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THE EFFECT OF INFRA-RED RADIATION ON RECTAL, SKIN AND HAIR-TIP TEMPERATURES OF RABBITS.

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SUMMARY : An experiment was conducted on the effect of infra-red (i.r.) radiation on female NZW rabbits. A 4x3x6 factorial design was employed in which the factors were : 4 intensities of i.r. radiant heating of 0.0, 1.9, 2.1, 2.4 MJ/m²/h ; 3 replicates and 6 rabbits. All animals were watered and fed a standard ration *ad libitum*. Rectal temperatures differed (P<0.001) between treatments and were highest at the "high" level of i.r. radiation (1°C higher than for controls). At the "medium" and "low" levels of i.r. heating RT's were respectively 0.3° and 0.2°C higher than in controls. In different i.r. treatments skin temperature (ST) was significantly different (P<0.001), being highest at the "high" i.r. level, with values of 42.8 ± 0.5°C. Under the "low" and "medium" levels, corresponding ST values were 37.8 ± 2.1 and 39.5 ± 3.0°C, respectively. Skin temperature differed with time of exposure (P<0.001), increased most rapidly (by 5.9°C) in the first 20 minutes, but only by a further 0.8°C in the subsequent 40 minutes. Between different level or i.r., hair-tip temperature (HTT) was significantly different (P<0.001), values being highest under the "high" i.r. treatment. Compared to controls, exposure to the "low", "medium" and "high" i.r. levels increased HTT by factors of 1.1, 1.3 and 1.6 respectively. Between different times of exposure, HTT also differed significantly (P<0.001) with most of this effect being in the first 20 minutes (a 1.6 fold increase). During the second 20-minutes interval a further significant increase was recorded, but of only 0.6°C. From the above results it can be concluded that the higher the level of i.r. heating, the more stressed the animals was.

RESUME : Effet de la radiation infrarouge sur la température rectale, de la peau et de la fourrure du lapin
L'effet de la radiation infrarouge a été étudié sur des lapines NZW. Un plan factoriel 4x3x6 a été employé dont les facteurs étaient: 4 intensités de radiation infrarouge (0,0 , 1,9 , 2,1 et 2,4 MJ/m²/h), 3 répétitions et 6 lapines. Tous les animaux étaient nourris (avec une ration standard) et abreuvés ad libitum. *Les températures rectales ont varié selon les traitements et étaient les plus élevées au niveau "haut" de radiation infrarouge (+ 1°C par rapport au lot témoin). Au niveau "moyen" et "bas" de radiation infrarouge les températures rectales étaient supérieures de 0.3°C et 0.2°C respectivement à celle du lot témoin. La température de la peau était significativement différente suivant les traitements (P<0.001), atteignant un valeur moyenne de 42.8 ± 0.5°C au niveau "haut" de radiation infrarouge. Aux niveaux "moyen" et "bas" la température de la peau était de 39.5 ± 3.0°C et de 37.8 ± 2.1°C respectivement. La température de la peau varie avec le temps d'exposition (P<0.001) augmentant très rapidement (+ 5.9°C) dans les 20 premières minutes, puis seulement de 0.8°C au cours des 40 minutes suivantes. La température de surface de la fourrure variait significativement suivant les traitements, la plus élevée étant enregistrée dans le traitement "haut" niveau de radiation infrarouge. En comparaison au lot témoin la température de la fourrure des lapines des lots "haut", "moyen" et "bas" était multipliée par 1,1 , 1,3 et 1,6 respectivement. La température de la fourrure variait aussi significativement (P<0.001) avec les différents temps d'exposition aux radiations infrarouges, avec le maximum d'effet durant les 20 premières minutes (+ 1,6°C). Durant les 20 minutes suivantes, on enregistre un augmentation, mais seulement de 0.6°C. Ces résultats permettent de conclure que plus l'exposition au radiations infrarouges est importante plus le stress des lapins est important.*

INTRODUCTION

As rabbits are normally kept outdoors or in semi-permanent sheds in tropical countries (CHEEKE *et al.*, 1987) they may be exposed to severe weather conditions, including the possibly stressful effects of solar radiation. Up to the present, a few thermogenic effects of solar radiation have been studied in rabbits (FINZI *et al.*, 1992), for example, on ear colour in relation to body and ear temperature, body posture and behaviour in different housing conditions, and heat tolerance of different breeds under condition of heat stress. No experiments have been carried out yet on skin temperature (ST) and hair–tip temperature (HTT) in rabbits. However, there have been a number of studies of both sheep and cattle, economically important species in hot, arid regions of such countries as Africa and Australia. In sheep the effect of i.r. radiation (a major component of solar radiation and on which can be simulated readily in the laboratory) on wool–tip and skin temperature has been studied by PARER (1963), who used a low temperature i.r. projector and concluded that highly significant quadratic relationship existed between wool–tip temperature and wool length. Previously, MACFARLANE *et al.* (1958) reported that the tip wool of sheep standing in the summer sun (mean environmental temperature of about 46°C) rose to 87°C by absorption of radiant energy, most of which was re-radiated.

Therefore, the current work was designed as a preliminary examination of the effects in NZW rabbits of various levels of i.r. radiation on rectal temperature (RT), ST and HTT as heat tolerant parameters.

MATERIALS AND METHODS

Six female rabbits were used, ranging in age from 8.5 to 10 months (9.5 ± 0.5 months) and in weight from 2858 to 3349 g (3162 ± 153.3 g). All rabbits were individually housed (75 cm x 42 cm x 38 cm wire cages) in an adjacent ante–room fitted with a wall mounted air conditioner (Kelvinator, model RF 500 G) which controlled temperature to within ± 1°C. Temperature in the ante–room was adjusted to a mean 23.8°C ; relative humidity to 60 ± 2 % and air movement to 0.20m/sec. A 4x3x6 factorial design was employed in which the factors were : 4 intensities or i.r. radiant heating, 3 replicates and 6 rabbits. Infra–red heat was applied to the experimental rabbits by tubular element projectors suspended vertically above their cages. The intensity of i.r. radiation was measured at rabbit height by means of a black globe thermometer and radiometer. The height of the projectors was adjusted to provide the 4 experimental regimes :

	Globe thermometer temp. °C	Mean air temp. of the hot room °C	i.r. intensity ($MJ/m^2/h$)
"control"	26.8	30.0	0.0
"low"	31.7	34.4	1.9
"medium"	35.0	42.5	2.1
"high"	40.0	54.4	2.4

Each replicate consisted of a maximum of 60 minutes exposure to each of the 4 i.r. intensities and the 6 rabbits were measured concurrently. Two days rest at 23.8°C in ante–room was allowed between successive i.r. exposures to minimize possible acclimation. Treatments were randomly allocated to the four test days in each replicate and the hot–room maintained at 30 ± 1°C and 45 ± 1 % RH.

Rectal temperature was routinely measured using a thermister thermometer with digital read–out "Digi–Thermo" by inserting the 4 mm diameter thermister probe to a depth of 6 cm for 1 minute. Skin and hair–tip temperatures were measured using a non–invasive infra–red gun thermometer. The gun thermometer (EVEREST 310) was held at a distance of 20 cm from the hair or skin using the built–in focussing system. Five measurements were made on adjacent areas (within 10 mm) and the average recorded. All animals were watered and fed a standard ration *ad libitum* from Fielders Feedmill, Tamworth.

The percentage of medullated fibres (uni-serial, multi–serial, fragmental and non medullated ; WILDMAN, 1954) was calculated from observations on 100 fibres from each animal, by shearing the animal in 1 cm^2 wide patches at 4 different positions (Fig 1).

Hair–coat depth was measured at 4 points along the mid–dorsal line as indicated in Fig. 1 using a VERNIER micrometer.

Figure 1 : Four different locations for measuring skin and hair-tip temperature, depth of hair coat, and medullation percentage of rabbit hair.

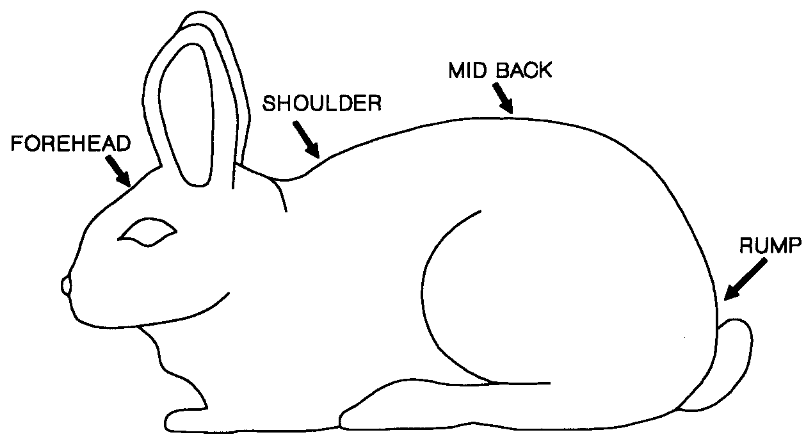


Table 1 : Mean rectal temperature of unacclimated rabbits exposed to different levels of i.r. radiation

Rabbit N°	1	2	3	4	5	6	SEM	Level of significance
RT°C	39.7[a]	40.1[b]	40.4[c]	39.9[d]	40.0[d]	39.7[a]	0.02	***
i.r. (J/m²/h)	0	1.9	2.1	2.4				
RT°C	39.6[a]	39.8[b]	39.9[c]	40.6[d]			0.02	***
Time (min)	0	20	40	60				
RT°C	39.4[a]	39.8[b]	40.2[c]	40.5[d]			0.02	***

Values within the same line with dissimilar superscripts differ significantly (*** P<0.001).

RESULTS AND DISCUSSION

Rectal temperature

Data on RT ar presented in Table 1 and Fig. 2 ; values differed (P<0.001) between treatments and were highest at the "high" level of i.r. radiation (1°C higher than for controls). At the "medium" and "low" levels or i.r. heating RT's were respectively 0.3° and 0.2°C higher than in controls ; figures which were statistically significant but low in magnitude and not indicative of high level of thermal stress. At different times of exposure, RT was also found to be significantly different (P<0.001). It increases gradually to reach a mean of 40.5 ± 0.7°C. In Fig. 2 it can be seen that RT was highest, compared to controls, in the "high" radiation group and that responses at the "low" and "medium" settings were intermediate. Differences between the latter 2 groups were, however, quite small in magnitude, and the actual levels reached (less than 40°C) do not indicate severe stress. A clear-cut indication of an increase in RT was achieved at 20 minutes of exposure, but actual differences are small. Very consistent results in the different animals (SEM = 0.02°C) yielded statistically significant results at levels of RT that are of doubtful biological significance. Viewed overall, and against a background of consistent increases in RT with time and level of i.r. radiation, it can be concluded that the higher the level of radiant heating, the more stressful it was for the rabbits. Between rabbits 1 and 6 were the most tolerant (lowest RT 39.7°C) and rabbit 3 was the least tolerant (mean RT 40.4°C) of i.r. heating. The current results are in close agreement with those of TRAMMELL *et al.* (1989), who found a rise of RT from 38.1°C to 38.6°C when ET rose from 16.8 to 32.2°C in rabbit does. Similar patterns were also found by CHIERICATO *et al.* (1992) in growing rabbits.

Figure 2 : Changes in rectal temperature (°C) in unacclimated female NZW rabbits exposed to various levels of i.r. radiation (0; 1.9; 2.1 and 2.4 Mj/m²/h) ; each point is the mean of 3 replicates, each with 6 rabbits.

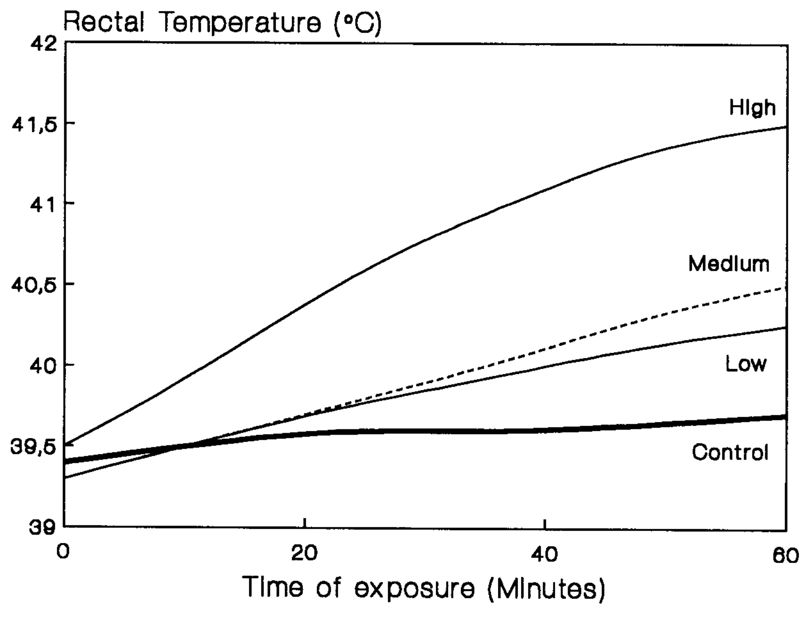


Table 2 : Mean skin temperature of unacclimated rabbits exposed to different levels of i.r. radiation

Rabbit N°	1	2	3	4	5	6	SEM	Level of significance
ST°C	39.0[a]	39.1[a]	39.4[b]	39.1[a]	39.1[a]	38.8[a]	0.05	***
i.r.(J/m²/h)	0	1.9	2.1	2.4				
ST°C	36.2[a]	37.8[b]	39.5[c]	42.8[d]			0.05	***
Time (min.)	0	20	40	60				
ST°C	34.3[a]	40.2[b]	40.8[c]	41.0[d]			0.03	***

Values within the same line with dissimilar superscripts differ significantly (*** P<0.001).

Skin temperature

Data on ST are presented in Table 2 and Fig.3. Between different i.r. treatments ST was significantly different (P<0.001), being highest at the "high" level, with values of 42.8 ± 5.0°C. Under the "low" and "medium" levels, corresponding ST values were 37.8 ± 2.1 and skin temperature differed with time of exposure (P<0.001). It increased most rapidly (by 5.9°C) in the first 20 minutes, but only by a further 0.8°C in the subsequent 40 minutes (Table 2). Differences between individual rabbits were also significant but reference to Table 2 indicates that this effect was limited to Rabbit 3, whose ST (39.4°C) exceeded that of the others by only 0.3–0.6°C. From the above results it can be concluded that the higher the level of i.r. heating the more stressed the animal was (as evidenced by the increases in ST). The findings were in general agreement with FINZI *et al.* (1992) who found that skin temperature of the ear increased from 35.60 ± 0.65 to 37.2 ± 0.60°C when the rabbits were reared underground and in cage respectively, under field conditions of 35.5°C ambient temperature at 14.00 pm. A similar pattern occurs in sheep. BROWN (1971), for example, found that ST increased from between 36.5 to 37.5°C at about 7.30 am to a maximum of approximately 44°C by about 10 a.m.

Figure 3 : Changes in skin temperature (°C) in unacclimated female NZW rabbits exposed to various levels of i.r. radiation (0; 1.9; 2.1 and 2.4 Mj/m²/h) ; each point is the mean of 3 replicates, each with 6 rabbits.

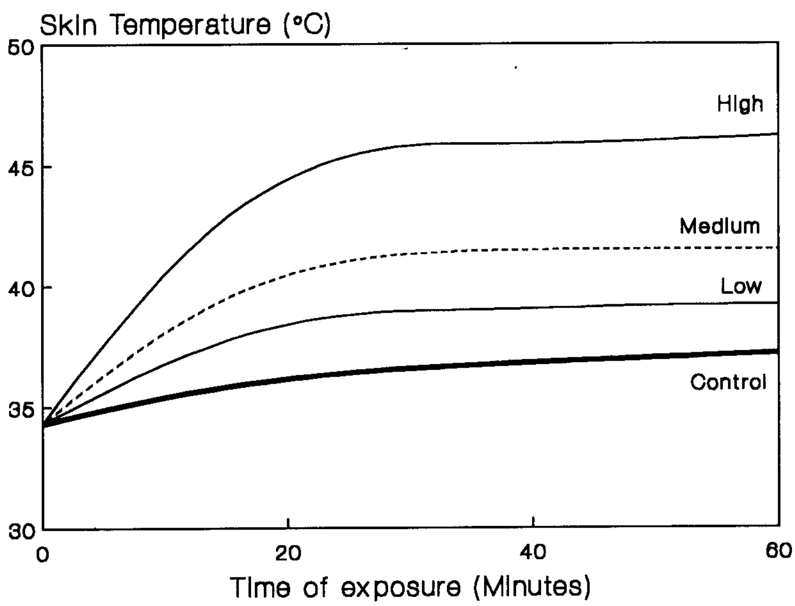


Table 3 : Mean Hair-Tip temperature of unacclimated rabbits exposed to different levels of i.r. radiation

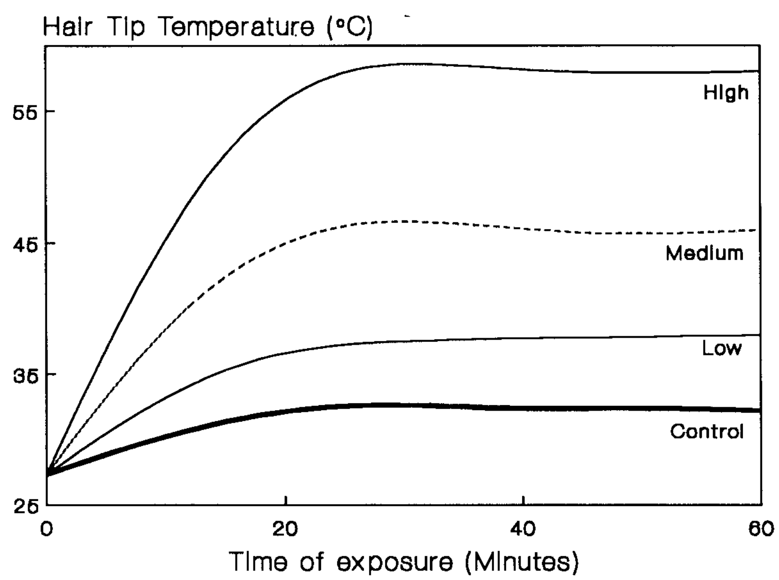
Rabbit N°	1	2	3	4	5	6	SEM	Level of significance
HTT°C	39.3ab	39.5a	39.7a	39.4ab	39.6a	38.8b	0.08	***
i.r.(J/m²/h)	0	1.9	2.1	2.4				
HTT°C	31.2a	35.1b	41.1c	50.1d			0.08	***
Time (min.)	0	20	40	60				
HTT°C	27.3a	43.0b	43.6c	43.6c			0.04	***

Values within the same line with dissimilar superscripts differ significantly (*** P< 0.001)

Hair - Tip temperature

Between different levels of i.r. HTT was significantly different (P<0.001 ; Table 3 and Fig. 4), values being highest under the "high" i.r. treatment. Compared to controls, exposure to the "low", "medium" and "high" i.r. levels increased HTT by factors of 1.1, 1.3, and 1.6 respectively (Table 3). Between different times of exposure, HTT also differed significantly (P<0.001), with most of this effect being in the first 20 minutes (a 1.6 fold increase). During the second 20–minutes interval a further significant increase was recorded, but of only 0.6°C. Figure 4 indicates that the same pattern occurred in al 3 i.r. groups, a rapid rise in the first 20 minutes, followed by a plateau level. Different rabbits also reacted differently (P<0.001) with respect to HTT although the magnitude of the differences was small (range 38.8 to 39.7°C ; Table 3). Rabbit 3 was again the most severely affected, but only marginally so. Rabbit 6 again was the most tolerant (i.e. lowest value) individual. Unfortunately, there appear to be not relevant experiments done on rabbits, so comparison has been made with other animals. On theorical grounds, differences in coat colour, depth, fibre diameter and medullation could amount for the observed differences in HTT. DOWLING's work in cattle indicates that the higher the % medullation, the greater the proportion of radiant heat reflected from coat. Density and length seem to vary in their importance in relation to heat tolerance. Thus while *Bos indicus* cattle are more heat tolerant and have a denser hair–fibre population than British breeds (DOWLING, 1955 ; WALKER, 1957a, 1957b) in the present data on rabbits the correlation with heat tolerance is negative, higher density being associated with higher ST and HTT. These data thus support WALKER's (1957b) conclusion that density is not the only factor associated with heat tolerance. Medullation and hair thickness may alter the ability of the hair coat to dissipate heat ; hair thickness (2.9 ± 0.3 vs 2.4 ± 0.5 mm) and % medullation (99.8 ± 0.5 vs 97.5 ± 1.9 %) were higher in the tolerant than in the intolerant rabbit, but for both parameters the differences were small.

Figure 4 : Changes in hair-tip temperature (°C) in unacclimated female NZW rabbits exposed to various levels of i.r. radiation (0; 1.9; 2.1 and 2.4 Mj/m²/h) ; each point is the mean of 3 replicates, each with 6 rabbits



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