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EFFECT OF GROWING SEASON ON GROWTH RATE AND BODY FLUID COMPARTMENTS OF BROILERS

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ABSTRACT

Two trials were carried out to study the changes in body fluid compartments of broilers during the growing (finishing) period (4 to 8 weeks) at two different seasons (winter and summer). Body weight, food consumption, ambient temperature, body temperature and respiration rate were determined weekly during the experimental period. Body fluid compartments were estimated randomly in 12 birds after 4, 6 and 8 weeks of age.

Results indicated that growth rate was significantly higher in winter than in summer and the differentiation between seasons started by the first week of age. Body fluid compartments as percentage from body weight decreased significantly with age (except ICF% and ISF% in summer). Concerning the effect of season, there was a significant reversed seasonal effects on TBW% at 4 and 8 weeks of age. In winter, most of body water was found in intracellular space, while in summer it was in the extracellular compartment specially in ISF. Meanwhile, plasma volume was higher in winter than in summer being significant when temperature difference was high.

Shifts in fluid compartments as percentage from TBW revealed that there was no significant difference between 6 and 8 weeks except a significant reduction in PV% in summer. Furthermore, from 4 to 6 weeks there was a significant reduction in ICF% in winter causing a significant rise in both ISF% and PV%. However, no significant changes occurred in summer.

Keywords: Broilers, growth rate, body fluid

INTRODUCTION

Total body water (TBW) comprises about 50 to 60% of animal's body weight, however this proportion is higher in young than in old animals. The volume of the body fluids is altered during adaptation to heat, cold or other stressful situations. Hahn et al. (1975) and Van Kampen (1980) stated that the influence of excessive heat on growth rate, mature body mass, body composition and body form depends on age at the heat exposure, its duration, and its intensity. Johnson and Farrell (1988) reported that total body water as percentage of body weight decreased significantly with age. Sturkie (1965) suggested that the reduction in total body water percentage with increasing age may be due to a reflection of the increase in body fat with aging in the hen. He also reported that extracellular fluid as percentage of body weight in laying hens decreased with the increase in their weight from 527.3 to 1759 gm. which was due to a reduction in both plasma volume and interstitial fluid, meanwhile, the percentage of intracellular fluid increased. Broberk (1973) stated that the increase in intracellular fluid with age is due to the increase in protein synthesis during growth.

Considering the effect of temperature (seasonality), Abdel- Razik et al. (1985) found that rabbits kept at 16°C and 65% relative humidity for 8 hrs daily had significantly lower TBW (ml or percentage of body weight) than those of the same age and kept at 33°C and 65% relative humidity for 8 hrs daily which was due to a significant increase in water turnover rate. Rodbard et al. (1951) found that acute hyperthermia in chickens increased the volume of extracellular water and plasma volume, while hypothermia decreased these fractions considerably. However, Khalil et al. (1992) found that extracellular fluids as percentage of body weight of hens was significantly ($P<0.05$) lower in summer than in winter (21% v.s. 35% of body weight, respectively). Whittow (1968) stated that the maintenance of an adequate blood volume is important in the interests of maintaining an adequate circulation.

The aim of the present study was to investigate the effect of rearing season on growth rate of broilers and its components as well as to study the shifts in body fluid compartments during the growing period in cold (winter) and hot (summer) seasons.

MATERIALS AND METHODS

The present study was carried out at the Poultry Experimental Station belonging to Animal Production Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt. Two trials were carried out to study the shifts in body fluids of broilers during the growing (finishing) period (from 4 to 8 weeks). Each trial comprised 50 one-day-old broiler chicks weighing about 39-40.4 gm. All birds were fed broiler commercial ration containing 22% crude protein and 2800 kcal/kg metabolizable energy during the whole experimental period. Food and water were offered ad libitum. Birds were housed in floor pens during the brooding period (4 weeks old) after which they were transferred to broiler cages (8 birds/floor) till the end of the experiment (8 weeks old). All birds were healthy and clinically free from diseases.

The two trials were done during winter and summer with mean ambient temperature (Ta) of 21±7.0°C and 32±3.0°C, respectively. Body fluid compartments, body temperature (Tb) and respiration rate (RR) were determined biweekly intervals from 4 to 8 weeks of age. Body weight (BW), feed consumption and feed conversion were measured every week (from 1 day until 8 weeks of age) as described by Amer (1977).

Body fluids were determined randomly in 12 birds after 4, 6 and 8 weeks of age. Total body water (TBW) was determined using Antipyrine method as described by Weiss (1958). Extracellular fluid (ECF) was determined by sodium thiocyanate method as described by Hix et al. (1959). Plasma volume (PV) was determined by Evan's blue method as described by Kennedy and Millikan (1938). A blank samples were withdrawn from the jugular vein before injection with the dyes in which hematocrit value (Ht) was determined according to Bauer (1970). Statistical analysis was carried out using SAS program (SAS, 1988). Percentages were transformed if necessary using arcsine transformation (Snedecor and Cochran, 1973).

RESULTS AND DISCUSSION

Thermo-respiratory responses:

During the brooding period Ta was kept around 35°C in the first week, then it was reduced gradually to the environmental temperature when the birds were 4 weeks of age (24.1±0.7°C and 32.8±0.4°C in winter and summer, respectively). During the following period (from 4 to 8 weeks), Ta decreased in winter while in summer an increase from 30 to 35°C occurred from 6 to 8 weeks of age (Table 1).

Table 1: Mean and standard error of ambient temperature (Ta) respiration rate (RR) and body temperature (Tb) in winter and summer

Age (week)		Ta (°C) W	Ta (°C) S	RR W	RR S t	Tb (°C) W	Tb (°C) S t
4	Mean	24.100	32.800	50.05	58.10**	40.57	41.10**
	SE	0.405	0.396	1.04	1.47	0.06	0.11
6	Mean	17.300	30.000	33.25	56.00**	41.10	40.80*
	SE	0.565	0.307	1.10	1.08	0.07	0.11
8	Mean	14.900	35.000	37.00	58.80**	40.97	41.50**
	SE	0.767	0.319	0.81	0.64	0.05	0.11

W = winter. S =summer. t= student t-test between seasons.

* significant at p<0.05 ** significant at p<0.01

In winter, Tb did not follow the changes in Ta, meanwhile RR decreased significantly ($p<0.05$) as Ta decreased from 24.1 to 17.3°C followed with a slight reduction when Ta decreased from 17.3 to 14.9°C. On the other hand, in summer Tb followed the changes in Ta, while there was no significant change in RR (Table 1). This increase in Tb during summer specially from 6 to 8 weeks indicates that birds were under heat stress.

Feed consumption and feed conversion:

Feed consumption, calculated during the whole period, was lower in summer than in winter (46.6 v.s. 77.9 g/bird/day, respectively). However, feed conversion was higher in winter than in summer (2.39 v.s 1.96, respectively) due to higher feed intake in winter although growth rate was higher in winter than in summer. Many authors reported that high environmental temperature reduced significantly feed intake causing a significant reduction in feed conversion (Cowan and Michie, 1983; Rose and Michie, 1987; Marsden et al., 1987 and Wolfenson et al., 1987). This reduction in feed consumption at high Ta can be considered as a thermoregulation mechanism to decrease heat production under such conditions.

Body weight (Growth rate):

Figure (1) shows that growth rate during the brooding and growing periods were lower in summer than in winter and the differentiation began at the first week of age. The low growth rate occurred in summer was due to high ambient temperature (30- 35°C) (Table 1) which has a direct effect on central nervous system (CNS) to reduce metabolic rate and feed consumption (77.9 v.s 46.6 g/bird/day in winter and summer, respectively) causing a reduction in total body solids. Also, high ambient temperature caused a reduction in body fluids through evaporative cooling. The lower growth rate in summer than in winter agrees with the results of Reece and Lott (1982) who found that during the growing period (4-8 weeks), the slope of growth rate of broilers was lower at 26.7°C than at 15.6°C. Also, Hurwitz et al. (1980) and Cerniglia et al. (1983) showed that weight gain of chickens decreased in a linear fashion with temperature.

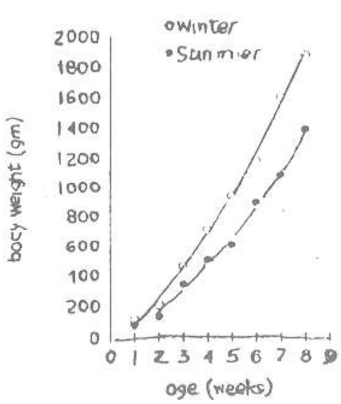

Fig. 1. Growth rate in summer and winter.

Body fluids:

The average TBW and its components at different ages in both seasons are presented in Table (2). It can be seen that the increase in all body fluid compartments with age was higher in winter than in summer. This was due mainly to higher growth rate in winter than in summer because age had different effect when body fluid compartments was expressed as percentage of body weight (Table 3).

Table (3) indicates that seasonal variation had different effects on TBW% in different age stages. While the effect of age was almost similar in the two seasons where TBW% decreased significantly ($p<0.05$) by age in both seasons. At 4 weeks of age, TBW% was significantly ($p<0.01$) higher in winter than in summer (78.65+0.34% v.s 67.50+0.32%, respectively). While, at 6 weeks of age, TBW% did not differ significantly between seasons. However, at 8 weeks of age the trend was opposite to that at 4 weeks where TBW% was significantly ($p<0.05$) higher in summer than in winter. This higher percentage of TBW in summer might be due to higher water turnover rate during this season (Abdel-Razik et al., 1985). Sturkie (1965) suggested that the reduction in TBW% with increasing age may be due to a reflection of the increase in body fat with aging.

Age had different trends of ICF% in the two seasons where ICF% decreased significantly ($p<0.05$) with age in winter while no significant change occurred in summer. Meanwhile, season had similar effect within different age stages where ICF% was significantly ($p<0.05$) higher in winter than in summer in all age stages which agrees with findings of Rodbard et al. (1951).

Age had similar trends of ECF% in both seasons as well as the effect of season on ECF% was similar in different age stages (Table 3). In both seasons, ECF% decreased significantly ($p<0.01$) with age. This reduction may be due to the increase in fat content as a result of high growth rate in adipose tissue which was previously observed by Kubena et al. (1972), Singh and Essary (1974), Evans et al. (1976) and Amer (1977). A significant reduction in ICF% during this periods confirms the above suggestion.

In different stages of the growth period, ECF% was significantly ($p<0.05$) higher in summer than in winter by about 19.23 to 19.78% (Table 3). Macfarlane (1968) showed that the increase in ECF% during summer may be an adaptive mechanism by increasing evaporative cooling under hot condition.

The effect of age on ISF% was similar to its effect on ICF% (Table 3). In winter, ISF% decreased significantly ($p<0.05$) with age while no significant changes occurred in summer. On the other hand, ISF% was significantly ($p<0.05$) higher in summer than in winter by about 21% throughout the growth period. Macfarlane (1968) demonstrated that interstitial fluid expanded at high environmental temperature to compensate the loss in plasma volume through evaporative cooling.

Table (3) shows that at 8 weeks of age PV% was significantly ($p<0.05$) lower in summer than in winter (2.19+0.06 v.s 5.96+0.17%, respectively), while no significant differences were found in the other two age stages. This reduction in PV% in summer may be due to the increase in evaporative cooling at hot climate (Macfarlane, 1968). In both seasons, PV% decreased with age but the effect was more pronounced in summer than in winter. It is of interest to note that a severe reduction in PV% (from 5.25% to 2.19%) occurred in summer when Ta increased from 30 to 35°C which may be attributed to death from heat stress (as indicated by the increase in Tb). A further study is recommended to investigate if this reduction in PV was due to hypoalbuminaemia as suggested by Forfar and Arneil (1984) or to disturbances in hormonal control of plasma volume. Forfar and Arneil (1984) reported that hypoalbuminaemia predisposes to the formation of increased amount of interstitial volume and decreased plasma volume. The reduction in plasma protein and plasma sodium concentration will decrease plasma osmotic pressure causing shift of fluids from plasma to interstitial space. The regulation of plasma volume in laying hens was studied by Arnason et al. (1986), Thomas et al. (1979) and Robinzon et al. (1990). They explained that the reduction in plasma volume stimulates the release of arginine vasotocin, which reduces urinary volume and increases Na+ retention. It also stimulates the secretion of aldosterone which enhances active Na+ transport.

Table 2. Mean and standard error (gm/ml) of body weight, total body water (TBW), extracellular fluid (ECF), intracellular fluid (ICF), interstitial fluid (ISF) and plasma volume (PV) in winter and summer

Age (week)		Body weight (gm)		TBW (ml)		ICF (ml)		ECF (ml)					
								ISF (ml)		PV (ml)		Total	
		W	S	W	S	W	S	W	S	W	S	W	S
4	X	586.75	548.75	462.07	369.85	279.31	91.15	142.73	246.14	40.03	32.55	182.76	278.70
	SE	28.62	20.33	23.82	12.27	14.01	3.75	9.85	10.54	1.61	1.32	10.76	10.72
6	X	1146.66	798.75	708.29	503.76	381.83	115.34	252.46	346.35	73.99	42.07	326.45	388.43
	SE	33.83	54.69	24.82	33.18	14.92	5.80	9.32	27.05	2.02	3.14	10.29	29.99
8	X	2307.91	1429.58	1294.74	864.44	695.05	217.73	462.69	615.28	136.99	31.43	599.68	646.71
	SE	63.66	36.89	34.26	24.35	24.12	12.85	17.57	16.02	4.02	1.26	18.21	16.95

Number = 12 W = winter. S = summer. X = mean.

Table 3. Mean and standard error of total body water (TBW%), extra and intracellular fluids (ECF%, ICF%), interstitial fluids (ISF%) and plasma volume (PV%) as percentage from body weight in winter and summer

Age (week)		TBW%		ECF%		ICF%		ISF%		PV%	
		W	S	W	S	W	S	W	S	W	S
4	Mean	78.65^{1}	67.50^{2}	31.08^{2}	50.78^{1}	47.57^{1}	16.72^{2}	24.22^{2}	44.80^{1}	6.86^{1}	5.98^{1}
	SE	0.34	0.32	0.68	0.63	0.44	0.65	0.81	0.84	0.15	0.25
	D	A	A	A	A	A	A	A	A	A	A
6	Mean	61.67^{1}	63.29^{1}	28.45^{2}	48.23^{1}	33.22^{1}	15.06^{2}	21.97^{2}	42.98^{1}	6.48^{1}	5.25$_{1}$
	SE	0.55	0.68	0.13	0.56	0.49	1.01	0.22	0.55	0.18	0.11
	D	B	B	B	B	B	A	B	A	A	B
8	Mean	56.12^{1}	60.44^{2}	26.01^{2}	45.24^{1}	30.11^{1}	15.19^{2}	20.05^{2}	43.05^{1}	5.96^{1}	2.19^{2}
	SE	0.19	0.46	0.52	0.31	0.59	0.76	0.54	0.28	0.17	0.06
	D	C	C	C	C	C	A	C	A	B	C

D = Duncan's multiple range t-test between age within each season. Identical capital letters means insignificant difference at $p<0.05$.

Identical superscript numbers means that there was no significant difference between seasons within each age.

W = winter.

S = summer.

Shifts in body fluid compartments as percentage of total body water (Table 4):

In both seasons, all fluid compartments as percentage of TBW did not differ significantly between 6 and 8 weeks of age except the significant reduction in PV% in summer. In winter, ICF% decreased significantly ($p<0.05$) from 4 to 6 weeks which was due to a significant ($p<0.05$) rise in both ISF% and PV% (Table 4). Accordingly, an opposite trend was found in ECF%. The increase in ECF% with age during winter although its percentage from body weight decreased means that with the increase in age fluids are transported to extracellular space due to the increase in body fat content. But due to the significant reduction in TBW% with age the percentage of ECF from body weight decreased. The ISF% increased significantly ($p<0.05$) from 30.75+0.91% at 4 weeks of age to 35.62+0.15% at 6 weeks of age. However, from 6 to 8 weeks of age ISF% increased slightly from 35.62+0.15 to 35.75+1.04%. A similar trend was found in PV% (Table, 4). These results indicate that in winter, fluid shifts with age from ICF to ISF and PV causing a reduction in ICF and an increase in ISF and PV as percentage from TBW. This may be due to the increase in fat content with increasing age as shown in carcass analysis made by Amer (1977).

In summer, both ICF% and ECF% did not differ significantly with age. This indicates that the significant reduction in ECF as percentage of body weight in summer (Table 3) was due to the significant reduction in TBW% but not to a reduction in ECF itself. The ISF% increased slightly from 66.38+1.26% at 4 weeks of age to 68.02+1.23% at 6 weeks of age after which it increased to 71.31+0.99% at 8 weeks of age being significant ($p<0.05$) as compared to the value at 4 weeks of age. However, there was a significant loss of water from PV to ISF as age increased from 6 to 8 weeks which coincided with an increase in Ta and Tb. As a result, ISF% was significantly higher while PV% was significantly lower as age increased from 4 to 8 weeks with the increase in Ta from 30 to 35°C. This indicates that under heat stress fluids shifted from plasma to ISF may be due to low albumin concentration (Forfar and Arneil, 1984).

Table 4. Mean and standard error of body fluid compartments as percentage from total body water in winter and summer

Age (week)		ICF%		ECF%		ISF%		PV%	
		W	S	W	S	W	S	W	S
4	Mean	60.50^{1}	24.76^{2}	39.49^{2}	75.23^{1}	30.75^{2}	66.38^{1}	8.74^{1}	8.85^{1}
	SE	0.73	0.92	0.73	0.92	0.91	1.26	0.23	0.35
	D	A	A	B	A	B	B	B	A
6	Mean	53.83^{1}	23.65^{2}	46.16^{2}	76.34^{1}	35.62^{2}	68.02^{1}	10.55^{1}	8.32^{2}
	SE	0.36	1.41	0.36	1.41	0.15	1.23	0.36	0.26
	D	B	A	A	A	A	AB	A	A
8	Mean	53.63^{1}	25.04^{2}	46.36^{2}	74.95^{1}	35.75^{2}	71.31^{1}	10.61^{1}	3.64^{2}
	SE	0.97	1.06	0.97	1.06	1.04	0.99	0.27	0.12
	D	B	A	A	A	A	A	A	B

As in Table (3).

As regard to seasonal effect, ICF% was significantly ($p<0.05$) higher in winter than in summer by about 28.59-35.74%. However, this difference between seasons tended to decrease as age increased (35.74% at 4 weeks of age and 28.59% at 8 weeks of age) may be due mainly to the increase in fat content in winter than in summer. As a result, ECF% was significantly ($p<0.05$) higher in summer than in winter by about 28.59 to 35.74%. The higher ECF as percentage from TBW or from body weight in summer than in winter indicates that this was not due to the changes in TBW between the two seasons but ECF was actually high in summer to compensate for the loss of water in evaporative cooling (Macfarlane, 1968). The ISF% was significantly ($p<0.05$) higher in summer than in winter by about 32-36% indicating that during summer water shifts from ICF to ISF to overcome the loss in water by evaporative cooling. Bass and Henschel (1956) suggested that since ISF forms water reserve for the evaporative cooling system and is involved in ridding the animal of the imposed heat load, any physiological adaptation which requires an increased plasma volume would operate more efficiently when a normal PV/ISF relationship is present, than when PV is increased at the expense of ISF. At 4 weeks of age, PV% was slightly higher in summer than in winter. However, it was significantly ($p<0.05$) lower in summer than in winter at 6 and 8 weeks of age (Table, 4). This indicates that although ISF was higher in summer than in winter, there was a loss of water from plasma to ISF which suggesting heat stress.

It can be concluded that the growing broiler comprised more water in summer than in winter, due to more fat percentage in winter than in summer. The reduction found in body fluid compartments with age during the growing period may be due to a significant increase in total body solids rather than to shifts between these compartments. However, there was a significant reduction in ICF% (as percentage of TBW) with age in winter due to the significant increase in body fat percentage. Rearing season had a significant effect on body fluid compartments causing higher percentage of ICF in winter, while ECF% was higher in summer due to significantly higher ISF%.

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تـأثير موسـم النمـو علـى معدل النمـو وتوزيـع سـوائل الجسـم فـى بـدراى المائدة

هشـام حسـين خليفـة – نبيـل فهمـى عبـد الحكيـم – احمـد محمـود ابراهيـم داوود

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تم اجراء تجربتين لدراسة التغـيرات فـى توزيـع سـوائل الجسـم اثنـاء فـترة النمو فى بدارى المائدة احداهما صيفا والاخـرى شـتاءا، حيـث اشـتملت كـل تجربة على ٥٠ طائر من نوع الهبرد عمر يوم ربيت الطيـور فـى بطاريـات تسمين (٨ طيور/ام) وغذيت على علقية تسمين تحتوى علـى ٢٢٪ بروتيـن و ٢٨٠٠ ك ك/كجم طـول فـترة التجربـة، تـم قيـاس وزن الجســم والغـذاء المأكول ودرجة حرارة المجمع ومعدل التنفس اسبوعيا بينما تم قياس درجـة حرارة الجو يوميا اما سوائل الجسم فقد قدرت علـى ١٢ طـائر عشـوائيا بعـد ٤، ٦و٨ اسابيع من العمر. وقد اظهرت النتائج ما يلى :

كـان معـدل النمـو اعلـى معنويـا فـى الشـتاء عنـه فـى الصيـف وقـد بـدأ الاختلاف عند عمر اسبوع، كذلك اوضحـت النتـائج انـه فـى كـلا الموسـمين كانت الزيادة اثناء النمو فى المادة الجافة اعلـى مـن الزيـادة فـى المـاء الكلـى وكان ذلك اوضح فى الشتاء عنـه فـى الصيـف ، وقـد ترتبـت علـى ذلـك ان النسبة المئوية لسوائل الجســم من الوزن الحى قد نقصـت معنويـا مـع العمـر (ما عدا السـوائل داخـل الخلايـا والسـوائل بيـن الخلايـا فـى الصيـف)، وجـد تداخل معنوى بين تأثير الموسم والعمر على النسبة المئويـة للمـاء الكلـى فـى الجسم وهذا يرجع الى اختلاف تأثير الموسم عند عمـر ٤ اسـابيع عنـه عنـد عمـر ٨ اسـابيع، وكذلـك وجـد ان نسـبة السـوائل خـارج الخلايـا أعلـى فـى الصيـف عنها فى الشتاء نتيجة لزيادة نسبة السـائل بيـن الخلايـا، بينمـا كـانت النسبة المئوية للبلازما أعلى فى الشتاء عنها فى الصيـف خاصـة عنـد زيـادة الفرق فى درجة حرارة الجو ، وقد اظهرت النتائج عدم وجـود تغـير معنـوى فى سوائل الجسم كنسبة من الماء الكلى بين عمرى ٦ و٨ اسابيع مع حـدوث نقص معنوى فى نسبة البلازما فى الصيف وذلك عند ارتفـاع درجـة حـرارة الجو من ٣٠ الى ٣٥م، امـا الاختلافـات بيـن العمـر عنـد ٤ و٦ اسـابيع فقـد وجد انخفاض معنوى فى الماء داخل الخلايا شـتاءا والـذى يرجـع الـى زيـادة نسبة الدهن فى الجسم وقد صـاحب ذلـك زيـادة معنويـة فـى نسـبة المـاء فـى السائل البينخلوى والبلازما بينما لم تحدث اختلافات معنوية فى الصيف خـلال هذه الفترة، يدل البحث على ان معدل النمو ومكونات الجسـم تختلـف حسـب موسم التربية كذلك فان حدوث نقص فى حجـم البلازمـا اثنـاء ارتفـاع درجـة حـرارة الجـو صيفـا قـد يكـون السـبب فـى ارتفـاع نسـبة الوفيـات صيفـا ممـا يستدعى اجـراء المزيـد مـن التجـارب لمعرفـة السـبب فـى فقـد السـوائل مـن البلازما فى الجو الحار بالرغم من توفر الماء امـام الطيـور ممـا يسـاعد فـى تقليل نسبة الوفيات صيفا.