Scientific Notes

Adaptation of Avian Eggshells to High Altitude. Adult birds and mammals compensate in part for reduced oxygen concentrations at high altitudes by increasing the rate of convective air flow across respiratory surfaces. Birds which breed at high altitudes are confronted by a special problem since gas exchange by avian embryos occurs not by convection, but by diffusion of gases through a fixed pore area in the egg shell. During development of the embryo, oxygen diffuses into the shell and CO_2 and water vapor out of the shell; the movement of each gas is directly proportional to the concentration gradients between the inside and outside of the shell and the total pore areas. Water loss from the egg during incubation must be of sufficient magnitude to allow formation of an air cell which the embryo uses to fill its lungs before pipping, but not large enough to desiccate the embryo. Since gases diffuse more rapidly at high altitude, oxygen will move into and CO_2 and water vapor will diffuse out of an egg more rapidly at altitude than at sea level if the pore area is held constant. Therefore, a bird laying her eggs at high altitude must compromise between the advantages of increased oxygen availability and the disadvantages of CO_2 and water vapor losses. The purpose of this study was to determine how pore area, measured indirectly as the conductance of the egg to water vapor, is related to altitude in two species of wild birds.

Eggs laid by robins and red-winged blackbirds between sea level and 11,500 feet were collected. Eggs of both species exhibited a reduction in pore area directly proportional to the reduction in barometric pressure with altitudes to 9000 feet. Eggs laid above that altitude had greater pore areas than those collected at 9000 feet. These data suggest that females laying between sea level and 9000 feet have compensated for the increased tendency of CO_2 and water vapor to leave the egg by reducing pore area. Apparently further reduction of pore area at higher altitudes proved maladaptive, since pore area began to increase. Further reduction of pore area above 9000 feet probably restricts adequate oxygen diffusivity. We are currently using scanning electron miscroscopy to determine if the reduction in pore area is based on variations in pore size or number, or both. Further studies will attempt to determine what environmental cues the females use to modify pore area and the manner by which the shell gland achieves such modifications.

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