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Perspectives — Palaeontology in 2017

by The Palaeontology [online] editorial board*1

Introduction

Every now and then at Palaeontology [online], we like to take a look at the world of palaeontology and reflect on what is happening in the field. Contrary to stereotypes, we believe that palaeontology and associated disciplines represent a fast-moving and exciting area of science. To highlight this, the members of the editorial board have each chosen a favourite paper from 2017. Picking just one paper was difficult for all of us, and it means that we have highlighted just five articles out of the many hundreds published in the past 12 months. Nevertheless, we hope that our choices reflect the breadth and depth of palaeobiological research in the twenty-first century. The papers include incredibly small and ancient invertebrates, wonderfully preserved dinosaurs, important marine mammals, the application of techniques from other disciplines to help us understand ancient echinoderms, and the evolution of the royal ferns. We also couldn't help but notice the festive season approaching — and so we have each taken the opportunity to briefly describe a favourite fossil for the holidays. So, in alphabetical order, here is our editorial board with their highlights.

Russell Garwood — A festive arachnid

One of my favourite fossils is *Eophalangium sheari*. Just as the end of the holiday season marks the start of a new year and all the changes this can bring, this fantastic creature is found at a turning point in evolution

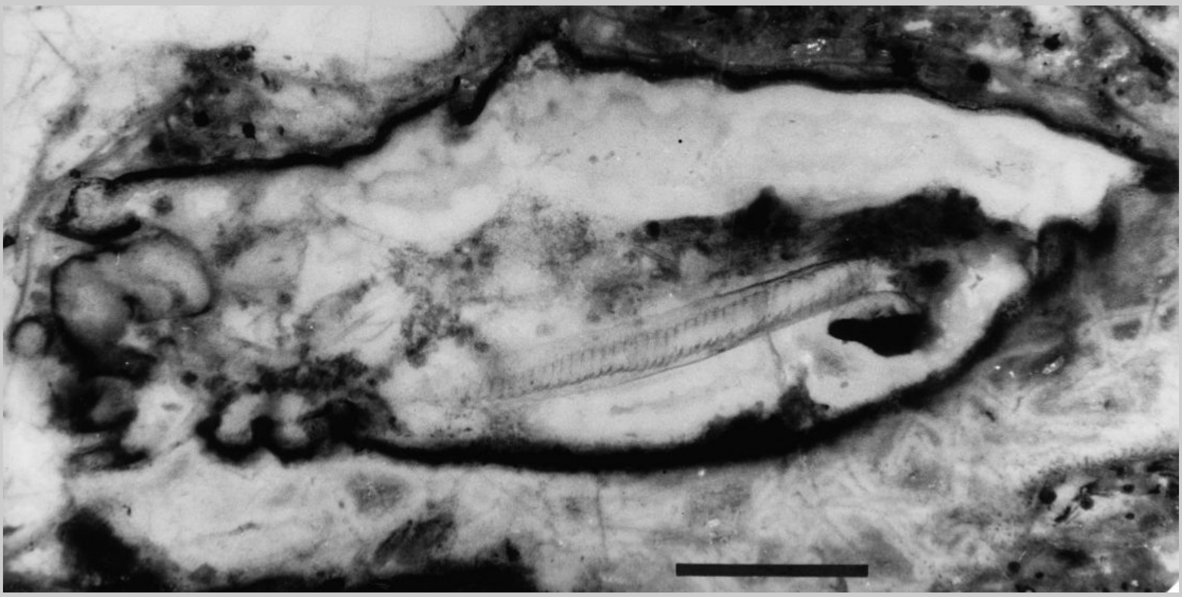

Figure 1 — *Eophalangium sheari*, a fossil harvestman arachnid from the 411-million-year-old Rhynie Chert in Scotland. The internal structure probably represents an ovipositor for laying eggs — so this is a female. The scale bar is 1 millimetre. Modified after Dunlop *et al* (2004).

It is one of the earliest land animals, a member of one of our best preserved terrestrial ecosystems from the Palaeozoic era (542 million to 251 million years ago). It is a wonderfully preserved harvestman arachnid — part of a group that is still around today — and is found alongside some of the earliest complex plant fossils and a number of other terrestrial arthropod fossils. It is so well preserved, we can even see its internal anatomy (Fig. 1). If I were to find this in my stocking, what a Christmas that would be!

Russell Garwood — Favourite invertebrate-fossil paper of the year: 'Exceptionally preserved Cambrian loriciferans and the early animal invasion of the meiobenthos' by Harvey and Butterfield in *Nature Ecology and Evolution*

There have been a lot of really exciting papers this year — in invertebrate fossils, the development of new methods and the study of evolution — which has made picking just one as a highlight something of a challenge. Nevertheless, needs must. One favourite of mine this year was the work of Harvey and Butterfield, who have described an assemblage of loriciferans from the late Cambrian period (around 497 million to 485 million years ago).

This phylum of tiny animals is closely related to arthropods and to priapulid worms. Their fossil record is limited because of both their minute size and the fact that they are unlikely to fossilize. This is true of many animals of this size that live in sediments: animals that constitute something called the meiofauna. This broad collection of organisms makes significant contributions to modern ecosystems but, because of a lack of fossils, their origins and relationships are hard to untangle.

The fossils described in Harvey and Butterfield (2017) are about one-third of a millimetre across as adults, showing that early in the group's history, the loriciferans had become part of the meiofauna (as they have been ever since). Because they are rather complex animals, however, the authors suggest that the loriciferans evolved from a larger-bodied ancestor. That they have been recovered as fossils — the researchers dissolved mudstones in very strong acid to retrieve them — also suggests that future studies may find more meiofauna.

That could help us better understand early animal evolution. Indeed, the paper concludes by saying that these approaches "offer a direct window onto cryptic animal ecosystems through deep time". So, as well as helping us understand the evolution of this particular group, there is also scope for exciting future discoveries with broad implications.

Figure 2 — A fossil loriciferan from the upper Cambrian recovered by dissolving mudstones in acid. From Harvey & Butterfield (2017).

Stephan Lautenschlager — A festive dinosaur

Dinosaurs might not have been well equipped to deal with snow and ice, but that doesn't mean there are no polar dinosaurs. The single known *Nanuqsaurus hoglundi* (the 'polar-bear lizard') fossil was found in northern Alaska, well beyond the Arctic Circle (Fig. 3). This small (roughly 3-metre) tyrannosaur lived during the late Cretaceous period (about 70 million years ago), when Alaska was ice-free and the temperatures were more moderate than today.

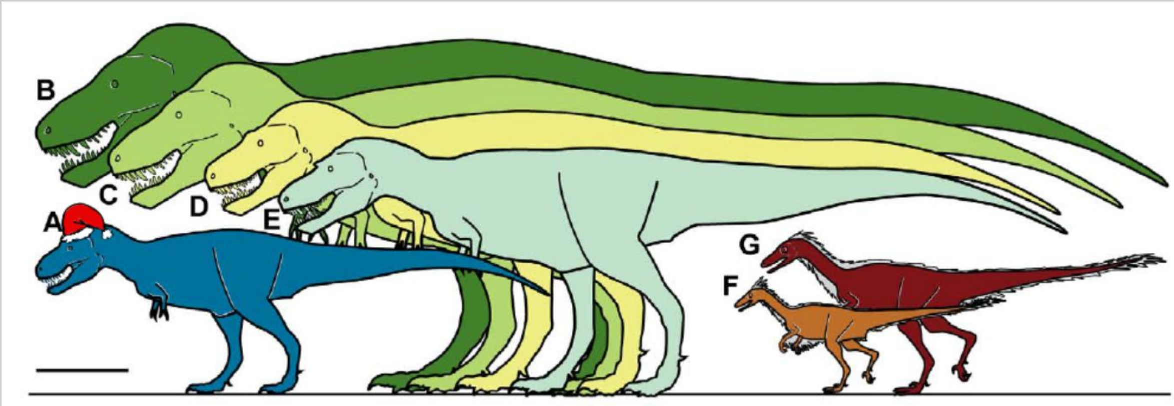

Figure 3 — *Nanuqsaurus hoglandi* (A) compared to other large tyrannosaurs (modified from Fiorillo & Tykoski, 2014)

Stephan Lautenschlager — Favourite dinosaur paper of the year: 'An exceptionally preserved three-dimensional armored dinosaur reveals insights into coloration and Cretaceous predator-prey dynamics' by Brown *et al.* in *Current Biology*

As usual, this year has seen its fair share of dinosaur papers. Some of those have shaken the very foundations of dinosaur palaeontology by proposing a substantial reorganization of the dinosaur family tree (Baron *et al.*, 2017). Instead of the longstanding division of dinosaurs into saurischians and ornithischians, Baron and colleagues argue for combining theropods and ornithischians in a new group, named Ornithoscelida. This has prompted a storm of public and academic discussion, but one thing became eminently clear from it: a lot more fossils — and well preserved ones — are needed to resolve such controversies.

One such fossil find this year was *Borealopelta*, an exceptionally well preserved ankylosaur from Alberta, Canada (Brown *et al.*, 2017; Fig. 4). This armoured dinosaur from the early Cretaceous (around 100 million to 113 million years ago) was found in fine-grained sandstones and shales representing an offshore environment, indicating that the carcass was washed into the sea shortly after the dinosaur died. Quick sedimentation and the low oxygen levels at the sea floor made sure that the body was quickly covered, and was preserved nearly intact for the following 100 million years. As a consequence, *Borealopelta* is one of the best ankylosaur specimens ever found, preserving not only many details of its body still in the original position, but also remnants of skin and horn sheaths covering the body armour. The fossil therefore looks unusually lifelike and almost if it was just asleep and not dead for millions of years. But that is not all. Pigments preserved in the fossilized soft tissues further revealed that the dinosaur had a reddish-brown colour pattern, which might have had a function in camouflaging it from predators.

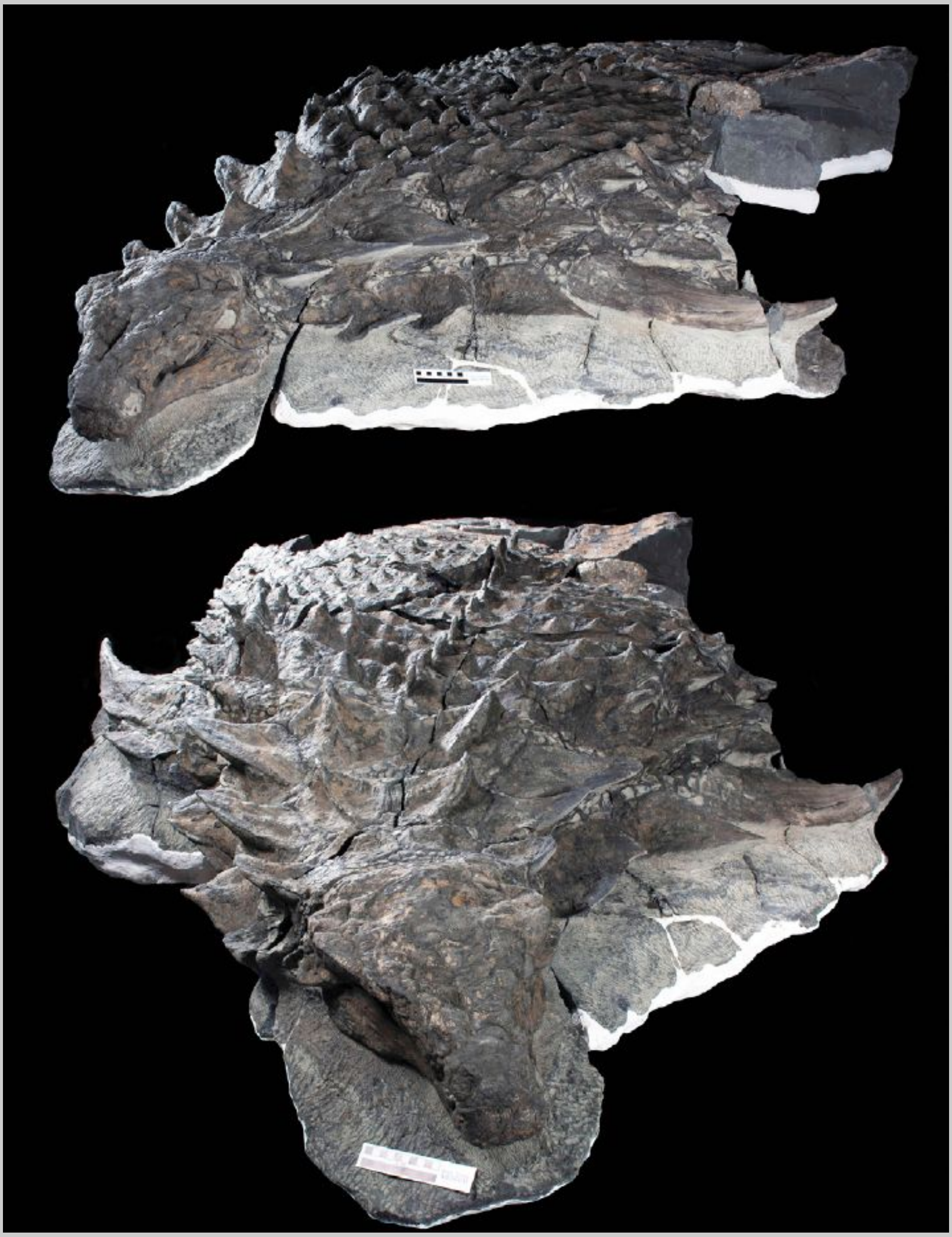

Figure 4 — The exceptionally well preserved fossil of *Borealopelta markmitchelli* (from Brown *et al*., 2017).

Rachel Racicot — Festive fossil dolphins

Odobenocetops peruvianus and *Odobenocetops leptodon* are archaic dolphins that seem to be a combination of several living Arctic-specialized species, such as the narwhal (*Monodon monoceros*) and walrus (*Odobenus rosmarus*). *Odobenocetops* fossils come from the Pliocene Pisco Formation, a rock formation between 3 million and 4 million years old on the southern coast of Peru. They are probably closely related to or nested in the group that includes narwhals and belugas (Monodontidae). The genus has an unusual shape for a dolphin (Fig. 5), including a skull shape similar to that of the walrus and knobs at the base of the skull indicating a good amount of neck mobility. This suggests that this animal probably fed on molluscs and other invertebrates from the sea floor, similar to extant walruses.

Figure 5 — Artist's reconstruction of the majestic *Odobenocetops* sp. Illustration by Pavel.Riha.CB. Reproduced under CC BY-SA 3.0.

Rachel Racicot — Favourite whale paper of the year: 'Infrasonic and ultrasonic hearing evolved after the emergence of modern whales' by Mourlam and Orliac in *Current Biology*

Many excellent papers have come out this year on marine-mammal fossils, setting the stage for renewed interest in the diversity of animals and the effects of Earth systems during critical intervals of marine-mammal evolution. Mourlam and Orliac investigated the inner-ear labyrinth of a variety of whales and their extant and extinct relatives (Fig. 6). The detailed analysis describes for the first time the anatomy of two whales from the early Eocene epoch (46 million to 43 million years ago), part of a group that was semiaquatic and could still walk on land (Protocetidae). The results show that these archaic 'walking whales' had an intermediate hearing range between land-dwelling artiodactyls (even-toed ungulates such as deer) and ocean-dwelling artiodactyls (whales and dolphins). The results are an important step forward in understanding the ecology and evolution of ancient whales as researchers begin to investigate further whether later-diverging, more fully aquatic-adapted whales had different hearing physiologies and ecologies from one another as they coexisted in the late Eocene epoch.

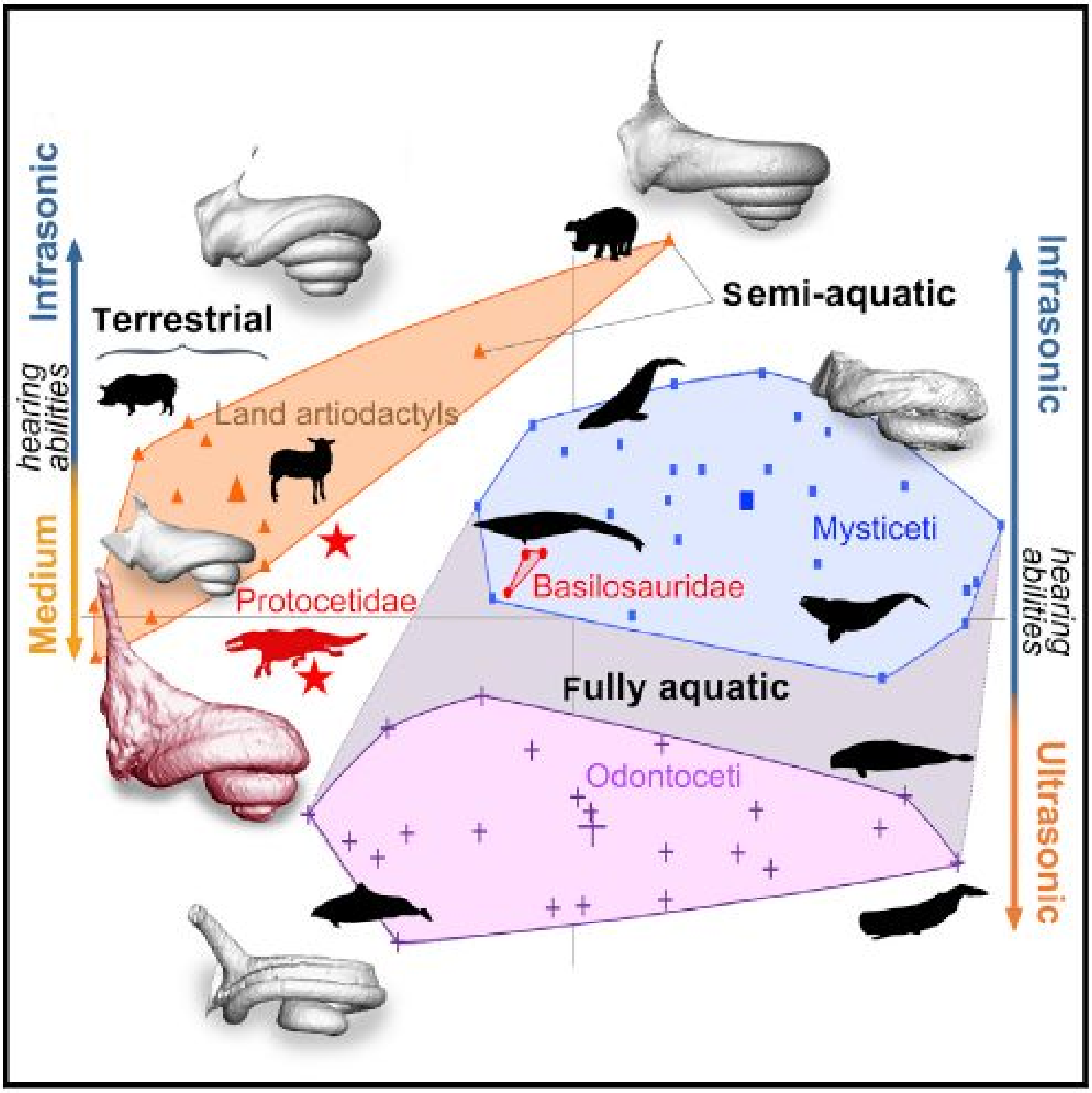

Figure 6 — Graphical abstract from Mourlam and Orliac (2017), showing an analysis reflecting the morphological distribution of nine hearing-related measurements and their association with hearing abilities in semi-aquatic and aquatic whales and their terrestrial relatives.

Imran Rahman — A festive starfish

In the run up to the holiday season, chances are you will see lots of Christmas trees with stars on top, but what could be more festive than your very own fossil starfish! The fossil record of starfish, or sea stars, is extensive, dating back to the Ordovician period, more than 450 million years ago. Some of the most famous examples come from a 400-million-year-old site of exceptionally preserved fossils in Germany, called the Hunsrück Slate, where starfish and other fossils are beautifully preserved as pyrite, or fool's gold (Fig. 7).

Figure 7 — The fossil starfish *Urasterella asperula* from the Devonian period of Germany. Photograph by Dwergenpaartje. Reproduced under CC BY-SA 3.0.

Imran Rahman — Favourite echinoderm paper of the year: 'A new model of respiration in blastoid (Echinodermata) hydrospires based on computational fluid dynamic simulations of virtual 3D models' by Waters *et al.* in the *Journal of Paleontology*

2017 was a great year for research on fossil echinoderms — the group of marine animals that includes starfish and sea urchins — including a bumper special issue in the *Journal of Paleontology* called 'Progress in Echinoderm Paleobiology' (co-edited by yours truly and currently free to access here). One of the more intriguing studies in this issue was that of Johnny Waters and colleagues, who focused on a peculiar extinct group of echinoderms called blastoids. Blastoids look superficially similar to crinoids (sea lilies), a group of echinoderms that is still alive today, but it is unclear exactly how closely related the two groups are. One particularly interesting characteristic of blastoids is their internal respiratory structures, called hydrospires. These structures are rather different from anything seen in living animals, and so working out how they functioned is a major challenge for palaeontologists.

Waters and colleagues analysed the function of blastoid hydrospires using a method called computational fluid dynamics, which is commonly used in engineering to test the performance of cars and planes. They created a virtual water tank on a computer and placed a 3D model of a fossil blastoid into it. They then ran simulations of water currents around and through the digital blastoid to test how the hydrospires affected fluid flow. Their results suggest that water entered the hydrospires through pores along the sides of the animal, travelling within these structures at low velocity to allow oxygen from the water to enter the animal's cells, before exiting near the mouth. In life, blastoids were probably positioned with their stems bent over, so that the hydrospires were oriented horizontally (Fig. 8). Studies such as that of Waters and colleagues demonstrate the great potential of using methods from other disciplines, such as engineering, to reconstruct the lifestyles of extinct fossil animals.

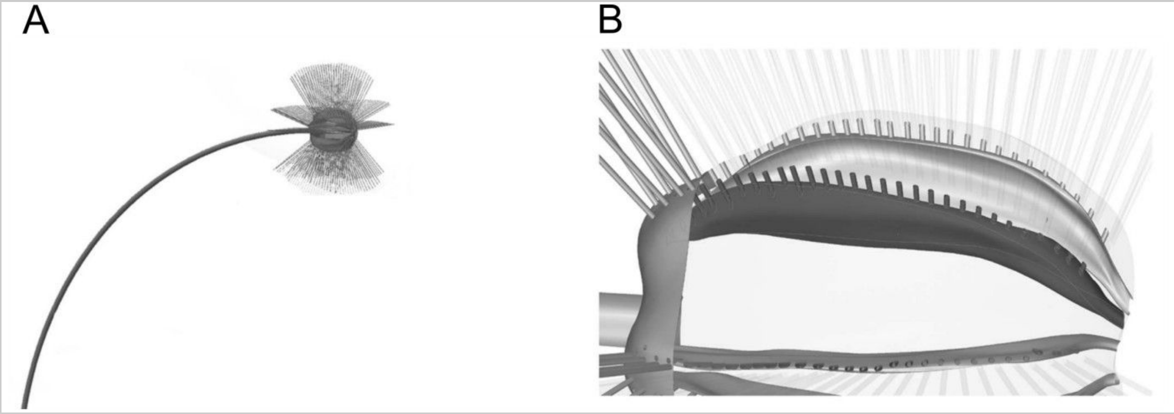

Figure 8 — Digital model of the blastoid echinoderm *Monoschizoblastus rofei*. A, Model of *Monoschizoblastus rofei* in hypothesized feeding position, with the stem bent. B, Close-up of the model in (A), showing the hydrospires and associated pores. Modified from Waters *et al.* (2017).

Alan Spencer — A festive palaeoplant

Although plants do not celebrate Christmas, or thrive in cold, snowy conditions, there are many fossil plants that today are recovered from such environments, in particular from Antarctica.

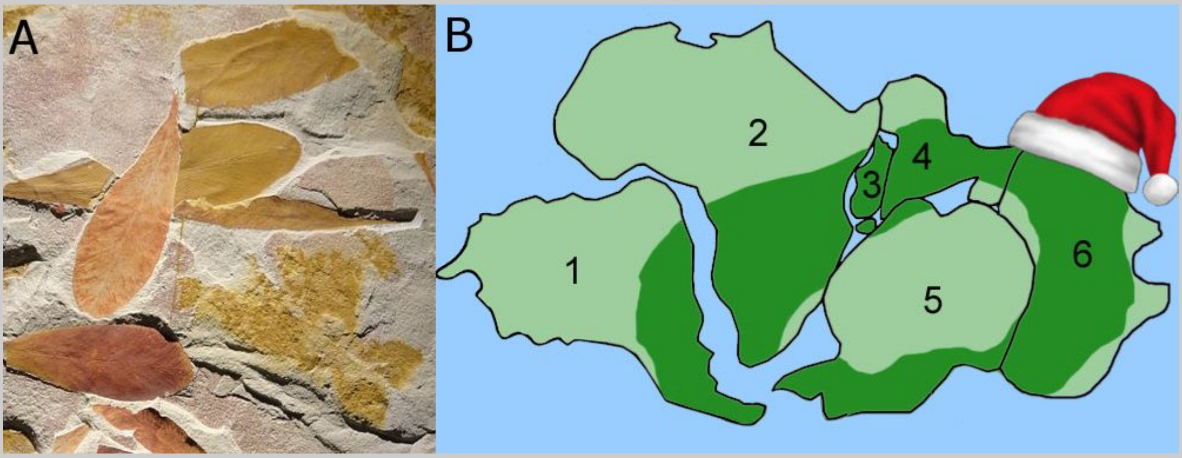

Figure 9 — A, *Glossopteris* sp. Image reproduced under a CC0 license. B, Distribution of *Glossopteris* fossils (dark green) on the modern continents, shown in their positions as parts of the super-continent Pangaea. 1, South America; 2, Africa; 3, Madagascar; 4, Indian subcontinent; 5, Antarctica; 6, Australia. Drawn by Petter Bøckman. Image reproduced under a Public Domain License.

The most famous was discovered by Robert Falcon Scott's doomed 1911–12 expedition, and is called *Glossopteris indica*. This prize fossil, an extinct 250-million-year-old beech-like tree, was found next to Scott's body. The study of the fossil and similar *Glossopteris* found in Australia, Africa and South America formed one of the 'proofs' that Earth's land masses once made up an ancient super-continent named Gondwanaland (now just called Gondwana; Fig. 9).

Alan Spencer — Favourite palaeobotanical paper of the year: 'The fossil Osmundales (Royal Ferns) — a phylogenetic network analysis, revised taxonomy, and evolutionary classification of anatomically preserved trunks and rhizomes' by Bomfleur *et al.* in *PeerJ*

Papers dealing with plant evolution — whether based on morphological similarities or genetic characteristics — tend to fall into the category of 'scientifically informative, but visually unappealing to read'. This is due in part to the nature of the information: vast data sets coding in 0 and 1, and for excitement the odd other numeral, leading to monotone evolutionary-tree diagrams. It was therefore highly pleasing to read Bomfleur *et al.*'s contribution dealing with the affinities of the Osmundales — also known as the royal ferns (Fig. 10) — the oldest surviving lineage of leptosporangiate ferns, which can be traced back to the Permian period (298 million to 252 million years ago), part of the late Palaeozoic era.

Figure 10 — 'Flowering' royal fern (*Osmunda regalis*); natural occurrence in a forest. Photograph by Christian Fischer. Reproduced under CC BY-SA 3.0.

The authors first tackled the thorny problem of standardization within specimen descriptions and their systematic classification (Fig. 11) — before this work, since the last family wide review in 1971 by Miller, 50 new species, 12 new genera and 4 new subfamilies have been described, all using differing terminology. The amount of work involved in standardizing them cannot be understated, and will provide a framework for the description of future fossil Osmundales specimens.

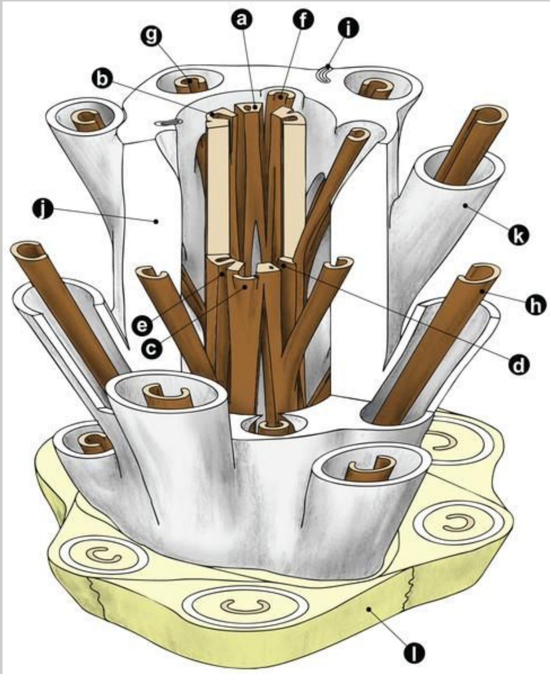

Figure 11 — Exploded diagram of a osmundoidalean rhizome showing a selection of general anatomical features. Figure 1 of Bomflour *et al* (2017). Image reproduced under CC BY 4.0.

Second, in this work, each character defined for use in the 'systematic–phylogenetic analysis' has been illustrated in colour (Fig. 12) and the individual coding shown with symbols.

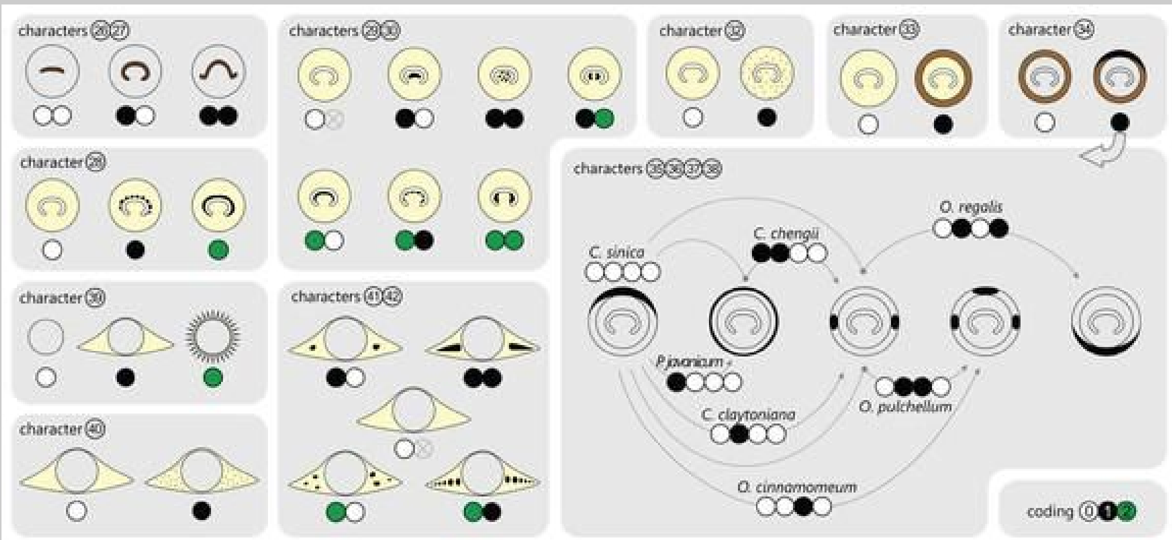

Figure 12 — Example of the illustrated diagrams showing selected anatomical features of Osmundales together with the respective character scoring used in the matrix. Figure 7 of Bomflour *et al* (2017). Image reproduced under CC BY 4.0.

This is not only very visually pleasing, but reduces the interpretive errors of any future work by showing exactly what has been coded into the matrix. Third, this paper goes one step further, by combining the morphological data with a phylogenetic analysis based on living Osmundales. This is an interesting technique that has rarely been used in fossil-plant studies. The authors' results have allowed a complete reclassification of the fossil Osmundales.

Conclusion

As you can see, 2017 has been a good year: methods by which we can understand past life have been developed, many exciting new fossils have been discovered, and other interesting findings have been achieved by revisiting old fossils that have been described before. Looking forward into 2018, the future is bright. Palaeontology is a vibrant and exciting discipline, and who knows what we may discover!

Suggestions for further reading

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[1]The Palaeontology [online] editorial board can be found here.