The Paleontograph

A newsletter for those interested in all aspects of Paleontology
Volume 1 Issue 1 January, 2012

From Your Editor

So, here we are at the beginning of something. I think that it would be good to tell you how this venture came about. I've edited The NJPS Paleontograph for sixteen years. NJPS, being the New Jersey Paleontological Society. Like many gem, mineral or fossil clubs, NJPS has started to fade away. There is a lack of members willing to step forward and do work for the group. It became a club that had a great newsletter but nothing else, no programs, field trips or activities. I grew tired of the situation and tried to get people to become more active but that was not to be, so I resigned. I don't know what will happen to the club, some are trying to keep it going.

But I enjoyed putting out the newsletter and felt proud of it. I was blessed with one main, very prolific, contributor, Bob Sheridan, who made me the envy of all other newsletter editors that knew my newsletter. Unlike other newsletter editors, I never had to write articles myself, in order to fill my newsletter. It turns out that Bob feels the same way I do about the whole thing.

So that brings us to here, today. First, the name. I like it and so I did a spin off from the old name. Not quite stealing it but very close. If someone complains, maybe I'll change it but for now this is it. I will distribute this newsletter to the former members of NJPS as well as my former complimentary subscribers. I also went out to the ***Paleolist***, from which I received some subscribers as well as my first new contributor.

I'll stop now. Please let me know what you think. I hope you all enjoy this new thing, we will see where it goes. It will be up to you.

TC

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

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The Stability of Jaw Anatomy in Devonian Fish

Bob Sheridan August 20, 2011

Fish with jaws (gnathosomes) appeared first in the Silurian, and by the end of the Devonian almost all fish were jawed. How different types of jaws arose among different types of fish is the subject of study by Anderson et al. (2011). They looked at 31 mandibular traits of 198 gnathosomes from the Silurian and Devonian divided into 8 time bins spanning ~420 Myr. to ~360 Myr. The gnathosomes can be divided into five kinds of fish: Acanthodii ("spiny sharks"), Actinopterygii (ray-finned fish--which are the most common type today), Chondrichthyes (cartilaginous fish, i.e. sharks), Placoderms (armored fish), and Sarcopterygii (lobe-finned fish).

First, examining assemblages of vertebrate fossils, these authors find that in the Upper Silurian, 0-50% of the animals were gnathosomes, depending on the assemblage. In the Early Lower Devonian, assemblages may contain anywhere from 0-100% gnathosomes. By the Middle Devonian assemblages contain 60-100% gnathosomes. By the Late Upper Devonian, all the assemblages contain nearly 100% gnathosomes. This is where we still are today, although the non-gnathosomes have changed. In the Devonian, almost all non-gnathosomes were Ostracoderms, armored jawless fish, but today the only jawless fish are lampreys and hagfish.

Here we need an aside about "disparity," which has to do, in this case, with how different the different genera are from each other in the 31 mandibular traits. These authors use non-metric multidimensional scaling to project the mandibular traits into a two dimensional "morpho-space". (Two is a useful dimension because it can be displayed on paper.) Distance in this morpho-space is a measure of disparity. If the fish are spread out in morpho-space, that means there is more anatomic variety. (There is usually an assumption that anatomic variety implies functional variety as well; however we usually do not have a handle on function in extinct animals.) Anderson et al. find that disparity started out low in the Upper Silurian, peaked in the Late Lower Devonian, and then settled into a low disparity after the Middle Devonian. Interestingly, which group of fish contribute to the disparity changes with time. In the Late Silurian, almost all the variation was within the Acanthodii. At the end of the Devonian, most of the disparity is from the Sarcopterygii and Placoderms. The jaws of Condrichthyes and Actinopterigyii never varied very much.

The authors make two points:
Since jawed and jawless fish coexisted for millions of years even after the disparity in jawed fishes had peaked, this argues against jawed fish replacing jawless fish in specific ecological niches because they are somehow superior. It is more likely gnathosomes were able to exploit lifestyles not available to jawless fish, which were probably confined to bottom-feeding.
The disparity of jaws is constant during the parts of the Devonian where there were a number of environmental upheavals: sea level changes, an extinction event (~375 Myr.) , and increase in oxygen (~400 Myr).

Sources:

Anderson, P.S.L.; Friedman, M.; Brazeau, M.D.; Rayfeld, E.J.
"Initial radiation of jaws demonstrated stability despite faunal and environmental change."
Nature 2011, 476, 206-209.

Wooly Before the Ice Age

Bob Sheridan September 5, 2011

There are two types of animals we know of that came in a "wooly" version in the Ice Age whereas the modern version is essentially hairless: elephants (as represented by the mammoth) and rhinos (as represented by the wooly rhino). This story is about the wooly rhino (genus Coelodonta--"cavity tooth"), which is best know from its Pleistocene fossils in northern Europe and Asia. The wooly rhino went extinct with other megafauna ~12,000 years ago.

Aside from being wooly, there are several differences between Coelodonta and modern rhinos:
The skull is especially long and low.
The limbs are stocky.
The two nasal horns are especially long, pointed forward, and narrow from side to side.

Cont'd

Wooly Cont'd
Since rhino horns are not made of bone, they are not usually preserved; hair is not usually preserved either. However, as with mammoths, there have been a few specimens mummified in permafrost or tarpits. These have horn and wool intact. Also as with mammoths, there are many cave paintings that record the appearance of the living animal.

One suggestion as to why the wooly rhino horn is long, narrow, and pointed forward is that it was used to scrape snow away so the rhino could browse on ground-level plants. (A similar suggestion is made for the extra-long tusks of the mammoth.)

This week Deng et al. (2010) describe a new well-preserved wooly mammoth skull and mandible for a new species they call *Coelodonta thibetana*. The skull is about three feet long. This specimen is unusual in two respects:
It is found in the Zanda Formation in southern Tibet at the foothills of the Himalayas. Most specimens are found in northern Asia.
It is 3.7 Myr. old (middle Pliocene), whereas most specimens are from the Pleistocene (less than 0.4 Myr.).

Unfortunately, the horn and wool are not preserved for this specimen, so one must go by the bone characters, and only for the skull. However, the nasal boss in the specimen is very large and is consistent with a flattened horn. Phylogenetic analysis of the new specimen with 15 other specimens of rhino, wooly and otherwise, shows that Coelodanta thibetana is most like the three other wooly rhino species, and the most primitive wooly rhino.

Isotope analysis of the new rhino specimen, plus other large mammals living at the same time suggests they all fed on C3 vegetation and they lived in a high-altitude cold climate. The authors suggest that *Coelodanta thibetana* represents the first cold-adapted rhino, the cold being due to the altitude at which it lived, rather than the global climate. Being pre-adapted for cold, it was able to migrate to low-altitude parts of northern Asia and then to all of Eurasia when the Ice Ages came.
Sources:

Deng, T.; Wang,. X.; Fortelius, M.; Li, Q.; Wang, Y.; Tseng, Z.J.; Takeuchi, G.; Saylor, J.E.; Saila, L.K.; Xie, G.
"Out of Tibet: Pliocene wooly rhino suggests a high-plateau origin of ice age megaherbivores."
Science 2011, 333, 1285-1288.

K-T Extinction of Birds

Bob Sheridan September 18, 2011

Birds originated in the Late Jurassic (if you count Archaeopteryx as the first bird) and diversified in the Cretaceous. (Most well-preserved Early Cretaceous birds are found in China.) In the Cretaceous there were two major classes of birds: Enantiornithes and Ornithurae which are distinguished by how the ankle and foot bones are fused. The Enantiornithes were the most abundant and diverse, but only the Ornithurae survive to the present day. The families of modern birds definitely existed in the Paleocene. Since data is scarce, two scenarios for the later evolution of birds have remained plausible:
Modern bird families existed in the Cretaceous and most survived the K-T extinction.
Almost all birds were wiped out at the K-T and the modern families arose later from the few survivors.
One way of addressing this is to see if "archaic" birds, i.e. not in modern families, survived to the end of the Cretaceous.

Longrich et al. (2011) examined bird fauna fossils from the Maastrichtian (the latest 1.5 Myr. of the Cretaceous). These are from the Hell Creek Formation (Montana), Lance Formation (Wyoming), and the Frenchman Formation (Salskatchewan). The main approach is to generate a phylogenetic analysis of the species existing at that time.

Interestingly, these authors confined their analysis mostly to characteristics of the coracoid bone. In mammals, the coracoid is part of our shoulder blade, but in birds, the coracoid is a long bone. The humerus articulates at one end of the coracoid, and the other end braces against the sternum. The clavicle (in birds called the furcula--or wishbone) also articulates with the coracoid. Apparently the coracoid is very distinctive for different types of birds. The authors also include some data about the tarsometatarsi bones for which the coracoid is not preserved in this set of fossil. In birds the ankle bones (tarsi) and foot bones (metatarsi) are fused, and these also differ among birds, especially between enantiornithes and ornithurines, as stated above.

The authors identified 17 types of coracoid, 15 of which could be assigned to a previously known fossil species. There are a number of enantiornithines and ornithurines. The coracoids show a reasonable range of bird sizes, from 200 grams to 5 kg.

Cont'd

Bird Extinction Cont'd
This is somewhat narrower than the range of modern birds, and the difference is probably due to the small number of samples, but it does suggest birds already filled a variety of ecological roles. We know from this sample that archaic birds such as enantiornithines survived until the end of the Cretaceous, although they were not as abundant as ornithurines at that time. Earlier work from the authors showed that no enanthiornithines survived to the Paleocene. Also, there are no modern families of birds represented in this sample.

Overall the data is consistent with a model where birds were diversified in the Mesozoic, almost all were wiped out at the K-T extinction, and the few survivors diversified into modern bird families.

Sources:

Longrich, N.R.; Tokaryk, T.; Field, D.J.
"Mass extinction of birds at the Cretaceous-Paleogene (K-Pg) boundary."
Proc. Natl. Acad. Sci. USA 2011, 108, 15253-15257.

Crops in Fossil Birds

Bob Sheridan September 24, 2011

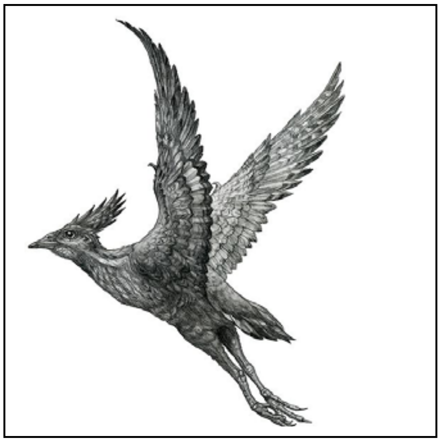
First a quick review of the unique digestive system of birds. Many birds have a crop, which is a sack-like extension of the esophagus. This usually is at the base of the throat in front of the furcula (wishbone) and outside the ribcage. Below the stomach, and inside the ribcage, is the gizzard, which is a very muscular organ that may incorporate gravel (or gastroliths). The crop provides a way to gather food quickly so that it can be digested at leisure at a safer location. The gizzard provides a way of grinding harder foods (since teeth are absent in birds). Not surprisingly, the presence of a gizzard and crop are usually associated with a diet of seeds in living birds.

There is much fossil evidence for gizzards in birds and in dinosaurs since gizzards contain stones, and there have been fossil birds with seeds among the stomach contents, for example in Jeholornis. However, evidence for crops in fossil birds is harder to come by. Zheng et al. (2011), after examining hundreds of bird fossils at the Tianyu Museum of Nature, report the presence of a crop in two types of birds from the Early Cretaceous of China. *Sapeornis chaoyangensis* ("bird from Chaoyang") is a basal bird with a beak but with a few premaxillary teeth. Two specimens of Sapeornis are preserved with a circular mass in font of the throat, which is packed with seeds. One specimen shows a mass of polished gastroliths in the ribcage where the gizzard ought to be. *Hongshanornis longicresta* ("bird of the Hongshan culture") is a basal ornithurine (which means it is in the class of modern birds) with a toothless beak and long legs. One specimen has a seed mass in front of the furcula and also has gastroliths in the ribcage.

The authors suggest that the earliest birds were insectivores and the presence of teeth and a long snout was necessary to handle that diet. They further suggest that a diet of seeds may have given rise to the presence of crop and gizzard, which in turn may have led to the loss of teeth. Since Sapeornis and Hongshanornis are not closely related, the gizzard and crop may have evolved several times in birds. Whether crop and gizzard always go together and whether they are associated with seed eating is not clear because the crop is seldom preserved. The authors point out that of nearly 100 Sapeornis specimens they examined, only the two mentioned here show evidence of a crop. Also Jeholornis, which is a known seed-eater based on stomach contents, shows no evidence of a crop in more than 100 specimens.

Sources:

Zheng, X.; Martin, L.D.; Zhou, Z.; Burnham, D.A.; Zhang, F.; Miao, D.
"Fossil evidence of avian crops from the Early Cretaceous of China."
Proc. Natl. Acad. Sci. USA 2011, 108, 15904-15907.



Hongshanornis

From

Wikipedia

Pavel Riha

Mosasaurs

Kenneth Quinn
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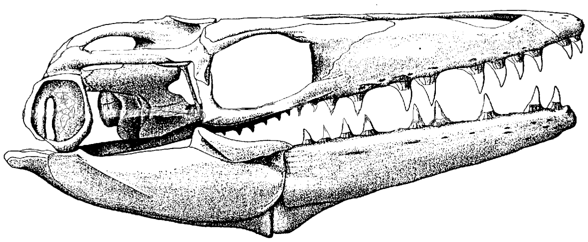
Mosasaurs were true reptiles that first appeared in the Cretaceous and disappeared at the very end of that period. It was long thought that their closest living relatives were the monitor lizards such as the Komodo Dragon, but recent research indicates that snakes are instead closer. There were a number of genera of mosasaurs and they showed a wide range of ecological slots; one, *Globidens,* had teeth designed to crush shellfish. There is indirect evidence that some kinds preyed on the squidlike ammonites - the bite marks on at least one ammonite shell exactly match the pattern of the teeth in a mosasaur jaw. In another genus of mosasaur, there are defects in the bones that are identical to those seen in the bones of whales that dive to great depths to seek their prey - giant squid! These defects are caused by the deep dives, so apparently these mosasaurs also sought their food at great depths.

The name of these reptiles comes from the area where they were first found - the valley of the Meuse River. To be precise, the first one discovered was found in a quarry near Maastricht, a Dutch city, in 1764.

My own experience with mosasaurs began on November 18, 1969; that date is easy to remember because it was my first wedding anniversary. I asked my wife what she wanted to do and she said - bless her! - "Let's go fossil hunting!" At that time I was still an undergraduate geology student at the University of Alabama and it was only an hour's drive to outcrops of the Mooreville Chalk, the northernmost formation of the chalky Cretaceous deposits of southern Alabama. We first tried an outcrop we had visited before but we found very few worthwhile fossils, so we started cruising rural roads for other outcrops. Near the tiny community of West Greene, we spotted roadside exposures and got out to look at them. At first, we saw very little to get excited about. My wife's method was to sit down in one spot and search it thoroughly, while mine was to roam the whole outcrop, so I started walking down a narrow strip right along the edge of the road. About 25 yards away from her, I looked down and started screaming! She looked up, thinking I had fallen and broken something. Instead, I had spotted dark brown bone - I had seen scraps of bone in this formation before, but not this big, and not several connected pieces! We started digging, and more of the animal emerged. By the time we were finished, we had about ten feet of reptilian skeleton exposed; missing were the tail and the left hind leg. At that time I had no knowledge of enclosing skeletons in a plaster of Paris jacket, so we just picked up the thoroughly mineralized bones. The owner of the adjacent private land had in the meantime driven by and I got permission to cross the fence and look for more fossils on his property but found nothing, not even a clam shell! Still, that was a great way to celebrate an anniversary!



Since then, I have found fragments of mosasaurs in Nebraska and Arkansas but no articulated bones. Nevertheless, these are no doubt the most common reptilian marine remains in Late Cretaceous deposits and anyone who looks for fossils in such deposits has a god chance of finding at least a piece of bone or one of their conical, curved teeth. Articulated skeletons - even partial ones - are of course much rarer, and should be reported to a reputable museum. I know, I know - but I should have! And I did donate all but a very few bones of my discovery to someone doing research on mosasaurs.

My mosasaur was in the genus *Clidastes.* This was no big surprise - it was perhaps the most common genus of mosasaur. However, there are currently 27 genera of mosasaurs! They ranged in size from 10 feet to 57 feet, and were almost worldwide in distribution. Fossils of them have been found in Europe, both Americas, Africa, Australia, New Zealand, and an island off the coast of Antarctica. I am not aware of any having been found on mainland Asia.

Ed. Note

For all you ever wanted to know about Mosasaurs, go to Mike Everhart's great website at: www.oceansofkansas.com

Trace Copper as a Marker for Melanin in Fossil Feathers

Bob Sheridan October 1, 2011

This story needs three bits of background. One is about x-ray spectroscopy. Three varieties are important here, with the acronyms EXAFS, XANES, and SRS-XRF. XANES measures the absorbance of x-rays in a material as a function of the wavelength of the x-ray--very much like visible spectroscopy. EXAFS measures the energy of scattered electrons ejected from the atoms in the material by the x-rays. In EXAFS the energy of the scattered electrons is a measure of the distance of other atoms to the atoms doing the absorbance. SRS-XRF is a type of x-ray fluorescence, where atoms absorbing x-rays emit visible light and one measures the visible light as a function of wavelength. Typically metals or other heavy elements are the ones that absorb x-rays. One has to have a strong source of x-rays to do x-ray spectroscopy, and this usually requires a synchotron, a large expensive piece of equipment.

The other story has to do with melanosomes. Modern feathers contain micrometer-size bodies called melanosomes that are embedded in the keratin. Melanosomes contain the pigment melanin, of which there are many varieties. The color of the pigment seems to be associated with the shape of the melanosomes: rod shapes (eumelanosomes) tend to contain black or grey pigment, more spherical shapes (pheomelanosomes) contain red or brown pigments. There have been at least two reports in the literature that feathers in fossil birds or dinobirds (from China) contain melanosomes, and the shape of the melanosomes in the fossils has been used to infer the color of those extinct animals.

Also relevant to this story is the fact that melanin is synthesized by the copper-containing enzyme tyrosinase, and copper atoms are incorporated into melanin as it is synthesized.

Wogelius et al. (2011) use all three types of x-ray spectroscopy to examine the feathers in a specimen of Confusciusornis, an early true bird from Early Cretaceous China. (Earlier the same lab used SRS-XRF to study the feathers of Archaeopteryx.) SRS-XRS shows that the downy feathers and some of the wing feathers closest to the body (but not the flight feathers at the tips of the wings) of Confusciusornis fluoresce when exposed to x-rays of the wavelength absorbed by copper. The inference is that the copper signature reflects the presence of copper incorporated into melanin; the incorporation is probably in the form of a metal-chelation, much as the heme in hemoglobin binds iron. The following experiments from the same paper support this claim:
The EXAFS and XANES spectra of the downy feathers are more consistent with modern copper-containing melanin than inorganic sources of copper like copper oxide.
Eumelanosomes can be detected in the fossil feathers by scanning electron microscopy in the same places as the copper is detected.
The copper signature can be seen in the darker parts of a fossil feather and eye of a fossil fish from Green River. The same thing is seen in a fossil squid.
The copper signature can be seen in the colored parts of two modern feathers from an eagle and a blue jay. Similarly with an extant squid.

The authors infer that Confusciusornis was probably dark colored close to the body but most of the wings were white. Also they suggest that copper detected by x-ray spectroscopy can be a marker for melanin in fossils where melanosomes themselves are not preserved.

Sources:

Wogelius, R.A.; Manning, P.L.; Barden, H.E.; Edwards, N.P.; Webb, S.M.; Sellers, W.I.; Taylor, K.G.; Larson, P.L.; Dodson, P.; You, H.; Da-qing, L.; Bergmann, U.
"Trace metals as biomarkers for eumelanin pigments in the fossil record."
Science 201, 333, 1622-1626.

Other Chemical Evidence for Melanin in Fossil Feathers

Bob Sheridan October 22, 2011

The last story I wrote described work by Wogelius et al. (2011). These authors used a variety of x-ray spectroscopic methods to link the presence of copper in fossil feathers with the presence of the pigment melanin (of which "eumelanin" is a subtype).

Cont'd

Melanin Cont'd

This was done for the Early Cretaceous bird Confusciusornis, plus some modern feathers and squid. In case you don't have that article handy, here is the recap: Modern feathers contain micrometer-size bodies called melanosomes that are embedded in the keratin. Melanosomes contain the pigment melanin, of which there are many varieties. The color of the pigment seems to be associated with the shape of the melanosomes: rod shapes (eumelanosomes) tend to contain black or grey pigment, more spherical shapes (pheomelanosomes) contain red or brown pigments. There have been at least two reports in the literature that feathers in fossil birds or dinobirds (from China) contain melanosomes, and the shape of the melanosomes in the fossils has been used to infer the color of those extinct animals. However, the problem with "melanosomes" in fossil feathers is that it is hard to rule out that they might be other types of round or elongated shapes a few microns in size, like modern bacteria.

This week I came across another study from the same laboratory (Barden et al., 2011) that extends the work with other forms of spectroscopy: energy dispersive x-ray spectroscopy (EDS), Fourier-transform infrared (FTIR) spectroscopy, electron paramagnetic resonance (PIR), and pyrolysis gas chromatography/mass spectroscopy (py-GCMS) . These were applied to the fossil feathers of two specimens of another Early Cretaceous bird from China called Gansus, and also applied to feathers from two modern birds: a black feather from a Maribou stork and a white feather from a White-napped crane .

EDS is much like scanning-electron microscopy, i.e. forms images of small objects, but one may also analyze the objects being scanned for their elemental composition. Melanosomes were seen in the dark parts of the fossil feather, and in the black modern feather, and not in the white modern feathers. Elemental composition of the modern feathers shows the presence of carbon, oxygen, and sulfur (which is not a surprise), but there is more calcium in the dark feather. Composition of the fossil feathers shows more carbon in the dark areas. Elemental composition of the fossil matrix is silicon and oxygen, again not surprising for rock. The interpretation of the elemental composition in terms of relating modern to fossil feathers is unclear, but it is clear that the original organic material is present in the fossil fossil.

Infrared spectroscopy measures the absorbance of infrared light by a material, and one may see the bond stretch frequencies of common chemical groups. The bottom line here is that the IR spectrum of the dark part of fossil feathers looks something like that of isolated melanin, and something like that a modern dark feather. The match is fairly vague, in my opinion, but it does again suggest that the fossil feathers are organic. There is no evidence for the chemical bonds expected for modern bacterial biofilms.

EPR reveals the environment of unpaired electrons. The EPR spectrum of the dark part of the fossil feathers, the black modern feather, and isolated melanin look about the same. The white modern feather has very little EPR signal. This is consistent with melanin being present in the fossil feathers.

py-GCMS uses heat to break molecules into fragments, whereupon the fragments are separated by molecular weight by mass spectroscopy. Interpretation of this, again, is not straightforward. However, one can be sure that the mass spectrum of the fossil feathers is different from that of the surrounding matrix.

The studies in Barden et al. are on the borderline of being doable, and harder to interpret than the those in Wogelius et al.. This is not surprising since these authors are trying to chemically analyze a very degraded, very thin film on a rock. The best one can say is that it appears that fossil feathers are not just impressions in the rock, but contain original feather material, including melanin.

Sources:

Barden, H.E.; Wogelius, R.A.; Li, D.; Manning, P.L.; Edwards, N.P.; van Dongen, B.E.
"Morphological and geochemical evidence of eumelanin preservation in the feathers in the Early Cretaceous bird Gansus yumenensis."
PLoS ONE 2011, 6, e25494.

Wogelius, R.A.; Manning, P.L.; Barden, H.E.; Edwards, N.P.; Webb, S.M.; Sellers, W.I.; Taylor, K.G.; Larson, P.L.; Dodson, P.; You, H.; Da-qing, L.; Bergmann, U.
"Trace metals as biomarkers for eumelanin pigments in the fossil record."
Science 201, 333, 1622-1626.

Triceratops to Nedoceratops to Torosaurus?

Bob Sheridan January 7, 2012

For most dinosaurs we have only few specimens. That makes it hard to guess the normal variation between members of a species, and it is therefore very easy to interpret a juvenile or a female, or an individual with some minor variation, as a different species or even a different genus. Even up to the middle of the 20th Century it was common for new dinosaur species to be named based on small differences. For instance, the animal in today's topic, Triceratops, has had 16 species assigned to it. Based on the variation of anatomy in Triceratops, for which many specimens are known, It was suggested by Ostrom and Wellnhoffer in 1990 that there were at most one or two Triceratops species.

Some workers, currently Jack Horner being the strongest proponent, look for ways to consolidate species based on growth stages. This becomes possible once one can estimate age of individual specimens based on bone histology. For example, he feels that among the bone-head dinosaurs Dracorex, Stygimoloch, and Pachycephalosaurus represent increasing old specimens of the same animal. To work out such a relationship one must show that there is a smooth transition in anatomy between the animals (making it plausible that one animal can "grow" into another) and the sizes and ages of the animals are consistent. Of course, if the number of specimens is small, it is possible to go overboard in this direction and falsely lump together different species. For example, if the few specimens you have of animal A happen to be young and the few of animal B happen to be old, you might be tempted to say A is the juvenile form of B although the age differences could be due purely to chance.

Today's story deals with two horned dinosaurs, the familiar Triceratops, and the less familiar Torosaurus. They both are large, have two long brow horns, a short nose horn, and short horns on the cheek bones. The major difference is in the frill. Triceratops has a shorter solid frill, whereas Torosaurus has a longer frill with large openings (or fenestrae). The brow horns of Triceratops point slightly upward while those of Torosaurus point forward. In 1990 Ostrom and Wellnhoffer suggested that Torosaurus could be a "male" Triceratops. However, in 2010 Scannella and Horner (Museum of the Rockies) suggested instead that Torosaurus represents the oldest Triceratops. This is based on three points:
1. Triceratops has a thinning of the frill in the locations where Torosaurus has fenestrae, i.e. there is plausible transition between species.
2.The bone histology age of known Torosaurus specimens is high.
3.In Triceratops that the brow horns tend to point more forward in the larger (presumably older) animals, consistent with the forward pointing horns of Torosaurus.

Early in 2011 Scannella and Horner joined another similar animal Nedoceratops (previously known as Diceratops) into this series. There is only one specimen of Nedoceratops (USNM 2412), but it makes a reasonable intermediate between Triceratops and Torosaurus. It has small fenestrae in the frill at the same place as the large fenestrae of Torosaurus. However, another worker Andrew Farke (Raymond M. Alf Museum of Paleontology) argued that Nedoceratops was not equivalent to Triceratops because it lacked a nose horn and the single specimen was already very old. Also, Nedoceratops has few episquamosals (bony growths at the margin of the frill) like Triceratops and not like Torosaurus. A new paper by Scannella and Horner (2011) rebuts the points from Farke. In particular, the paper notes that the number of squamosals and presence of a nose horn core varies so much among Triceratops, and that the preservation of these features is also variable, so that those features cannot be used to rule out a relationship of Nedoceratops and Triceratops.

This is once again a case of taking some ambiguous evidence from few specimens and arguing about which side has the burden of proof, the side of "splitters" (more species) or that of "lumpers" (fewer species). My personal prejudice is to apply Occam's Razor in ambiguous cases: don't assume more species than there is clear evidence for.

Sources:

Scannella, J.B.; Horner J.R. "'Nedoceratops': and example of a transitional morphology." PLoS ONE 2011, 6, e28705