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Genotype-Environment Interaction in Relation to Heat Tolerance in Chickens 2. Variation in Juvenile Growth of Warm Regions' Oriented Breeds

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Abstract: This study aimed to assess the variation in growth patterns of the warm region breeds in response to the intermittent prolonged heat stress conditions. Three warm region breeds (Fayoumi, Sinai Bedouin and White Baladi) and a commercial broiler strain were brooded for 8 wks in two thermal (heating and non-heating) treatments. The target ambient temperature in the heating treatment was 35°C from hatch to 4 wks of age (early prolonged heating period), declined to 24-25°C during the 5th and 6th wks (heat termination period), then raised to 35°C during the 7th and 8th weeks (re-heating period). The optimum brooding temperatures were provided in the non-heating treatment. The effect of heat on growth was breed-dependent. All heated chicks practiced a compensatory growth during the heat termination period. Early prolonged heat exposure did not provide broiler and Sinai Bedouin chicks with a heat reference to challenge the late re-heating. Reference to heat tolerance was rather limited to the age, body size and duration of heat exposure. Fayoumi and White Baladi chicks were not mostly influenced by heat allover the experimental period. The sex differences in Growth Rate (GR) in heated and non-heated birds were similar, thus the variation in GR between both sexes in heating conditions were due to normal sex variation. No significant differences were found between the variance estimates in GR of heated and non-heated broiler chicks, evincing lack of the genetic background for heat tolerance. The variance estimates in GR of heated Sinai Bedouin and Fayoumi males and females were significantly larger than those of the non-heated correspondents, evincing the existence of a genetic background for heat tolerance. The results indicate the feasibility of exploiting the genetic potential of the warm regions' oriented breeds in appropriate breeding programs.

Key words: Growth, heat tolerance, warm regions' oriented breeds

Introduction

The permanent and biologically founded genetic-environment interaction can be employed to maximize the efficiency of poultry production in regions providing sub-optimal environments (Horst, 1985 and 1989), by recognizing and exploiting the genotypes adapted to such environments. In this concern, high environmental temperature is a major factor restricting the poultry production in hot regions, using the contemporary commercial strains. Chamruspollert *et al.* (2004) reported less 7-21 day weight gain for the broiler chicks raised under a temperature of 35°C than for those raised under a temperature of 25°C. It was reported that the elevation in the environmental temperature causes many physiological responses lead to the decline in the performance of growing birds. Pym *et al.* (1984) attributed the heat susceptibility of broiler chicks to the high internal heat production associated with the selection for fast growth and feed consumption.

The negative effects of heat waves have been found to vary in the magnitude among different breeds, revealing the existence of genetic basis for resistance to heat (Washburn, 1985; Howlider and Rose, 1987 and 1989; Washburn *et al.*, 1992; El-Gendy *et al.*, 1995; Yalcin *et al.*, 2001). Reports indicate that breed differences in resistance to high temperature are associated with the breed differences in body weight. Berrong and Washburn (1998) reported significant less weight gain for the heat-stressed broiler chicks than for the heat-stressed random-bred chicks. El-Gendy (1992) and El-Gendy *et al.* (1995) reported that the within-breed variation in body weight under the heat stress conditions was a combination of the normal genetic variation in body weight and the variation in response of body weight to the heat stress conditions. The continuous selection for fast growth has resulted in broiler populations that became susceptible to heat stress conditions (Washburn *et al.*, 1980; Meltzer, 1987; El-Gendy *et al.*, 1995). Differences in the overall genetic background between breeds could also be involved in the heat tolerance (Deeb and Cahaner, 2001a). Yalcin *et al.* (1997) compared the performance of three commercial broiler lines, developed in three different breeding companies, under natural hot and temperate climates. The three lines exhibited similar growth rates in the temperate climate but differed in the magnitude of their growth rates in the hot climate. Also, Deeb and Cahaner (2001b) compared the growth of dwarf and non-dwarf broiler chicks segregated from the same families, thus had similar genetic backgrounds and differed only in the growth rate. The dwarf chicks were not superior over the non-dwarf chicks under high ambient temperature,

suggesting that the broiler lines differ in their response to high ambient temperature, possibly due to the differences in various aspect of their overall genetic background.

The early short-term thermal conditioning has been found to support birds with a defense against the late heat waves. Yahav (2000) found that the broiler chicks of 3-7 day old could be acclimated to a wide range of ambient temperature. According to May *et al.* (1987) and Lott (1991), the strains genetically selected for fast growth attained considerable resistance to heat stress conditions after the exposure, for 3 days, to a daily acclimation cycle of 24-35-24°C. Also, Yahav and McMurtry (2001) reported the ability of broiler chicks to withstand a temperature of 35°C at 42 days of age, due to the exposure to a thermal conditioning of 36-37.5°C at 3 days of age.

There are many breeds adapted to the hot climates. Most of these breeds are not substantially characterized on genetic bases, so that appropriate breeding programs do not target them. The objectives of this study was the assessment of the variation in juvenile growth patterns of three Egyptian breeds, local to warm regions versus a commercial broiler strain in response to the intermittent prolonged heat stress conditions.

Materials and Methods

Breeds, housing and management: Chicks of four breeds of chickens, differing in their overall genetic backgrounds, were used. The breeds were Sinai Bedouin, Fayoumi and White Baladi, which are native to Egypt and local to warm regions and a commercial broiler strain. Sinai Bedouin has been found in the Sinai desert. Fayoumi has been developed long time ago in Fayoum, which is a lowland region near the Nile river valley. White Baladi has been derived, in the late 1960s in the faculty of agriculture of Cairo University, from the random-bred Baladi chickens that are commonly found along the Nile river valley. Two hundred chicks of each breed were used and all chicks were hatched at the same day. Upon hatch, the chicks of each breed were wing banded and randomly divided into two equal groups, a group allocated to a heating treatment and a group allocated to a non-heating treatment (control). The target ambient temperature in the heating treatment was 35±2°C from hatch to 4 weeks of age (early prolonged heating period). It suddenly declined to 24-25°C and held constant during the 5th and 6th weeks of age (heat termination period) and suddenly raised again to 35±2°C and held constant during the 7th and 8th weeks of age (re-heating period). The target ambient temperature in the non-heating treatment was 35°C from hatch to 3 days of age and reduced gradually to reach 32°C at 7 days of age. It then decreased by 2°C/week to reach 24-25°C at 5 weeks of age and held constant until the experiment was terminated at 8 weeks of age. The chicks of all breeds of each treatment were intermingled and placed in two floor pens in a conventional-type house. All chicks were fed, *ad libitum*, a broiler starter medicated ration (3000 kcal ME/kg and 22-23% CP) until 4 weeks and a broiler finisher medicated ration (3200 kcal ME/kg and 19-20% CP) thereafter. Drinking water supply and illumination were continuous during the experimental period.

Measurements and statistical analysis: Body Weights (BW) of all chicks were individually obtained upon hatch and biweekly until 8 weeks of age. Body Weight Gains (BWG) and Growth Rates (GR) were obtained biweekly on individual basis. GR was calculated as BWG in two weeks as a percentage of the average of body weights at the beginning and at the end of the two weeks. Analysis of variance was carried out using the General Linear Model (GLM) procedure of statistical analysis system (SAS, 1997). The statistical model was:

$$Y_{ijkl} = \mu + B_i + S_j + T_k + BS_{ij} + BT_{ij} + ST_{jk} + \varepsilon_{ijkl}$$

Where, Y is the given individual measurement (BW, BWG or GR), μ is the overall mean, B, S and T are the effects of breed, sex and thermal treatment respectively and ε_{ijkl} is the random error within breed, sex and thermal treatment. Significant breed differences were shown by Duncan's multiple range test (Duncan, 1955). Statistical comparisons between the variance estimates in GR of sexes or thermal treatments within breed were performed according to Ott (1986). For this, the data sets of GR were examined for normality before ongoing into the comparisons between variance estimates.

Results

Levels of significance for different effects on BW, BWG and GR are presented in Table 1. Significant and consistent breed effect was shown on all traits. Thermal treatment had influenced 4-, 6-and 8-wk BW, but 2-wk BW. The effect of breed-thermal treatment interaction on 4-6 wk BWG was significant (P = 0.04). No significant effects were obtained for the sex-thermal treatment interaction on any of the traits. Also, the effect of breed-thermal treatment interaction on GR was not significant.

Body weight: Table 2, presents least squared means of BW of heated and non-heated chicks. No significant differences in 2-wk BW were found between heated and non-heated broiler chicks. The continuous heat exposure of broiler chicks resulted in a significant detraction, compared to the non-heated counterparts, in 4-wk BW by 16.7 and 15.1%, for males and females respectively. However, BW of heated chicks of the local breeds, except Sinai Bedouin males, did not significantly differ from the non-heated chicks during the entire period. The heated White Baladi males were even 8.4%

Table 1: Levels of significance for the effects of breed, sex and thermal treatment and their 2-way interactions on body weights, body weight gains and growth rates

	P ≤											
	Body Weight (BW)				Body Weight Gain (BWG)				Growth Rate (GR)			
Effect	2 wk	4 wk	6 wk	8 wk	0-2 wk	2-4 wk	4-6 wk	6-8 wk	0-2 wk	2-4 wk	4-6 wk	6-8 wk
Model	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Breed (B)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
Sex (S)	0.0938	0.2330	0.0002	0.0001	0.0928	0.0320	0.0001	0.0001	0.2780	0.0002	0.0004	0.0001
Thermal treatment (T)	0.7789	0.0001	0.0299	0.0001	0.9484	0.0001	0.0631	0.0001	0.4576	0.0005	0.0001	0.0001
B*S	0.4186	0.8718	0.5157	0.0348	0.3753	0.8954	0.0106	0.0051	0.3102	0.5506	0.0838	0.8432
B*T	0.0157	0.0001	0.0085	0.0001	0.0138	0.0001	0.0448	0.0001	0.0682	0.0883	0.2932	0.0736
S*T	0.2877	0.8518	0.9825	0.6262	0.2630	0.3732	0.9619	0.2384	0.7022	0.1582	0.8076	0.7550

Table 2: Effect of breed, sex and thermal treatment and their 2-way interactions on body weight (LSM±SE, g) of commercial broiler (CB), Sinai Bedouin (S), Fayoumi (F) and White Baladi (WB) chicks

	2-wk BW			4-wk BW			6-wk BW			8-wk BW		
Breed	NH	H	diff. %	NH	H	Diff. %	NH	H	diff.%	NH	H	diff. %
♂♂												
CB	226±12[a]	220±14[a]	2.7	945±34[a]	787±30[a]	16.7*	1908±44[a]	1792±58[a]	6.1	2284±80[a]	2238±64[a]	22.4*
S	144±7[b]	125±7[b]	13.2	420±27[b]	350±19[b]	16.7*	808±48[b]	706±40[b]	12.6	1224±76[b]	932±58[b]	23.9*
F	78±5[c]	85±3[c]	9.0	205±14[c]	205±6[c]	0.0	364±24[c]	404±8[c]	11.0*	577±30[c]	561±12[c]	2.8
WB	64±6[c]	73±3[c]	14.1	179±22[c]	194±8[c]	8.4*	315±45[c]	366±15[c]	16.2	525±68[c]	502±20[c]	4.4
C.V.	21.0	22.1		20.0	18.2		16.5	17.4		18.1	17.7	
♀♀												
CB	224±11[a]	245±9[a]	9.4	949±27[a]	806±26[a]	15.1*	1789±33[a]	1714±45[a]	4.2	2573±71[a]	2073±56[a]	19.4*
S	152±11[b]	135±10[b]	11.2	427±35[b]	341±27[b]	20.6	765±60[b]	683±41[b]	10.7	1141±91[b]	858±46[b]	24.8*
F	82±7[c]	83±2[c]	1.2	200±5[c]	190±5[c]	5.0	337±8[c]	336±9[c]	0.3	511±15[c]	453±11[c]	11.4*
WB	70±8[c]	77±3[c]	10.0	168±5[c]	179±7[c]	6.5	302±12[c]	321±12[c]	6.3	468±18[c]	418±15[c]	10.7
C.V.	21.1	20.7		14.2	20.8		10.8	17.1		13.7	15.9	

LSM = least square mean, BW = body weight, NH=non-heated chicks, H=heated chicks,
Diff. % = |BW of NH-BW of H| ÷ BW of NH* 100,
[a,b,c,d],BW of different breeds with different superscripts are significantly different (P ≤ 0.05),
*Significant effect of thermal treatment or sex, within breed (P ≤ 0.05)

significantly heavier in 4-wk BW than those non-heated. The heat termination period resulted in no significant reductions in 6-wk BW in all heated chicks, compared to those non-heated. The heated Fayoumi and White Baladi males and females were rather consistently heavier than those non-heated and the difference in Fayoumi males (11%) was even significant. The re-heating period resulted in significant detractions in 8-wk BW of the heated broiler and Sinai Bedouin males, compared to those non-heated, by 22.4 and 23.9%, respectively. Also, heated broiler, Sinai Bedouin and Fayoumi females had significantly less 8-wk BW by 19.4, 24.8 and 11.4%, respectively, than the non-heated counterparts. Heated White Baladi males and females, however, performed 8-wk BW significantly comparable to those non-heated. The coefficients of variation (CV) in BW of heated and non-heated males did not differ much from each other. However the CV of heated females were, in general, greater than those of non-heated females.

Body weight gain: Least squared means of BWG of heated and non-heated chicks are presented in Table 3. Only heated Sinai Bedouin males significantly gained less than the non-heated birds during the 0-2 wk period (17%). The heated broiler males and females significantly gained 21.4 and 23.9% less than their non-heated chicks during the 2-4 wk period. During the heat termination period, no significant differences were found in BWG in all breeds, except for heated Fayoumi males that significantly gained 25.2% more than those non-heated. During the re-heating period, all heated chicks consistently and significantly gained less than their non-heated counterparts. The reductions in heated 6-8 wk BWG were the most in broiler males and females (58.1 and 54.1%, respectively) and were the least in Fayoumi males and females (26.3 and 33.7%, respectively). The CV in BWG of heated males over the experimental period tended to be greater than of the non-heated males, but this trend was not obvious in females.

Growth rate: The 0-2 wk GR was significantly the fastest (140%) in the non-heated broiler males and was the slowest (75%) in the non-heated White Baladi males (Table 4). The results of GR indicate that the early-prolonged heating period was relevant to all local

Table 3: Effect of breed, sex and thermal treatment and their 2-way interactions on body weight gains (LSM±SE, g) of commercial broiler (CB), Sinai Bedouin (S), Fayoumi (F) and White Baladi (WB) chicks

	0-2 wk BWG			2-4 wk BWG			4-6 wk BWG			6-8 wk BWG		
Breed	NH	H	diff. %	NH	H	diff. %	NH	H	diff.%	NH	H	Diff.%
					♂♂							
CB	187±12^{a}	182±14.0^{a}	2.7	720±25^{a}	566±22^{a}	21.4*	964±21^{a}	1015±46^{a}	5.3	975±53^{a}	409±43^{a}	58.1*
S	112±7^{b}	93±7.0^{b}	17.0*	266±22^{b}	226±18^{b}	15.0	389±24^{b}	355±24^{b}	8.7	416±34^{b}	226±25^{b}	45.7*
F	55±5^{c}	60±2.3^{c}	9.1	127±10^{c}	121±5^{c}	4.7	159±13^{c}	199±5^{c}	25.2*	213±13^{c}	157±8^{c}	26.3*
WB	36±6^{d}	41±2.4^{d}	13.9	115±17^{c}	122±7^{c}	6.1	137±27^{c}	172±7^{c}	25.5	209±25^{c}	139±6^{c}	33.5*
C.V.	26.3	29.0		21.6	23.8		16.7	22.0		26.9	37.6	
					♀♀							
CB	186±11^{a}	217±9^{a}	16.7	724±19^{a}	551±19^{a}	23.9*	840±32^{a}	907±25^{a}	8.0	784±50^{a}	360±32^{a}	54.1*
S	119±10^{b}	103±10^{b}	13.4	275±32^{b}	206±20^{b}	25.1	338±30^{b}	342±20^{b}	1.2	376±32^{b}	175±18^{b}	53.5*
F	57±15^{c}	58±2^{c}	1.8	119±2^{c}	108±4^{c}	9.2	136±6^{c}	146±6^{c}	7.4	175±9^{c}	116±5^{c}	33.7*
WB	42±7^{d}	46±2^{d}	9.5	98±7^{c}	102±6^{c}	4.1	134±10^{c}	142±7^{c}	6.0	166±10^{c}	101±7^{c}	39.2*
C.V.	26.0	26.7		15.4	25.1		18.1	18.1		26.4	37.0	

LSM = least square mean, BWG = body weight gain, NH=non-heated chicks, H=heated chicks.
Diff. % = |BWG of NH-BWG of H| ÷ BWG of NH* 100.
^{a,b,c,d}, BWG of different breeds with different superscripts are significantly different ($P \leq 0.05$).
*, Significant effect of thermal treatment or sex, within breed ($P \leq 0.05$).

Table 4: Effect of breed, sex and thermal treatment and their 2-way interactions on growth rates (LSM±SE, %) of commercial broiler (CB), Sinai Bedouin (S), Fayoumi (F) and White Baladi (WB) chicks

	0-2 wk GR			2-4 wk GR			4-6 wk GR			6-8 wk GR		
Breed	NH	H	Diff. %	NH	H	diff. %	NH	H	diff. %	NH	H	diff. %
					♂♂							
CB	140±3^{a}	139±4^{a}	0.7	123±2^{a}	113±3^{a}	8.1*	68±2^{a}	79±3^{a}	16.2*	41±2^{b}	21±2^{b}	48.8*
S	127±3^{b}	116±4^{b}	8.9	94±5^{b}	94±4^{b}	0.0	64±3^{ab}	67±2^{b}	4.7	40±2^{b}	27±3^{a}	23.5*
F	108±4^{c}	110±2^{b}	1.9	89±3^{b}	83±2^{c}	6.7	55±2^{bc}	66±2^{b}	20.0*	46±3^{ab}	32±1^{a}	30.4*
WB	75±8^{d}	78±3^{c}	4.0	94±4^{b}	91±2^{bc}	3.2	53±7^{c}	61±1^{b}	15.1	51±3^{a}	32±1^{a}	37.3*
C.V.	10.5	11.5		12.7	14.0		16.2	11.7		16.2	27.0	
					♀♀							
CB	141±2^{a}	147±1^{a}	4.3	124±2^{a}	104±1^{a}	16.1*	61±2^{a}	72±1^{a}	18.0*	36±2^{b}	19±2^{c}	47.2*
S	128±4^{a}	117±6^{b}	8.6	94±7^{b}	85±6^{b}	9.6	57±3^{ab}	69±4^{a}	21.1	39±1^{ab}	23±2^{bc}	41.0*
F	106±6^{b}	108±2^{c}	1.9	85±5^{b}	79±2^{b}	7.1	51±2^{b}	55±2^{b}	7.8	41±1^{a}	30±1^{a}	26.8*
WB	82±6^{c}	85±2^{d}	3.7	84±8^{b}	80±3^{b}	4.8	56±3^{ab}	57±2^{b}	1.8	43±2^{a}	28±2^{ab}	34.9*
C.V.	10.6	12.1		15.3	16.0		12.9	15.7		12.2	27.5	

LSM = least square mean, GR = growth rate, NH=non-heated chicks, H=heated chicks.
Diff. % = |GR of NH-GR of H| ÷ GR of NH* 100.
^{a,b,c,d}, GR of different breeds with different superscripts are significantly different ($P \leq 0.05$).
*Significant effect of thermal treatment or sex, within breed ($P \leq 0.05$).

breeds. However, heated broiler males and females were less in 2-4 wk GR than their non-heated correspondents, by 8.1 and 16.1% respectively. During the heat termination period, the heated males and females of all breeds grew in faster rates than those non-heated and the differences were significant in broiler and Fayoumi chicks. During the re-heating period, the heated chicks of all breeds dramatically and significantly grew in retarded rates. The differences in 6-8 wk GR were largest in broiler males and females (48.8 and 47.2%, respectively) and were smallest in Fayoumi males and females (30.4 and 26.8, respectively). In general, the negative effect of heat on GR was observed in both sexes, but was in less extent in Fayoumi and White Baladi females. It is also observed that the CV in GR of heated males and females were firmly greater than in those non-heated, suggesting the study of the variance estimates in GR.

Variation in growth rate: The variance estimates in GR were obtained for the individuals within breed, sex and thermal treatment (Table 5). The variance estimates in 0-4 wk GR of heated and non-heated broiler chicks, within sex, were not significantly different, although heated birds showed less GR. Also, no significant differences were observed when the variance estimates of different sexes, within thermal treatment were compared. The variance estimates in 4-6 wk GR of heated and non-heated broilers, within sex, were not statistically different, although the heated birds significantly performed faster GR. The variance estimates in 6-8 wk GR of heated broiler males and females were similar to those of the non-heated correspondents, although of the significant differences in their GR. For Sinai Bedouin chicks, the variance estimates in 0-4, 4-6 and 6-8 wk GR of heated females were significantly and consistently greater than those in the non-heated birds. Heated females also significantly revealed more variance estimates than heated males, in 0-4 and 4-6 wk GR. The variance estimate in 6-8 wk GR

Table 5: Statistical inferences on the comparisons of variance estimates in growth rates of different sexes or different thermal treatments within breed

	Commercial broilers			Sinai Bedouin			Fayoumi			White Baladi		
Sex	NH	H	$\lvert\sigma^2_{NH}-\sigma^2_{H}\rvert$	NH	H	$\lvert\sigma^2_{NH}-\sigma^2_{H}\rvert$	NH	H	$\lvert\sigma^2_{NH}-\sigma^2_{H}\rvert$	NH	H	$\lvert\sigma^2_{NH}-\sigma^2_{H}\rvert$
0-4 wk Growth rate												
♂♂	4.04	4.37	0.33	62.57	29.92	32.65	45.43	22.18	23.25	152.52	39.56	112.96
♀♀	2.37	2.99	0.62	32.04	155.50	123.46**	6.60	75.34	68.74**	84.46	65.61	18.85
$\lvert\sigma^2_{♂}-\sigma^2_{♀}\rvert$	1.67	1.38		30.53	125.58**		38.83**	53.16**		68.06	26.05	
4-6 wk Growth rate												
♂♂	33.76	65.93	32.17	108.37	80.28	28.09	36.60	61.31	24.71	327.97	36.48	291.49*
♀♀	66.42	23.72	2.80	66.10	240.25	174.15*	16.48	62.88	46.40*	52.13	50.13	2.00
$\lvert\sigma^2_{♂}-\sigma^2_{♀}\rvert$	32.66	42.21		42.27	159.97*		20.12	1.57		275.84*	13.65	
6-8 wk Growth rate												
♂♂	32.38	48.58	16.20	51.12	133.40	82.28*	69.56	53.73	15.83	38.69	11.42	27.27
♀♀	35.05	30.25	4.80	1.32	91.97	90.65**	10.96	38.32	27.36*	30.47	43.03	12.56
$\lvert\sigma^2_{♂}-\sigma^2_{♀}\rvert$	2.67	18.33		49.8**	41.43		58.60*	15.41		8.22	31.61**	

NH = non-heated chicks, H=heated chicks,

*, Inequality of variance estimates of different thermal treatments or different sexes, within breed ($P \leq 0.05$),

**, Inequality of variance estimates of different thermal treatments or different sexes, within breed ($P \leq 0.01$)

of heated males was significantly greater than that of the non-heated correspondents. Similar to Sinai Bedouin chicks, heated Fayoumi females significantly revealed more variance estimates in 0-4, 4-6 and 6-8 wk GR than the non-heated females, although GR were not significantly different. The differences in variance estimates were less evident in male comparisons. White Baladi chicks showed different trend, where no significant differences in any of the variance estimate comparisons appeared, but for the sex comparison of the 6-8 wk GR.

Discussion

The significant effect of thermal treatment on 4-, 6-and 8-week BW, but 2-week BW, indicates that the effect of heat was age-dependent. The effects of the interaction between breed and thermal treatment on BW and BWG were significant, indicating that the effect of heating treatment was breed-dependent too. The significant effect of breed-thermal treatment interaction on 4-6 week BWG reveals the ability of some breeds to compensate the negative effect of heat on growth after heat termination. The association between breed differences in BW and the response to heating conditions was previously reported (Washburn, 1985; Washburn *et al.*, 1992; Suk and Washburn, 1995; Yalcin *et al.*, 2001; Deeb and Cahaner, 2001a and 2002). The heavier or the rapidly grown the breeds are the more susceptible to heating conditions. Evidences were also reported for the superiority in heat tolerance, of Sinai Bedouin and White Baladi over White Leghorn and broiler chicks (Arad *et al.*, 1981; El-Gendy *et al.*, 1995).

BW and BWG somewhat differed in the response to heating and non-heating treatments. For instance, the depression in BW during the heat termination period was significant particularly for broilers and Sinai Bedouin, but no depression was found in their BWG. Also, it is observed that CV in BW were apparently larger in heated compared to non-heated females and this was not obvious in males. The CV in BWG for heated birds were larger than those for non-heated birds and this was more obvious in males than in females. In addition, the results of BW and BWG indicate that both sexes of Fayoumi and White Baladi performed normal growth under heating conditions. Whereas heated broiler and Sinai Bedouin males grew in similar rates to their heated females. Thus growth of males seemed to be suppressed and accordingly females appeared more tolerant to heat. Such results proposed the study of GR of the birds.

The results of 0-2 and 2-4 wk GR indicate that the broiler chicks, which have been selected for rapid growth under temperate conditions, do not achieve their genetic potential under high temperature conditions. Evidences for the negative association between high temperature and growth rate were previously reported (Cahaner and Leenstra, 1992). Deeb and Cahaner (2002) and Deeb *et al.* (2002) reported negative correlation estimates between genetic potential of growth rate and actual growth rate under heating conditions. The results of the 4-6 wk GR reveal that heated chicks of all breeds practiced a compensatory growth after heat termination. The compensatory growth in chicks was an immediate phase following the heat termination, resulting in complete compensation for the loss of weight gains (Yahav and Hurwitz, 1996; Yahav *et al.*, 1997; Yahav and Palvnik, 1999).

The significant reductions in 8-wk BW of re-heated broiler and Sinai Bedouin chicks reveal that chicks did not perform heat resistance aquatinted from the early heating. Whereas, re-heating of White Baladi chicks did not result in significant decreases in 8-wk BW. The results of 6-8 wk GR of the heated chicks indicate that early heating did not provide birds with a heat reference

to challenge future re-heating and the heat defense is rather limited to the age and body size and duration of heat exposure. Broiler chicks that experienced short-term heat conditioning during the early days withstood the heat waves at older ages (Lott, 1991; Yahav and Plavnik, 1999; Yahav and McMurtry, 2001). Deeb and Cahaner (2001b) reported that the broiler chicks might practice better thermoregulation during acute heat stress. If the heat stress becomes chronic, the chicks do not show reference of heat tolerance. Since, Fayoumi and White Baladi chicks were not entirely influenced by heat allover the experimental period, so the temperature of heating treatment was within the thermal zone relevant to them and their body sizes might be below the threshold at which heat retards growth. Therefore, the local breeds showed heat tolerance varying in the extent based on the extents of their genetic backgrounds that enable them to withstand the heating conditions. Whereas, heated commercial broiler chicks suffered most, because of lacking the genetic background for heat tolerance. El-Gendy *et al.* (2006) reported significant variation in overall genetic backgrounds, based on the genome scanning using RAPD-PCR analysis, among the Sinai Bedouin, Fayoumi, White Baladi and broiler chickens. It was reported that the genome differences might reflect the breed differences in the adaptation to warm regions. Arad *et al.* (1981) reported the genetic superiority of Sinai Bedouin over White Leghorn in withstanding the desert environmental conditions. The sex differences in GR in heated and non-heated birds, by breed, were similar. Therefore, the variations in GR between both sexes in heating conditions are due to the normal sex variation in growth. This, in turn, indicates that females are not indeed superior to males in the heat tolerance.

The comparisons of variance estimates in growth rates of heated and non-heated broiler chicks through the entire experiment indicate that heat did not influence the variation, although the observed retardation in the growth. This evinces the lack for genetic bases for heat tolerance in commercial broiler chicks. Since the commercial broiler chicks are all fast growers, they detract their growth rates when heated to withstand the negative effects of high temperature, through reducing feed consumption. The more variance estimates obtained in growth rates of heated Sinai Bedouin and Fayoumi males and females, compared to their non-heated correspondents, evince the existence of genetic bases for heat tolerance which boosts the ability of birds to cope with the heat stress conditions. This genetic basis interacts with the genetic background of growth and, in turn, increases the variation in growth rate. The results are in agreement with the results of Washburn (1985), El-Gendy (1992) Washburn *et al.* (1992) and Deeb and Cahaner (2001a and 2002), for the existence of genetic background for heat tolerance that interacts with the genetic background of growth. Also, Deeb and Cahaner (2001b) observed a drastic increase in the variation in weight gain, feed efficiency and body temperature in heated birds suggesting a relationship between growth rate and heat tolerance. The results also suggest GR to reliably explain the birds' growth performance in hot climates and the feasibility of exploiting the genetic potential of the warm regions' oriented breeds in appropriate breeding programs.

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