JOURNAL OF ANIMAL BEHAVIOUR AND BIOMETEOROLOGY

RESEARCH ARTICLE
Published Online: May 7, 2024
https://doi.org/10.31893/jabb.2024013

Effect of housing systems on behaviour and growth performance in fattening rabbits

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Abstract This study was conducted to investigate different housing systems and their effects on the growth performance and behaviour of fattening rabbits. The 120 animals were randomly allocated into 3 treatment groups based on the type of housing, from 35 to 84 days: cages (CG), 10 collective wire cages; each housing, 4 animals in 0.3 m²; closed pens (CP), 10 closed pens accommodating 4 rabbits, each with 0.525 m² and straw bedding on the ground; and an open-air system (OA), with 2 pens in the field each measuring 80 m², housing 20 rabbits in each pen. Live weight and feed intake were monitored every week. At the ages of 70 and 84 days, 10 rabbits per treatment were slaughtered, and blood samples were collected to measure haematocrit, cortisol and corticosterone levels. At the same age, 10 additional rabbits per treatment were chosen for an open field test. Compared with CG rabbits, OA rabbits exhibited a significantly lower final weight (2563 g *vs*. 2980 g). Compared with CG rabbits, OA rabbits also demonstrated reduced weight gain (33.1 *vs*. 41.8 g/d) and a decreased intake of pelletized feed (111.5 *vs*. 139.6 g/d). Corticosterone and haematocrit levels were smaller in other lodgements than in caged rabbits, which may suggest a poorer wellbeing status. This study indicated that animals housed in the outdoor system travelled greater distances (P<0.05) than did those housed in other housing types. The choice of rabbit housing during the growing period has an impact on growth performance, which is compromised in the outdoor system, and behaviour, which is negatively affected in the cage system.

Keywords: rabbits, growing, behaviour, cages, pens, open field

1. Introduction

The practice of breeding animals in cages appears to be associated with more stressful systems for consumers and is anticipated to be prohibited in Europe in the coming years. Therefore, it is imperative to explore other alternative breeding systems, particularly pens. It is expected that higher meat quality and enhanced welfare standards can be achieved when animals are reared in alternative systems. Numerous studies have examined alternative housing systems for fattening rabbits (Maertens and Van Oeckel 2001, Orova et al 2004; Jekkel et al 2010; Krunt et al. 2020; Monteiro et al 2024). Housing systems featuring floor pens or outdoor pens seem to mitigate stress and aggressive behaviour in animals (Maertens and Van Oeckel 2001; Lebas 2001). However, these rearing conditions are generally associated with increased mortality and reduced growth and feed consumption, which worsens feed efficiency (Chu et al 2004; Szendro and Dalle Zotte 2011; Matics et al 2014).

Pen housing provides a larger area and a closer proximity to the natural environment than traditional cages, enabling animals to engage in increased exercise activity and access to straw, resulting in higher energy requirements (Dal Bosco et al 2000; Maertens and Van Herck 2000). However, it may also lead to decreased live weight gain (5-10%) and a worsened feed conversion ratio (Maertens and Van Oeckel 2001; Matics et al 2019).

In larger groups, there is an increased incidence of aggressive behaviour, which is detrimental to both growth and animal wellbeing (Bigler and Oester 1996; Princz et al 2008; Krunt et al 2020). The determination of cortisol and corticosterone levels can serve as a valuable indicator of social stress in rabbits (Podberscek et al 1991; Szeto et al 2004), which is responsive to housing conditions. When rabbits are raised on the ground (particularly in deep litter), the risk of infection and intestinal inflammation is elevated, resulting in increased mortality (Bhat et al 1996; Dal Bosco et al 2000; Krunt et al 2023).

Works on extensive housing systems have sometimes produced inconclusive results due to the many variables involved (number of animals in the group, density, type of housing, among others). Therefore, the objective of this work was to investigate the effects of housing systems (cages, closed pens or open-air pens) on the performance and behaviour of rabbits between 35 and 84 days of age during the fattening period.

2. Materials and methods

2.1. Experimental design

 Received: December 20, 2023 | Accepted: January 13, 2024

This work was conducted in the experimental rabbit farming facility of the Department of Animal Sciences at the University of Trás-os-Montes e Alto Douro in Vila Real Portugal. The experiment was carried out in accordance with the Portuguese Law on Animal Welfare in Investigation and Experimental Research (Decree No. 113/2013, August 7) and the recommendations of the European Group on Rabbit Nutrition (Fernández-Carmona et al 2005).

Rabbits of both sexes, NZ x Cal, were randomly allocated into three groups, each consisting of 40 weaned rabbits (for a total of 120 rabbits). The animals were monitored from 35 to 84 days of age and exposed to three distinct housing systems. The distribution of rabbits across replicates and treatments was uniform and well balanced. At 35 days, weaned rabbits were sexed, individually tattooed for identification and then divided into three groups (Figure 1).

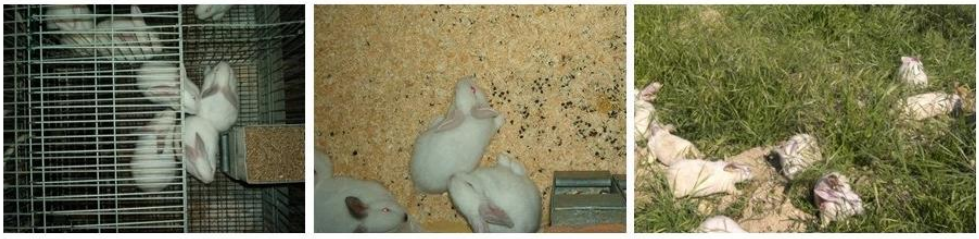

Figure 1 Housing systems of rabbits: cages (a), closed pens (b), and open-air pairs (c).

Both sexes were equally represented in the 3 treatment groups. In the caged group (CG), 40 rabbits were housed in 10 cages, for a total area of 0.3 m^2 (0.5 m × 0.6 m; 4 rabbits were housed per cage). In the closed pen (CP) group, 40 rabbits were placed in 10 pens with a total area of 0.525 m^2 (1.05 m × 0.5 m; 4 animals were housed per pen), and a 10 cm deep layer of wood bedding was used as bedding (Table 1). The animals in the cages and pens were housed in buildings with an air temperature maintained between 20°C and 25°C and received 12 hours of light daily (from 8:00am to 8:00pm). The open-air system (OA) group consisted of 40 animals housed in 2 outdoor pens, each measuring 80 m^2, with access to fresh grass on the ground (10 m × 8 m; 20 rabbits were housed per pen) in an outfield without any shelter to protect the animals. The study was conducted between May and June, based on data from the local weather station, with a moderate temperature of 18°C (10°C to 26°C) and a total rainfall of 50 mm over 5 to 7 days of rearing and 10 to 12 days of sunshine.

Table 1 Number of units, number of housed rabbits per unit, cage dimensions (W x L x H, m), floor surface area (m^2) and stocking density (rabbits per m^2) as a function of the three housing systems studied (wired cages, closed pens or open air).

Housing	Housing/number	Number of rabbits housed	Pens or cages dimension (W x L x H, m)	Floor surface (m^2)	Stocking density (rabbits per m^2)*
CG	Cages/10	4	0.5 x 0.6 x 0.4	0.300	13.3
CP	Closed park/10	4	0.5 x 1.05 x 1.2	0.525	7.7
OA	Open air pasture/2	20	10 x 8 x 1.5	80	0.25

*Stocking density recommended: 16 rabbits/m^2 (EFSA, 2005).

Throughout the experimental period, all animals had ad libitum access to water and a pelletized diet (91.6% organic matter, 16.2% crude protein, 24.7% starch, 3.7% crude fat, and 17.2% acid detergent fibre). The rabbits housed in outdoor pens also had access to natural pastures. The main species in the pastures in the northeast region of Portugal include red fescue (*Festuca rubra* L.), creeping velvet grass (*Holcus mollis* L.), common velvet grass (*Holcus lanatus* L.), bristlegrass (*Agrostis setacea curtis*), perennial ryegrass (*Lolium perenne* L.) and smooth cordgrass (*Bromus inermis leyss*). The pulse content is relatively low, 120 g/kg of the total mixture. The composition of this blend (g per 100 g of hay dry matter) is 8 g of crude protein, 70 g of neutral detergent fibre, and 6 g of ash (Rodrigues et al 2007).

2.2. Measurements

The body weight and feed intake of the rabbits were measured weekly from 35 to 84 days of age to obtain the live weight (LW), daily weight gain (DWG), daily feed intake (DFI) and feed conversion ratio (FCR). The intake of pasture water was not monitored. Mortality was monitored daily. At 70 and 84 days of age, 10 blood samples/treatment were collected after slaughter to obtain hematocrit, cortisol and corticosterone values.

2.3. Statistical analysis

All the data were subjected to analysis of variance (ANOVA), with housing type serving as a source of variation. Blood parameters were subjected to two-factorial analysis, considering their interaction with the housing system and age as factors. Means were compared using the Tukey test. Mortality was assessed using the χ^2 test. The statistical analyses were performed using JMP-SAS software (v.13-JMP-SAS Institute, Inc., Cary, NC). The growth data

encompassed 3 distinct periods: from weaning to first slaughter (35-70 days), from first to second slaughter (70-84 days), and throughout the entire growing period (35-84 days).

3. Results and discussion

3.1. Growth performances

Table 2 shows the growth performance results. The rabbits gender had no impact on growth performance; thus, this factor was not considered in the presentation of the results. The obtained results were in line with expectations, as the initial sex distribution was balanced, confirming prior findings (Oliveira and Lui 2006; Martínez-Bas et al 2018).

Over the entire period (35-84 days), compared with caged rabbits, animals under openfield conditions exhibited a significantly lower final weight (P<0.05), approximately 424 g less or a 14% reduction in weight. The live weight at the end of the experiment was similar between rabbits in cages and those in closed pens. The same effects were observed for the average daily gain during this period. Weight gain was also significantly greater in rabbits housed in cages or closed pens than in those housed in open-air conditions. Caged rabbits demonstrated weight gain and feed intake approximately 25% greater than those of their open-air counterparts. Throughout this phase (from the 35th to the 84th day of age), feed intake and weight gain were identical between the cages and closed pens and superior to those in the open field.

Table 2 Live weight, weight gain and pellet feed intake of rabbits according to housing type.

	Housing System			SEM[1]	P value
	Cage	Closed park	Open air		
Live weight (*g*)					
35 d	938.4	956.7	961.0	12.07	0.377
70 d	2512.3 [a]	2394 [b]	2098.2 [c]	28.33	<0.001
84 d	2987.3 [a]	2976.6 [a]	2563.3 [b]	36.37	<0.001
Weight gain (*g/d*)					
35-70 d	44.96 [a]	41.03 [b]	32.76 [c]	0.78	<0.001
70-84 d	33.93 [ab]	40.21 [a]	31.66 [b]	1.89	0.011
35-84 d	41.81 [a]	41.36 [a]	33.13 [b]	0.76	<0.001
Pellet feed intake (*g/d*)					
35-70 d	131.35 [a]	122.02 [a]	97.32 [b]	2.77	<0.001
70-84 d	159.42 [b]	179.81 [a]	138.04 [b]	4.22	0.003
35-84 d	139.62 [a]	133.33 [ab]	111.46 [b]	2.83	0.02
Pelleted feed conversion ratio					
35-70 d	2.92	2.98	2.96	0.057	0.857
70-84 d	4.76	4.47	4.40	0.182	0.874
35-84 d	3.36	3.26	3.46	0.064	0.325
Mortality[£] (%)					
35-70 d	5.0 (2)	15.0 (6)	10.0 (4)		ns
70-84 d	0.0 (0)	3.0 (1)	0.0 (0)		nd
35-84 d	5.0 (2)	17.5 (7)	10.0 (4)		ns

[1] – Stand error of mean

Means with different letters in the same row differ significantly (Tukey test). On average, n=40 per treatment; on the basis of feed intake and feed conversion ratio, n=10 in cages and closed parks and n=2 in open air; nd – not determined. £- χ^2 analysis; ns – not significant

In the initial phase of the growth period (35-70 days), the results mirrored the overall period. In the subsequent phase (70-84 days), the performance of rabbits reared in pens was consistent with that in the first phase, whereas the performance of CG rabbits was diminished. This alteration in feed intake and growth may suggest that caged rabitts encounter issues contributing to reduced growth performance or that rabbits in pens exhibit compensatory growth during this period.

The rabbits produced in an openfield system demonstrated the poorest performance. It is probable that pasture intake did not adequately compensate for the decreased consumption of pelletized feed, resulting in reduced weight gain (McNitt et al 2003; Princz et al 2008; Jekkel et al 2010; Pinheiro et al 2011; Matics et al 2019). Reduced feed intake in openfield systems has been previously associated with decreased daily weight gain (Maertens and Van Heck 2000; Pinheiro et al 2011; Loponte et al 2018). We can also consider that other factors related to the openfield system could contribute to the negative effects observed on performance, including the increased energy maintenance needs of rabbits due to increased locomotor activity (Maertens and Van Heck 2000) and the energy spent on thermoregulation. No effects were observed on rabbit mortality, possibly due to the limited number of animals. To achieve statistically significant differences in mortality rates with a 5% margin, approximately 200 animals per group were needed. The lower mortality rate during the period from 70 to 84 days can be attributed to the shorter duration (14 days), fewer rabbits involved, and increased resistance of older animals.

3.2. Behaviour

Table 3 shows the results for the behavioural indicators. The amount of time wasted by the animals in locomotion was not influenced by the treatment. When examining the distance covered by the animals during locomotor activity in the open field test, the distance travelled by the animals housed in closed pens was greatest, which was greater than that travelled by rabbits in cages or under outdoor conditions. The animals were raised in cages or outdoors and covered similar distances. Animals in closed pens covered almost twice the distance in the same duration as animals in the other groups, potentially indicating better adaptation to their housing conditions. In contrast to our findings, Trocino et al (2014) observed more movements and longer exploration times in rabbits housed in cages than in animals kept in pens. The number of rabbits per enclosure and their dimensions may account for the observed differences.

Table 3 Locomotor activity (open field test) according to housing type at 84 days.

	Housing			SEM	P level
	Cage	Closed park	Open-air		
TLA (min)	7.88	7.45	8.21	0.717	0.752
DAL (m)	23.22 [b]	40.67 [a]	22.44 [b]	4.716	0.018

[1] – Stand error of mean. Means with different letters in the same row differ significantly (Tukey test). Locomotor activity (TLA) and distance walked by the animal during locomotor activity (DAL)

Blood cortisol and corticosterone concentrations, as well as haematocrit levels, were greater in rabbits housed in cages than in those housed outdoors (Table 4). The hormone concentrations in the rabbits in the closed pens were intermediate, and the differences were not significant compared to those in the OA group. Trocino et al (2014) noted that rabbits housed in bicellular cages had lower corticosterone concentrations than rabbits housed in collective pens. Indeed, numerous variables, such as density, group size, and the number of animals, can impact rabbit behaviour, making it challenging to pinpoint the predominant effect. The lower corticosterone concentration in openfield rabbits may suggest reduced stress and improved wellbeing during the growing period. Jekker et al. (2010) and Trocino et al (2018) suggested that the accommodation of rabbits in deep litter has a positive impact on the frequency of social and stereotypical behaviours.

Table 4 Blood parameters and stress indicators according to housing type.

	Housing System (HS)			Slaughter Age (SA)		SEM [1]	P value		
	Cages	Closed Park	Open air	70d	84d		HS	SA	HSxSA
	20	20	20	30	30				
Cortisol (ug/ml)	2.09 [a]	1.11 [b]	1.08 [b]	1.24	1.61	0.186	0.039	0.313	0.139
Corticosterona(ug/ml)	11.03 [a]	6.80 [b]	4.28 [b]	6.02	8.72	0.721	0.0001	0.026	0.201
Hematócrito (%)	45.10 [a]	40.32 [b]	38.72 [b]	40.73	42.02	0.665	0.003	0.281	0.174

[1] – Stand error of mean. Means with different letters in the same row differ significantly (Tukey test).

4. Conclusions

Rearing rabbits in openfield pens results in a deterioration of performance in relation to rabbits raised in cages or in closed pens, but it enhances animal wellbeing. It would be of interest to replicate this study by increasing the sample size to investigate the influence of the housing system on carcass quality and gut development.

Acknowledgments

The authors would like to thank the University of Trás-os-Montes and Alto Douro for providing conditions to carry out the work

Ethical consideration

The experiment was carried out in accordance with the Portuguese Law on Animal Welfare in Investigation and Experimental Research (Decree No. 113/2013, August 7)

Conflict of interest

The authors have declared not confli of interest, tha researche was conducted in the adsence of any commercial or financial relationships.

Funding

This work was also supported by the projects UIDB/00772/2020 (Doi:10.54499/UIDB/00772/2020) funded by the Portuguese Foundation for Science and Technology (FCT).

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