Dinosaur Egg Parataxonomy [1]

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Dinosaur egg [5] parataxonomy is a classification system that organizes dinosaur eggs by descriptive features such as shape, size, and shell thickness. Though egg [5] parataxonomy originated in the nineteenth century, Zi-Kui Zhao from Beijing, China, developed a modern parataxonomic system in the late twentieth century. Zhao's system, published in 1975, enabled scientists to organize egg [5] specimens according to observable features, and to communicate their findings. The eggshell protects the developing embryo, enables gas exchange between the embryo and the environment external to the egg [5], and the internal components of the egg [5] provide nutrients for the embryo. Those external and internal features that support a developing embryo leave their mark on eggshells. Dinosaur egg [5] parataxonomy classifies those characteristics and provides insight into dinosaur egg [5]-laying behaviors, reproductive physiology, and embryonic development.

In 1975, paleontologist Zi-Kui Zhao at the Institute of Vertebrate Paleontology and Paleoanthropology in Beijing, China, published research about Mongolian fossilized eggs. He used Zhao's system to discuss the eggs. Zhao's parataxonomic system reinforced the practice of identifying egg [5] features, such as size, ornamentation of the shell, and microstructure of shell units. Zhao suggested that each parataxonomic rank depended not just on groupings of similar morphological characteristics of the eggshell, but must also reflect the evolutionary history of the characteristic. He said that a scientist working to categorize a fossilized egg [5] shell must consider how similarities in morphology [8] can signal functional and evolutionary divergence between related species. Zhao published his system in Chinese, and his work was not translated into English for over a decade. Therefore, his egg [5] parataxonomic system was not immediately available to the English-speaking world.

Parataxonomy gained wider acceptance in 1991 when Konstantin Mikhailov at the Paleontological Museum of Russian Academy of Science in Moscow, Russia, published research about Mongolian fossilized eggs. He used Zhao's system to discuss the eggs. Mikhailov illustrated the benefits of adopting Zhao's parataxonomy. Mikhailov's work was translated into English, and over the next few years, more paleontologists began to use about Zhao's system. Mikhailov wrote further about the lack of a universal schema for dinosaur egg [5] classification, including a 1996 paper titled "Parataxonomy of Fossil Egg Remains (Veterovata): Principles and Applications."

In this paper, Mikhailov and his colleagues argued that the methods and criteria used to identify and classify fossilized eggs is fragmented and likely resulted from the rare nature of the fossils, as well as from the geographical isolation of separate egg [5] discoveries. They suggested that an increase in fossil egg [8] discoveries required scientists to adopt a universal nomenclature.
Sources for classifying, explaining and communicating results/discoveries about dinosaur eggs, paleontologists such as Zhao and In to the first decades of the twenty-first century, the majority of paleontologists who studied fossil eggs used the formalized dinosaur egg paratonomy within a larger category called Veterovata, meaning old eggs. That category enabled scientists to situate dinosaur eggs within larger categories of other fossilized eggs, for example those of ancient birds and crocodiles.

The paratonomic system divides eggs into the categories of family, genus, and species. Scientists assign fossil eggs to species based the egg size, including length, width, and volume, the range of eggshell thickness, the eggshell's surface pore patterns, and the ornamentation details of the shell. The genus classifies the fossilized egg within a slightly wider range of egg size, type of pore canals, and surface ornamentation grouping. Above the genus level, there are three main categories based on shapes that commonly occur, small round bodies (Spherulitic), prism shaped (Prismatic), and resembling a bird (Ornithoid). These categories classify the eggshell's structure, with particular attention to shell units.

A part of the paratonomic system requires scientists to collect evidence from extant avian and crocodilian eggs for comparison with dinosaur eggshell. Crocodiles and birds are the closest living relatives to dinosaurs. The comparison enables scientists to hypothesize about dinosaurian structures that they cannot see in fossils, such as reproductive organs, based on evolutionary relationships. For example, birds and crocodiles have a part of the reproductive tract that adds a specific layer to the egg as it moves down the oviduct, called assembly-line oviducts. Scientists infer that dinosaurs also had assembly line oviducts. Scientists compared the eggshell of dinosaurs to those of crocodiles and birds and found that they all share common microscopic features including a hard calcite construction. Therefore, scientists theorize that dinosaur reproductive organs were likely similar to birds and crocodiles.

Scientists infer aspects of the dinosaur reproductive tracts by comparing the shape of dinosaur eggs with those of other archosaurs. For example, some birds lay asymmetric eggs, compared to round crocodilian eggs. Certain dinosaur eggs, including those containing embryos of the birdlike dinosaur, Troodon formosus, are also asymmetric, which suggests that dinosaurs such as Troodon had birdlike reproductive tracts.

Features of the eggshell, identified using paratonomy, also provide clues about dinosaur reproductive behavior, such as how dinosaurs could have constructed their nests and whether or not parents incubated those nests. The density of pores across the eggshell indicates the amount of gas exchanged between the embryo and the outside environment. Many dinosaur eggshells have a high density of pores, which could have facilitated gas exchange in environments where oxygen was not readily available. Living reptiles lay eggs with high pore density and incubate their eggs using either sediment or dense vegetation. Scientists hypothesize that some dinosaurs may have used similar methods to build nests.

Eggs can also indicate the developmental stages of dinosaurs have reached upon hatching. Living animals emerge from their eggs in a variety of developmental stages. For example, crocodiles can move around and eat on their own, and scientists call them precocial young, whereas some birds hatch unable to leave the nest to feed themselves without the help of their parents, called altricial young. Precocial young require fully developed teeth and bones upon hatching, enabling them to support their own weight and to consume food. Altricial young are less developed, and must remain in the nest after hatching. While scientists examine the correlation between egg size, growth, and the developmental stage of hatching, they debate whether dinosaurs produced either precocial or altricial young.

In the first decades of the twenty-first century, the majority of paleontologists who studied fossil eggs used the formalized paratonomic scheme. However, not all scientists used this method, and some argue that it has faults. By establishing methods for classifying, explaining and communicating results/discoveries about dinosaur eggs, paleontologists such as Zhao and Mikhailov enabled scientists to study eggs in detail, and to discuss features such as pore systems and eggshell ornamentation.

Sources

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