their flock age and/or their mass. Experiments testing this hypothesis are now under way and a model, which takes into account the above parameters and allows for more precise determination of optimal incubator humidity, is being constructed.


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**Relationships between Eggshell Pigmentation, Ultrastructure and Water Vapour Conductance In The Houbara Bustard (Chlamydotis undulata macqueeni)**

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**ABSTRACT**

Typically, aviculture of the Houbara is based around artificial insemination of females and artificial incubation of eggs. As part of efforts to better understand the incubation requirement of Houbara eggs, the ultrastructure of the eggshell has been investigated in relation to the degree of pigmentation and its water vapour conductance.

Eggshells were graded on the basis of the degree of their pigmentation: "very light" (almost white shells; N = 5), "light" (pale buff; N = 7), "mid" (buff with some spots; N = 21), which was the commonest shell type, and "dark" (dark buff with widespread spots; N = 7). Pieces of shell measuring were taken from the equatorial region of each egg...
and set in Leit-C carbon-based cement on aluminium microscope stubs. Pieces of shell were set either flat on the stub surface with the external surface uppermost, or set vertically into the cement so that presented the fractured surface uppermost. Specimens were gold-coated using a sputter-coater (Emitech) for 3 minutes. Microscopy was carried out using a Hitachi S-570 scanning electron microscope operating at 20 kV. For each of the eggshells an image was taken of both the external surface and the radial fracture surface, with the microscope scale bar set at 100 μm.

Prior to determination of shell thickness, the organic shell membranes and any organic shell accessory material were removed by treatment with hypochlorite. Shell thickness was measured using a Mitutoyo ball-head micrometer measuring to 1 μm. Pore counts were taken on shell pieces which were painted on the inside surface with Evans blue solution. Penetration of the dye through the pores allowed them to be counted on the outer surface using a stereo microscope at a magnification of ×32 (an area of 21.65 mm²). Two replicates of between 4 and 10 samples of shell from each egg were examined for pores and the average pore density calculated on the basis of the total area investigated. Values for pore diameter and density, in conjunction with the surface area (calculated from initial egg mass [IEM]) allowed for functional pore area and water vapour conductance (G_{H2O}) to be calculated for each eggshell.

Ultrastructural characteristics of the eggshells were correlated to the degree of pigmentation. Compared with "mid" and "dark" shells, "very light" and "light" shells were thinner with wider, more numerous pores. Compared with more normal shells, coverage of shell accessory material was less extensive in the lighter shells. The paler shells had significantly higher G_{H2O} values that approached values predicted from IEM. By contrast, "mid" and "dark" shells had G_{H2O} values only approximately one third of the values predicted from IEM.

These results suggest that the shell characteristics of the Houbara egg are adapted to the dry nesting environment normally encountered in the wild. Under artificial conditions, a low humidity will be required for "mid" and "dark" shelled eggs to achieve the correct weight loss during incubation. Under such conditions, "light" and "very light" shells will allow excessive weight loss and a higher humidity will be required to prevent dehydration. Eggshell colour will allow the appropriate starting humidity to be selected.

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Measuring the Conductance of the Eggshell to Adapt Humidity in the Incubator: Perspectives

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ABSTRACT

To achieve a high hatchability and chick quality, circumstances during the incubation have to be optimal. For temperature, the exact optimum is known and is fixed for all broiler hatching eggs (Lundy, 1969). On the other hand, an exact optimum for incubation-humidity is known to be different for the eggs, even if originating from exactly the same flock. This difference is declared by the high variation in eggshell conductivity (French & Tullett, 1991).

To have the highest chance for hatchability and high chick-quality, an egg has to lose about 11% of its initial mass by evaporation by day 18 (Tona et al., 2001). The speed of this evaporation process is regulated by the conductance of the eggshell on one hand, and the humidity in the incubator on the other hand (Meir & Ar, 1987). The conductance of the eggshell is fixed for each egg, but there is a high natural variation on this eggshell property. The humidity in the incubator is maintained by the equipment and can be changed.

Till now, in many hatcheries all eggs are incubated at the same humidity-level. By doing so, a lot of eggs lose the optimal 11% of their initial mass, but for a lot of eggs this mass loss is not optimal, a range from 5 to 16% is normal. This results in a decreased hatchability and chick quality. If it is be possible to measure the conductivity of the eggshell...