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The Ear Lobes of Rabbits as a Site of Body Temperature Regulation

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THE ROLE of the ear lobes on body temperature regulation was demonstrated by covering the ear lobes by either polyethylene plastic, bags, felt pad, vaseline or also by cutting the ear lobes totally. Body temperature increased till the end of the experiment due to ear lobe cut, also skin and hair temperatures increased by the same treatment. Polyethylene plastic, felt pad and vaseline coating also caused an increase in the same previous physiological body reactions followed by the control group respectively. Also respiration and pulse rate increased significantly according to previous treatments. This showed that the ear lobes play an important role in body temperature regulation in the rabbits.

The size of the whole animal and its appendages are physical factors which affect heat dissipation from its body. The rabbits reared at 28.3° C. have larger ears to provide them with a wide surface practically hairless, for non-evaporative cooling as well as evaporative cooling. Rabbits in warmer zones have larger ears than in the arctic (Johnson *et al.*, 1957). These findings agree with Allen's rule (1977). This rule relates the size of appendages to the climate (Brody, 1945). Harrison *et al.* (1959) and Chevillard *et al.* (1962) agreed upon this phenomenon.

As evaporative cooling is the principal channel of heat loss at high enviromental temperatures, pulse rate may also, indirectly, reflect a homothermic attempt to dissipate the body heat by increasing more blood in the periphery (Johnson *et al.*, 1957; Davson, 1960; Konradi, 1960 and Schmidt-Nielson, 1964). Horoux and Plerre (1957) stated that short exposure to cold (6°C. for two hr) had no effect on the vascularization of any organ of the 30°C. acclimated white rats. Meanwhile, the cold acclimated animals (6°C) produced 12 folds increase in number of opened capillaries indicating a higher metabolism. Gilson (1950) reported that acclimatization of albino rats to cold air (4°-6°C) produced some circulatory and endocrine variations. Protracted exposure resulted in systolic hypertension and peripheral vascular derengments. Jacobson (1958) stated that peripheral vasoconstriction indicated by conductance measurements was induced by constant low body temperature and the degree being a function of the level of temperature. Johansen (1962) found that subjecting muskrats to a positive heat blood by general body heating or following exercise, raised the tail skin temperature to 35°-37°C. Tail blood flow increased concomitantly by a factor more than 400 times. The vasodialation and subsequent increase in tail blood flow prevented heat accumulated and incerased rectal temperature. The blocking of the tail nerve at maximum blood flow led to a prompt decrease in tail temperature and a rapid increased in rectal temperature. The authors also concluded that the muskrat tail is an indispensible heat exchanger, and that the consicous changes in the tail blood flow are mediated through a sympathetic vasodialator mechanism. Rats acclimated indoor to 18°C. and5°C for 3 months show the same increase in the number of opened capillaries of the ears to that acclimated to 30 °C. and to controls acclimated to summer and winter outdoor rats (Horous, 1959). Grant (1950) showed that rabbits restrained in normal postureby enclosure in a loosely fitting wire mesh cage showed hypothelmic features. The effect was due to pardoxical activation of heat loss mechanisms which was polypnea and ear vasodialation. Meanwhile, Grant (1963) observed that the vessels of the rat's ear lobe did not dilate in response to body warming or to sympathetic nerve actino. Honda *et al.* (1963), suggested an equation for the relation between skin temperature and blood flow in the rabbit ear as foollows :

$$F_s = K_1 - K_2 e - aF \qquad \text{or} \qquad T_s = \frac{F T_R + K_3 T_r}{K_2 + F}$$

where T_s is skin temperature ;

f is peripheral blood flow ;

T_R is rectal temperature ;

T_r is room temperature, and

K_1, K_2, K_3 and a are constants.

The constants vary with ambient temperature.

Material and Methods

This work has been carired out in the Poultry Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt, at August. Egyptian native White "Giza" rabbits weight 3 to 4 kg on the average for males and females respectively were used. Animals were housed individually in a brick battery concrete building and were fed on concentrate ration composed of wheat bran and barley. Egyptian clover during winter, and shopped green maize leaves during summer were supplied.

Body temperature was measured by inserting the clinical thermometer rectally for one minute. Skin, hair and ear lobe temperatures were measured by a thermocouple of pointed probe while respiration and pulse rates were estimated by a manual counter.

Five groups of male adult white "Giza" rabbits were used for this experiment during August (1963.) The ear lobes of the first three groups were covered tightly with polyethylene plastic bagun felt pad and vaseline respectively. The fourth group ear lobes were cut without anaesthesia avoiding severe bleeding by sealing the main ear lobe blood vessels and using collodion solution. The animals of the fifth groups were kept normal as control group. Air temperatue, body temperatue, skin and hair temperatures of the back, respiration rate and pulse rate were taken, once before experiment and directly after treatment every ten minutes, from 7 a.m. till 5 p.m. for every individual.

Results and Discussion

Many authors (Brody, 1945; Dulkes, 1955; Johnson *et al.*, 1957-1958; Davson, 1960 and Konradi,1960) have emphasized the role of the rabbit's ear lobes in the regulation of body temperature. Studies have revealed the special arrangement and structure of the vascular bed and the vasomotion control of blood supply to the ear lobe.

The present experiment was carried out to demonstrate the part played by the ear lobe in heat dissipation and the different channels of heat loss. Several techniques were experimented to hinder the ear lobe action (vaseline, polyethylene plastic and felt pad of the ear pinnae), or to abolish it totally (ear lobe cutting). The reactions of the animals under these different conditions were recorded at successive hour intervals of ten hr. Body temperature did not vary form normal (control) by coveing ear lobe with vaseline (Table 1). Cutting ear lobe induced the greater increase in body temperature followed by felt coating at the first two hr of the experiment and polyethylene plastic coating in the last hr of experiment (Table 1). These results indicate obviously the assessment of both channels of heat dissipation by ear lobe, that is water evaporaion and both radiation and convection. Cutting ear lobe whicsh abolishes these two channels increased body temperature by 0.7°-0.9°C. Felt coating seems to affect radiation and convection more than evaporation which can be observed from Table (1) as the great increase in body temperature at the beginning of the experiment was 0.3°. while it was only 0.1°. at the end of experiment. On the contrary, polyethylene plastic coating seems to affect greatly water evaporation which is the major channel of heat dissipation at the end of the experiment. Accordingly, the increase in body temperature was 0.2°C. at the first period, while it was 0.5°C. at the terminal period (Fig. 1).

Skin and hair temperatures increased slightly in control group by time sequence and air temperature increase along the day. Also, rapid and higher increase occurred in all treated groups (Table 1). The rate of this increase was the lowest in vaseline group followed by flet, polyethylene plastic and ear lobe-ectomized groups respectively.

Respiration rate increased greatly in all treated groups by the same rate after one hr treatment and the rise continued until ten hr in the same trend, except for the vaseline group which decreased slightly (Table 1). This increase in respiration rate is the major physiological reaction for controlling body temperatur to be constant (Brody, 1945 ; Johnson *et al.*, 1957-1958 and Davson, 1960). The increase in skin and hair temperatures and respiration rate of the treated groups in comparison to that of the control group was greater at the start of the experiment in the morning than at the end of the experiment at the evening. This means that the treatments of the ear lobe were more effective at low air temperature (26°C) than at high temperature

TABLE 1. **Effect of ear lobe temperature on body reaction of rabbits during the different hours of the day**

Items	Treatment results	Control	Vaseline	Pad	Polyethylene plastic	Ear lobe cut
Body temp.	Change after 1 hr treatment	0.0	0.0	0.3	0.2	0.7
	Change after 10 hr treatment	0.0	0.0	0.1	0.5	0.9
Skin temp.	Change after 1 hr treatment	0.1	0.5	0.7	0.7	0.9
	Change after 10 hr treatment	0.3	0.3	0.7	0.9	1.0
	Change in treated/control 1 hr	—	5.0	7.0	7.0	9.0
	Change in treated/control 10 hr	—	1.0	2.3	3.0	3.3
Hair temp.	Change after 1 hr treatment	0.5	0.9	1.6	1.7	1.9
	Change after 10 hr treatment	1.8	3.2	2.7	3.7	4.0
	Change in treaqted/control 1 hr	—	1.8	3.2	3.5	3.8
	Change in treated/control 10 hr	—	1.8	1.5	2.1	2.2
Respiration rate	Change after 1 hr treatment	8.0	98.0	79.0	100.0	95.0
	Change after 10 hr treatment	17.0	83.0	95.0	97.0	92.0
	Change in treated/control 1 hr[1]	—	12.3	12.1	12.5	12.0
	Change in treated/control 10 hr	—	4.9	5.6	5.7	5.4
Pulse rate	Change after 1 hr treatment	2.0	48.0	60.0	52.0	27.0
	Change after 10 hr treament	2.0	53.0	65.0	61.0	31.0
	Change in Treated/control 1 hr	—	24.0	30.0	26.0	13.5
	Change in treated/control-10 hr	—	26.5	32.5	30.5	15.5

(ε4₀ C) and this result may indicate that the ear lobes are the primary site ofrheat regulation in rabbits. They shear the major part in body temperature egulation at the fairly low temperature and so saving a good part of the activity of the other participants, skin, hair and respiratory system. However, at high temperature all systems are at full work in heat regulation especially that concerned with water evaporation from the respiratory system. The percentage of heat loss due to ear lobe participation at different environmnental temperatures, and the critical high temperature at which ear lobes come to the lowest effect need further study (Table 2, 3, 4, 5 and 6).

Pulse rate also increased in all treated groups and the rate of increase was greater after ten hr than after one hr (Table 1). The increase in pulse rate of ear lobe-ectomized rabbits was about half of the other treated groups due to the lack of great peripheral vasodialatation in the ear lobe-ectomized rabbits.

In conclusion it could be stated due to this experiment that the ear lobes are not so important in body temperature regulation the ear lobes are not so important in body temperature regulation at high environmental air temperature. This is against the general idea of the high importance of ear lobe in heat regulation.

By F test, all physiological body reactions showed highly significant differences according to ear lobe treatment and time sequence except body temperature differences which were significant at 5% level of probability for ear lobe and not significant for time sequence(Table 2).

TABLE 2.**Mean values of body temp. of the different treatments of ear lobe.**

Treat. / Time hr	Control	Vasline	Felt pad	Polyethylene plastic	Ear lobe cut
Before exp.	39.7	39.8	39.8	39.7	39.7
1	39.7	39.8	40.1	39.9	40.4
2	39.6	39.7	40.1	39.9	40.1
3	39.7	39.6	39.9	40.1	40.1
4	39.7	39.6	39.8	40.2	40.3
5	39.8	39.7	39.9	40.2	40.5
6	39.7	39.6	39.8	40.2	40.5
7	39.8	39.7	39.9	40.1	40.5
8	39.7	39.8	39.9	40.1	40.6
9	39.7	39.8	39.9	40.1	40.6
10	39.7	39.8	39.9	40.2	40.6

TABLE 3. Mean valus of body temps of skin of back

Treat. / Time hr	Control	Vasline	Felt pad	Polyethelene Plastic	Ear lobe cu-
before exp.	39.0	39.0	39.0	38.9	38.9
1	39.1	39.5	39.7	39.6	39.8
2	39.2	39.3	39.8	39.6	39.7
3	39.1	39.2	39.8	39.6	39.7
4	39.2	39.1	39.6	39.7	39.7
5	39.3	39.3	39.5	39.7	39.8
6	39.3	39.2	39.4	39.6	40.0
7	39.3	39.2	39.6	39.7	40.0
8	39.4	39.2	39.5	39.8	40.0
9	39.4	39.3	39.8	39.8	40.0
10	39.3	39.3	39.7	39.8	39.9

TABLE 4. Mean values of body temp. of hair temperature

Before	33.8	32.8	32.7	32.5	32.5
1	34.3	33.7	34.3	34.2	34.4
2	35.5	34.2	34.7	34.0	34.4
3	35.3	34.2	35.1	34.8	34.7
4	35.6	34.2	35.1	35.1	35.2
5	35.2	35.0	35.0	35.3	35.0
6	35.3	35.2	35.3	35.6	35.9
7	35.8	35.4	35.2	35.5	36.2
8	35.9	36.0	35.5	36.1	36.3
6	35.6	36.1	35.5	36.0	36.6
10	35.6	36.0	35.4	36.2	36.5

TABLE 5. Means values of body temp. of respiration rate

Treat. / Time hr	Control	Vasline	Felt pad	Polyethyleene plastic	Ear lobe cut
Before.	227	224	224	221	219
1	235	322	321	300	314
2	235	320	326	310	285
3	236	295	319	319	283
4	233	286	304	321	290
5	232	286	308	312	306
6	232	286	313	312	295
7	245	298	303	316	292
8	247	304	306	324	288
9	235	300	296	313	297
10	244	307	319	318	311

TABLE .6 Mean values of body temp. of pulse rate

Before	245	264	248	252	268
1	247	312	308	304	295
2	246	311	313	300	284
3	245	295	311	320	289
4	238	284	302	319	297
5	245	291	300	302	296
6	249	287	300	309	294
7	253	286	285	317	292
8	257	304	285	315	294
9	247	315	296	311	302
10	247	317	313	313	299

TABLE 7. **Analysis of variance for white male "Giza" rabbits as influenced by ear lobe treatment, time sequence and air temperature classes.**

Items	Source of variation	D.F.	Sum of squares	Mean squares	F value
Body temp.	Ear lobe treat.	4	147.46	36.87	2.25*
	Time Sequence	9	7.27	0.81	0.05
	Air temp. classes	10	54.89	5.49	0.34
	Error	1236	20045.16	16.22	—
Skin temp.	Ear lobe treat	4	87.23	21.81	16.17**
	Time sequence	9	36.73	4.08	3.03**
	Air temp. classes	10	13.79	1.38	1.02
	Error	1236	1670.33	1.35	—
Hair temp.	Ear lobe treat.	4	96.06	24.02	56.24**
	Time sequence	9	109.04	12.12	28.33**
	Air temp. classes	10	530.94	53.09	124.39
	Error	1236	527.49	0.43	—
Resp. rate	Ear lobe treat.	4	909279.67	224819.92	403.42**
	Time sequence	9	30781.00	3420.11	6.12**
	Air temp. classes	10	366050.49	36605.05	65.69**
	Error	1236	688800.59	557.28	—
Pulse rate	Ear lobe treat.	4	719683.82	179920.96	501.40**
	Time sequence	9	11771.45	1307.45	303.65**
	Air temp. classes	10	212894.13	21289.41	59.33**
	Error	1236	440522.85	358.84	—

** Significant at 1% level of probability.

* Significant at 5% level of probability.

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صيوان الأذن فى الأرانب كمنظم لدرجة حرارة جسمها

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اجريت تجارب على صيوان أذن الارانب سواء بقطعها أو تغطيتها بالبولى أيثيلين او الفازلين ووجد أنها اذا عرضت للحرارة بعد هذه المعادلات زادت درجة حرارة جسمها نظرا لتوقف عمل صيوان الاذن عن أداء دوره فى خفض درجة حرارة الجسم .