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EFFECT OF HAIR SHEARING ON LIVE PERFORMANCE AND CARCASS TRAITS OF GROWING RABBITS UNDER HOT AMBIENT TEMPERATURE

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Abstract: The aim of the study was to examine the effect of hair shearing in growing rabbits reared at high ambient temperature. The live performance and carcass traits of growing rabbits reared at 20°C (not sheared, C, n=50) or at 28°C (not sheared, H, n=50, or sheared at 5, 7 and 9 wk, HS, n=50) were compared. The ambient temperature and relative humidity were 20.5±1.1°C and 54±11% in the 20°C room and 28.8±0.2°C and 35±8% in 28°C room, respectively. Feed intake of H and HS groups decreased by 29.0 and 20.4%, respectively, compared to C rabbits (*P*<0.001). The same data for weight gain were 24.6 and 16.9% (*P*<0.001), and for body weight at 12 wk were 16.8 and 11.5% (*P*<0.001). At the same time, the feed conversion ratio improved (C: 3.53, HS: 3.34, H: 3.31; *P*<0.001). Nevertheless, the mortality rate of rabbits was not affected by the studied treatment and was overall low (0-4%). No differences were observed in dressing out percentages either (ratio of chilled carcass (CC) to the slaughter weight: 61.6-61.9%). The ratio of liver to CC differed among the experimental groups, with the highest value recorded in C group and the lowest in H group; HS rabbits showed intermediate results (C: 4.86%, HS: 4.27%, H: 3.91%; *P*<0.001). Lower ratios of fat deposits to reference carcass were also observed in rabbits kept at high ambient temperature (perirenal fat: C: 2.59%, HS: 1.82%, H: 1.60%; *P*<0.001; scapular fat: C: 0.89%, HS: 0.66%, H: 0.51%; *P*<0.001). It can be concluded that the negative effect of higher ambient temperature (28 *vs*. 20°C) on production in growing rabbits can be reduced significantly by hair shearing.

Key Words: growing rabbits, climate, hair shearing, production, slaughter traits.

INTRODUCTION

Rabbits are particularly sensitive to high temperature because their bodies are covered with fur and they have few functional sweat glands, which limits their ability to eliminate excess body heat (Maya-Soriano *et al.*, 2015). As demonstrated by different papers (Fernández-Carmona *et al.*, 1995; Marai *et al.*, 2002; Szendrő *et al.*, 2018), high temperature has detrimental effects on the growth and reproductive performance of rabbits. This represents a regular problem in rabbit breeding in hot climate areas and in Mediterranean countries. Due to global warming, the average temperature of the Earth is rising and, at the same time, the frequency and duration of extreme weather conditions are also increasing (NASA Goddard Institute for Space Studies). As a consequence, the periods with high temperature have become a problem not only in hot climate areas but also in the temperate zone.

As perspiration is an ineffective way to control body heat due to the rabbit's fur, reducing hair length can be an effective method to mitigate the negative effects of heat stress. Schlolaut (1995) showed that sheared Angora rabbits exhibited a sudden amelioration of their feed intake, independently of the season (winter or summer), which decreased again parallel with the increasing fur length. Finzi *et al.* (1992) also reported a higher feed intake when rabbit bucks were

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sheared, without any effect on quantity and quality of semen. Lukefahr and Ruiz-Feria (2003) observed lower body temperature and higher growth rate in fur clipped growing rabbits farmed under warm ambient temperature. Jackson *et al.* (2006) compared the production of naked and furred growing rabbits and they observed a higher feed intake and higher body weight in the naked counterpart; this led to the hypothesis that naked rabbits can adapt better to hot climates. Finally, Szendrő *et al.* (2007) observed an increase in milk yield and litter weight in summer when the hair of meat-type rabbit does was sheared.

Despite the above-cited extensive research on the topic, to the author's knowledge no past experiments evaluated the slaughter and carcass traits of sheared rabbits reared under high ambient temperature.

Based on the above-mentioned considerations and since hair shearing seems a promising tool to improve the productive traits of rabbits reared under high temperature, the objective of the present experiment was to study the effect of hair shearing on the growth performance and carcass traits of growing rabbits reared under high ambient temperature.

MATERIALS AND METHODS

The investigation was not a permission-needed activity. All animals were handled according to the principles stated in EC Directive 2010/63/EU regarding the protection of animals used for experimental and other scientific purposes.

Animals and experimental design

The experiment was carried out at the rabbit farm of Kaposvár University (Hungary) from 15 April to 03 June 2019. Five-week old weaned Pannon Ka rabbits were housed in two rooms where the temperature was controlled with air conditioning (Fujitsu Air conditioning-system, ARYG30LMLE, Fujitsu General Limited, Suenaga, Takatsu-ku, Kawasaki, Japan) and extractor ventilation. During the experiment, the ambient temperature and the relative humidity were continuously registered every 30 min with an EBI 300 USB data collector (ebro Electronic GmbH, Ingolstadt) in both rooms. The ambient temperature (Ta) and relative humidity (RH) were 20.5±1.1°C and 54±11% in the control room and 28.8±0.2°C and 35±8% in the higher temperature room, respectively. Temperature-humidity index (THI) was calculated based on Marai *et al.* (2002), as follows:

$$THI = db°C - [(0.31 - 0.31\ RH)\ (db°C - 14.4)], \quad (1)$$

where db°C dry bulb temperature in Celsius and RH=relative humidity percentage/100. The calculated THI were 19.7±1.01 and 25.9±0.47 in 20 and 28°C rooms, respectively.

Rabbits reared under normal temperature (20°C) were furred (control: C group, n=50), while in the room with higher temperature (28°C) there were two groups of rabbits: one was furred (H group, n=50), whereas in the other group rabbits were sheared on the back and on both sides of the body (Figure 1) at 5, 7 and 9 wk of age (HS group, n=50), using a shearing machine (AESCULAP Favorita II, B.Braun, Aesculap Suhl GmbH, Suhl, Germany) for Angora rabbits. The shearing lasted approx. 2 min per animal. After each shearing, the hair length was about 2 mm.

In both rooms the daily lighting was 16 h. All rabbits received commercial pelleted diet (5-9 wk: dry energy (DE): 9.94 MJ/kg, crude protein (CP): 15.7%, crude fibre (CF): 19% with medication, 9-12 wk: DE: 10.6 MJ/kg, CP: 16.3%, CF: 17.7% without medication) *ad libitum* and the water was freely available from nipple drinkers. Rabbits were housed in wire mesh cages (length: 40 cm, width: 38 cm, height: 30 cm; 2 rabbits/cage).

Body weight (BW) of rabbits was measured at 5, 7, 9, 11 and 12 wk of age, feed intake (FI) was manually measured for the periods 5-7, 7-9, 9-11 and 11-12 wk; daily weight gain (DWG) and feed conversion ratio (FCR) were then calculated. Evaluation of BW and DWG were based on individual data, whereas feed intake and feed conversion ratio were based on the cage unit (n=25 replicates/treatment – two rabbits per cage). When calculating feed intake, it was assumed that morbid rabbits did not consume any pellets for the 2 d prior to their death. Mortality was recorded daily. At the age of 12 wk, rabbits were transported to a slaughterhouse (transport with fasting length was 4 h) and slaughtered by cutting the carotid arteries and jugular veins after electrical stunning. After 24 h chilling at 4°C, the carcasses were dissected following the recommendations of the World Rabbit Science Association (WRSA), as described by Blasco and Ouhayoun (1996).

Figure 1: Sheared rabbit.

Statistical analysis

Data were analysed by SAS package (9.4). The body weight measurements at different ages, the average daily weight gain measurements at different periods and all carcass traits were analysed by Mixed model as followings:

$$Y_{ijk}=\mu+\tau_i+c_j+\varepsilon_{ijk}, \quad (2)$$

where Y_{ijk} is the observation k in group i, cage j, μ is the overall mean, τ_i the fixed effect of group i (C, H, HS), c is the random effect of cage j, ε_{ijk} the random error. Tukey's multiple comparison test was used to determine which means amongst a set of means differ from the rest.

For feed intake and feed conversion measurements at different periods the model was:

$$Y_{ij}=\mu + \tau_i + \varepsilon_{ik}, \quad (3)$$

where all effects were the same as defined previously.

Mortality data were analysed using Fisher's Exact Test for Count Data.

RESULTS AND DISCUSSION

Although the 28°C applied in H and HS groups is above the thermo-neutral zone of growing rabbits (15-20°C; Verga *et al*., 2007), due to the low RH (35%) the calculated THI value (25.9) is considered as absence of heat stress by Marai *et al.* (2002).

Live performance values of furred and sheared growing rabbits housed in rooms with normal and high ambient temperature are shown in Table 1. The negative effect of heat stress on animal production is well known (Fuquay, 1981; Renaudeau *et al*., 2012). High ambient temperature has been shown to primarily affect the FI of rabbits (Marai *et al*., 2002; Szendrő *et al*., 2018: 5, 15, 23 and 30°C), which is consistent with what was observed in the present study: FI decreased by 29.9% in H group compared to C rabbits, whereas a lower decline was observed in HS group (20.4%). In addition, it was observed that the FI decrement caused by higher temperature was smaller in younger than in older rabbits (5-7 wk 21.6 and 15.6%, 11-12 wk 28.5 and 22.1% in H and HS groups, respectively). Digestion generates metabolic heat so, as older rabbits consume more feed, they produce more heat than younger ones (Renaudeau *et al*., 2012). Moreover, the different body weight/body surface ratio of younger and older animals also affects the heat dissipation, so the higher temperature is perceived differently in young or mature rabbits. Previous research (Stephan, 1980: 5°C and 80% RH *vs*. 18°C and 70% RH *vs*. 30°C and 60% RH; Chiericato *et al.,* 1996:

Table 1: Live performance of furred and sheared growing rabbits housed in rooms with normal and high ambient temperature.

	Ambient temperature				
	20°C	28°C			
	Hair shearing				
Traits	No	Yes	No	SEM	*P*-value
Group	C	HS	H		
n (rabbit)	50	50	50		
Body weight (g)					
5 wk	904	899	900	6.52	0.956
7 wk	1563[b]	1452[a]	1419[a]	9.70	<0.001
9 wk	2119[c]	1936[b]	1866[a]	13.0	<0.001
11 wk	2602[c]	2300[b]	2181[a]	19.6	<0.001
12 wk	2816[c]	2496[b]	2345[a]	21.9	<0.001
Weight gain (g/d)					
5-7 wk	47.1[c]	39.5[b]	37.1[a]	0.47	<0.001
7-9 wk	39.7[c]	34.6[b]	31.8[a]	0.39	<0.001
9-11 wk	34.6[c]	26.0[b]	22.5[a]	0.69	<0.001
11-12 wk	30.8[b]	25.9[ab]	23.4[a]	0.99	0.018
5-12 wk	39.0[c]	32.5[b]	29.5[a]	0.42	<0.001
Mortality (%)					
5-12 wk	2.00	4.00	0.00	–	0.773
n (cage)	25	25	25		
Feed intake, g/d					
5-7 wk	97.4[c]	82.2[b]	76.4[a]	1.27	<0.001
7-9 wk	131[c]	105[b]	90.4[a]	2.12	<0.001
9-11 wk	149[c]	115[b]	99.7[a]	2.72	<0.001
11-12 wk	172[b]	134[a]	123[a]	3.62	<0.001
5-12 wk	137[c]	109[b]	97.3[a]	2.22	<0.001
Feed conversion ratio					
5-7 wk	2.07	2.09	2.06	0.02	0.705
7-9 wk	3.31[c]	3.03[b]	2.85[a]	0.03	<0.001
9-11 wk	4.38	4.35	4.50	0.06	0.534
11-12 wk	5.26	4.85	5.65	2.25	0.097
5-12 wk	3.53[b]	3.34[a]	3.31[a]	0.03	<0.001

[a,b,c]Means with different letters on the same row differ significantly.
SEM: standard error of means.

27.2±2.6°C and 68-80% RH *vs*. 11.3±1.0°C and 64-67% RH; Zeferino *et al.,* 2011: 18°C *vs*. 25°C *vs*. 30°C) compared the FI of growing rabbits reared at comparable temperatures to those tested in the present experiment and they observed similar findings, but the magnitude of the FI reduction was a bit smaller (15.6-24.8%). The main reason whereby rabbits struggle to lose the heat load is primarily attributable to their fur (Lebas *et al*., 1997; Marai *et al*., 2002), which explains why the negative effect of higher temperature, expressed as FI but also on the other tested productive parameters, was lower on sheared rabbits (HS) compared to the H ones. Schloaut (1995) noted that, after hair shearing, the FI of Angora rabbits suddenly increased and then gradually decreased until the next shearing time, which was attributable to the progressive hair growth. The direct positive response of rabbits to hair length was also emphasised by Jackson *et al.* (2006), comparing furred and naked rabbits (30.2-35.1°C and 53.7-68.9% RH): they reported a greater difference in FI between the two groups (20.8%) compared to those observed in the present

Table 2: Carcass traits of furred and sheared growing rabbits housed in rooms with normal and high ambient temperature.

	Ambient temperature				
	20°C	28°C			
	Shearing				
Traits	No	Yes	No	SEM	*P*-value
Group	C	HS	H		
N (carcass)	49	47	47		
Slaughter weight (SW), g	2751[c]	2458[b]	2310[a]	21.1	<0.001
Chilled carcass (CC), g	1693[c]	1517[b]	1430[a]	12.9	<0.001
Reference carcass (RC), g	1439[c]	1290[b]	1218[a]	11.2	<0.001
Ratio of RC to CC	85.0	85.0	85.2	0.08	0.583
Chilled carcass,% SW	61.6	61.7	61.9	0.15	0.696
Reference carcass,% SW	52.4	52.4	52.7	0.15	0.576
Head,% CC	7.99[a]	8.62[b]	8.93[b]	0.07	<0.001
Thoracic cage organs,% CC	1.25	1.23	1.18	0.01	0.225
Liver,% CC	4.86[c]	4.27[b]	3.91[a]	0.06	<0.001
Kidneys,% CC	0.90[b]	0.88[b]	0.80[a]	0.01	<0.001
Fore part,% RC	28.9[b]	28.3[a]	28.4[a]	0.08	0.010
Mid part,% RC	31.4	31.5	31.5	0.10	0.870
Hind part,% RC	30.8[a]	31.9[b]	32.2[b]	0.10	<0.001
Perirenal fat,% RC	2.59[b]	1.82[a]	1.60[a]	0.06	<0.001
Scapular fat,% RC	0.89[c]	0.66[b]	0.51[a]	0.02	<0.001
Meat to bone ratio	2.86	2.74	2.79	0.03	0.220

[a,b,c]Means with different letters on the same row differ significantly.
SEM: standard error of means.

experiment between H and HS groups (10.7%), which was due to the fact that rabbits in the present experiment were covered with shorter or longer hair during the whole experimental period, whereas in the previously-cited experiment the rabbits were furless. Another reason for the higher difference in the results of the cited study is the significantly higher temperature and humidity.

Results of the present experiment highlighted that DWG was also negatively affected by higher temperature: it decreased by 24.6% and 16.9% in the H and HS groups, respectively, compared to C rabbits (Table 1). The effect of higher temperature on DWG was lower in the experiment of Chiericato *et al.* (1996) than in the present trial. In contrast, Stephan (1980) observed a higher decrease. Even though the fluctuation of DWG was greater than that observed for FI, there is nevertheless a close connection between the DWG and FI. The reason to explain the variability in the literature regarding this outcome could be the genetics of the rabbits, as well as the health status (morbidity, mortality) of the examined stocks. Comparing the DWG of H and HS groups, it can be stated that a similar difference was found to that reported by Jackson *et al.* (2006) between furred and naked rabbits (9.2 and 10.9%, respectively). From the productive point of view, a difference of around 10% in DWG as reducing effect of shearing on heat load can be considered notable. The initial BWs of rabbits was similar in the three experimental groups when assessed at 5 wk of age but, as a result of the difference in DWG, the BW of H and HS rabbits was lower (by 16.5% and 11.5%, respectively) than in C group at 7, 9, 11 and 12 wk. In their experiment, Chiericato *et al.* (1996) observed a smaller decline in BW, while the difference between H and HS groups was similar to that found by Jackson *et al.* (2006) comparing naked and furred rabbits. Other researchers also reported positive productive outcomes when rabbit bucks (Finzi *et al.*, 1992) or does were sheared (Szendrő *et al.*, 2007) in an effort to cope with the high ambient temperature.

Although some authors (Chiericato *et al.*, 1996; Zeferino *et al.*, 2011) did not detect any differences in the FCR of rabbits housed at normal or warm temperature, in the present study different outcomes were observed among the

C, H and HS groups (Table 1) in the periods 7-9 wk and 5-12 wk. Our findings agree with the experiments by Lebas and Ouhayoun (1987), and Chiericato *et al.* (1993: 11°C and 66% RH *vs*. 27°C and 74% RH; 1994: 12°C *vs*. 30°C; 74% RH). The improved FCR in H and HS rabbits compared to C ones was not fully expected, as it is true that higher temperature lowered FI, but also DWG and thus BW. Instead, the reason behind this finding could hypothetically be attributed to a difference in the digestibility of nutrients, as demonstrated by previous studies (Hermes *et al.,* 1999; Kovitvadhi *et al.,* 2019); specifically, they observed enhanced dry matter, crude protein, ether extract and crude fibre digestibility in rabbits farmed at high ambient temperature. The lower feed intake in high temperature conditions should increase gut transit time, allowing rabbits to maximise the efficiency in the absorption of nutrients which would justify such findings; this would however merit further investigation.

Hair cutting effectively lowers body temperature of rabbits, thus improving their welfare condition under warm ambient conditions: this was directly demonstrated on naked rabbits (Lukefahr and Ruiz-Feria, 2003) and, indirectly observed through the live performance in the present experiment. Despite this, the mortality rate of rabbits was not affected by the treatments (0-4%; P=0.773); only three animals died during the whole experimental period, n=1 C and n=2 HS.

Carcass traits of furred and sheared rabbits housed in rooms with normal and high ambient temperature are summarised in Table 2. As a result of the live performance, the slaughter weight and different carcass weights also differed in the three experimental groups: the highest values were recorded in the C group and the lowest in H group, while HS rabbits and carcasses displayed intermediate results. Results were consistent with the findings of Kovitvadhi *et al.* (2019), comparing rabbit reared either at +24°C or under severe heat stress condition, also regarding carcass yields. In contrast, Chiericato *et al.* (1996) recorded better results in rabbit reared at high temperature (+26°C), which was however not surprising as the other group of rabbits was kept at +11°C, which is below the lower threshold limit of +15°C recommended for rabbits (Perez *et al.,* 1995).

Ratio of head to CC was higher in H and HS group than in C rabbits, which shows the relative lower growth of other parts of body under higher temperature. Significant differences were also found in the ratio of liver to CC, with the highest value in C group and the lowest in H, while HS rabbits presented a higher ratio compared to H group, but lower compared to C rabbits (P<0.001). Likewise, the ratio of kidneys to CC significantly differed according to the treatment, with higher values in C and HS groups compared to the H group (P<0.001). These findings may be in close connection with the heat effect, but are not consistent with the findings of Kovitvadhi *et al.* (2019), as they observed no effect due to ambient temperature on the organ to CC ratio. Considering poultry species, the liver size was also found to decrease when chickens were farmed at high temperature (Balnave, 1972). The ratio of the fore part to reference carcass (RC) was higher in C group than in the H and HS groups (P<0.01), while an opposite trend was found in the ratio of hind part to RC, with the lowest value being recorded in C rabbits (P<0.001). Chiericato *et al.* (1996) obtained different results compared to our experiment, while Metzger (2006) also found that there is a negative correlation between the body weight of rabbits and the hind leg part ratio. The explanation for this phenomenon may be that, at a younger age (before the age of 8-10 wk), the proportion of the hind part of the body increases more significantly than at later ages (Deltoro and López, 1986). In the present experiment, ambient temperature, FI and ratio of fat deposits of rabbit carcasses were found to be connected, which was expected. These findings were similar to those of Chiericato *et al.* (1996) and Lebas and Ouhayoun (1987). Chiericato *et al.* (1993) also observed higher ratios of fat deposits in winter than in summer. The differences often detectable between H and HS groups in terms of carcass traits, as was observed for live performance, showed that hair shearing mitigated the effects of higher temperature. However, overall results showed that neither high ambient temperature nor shearing had a considerable effect on the carcass traits.

CONCLUSIONS

The present research demonstrated that the negative effects of higher ambient temperature (28 *vs*. 20°C) on the live performance and carcass traits of growing rabbits can be partially mitigated by shearing their hair.

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