EFFECT OF ENVIRONMENTAL CONDITIONS ON PRODUCTIVE AND PHYSIOLOGICAL RESPONSES IN GROWING RABBITS

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ABSTRACT

Environmental conditions are important for the welfare of intensively-reared rabbits. The presence inside the cage of a piece of wood represents a form of environmental enrichment, but also an alternative type of feeding. A trial was carried out to study the effect of lighting and type of feeding on the productive performance, bone conditions and plasma profile of growing rabbits. Male rabbits (Hycole genotype) were reared from 44 to 80 days in single cages and submitted to either of two photoperiods: long 9L:15D (group LP) or short 5L:19D (group SP) and to either of two types of feeding: feed only (group F) or feed and a piece of wood (group W). The experimental factors were arranged following a factorial model 2x2 and their interactions (LPF – LPW – SPF – SPW) were also considered. Wood of *Salix alba* was used, placed on the slat of each cage.
Lighting did not affect the productive performance, whereas significant effects of feeding type were observed: the W group had a significantly higher ($P<0.05$) growth rate and feed intake than the F group. The feed:gain ratio did not change according to the feeding type.
Lighting did not affect femur and tibia length and modulus of elasticity, but SP rabbits showed higher ($P<0.05$) tibia stress than the LP group. Calcium was lower ($P<0.01$) in SP bones. The physical and chemical characteristics of the femur and tibia were unaffected by feeding type, except for calcium which was slightly lower in W tibiae. The plasma profile did not change according to experimental factors except for urea, which had a higher ($P<0.05$) level in W rabbits than in F animals.
The data obtained indicate that the lighting type does not represent an environmental factor capable of strongly affecting the productive performance of growing rabbits kept in conventional cages. However, it becomes more important for the skeletal status, especially when applied to rabbits reared in enriched cages since an interaction between photoperiod and wood activity may exist.
The results demonstrate that the use of *Salix alba* wood for growing rabbits allowed a better productive performance without notable effects on skeletal bones or plasma profile.

Key words: Rabbit, Lighting, Cage enrichment, Bone, Blood.

INTRODUCTION

There are several environmental factors which influence animal welfare under intensive breeding conditions, such as lighting, temperature, gases, type of floor and cage enrichment. In poultry production, enriched cages (Blokhuis *et al*., 2007) with sand baths provide elements favouring the natural behavior of the birds. Wild rabbits spend the majority of their day in underground tunnels and need to gnaw at hard surfaces to wear down their continually growing, open-rooted teeth (Verga *et al*., 2004). Furthermore, the ingestion of crude fiber, such as wooden material, could influence intestinal physiology and cecotrophy (Gidenne *et al*., 1998). The composition of the wood and the quantity of particular molecules known for their positive or negative influence on the physiological response of humans and animals may also be relevant (EFSA, 2005).

The purpose of this trial was to study the effect of lighting and the presence of a piece of *Salix alba* wood within the cage on productive performance and on some physiological responses of growing rabbits.

MATERIALS AND METHODS

Animals and experimental design

The trial was conducted on 64 Hycole male rabbits from 44 to 80 days of age. The animals were weaned at 28 days of age and were reared in single cages. These were placed in two rooms with different lighting conditions: the first room had natural lighting with a photoperiod of 9L:15D (group long-photoperiod, LP), whereas in the second room the windows were covered with black tissue and the photoperiod was of 5L:19D (group short-photoperiod, SP) provided by incandescent bulb lamps. The light intensity in the LP room was variable according to the outdoor weather and the presence or not of cloudy days (13±7 lux), whereas in the SP room the light intensity was constant (10±5 lux). Each room contained 32 cages: in 16 of them, only a feeder and drinker were present (group feed, F), whereas in the other 16 cages a piece (20 cm length, 6 cm diameter) of S*alix alba* wood was placed on the slat (group wood, W). Thus, there were four distinct groups: LP-F, LP-W, SP-F and SP-W.
The temperature was 18°C and the relative humidity averaged 55%. On a weekly basis the feed intake, the wood intake and live body weight were checked. Health status was monitored daily. All rabbits were fed a pellet feed *ad libitum* and the LP-W and SP-W rabbits were also allowed access to *Salix alba* wood (Table 1). At 81 days of age, 8 rabbits per each group underwent blood sampling and were then slaughtered.

Table 1: Chemical composition (% on dry matter basis) of the feed and of *Salix alba* wood

		Salix alba wood	
	Feed	Xilem and cortex	Cortex
Dry matter (%)	89.80	90.00	88.54
Crude protein	17.68	0.54	10.30
Ether extract	2.94	1.22	7.05
Crude fiber	3.61	0.86	1.55
NDF	14.94	71.74	32.33
ADF	35.74	92.71	55.41
ADL	18.51	77.71	46.46
Ash	8.44	11.81	18.86
Calcium, ppm	13344	1808	40249
Phosphorus, ppm	7181	255	925
Tannins – tannic acid (%)	0.03	0.13	0.82

*Supplement per kg of feed: vit. A (10000 IU); vit. D_3 (1800 IU); α-tocoferol 91% (15 mg)

Physical and Chemical Analyses

The animals were slaughtered, the hind legs were removed from the carcass and the femur and tibiae were separated from the muscles. Some physical and chemical analyses were performed on the femur and tibiae. The length of the bones was checked by means of a calibre. Stress and modulus of elasticity were calculated as previously mentioned (Newman and Leeson, 1998). The feed, wood and bones were submitted to chemical analyses (AOAC, 2000). The NDF, ADF and ADL fractions of crude fiber were quantified by Goering and Van Soest (1970). Blood was collected in vacutainers with lithium heparin and then were centrifuged at 3500 rpm per 15' and stored at -20°C prior to further analyses. Plasma was analyzed using the HITACHI-911 (Roche BM) instrument and kits.

Statistical analysis

All data underwent one-way ANOVA with photoperiod and feeding type as main factors and their interaction was also considered using the GLM procedures of SAS (SAS Institute, 2000).
Significant differences among the means were determined using Duncan's multiple range test (SAS Institute, 2000).

RESULTS AND DISCUSSION

Table 2 summarizes the productive performance of the rabbits throughout the experimental period. The photoperiod did not affect the productive performance as the growth rate, feed intake and feed:gain ratio were similar between LP and SP groups. The presence of wood significantly (P<0.05) increased the daily body gain and the feed intake. The final live weight of W rabbits was 4% higher (P=0.07) than that of F rabbits.

Table 2: Productive performance of growing rabbits from 44 up to 80 days of age

	LP	SP	Prob.	F	W	Prob.	RMSE
Live weight (g)							
at 44 d	1389	1336	n. s.	1359	1366	n. s.	123
at 80 d	3215	3167	n. s.	3126	3256	0.07	257
Growth rate (g/d)	50.71	50.88	n. s.	49.08	52.51	<0.05	5.32
Feed intake (g/d)	192	192	n. s.	187	197	<0.05	16.31
Feed: gain (g/g)	3.80	3.79	n. s.	3.83	3.79	n. s.	0.27

n.s.= not significant; RMSE: root mean square error (54 degrees of freedom)

The positive effect of the presence of wood on the growth rate was significant (P<0.05) particularly from 62 to 80 days of age (data not shown) and in the LP group (Table 3). The wood intake was higher in the SP group as a significantly higher (P<0.05) ingestion was observed from 62 to 80 days of age (data not shown).

Table 3: Productive performance of growing rabbits: effects of interactions

	LPF	LPW	SPF	SPW	Prob.	RMSE
Live weight (g)						
at 44 d	1374	1404	1343	1328	n. s.	123
at 80 d	3082[b]	3347[a]	3169[ab]	3165[ab]	0.05	257
Growth rate (g/d)	47.43[b]	53.99[a]	50.73[ab]	51.03[ab]	<0.05	5.32
Feed intake (g/d)	183	200	190	194	n. s.	16.31
Feed: gain (g/g)	3.89	3.71	3.76	3.81	n. s.	0.27

Means with different letter on the same row differ significantly; n. s.= not significant
RMSE: root mean square error (54 degrees of freedom)

The results agree with other authors (Maertens and Van Oeckel, 2001; Luzi *et al*., 2003), who observed a marginal improvement in the growth rate and final body weight of rabbits reared in cages containing a piece of wood. Other results indicate a lack of effect or a negative one on productive yields or on the health state (Mirabito *et al*., 2000; Verga *et al*., 2004) of growing rabbits. Yet, the experimental conditions were different between those studies and the present ones; therefore, the discrepancies are difficult to interpret. Table 4 shows the physical characteristics of the leg bones.

Table 4: Physical and chemical properties of femur and tibia bones

	LP	SP	Prob.	F	W	Prob.	RMSE
Femur physical properties:							
Lenght (mm)	98.4	98.8	n.s.	99.2	98.0	n.s.	0.55
Stress (kg/mm^2)	6.9	7.0	n.s.	6.7	7.1	n.s.	1.64
Modulus of elasticity (kg/mm^2)	229	257	n.s.	218	267	n.s.	66.44
Femur chemical properties:							
Calcium (%)	25.69	24.66	<0.01	25.39	24.97	n.s.	0.97
Phosphorus (%)	11.54	11.20	n.s.	11.38	11.36	n.s.	0.31
Tibia physical properties:							
Lenght (mm)	104.6	105.2	n.s.	105.6	104.2	n.s.	0.21
Stress (kg/mm^2)	13.7	15.7	<0.05	15.2	14.3	n.s.	2.68
Modulus of elasticity (kg/mm^2)	338	403	n.s.	344	397	n.s.	95.68
Tibia chemical properties:							
Calcium (%)	26.97	25.64	<0.01	26.74	25.87	<0.05	1.11
Phosphorus (%)	11.96	11.46	n.s.	11.82	11.60	n.s.	0.36

n. s.= not significant; RMSE: root mean square error (26 degrees of freedom)

Photoperiod did not affect the length of the femur and tibia. The femur showed similar stress and modulus of elasticity in LP and SP rabbits. However, the tibia showed a stress (P<0.05) and a modulus of elasticity that were 16% higher in the SP than in the LP group. The chemical composition of the femur and tibia are shown in Table 4. Calcium levels of the two bones were significantly lower ($P<0.01$) in the SP than in the LP group. These results may be attributed to the fact that, in addition to a long photoperiod, the exposure of rabbits to natural light containing UVA rays, despite being filtered by the window glass, might have influenced mineral absorption and metabolism.

In Table 4 the physical characteristics of the femur and tibia are summarized according to the type of feeding. The presence of wood did not affect any physical variables in the two bones. The minerals in the femur did not change between groups. In the tibia, the same results were observed except for the calcium level which was lower ($P<0.05$) in the rabbits with wood. This result may be explained by the presence of tannins in the cortex of S*alix alba*, as observed by other authors in young rabbits (Al-Mamary *et al*., 2001).

Table 5 shows the metabolic profile of the rabbits. Glucose did not differ between the LP and SP groups nor did total proteins and urea. No significant effect was observed for AST and ALT. Calcium and phosphorus were also similar between the groups. The presence of wood did not affect the plasma levels of glucose, enzyme activity or mineral profile. The presence of tannins, at the level ingested, did not negatively influence the hepatic enzyme activity. Regarding parameters involved in protein metabolism, proteins were similar, whereas urea was significantly ($P<0.01$) higher in rabbits with wood in the cage. The reason for the higher plasma urea in W rabbits is not completely clear but it may be due to increasing feed intake (and thus higher protein intake) per unit of metabolic weight (data not shown). A second explanation which might have contributed to higher urea may be an increase of cecotrophy.

Table 5: Plasma profile of growing rabbits at the end of experimental period

	LP	SP	Prob.	F	W	Prob.	RMSE
Metabolites:							
Glucose (mmol/l)	7.31	7.22	n.s.	7.24	7.28	n.s.	0.45
Total proteins (g/l)	59.43	57.15	n.s.	57.44	59.14	n.s.	3.42
Urea (mmol/l)	6.13	6.38	n.s.	5.65	6.86	<0.001	0.95
Enzymes:							
ALT (UI/l)	47.44	38.45	n.s.	43.88	42.01	n.s.	13.08
AST (UI/l)	38.78	42.94	n.s.	44.15	37.56	n.s.	18.71
Minerals							
Calcium (mmol/l)	3.74	3.76	n.s.	3.70	3.80	n.s.	0.17
Phosphorus (mmol/l)	2.03	1.96	n.s.	2.01	1.98	n.s.	0.10

n. s.= not significant; RMSE: root mean square error (26 degrees of freedom)

CONCLUSIONS

The results indicate that photoperiod does not represent an environmental factor capable of strongly affecting the productive performance of growing rabbits kept in conventional cages for short periods of time. When the photoperiod is applied on rabbits reared in enriched cages, an interaction between photoperiod and activity on the piece of wood may occur. An enriched cage seems to be a comfortable environment for growing rabbits as has been stated by other authors, but the positive results may be a consequence of a better nutrition rather than reduced stress conditions of animals reared in conventional cages.

The presence and the chemical composition of the wood seems to be an important factor in some physiological aspects of growing rabbits; which specific factor present in the wood can influence the response of the animals must still be elucidated. Further research is needed in order to study the role of tannins on the physiology of the rabbits.

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