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Maturation of Homeothermy in Fayoumi Chickens

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THIS WORK was carried out on 417 one day old Fayoumi chickens from the flock of Poultry Research Unit of The Faculty of Agriculture, Cairo University. Changes in body temperature and respiration rate were taken as a criterion for homeothermic maturation. The development of homeothermy in the newly hatched chickens when raised at normal brooding temperature of 31° and when subjected to heat stress was investigated.

Under normal brooding conditions body temperature of Fayoumi chicks increased from 105.3° F at 2 days of age to 107.8° F at 27 days after hatch. During this period respiration rate, on the contrary decreased from 86 to 78 breaths/minute for 2 and 27 days old chickens respectively. The data also revealed age differences in the response to either abrupt or gradual increase in air temperature from 31° to 42°. Body temperature of all ages increased with elevation of ambient temperature. Respiration rate increased only in 6 days old chicks and polypnea was pronounced in 14 and 27 days old chicks.

Diurnal variations in body temperatures and respiration rates of all examined ages were also indicated.

Maturation of thermoregulatory mechanisms after hatch or birth is a common phenomenon in all homeothermy even in highly developed mammals such as man, Brody (1945) stated that "an important adaptation to environment is that birth or hatching under natural conditions occurs during seasons when the environmental temperature is optimal, thus allowing time for development of homeothermy".

Experiments carried out to investigate the development of thermoregulation in the fowl followed two procedures. The first included observations on the changes in body temperature during the first 5-40 days after hatch in chickens reared under various environmental air temperature. The second procedure was studying other physiological reactions of the chickens as affected by environmental and body temperatures.

Most of the investigations on the development of homeothermy in newly hatched chicks of different breeds during the first 10 - 40 days of age indicated that an increase in body temperature occurs with the advance of age (Lamoreux and Hutt, 1939; Sholes and Hutt, 1942; Ram and Hutt, 1955 and Freeman, 1965). The rise of body temperature with age was of a biphasic character: a sharp increase during the first 4-5 days after hatch followed by gradual slower rate of increase up to 14-21 days, with marked drop during the first 5-9 days of age.

Relatively more information on the developmental changes of homeothermy in chickens has been obtained during exposure of baby chicks to low environmental temperatures; physiological homeothermic mechanisms start to function at the *7th* - *8th* day after hatch, and are fully developed at about 21 days of age (Randall, 1943; Wekstein and Zolman, 1967, 1969, 1970 and 1971).

Comparatively few information has been published on testing the development of homeothermy in the baby chickens by studying the physiological reactions to heat stress as that published by Randall (1943) and Freeman (1963).

The present experiment was conducted to determine the age of prominant development and the age of the full maturity of homeothermy in the Egyptian Fayoumi chicks by studying the changes in body temperature and respiration rate of the baby chickens during the first 27 days of age when raised under brooding temperature of 31° and subjected to heat stress of 42°.

Material and Methods

This work was carried out during 1973 - 1974 in the Poultry Research Unit of the Faculty of Agriculture, Cairo University, Egypt.

Experimental animals

The work comprised 417 chickens of the Fayoumi native Egyptian breed.

Upon hatching chickens were individually weighed, wingbanded and placed in electrically heated brooding pens at 31° ± 2°.

Chicks were fed on a ration composed of 22% decorticated cotton seed meal, 15% ground barley, 40% ground maize, 5% wheat bran, 10% rice bran, 5% blood meal, 1.0% Phizer mineral mixture, 1.5% lime and 0.5% sodium chloride. Food and water were available libitum for all chicks.

Procedures

Daily maximum and minimum ambient air temperature, inside the brooding pens, were recorded twice daily at 7 a.m. and 4 p.m, throughout the experiment by maximum and minimum thermometers.

The air temperature was controlled by a set of electrical heaters and thermostats in accordance with the particular studies. No attempt was executed to control the humidity within the particular studies. No attempt was executed to control the humidity within the pens.

The body temperatures and respiration rates were taken at various times throughout the test according to the design of each experiment. Rectal temperatures were measured by a clinical thermometer inserted in the cleaca for two minutes. Respiration rate per min was obtained by visual observation (counting the movement of the abdomen in 30 seconds and then doubled).

Two experiments were conducted to study the development of homeothermy during the first 27 days after hatch.

Experiment a

Age differences in the response of Fayoumi chicks to abrupt increase in ambient temperature

A number of 387 Fayoumi chickens was used to study the development of their homoethermic reaction at successive ages; 2,3,4,5,6,7,10,14,21 and 27 days old. After hatch, chickens were kept in brooding pens at temperature 31 $\pm$ 2° (about 88°F) until the particular age of the test, at that day chickens were weighed, divided into two groups, a control group which remained under 31° and the test group. The number of chicks in the control groups at the ages shown above was 37,25,30,12 and 10 for 2,3,4,5 and 6 days old respectively and 15 for each of the other ages (7,10,14,21 and 27 days). The test group was exposed to a high ambient temperature of 42$\pm$2° (about 108°F) in the controlled temperature pens for a period of 8 hr. The number of exposed chickens in each age was 41,30,25,15,12 for 2,3,4, 5 and 6 days respectively and 15 from each of other ages (7,10,14,21 and 27 days).

Rectal temperature and respiration rate of both groups were recorded simultaneously just before the test, and after 1, 2,4 and 8 hr starting at 8-9 a.m.

Experiment b

Age difference in the reaction of Fayoumi chickens to gradual increase in ambient temperature

In this study 10 Fayoumi chickens of each 2, 6 and 9 days old were used.

From the day of hatch chickens of each age group were separately kept in a wire cage inside a common brooding pen at 27$\pm$ 62° (about 81°F).

At the beginning of the test chickens were weighed, their body temperature and respiration rate were recorded, then the air temperature was gradually increased throughout 5 hr to 42° in five steps (3°/ hour) by putting additional electrical heaters.

Rectal temperature and respiration rate of all chicks of each age were recorded at the successive air temperatures (27°,30°,33°,36°,39° and 42°).

Results and Discussion

Experiment a

Changes in body temperature and respiration rate of Fayoumi chicks during the first 27 days of age, under normal brooding temperature of 31° (88°F)

A. Body temperature; During the first 4 days after hatch there was a gradual significant increase (P 0.01) in body temperature of the Fayoumi chicks brooded under 31°, through all the day except at 8 a.m., where a significant drop (P 0 05) in body temperature at the fourth day was observed (Table 1 and Fig. 1-A). From the fourth day of age and up to the seventh day there was a sharp significant increase (P 0 01) followed by another gradual increase from the tenth day up to 27 days where body temperature became the same as adults (107.5°F at 8 a.m. and 108.2°F at 4p.m.) (Table 1 and Fig. 1-A).

It could be stated from this result that the first week of age is a critical period of the development of homeothermy and that homeostasis is fully attained after 4 weeks of age.

Adult body temperature of Fayoumi chicks as Kamer and Khalifa (1964) found was 106.9°F. Obeidah *et al.* (1974) reported 106.8°F for morning and 107. 3°F for evening body temperature of 2 months old Fayoumi chickens. Shafie *et al.* (1977) reported that the body temperature of three months Fayoumi chickens brooded at 33° and 25° was 108.2°F and 108.1°F respectively.

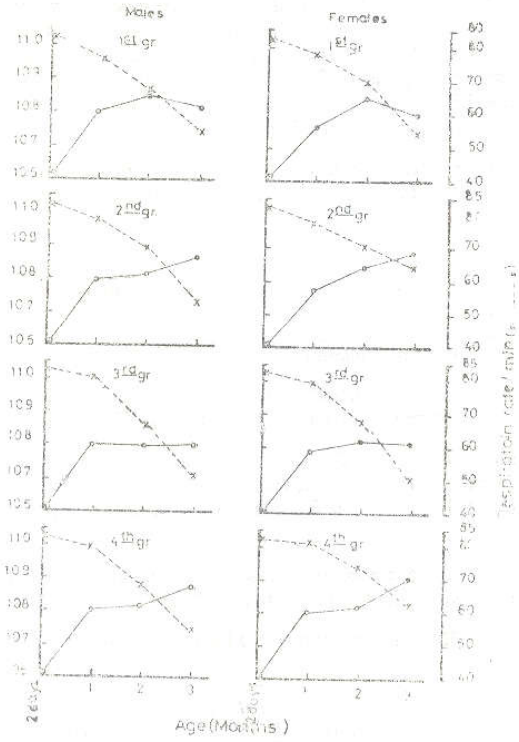


Fig. 1. Effect of acclimation to different ambient temperatures on body temperature and respiration of Fayoumi chicks.

Diurnal variation in body temperature

As shown in Table 1 and Fig. 2-A, at the second day after hatch there was a significant difference (P 0.01) between the morning and evening body temperatures (evening body temperature was higher than the morning one by + 0.3°F. The amplitude of the overall diurnal variation in body temperature

decreased during the third and fourth days after hatch then sharply increased at the fifth and sixth days of age reaching its highest value (+0.9°F) at the sixth day. These increases in the amplitude of diurnal variation were followed by a decrease on the seventh day, it became 0.3, then it rose again to + 0.7 at ten days of age and stayed constant up to 27 days after hatch.

TABLE 1. Mean± S.E. of body temperature of chicks during the first 27 days after hatch at successive hr under normal brooding temperature of 31° (88°F).

	Body temperature (°F) at successive daily periods				
Day time	8a.m.	9a.m.	10a.m.	12n.	4p.m.
Age (Days)	0	1	2	4	8
2	105.1±0.08	105.2±0.10	105.2±0.09	105.4±0.07	105.4±0.08
3	105.6±0.02	105.6±0.08	105.5±0.07	105.6±0.08	105.5±0.08
4	105.3±0.13	105.6±0.09	105.7±0.04	105.7±0.09	105.4±0.09
5	105.7±0.12	105.8±0.10	105.8±0.09	105.9±0.15	106.2±0.11
6	105.9±0.09	106.1±0.19	106.1±0.15	105.4±0.12	106.8±0.03
7	106.4±0.06	106.1±0.06	106.0±0.07	106.0±0.08	106.7±0.11
10	106.4±0.15	106.5±0.13	106.7±0.14	106.7±0.14	107.3±0.13
14	106.9±0.15	107.2±0.13	107.2±0.14	107.0±0.14	107.6 0.13
21	107.0±0.12	106.9±0.07	106.9±0.06	107. ±0.11	107.7±0.09
27	107.5±0.17	107.8±0.15	107.8±0.12	107. ±0.11	108.2±0.11

Diurnal fluctuations of body temperature in Rhode Island Red and White Leghorn chicks from 1 to 10 days of age were reported by Lamoreux and Hutt (1939). Obeidah *et al.* (1974) also indicated variation between morning and evening body temperature of one day, 2 and 3 months old Fayoumi chicks.

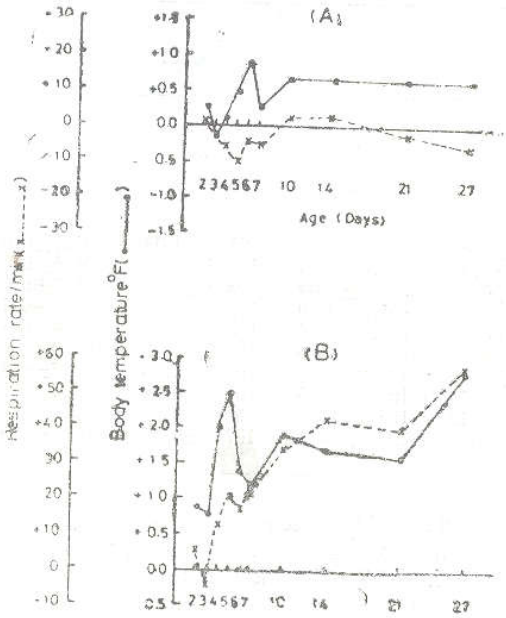
B. Respiration rate : There was a significant decrease (P 0 01) on the 21 *st* day and it was maintained at this level until the 27 *th* day after hatch (Table 2 and Fig. 1-A).

In general (except at the second, tenth and fourteenth day after hatch) evening respiration rate was lower than the morning (Table 2 and Fig. 2A). Maximum difference was observed at 5 days of age (- 10 breath/min).

From the results of this experiment, it is evident that body temperature of newly hatched Fayoumi chicks, brooded under normal brooding temperature of 31°, increases with advancement of age from 105.4 at 2 days to 108.2°F at 27 days after hatch. Respiration rate on the contrary, decreased from 85 to 77 breath/min. It is also clear that the amplitude of diurnal variation in both body temperature and respiration rate fluctuates during the first 7 days after hatch.

2. *Age difference in the response of newly hatched Fayoumi chicks to heat stress of* 42° (108°*F*)

A. Body temperature: Exposure of Fayoumi chicks of all examined ages to high ambient temperature of 42° (10° F) caused abrupt significant increase (0.01) in their body temperature after 1 hour exposure (Table 3, Fig. 1-B), followed by significant (P 0.01) gradual decrease in body temperature through the next 4 hr of exposure. The body temperature of 4, 7 and 14 days old chickens rose from 106.8°F, 106.7°F and 107.6°F after 4 hr to 107.2°, 107.5 and 108.6°F respectively after 8 hr. Body temperature of other examined ages slightly decreased or became nearly constant.



Age (Days)

Fig. 2. Over all variation in body temperature and respiration of Fayoumi chicks during the first 27 days after hatch A-under normal brooding temperatur of 31° (88°F). B-after exposure to heat stress of 42° (108°).

Response of the 27 *th* day old chicks to heat stress differed from that of the younger ages, a sharp increase in body temperature from 107.6° to 110.9°F (Table 3) was observed after 1 hr exposure followed by significant (P 0.01) decrease (110.43°F) after 2 hr exposure and remained nearly at this level (110.4°F) for the following 6 hr of exposure.

Overall changes in body temperature after 8 hr exposure to heat stress indicated that from the second to the fifth day of age, there was a gradual increase in the respones by increasing body temperature (Table 5 and Fig. 2-B). This was followed by reduction in the amplitude of overall changes in body temperature at the 6 *th* and 7*th* day of age then the reaction became greater at the 10 *th* day.

TABLE 2 Mean ± S.E. of respiration rate of chicks during the first 27 days after hatch at successive hours under normal brooding temperature of 31° (88°F.)

Day time	Respiration rate per minute at successive daily periods				
	8 a.m.	9 a.m.	10 a.m.	12 n.	4 p.m,
Age (Days)	0	1	2	4	8
2	83±1.88	87±1.72	88±1.70	86±1.07	85±1.74
3	92±2.50	93±2.74	94±2.37	94±2.29	89±2.33
4	85±2.79	86±2.38	86±2.54	84±2.19	80±1.97
5	91±2.59	88±1.92	88±1.82	85±2.52	81±2.39
6	91±3.20	92±3.96	88±3.43	90±3.51	87±3.21
7	89±2.10	85±2.70	87±2.55	88±2.59	86±3.20
10	86±2.57	87±3.32	89±3.67	89±3.70	89±4.02
14	91±3.62	94±3.98	97±4.43	97±4.69	94±4.58
21	81±2.33	78±2.03	82±2.32	79±2.61	79±2.13
27	82±2.76	79±2.88	76±1.48	77±1.69	77±1.66

TABLE 3. Age difference in the response of chicks to high ambient temperature of 42°. (108°F) body temperature (F°).

Age (Days)	Time of exposure in hourly periods				
	0	1	2	4	8
2	105.0±0.11	107.0±0.11	106.4±0.11	106.1±0.11	105.9±0.10
3	105.5±0.09	106.8±0.4	106.4±0.11	106.1±0.08	106.3±0.08
4	105.2±0.12	107.6±0.12	107.1±0.07	106.8±0.09	107.2±0.11
5	105.8±0.12	108.5±0.12	108.2±0.15	108.2±0.13	108.3±0 10
6	106.0±0.14	108.2±0.22	108.0±0.20	107.8±0.21	107.4±0.18
7	106.3±0.14	107.7±0.14	107.1±0.10	106.7±0.12	107.5±0.14
10	106.4±0.18	108.7±0.18	108.0±0.17	108.0±0.23	108.3±0.28
14	106.9±0.13	108.8±0.13	108.2±0.19	107.6±0.06	108.6±0.17
21	107.2±0.09	110.0±0.08	109.5±0.08	109.1±0.09	108.8±0.16
27	107.6±0.13	110.9±0.17	110.3±0.10	110.4±0.16	110.4±0.17

After the 10*th* day and up to the 21*st* day after hatch the value of the overall changes decreased then sharply increased from + 1.6 to × 2.8 (Table 3 and Fig. 2-B) at the 27*th* day of age.

B. Respiration rate: Fayoumi chickens of all tested ages, except those of 2 and 3 days old, sharply increased their respiration rate after one hour exposure to heat stress of 42° (108°F) ambient temperature (Table 4 and Fig. 1-B, 2-B). Maximum increase in respiration rate was observed after 4 hr exposure in the 2, 6, 21 and 27 days old chicks (Table 4), while chicks of 5,7,10 and 14 days old reached maximum level after 8 hr exposure (Table 4 and Fig. 1-B).

Respiration rate of the 3 days old Fayoumi chickens was not affected by exposure to heat stress of 42° ambient temperature.

Overall variation in respiration rate of chickens exposed to heat stress indicates an increase in its value with the advancement of age. A drop in the amplitude of respiration rate was observed in 6 days old chickens coinciding with a similar case in body temperature (Table 5). This indicates that physiological developmental changes in the homeothermal ability of the chicken occur at this age. After this age, the respiration rate showed successive great increase in response to heat stress with advancement of age.

Experiment b

Age difference in the response of Fayoumi chicks to gradual increase in ambient temperature

Experiments carried out on the effect of abrupt increase in air temperature from 31° (88°F) to 42° (108°F) showed that the 6 *th* and 9 *th* day of age were characterized by changes in the response to heat stress. At normal conditions environmental temperature during the day increases gradually. Thus this experiment was designed to study the effect of gradual increase in ambient temperature on the homeothermic development at 6 and 9 days of age.

A. Body temperature

When room temperature increased from 27° to 30° significant increase in body temperature of all ages was observed (P 0.01) for 2, 6 and 9 days old chicks. The response of all ages to this increase was nearly the same (+ 0.5) (Table 6). Two phases in the response of 2, 6 and 9 days old chickens to the rise in ambient temperature were indicated.

The First phase: When air temperature rose from 27° to 36°, it was characterized by nearly linear significant increase of 0.5° in body temperature for each increase of 3° in body temperature.

The second phase: showed a drop in the body temperature at 39° air temperature followed by another increase at 42° (Table 6 and Fig. 3).

B. Respiration rate

Gradual increase in air temperature from 27° to 42° had no significant effect on respiration rate of the 2 days old chickens. Air temperature less than 39° had no significant effect on respiration rate of 6 and 9 days old chickens (Table 7 and Fig.3). Significant increase (P 0.0.5) in respiration rate of these two ages were observed only when the room temperature rose to 42°.

TABIE 4 Age difference in the response of chicks to high ambient temperature of 42° (108°F) respiration rate/minute.

Age (Days)	Time of exposure in hourly periods				
	0	1	2	4	8
2	85±1.82	86±1.94	89±1.99	92±2.38	91±2.07
3	93±1.03	93±2.54	93±2.25	95±2.67	89±1.93
4	88±2.99	102±3.91	104±3.62	103±3.09	101±3.90
5	93±3.01	106±3.40	111±5 28	113±4.76	114±5.12
6	91±5.64	100±5.25	104±5 68	109±6.23	108±7.84
7	85±2.44	101±3.84	95±3.51	103±3.25	108±3.78
10	85±2.30	111±4.97	108±4.26	116±4.66	199±5.19
14	83±2.98	107±6.31	111±4.82	115±4.32	126±6.82
21	84±2.12	108±4.81	111±3.88	125±3.82	124±4.42
27	83±2.27	128±4.10	129±3.91	139±3.13	140±3.09

TABLE 5. Net effect of exposure to heat stress of 42° (108°F) on body temperature and respiration rate of chicks at different ages.

Age (days)	Changes in body temperature °F	Changes in respiration rate
2	+0.6	+4
3	+0.9	—1
4	+1.9	+18
5	+2.0	+31
6	+0.5	+21
7	+0.9	+28
10	+1.2	+31
14	+1.0	+40
21	+0.9	+42
27	+2.1	+62

As the body temperature decreased at 39° air temperature, the respiration rate of 6 and 9 days old chicks decreased.

TABLE 6. Age difference in the response of chicks to gradual increase in ambient temperature in hourly periods.

Air temperature	27° 81°F	30° 86°F	33° 91°F	36° 97°F	39° 102°F	42° 108°F
Periods	0	1st. hr	2nd .hr	3rd. hr	4th. hr	5th. hr
Age	Body temperature °F					
2	105.5±0.09	106.0±0.09	106.2±0.09	106.7±0.13	106.5±0.14	106.5±0.12
6	105.8±0.15	106.3±0.15	106.9±0.13	107.7±0.17	107.5±0.19	107.8±0.26
9	106.5±0.07	106.9±0.13	107.6±0.07	108.3±0.16	108.4±0.10	108.6±0.13

TLBLE 7. Age difference in the response of chicks to gradual increase in ambient air temperature in hourly periods.

Air temperature	27° 81°F	30° 86°F	33° 91°F	36° 97°F	39 ° 102°F	42° 108°F
Periods	0	1st. hr	2nd. hr	3rd. hr	4th. hr	5th. hr
Age (days)	Respiration rate/minute					
2	81±2.87	84±3.97	87±4.47	87±3.42	89±5.23	89±4.95
6	82±3.38	84±2.86	88±1.98	91±4.58	86±4.76	94±4.46
9	91±4.31	94±3.63	94±4.68	96±3.	93±3.79	103±3.65

TABLE 8. Age difference in the response of chicks to abrupt and gradual increase in ambient temperature.

Treatment	Abrupt increase from 30° to 42° 86° to 108°F		Gradual increase from 30° to 42° within 5 hr 86° to 108°F		
	Body temperature F°				
Age (Days)	Before exp. (at 30°)	After I hr. exp.in 42°	Difference	Before exp. (at 30°)	After exp. in 42°	Difference
2	105.0±0.11	107.0±0.11	+2.0	106.0±0.09	106.9 + 0.12	+0.9
6	106.0±0.14	108.2±0.22	+2.2	106.3±0.15	107.8±0.26	+1.5
9	106.4±0.18	108.7±0.17	+2.3	106.9±0.13	108.6±0.13	+1.7

TABLE 9. Age difference in the response of chicks to abrupt and gradual increase in ambient temperature.

Treatment	Abrupt increase from 30° to 42° 86° to 108°F			Gradual increase from 30° to 42° within 5 hr 86° to108°F		
	Respiration rate/minute					
Age (Days)	Before exp. (at 30°)	After 1 hr exp. in 42°	Difference	Before exp (at 30°)	After exp.in42°	Difference
2	85±1.82	86±1.94	±1	84±3.97	89±4.95	+5
6	91±5.64	100±5.25	±9	84±2.86	94±4.46	+10
9	85±2.30	111±4.97	±26	94±3.63	103±3.65	+9

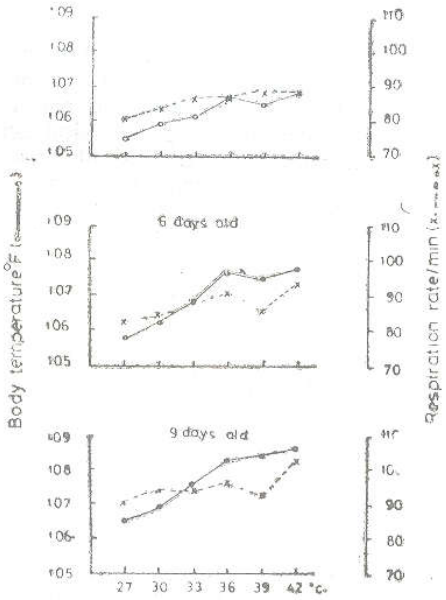


Fig. 3. Age difference in the response of Fayoumi chicks to gradual increase in ambient temperature in hourly periods.

Then it increased at 42° ambient temperature (Fig. 3) similar to the case with body temperature. (Tables 8 and 9) represent the effect of abrupt increase in air temperature from 30 to 42° and the effect of gradual increase from 30 to 42° within 5 hr on body temperature and respiration rate. The two days old chicks were less affected by the gradual increase in ambient temperature.

The response of 6 and 9 days old chickens to the gradaul increase in air temperature was almost the same for both body temperature and respirat ion rate at levels nearly double to that of the 2 days old ones. On the other hand, the increase in body temperature of the 2. 6 and 9 days old chickens was nearly the same when there was a sudden increase in air temperature, the response of respiration was totally different. No changes in respiration rate of the 2 days old chicken were observed. Slight not significant increase in respiration rate of the 6 days old chicks occurred. Highly significant in crease (P 0.01) in respiration rate of the 9 days old chicks after abrupt increase in air temperature (Table 9).

Conclusion

The present study proved that the body temperature of new hatched chicks increases with the advancing age and became steady only after 27 days old. Obvious changes in the rate of rise in body temperature existed at 4,7 and 14 days of age. Some authors believe that replacement of yolk by other active metabolic tissue, increase in heat production and gradual replacement of down feather by plumage feathers are responsible for such changes (Baldwin and Kendeigh, 1932 and Freeman, 1965 and 1970). It could be stated that changes which occur in the physiological activities of systems directly involved in heat production and heat loss rather than changes in insulation are the basis of the functional develoment of thermoregulation in birds. Modification of thyroid activity, of the function of the heat regulation centre in the hypothalamus and the gradual establishment of the functional interrelationship and the integration between this centre and the respiratory and panting centres are the main thermoregulatory mechanisms of maturation of homeothermy.

Respiration rate during the first month decreased but was still higher than that of three months of age in chickens brooded at 25° or 33°.

The main channel of heat dissipation in hyperthermic birds is evaporation through the respiratory system. Respiratory evaporative loss increases in a linear manner with the increase in respiratory frequency.

The efficiency of the panting centres defines the susceptibility of the bird total to elevation in air temperature. Even under moderate cold conditions of 20° (68°F) evaporation through respiratory tract presents about 50% oft he total body water loss. This amount is increased by elevation in ambient temperature to reach 72-75% of the total evaporative water loss when air temperature rose to 350°-40° (95°-104°F) (Richards, 1976). These findings indicate that thermal polypnea is the major thermoregulatory mechanism responsible for maintaining body temperature of hyperthermic birds constant.

The rate at which the fowl could increase its respiration during hyperthermia defines its resistance to heat stress. This is supported by the work of Weiss and Borbely (1957) who found that the summer group of chickens were more resistant to heat stress than the winter group because the former were able to increase their respiration frequency in a higher rate.

It is obvious from the present experiment that during hyperthermy only from the 5th day of age the rise in respiration rate was parallel to the increase in body temperature. In 14 and 21 days old chickens, the rate of increase in respiration rate exceeded that of the rise in body temperature. The 27 days old chick was able to prevent further increase in its body temperature by increasing respiration rate to 1.8 folds. However, elder ages were able to increase their respiration rate but this rise was not sufficient to prevent further increase in body temperature after 8 hr exposure to heat stress.

From the fore-mentioned discussion, it could be stated that functional developmental changes in the respiratory and in panting centres begin at 6 days of age and are fully developed at 3 months of age. These developmental changes could be an establishment of functional interrelationship between respiratory, panting and heat regulation centres in the hypothalamus.

The present results indicate that chickens of different ages can tolerate gradual increase in air temperature better than to abrupt changes. This is clear from the response of body temperature and respiration rate.

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النضج الحرارى فى كتاكيت الفيوم

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اظهرت النتـائج أن الحضـانة العادية أدت الى ارتفاع حرارة جسـم كتاكيت الفيومى من ٣ر١٠٥° ف عند عمر يومين الى ٨ر١٠٧° ف عنـد عمر ٢٧ يوم بعد الفقس • أثناء هذه الفترة سرعة التنفس أنخفضت من ٨٦ الى ٧٨ مرة/ دقيقة التغير المفاجىء أو التدريجى للحرارة من ٣١°م الى ٤٢°م أدت الى رفعه درجة حرارة الجسم وعدد مرات التنفس فى الدقيقة • كذلك وجد تغيرات يومية لدرجات الحرارة وعدد مرات التنفس •