theropod) femur orientation.

Caudal spinous processes

In addition to limb structure and centre of mass, a third key avian structure that might serve as an objective adjudicator between dinosaur and bird is the height of spinous processes on tail vertebrae. Theropods had tall spinous processes used for muscle attachments, resulting in powerful and finely controlled tail movements. But flying birds generally have few or no spinous processes on their caudal vertebrae. Therefore, somewhere along the supposed evolutionary line, theropods dropped the spinous processes. Those dramatic reductions in muscle attachments and in mass surely reduced control of the tail. Wouldn't its fully tailed cousins outcompete it on tight turns while chasing food? This means that natural selection would tend to keep the heavy tail musculature instead of moving the centre of mass forward for flight.

Admittedly, spinous processes may not help classify all the feathered dinosaur candidates, since some extinct ground-based birds may have had somewhat prominent ones. But could they at least help identify *flying* birds in the fossil record? For example, *Microraptor*'s long, bony tail vertebrae had no spinous processes, consistent with a flying, not a primarily running anatomy. It did have feathers connected to its hind legs. It had bird feathers, possibly bird fixed thighs, and non-theropod caudal vertebrae. So why not classify it as a four-winged, extinct, feathered, running/gliding bird?

Perforate acetabula

Probably the most definitive anatomical characteristic of dinosaurs is their open (or 'perforate') acetabula. The three hip bones ilium, ischium, and pubis join at the acetabulum—the socket into which the head of the femur articulates. Other tetrapods, including non-dinosaur reptiles, mammals and birds, have a closed, cup-shaped acetabulum, which derives from the Latin for 'little vinegar cup'. All (and only) dinosaurs had no bone at the back of their acetabula. Figure 3 shows two dinosaurs' open acetabula.

Thus, a definitive feathered dinosaur fossil should show preserved, branching feathers associated with a skeleton having an open acetabulum. *Archaeopteryx, Scansoriopteryx,* and *Microraptor* had partially open but largely closed acetabula[7] unlike those completely open in dinosaurs and unlike those completely closed in modern birds. In conformity to their many other bird-like features such as feathers, these at least seem better described as odd, extinct birds than as 'feathered dinosaurs'. Has anyone found a fossil with a completely open acetabulum plus feathers? If so, why not simply let that evidence cut to the chase of changing feathered dinosaur doubters' minds?

Avian lung

Birds use flow-through, one-way lungs, connected to air sacs and even to their hollow bones. This system

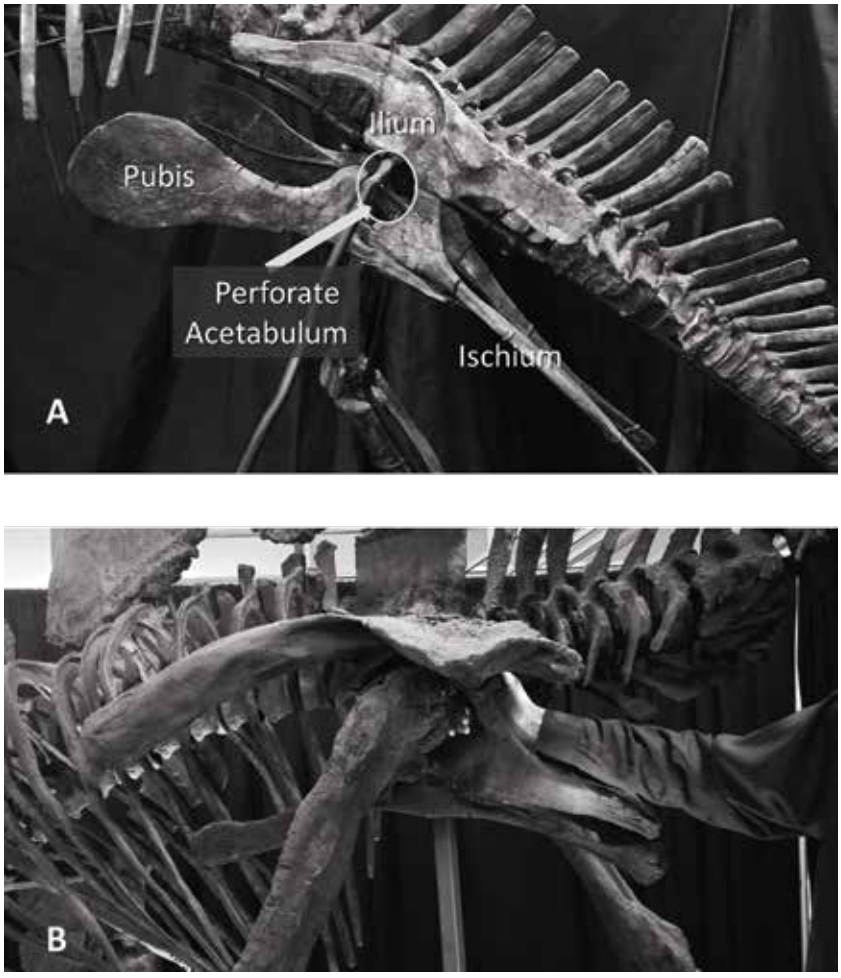

Figure 3. Perforate acetabula in dinosaurs. A) Steel armature travels through the perforate acetabulum seen in an original fossil juvenile *Edmontosaurus*. Bones of the ornithischian hip girdle are also labelled. B) Author's (BT) fingers extend through the open acetabulum in a replica fossil adult *Stegosaurus* (also order Onithischia). The acetabulum is proposed as an anatomical indicator of feathered dinosaurs. Note also the prominent caudal spinal processes for tail muscle attachments. Birds lack these processes.

keeps air flowing in one direction through gas-exchanging parabronchi in their elliptic-shaped lungs, and blood moves through the lung's blood vessels in the opposite direction for efficient oxygen uptake.[10] This excellent engineering design explains why birds don't gasp for breath after they land.[11] *Archaeopteryx* had such a system.[24]

However, reptiles, probably including *Sinosauropteryx*, have a bellows-like lung.[25] But could one type turn into another by slow-and-gradual changes if each stage must have a selective advantage over the prior one? On the contrary, the hypothetical intermediate structures would probably have lethal selective disadvantages including a diaphragmatic hernia:

> "The earliest stages in the derivation of the avian abdominal air sac system from a diaphragmatic-ventilating ancestor would have necessitated selection for a diaphragmatic hernia in taxa transitional between theropods and birds… . Such a debilitating condition would have immediately compromised the entire pulmonary ventilatory apparatus and seems unlikely to have been of any selective advantage."[25]

Despite their bellows-like lungs, some reptiles, including iguanas, monitor lizards, and alligators, have been discovered to possess a form of unidirectional airflow.[26] However, they don't need the avian system of air sacs and parabronchi; instead, the airways are shaped and angled to generate jets that produce one-way airflow,[27] an ingenious design that humans may never have imagined possible.[28]

These unique and exquisitely functional lungs come nowhere close to solving the basic problem of how to go from one structure to another with the undoubtedly lethal intermediate forms between bellows and flow-through lungs. It also raises the question of what selective forces would drive such a change. Why evolve flow-through lungs for unidirectional airflow if this can be managed by properly designed bellows lungs? And unidirectional airflow couldn't have been driven by the requirement for flight, since it supposedly arose in non-flying creatures—never mind the fact that a mere requirement for flight could never actually engineer a body fit for flight.

All creation researchers—whether they accept feathered dinosaurs or not—should agree that this hypothetical lung transition remains a huge problem for evolution. We further suggest that it adds caution to feathered dinosaur interpretations. Of course, lungs are soft tissue, so fossil interpretation is always problematic without exceptional preservation or close analysis of the difficult-to-access interior rib cage for attachment points of muscles involved with breathing. Creation-based feathered dinosaur proponents should reject an evolutionary transition between these distinct types since no data supports such a scenario, but their case for feathered dinosaurs would be strengthened by demonstrating, for example, that *Archaeopteryx* had a bellows lung after all, or that the claimed feathered dinosaurs had the avian parabronchial flow-throw system.

Quill knobs

Some researchers have granted feathered dinosaur status to fossils on the basis of quill knobs. These bone bumps occur as small, shallow tubercles along the rear ulna in birds that use powered flight. Each one anchors a ligament that attaches to the base of a large pennaceous feather. This system helps critical flight feathers resist the physical rigours of strong flight. Quill knobs in extant birds have regular sizes and maintain regular distances between one another. In contrast, the supposed quill knobs on the few feathered dinosaur candidates with forearm tubercles have more variations in size, show irregular spacing, and instead of a neat row along the rear (caudal) ulna, are oriented at different angles along the bone. This latter feature means that if the tubercles were quill knobs, their attached feathers would stick out in places unfit for wings and possibly unfit for anything.

Extant non-avian bones can have small bumps for use as attachment points for sheets of connective tissue or tendons that have nothing to do with feathers. Why must these fossil bone bumps carry quill knob status when they fail to match avian quill knobs?

Quill knobs do not occur on some gliding birds' bones today, e.g. the albatross, so the feature is not diagnostic of all birds. Some *Velociraptor* forearms had bumps interpreted as quill knobs, but most have no bumps there.[29] Features that have equivocal interpretations like fibres and tubercles always seem to receive the most evolution-friendly options. Thus, evolutionary bias may have unduly influenced interpretations of fibres as feathers and shallow tubercles as quill knobs.

Conclusion

Differences among creation researchers over 'feathered dinosaurs' should not trump agreement on larger issues. Believers in biblical creation agree, on solid anatomical grounds, that dinosaurs did not evolve into flying birds. We also agree on biblical grounds that if there were feathered dinosaurs, then God must have directly made them that way or designed them with the potential to develop that way. Disagreement arises over whether any candidate fossil *demands* feathered dinosaur status.

The current admittedly non-expert authors welcome suggestions of additional anatomical touchpoints for consideration, application of these touchpoints in evaluations of candidate feathered dinosaurs, and in short more convincing evidence than so far presented. In addition, we suggest that discussions about feathered dinosaurs avoid authority-based arguments when possible, deal with the role that evolutionary bias might play in secular cladistics

and fossil feature interpretations, and offer appropriately objective means to adjudicate between secular identifications of a particular fossil as a feathered dinosaur and secular identifications of the same particular fossil as not a feathered dinosaur.

In short, more concrete evidence such as feathers, femurs, and acetabula, or more clear explanations of that evidence, should help resolve disagreement over how to categorize certain strange and extinct birds or bird-like creatures.

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