Breed Differences in Physiologic Response to Embryonic Thermal Conditioning and Post-hatch Heat Stress in Chickens

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Summary and Implications

The long range global forecast is for greater numbers of chickens being reared in extreme heat conditions; thus, genetic stocks will need to be selected for performance in warmer production environments. Eggs from three genetic lines were either incubated by conventional "normal" or thermal conditioning (elevated) and the hatched chickens were reared in either normal temperature or heat-stressed environments. Biological and genetic data were collected to identify biomarkers that could be used for genetic selection. The differences observed among lines indicate that a portion of heat tolerance is related to genetics. This study also demonstrates that elevated embryonic incubation alters the chickens' response to heat stress. Furthermore, blood parameters may be used as biomarkers for selection.

Introduction

The future of poultry production will likely include more heat extreme conditions due to both expansion into naturally hotter environments and global warming. To address these changes, we initiated a study to evaluate effects of embryonic thermal conditioning and cyclic heat stress on chicken performance. It has previously been demonstrated by others that there is a genetic component to heat tolerance and it is hypothesized the embryonic thermal conditioning may alter heat resistance post-hatch. Physiological data will be evaluated for use as selection markers for heat tolerance. The overall objective for this project is to determine genetic differences in order to adapt chicken production to climate changes through breeding. The specific objective of the current phase is to determine the effect of genetic, embryonic thermal conditioning, and post-hatch heat stress on physiological response.

Materials and Methods

Two pure lines and a multi-generation cross of these lines were used. The genetically distant commercial broiler breeder line and highly inbred Egyptian Fayoumi line are held as pure lines at ISU. The multi-generational line originates from the cross of a broiler male with Fayoumi females and the resulting offspring were intermated for 17 more generations.

For the first generation of the current project, eggs of each line were incubated either under normal conditions or at a 2 C^0 elevated temperature for embryonic days 10 -18. At 15 days of age, chicks from both normal and elevated incubation treatment were housed in environmental chambers and after 7 days of acclimation, the chicks were either subjected to 8 hours of daily cyclic heat stress or held at room temperature for seven consecutive days. Samples and data were collected for acute heat stress (first day of heat stress) and chronic heat stress (last day of heat stress). Sample collection included 13 blood parameters, and production data included individual body weights and body temperatures. The data were evaluated for potential use as a bio-marker for heat-tolerance in poultry.

Full sibs of the chicks from the first generation (either normally incubated or thermally conditioned as embryos) were reared and used to generate a second generation experimental population. The second generation eggs were all incubated under normal conditions and the animal experiment was as described for the first generation.

Results and Discussion

There were 1912 total chicks in the study in generation 1 and generation 2. The data were analyzed across both generation which included the effect of thermally conditioned eggs of generation 1 compared to normally incubated eggs of generations 1 and 2.

Chickens from thermally conditioned eggs overall had lower body temperature at chronic time point than chickens from normally incubated eggs (P=0.0002). Mechanisms by which thermal conditioning altered body temperature are not clear and warrant further investigation. The molecular work to come may provide greater understanding of this phenomenon. For both acute and chronic time-frames, chickens under heat stress had a significantly (P<0.0001) higher cloacal body temperature than chickens housed at normal temperature. Not surprisingly, chickens under heat stress had hotter core body temperature.

Differences in blood gas parameters were most significant at the chronic stage of heat stress rather than the acute stage (Figure 1). Chickens from elevated incubation temperature had lower partial oxygen levels (P=0.004) and higher pH levels (P=0.004) compared to chickens from normal room temperature. Chickens under heat stress had lower hemoglobin levels (P=0.0001) and lower CO_2 levels (P=0.0001) than chickens housed in normal temperature. Heat stressed chickens had higher saturated oxygen levels (P=0.002) and higher pH (P=0.0001) than normal temperature chickens. These blood measurements are thus candidates for use as biomarkers of heat tolerance.

The interaction of line and egg treatment affected body weight gain. Broilers with elevated egg treatment had greater weight gains (d28-d21; *P*<0.0001) than normal egg treatment broilers while normal egg treatment AIL chicks had greater gains than AIL from elevated egg treatment (Figure 2). For both Fayoumi and broilers, chicks from normally incubated eggs had higher chronic cloacal temperatures than chicks from elevated incubation (*P*<0.006). These data demonstrate the interaction of genetic line with incubation treatment on physiological traits.

In summary, this study establishes the combined effect of genetics and egg incubation conditions on production parameters. Thermal conditioning of eggs had an effect on body temperature. Additionally, several blood parameters, including hemoglobin, CO_2 levels, saturated O_2 and pH, appear to be good candidates for predicting response to heat stress.

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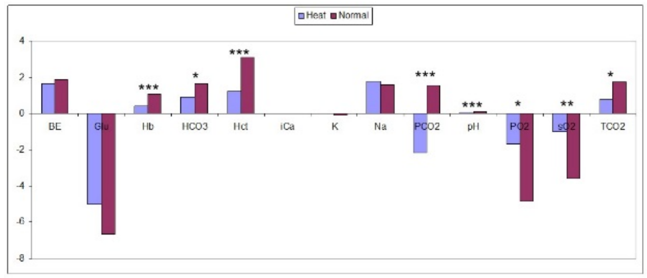
Figure 1. Chick treatment effect on change in blood parameters during chronic heat stress (day 28).



* P < 0.05; ** P < 0.01; *** P < 0.001

iSTAT blood measurements: BE= Base excess, GLU= Glucose, Hb= Hemoglobin, HCO3= Bicarbonate HCO3, ct=Hematocrit, iCa=Ionized Calcium, K=Potassium, Na=Sodium, PCO2= Carbon dioxide partial pressure, sO2= Saturated oxygen, TCO2= Total carbon dioxide

Figure 2. Egg treatment interaction with genetic line effect on body weight gain between days 28 and 20. Columns with different lettering differ at *P*<0.05 as determined by Tukey HSD test.