The Paleontograph

A newsletter for those interested in all aspects of Paleontology
Volume 2 Issue 6 November, 2013

From Your Editor

Welcome to our latest issue. It's getting cooler out and the field season is coming to an end. I didn't do nearly as much collecting as I would have liked. Between my new grandchild, my job and my health I had little time for collecting. I'm walking around with a sling on my arm following shoulder surgery. Yet another sign of my advancing age. The good thing about advancing age is that retirement comes along with it. That is something in my near term future which I am very happy about. Enough about me.

Has anyone been out on a good trip? Remember, I'm always looking for an article on any related topic written at any level. I have a few good pieces for you this issue and I hope you enjoy it.

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

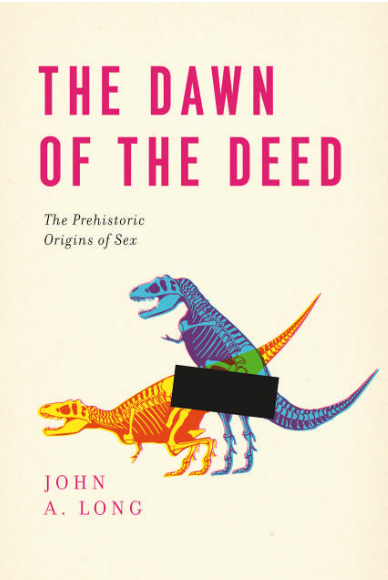
Edited by Tom Caggiano and distributed at no charge

Tomcagg@aol.com

Dawn of the Deed--A Review

Bob Sheridan June 8, 2013

The cover of "Dawn of the Deed" shows two Tyrannosaurus skeletons mating. The invisible "naughty bits" are covered by a black censor bar. With a cover like that, who could resist reading such a book?



The author, John Long, is the vice-president of research of collections at the Natural History Museum of Los Angeles County and formerly Head of Sciences at Museum Victoria and Curator of Vertebrate Paleontology at the Western Australian Museum. He is the author of a number of paleontology books, the most famous of which is probably "The Rise of Fishes" (1996).

The "hook" for this book is the discovery by Long's team of a placoderm (armored jawed) fish with embryos inside. The specimen, later given the name Materpiscis ("mother fish") is from the Gogo Formation in western Australia, a lagerstatte for a Devonian reef community which often preserves soft tissue in three dimensions inside limestone nodules. Live birth implies internal fertilization, which in turn implies copulation. This is interesting for two reasons. First, most advanced fish today rely on external fertilization of eggs. Second, at 380 million years, this fossil is the earliest known example of internal fertilization in vertebrates. One would expect the male fish to have some copulatory device such as the claspers seen in modern sharks, and indeed subsequent investigations found placoderm specimens (of other species) with bony claspers.

You can see a short video, featuring John Long, on this topic on Youtube (http://www.youtube.com/watch?v=wUJQEmRK1jA).

Of course, copulation among invertebrates goes back a long way, and we have fossilized ostracods and harvestmen spiders (daddy-longlegs) from the Silurian (20-40 Myr. earlier than Materpiscis) with obvious penises, much like those of their modern counterparts.

This is a very mixed book. About a third of it covers the author's work on Devonian fish and some personal anecdotes about it. About a third of it describes the very weird (to us, anyway) variations on copulation among modern animals, including the variations on sexual organs. If vertebrates seem weird, invertebrates, specifically insects, are downright bizarre in their sexuality. One sixth of the book concerns the history of the science of fertilization and the development of reproductive organs. One sixth of the book is speculation about the mating habits of extinct animals, in particular dinosaurs (which I presume is illustrated by the cover art). I did learn many things, for example:

1. The Argentine duck has the longest penis for the size of a vertebrate animal (about as long as its entire body), and said penis can shoot out at 75 miles per hour.
2. The claspers of modern sharks are not just to position the female during copulation but also transfer sperm.
3. There are at least three types of penis among mammals, only one of which relies on blood pressure to become ready.
4. The same Hox genes that control the construction of fins and claspers in fish control the development of legs and genitalia in tetrapods.
5. The explanation of what fertilization is, a sperm penetrating an egg, came as late as 1876.

"The Dawn of the Deed" is an easy read and quite amusing. Don't be misled that this book is primarily about paleontology, since the paleontology is only a small part. In that respect, I am reminded of another book "Your Inner Fish" by Neil Shubin, which started off with the discovery of Tiktaalik (considered a "missing link" tetrapod), but took most of its material about evolution from the biology of living animals.

Sources:
Long, J.A.
"Dawn of the Deed. The Prehistoric Origins of Sex." The University of Chicago Press, Chicago and London, 2012, 278 pages, $26 (hardcover).

The Oddest Couple: A Mammal-like Reptile and an Amphibian in the Same Burrow

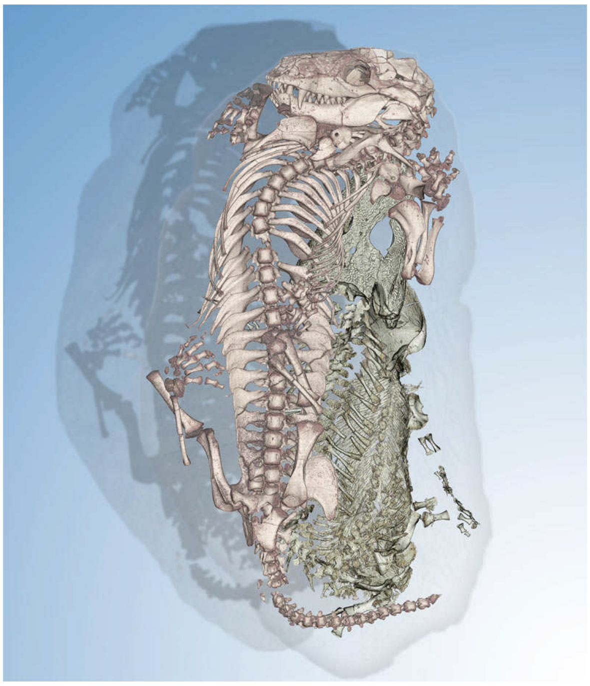
Bob Sheridan June 30, 2013

It would be helpful to start with a little information about the animals in this story. Thrinaxodon is an Early Triassic mammal-like reptile (specifically a cynodont) with some of the characteristics of a true mammal. Pits in the skull in the lip are are interpreted as indication that thrinaxodon might have had whiskers. Also it had a well-developed secondary palate, well-differentiated teeth (suitable for a carnivore), and probably breathed with a diaphragm. Thrinaxodon was 12-20 inches long. Its remains are found in Africa and Antarctica. Thrinaxodon remains are often found in burrows, hinting that it estivated. Estivation is entering a period of torpor during climate stress (usually during hot and/or drought conditions), something expected in the Triassic.

Broomistega is an Early Triassic amphibian with a broad, flat head. It is the only survivor into the Triassic of a branch of amphibians called the rhinesuchids, almost all of which went extinct at the end of the Permian. Broomistega remains are found in the Karoo Basin in South Africa. While amphibians of this type could be very large, Broomistega was probably less than two feet long.

It would not be unusual to find Thrinaxodon and Broomistega in the same formation. However, a very recent report by Fernandez et al. (2013) describes these two animals buried together in the same burrow. The burrow cast (a rough cylinder about 11 inches long and 6 inches in diameter) was excavated in South Africa in 1975. It was broken apart at that time. Part of a Thrinaxodon skull is visible in one piece and some bone fragments are found in the other. It was only recently that the cast was CT-scanned at the ESRF (European Synchotron Radiation Facility) in France.

The results are quite startling. A complete, fully articulated Thrinaxodon skeleton lying on its stomach on the floor of the burrow takes up the length of the cast. Nestled against it is the articulated skeleton (minus the tail) of a Broomistega lying on its back. The Thrinaxodon has its neck angled strangely, but is generally uninjured. However the Broomistega has seven broken ribs, a few of which show signs of healing. Four layers of sediment fill the burrow, which was oriented horizontally. The second layer covers both skeletons.



Of course, one wonders how two specimens got into one burrow. Given their articulated condition it is almost certain that both entered the burrow intact, if not still alive. The Thrinaxodon was probably first because it is on the bottom. There is some speculation whether this represents some kind of inter-species behavior, where both animals were alive and conscious in the burrow before being buried by sediment, and the animals are tolerating each other. Another possibility is that the Broomistega went into the burrow aiming to eat the Thrinaxodon but died before he could do it (because the Thrinaxodon shows no sign of being disturbed). Or one could imagine the opposite: the Thrinaxodon dragged a Broomistega carcass into the burrow for a meal later. The most likely scenario, however, is that the Thrinaxodon was estivating or was already dead when the Broomistega entered the burrow trying to estivate itself or hide after being injured.

Interestingly, this specimen of Broomistega represents the first articulated rhinesuchid known.

Sources:

Fernandez, V.; Abdala, F.; Carlson, K.J.; Cook, D.C.; Rubidge, B.S.; Yates, A.; Tafforeau, P. "Synchrotron reveals Early Triassic odd couple: injured amphibian and aestivating therapsid share burrow."
PLoS ONE 2013, 8, e64978.

Beetle Damage on La Brea Fossils

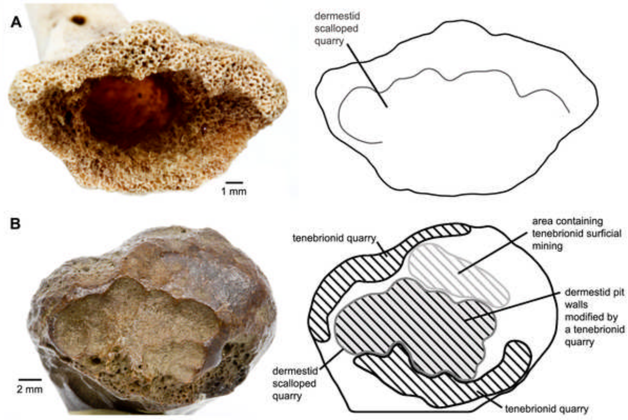
Bob Sheridan July 14, 2013

The La Brea "tarpits" in Los Angeles are probably the richest source of well-preserved Pleistocene fossils. Thousands of individual bones have been recovered. Specimens are heavily biased toward carnivores (usually the saber-tooth cat Smilodon and the Dire Wolf). The thought is that the tarpits, which are formed when natural asphalt seeps above ground, forms a natural trap that immobilizes herbivores, which attracts predators, who also become trapped. Already we can infer something about the climatic conditions under which animals are trapped, since asphalt would solidify and not be sticky under 18 degrees C.

A small proportion of La Brea bones show insect damage. This is usually confined to large herbivores and almost always on the toe bones, and restricted to the spongy portions of the bone. Since toes are the most likely part of the animal to be buried in the asphalt, it is a little hard to explain why toes would be attacked first. However, it must be remembered that insects can start at the exposed parts of the flesh above the asphalt and burrow downward.

A recent study by Holden et al. (2013) endeavors to identify which insects are doing the damage and to determine what this implies about the taphonomy of La Brea fossils. These authors examined the damage to fresh chicken bones and pork ribs created by the larvae of dermestid beetles and tenebrinoid beetles. Both beetles are found in modern Los Angeles. Dermestid beetles are well-recognized as scavengers of carcasses, both as larvae and adults. They are commonly used at museums to clean skeletons. Tenebrinoid beetles are less familiar. They are known mostly as pests that eat grain, but they also attack carcasses. Both types of beetles are also found as fossils in La Brea, with tenebrinoids outnumbering dermestids by 10:1. This may reflect their abundance in the Pleistocene or it may be that dermestids, being more fragile, are not as well preserved.

Both modern beetles leave distinct types of traces on the spongy portions of fresh bone, the dermestids create hemispherical pits and circular bores 1 or 2 millimeters in diameter, whereas tenebrinoids produce shallow grooves. The traces in La Brea fossils are very similar to the traces produced by the modern beetles, with the exception that some fossil traces appear to be a smaller version of the modern dermestid-type trace. Several generations of beetles would be required required to produced damage as great as observed in the La Brea bones.



Using the habits of the dermestid and tenebrinoid beetle and an estimate of how long it would take to create the extent of damage to bone, one can estimate what the climate conditions were and how long a carcass was exposed before being buried in asphalt. Dermestids larvae pupate at temperatures above 25 degrees C and require 60-80% humidity. Tenebrinoid beetles are more tolerant of low humidity. In modern studies, beetles attack carcasses in the later stages of decay, after fly larvae have done their work. Also we know the generation time of these beetles. The authors estimate that La Brea carcasses might have been exposed for several months before being buried, almost the entire warm season.

The observation that only herbivore feet in La Brea show insect damage may be explained in a few ways. For example:

1. These beetles are known to look for fairly fatty or thick skin to burrow into. Herbivores have thicker skin on their feet than do carnivores.
2. Scavengers removed the parts not trapped in asphalt before beetles could infest them, and herbivore feet would remain.

Sources:

Holden, A.R.; Harris, J.M.; Robert M. Timm, R.M. "Paleoecological and Taphonomic Implications of Insect- Damaged Pleistocene Vertebrate Remains from Rancho La Brea, Southern California" PLoS ONE 2013, 8, e67119

It's the Little Things

Alan Russo

It's kind of funny how things work out. When I lived in New York, I would travel to North Carolina relatively often. From very early on, when I first got my driver's license, I would head to NC to explore Nature. First it was just seeking natural places, than it was to explore Nature Conservancy Land, than it was to go Birding and then, of course, to "hunt" Fossils.

I have been living in NC for about eight years now and since I have been down here, I have only been on four Fossil excursions and one of those was to the Aurora Fossil Museum to collect gravel for a program I was doing for the Senior Center I work for. As nice as the Museum is, it is hardly an "expedition". So technically I have only been on three.

When I first moved down here, my friend Tom Caggiano gifted me with a membership to a NC Fossil club. Unfortunately, the trips were either too far away or at a very inconvenient time, between work and dealing with a new house, I never got to go on any trips. I was able to stay on the mailing list for a while and one day got an e-mail saying there was going to be a collecting trip to Gulf, NC. Turns out, Gulf is only about twenty minutes from my house. I was very excited, it had been a long time since I got down and dirty collecting Fossils and I needed the fix badly.

In Gulf, there is an old abandon Pomona Terra-cotta quarry that has a small outcropping of Middle Pekin Formation of the Deep River basin. The formation is late-middle Triassic and has, in the past, yielded some important tracts of reptile footprints and lots of plant fossils from that era. Unfortunately, the collecting area is small and over worked so things are getting harder to find.

The trip was in December. Luckily it was a beautiful day and the exposure was on a South facing slope, so, after the sun started to peek around the trees it got so warm I was down to a tee shirt in no time. The rock was more like hardened clay than rock, and very fragile, it was hard to get a piece of any substantial size. I was working in an area below a pine tree between the roots which made things even more difficult. And to top it off, the Fossil layer went right between the roots.

I did find some nice plant fossils, one of which looked like it could have been part of a Palm Frond or some other kind of Palmate shaped leaf.

Little things Cont'd

As I was collecting I remember finding a tiny leaf about .25 in long, I didn't have my reading glasses on at the time so I just put it in the "keepers" pile and figured I would check it out when I got home. A couple of days later while going through my finds I saw the small leaf again. I put it under the dissecting scope without much expectation; the matrix was very course and sandy like, so I didn't expect much detail. When I looked in the scope I couldn't believe my eyes, the tiniest veins of the leaf were visible and an intricate pattern of leaf structure was apparent. Considering how course the particles were that made up this rock and how small the leaf was, this seemed to me to be an amazing feat.

Of the two times I have been to Gulf to collect, this tiny leaf is by far my favorite find. For those of you who know me, you know, I would rather find a beautiful Plant Fossil than a Dinosaur bone any day of the week, and of all the plant Fossils I have found in countless places around the country, I consider this very tiny leaf one of my favorites.
Peace

Ocepechelon, A Late Cretaceous Turtle with an Unusual Snout

Bob Sheridan July 27, 2013

Sea turtles reached very large sizes in the Late Cretaceous. The largest known are Protostega (from Kansas) and Archelon (from North Dakota and Wyoming). Both were about 10 ft. long and weighed about two tons. The largest living sea turtle is about 6 ft. long.

Bardet et al. (2013) describe the skull of another fossil turtle, this one from phosphatic deposits Morocco, which are dated to 67 Myr.. The name given to the specimen is *Ocepechelon bouyai* (The genus is named for OCP, the acronym for the mining company exploiting the phosphatic deposits, and "chelon", which is Greek for turtle. The species is named for Baadi Bouya, the head of the OCP Geological Survey.) The skull of Ocepechelon is approximately 1 ft. wide and 2 ft. long, which would make it one of the largest known turtles.

The skull of Ocepechelon is very flat from top to bottom, unlike most modern and fossil sea turtles, which tend to have deep skulls. Whereas almost all turtles (marine and otherwise) have their nostrils at the end of their snouts, the nostrils of Ocepechelon are at the top of its head, almost between the eyes. This is similar to the condition in some other aquatic animals: for example whales and phytosaurs (Triassic animals superficially similar to crocodiles). Almost all marine turtles have a toothless hooked beak at the end of short snout, but Ocepechelon is unique in that its snout tapers toward the end and ends in a narrow rounded tube. (I am reminded of the end of a turkey baster.) The authors refer to this as "pipette-like" and point out the resemblance to the snouts of beaked whales.

Given the resemblance of the skull of Ocepechelon to that of beaked whales, which are toothless and feed by sucking their prey into their mouths instead of grasping it, the authors suggest that Ocepechelon has converged onto the same feeding strategy. Suction feeding is common for modern aquatic vertebrates, but has not been seen before in any fossil marine reptile. Some modern turtles use suction feeding, but they have conventional-looking skulls.

Phylogenetic analysis suggests that Ocepechelon is in the same family of Protostega, which is a remote relative of the modern leatherback turtle

Sources:
Bardet, N.; Jalil, N.-E.; de Lapparent de Broin, F.; Germain, D.;Lambert, O.; Amaghzaz, M.
"A Giant Chelonioid Turtle from the Late Cretaceous of Morocco with a Suction Feeding Apparatus Unique among Tetrapods"
PLoS ONE 2013, 8, e63586

Tyrannosaurus not an Obligate Scavenger

Bob Sheridan August 3, 2013

Some of you might remember the silly "T. rex predator vs. scavenger" debate in the 1990's. It was silly because:

1. It depended on a false dichotomy. Almost all large vertebrate carnivores are both predators and scavengers depending on the situation. The obligate scavengers are birds like vultures that can scan large areas looking for carcasses without spending a great deal of energy.
2. Jack Horner was about the only proponent of the "obligate scavenger" idea and he made some pretty strange arguments: T. rex had tiny arms too small to break a fall, so he couldn't run fast; T. rex had very large olfactory bulbs, and the only reason for that is to sniff out carcasses; T. rex was big to chase other animals away from carcasses; etc. I suspect Horner made these arguments to stir up people's thinking. I can't believe he took his own arguments seriously, because a few seconds' thought would find a counterexample for each one.

There are plenty of trace fossils from the Late Cretaceous that indicate feeding: large toothmarks and even embedded teeth in herbivore bones. Also we have coprolites, presumably from T. rex, that contained lots of bone fragments. So we know what T. rex was probably eating: mostly hadrosaurs and ceratopsians. However, to resolve the predator vs. scavenger issue, we need to show that the prey animals were alive when T. rex encountered them. I have been hearing for several years about a specimen that would do that, but a description of it has just been published (DePalma et al., 2013).

The specimen in question is two fused vertebrae, probably from the mid-tail of a hadrosaur the size of Edmontosaurus. The specimen is from the Hell Creek Formation in South Dakota (Latest Cretaceous), and is currently at the Palm Beach Museum of Natural History. The bone of the two vertebrae is overgrown such that they form a single rounded mass. CT scanning shows the crown of a theropod tooth, about 4 cm long, embedded in the lower half, at right angles to the axis of the vertebrae and lodged between the centra of the two vertebrae. The resolution of the CT scan is good enough that one can see individual denticles (serrations) on the tooth.

Clearly for the bone to overgrow as it did, the hadrosaur had to survive the attack by months or years (we don't know how fast hadrosaurs healed injuries). In any case, the hadrosaur was alive when it received the tooth, and therefore the theropod that attacked it was definitely a predator. One can easily imagine the predator chasing after the hadrosaur and trying to grab it by the tail. The only thing left is to connect the embedded tooth to T. rex, based on the size, shape, and density of denticles. This is clearly a tyrannosaur tooth based on its roundish cross-section, as opposed to the blade-like cross-section of most theropods. However, other tyrannosaurs found in the Hell Creek Formation, such as Albertosaurus and Nanotyrannus, can be eliminated from consideration. Their teeth are too small and their denticles too fine. The tooth most closely matches teeth sub-adult specimens of T. rex.

None of this precludes T. rex being a scavenger on occasion.

Sources:

DePalma, R.A.; Burnham, D.A.; Martin, L.D.; Rothschild, B.M.; Larson, P.L.
"Physical evidence of predatory behavior in Tyrannosaurus rex."
Proc. Natl. Acad. Sci. USA 2013, 110, 12560-12564.

Aquatic Mammals and Myoglobin

Bob Sheridan June 16, 2013

Although I follow the literature on evolutionary topics, for the Paleontograph I usually write summaries of articles that involve actual fossils. This time I will make an exception because the work of Mireta et al. (2013) is very simple and satisfying. There is a confluence of three topics: mammals that hold their breath for a long time, the concentration of myoglobin in muscle, and the surface charge on myoglobin.

Cont'd

Myoglobin Cont'd

Most land mammals can hold their breath for a few minutes at most, whereas a number of aquatic mammals (whales, seals, etc.) can dive for many minutes at a time, up to hours in the case of some of the larger whales. There is some correlation of the maximum minutes per dive and the mass of the mammal. The study I am reporting includes aquatic animals as small as the muskrat and the platypus and as large as the sperm whale.

Myoglobin is a small (~140 amino acid protein) that binds oxygen. The protein portion binds an iron-containing heme group; the iron atom does the actual binding of the oxygen. Myoglobin is what gives muscles their red color (the heme being the source of the color). By the way, sperm whale myoglobin is the first protein for which a structure was solved by x-ray crystallography. This is because myoglobin is fairly small, abundant, and easy to purify. (As an aside, I note that the protein that carries oxygen in our blood is hemoglobin, which is assembled from four myoglobin-like subunits. Horse hemoglobin is among the first half dozen proteins for which the structure was solved.)

The concentration of myoglobin is much higher in the aquatic mammals than the terrestrial mammals, perhaps up to 30-fold. The color of the muscle in such animals is so intense as to be almost black. This makes sense: the aquatic animals are able to store oxygen not only in their blood, but also in their muscles. The high concentration of myoglobin obviously evolved independently several times since the mammals with high myoglobin concentration are not all related to each other. Interestingly, there is a small increase in myoglobin concentration in mammals that are burrowers or who live at high altitudes.

The other topic is charge on proteins. Proteins are a linear chain of amino acids and some amino acids contain a positive or negative charges. Most proteins are more or less globular because the amino acid chain folds tightly against itself. Almost always the charged amino acids are at the surface of any given protein. Different proteins have different amounts of total charge at the pH of blood, even myoglobins from different species. The amount of charge can be simply calculated from knowing the amino acid sequence of the myoglobin from any given species (and the sequence is known for most mammals). Also the charge can be measured through electrophoresis: more highly charged myoglobins travel further through a gel to which an electrical gradient has been applied. Here is the interesting part: the terrestrial animals have a surface charge between 0 and +3 at pH 6.5, whereas the aquatic animals are always over +3. There is a correlation between the log of the concentration of myoglobin in the muscle of a mammal and the charge. The explanation of the authors is the following: when proteins have little surface charge, they would tend to precipitate out into an insoluble mass at higher concentrations. Proteins with high charges would repel each other and not precipitate as easily. Hence the high charges in the aquatic mammals, allows higher concentrations of myoglobin in their muscles.

The most fascinating part of this paper is the idea that, given a mammalian family tree, one can predict the myoglobin sequence, and hence the overall charge, for common ancestors of extant mammals. Therefore one may estimate the aquatic habits of groups of mammals as a function of time. For instance in artiodactyls one can see a baseline charge of +2 increasing to a charge of +5 for all the whale ancestors about at the level of Basilosaurus. In Carnivora, a similar thing happens for the ancestor of seals at Enaliarctos. In rodents one sees two independent increases, one along the ancestry of the beaver and one for the muskrat. Afrotheria is the set of mammals evolved from a common ancestor in Africa; it includes animals as diverse as the elephant, manatee, hyrax, and aardvark. It appears that the ancestors of the hyrax and elephant had a more highly charged myoglobin (+5) than the current animals do (+2), indicating a possible aquatic ancestor for both of these currently terrestrial animals. It has been suspected for some time, based on various anatomical features, that elephants may have had aquatic ancestors.

Given the charge on myoglobin and the mass of the animal one may therefore predict dive times for extinct animals.

Sources:

Mirceta, S.; Signore, A.V.; Burns, J.M.; Cossins, A.R.; Cambell, K.L.; Berenbrink, M.
"Evolution of mammalian diving capacity traced by myoglobin net surface charge."
Science 2013, 340, 1234192 (research article).