Dinosaur relationships revisited

For over 130 years scientists/palaeontologists/ have thought that Dinosaurs were divisible into two family groupings known as the Saurishia and Ornithischia: this is the ‘Seeley Model’ created in 1887. All modern textbooks and researchers repeat this story without question, but is it correct? New research is now challenging this long-held view.

A fresh look at the basal relationships between the major dinosaur clades had its origin in some detailed anatomical work that I completed on the Early Jurassic ornithischian dinosaur *Heterodontosaurus* (Norman et al. 2011). Peculiarities in the anatomy of that animal called into question my understanding of how ornithischians were defined and whether they were more closely related to saurischians (theropods in particular). Therefore, I decided to devise a research project that would examine the fundamental question: where did the Ornithischia come from? In order to test the Seeley model of dinosaur evolution.

Detailed examination of the anatomy of all the new discoveries, as well as that of the previously known taxa, from across the Triassic-Jurassic transition zone (230-200 Ma) enabled the construction of an exceptionally large database of information that could be analysed using systematics software. The result generated and carefully verified by the analysis of this new database was exciting because it suggested something entirely novel and challenging in the face of all previous work. We knew that such a novel proposal, if published, would initially be met with skepticism among colleagues, and our data would be examined carefully for misinterpretations or factual errors.

The result blew the orthodox view of dinosaur relationships apart: it supported a grouping of ornithischians with theropod saurischians, and excluded the sauropodomorph saurischians; this pattern had not been recovered by any previous numerical analysis. Feeling sufficiently confident about this outcome we considered it necessary to give a name to this new clade of dinosaurs (Ornithischia + Theropoda). As we mulled over a variety of possible names we eventually re-discovered an article written in 1870 by Thomas Henry Huxley. Huxley clustered together the Megalosauridae and Composgnatha (theropods) along with Iguanodontidae and Scelidosauridae (ornithischians) – at the time he had no idea about the existence of either theropods or ornithischians – nevertheless, he called this grouping the **Ornithoscelida** (‘bird-limbs’) so a perfectly legitimate name for this grouping was in effect ready-made.

<New family tree near here>

Ornithoscelidan novelties

The proposed close relationship (common origin) of theropod and ornithischian dinosaurs has some interesting consequences that seem to make a little more sense of the evolutionary history of dinosaurs.

*Filaments and Feathers*

Birds are characterized by their possession of feathers, but as we well know some of their theropod dinosaurian ancestors also had either filament or feather-covered bodies. Among the other major groups of dinosaurs the sauropodomorph saurischians show no evidence of either filament or feather coverings; however, the ornithischians are now known to exhibit epidermal spines and filament, and in a few instances feather-like structures as well.

<*Kulindadromeus*?? A feathered ornithischian reconstruction>

This distribution now makes a little more sense because it can now be claimed that both theropods and ornithischians had the capacity to grow epidermal structures in their skin (filaments and/or feathers) and that they inherited this ability from a common ancestor. In contrast, the collateral branch of dinosaurs, the sauropodomorph saurischians, might never have had that ability (or lost it very early in their history). In terms of logic, it is arguably simpler to go with the idea of common inheritance implicit in the ornithoscelidan pattern, than the alternative explanations (not that biological evolution knows anything about a philosopher’s logic).

*Bird-like hips*

Another interesting observation concerns the pattern of hip structure that was explained earlier. It has always been acknowledged that paradoxically ornithischians had an ‘ornithic’ pattern of pelvic bones, and yet ornithischians had nothing whatever to do with the origin of birds. The fossil record demonstrates with beautiful precision that birds, with their bird-like pelves, arose from theropod saurischians, and, by implication, evolved the bird-like pelvis independently of that seen in ornithischians. However, the new pattern of evolution suggested by the ornithoscelidan grouping suggests that both ornithischians AND theropod saurischians had the ability to construct the ornithic pattern of hip bones (never seen in sauropodomorph saurischians), they just did so at slightly different times in Earth history! That is to say Early vs Middle Jurassic times respectively.

*Odd bones*

Finally, another intriguing little factoid: ornithischians are characterized by their ability to grow long bony tendons (ossified tendons) along the sides of their spines. These bony rods are not found in theropod or sauropodomorph saurichians, but curiously such tendons are found in the legs and on either side of the spine in some modern birds. Again could this have been a biological tendency that reflects the common ancestry of ornithischians and theropod birds?

Challenges

Shortly after our paper promoting the idea of the Ornithoscelida was published in the journal Nature (Baron et al. 2017a), a consortium of workers submitted a critique of our proposal in the same journal (Langer et al. 2017). These workers followed two lines of argument. Firstly, the group re-scored the datamatrix, which we had created to generate the new topology (=pattern of relationships); in doing so they altered about 10% (~1200) scores and when they re-ran the matrix it produced a pattern that, they claimed, reverted to the traditional topology implied by Seeley’s work. In truth, the statistical support for their revised topology was weak and was barely ‘better’ than any of the alternative topologies. The other line of argument they pursued was to address a minor observation that we had made about the likely geographic area of origin of the first dinosaurs. They used a series of algorithms to demonstrate that Gondwana (and in particular South America) was, without question, the most likely ‘centre of origin’ of dinosaurs.

We re-examined the alterations that the consortium had made to our matrix and unearthed a surprising number of errors. In the end we decided that rather than having to explain all their errors in detail (we were not offered sufficient space to do that in our reply) we could simply correct their scorings for one taxon (*Pisanosaurus*) – a fragmentary, animal that was allegedly the earliest known ornithischian. Correcting just these errors and re-running the analysis (Baron et al. 2017b) reproduced our preferred pattern of relationships (and that was without correcting all the other errors that had been introduced). For the ‘area of origin’ argument, it is a fact that the data is heavily skewed in favour of a Gondwanan/South American area of origin for early dinosaurs. This is, of course, why the analyses trend in that direction; so, no real surprises there. In response (Baron et al. 2017b) we simply noted that we were suggesting that researchers should not blind themselves to the fact that the earliest near-dinosaurs and true dinosaurs are also known to exist, in fragmentary form, globally. These types of animals had long-striding legs and they could therefore have dispersed across the world readily in a geological ‘blip’ time (100>1000 years – an un-measurably short time in geological terms). Indeed the entire concept of a ‘centre of origin’ for dinosaurs is very hard to sustain when applied to the Pangea of Triassic World.

[It is interesting to note that an article published later last year (Agnolin & Rosadilla, 2017) reassessed the fossil remains of *Pisanosaurus*, They concluded that *Pisanosaurus* was not an ornithischian at all, but belonged to the non-dinosaurian group known as silesaurids (as we had tentatively suggested in our rebuttal (Baron et al. 2017b)).] – deletable of course, even if it is relevant.

Future developments?

Further work has since been done on a number of enigmatic early dinosaurs, such as *Chilesaurus* (Baron & Barrett 2017) and it is becoming increasingly clear that such dinosaurs display an anatomy that makes greater sense if the Ornithoscelidan : Saurischian (sauropodomorph) split is accepted, instead of the more traditional Seeley model.

Clearly, these are still very early days with respect to a more general, researcher-wide, acceptance of such a revolutionary suggestion. Thus far our proposal has proved to be sufficiently ‘robust’ (scientifically speaking) that it has been able to withstand the first wave of criticism; there will be, no doubt, more critiques and revisions in the future, this is entirely right and proper, any new theory has to be tested repeatedly before it is accepted. It will be very interesting to see how this area of research and general understanding develops over the next 2-5 years. I am currently describing one of the earliest, well-preserved, ornithischian dinosaurs from the Early Jurassic: *Scelidosaurus* (mentioned at the beginning of this article). Slightly unusually this dinosaur, that is proving to be rather important with respect to our understanding of the evolutionary diversification of the Ornithischia, (from within the Ornithoscelida) has yet to be properly described – so … in many respects it will be interesting to ‘watch this space’!

Comment:

*Yes, I know this is supposed to be a ‘simplistic’ briefing. I have included technical references, but these could be stripped out of course. A book I wrote ( Norman 201)7 actually proposes (tentatively) this new scheme of dinosaur relationships, but also gives a bit of the history associated therewith.*