

## A Comparison of Respiratory Pores in Avian and Dragonfly Eggshells

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### Introduction

Avian fetus in chicken eggs and dragonfly eggs consume oxygen diffusing through breathing pores on egg shells. Three types of pores in avian egg shells are morphologically classified to simple straight pores, trumpet shaped pores and branched pore systems [1]. Complexed breathing pores exist on egg shells in running big birds. Depressions where pores are open can be clearly seen on fossil Moa egg shell fragments also [2]. Many Scientists studied hard to estimate effective surface area for the sufficient inflow of air.

### Avian Fetus Consumes Oxygen Diffusing in Through Breathing Pores on Egg Shells

#### Problems in oxygen uptake in avian eggshells

Avian fetus has no active machine for oxygen uptake. It is protected in egg shells. The protection, however, causes some trouble. Rain drops block the respiratory pores easily.

Japanese cranes leave their eggs in their nest once their eggs get wet by the unexpected shower. Breathing pores of the eggshells are soon closed by the unexpected shower drops (Figure 1). Parent cranes detect the unhappy event and soon give up their effort for hatching their eggs. They give up their effort for hatching and leave their eggs.

Parent cranes detect the unhappy event, soon give up their effort for hatching and leave their eggs, once their eggs are wet by shower. The parent cranes know that their fetus should be kept dry and supplied with oxygen. Fetus should be warmed to maintain their high metabolic rates. They are readily suffocated, once losing oxygen supply through respiratory pores.

#### Oviposition and eggshell surface in a dragonfly

The female dragonfly, *Sarasaeschna pryeri*, lays eggs in clean fresh water shown in Figure 2. A scanning electron microscopic micrograph (right) of an egg shell surface is shown on the right-hand side. Many micropores can be seen on the cuticle surface.

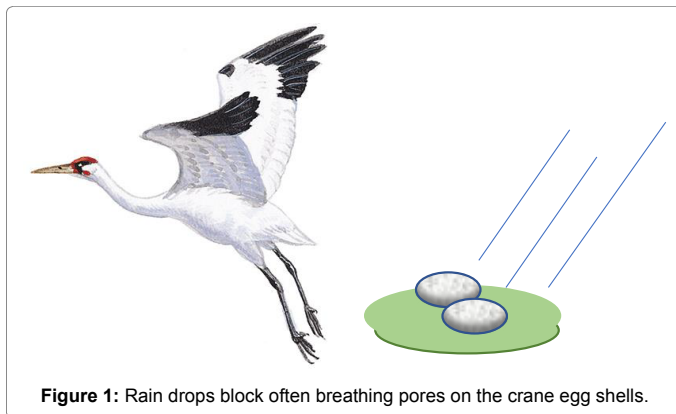


Figure 1: Rain drops block often breathing pores on the crane egg shells.

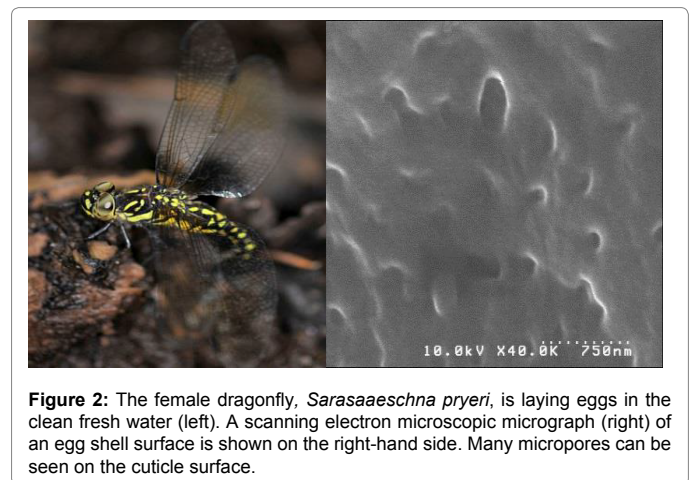


Figure 2: The female dragonfly, *Sarasaeschna pryeri*, is laying eggs in the clean fresh water (left). A scanning electron microscopic micrograph (right) of an egg shell surface is shown on the right-hand side. Many micropores can be seen on the cuticle surface.

The female dragonfly, *Sarasaeschna pryeri*, understands that her small eggs should be kept in the clean fresh water containing much oxygen, to maintain their metabolic engine. Oxygen molecules dissolved in water move into the larva inside of the eggshell by diffusion through micro-pores open for oxygen.

#### Reasonable biological designs exist in the biological world

A comparison of egg weights, respiratory pore diameters and total cross-sectional areas in three bird species and a dragonfly (Figure 3) are mentioned in Table 1 [3].

#### Discussion

Large variations in the size and shape were induced in the biological world.

Remarkable evolutionary changes proceeded also in “eggshells”. In eggshells of the dragonfly respiratory pores are formed in the egg cuticle [4].

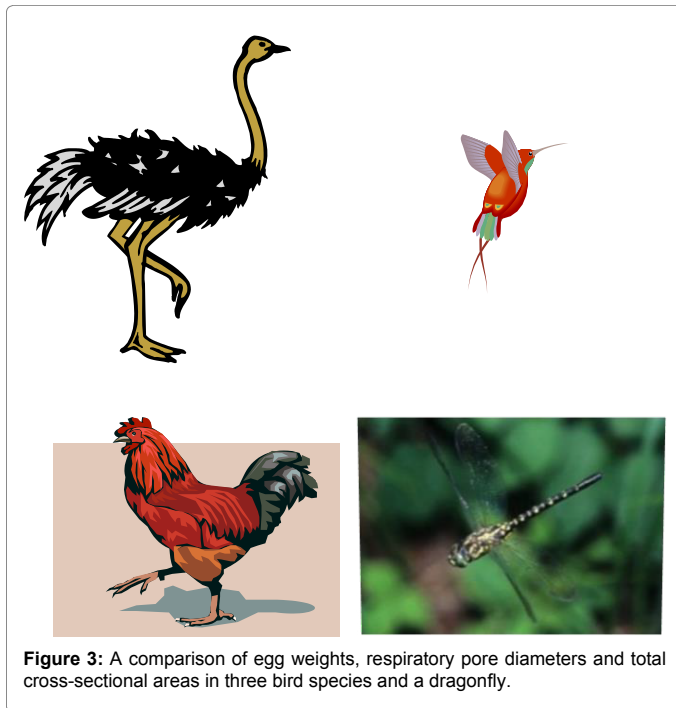
The fundamental passage route for oxygen is small pores running through egg shells. The huge egg shell of ostrich has a pore diameter of hundred micro-meter. The small sized pore of dragon fly egg cuticle is designed by the nature also for the steady oxygen passage but only through a very small size. Oxygen flows in according to the physical gradient of the oxygen following the physical law. If too much oxygen

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is supplied to eggs, the excessive oxygen destroys the biological tissue by super-oxidation. Thus, a clever selection proceeded over a long time in nature.

### Conclusion

Reasonable respiratory micro-pores exist on avian and dragonfly eggshells as the results of natural selection. Hence, we can say that nature has a big role to play with the living world.

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Species	Egg White	Pore Diameter	Pore Length	Total Pore Area%
Ostrich	1368 g	107.0 $\mu\text{m}$	1920 $\mu\text{m}$	0.11%
Dom. hen	60 g	13.8 $\mu\text{m}$	350 $\mu\text{m}$	0.03%
Nectarinia	0.86 g	2.5 $\mu\text{m}$	50 $\mu\text{m}$	0.0014%
<i>Sarasaeschna pryri</i> dragonfly	0.0014 g	74.7 nm	?	0.17%

**Table 1:** A comparison of egg weights, respiratory pore diameters and total cross-sectional areas in three bird species and a dragonfly are summarized in the table.