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Genotype Influences Body Composition of Developing Chicken Embryo

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Abstract: The effect of genotype on postnatal efficiencies of chickens has been well documented. However, little is known about the effect of genotype on body composition and metabolic physiology of chickens during embryonic development. To test the hypothesis that even with equalised egg weight at setting during incubation, there could be some effect of genotype on body composition, an experiment was conducted with embryonic chicks of broiler and layer genotypes at four stages of development during incubation (viz. 12, 16, 18, 20thd). Wet weight ($P<0.01$) and dry weight ($P<0.05$) of embryos were higher in broilers compared to layers. Irrespective of genotype, the wet and dry weights increased ($P<0.01$) progressively and significantly from day 12 to day 20. Water content was not found to be affected by genotype but goes progressively down till 20th d of incubation. Body nitrogen concentration was higher ($P<0.05$) in the pre-hatch chicks of broiler vs. layer genotype but stage of development did not significantly influence the value of this parameter. Broiler had higher ($P<0.05$) ether extract than layer prehatch chicks. Ether extract increased progressively and significantly ($P<0.01$) during the entire period of pre-hatch development. Body ash content was neither affected by genotype nor stage of development during embryonic period. This appears to be the first report that demonstrates differences in the body composition of broiler and layer genotype during embryonic life life itself.

Key Words: Genotype, body composition, developing chicken embryo

Introduction

Body composition study is of considerable interest to animal and human health researchers. This is because it has got relation to 1) meat quality in animals and 2) obesity and related metabolic disorders in human beings. Nutritional and developmental physiology during embryonic life is important because any changes during this period can have effect on metabolism with consequent impact on body composition, through changes in efficiency of nutrient metabolism and utilisation. The study on developmental biology of embryonic chicken is of special significance not only for poultry industry but also for biomedical research because nutritional requirements at organ level (such as amino acid requirements of brain) of embryonic chicken and human fetus largely coincides (Gelder and van Belanger, 1989).

Studies on chickens have been done that indicate effects of breed, sex, strain, nutrition and or combination of one of these on postnatal growth, carcass composition (Edwards and Denman, 1975; Robbins and Ballew, 1984; Jones *et al.*, 1986) and physiological reasons thereof (Porter, 1998). Some experiments (Al-Murrani, 1978) indicated differences in embryonic and postembryonic growth because of differences in egg size. However, with equalised egg weight at setting, changes in growth and body composition of prehatch chicks of broiler and layer genotypes seems to be not investigated. This study was undertaken to find an answer to the question" With equalised egg weight at setting, does the genotype influences the growth and body composition of prehatch chicks of broiler and layer genotype during embryonic development?"

Materials and Methods

Selection and incubation of fertilized eggs: Fertilized embryonated eggs of commercial broiler and layer genotype of uniform shape, size and approximately the same weight (59 $\pm$ 1 g) were obtained from the Phoenix Hatcheries, Jabalpur (MP). They were incubated in a model step up mammoth incubator at 100 °F and relative humidity of 86 $\pm$ 1%. The prehatch chicks of four developmental stages studied were in 12, 16, 18 and 20th day stage of incubation. The total pre-hatch chicks were divided into four groups of six each upon genotype at every stage of development. They were killed by decapitation. Study on the ponderal changes and chemical analysis of the whole chick was carried out as per AOAC (1980).

Statistical Analysis of the Data: Analysis of variance of the data on body composition was performed as genotype and stage of development as major factor and interaction between them (Snedecor and Cochran, 1968). The means determined to differ significantly were separated using the least square means procedure and the probability level determining significance was $P \leq 0.05$ or $P \leq 0.01$.

Result and Discussion

The embryonic chick, growing in the ovaparine environment is endowed with the parental genetic heritage and nutritional reserves provided by mother hen. Phenotypic expression of genetic differences may be related to differential rates of assimilation of organic and inorganic constituents from extra-embryonic reserves. Several reports (Romanoff, 1960; Asmar *et al.*, 1972; Prabhu, 1977) attest to remarkable shifts in the rate of transfer of biochemical moieties at different stages of embryonic growth and development. The results of the hypothesis tested indicate that even with equalised egg weight at setting, such differential rates of transfer of moieties are not only (developmental) stage oriented as reported before but are also probably the cause of changes in growth and body composition of broiler and layer genotypes during embryonic life itself. In present report, we describe the normal developmental changes in the body composition of embryonic chicks of broiler and layer genotype at 12, 16, 18 and 20th day of incubation period.

Ponderal changes and chemical analysis of whole prehatch chick: The data on ponderal changes, water percentage and chemical composition in the pre-hatch are summarized in Table 1. Wet as well as dry weight of the pre-hatch chicks was significantly ($p<0.01$) altered by the genotype as well as stage of development. These weights were significantly higher in the broiler vs. layer pre-hatch chicks. Irrespective of genotype, the wet and dry weights increased progressively and significantly from day 12 to day 20. Similar changes were described by Rinaldini (1960); Bray and Iton (1962); Hassan and Nordskog

Table 1: Body composition of broiler and layer genotypes of pre-hatch chicks during different stages of embryonic development

Days	Genotype	Wet Weight (g)	Dry Weight (g)	Water content (%)	Total Nitrogen (g/g dry)	Ether Extract (g/g dry)	Ash (g/g dry)
12	Broiler	5.802	0.525	90.057	0.103	0.156	0.059
	Layer	5.202	0.449	91.348	0.100	0.128	0.047
		5.50^{a}	0.49^{a}	91.15^{c}	0.102^{ab}	0.142^{a}	0.053
16	Broiler	13.193	2.580	80.623	0.112	0.234	0.062
	Layer	11.562	2.241	79.963	0.098	0.205	0.056
		12.38^{b}	2.41^{b}	80.29^{b}	0.105^{ab}	0.220^{b}	0.059
18	Broiler	24.195	5.510	77.288	0.123	0.267	0.060
	Layer	21.762	4.300	78.943	0.100	0.254	0.053
		22.98^{c}	4.91^{c}	78.11^{b}	0.112^{b}	0.261^{c}	0.057
20	Broiler	45.500	12.103	73.476	0.096	0.380	0.051
	Layer	43.279	11.097	74.358	0.095	0.335	0.500
		44.39^{d}	11.59^{d}	73.91^{a}	0.095^{a}	0.357^{d}	0.050
$\bar{x} \pm$ SEM		21.132	4.815	80.757	0.103	0.245	0.111
		1.67	0.190	0.206	0.002	0.007	0.012
P Value	D.F						
Genotype (G)	1	**	*	NS	*	<0.05	NS
Stage (St)	3	**	**	**	NS	<0.01	NS
G x St	3	NS	NS	NS	NS	NS	NS

Each mean on wet weight, dry weight and water content is average of six and each mean on total N, ether extract and ash is average of three observations. Pooled means with in a column with different superscript differ significantly (*$P<0.05$, **$P<0.01$), N.S. = Non significant

(1971); Asmar *et al.*(1972). However, Romanoff (1929) observed relatively slow growth between day 9 and day 16, which, according to him, could be ascribable to variation in the magnitude of biochemical changes. Environmental factors like relative humidity and temperature also appeared to influence the pre-hatch growth profile.

It is noteworthy that even with equalized egg weight at setting, the average wet weight of the pre-hatch chicks (data pooled over stages) was significantly higher in the broiler vs. layer genotype. Halbersleben and Mussehl (1922) found that chick weight was related to the weight of eggs, and averaged about 65%. Byerly (1930) observed that the weight or pre-hatch chicks varied, albeit within limits, in the different breeds even with equal sized eggs. Hardin (1972) stated that breed differences in the weight of pre-hatch chicks were not merely associated with differences in the average egg weight, but reflected true genetic differences. Shanawany (1984) showed clear positive co-relation between egg weight at setting and embryo weight at 18th day of incubation and hatchling weight. With the same egg weight, no effect on embryo weight was reported.

The percentage of water decreased significantly at day 16 vs. day 12 but remained virtually unaltered up to day 18. It again registered a significant decrease at day 20. Overall, the percentage of water in whole chick significantly declined during pre-hatch development. This decrease was conspicuous between day 12 and day 16. The apparent decrease at day 18 was, however, not significant. A noteworthy decrease in the percentage of water occurred at day 20. These variations might be related to differential rates of cell maturity. Similar observations were recorded by Romanoff and Romanoff (1967).

A significant ($p<0.05$) effect of genotype on total N concentration was found. However, the stage of development did not significantly influence the value of this parameter. The values of total N concentration (on dry weight basis) in the pre-hatch chicks in the present study are close to the data compiled by Romanoff and Romanoff (1967). The average N concentration was significantly higher in the pre-hatch chicks of broiler vs. layer genotype. This observation points to superior tissue development in the broiler chicks even before hatch. As stated earlier, egg weight at setting remaining equal, the average wet weight of the broiler pre-hatch chicks was significantly higher than that of the layer pre-hatch chicks. Jones *et al.* (1986) demonstrated differences in the fractional rates of protein synthesis between broiler and layer chicks at two weeks old birds.

Ether extract showed a significant effect of genotype ($p<0.05$) as well as the stage of development ($p<0.01$). An effect opposite to the nitrogen, ether extract increased progressively and significantly during the entire period of pre-hatch development. The findings of Speake *et al.* (1993) are noteworthy in this context. They reported major increases in the activity of lipoprotein lipase in adipose tissue and heart from day 12 of development, concomitant with the beginning of the period of lipid uptake from the yolk. The lipoprotein lipase hydrolyses circulating triglycerides to free fatty acids which are either stored in the form of fat in the body or undergo oxidation in the muscle. The significantly higher average value of ether extract recorded in the broiler vs. layer pre-hatch chicks is also noteworthy. This is in consonance with the inherent superior fat synthesizing ability in the former, which is well known fact. Compared to layer strain, growth of abdominal fat pad and its greater lipoprotein lipase activity is a major cause for rapid growth in broiler chicken (Griffin *et al.*, 1987)

During embryonic stages, variation in the normal developmental maturity is dictated by relative proportions of yolk and albumen and is largely attributed to albumen content (Hill, 1993; Finkler *et al.*, 1998; Peebles *et al.*, 2001). Albumen is the primary source of water (determinant of body mass) in the egg and is primary determinant of hatchling size (Finkler *et al.*, 1998). As all the eggs (of similar size) were originating from the flock reared under same managerial and feeding conditions, the differences between composition particularly albumen can not be expected.

The changes in the body composition described above also correspond to the metabolic organs development. Several reports from our laboratory (Pal *et al.*, 1991a; Pal *et al.*, 1991b; Pal and Parmar, 1995; Pal *et al.*, 2002a) on rapid proliferation of liver, thymus, brain and various physiological and morphological changes that occurs during the course of development in these tissues support present findings. More recently, Pal *et al.* (2002b) have reported higher activities of gluconeogenic enzymes in liver and brain of developing chicken embryo which probably reflects higher demand for observed deposition of protein and fat in broilers due to its rapid development, compared to layers embryo. The embryos of poults hatching with higher blood glucose concentration has been reported to grow at faster rate than with low blood glucose level (Christensen *et al.*, 2000b).These authors(Christensen *et al.*, 2000a) also reported that the embryonic growth differs evenwhen not mediated by egg size and functional characteristics and it is probably paternal factor that influences embryonic growth, which in this context is genotype. Total ash content in the pre-hatch chicks did not exhibit any

significant influence of genotype or stage of development. Calcium mobilization from the yolk appears to be at par in the pre-hatch chicks of the two genotypes. Demonstration of hepatic alkaline phosphatase activity of virtually the same magnitude is pertinent in this context (Pal *et al.*, unpublished data).

It can be noted from Table 1 that the major growth and changes in body composition of prehatch chicks occurs during late stages of embryonic development which corresponds to metabolic ontogenesis of equivalent magnitude (Pal *et al.*, 2002b; Pal *et al.*, unpublished data). When compared to other species, these changes resemble to rapid growth and metabolic development of fetus during the last third of generation (Hocquette *et al.*, 2000; Jadhao *et al.*, 2001)

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