# Dinosaur eggs

Kurt Schläpfer

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Prof. Dr. K. Schläpfer
St. Gallerstrasse 60, CH-9032 Engelburg, Switzerland
E-Mail: schlaepfer@datacomm.ch

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## Introduction

It is assumed that all dinosaurs reproduced by laying eggs, i.e. they were oviparous. About 240 dinosaur egg sites have been described. As an example, more than 100,000 dinosaur eggs originating from 20 dinosaur species were found at a nesting site in the Henan Province in China (HAO 2016). But, despite the many egg discoveries, the existing knowledge about dinosaur eggs is still poor. About 1,000 species of dinosaurs are known today from which about 650 are described in more detail. But not more than 160 different dinosaur eggs or eggshell fragments are so far reliably described. And most eggs cannot be assigned to a certain dinosaur species. The author of this text was only able to identify 30 eggs of which the dinosaur species is known (see Appendix 1).

## Egg classification

Since most discovered eggshells cannot be attributed to a particular dinosaur species, a classification was developed which describes the eggs in terms of their size, volume, eggshell thickness, eggshell surface and the structure of the eggshell. In this way a parallel classification of the eggs (parataxanomy) was created based on the order criteria oofamily, oogenus and oospecies.

Parataxonomy for the classification of dinosaur eggs was first proposed by ZHAO (1975) and gained wider acceptance in 1991 when MIKHAILOV published research about Mongolian fossilized eggs. In 1996 MIKHAILOV published a list of 11 egg families, 23 egg genera and 49 egg species, which reflected the state of knowledge about dinosaur eggs at that time.

Table 1 shows a list based on sources from 2009 (LIANG XQ ET AL.) and 2016 (TANAKA K.). This list includes:
25 oofamilies
72 oogenera
167 oospecies.
This list may contain duplicate entries. Furthermore, not all recent egg discoveries may have been included. But in general terms, some 160 eggs of dinosaur species are currently described of which only about 30 can be assigned to a certain dinosaur species. And some others can be linked to a certain taxonomic group of dinosaurs.

A description of the nearly 30 dinosaur eggs that can be assigned to a specific species is given in Appendix 1. In some cases, very different data have been found for eggs of the same species. For example, four different eggs of the *Oviraptor* are described whose volumes differ by a factor of up to three. Since such differences in egg size are unlikely in the same species, the data given in Appendix 1 should be viewed with a certain scepticism.

*Table 1: Parataxonomic list of the dinosaur eggs*

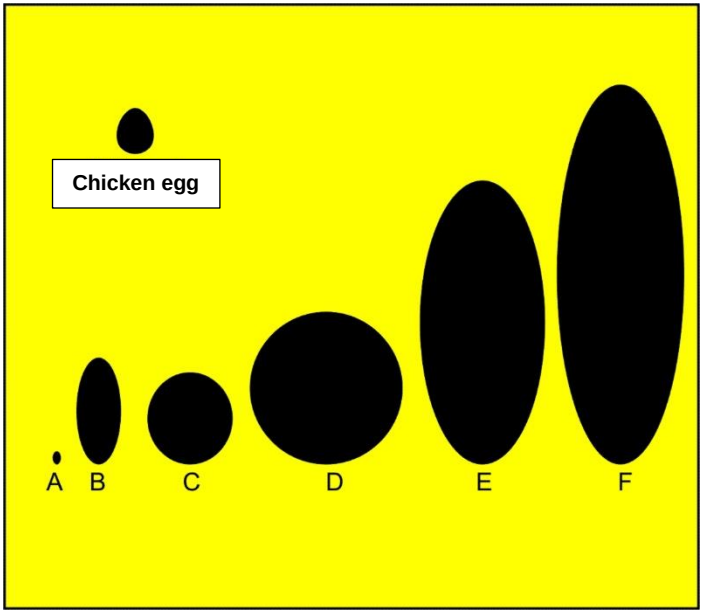
| **Oofamily** | **Oogenera** | **Oospecies** |
|---|---|---|
| *Arriagadoolithidae* | 2 | 2 |
| *Belonoolithae* | 1 | 1 |
| *Cairanoolithidae* | 1 | 2 |
| *Dendroolithidae** | 3 | 15 |
| *Dictyoolithidae* | 4 | 7 |
| *Elongatoolithidae* | 11 | 28 |
| *Faveoloolithidae* | 4 | 8 |
| *Fusioolithidae* | 1 | 2 |
| *Gobioolithidae* | 1 | 2 |
| *Laevisoolithidae* | 3 | 3 |
| *Medioolithidae* | 3 | 3 |
| *Megaloolithidae* | 2 | 22 |
| *Montanoolithidae* | 1 | 1 |
| *Oblongoolithidae* | 1 | 1 |
| *Ovaloolithidae* | 1 | 8 |
| *Pachycorioolithidae* | 1 | 1 |
| *Phaceloolithidae* | 1 | 1 |
| *Pinnatoolithae* | 2 | 6 |
| *Polyclonoolithidae* | 1 | 1 |
| *Prismatoolithidae* | 6 | 18 |
| *Similifaveoloolithidae* | 1 | 2 |
| *Spheroolithidae* | 4 | 15 |
| *Stalicoolithidae* | 2 | 2 |
| *Tubercuoolithae* | 2 | 2 |
| *Youngoolithidae* | 1 | 2 |
| *Incertae sedis* | 12 | 12 |
| **Total** | 72 | 167 |

* also known as *Phaceloolithae*

**Egg size**

In view of the size of dinosaurs one is tempted to assume that their eggs must have been much larger than the largest bird eggs. But this is not the case. The elephant bird (*Aepyornis maximus*), which became extinct over 350 years ago, laid even larger eggs than were found for dinosaurs.

*Figure 1: Comparison between dinosaur eggs and a chicken egg*




*A smallest known egg (species unknown) 18×11 mm*
*B Oviraptor philoceratops 150×63 mm*
*C Hadrosaurus foulkii 130×120 mm*
*D Titanosaurus blanfordi 215×215 mm*
*E Tarbosaurus bataar 400×175 mm*
*F largest known egg (species unknown) 610×179 mm*
*Chicken egg 57×43 mm*

Until the mid-1990s, the largest dinosaur eggs found were about the size of a soccer ball. Then, surprisingly, much larger eggs of elongated shape were found in China, about twice the size of a soccer ball. The largest of these eggs has a volume of just under ten litres. Unfortunately, these eggs could not yet be assigned to a dinosaur species. Sometimes, even larger eggs were reported, but this was never confirmed with reliable data. The smallest dinosaur egg found so far is almost 50 times smaller than a chicken egg. With a weight of 1.2 grams it corresponds approximately to the egg of a great tit (*Parus major*). But the dinosaur species laying this egg is unknown.

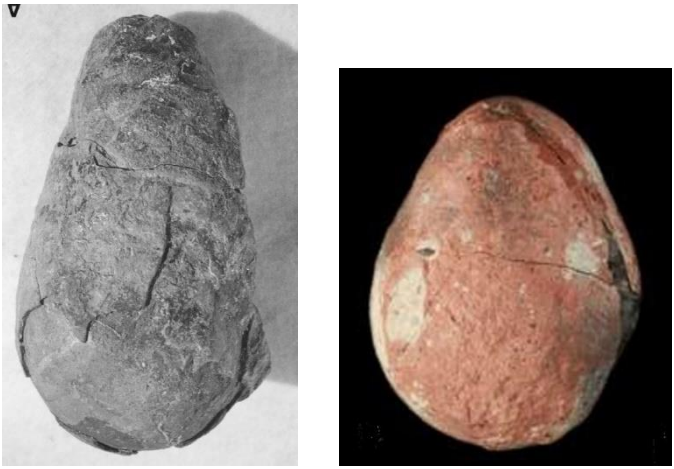
**Egg shape**

Dinosaur eggs can be either round or elliptical or elongated. This can be described by the length to width ratio. While this value is always smaller than 2:1 for bird eggs, it can be over 3:1 for dinosaur eggs. Most known dinosaur eggs are symmetrical, but there are also exceptions (see figure 2). As an example: The egg of *Troodon formosus* is pear-shaped (VARRICCHIO 2002), and the egg *Parvoblongoolithus jinguoensis* is described as ovoid (SHUKANG 2015).

**Eggshell thickness**

The eggshell thickness is subject to relatively tight limits: If the shell is too thin, it can break when the eggs are laid. It is assumed that the eggs of large dinosaurs fell from a height of more than one meter. However, if the eggshell is too thick, the chick is no more able to break open the eggshell. In addition, the oxygen supply to the embryo is reduced with increasing eggshell thickness. According to current knowledge, eggshells may not be thicker than about 6 mm. The eggshell thicknesses measured for dinosaurs range from 0.3 mm to 4.75 mm.

*Figure 2: Dinosaur eggs with asymmetric egg shape*

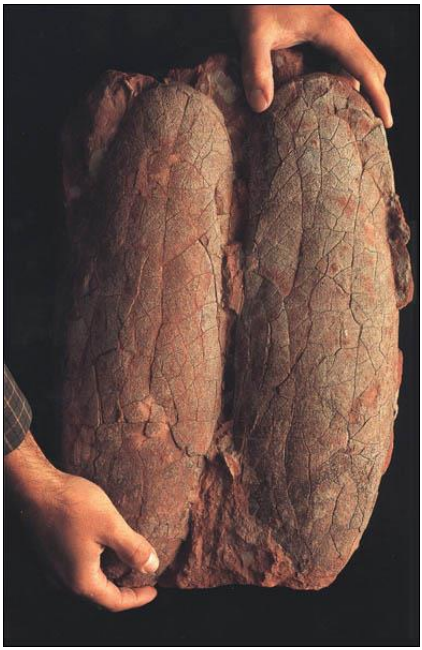


*Left: Pear-shaped egg of the Troodon formosus*
*Right: Ovoid egg shape of Parvoblongoolithus jinguoensis*

**Clutch size**

For birds, the clutch size can vary between one and about 25. Much larger clutch sizes are typical for reptiles: e.g. up to 240 eggs for turtles, up to 150 eggs for crocodiles and over 100 eggs for snakes. The maximum clutch size for dinosaurs is 40 eggs. Many dinosaurs had two fallopian tubes so that they could lay two eggs together. As these eggs often stuck together, they are called twin eggs (see figure 3). For reproduction, the number of clutches per year or the number of eggs per year is more relevant than the clutch size. It is assumed that dinosaurs laid a maximum of 200 eggs per year.

*Figure 3: Twin eggs of dinosaurs*



*These eggs represent the largest dinosaur eggs found so far. The eggs depicted are about 37 cm long. The largest eggs of this kind are 60 cm long.*

**Eggshell coloration**

Until recently it was believed that all dinosaur eggs were colourless, just as is the case with all reptile eggs. But then a remarkable discovery was made: The blue-green pigment biliverdin has been detected in the eggshell of a smaller dinosaur (WIEMANN 2017). This pigment is responsible for the blue-green coloration of bird eggs, for example the eggs of blackbirds and thrushes. The discovery is remarkable in that the pigment biliverdin is an organic substance that should be completely degraded after 65 million years.

**The egg size in relation to the body mass**

An interesting feature of an egg is its size in relation to the egg-laying animal. From the avian fauna relatively exact data are available. In general, the eggs of small birds are relatively larger than those of large birds. The smallest birds, for example the hummingbirds, lay eggs whose weight amounts to approximately 15% of the body weight, while for the largest living birds, the ostriches, the relative egg size is only 1.5%. However, there are also extreme values for birds: The egg weight of the Wilson's storm-petrel (*Oceanites oceanicus*) is 30% of the body weight of the female bird, and for the little spotted kiwi (*Apteryx owenii*) this value is 23%. It should be emphasised that such data for birds are based on reliable averages. For dinosaur eggs, the availability of data is much poorer. Like avian eggs, dinosaur eggs differ in size within a clutch or from animal to animal. But intact dinosaur eggs of the same species are not so numerous that average values can be determined. The same problem arises, if the exact body weight of dinosaurs is of interest.

The largest dinosaur whose eggs are known is the *Argentinosaurus huinculensis*. G. V. MAZETTA (2004) calculated an average animal weight of 76.1 tons using different formulas. Its eggs weigh about 4.7 kg. Hence, the egg weight is less than 0.01% of the animal body weight. Or in other terms: The adult animal is about 16,000 times heavier than the egg from which it hatched. This fact is interesting as it tells something about how fast a dinosaur has to grow until it attains adult size. ERICKSON (2001) calculated that the *Argentinosaurus huinculensis* must have grown at a maximum rate of 55.64 kg per day what is equivalent to about two tons per year.

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## Appendix 1: Egg characteristics of some dinosaur species

| Species | L (mm) | B (mm) | L/B | Eggshell thickness (mm) | Volume (ml) | Egg weight (g) |
|---|---|---|---|---|---|---|
| *Argentinosaurus huinculensis* | 200 | 200 | 1.0 | | 4188 | 4732 |
| *Titanosaurus blanfordi* | 215<br>237 | 215<br>171 | 1.0<br>1.4 | 1.3<br>3.1 | 5203<br>3628 | 5853<br>3863* |
| *Oviraptor philoceratops* | 150<br>175<br>200<br>190 | 62.5<br>84.3<br>97<br>72 | 2.4<br>2.08<br>2.06<br>2.64 | 0.6 | 307<br>634*<br>985<br>502* | 332<br>693*<br>1084<br>549* |
| *Hypselosaurus priscus* | 250<br>300 | 230<br>250 | 1.09 | | 6923<br>9563* | 7754<br>10,452* |
| *Maiasaura peeplesorum* | 110 | 79 | 1.4 | 1.0 | 360 | 407 |
| *Citipati osmolskae* | 190 | 72 | 2.6 | 0.6 | 515 | 556 |
| *Telmatosaurus transsylvanicus* | 175 | 158 | 1.1 | 2.3 | 2287 | 2630 |
| *Segnosaurus galbinensis* | 88<br>114 | 82<br>114 | 1.07<br>1.0 | | 310<br>756* | 335<br>826* |
| *Lourinhanosaurus antunesi* | 130 | 94 | 1.4 | 0.9 | 601 | 685 |

| Species | L (mm) | B (mm) | L/B | Eggshell thickness (mm) | Volume (ml) | Egg weight (g) |
|---|---|---|---|---|---|---|
| *Troodon formosus* | 150<br>130 | 70<br>65 | 2.14<br>2.0 | 1.0<br>0.85 | 385<br>288<br>296 | 424<br>317<br>314 |
| *Protoceratops andrewi* | 153<br>150 | 57<br>54 | 2.68 | 1.3<br>1.0 | 260<br>223* | 291<br>244* |
| *Bactrosaurus johnsoni* | 85 | 67 | 1.26 | 1.8 | 200<br>230 | 226<br>251* |
| *Hadrosaurus foulkii* | 130 | 120 | 1.08 | | 980 | 1058 |
| *Therizinosaurus cheloniformis* | 84 | 60 | 1.4 | | 158 | 171 |
| *Saltasaurus* | 190 | 190 | 1.0 | | 3591 | 4058 |
| *Saurolophus angustirostres* | 150 | 150 | 1.0 | | 1767 | 1908 |
| *Tarbosaurus bataar* | 400 | 175 | 2.3 | | 6413 | 6926 |
| *Mussaurus patagonicus* | 25 | 25 | 1.0 | | 8.18 | 8.6 |
| *Hypacrosaurus stebingeri* | 190 | 190 | 1.0 | | 3.59 | 3.92* |
| *Massospondylus carinatus* | 60 | 60 | 1.0 | | 110* | 128 |
| *Deinonychus antirrhopus* | | 70 | | | | |
| *Byronosaurus jaffei* | | | | 0.45 | 178 | 189 |
| *Nemegtomaia barsgoldi* | | | | | 231 | 245 |
| *Torvosaurus gurneyi* | 150 | 150 | 1.0 | 1.2 | 1721* | 1881* |
| *Bonapartenykus ultimus* | 70 | 70 | | | 175* | 191* |
| *Machairasaurus leptonychus* | | | | | 231 | 245 |
| *Heyuannia huangi* | 200 | 78 | | | 621 | 276 |
| *Beibeilog sinensis* | 415 | 155 | 2.68 | 2.13 | 4450* | 4864* |
| Largest egg | 610 | 179 | 3.41 | 4.75 | 9968* | 10,895* |
| Smallest egg | 18 | 11 | 1.63 | 0.354 | 1.11* | 1.21* |

* Egg volume or egg weight calculated using the formulas shown below

If the length and width of dinosaur eggs are known, the volume V (ml) and weight W (g) from the length L (cm) and width B (cm) can be calculated as follows:

$V = 0.51 \times L \times B^2$

$W = 0.557 \times L \times B^2$

Then: $W = 1.093 \times V$

While the volume formula is quite accurate, the weight calculation includes the eggshell weight, which is only considered with an average factor in the formula. The weight formula is therefore less accurate than the volume formula.