WIRE-FLOOR PENS AS AN ALTERNATIVE TO METALLIC CAGES IN FATTENING RABBITS: INFLUENCE ON SOME WELFARE TRAITS

A Martrenchar†, E Boilletot, J-P Cotte and J-P Morisse

Agence Française de Sécurité Sanitaire des Aliments BP 53, 22440 Ploufragan, France

† Contact for correspondence and requests for reprints

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The possibility of improving the welfare of fattening rabbits by rearing them in pens instead of cages was investigated. Time budgets, locomotion, ear lesions, breaking strength of the femur and productivity were compared in fattening rabbits kept at the same stocking density (15 rabbits m^{-2}) either in standard cages of 0.4m^2 (6 animals) or in pens of 1.6m^2 (24 animals). Behavioural observations, performed by video recording at 6 and 9 weeks of age, indicated that the frequency of rabbits walking over one another was higher in cages than in pens at 9 weeks of age. Although the time spent in locomotion did not differ significantly, the number of consecutive hops performed by animals was clearly increased in pens at 6 weeks and tended to be higher at 9 weeks. In pens (without a ceiling), rabbits were observed 'keeping watch' with a characteristic fully upright posture; this was not possible for rabbits in cages (with ceilings at 30cm).

Ear lesions were more frequent in caged rabbits than in penned; this might be due to the caged rabbits walking on one another, due to the lack of space to perform locomotory behaviour. Weight, diameter and breaking strength of femur tended to increase in rabbits kept in pens. In penned rabbits, body and carcase weight were significantly reduced (by 2.0% and 3.4% respectively) when compared with caged ones. However, overall, the use of wire-floor pens of 1.6m^2, housing 24 animals, was considered to be beneficial to fattening rabbits' welfare when compared to standard-sized cages holding 6 animals.

Keywords: *animal welfare, cage housing, fattening rabbits, group size, pen housing*

Introduction

Since the 1970s, wire-grid cages have been the most commonly used system for the intensive production of fattening rabbits. Higher productivity at lower cost, as well as control of parasitism and consequently more uniform products, were the main stimulus for the use of metallic cages (Morisse & Maurice 1994). Rabbits are routinely kept in small groups (6 to 9 rabbits). Morisse and Maurice (1997) have suggested that animal welfare is reduced at stocking densities above 16 rabbits m^{-2}, for animals slaughtered at 10 weeks of age and weighing 2.5kg each (ie 40kgm^{-2}). Domestic rabbit behaviour is much the same as that of their wild counterparts (Löliger 1992; Verga 1992). However, it is obvious that some

behaviours, like locomotory movements, are less markedly performed due to lack of space in cages.

While wire-grid floors have been implicated by several studies in the development of footpad injuries among breeding rabbits (Marcato & Rosmini 1986; Drescher & Schlender-Bobbis 1996; Rommers & Meijerhof 1996), this is not a concern in fattening rabbits because of the short time they spend on the wire floor. In addition, young rabbits do not show a preference for straw litter when offered a choice between straw and wire-grid floor (Morisse *et al* 1999). Despite a good adaptation to the wire-grid itself, the overall welfare of fattening rabbits in standard metallic cages remains questionable.

The aim of this study was to try to improve the welfare of rabbits, and particularly their locomotory behaviour, by housing them in metallic pens in large groups without modification of the stocking density. Pen versus cage housing has already been investigated in laboratory and breeding rabbits (Stauffacher 1992; Krohn *et al* 1999), but few investigations have concerned fattening rabbits kept under commercial conditions (Rommers & Meijerhof 1998). Our hypothesis was that, since rabbits usually rest in close contact with each other (huddling effect), increasing group size would result in more space available for locomotion.

Materials and methods

Experimental design

Three-hundred-and-sixty Hycol® rabbits (produced on our experimental farm) were the subjects of our study. The animals were 32 days old at the start of the study. They were selected on the basis of their sex, maternal origin and body weight and assigned to the same building in 8 pens of 24 rabbits (12 males and 12 females) and 28 cages of 6 rabbits (3 males and 3 females).

The pens had 1.6m² of available floor area (160cm x 100cm), were separated by wooden panels (80cm high) and had no ceiling. The cages measured 77x51x30 cm (length x width x height) and were separated by wire netting. The stocking density was the same (15.0 to 15.3 rabbits m^{-2}) in both housing systems. The floor of both the cages and pens was made of wire netting and the size of mesh was 75x12.5 mm with a wire diameter of 2.5mm.

The pens and cages were equipped with external linear feeders, (100cm and 25cm long respectively) and with nipple drinkers (4 and 1 respectively). Animals were fed a standard diet (Maxicopa, by Unicopa, Languidic, France) *ad libitum*. Lights were on 8h daily (from 0900h to 1700h). Room temperature was maintained at 17 ± 2 °C by a heating control system.

Ethical note

The stocking densities used in our studies were higher than those recommended by the World Rabbit Science Association (WRSA) (Löliger 1992). The WRSA recommends 800cm^2 per fattening rabbit older than 6 weeks, until 3.3kg liveweight (12.5 animals per m²). However, there was no cause for concern, since our final stocking density (2.5kg x 15.3m^2 = 38.25 kgm^{-2}) was lower than the WRSA corresponding value (3.3kg x 12.5m^2 = 41.25 kgm^{-2}). WRSA recommendations are based on a slaughtering age of 12 weeks or more (ie a final liveweight of 3.0-3.3 kg), whereas in France the animals are slaughtered at 10 weeks (final liveweight = 2.5 kg). The stocking density in this experiment was much lower than those used in commercial conditions (18-20 rabbits per m^2 = 45-50 kgm^{-2}) (Henaff & Ponsot 1986; Lebas 1994). Previous studies have shown that a stocking density of 38kgm^{-2} is an acceptable

compromise between animal welfare and financial considerations (Morisse & Maurice 1997). In a similar way, the height of our cages (30cm) was below the WRSA recommended value of 35cm. The reason for this is that 30cm is the standard height of cages used in France under intensive conditions (Henaff & Ponsot 1986; Lebas 1994). It should also be noted that whether the height is 30cm or 35cm, in both cases the animal is unable to stand in a fully upright position. For this reason, we investigated the possibility of removing the ceiling in the pens.

The animals were slaughtered according to the Council Directive 93/119/EC on the protection of animals at the time of slaughter or killing (1993). In addition, all authors held an individual ethical approval delivered by the French Ministry of Agriculture which permitted them to use live animals according to ethical principles of experimentation.

Behavioural traits

Behaviour was recorded by video cameras with infrared lighting for 1min at 15-min intervals during two 24h observation periods when the rabbits were 6 and 9 weeks old. The behaviour of all animals in the cage or pen was recorded. The unit of observation was the pen (n = 8) or the cage (n = 8). The frequency of behaviours was determined from instantaneous scans (Altman 1974), starting at the beginning of each 1-min sequence (ie n = 96 scans at each period).

The activities were classified into eight mutually exclusive categories as follows: i) feeding; ii) comfort behaviours related to body care: scraping, licking, yawning, stretching (McFarland 1981); iii) social and marking behaviours directed towards others: mutual grooming, licking, sniffing (or nose-to-body contacts); iv) aggressive encounters; v) investigatory behaviours: standing upright and activities related to equipment (licking, nibbling, gnawing or chin marking material); vi) locomotory behaviours involving movement of the whole body (McFarland 1981) ; vii) stereotypies, as defined by Murphy (1978): 'activities performed repeatedly in a fixed manner and in response to no discernible stimulus and with no discernible goal'. Some activities, essentially wire gnawing, which was considered as a stereotypy, were not easy to determine with certainty on an instantaneous scan. In cases of doubt, we let the tape run for a few seconds to observe the animal's movement to be sure which activity it was actually performing on the instantaneous scan; and viii) when no categorized activities were observed or when animals were hidden by other individuals lying on top of them, rabbits were considered to be resting.

Particular attention was paid to 'locomotion', which was studied by focal sampling during an uninterrupted 30min period from 0500h to 0530h (ie within a period of high activity). For each pen and cage, the total number of single, double, triple and quadruple hops was recorded during the 30min session and divided by the number of animals present in pens or cages to give an individual mean value. In addition, the number of events in which a rabbit performing a locomotory activity walked over a lying rabbit, were also recorded at 6 and 9 weeks of age; results were expressed as the number of 'walking over' events per 30min divided by the total number of rabbits per replicate (6 for the cages and 24 for the pens). The reaction of the rabbit that was being walked over was noted: a 'disturbance' being defined as a lying animal which moved because another animal was walking on it.

Lesions

The frequency and severity of scratches were observed on each rabbits' ears the day before slaughter, according to the following scores: 0 = absence; 1 = a single and superficial lesion;

2 = 2 or 3 superficial lesions; 3 = 1 or more severe lesions. The occurrence of lesions or injuries on other parts of the body was also checked.

Bone strength

After processing at the slaughter plant, two carcases of equivalent weight were selected from each pen and each of the eight cages used for behavioural observations. Right femurs were removed and carefully dissected. Their maximum diameter (mm) was measured at the mid point and they were weighed. The bones were then broken using a three point bend tensiometer (400 M Test System, MTS Systems, Ivry-sur-Seine, France) to measure their breaking strength and elasticity. The bones were positioned on supports 40mm apart and a load was applied at 5mm min^{-1} to the long axis of the bone. The breaking strength was the peak load (in Newtons) before the bone broke. The elasticity was assessed by measuring the bone deformation before rupture (vertical distance in cm covered by the load from the moment it entered contact with the bone to the moment the bone broke).

Productivity traits

Animals were individually weighed the day before slaughter (at 10 weeks). Feed conversion was calculated for each pen and for each cage. Dressing percentages (carcase weight divided by final liveweight) were calculated from the carcase weight data collected at the slaughterhouse.

Statistical analyses

For the behavioural observations, the means for all animals in a pen or in a cage were calculated and treated as single data points. Data that fitted a Gaussian distribution were analysed by a two-group *t*-test, while those that did not fit a normal distribution were subjected to the non-parametric Mann-Whitney *U* test. Qualitative values were analysed using chi-square tests.

Results

Behavioural traits

Results are given in Table 1. At 9 weeks of age, rabbits spent significantly less time resting in cages than in pens ($P < 0.05$). When compared to pens, animals in cages spent more time feeding at 9 weeks and in social activities at both 6 and 9 weeks ($P < 0.05$). Although some rare instances of aggression were reported by animal keepers (squeals, hairs found on the pen/cage floor), no aggressive encounters were observed during our scan and focal observations.

The frequency of locomotion was not significantly different between pens and cages (Table 1). However, in pens the mean number of double, triple and quadruple hops was higher than in cages at 6 weeks ($P < 0.01$), and tended to be so for quadruple hops at 9 weeks of age (Table 2).

Although rare, 'keeping watch' with the body held in an upright posture, was observed significantly more often in pens than in cages. At 6 weeks the numbers of upright postures performed within the 30min sessions were 0.7 in pens vs 0.4 in cages ($P < 0.01$). At 9 weeks of age, rabbits were also observed in upright attitudes more often in pens than in cages: 0.7 vs 0.2 respectively ($P < 0.01$). It is important to note that in cages, a full, upright posture was not observed. The minimum height required to perform a full upright posture was estimated to be about 50cm and this was clearly impossible in the 30cm-high cages.

Table 1 **Comparison of the behaviour of 6- and 9-week-old rabbits kept in cages (6 per cage) or pens (24 per pen). Values are the mean (± SEM) percentages from scan samples (n = 96) with one data point per pen/cage.**

Age	6 weeks		9 weeks	
	Cages (n = 8)	Pens (n = 8)	Cages (n = 8)	Pens (n = 8)
Resting	62.3 ± 1,3[a]	65.3 ± 1.3[a]	63.9 ± 1.0[a]	68.4 ± 1.0[b]
Feeding	14.6 ± 2.4[a]	13.5 ± 0.5[a]	10.5 ± 0.6[a]	8.9 ± 0.2[b]
Comfort	18.5 ± 0.4[a]	18.7 ± 0.9[a]	20.9 ± 0.9[a]	19.8 ± 0.9[a]
Social	1.4 ± 0.5[a]	0.4 ± 0.1[b]	1.7 ± 0.2[a]	0.5 ± 0.1[b]
Investigation	0.9 ± 0.2[a]	0.4 ± 0.1[a]	1.2 ± 0.3[a]	1.0 ± 0.1[a]
Locomotion	2.0 ± 0.5[a]	1.7 ± 0.1[a]	1.7 ± 0.3[a]	1.5 ± 0.8[a]
Stereotypy	0.2 ± 0.1[a]	0[a]	0.1 ± 0[a]	0[a]

Within the same age, data in a row lacking a common lettered superscript are significantly different ($P < 0.05$)

Table 2 **Number of single and multiple (2-4) hops performed during a 30min focal observation session by 6- and 9-week-old rabbits kept in cages (6 per cage) or pens (24 per pen). Values are the mean (± SEM) with one data point per pen/cage (sum of hops performed by all rabbits/number of rabbits in the cage/pen).**

Age	6 weeks		9 weeks	
	Cages (n = 8)	Pens (n = 8)	Cages (n = 8)	Pens (n = 8)
1	5,8 ± 0.8[a]	4.5 ± 0.3[a]	12.0 ± 1.0[a]	5.4 ± 0.5[b]
2	1.5 ± 0.3[a]	2.9 ± 0.3[b]	2.4 ± 0.6[a]	2.5 ± 0.3[a]
3	0.2 ± 0.1[a]	1.3 ± 0.15[b]	0.5 ± 0.2[a]	0.7 ± 0.1[a]
4	0[a]	0.4 ± 0.1[b]	0.05 ± 0.03[a]	0.2 ± 0.05[a] *

Within the same age, data in a row lacking a common lettered superscript are significantly different ($P < 0.01$). * $P = 0.058$

The mean (±SEM) number of 'walking-over' events per 30min per animal was not influenced by treatment at 6 weeks of age (cages 1.08 ± 0.14 vs pens 1.00 ± 0.11; $P = 0.648$), but was higher in cages compared to pens at 9 weeks of age (4.13 ± 0.71 vs 1.93 ± 0.15; $P = 0.009$). The number of disturbances per 30min per animal was low and was unrelated to treatment at both ages (cages 0.04 ± 0.03 vs pens 0.04 ± 0.01 at 6 weeks of age, $P = 0.253$; and cages 0.21 ± 0.06 vs pens 0.11 ± 0.03, $P = 0.169$ at 9 weeks).

Lesions

The distribution of ear lesions was clearly dependent on the housing system. The percentages of animals without any scratches were 64.9% in cages and 92.7% in pens respectively ($P < 0.01$). Ear scratches of slight or mean intensity (scores 1 and 2) were observed more frequently in cages than in pens respectively: 22.6% vs 7.3% (score 1) and 12.5% vs 0% (score 2). No score 3 lesions were observed. No lesions were noted on other parts of the body.

Bone strength

Results are given in Table 3. Although not significant, bone weight and breaking strength tended to be higher in rabbits kept in pens. Bone diameter was significantly higher in rabbits

kept in pens than in those housed in cages ($P < 0.05$). Deformation before bone breakage was lower in pens than in cages ($P < 0.05$).

Table 3 **Carcase weight and characteristics of the femur in 10-week-old rabbits kept in cages (n = 8, 6 per cage) or pens (n = 8, 24 per pen). Values are the mean (± SEM) with one data point per animal (2 animals per cage/pen were used for femur analyses).**

	Cage (n = 16)	Pens (n = 16)	*P* value
Carcase weight (g)	1442 ± 29	1447 ± 20	0.891
Bone weight (g)	10.1 ± 0.2	10.6 ± 0.1	0.061
Bone diameter (mm)	6.4 ± 0.1	6.8 ± 0.1	0.047
Bone deformation (mm)	1.5 ± 0.1	1.3 ± 0.1	0.038
Breaking strength (N)	299 ± 14	315 ± 11	0.392

Productivity traits

Results are given in Table 4. Liveweight ($P < 0.001$) and daily gain ($P < 0.001$) at 72 days, carcase weight ($P < 0.001$) and dressing percentage ($P = 0.032$) were lower in pens than in cages. Food conversion ratios were similar between treatments.

Table 4 **Influence of housing systems on productivity traits in rabbits kept either in cages (6 per cage) or pens (24 per pen). Values are mean (± SEM) with one data point per animal.**

	Cage (n = 168)	Pens (n = 192)	*P* value
Liveweight at day 32 (g)	695 ± 4	702 ± 3	= 0.167
Liveweight at day 72 (g)	2536 ± 12	2483 ± 11	< 0.001
Daily gain (gd^{-1})	44.9 ± 0.3	43.4 ± 0.2	< 0.001
Carcase weight (g)	1452 ± 7	1402 ± 7	< 0.001
Dressing (%)	57.3 ± 0.1	56.5 ± 0.2	= 0.032
Food conversion ratio (n = 8)	3.1 ± 0.1	3.1 ± 0.1	= 0.908

Discussion

In our previous observations (Morisse & Maurice 1997; 1999), rabbits spent more than 60 per cent of their time at rest. Their dominant activities were grooming (an essential part of their comfort behaviour) and feeding which became less frequent as rabbits became older.

In the present study, rabbits of all ages were more engaged in social activities in cages than in pens. In addition, nine-week-old rabbits spent more time resting in pens than in cages. The reason for this remains unclear. We hypothesize that, due to the tendency of rabbits to lie down in close contact with one another when resting, the space available for rabbits willing to perform locomotory activity was greater in pens than in cages. Although the stocking density was the same in cages and pens, housing fattening rabbits in pens may provide a means to give the animals more space to move. Resting rabbits might then feel more quiet and secure in pens than in cages because they are less disturbed by rabbits performing locomotory activities.

There was a lower incidence of ear scratches in pens compared to cages. However, we do not feel that these ear scratches were due to agonistic interactions. Instead, we suspect that they were related to rabbits walking on one another when moving. Our interpretation is

supported by the lack of aggressive encounters recorded, by the absence of score 3 ear lesions, and by the higher frequency of 'walking-over' events in cages than in pens at 9 weeks of age.

Of course, the occurrence of aggression cannot be excluded but, as reported by Lehman (1991), agonistic behaviour leading to injuries is related to sexual behaviour that generally does not occur before 11-12 weeks of age. This is confirmed by Rommers and Meijerhof (1998) who observed a much higher frequency of skin lesions at 80 days of age than at 73 days of age. Consequently, our results cannot be extrapolated to older rabbits. However, the best way of further reducing the frequency of ear lesions in rabbits, if financial considerations are excluded, would probably be to reduce the stocking density and to provide the animals with resting areas.

Although rare, the posture of 'watcher' with the body upright, was observed more frequently in pens (without a ceiling). It is obvious that 9-week-old rabbits in 30cm high cages can hardly adopt this posture. In the pens, we found that 80cm high walls were sufficient to prevent any escape.

The frequency of 'locomotion' was not greater in pens compared to cages. Nevertheless, when considering the modalities of locomotion, the focal recordings demonstrated that the frequency of double and triple hops was, as expected, higher in pens than in cages. Our results are concordant with Lehman's observations (1991) which demonstrated that caged rabbits were unable to perform normal locomotion involving two or more successive hops. In our cages, the higher frequency of single hops can be related to the afore-mentioned finding that at 9 weeks of age there were fewer rabbits resting in cages than in pens, due to the high frequency of walking over events.

It is generally accepted that the reduction of locomotion in cages reduces the breaking strength of bones in laying hens (Knowles & Broom 1990; Nørgaard-Nielsen 1990). Nevertheless, in rabbits, fractures are exceptional if animals are handled in a correct way. However, according to Stauffacher (1992), osteoporosis and skeletal abnormalities can arise in rabbits when locomotory movements are restricted. In our study, housing in pens induced some modifications: a slight increase in the weight and diameter of femur. Moreover, the lower vertical deformation just before breaking, at the place where loading was applied, can be interpreted as a lower elasticity, ie as a higher hardness of bone material.

Live and carcase weights were reduced by an average of 50g in rabbits kept in pens compared to cages. Our results are not consistent with the findings of Rommers and Meijerhof (1998) who reported that growth was independent of group size. Nevertheless, in our experimental conditions, performance in pens remained very competitive, with a daily gain of $43.4gd^{-1}$; Rommers and Meijerhof (1998) found that daily gains did not exceed $41gd^{-1}$ at the same age.

Despite a lower growth rate, the food conversion rate was not higher in rabbits housed in pens, although they had a lower growth rate. It can, therefore, be postulated that food intake was slightly lower in pens than in cages. This is supported by the lower feeding time observed at 9 weeks of age (Table 1). Our results did not allow us to distinguish between two possible explanations of this: i) accessibility to diet was more impaired in pens than in cages by rabbits lying against feeders; or ii) requirements for energy (and food intake) were reduced in animals kept in pens due to their lower activity. We consider that a small reduction in production performance (with no real economical impact) should not stand in the way of changes in housing which improve welfare.

Conclusion and animal welfare implications

The results of this study suggest that fattening rabbits may experience a higher level of welfare when housed in groups of 24 animals, in 1.6m² pens without ceilings, rather than in small groups of 6 animals in standard 0.4m² cages.

Penned rabbits spent more time lying down and, from the frequency of scratches on their ears, we may infer that crowding is less important than in cages. The total time spent in locomotion was unchanged but the way they moved was modified. In pens, despite the unchanged stocking density, the larger floor space allowed rabbits to perform more successive hops. In the absence of a ceiling, the upright posture of 'watcher', was observed more frequently in pens than in cages with a ceiling 30cm high (but the same observation would have likely been seen with a ceiling 50-60 cm high). Although bone deficiencies are unusual in fattening rabbits, housing in pens tended to improve bone hardness, to some extent, as measured in the femur. The small reduction of productivity observed in pens is of little importance, with regard to the improvement of welfare, in comparison with cages.

A further advantage of pens, although not evaluated in this study, is that they would allow more complete litters to be housed together, minimizing the number of young rabbits removed from their own litter. Moreover, pens, with their larger floor space, would be more appropriate for providing young animals with toys or accommodation (hiding places or hay) designed to enrich their environment. Further investigation would be necessary to confirm these last assumptions, as well as to determine the optimal group size for rabbits housed under these conditions.

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