The Paleontograph

A newsletter for those interested in all aspects of Paleontology
Volume 4 Issue 1 March, 2015

From Your Editor

Welcome to our latest issue. Spring is almost here and so is field season which always gets me excited. I know I must sound like a broken record (that phrase really dates me) but I have been very busy and I apologize for the long time since the last issue. With this issue we start Volume 4.

I am working on moving to Colorado, which I am very excited about. The move will bring me much closer to my collecting areas and I will be able to turn what is now a weeklong trip into a long weekend trip. Of course, the main reason for the move, is that it will bring me much closer to my granddaughter.

So please enjoy this latest issue.

The Paleontograph was created in 2012 to continue what was originally the newsletter of The New Jersey Paleontological Society. The Paleontograph publishes articles, book reviews, personal accounts, and anything else that relates to Paleontology and fossils. Feel free to submit both technical and non-technical work. We try to appeal to a wide range of people interested in fossils. Articles about localities, specific types of fossils, fossil preparation, shows or events, museum displays, field trips, websites are all welcome.

This newsletter is meant to be one by and for the readers. Issues will come out when there is enough content to fill an issue. I encourage all to submit contributions. It will be interesting, informative and fun to read. It can become whatever the readers and contributors want it to be, so it will be a work in progress. TC, January 2012

Edited by Tom Caggiano and distributed at no charge

Tomcagg@aol.com

Homo floresiensis: The Controversy That Will Not Die

Bob Sheridan September 1, 2014

It has been about 10 years since the description of *Homo floresiensis* (often referred to has "the hobbit"), and I have had the opportunity of relating many of the reports about it in the Paleontograph since that time. So fair warning, I will be repeating some of my earlier writing in setting up the background. In 2004 remains of a new hominin was discovered in Liang Bua cave on the island of Flores in Indonesia (Brown et al., 2004). The original specimen called LB1 appeared to be very small (1 meter tall), had a very small brain for its body size, and yet was very recent (~18,000 years). Many postcranial remains of *Homo floresiensis* were found spanning a time of 90,000 years, plus some associated stone tools. However, there was and, I believe still is, only one skull available, although a second (chinless) jaw was found. The controversy was over what LB1 represented. The opposing camps were:

1. *Homo floresiensis* is a new very primitive small hominin that survived until 18,000 years ago without anyone being aware of it before. The original origin story is that Homo floresiensis is a variety of Homo erectus (fairly large hominin species known to exist in Indonesia until about 1 Myr ago) that underwent "island dwarfing."
2. The *Homo floresiensis* remains are of a pygmy group of modern humans (today there are many groups of small-statured people around Indonesia), and the LB1 skull is from a pathological individual with an anomalously small brain (perhaps because of microcephaly).

Note that both explanations seem improbable. There never had been any hominin other than Homo sapiens known to survive more recently than 30,000 years ago; the last rivals were the Neanderthals who were large and had large brains. On the other hand, pathological conditions like microcephaly are so rare that it would be unexpected that the one preserved skull among a large group of hominins would show that condition. It also struck me since that there is a third far-fetched possibility, that the dating is wrong because of some not-yet-realized issue with Liang Bua, but as far as I have read, no one has offered that explanation. This controversy was very fierce and took on a political dimension, with many accusations about the discoverers trying to hide the fossils from examination. Also there were accusations that the Indonesian paleoanthropologists, who generally favored the second explanation, unfairly restricted access to Liang Bua.

Most of the original controversy concerned the skull of LB1, whether or not its brain (as an endocast) was the same size and shape as that of microcephalics, whether some modern humans lack chins (some do!), etc. A recent work by Baab et al. (2013) suggested that indeed LB1 is similar in skull morphology to Homo erectus and not similar various pathological conditions like microcephaly (the brain failing to grow during development), "cretinism" (caused by lack of thyroid hormone or insensitivity to it), and Laron syndrome (lack of sensitivity to human growth hormone).

If you look at parts other than the skull, the situation gets even weirder. An analysis by Trocheri et al. (2007) of the wrist bones and Jungers et al. (2009) of the ankle bones of *Homo floresiensis* showed that that these parts are much more primitive than expected from modern humans (including ones with various deformities), even more primitive than expected for *Homo erectus*, perhaps equivalent to *Homo habilis*, which lived up to 1.5 Myr ago. *Homo habilis* is already small, so no dwarfing is required. However, since *Homo habilis* is known only from Africa, we have the problem of how such creatures would get to an island in Indonesia.

There was also some discussion about whether the stone tools found in Liang Bua could have been made by a small-brained hominin. It has always struck me as a strange argument because we just do not know what type of brain is required for which tools.

I was surprised to see a revival of the "pathological modern human" explanation in PNAS this week. There are two papers from the same group of authors: Eckhardt et al. (2014) and Hennenberg et al. (2014). This is a collaboration between the University of Adelaide (Australia), Penn State, and the National Institutes of Earth Sciences (China). These are the arguments presented:

1. The proposed Homo floresiensis is an unexpected anomaly, with a brain much smaller than expected using the trajectory of previously known hominins.

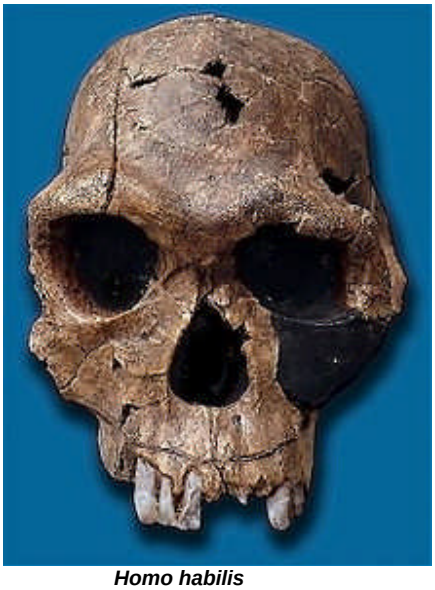
Cont'd

Hobbit Cont'd

1. The proponents of the "new species" idea keep changing their explanation of the origin of *Homo floresiensis* even though the data has not changed in a long time.
2. The skull of LB1 is detectably asymmetrical, and the upper arm bones of LB1 show deformities relative to other arm bone specimens of *Homo floresiensis*. (Most of the time asymmetry in a fossil skull would be assumed to be due to distortion after fossilization, but none of the other bones are distorted.)
3. Pathologies are not so rare that we would never find a fossil example.
4. Each individual trait (small stature, lack of a chin) for *Homo floresiensis* has some precedent in modern populations and does not require thinking up a new species.
5. The stature of *Homo floresiensis* is underestimated. There are other ways to calculated it (for instance using limb proportions from modern Asian pygmies) that would make the height about four feet instead of three feet, within the range of modern pygmies.
6. Skulls have been found in Flores (but not in Liang Bua) that are in the lower range of modern humans in brain size.
7. People with Down's Syndrome have unusually short femurs, may have asymmetric skulls, and can have brains much smaller than average. Also Down's Syndrome is not particularly rare. Therefore pygmy *Homo sapiens* with Down's Syndrome is the best explanation of LB1.
8. One should not erect a new species based on a single (possibly pathological) specimen unless other possibilities are eliminated.

A lot of this is a reboot of the arguments from 2004, substituting Down's syndrome for microcephaly. To me some of these points are irrelevant or misguided. For instance, I don't think anyone disputes that finding a small-brained hominin in recent times is unexpected, as in point 1. I don't think point 2 is an indication of a problem either; it is a good thing to find new explanations for old data, and is not the same as "grasping at straws." Point 5 could be used to say that Neanderthals are really *Homo sapiens*; each of their individual skull traits can be found in modern humans. I don't think we can take the characteristics of fossils found elsewhere on Flores to be a counterexample to LB1, as in point 7. Finally, paleoanthropologists are always raising new species based on a single specimen, as in point 9, although it must be admitted that having more specimens is always better. On the other hand, some of the other points seem valid. In particular, it is true that many times in paleontology looking at things slightly differently has eliminated seeming anomalies. (My favorite is when the original weird reconstruction of Hallucinogenia was realized to be a very ordinary-looking velvet worm turned upside down.) However, every now and then an anomaly turns out to be something unbelievably bizarre and yet real.

Homo floresiensis



Homo habilis

Hobbit Cont'd
As with many controversies in science, it comes down to arguing who has the burden of proof and which way Occam's Razor cuts (i.e. which explanation involves the fewest ad hoc assumptions). One group says that if the fossil remains imply X, then the most likely explanation is X. Another group (in this case Eckardt et al.) says that if X is unexpected all non-X explanations must be eliminated first. This is a common situation in paleontology, a field that deals with biology, where there is an exception to every rule, and where much data is missing, and one cannot produce more at will. What appears to be X may not be X, and it may be impossible at any given time to fully eliminate non-X. There is not yet enough data to judge the relative likelihood of either hypothesis, both of which still seem improbable at the moment. However, finding one more skull in Liang Bua would clear up much of the controversy.

Sources:

Baab, K.L.; McNulty, K.P.; Harvati, K.
"*Homo floresiensis* contextualized: a geometric morphometric comparative analysis of fossil and pathological human samples."
PLoS ONE 2013, 8, e69119.

Brown, P.; Sutikna, T.; Morwood, M.J.; Soejono, R.P.; Jamitko; Saptomo, E.W.; Due, R.A.
"A new small-bodied hominin from the Late Pleistocene of Flores, Indonesia."
Nature 2004, 431, 1055-1061.

Eckhardt, R.B.; Henneberg, M.; Weller, A.S.; Hsu, K.J.
"Rare events in earth history include the LB1 human skeleton from Flores, Indonesia, as a developmental singularity, not a unique taxon."
Proc. Natl. Acad. Sci. 2014, 111, 11961-11966.

Hennenberg, M.; Eckhardt, R.B.; Chauvanaves, S.; Hsu, K.J.;
"Evolved developmental homeostasis disturbed in LB1 from Flores, Indonesia, denotes Down syndrome and not diagnostic traits of the invalid species *Homo floresiensis*."
Proc. Natl. Acad. Sci. 2014, 111, 11967-11972.

Jungers, W.L.; Harcourt-Smith, W.E.H.; Wunderlich, R.E.; Tocheri M.W.; Larson, S.G.; Sutikna, T.; Due, R.A.; Morwooed, M.J.
"The foot of *Homo floresiensis*."
Nature 2009, 459, 81-84.

Trocheri, M.W.; Orr, C.M.; Larson, S.G.; Sutikna, T.; Jatmiko; Saptomo, E.W.; Due, R.A.; Djubiantono, T.; Morwood, M.J.; Jungers, W.L. "The primitive wrist of *Homo floresiensis* and its implications for hominin evolution."
Science 2007, 317, 1743-1745.

How It All Began

Alan Russo

It was the early 1980s and I had a real lust for traveling. I also had a strong love for Nature and exploration. I loved to travel to new Ecosystems, discovering new plants and animals I had never seen before. I had a real love for the natural sciences and many of my hobbies revolved around them. I had always had a real fascination with fossils and always thought it would be cool to find one. At this point in my life I had not found a fossil, and like most people, I thought you had to be a scientist or paleontologist to find one.

It was summer and I was itching to hit the road. I had plenty of vacation time so my girl and I decided to go to Niagara Falls, a place I had never been, but always wanted to see. Besides, stopping along the way to explore would be the best part of this long trip.

We had been on the road for a while and I was getting tired, so we checked out the map to see what was around. I saw a place called Darian Lakes State Park and thought it sounded pretty good so we headed there. We got there around dinner time and set up camp. I started to get dinner ready and my girl decided to go check out the river behind our camp site just to relax a bit before dinner. About a half an hour later she came back with a big smile on her face, “I think I found a fossil”. “You can’t just go out and find fossils” I said with certainty in my voice. “Look” she said, I did, and I couldn’t believe my eyes! She had found a rock with a shell impression in it. No mistake, it was a fossil. Needless to say I was super excited. I woofed down dinner and asked her to show me where she found it.

Cont'd

When I got down to the river I started exploring and just about anywhere I looked, there was some trace of a marine animal. I knew enough about marine life that I was certain they were marine in origin and I also recognized a few from books I had read on fossils. Needless to say I spent the whole rest of the day exploring and digging up rocks to see what treasures I could find. Change of plans, this campsite will become more than an overnight resting place; we will stay a couple of days exploring the river.

The next day we spent most of the day looking for fossils. We decided to walk down the river to see what we could find. The river was shallow and cool and meandered through the forest at a slow pace. I'll never forget this one spot on the river where the bank was tall and steep. As I started to climb up the loose gravel, I could see fossils lying everywhere. There were lots of curved conical shaped fossils; I later learned were horn corals. All and all, we found some amazing stuff that day.

When we got home from the trip I spent some time going through what I had found. I couldn't ID most of it, so I went to the Gregory Museum in Nassau County, LI and was told I could bring in some samples in to get identified. The Nassau County Curator of Geology sent back the samples all numbered and identified with descriptions for each. I still have the typed letter and hand written ID sheet (no computers back then) with my collection. I have only been back to Darian Lakes State Park one other time many years later and it wasn't as good as I remember back then, but it was good enough where I would go back again if I had the chance. Needless to say, my life hasn't been the same since.

Spinosaurus Shown to be a very Unusual Theropod

Bob Sheridan, September 12, 2014

Spinosaurus is already a very famous theropod. The original holotype (fairly fragmentary) specimen was excavated from Egypt in 1912 by German paleontologist Ernst Stromer. One interesting aspect is that the holotype was destroyed by a bombing raid on Munich during World War II, although plaster casts survive. There are at least three unusual things about Spinosaurus. First, it is very large, probably longer than Giganotosaurus, although a firm estimate was hard to come by given the incompleteness of the known specimens. Second, it has a long snout with conical teeth, and there is a notch near the tip the maxilla, somewhat like the snout of a crocodile. This gave rise to the speculation that Spinosaurus ate fish. This speculation was confirmed by looking at isotope ratio in the bones. Third, it has very long neural spines; it had some kind of dorsal sail or hump. At least five other very fragmentary specimens have been excavated between 1915 and 2005. Similar theropods are Suchomimus (from Niger) and Baryonyx (from England). The biggest difference is that these dinosaurs are smaller and lack the tall sail. Although "Jurassic Part III" is an awful movie, it did have a scene where Spinosaurus beats Tyrannosaurus in a fair fight. Of course, Spinosaurus lived about 40 Myr. before Tyrannosaurus, so that could never happened in real life.

Cont'd

Spinosaurus Con't

Ibrahim et al. (2014) describe a new specimen of *Spinosaurus aegypticus* excavated from Morocco. This is a subadult specimen which is much more complete than any previous Spinosaurus specimen. The bones were scanned and processed digitally, so it is possible to extrapolate a complete size-adjusted adult Spinosaurus skeleton from the new specimen and previous specimens. From this, Spinosaurus would indeed be very large: 15 meters long, as compared to 12.5 meters for Tyrannosaurus.

The new specimen reinforces the idea that Spinosaurus is a quite unusual theropod. The long snout with conical teeth is consistent with older specimens. The new specimen shows clearly that the nostrils are not at the tip of the snout, but at the upper part of the skull near the eyes. The forelimb is very long and thick for a theropod. The pelvis, on the other hand is very small, and the hindlimbs are very short, not much longer than the arms. Whereas most large theropods have their femurs about the same length as the tibia, Spinosaurus has a very short femur. The center of gravity of Spinosaurus would be far in front of the pelvis. Clearly, this is not an animal that could walk on its hind legs like most theropods. Digit I of the foot (i.e. the big toe) is very long in Spinosaurus, whereas in most theropods it is so small, it would never touche the ground. The tail lacks stiffening lateral processes on the vertebrae, so was probably very flexible.

Also unusual is the bone density in Spinosaurus. In most theropods, the long bones tend to be hollow, whereas in Spinosaurus the hollow spaces are smaller; the bone density seems 30-40% higher than expected.

To the authors, all these characteristics suggest "fish-eating swimmer" as a lifestyle. Although one can explain away individual characteristics (for example there are land-dwelling sauropods with high nostrils), that seems the simplest explanation for the whole package. How to explain the long neural spines as part of an aquatic lifestyle is not as straightforward. The spines show vertical striations, which suggest to the authors that they were covered snugly with skin, as opposed to being embedded in a hump. This would suggest Spinosaurus had a "sail." The usual suggested explanations for having a sail are thermoregulation and display. A swimming creature would be surrounded by water, so a thermoregulating sail probably would be of no use. This leaves the function of the sail as display, with the assumption that it would protrude above the water while Spinosaurus was swimming.

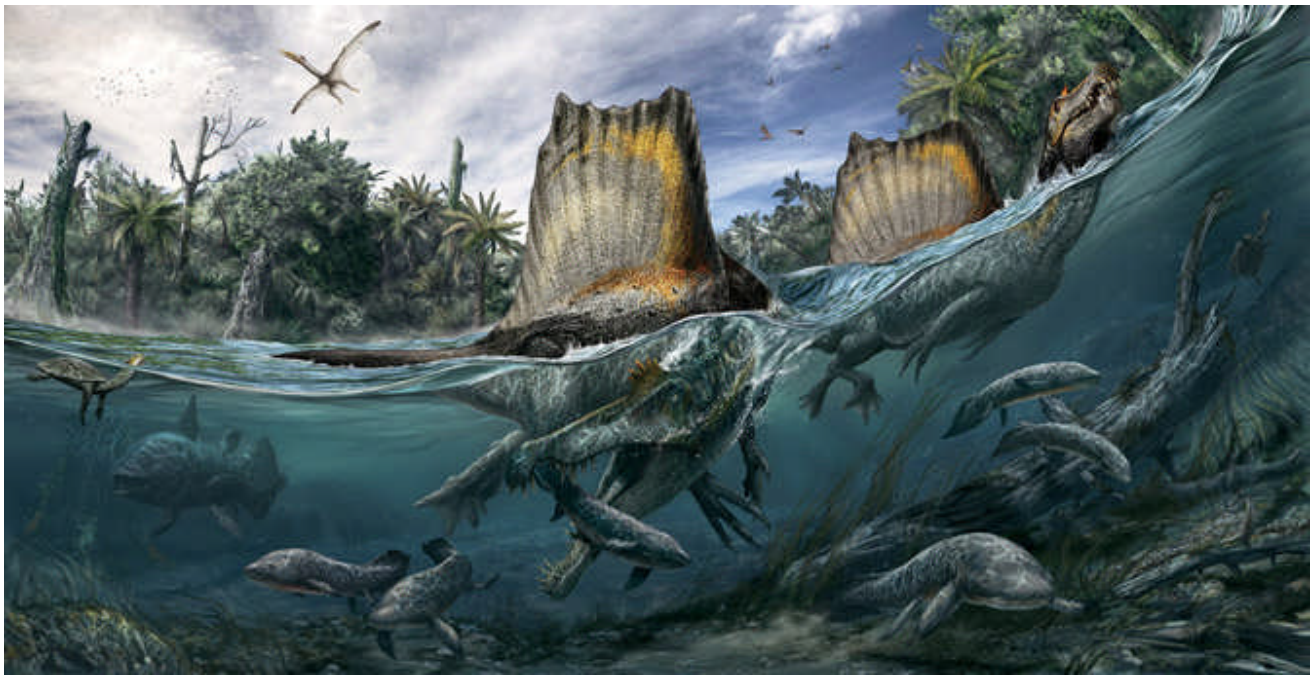
While there are other dinosaurs that probably ate fish, this is the strongest evidence for a swimming dinosaur.

Sources:

Balter, M. "Giant dinosaur was a terror of Cretaceous waterways." Science 2014, 345, 1232.

Ibrahim, N.; Sereno, P.C.; Dal Sasso, C.; Maganuco, S.; Fabbri, M.; Martill, D.M.; Zouhri, S.; Myhrvold, N.; Iurino, D.A. "Semiaquatic adaptations in a giant predatory dinosaur." Science 2014, 345, 1613-1616.

Picture from National Geographic



How Helicoprion Ate

Bob Sheridan, September 20, 2014

Helicoprion is one of those problematical fossils the interpretation of which is not obvious until many years after its first discovery. The specimens of Helicoprion (which are Late Carboniferous to Early Triassic in age) appear to be a two-dimensional spiral with three turns. Attached to the spiral are several dozen triangular teeth pointing outward, with small teeth in the center of the spiral and large teeth on the outside. (Hence the name "tooth-whorl", and the whorl has been compared to the blade of a circular saw.) The spirals can be up to 17 cm in diameter. The first discovery of Helicoprion was in 1899. Specimens have been found in Asia and North America. Note that since sharks have skeletons made mostly of cartilage, it is not unusual that nothing but teeth or the parts of the jaw supporting the teeth are preserved.

Since the teeth resemble shark teeth and since individual rows of shark teeth grow out in whorls, it is quite clear Helicoprion represents some kind of shark, albeit an unusual one. Where the whorl on the shark would be was not clear for a long time, and there have been many guesses: upper jaw, lower jaw, some kind of spiral crest on the head or dorsal fin, etc. Even when we could establish the whorl in the lower jaw, did the whorl point up into the mouth or down? Not until the discovery of the skull of a similar shark Ornithoprion in the 1960s did we have an idea that the tooth-whorl was in the lower jaw and that the jaw was short, no longer than the diameter of the whorl.

Helicoprion specimens have recently been CT-scanned and we therefore know the position of the whorl relative to the jaw bones. About half of the whorl is exposed, and half buried in the jaws. The whorl points into the mouth with the largest teeth pointing toward the throat. The upper jaw is not preserved. However, since we know the position of the upper jaw relative to the lower jaw in sharks, a good guess can be made as to the position of the upper jaw. As expected, the lower jaw of Helicoprion is very narrow from side-to-side and there are no other teeth aside from those in the whorl. The jaw has a unique process that points upward and keeps the mouth closing far enough that the whorl would puncture the roof of the mouth. Given the location and size of processes on the jaw bones, a good guess can be made as to the muscle attachments.

So we have a shark with a circular saw blade inside the mouth and no other "tools." How would this be used? Ramsay et al. (2015) do a biomechanical analysis and suggest a feeding mechanism. The analysis is very complex, involving gap angles, forces applied by muscles, etc. However, the conclusion is fairly simple. First, Helicoprion must have been limited to soft-bodied prey. Given that there is nothing hard to push the teeth against, no crushing would be possible. The "saw" would be used more like a rake to start with: With the mouth fully open, the teeth toward the front of the mouth snag the prey and draw it closer to the roof of the mouth, at which point the largest teeth chop the prey as the mouth closes. Repeated motions would continue to draw the prey toward the throat. The authors imagine Helicoprion grabbing a nautiloid by the tentacles, and drawing the soft parts out of the shell, which is then discarded uncrushed.

Sources:

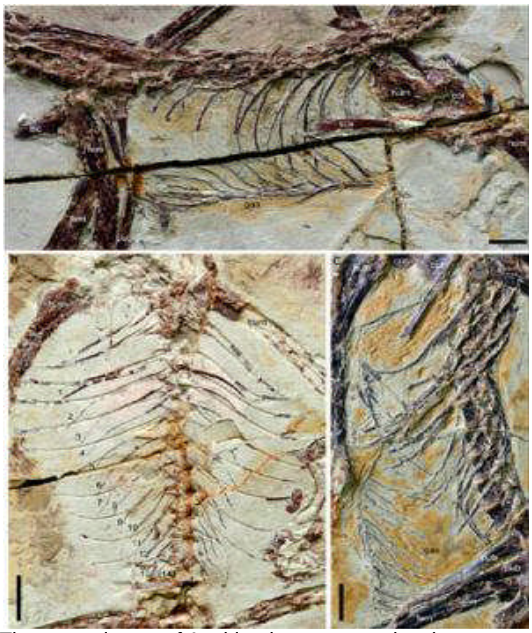
Ramsay, J.B.; Wilga, C.D.; Tapanila, L.; Pruit, J.; Pradel, A.; Sclader, R.; Didier, D.A.
"Eating with a saw for a jaw: functional morphology of the jaws and tooth-worl in Helicoprion davisii."
J. Morphology 2015, 276, 47-64.

Early Birds Without a Sternum

Bob Sheridan, September 26, 2014

The sternum is the bony plate in front of the chest. It is present in most mammals, birds, and reptiles. In mammals, the first seven or so pairs of ribs attach to the sternum as does the collar bone. In modern birds the sternum is especially developed. Almost always it has a keel, a planar forward projection perpendicular to the ribs. The obvious function is to give a large attachment to the flight muscles.

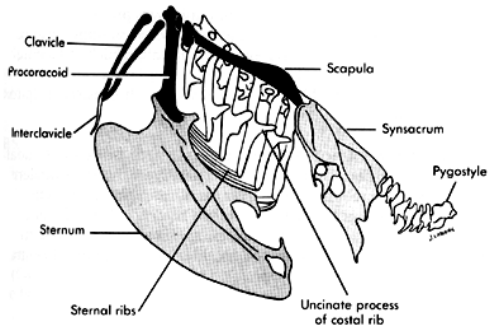
When we get to fossil dinosaurs and birds, the sternum may or may not be preserved in any one skeleton. However, look at a large enough number of fossils of the same kind of animal and the expectation is we will eventually see a preserved sternum. For example, most theropod skeletons have some kind of sternum, including most fossil birds and feathered dinosaurs. A recent paper by Zheng et al. (2014) suggests there may be exceptions.



Three specimens of Anchiornis sp. preserving the complete or nearly complete gastral basket but no sternal ossifications including sternal ribs, Scale bars equal 1 cm. Credit: ZHOU Zhonghe

These authors have available to them a large number (up to 200) of very well preserved skeletons of many birds and near-birds. In their paper they discuss Anchiornis and Sapeornis. Anchiornis is a small feathered dromeosaur (a troodont), and Sapeornis is considered a primitive bird with a few teeth but with a very short tail. (Together, troodonts and dromaeosaurs are considered a sister group to birds.) In no skeleton of Anchiornis (n=229) or Sapeornis (n=106) is there any sign of a bony sternum. In cases where soft tissue is partly preserved, there is no sign of a cartilaginous sternum. Also, almost all of the specimens appear to be adults, so one cannot argue that the sternum did not have time enough to ossify. In contrast, the closest known animals to those two for which we have many specimens, Microraptor (a dromeosaur) and Jeholornis (another primitive bird), respectively, have a clear sternum.

In birds and dinosaurs with a sternum the coracoid bone has a flat end where it articulates with the sternum. In the species without sternums, the coracoid bone has a rounded end. The authors point out that Archaeopteryx is anatomically very similar to Anchiornis, and none of the known specimens of Archaeopteryx (10 at the time Zheng et al. made the study) has a preserved sternum. The authors also point out that another troodont dinosaur Mei also lacks a sternum and has a rounded coracoid.



Since we consider a sternum an essential part of flight, it is very puzzling why many animals at the transition between dinosaurs and birds lack a sternum, especially since Sapeornis seems to have many other characteristics of flying birds, including long arms and fan-like feathers. One speculation is that these animals had some way of compensating for the lack of a sternum for flight-like functions.

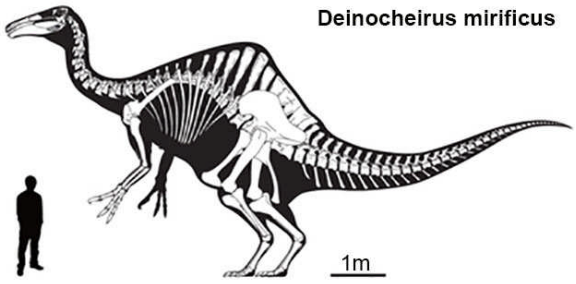
Sources:

Zheng, X.; O'Conner, J.; Wang, Z.; Wang, X.; Wang, M.; Zhang, X.; Zhou, Z.
"On the absence of sternal elements in Anchiornis (Paraves) and Sapeornis (Aves) and the complex early evolution of the avian sternum."
Proc. Natl. Acad. Sci. USA 2014, 111, 13900-13905.

"Horrible Hands" Turns out Weird

Bob Sheridan, October 25, 2014

Not long ago I wrote about Spinosaurus, an example of a dinosaur that seemed somewhat unusual, but was incompletely known. When a new, almost complete specimen was examined, Spinosaurus turned out very weird, the only known example of (it is thought) an aquatic dinosaur. Today's story is similar. The dinosaur is Deinocheirus ("horrible hands"). The original specimen, collected in Mongolia in 1965, consisted of giant (2.4 meter) arms. Other than it probably was an unusually large ornithomimid, nothing else was known about Deinocheirus for 50 years. Ornithomimids (from the Late Cretaceous) are called "ostrich-like" dinosaurs because of their long legs, long neck, and small toothless head with large eyes. (The long arms are not ostrich-like, however.) When I was a kid, Struthiomimus was probably the most famous example, but today, thanks to "Jurassic Park," Gallimimus is probably more famous. Most ornithomimids would be small to moderate in size (less than 4 meters long) and were probably very fast runners, given that their tibias were much longer than their femurs. It is thought that ornithomimids were herbivores or omnivores because many skeletons have piles of gastroliths in their stomach area; the gastroliths presumably fill in for the missing teeth as grinders of plant material.



Lee et al. (2014) describe three new specimens of Deinocheirus that were excavated between 2006 and 2009 at two different locations in Mongolia. Between the three specimens, Deinocheirus is now completely known. As expected, Deinocheirus turned out to be very large, about 11 meters long (compared to 12.5 meters for Tyrannosaurus). Phylogenetic analysis does nest it firmly among the ornithomimids, and it does have many ornithomimid features such as a longish neck and toothless beak. However, it is a very unusual ornithomimid. Starting from the head: It's skull is unusually long and has a very heavy jaw. Its eyes are very small compared to the size of the skull. Deinocheirus has elongated neural spines with the longest ones being just above the hips, which would give it a "sail" or "hump," not quite as large relative to body size as that of Spinosaurus. The neural spines are linked by intervertebral ligaments. The tibia is shorter than the femur and the overall length of the legs compared to the body is less than in other ornithomimids. The toenails are very broad. Some of the characteristics, such as the small eyes and short tibia are typical of very large theropods. Clearly, Deinocheirus was not a runner.

As with many ornithomimid specimens, one specimen of Deinocheirus was found with >14,000 gastroliths. Stomach contents also contain fish vertebrae and scales. The authors suggest that the lifestyle of Deinocheirus is a omnivore that got most of its food from ponds and streams.

In appearance Deinocheirus resembles Therizinosaurus, another very large, long-clawed, unrelated theropod that has taken up herbivory as a lifestyle.

Sources:

Holtz, T.R.
"Paleontology: mystery of the horrible hands solved."
Nature 2014, 515, 203-205.

Lee, L.-N.; Barsbold, R.; Currie, P.J.; Kobayashi, Y.; Lee, H.-J.; Godfroit, P.; Escuillie, F.; Chinzorig, T.
"Resolving the long-standing enigmas of a giant ornithomimosaur Deinocheirus mirificus."
Nature 2014, 515, 257-260.