UNIVERSITY OF FLORIDA
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Incubation and Hatching of Ratites [1]

H.R. Wilson[2]

Introduction

Developmental Factors

Embryonic development is initiated in the infundibulum portion of the oviduct at the time of fertilization. Thereafter, the environment will have major effects on the embryo. The environmental conditions in the oviduct during egg formation and during the storage period from oviposition (egg laying) to placement in the incubator can have significant effects on subsequent hatchability. Time of exposure to the various conditions is also a major factor. However, the environmental factors that are most critical to the normal development of the embryo are those that occur during the incubation and hatching processes. These factors include incubation temperature and time, humidity, egg orientation, egg turning, ventilation, and sanitation.

Egg Formation

The embryo begins development while the egg albumen, egg membranes and eggshell are being formed in the oviduct. Therefore, egg formation time affects the stage of the embryo at the time of lay. This stage of embyonic development has been shown in chickens and turkeys to affect the embryo's potential for survival during pre-incubation egg storage. A similar phenomenon also may occur inratites. However, egg formation time is difficult to alter.

Environmental Factors

Incubation Temperatures

While the other factors must be controlled during incubation, temperature is the most critical for maximum hatchability. There has been insufficient research to determine the optimum incubation temperature for ratite eggs. The optimum temperature is almost certain to change with increased age of the embryo. Therefore, temperature settings of single-stage incubators (all eggs set at the same time and all embryos one age) would be different, probably decreased, as the embryos become older. In multi-stage incubators (eggs set at different times and embryos of various ages) a single, "average" temperature would be used continuously. Common incubator temperatures for ratites range from 96.7 to 97.7°F for multi-stage machines. Optimum temperatures will vary with individual incubators, manufacturer and model, geographical and within-building location, number of eggs in the machine, and many other factors. Incubators without

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2. H.R. Wilson, professor, Dairy and Poultry Sciences Department, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

fans are normally run about 2°F higher than those with fans. Several influences are introduced due to breeder genetics, age, health, nutritional status, and other factors. Although the optimum incubation temperature is usually understood to mean the onewhich results in maximum hatchability, it also results in the most efficient embryonic growth and the highest quality chick. Furthermore, post-hatch growth also may be affected. The hatcher temperature should be approximately 1°F lower than that of the incubator because of the large amount of heat generated by the late-stage embryos.

Heat Stress . In general, the detrimental effect of high temperature on hatch increases with increased temperature, with increased exposure time, and with younger embryos. However, some early stages are more resistant and embryos near hatching are very susceptible to high temperature stress. Some of the age effects may be associated with oxygen consumption, heat production, and the growth stage of the chorioallantois (the embryonic membrane that attaches to the shell). The circulatory and nervous systems seem to be the most susceptible to heat stress.

Cold Stress . Sensitivity of the embryo to cold stress increases as embryonic age increases. The major effects of cold stress appear to be retarded and abnormal development of the circulatory system and heart, reduced growth and development of the embryonic membranes, and subsequently, reduced respiratory efficiency and utilization of yolk, albumen and shell. Duration of cold stress exposure and embryonic age are major factors contributing to the effects of the exposure. Short-term cold exposure of embryos at certain ages may not even be detrimental, although incubation time will be increased.

Incubation Time

Incubation time (i.e., time from set to hatch) often is an indicator of incubation temperature. Temperatures above optimum shorten incubation time, whereas temperatures below optimum lengthen incubation time. However, caution should be used in changing incubation temperatures based on incubation times, because incubation time is a very heritable trait. Therefore, obvious differences in incubation times can be seen in eggs from different hens. The "average" incubation times for ratite eggs at normal incubator temperatures are 39 days for the rhea, 42 days for the ostrich, and 56 days for the emu.

Egg Turning and Orientation

Egg turning during incubation involves turning frequency, axis of setting (egg orientation), axis of rotation, turning angle, plane(s) of rotation, and stage of embryonic development requiring turning. The absence of egg turning has been shown to result in adhesion of the embryo to the inner shell membrane, premature or abnormal adhesion of the embryonic membranes to the inner shell membrane or other structures, increased incidence of malpositions (abnormal embryo position), decreased albumen utilization, abnormal fluid distribution in the egg, decreased oxygen exchange surface of the chorioallantois (large embryonic membrane attached to the shell), and a poorly developed yolk sac (embryonic membrane enclosing the yolk). The critical period for turning ostrich eggs is thought to be during the first two weeks of incubation, and turning after 24 to 28 days of incubation (or after closure of the chorioallantois) probably has little or no beneficial effect. Eggs are normally transferred to a hatcher 1 or 2 days prior to expected pipping (breaking of the shell) of the first egg and are not turned thereafter. An optimal turning frequency has not been determined for ratite eggs. However, 24 times per day is practical and appears to give satisfactory results. Neither tilting and returning to the original position nor shaking of the egg are viable substitutes for turning. Eggs from most species, when set with large end (air cell) up and turned around the small axis, hatch as well as, or better than, when set horizontally and turned around the long axis (the natural way). Eggs set air cell end up hatch best when turned 90° to rest at a 45° angle, whereas those set horizontally hatch best when turned approximately 180°. Turning horizontally set eggs only in one direction will cause rupturing of membranes and blood vessels resulting in mortality.

Setting eggs with the air cell down causes most embryos to be malpositioned with the head up and away from the air cell. If the egg is set with the air cell down for the first week and then placed with the air cell up thereafter, the embryo will usually orient properly.

Ventilation

Ventilation within the incubator and hatcher provides an adequate oxygen supply, removes excess carbon dioxide, and is a factor in maintaining the proper humidity level. Ventilation recommendations may vary considerably from one type or model of incubator to another. Furthermore, single-stage incubators require adjustment of ventilation in respect to the age of the embryo. Oxygen consumption and carbon dioxide production increase rapidly in the last two-thirds of incubation, and will essentially double during the last week. Hatchability may be reduced at altitudes of more than 3,000 ft. and may reach zero at altitudes of more than 12,000 ft. The reduced barometric pressure at high altitudes decreases oxygen tension and increases the effective conductance of the egg shell. Therefore, the embryo suffers from lack of oxygen and an excessive loss of water and carbon dioxide. Oxygen supplementation and decreased ventilation usually corrects the problem. Recommended incubator levels are 21% oxygen and .05 to .10% carbon dioxide for ratite eggs incubated at less than 3,000 ft. altitude. However, few supportive data are available.

Humidity

Incubator manufacturers usually recommend optimum relative humidity settings for each model and each species of bird. Adjustments normally are needed in each machine to obtain the desired egg weight loss. Present data indicate that normal hatchability should be expected in ostrich eggs that lose 12 to 17% of initial weight from setting to 38 days of incubation. Weight loss at 38 days can be projected from 7-day or other intermediary-loss calculations. The 38-day actual loss will usually be about .5 to 1.5 percentage points less than that projected from 7-day loss. The major factors that determine egg weight loss are shell porosity and relative humidity. Secondary factors are egg size, altitude, and incubation temperature. Approximate relative humidity requirements are 15-20% for the ostrich, 25-40% for the emu, and 35-65% for the rhea. Although the primary effect of humidity is on water loss from the incubating egg, it also affects utilization of minerals from the shell, gas exchange and other functions. It is interesting to note that the water content of the newly hatched chick (~76%) isessentially the same as the water content of the combined yolk and albumen of a fresh egg. Egg weight at setting, debris weight after hatch, and weight loss during incubation are the primary determining factors for chick weight at hatching. Insufficient water loss results in large, sluggish, edematous chicks which are often in a malposition in the egg causing problems in pipping the shell and in hatching. Excessive water loss results in small, dehydrated, weak chicks that may not be strong enough to hatch. Chick weights of 60 to 65% of egg weight at setting appear to be in the normal range for ratites, as it is for other domestic species.

When eggs are transferred to the hatcher the humidity should remain the same as in the incubator until the embryos begin to pip the shells. At that time the humidity should be increased to prevent membranes from drying too quickly which causes the embryo to stick in the shell. Humidity during the hatching process should be approximately 40% in the ostrich, 60% in the emu, and 70% in the rhea. These are estimates, due to the lack of research data. In eggs that lose 10% or less of their weight through 38 days, some advantage may be gained by drilling about four 2mm holes in the shell over the air cell at the time of transfer to the hatcher. This has little effect on egg weight loss but does allow the chick to survive by lung respiration after pipping into the air cell. Many of these embryos will require some assistance in hatching because they will be in some degree of malposition due to their edematous condition.

Improving Hatchability

The tremendous variation observed in shell porosity and weight loss of ostrich eggs indicates wide genetic variability among hens. Under large commercial conditions this large variation would be intolerable and uneconomical. The most rapid and satisfactory progress in improved hatchability is likely to be achieved through selecting hens that lay eggs with good shell quality and adequate, uniform shell porosity.

Most ratite eggs are laid in nests that the male has dug in the soil of the pen. The eggs are exposed to sun, rain, temperature extremes, and the microbial inhabitants. At the time of lay, the egg is wet and an ideal environment exists for microorganisms to enterthe moist pores as the egg cools and the contents contract. Because of these conditions, contamination is often a significant source of loss of ratite eggs. Decontamination by fumigation or disinfection is ineffective after the organisms are inside the shell. Therefore, preventative measures should be diligently practiced.

Summary

From fertilization to the moment of hatching, development and growth of the avian embryo is affected by its environment. The time in the oviduct and the conditions therein, the post-oviposition/pre-incubation holding time and environment, the health and nutrition of the breeders, the structure and content of the egg itself, and the environment in the incubator and hatcher all affect the successful development of the fertilized ovum. The time required for the incubation process is determined by the genetic constitution of the species and modified by strain and individual differences, the egg structure, and various aspects of the environments to which the egg is exposed. Interrelationships that exist among the genetics of the embryo, the structure and size of the egg, the handling procedures, and the environment from fertilization to hatch result in a complex set of requirements that will vary from one hatchery to another.