EFFECT OF CAGE DENSITY ON PERFORMANCE OF FATTENING RABBITS UNDER HEAT STRESS

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ABSTRACT

Three hundred cross-breed rabbits of New Zealand, California, Butterfly, Dutch and Satin, weaned at 30 days and weighing 535±8 g (standard error) were assigned at random to four treatments: 6, 12, 18 and 24 rabbits/m^2 (3, 6, 9 and 12 rabbits/cage, respectively, each cage of 0.5 m^2) resulting 10 cages/treatment. During the experimental period (from weaning to 2.2 kg body weight) individual live weight, cage feed intake, the incidence of diarrhoea, ringworm and injured rabbits were recorded. The maximal temperature-humidity index ranged from 31 to 35 indicating a temporal severe heat stress. At the end of the experimental period 10, 20, 30 and 30 rabbits from the treatments with densities of 6, 12, 18 and 24 rabbits/m^2, respectively, were slaughtered and carcass performance recorded. Average daily gain and feed intake from weaning to the end of experimental period decreased by 0.31±0.070 and 1.20±0.25 g, respectively, per each unit that the density increased at the beginning of the experiment (P=0.001). The length of the fattening period increased by 0.91±0.16 d (P=0.001) per each unit of increment of density. However, rabbit production (expressed in kg/m^2) increased linearly and quadratically with the density (P<0.008). Cage density did not affect feeding efficiency, that was on average 0.214 g/g (P=0.37). Animals housed at the highest density compared to the average of those caged at lower density tended to show a higher incidence of ringworm (68.9 vs. 39.4%; P=0.075), a higher injured animals (16.8 vs. 3.03%; P=0.12) and a higher mortality (20.5 vs. 9.63; P=0.043). Density did not modify dressing out percentage and chilled carcass weight. Increasing density reduced linearly dorsal length (P=0.001) and reduced linearly and quadratically drip loss percentage (P=0.097 and 0.018, respectively). Based on these results, under our heat stress conditions it is recommended to avoid densities higher than 18 rabbits/m^2.

Key words: Cage density, Growing performance, Carcass performance, Heat stress.

INTRODUCTION

Rabbit's production demands great quantity of labours, to create an adequate environment in relation with both hygiene and comfort that allows them better performance on each physiological stage. El-Raffa (2004) indicates some indispensable requirements to achieve an ideal production in hot climates: high race efficiency productive, suitable sheds, comfortable cages, granulated and balanced food, suitable water, as well as a good hygiene and managing program, to avoid heat stress. The increase of animals per cage reduces investment costs in cages and equipments, but it worsens animal performance (Maertens and De Groote, 1984; Aubret and Duperray, 1992; Nieves *et al*., 1996; Mbanya *et al*., 2004). The European Food and Safety Authority (EFSA, 2005) recommended a minimum surface of 625 cm^2/rabbit and not more than 40 kg/m^2 at the end of fattening, in order to avoid disturbances in rabbit behaviour. However, the behaviour of rabbits depends on their age. Rabbits at the end of fattening preferred lower densities, and when caged at high densities spent less time for eating (Morisse and Maurice, 1997). Densities higher than 19 rabbit/m^2 reduced feed intake and growth rate, with no effect on feed efficiency and mortality (Maertens and De Groote, 1984; Aubret and Duperray, 1992).

Facilities more used in tropical condition are open sheds, where whether control is very difficult which increase heat stress during fattening. In these conditions the increase of cage density on performance might be more important than in European conditions. At this respect, Nieves *et al*. (1996), Andrea *et al*. (2004) and Mbanya *et al*. (2004) recommend 5 – 16 rabbits/m^2 as an adequate range for tropical condition. Nevertheless none of them describe climate conditions. Otherwise, some authors did not report any effect on productive performance at 19.6 rabbits/m^2 (Prawirodigdo *et al*., 1985; Camacho *et al*., 2003).

The aim of this work was to study what cage density is the optimum under the heat stress environmental conditions of Maracaibo (average temperature 28ºC and relative humidity 76%) by measuring growth performance, mortality rate, injured animals and carcass performance.

MATERIALS AND METHODS

Three hundred cross-breed rabbits of New Zealand, California, Butterfly, Dutch and Satin, weaned at 30 d were transported just after weaning from a commercial farm to our facilities (7 hours long). Animals were housed in flat-deck cages of 500 × 100 × 500 mm (0.5 m^2) equipped with one nipple drinker and one hopper feeder (30 cm available) each one. Water was filtered before stored in the farm water-tank. The farm is an open-air building equipped with a ventilator to favour air recycling and a mesh (80% shade) in the windows to avoid animals were exposed to the sun. Our region climate (Maracaibo) is characterized as tropical very dry forest (Holdrige, 1978). The temperature-humidity index (THI) was calculated according to Marai *et al.* (2001): THI = dbºC – [(0.31 – 0.031 RH) × (dbºC – 14.4)], where dbºC is dry bulb temperature in Celsius degrees, and RH is the relative humidity as percentage. According to Marai *et al.* (2002) there is heat stress when THI is higher than 28.9, and under 27.8 there is no heat stress. The treatments consisted in cage the rabbits at 6, 12, 18 and 24 rabbits/m^2 (or 3, 6, 9 and 12 rabbits/cage) and rabbits were assigned randomly to one of this four treatments (10 cages/treatment). The average weaning weight was 535 ± 8.0 g (standard error) and rabbits were identified by a number written in their ears. A commercial diet was offered *ad libitum*. Individual weight of animals, cage feed intake and mortality were recorded. Dead animals were not substituted Mortality, diarrhoea incidence and injured animals were expressed in percentage per cage. The experiment finished when the average weight of the cage reached 2.2 kg/rabbit. Then 10, 20, 30 and 30 rabbits corresponding to rabbits caged at 6, 12, 18 and 24 rabbits/m^2, respectively, were slaughtered between 9.30 and 11.00 h. Rabbits were stunned by a neck hit and then bleeded. Afterwards, they were dissected according to Blasco *et al.* (1993). The results obtained in this study for growth traits performance (expressed per cage) were analyzed as a completely randomized design with the average weaning weight per cage as a linear covariate and cage density was included as a linear and quadratic covariate, by using the General Linear Model procedure of SAS (SAS Inst. Inc., Cary, NC). The model used to study carcass traits included the sex as a classified effect, slaughter weight as a linear covariate and cage density was included as a linear and quadratic covariate, by using the General Linear Model procedure of SAS. When quadratic effects were significant the maximum/minimum was calculated and commented, except if it laid out of the range studied. All data are presented as least-squares means.

RESULTS AND DISCUSSION

Inside the farm the relative humidity ranged from 67 to 94% and the minimum temperature varied from 21 to 29ºC (that would correspond to the night period, when animals eat most of the feed). According to the review of Cervera and Fernández-Carmona (1998), these temperatures would be lower than the upper critical temperature of weaned rabbits (30ºC), but higher than the value for adult rabbits (25ºC). The THI calculated ranged between 21 and 28, and according to Marai *et al.* (2002) this would be not heat stress. At the maximum temperatures (recorded around 15:00 h, and varied from 24 to 35ºC) THI ranged from 31 to 35, and it implied a very severe heat stress which would impair growing performance response.

Feed intake and growth rate (both expressed per day and rabbit) from weaning to the end of fattening impaired by 1.20 ± 0.25 and 0.31 ± 0.070 g, respectively, per each unit that increased cage density (rabbits/m^2) at the beginning of the experiment (P<0.001) (Table 1). This negative effect was recorded in all the fattening stages. However, cage density had no effect on feed efficiency that was on average 0.214 g/g (P=0.37). Accordingly, the reduction of growth rate when cage density increased is directly related to the reduction of feed intake as observed previously (Maertens and de Groote, 1984; Aubret and Duperray, 1992; Nieves *et al.*, 1996; Mbanya *et al.*, 2004). As a consequence, the length of fattening period increased by 0.91 ± 0.16 d (P=0.001) per each unit that increased cage density.

Table 1: Effect of cage density on growth performance from weaning (30 d of age) to slaughter (2.2 kg body weight)

Initial density (rabbits/m^2)	6	12	18	24	SEM[1]	L[2]	P_{cov}[3]
Initial density (cm^2/rabbit)	1667	833	555	417			
Length (d)	73.1	79.0	82.5	90.3	1.94	0.001	0.001
Daily gain (g/d/rabbit)	21.3	20.4	17.5	16.0	0.83	0.001	0.001
Feed intake (g/d/rabbit)	97.4	94.1	83.7	76.9	2.96	0.001	0.055
Feed efficiency (g/g)	0.219	0.218	0.210	0.208	0.0095	0.37	0.041
Mortality† (%)	9.42	10.2	9.27	20.5	4.10	0.14	0.002
Ringworm‡ (%)	37.3	44.0	36.6	68.9	12.8	0.20	0.083
Diarrhoea (%)	13.3	10.2	5.80	12.0	3.81	0.64	0.10
Injured‡ (%)	0.0	8.00	1.10	16.8	6.07	0.26	0.74
Final cage density							
Live body weight§ (kg/m^2)	11.3	24.2	34.3	41.1	1.54	0.001	0.008
No rabbits/m^2 §	5.19	10.8	16.4	18.9	0.56	0.001	0.001

[1]n = 10 cages/treatment. [2]Linear effect of density. [3]Effect of average weaning weight per cage. §Quadratic effect of density (P<0.050). †Significant effect of contrast 24 vs. (18, 12, 6) rabbits/m^2 (P<0.050). ‡Tendency effect for contrast 24 vs. (18, 12, 6) rabbits/m^2 (0.050<P<0.15)

The incidence of ringworm and the animals injured were not affected linear or quadratically by cage density (Table 1). However, rabbits caged at the highest density compared to the average of the three lower densities tended to be more sensible to ringworm (68.9 vs. 39.4%; P=0.075), and to show a greater aggressiveness (reflected in the higher percentage of injured animals, especially in the ears and tail; 16.8 vs. 3.03%; P=0.12). This result indicates the negative impact of high densities on rabbit behaviour due to the lack of comfort, and it is in agreement with the impairment of growth performance in the last fattening period. The highest density also increased mortality rate in the whole fattening period compared to the average of the three lower densities (20.5 vs. 9.63; P=0.043). This result differs from previous studies that did not find any relation between cage density and mortality (Maertens and de Groote, 1984; Aubret and Duperray, 1992), but it is in agreement with the trend observed in tropical conditions (Nieves *et al.*, 1996; Mbanya *et al.*, 2004). The negative effect of density on growth performance did not avoid that the final rabbit production (kg/m^2) increased linearly with density (P=0.001). In this case, a quadratic effect was also observed (P=0.008), in a way that rabbit production did not increased directly proportional to the number of rabbits, that is due to their lower growth rate and higher mortality at the highest cage density. Accordingly, in order to reduce mortality, ringworm and injured animals it is required to be below 41 kg/m^2, which is the highest value recommended in Europe (Trocino and Xiccato, 2006). In our conditions of heat stress it could be suggested a cage density around 16-18 rabbits/m^2 in order to produce around 34 kg/m^2, and reduce one week the length of fattening compared to animals caged a the highest density.

Although rabbits were slaughtered when the average weight of the cage was 2.2 kg/rabbit, a negative effect of cage density is observed on slaughter weight (P=0.041), and it has been used as a covariate when carcass traits has been analysed (Table 2). Cage density had minor influence on carcass compared to growth traits, and this is in agreement with previous works (Aubret and Duperray, 1992; Xiccato *et al.*, 1999; Combes and Lebas, 2003). Cage density reduced linearly dorsal length (P<0.001) which is another signal of the lack of comfort in animals caged at high densities. Drip loss percentage increased linear and quadratically (P=0.097 and 0.018, respectively) with decreasing densities, showing a minimum value for a density of 18 rabbits/m^2. The slaughter of younger animals (with almost the same weight: 2.2 kg) when cage density decreased might account for this result as other authors have detected an increase in drip loss percentage when age at slaughter decreased (Xiccato *et* *al.*, 1993; Bernardini *et al.*, 1995). This result is related to the quadratic trend (P=0.12) of cage density on dressing out percentage which showed a maximum for 17.1 rabbits/m^2. Cage density also affected quadratically to the lumbar circumference obtaining a maximum value for 14.3 rabbits/m^2. The sex had minor influence on carcass traits. Females were heavier at slaughter compared to males (P=0.022), but they tended to have a longer lumbar circumference (P=0.11). Neither cage density nor sex had effect on hot carcass weight.

Table 2: Effect of cage density and sex on carcass performance

Initial density (rabbits/m^2)	6	12	18	24	Sex		rsd	L[1]	P_{sex}[2]	P_{cov}[3]
Initial density (cm^2/rabbit)	1667	833	555	417	Males	Females				
$N_{females}$	4	10	14	14						
N_{males}	6	10	15	16						
Live body weight at slaughter (BW) (g)	2261	2265	2159	2198	2188	2253	130	0.041	0.022	–
Hot carcass weight (% BW)	62.9	62.9	62.5	62.5	62.7	62.7	2.05	0.52	0.92	0.20
Chilled carcass weight (CCW) (g)	1230	1256	1262	1250	1252	1248	53	0.61	0.83	0.001
Dressing out percentage‡ (% BW)	55.7	56.9	57.2	56.6	56.7	56.5	2.48	0.56	0.88	0.014
Drip loss percentage† (%) HCW	11.3	9.62	8.52	9.41	9.54	9.85	2.50	0.097	0.88	0.016
Dorsal length (cm)	26.9	27.3	26.1	25.4	26.2	26.6	1.61	0.001	0.37	0.039
Thigh length (cm)	7.21	7.13	7.52	7.20	7.25	7.28	0.76	0.86	0.76	0.17
Lumbar circumference† (cm)	16.3	16.7	16.5	16.1	16.2	16.5	0.86	0.13	0.11	0.001

[1]Linear effect of cage density. [2]Effect of sex. [3]Effect of live body weight at slaughter. [4]Thymus, trachea, oesophagus, lungs and heart. †Quadratic effect of cage density (P<0.05). ‡Quadratic trend of cage density (0.05<P<0.15)

CONCLUSIONS

Based on these results, under our heat stress conditions it is recommended to avoid densities higher than 18 rabbits/m^2.

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