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PERFORMANCE OF RABBIT DOES HOUSED IN COLLECTIVE PENS AND INDIVIDUAL CAGES

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Abstract: In society today, there is increasing concern for the welfare of farm animals. New models of rabbit breeding are proposed, such as group housing of rabbit does in a semi-group system or environmental enrichment of individual housing. This work aimed to evaluate the reproductive performance and metabolic aspects of rabbit does housed in collective pens, comparing them to individual cages provided with a platform. Forty-eight animals were distributed in 24 individual cages (40×98×57 cm; width, length and height) and four collective pens (six does per pen; 240×100×65 cm) and remained during four cycles. The does previously housed in collective pens gained less weight and reached lighter weights by the first insemination day (3669 *vs.* 3872 g; $P<0.01$), but regained weight over the cycles and had a similar weight during the experiment (4306 *vs.* 4329 g). It was observed that there was a lower feed intake in the period before delivery in collective pens, which contributed to the lower kit birth weights (57.2 *vs.* 60.1 g/kit for collective pens and individual cage respectively; $P<0.05$). There were no differences in perirenal fat thickness, litter size at birth and milk yield, although does housed in collective pens had a lower feed intake (499 *vs.* 526 g dry matter/d for collective pens and individual cage, respectively; $P<0.001$) and lost more perirenal fat after grouping (–0.05 *vs.* +0.15 mm for collective pens and individual cage, respectively; $P<0.05$), and produced less milk the day after grouping (221 *vs.* 283 g for collective pens and individual cage, respectively; $P<0.05$). In collective pens, a higher number of inseminations to reach a pregnancy (1.43 *vs.* 1.24 for collective pens and individual cage, respectively; $P<0.05$) and lower number of weaned (56 *vs.* 66 for collective pens and individual cage, respectively; $P<0.05$) kits per doe per year were revealed for does in individual cages. Overall, the use of collective pens prejudiced some parameters and needs to be economically evaluated for adoption on commercial rabbit farms.

Key Words: rabbit breeding, welfare, housing systems, semi-group system.

INTRODUCTION

Currently, modern society is increasingly demanding more attention to the welfare issues in current rabbit breeding systems. In some European countries, new rules are being implemented; the transition towards new housing systems to provide better living conditions is already taking place (European Commission, 2017). Moreover, this housing system is usually better valued by some consumers, paying a higher price for rabbits produced under more friendly conditions (Rommers and De Greef., 2018). Some alternate housing systems have been proposed, whose main goals is to increase the useful area, the activity level and to improve the behaviour of the housed animals. One system is based on an individual cage with a platform, improving the total area without the need to increase the dimensions of the current farms to house the same number of rabbits does. This collective housing system is gaining prominence (Szendrő *et al.,* 2016; Rommers and De Greef, 2018; Zomeño *et al.,* 2018; Szendrő *et al.,* 2019).

However, rabbit management in collective pens is extremely difficult due to the dispute among females to establish social hierarchy. On farms, rabbit does are constantly in states of pregnancy and lactation and in this latter period they

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present greater aggressiveness, mainly in the pre- and post-kindling period, which can increase the infanticide rate and injuries. Considering this problem, the latest developed systems have considered two different periods, where the rabbit does remain part of the time as a collective and part in individual units. This alternative is commonly called the semi-group or part-time system (Graf *et al.,* 2011; Maertens and Buijs, 2013; Rommers *et al.,* 2014; Buijs *et al.,* 2015; Maertens *et al.,* 2015; Cervera *et al.,* 2017; Rommers and De Greef, 2018; Zomeño *et al.,* 2018; Szendrő *et al.,* 2019).

In the management of a semi-group, with cycle of 42 d between parturitions, the rabbit does are separated at 28 d of pregnancy and re-grouped when the kits are 18 d of age. This schedule is important to ensure greater independence of the kits (Buijs *et al.,* 2014, 2015; Cervera *et al.,* 2017). Although the purpose of this system is to improve the housing conditions of the rabbit does, the establishing of a new hierarchical scale will take place in every regrouping, causing agonistic behaviour between the animals, increasing the occurrence of injuries that can impinge on animal welfare and increase the number of culled rabbit does (Rommers *et al.,* 2006; Graf *et al.,* 2011; Szendrő and McNith, 2012; Szendrő *et al.,* 2016, 2019; Cervera *et al.,* 2017; Rommers and De Greef, 2018; Zomeño *et al.,* 2018). In addition, it is not clear how these housing systems can compromise rabbit performance.

Thus, considering the previous information and the lack of experimental results that clarify which housing conditions are suitable for rabbit farms, this work aims to evaluate and compare metabolic aspects and productive performance between rabbit does housed in collective pens and individual cages.

MATERIAL AND METHODS

Housing conditions

This research was carried out at the experiential farm of Universitat Politècnica de València (UPV), with average temperatures from 16 to 21°C. The lighting schedule was 16 h of light and 8 h of dark, and the building was artificially ventilated. The experimental proceedings were approved by the UPV ethics committee as set forth in Royal Decree 53/2013 on protection and use of animals for experiments (BOE, 2013).

The dimensions of the collective pens (Figure 1) were 240×100×65 cm (width, length and height). These measures include nests for the 6 rabbits, each measuring 40×22×37 cm. Due to the inclusion of the nests, the height of the collective pen increased by 8 cm at the bottom. Individual cages (Figure 2) were 40×98×57 cm with a wire mesh platform (40×26 cm) installed at 22 cm height. All cages and pens had a plastic footrest per doe to prevent footpad injuries.

Four days before parturition, the rabbit does from the collective pens were housed individually by adding wire walls (100×80 cm of length and height) to divide the pen. Next, the nests were provided to all pregnant does in both housing systems. After 18 lactation days the wire walls were removed, again transforming the individual spaces into a collective pen. Does were housed in groups with their litters until 28 d of age, when kits were weaned. Afterwards, if necessary, the group of rabbit does was redefined by adding or removing some of them.

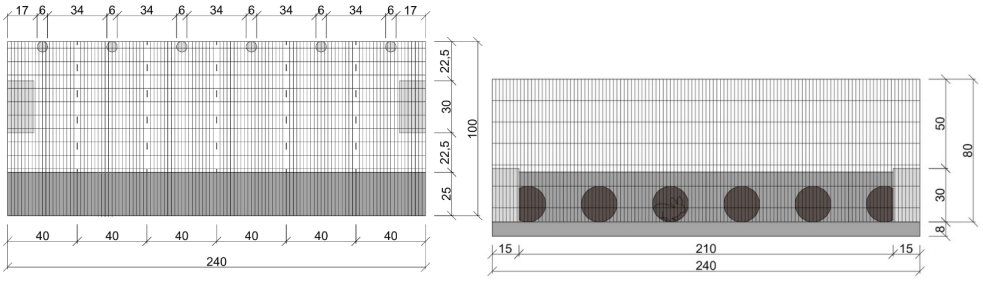

Figure 1: Top view and front view of collective pens. Distances in cm.

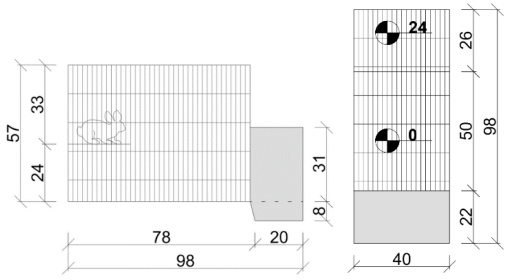

Figure 2: Side view and top view of individual cage. Distances in cm.

Animals and experimental procedure

The present work evaluated the performance of the rabbit does and their litters over four reproductive cycles. One and a half months before the first artificial insemination (AI), 48 rabbit does (14 wk of age, crossbred from maternal lines H and LP, Polytechnic University of Valencia-UPV) with 3000 g of body weight (BW) were allocated randomly into the two housing systems chosen: collective pens (n=24 rabbit does, 6 does per pen) and individual cages (n=24 rabbit does). The animals had free access to fresh water through automatic drinkers and were fed *ad libitum* with a commercial pelleted diet (composition: 91% of dry matter (DM), 8% of ash, 17% of crude protein, 34% of neutral detergent fibre, 17% of acid detergent fibre and 3.2% of lignin).

Data from 161 kindling (70 in collective pens and 91 in individual cages) and 148 weaning periods (62 and 86, respectively) were recorded. The traits measured for rabbit does were BW, feed intake and perirenal fat thickness (PFT). BW was controlled at the first day of housing, first AI day, as well as 27 d of pregnancy, and at kindling and 18 and 28 d of lactation in each reproductive cycle. Feed intake was calculated in four periods: from 27th day of pregnancy to kindling (27P-K), from kindling to 18 d of lactation (K-18L), from 18 d of lactation to weaning at 28 d (18L-W) and from weaning to 27th day of pregnancy (W-27P). The PFT of rabbit does was measured at kindling and at 18 and 28 d of lactation by ultrasound to evaluate body condition, as described by Pascual *et al.* (2004).

The reproductive rhythm adopted after first kindling was 42 d, in which the rabbit does were inseminated 11 d after the kindling and every 21 d if not pregnant. AI was done using polyspermic semen of R line (selected for growth rate, UPV), supplying GnRH hormone by intramuscular injection. No oestrus synchronisation was performed. Pregnancy was tested by manual palpation at 11 d post-AI. In addition, the number of attempts to get a doe pregnant, as well as the elapsed period between two consecutive pregnancies, was recorded.

The litter traits evaluated were the number of total and live kits and total and live litter weights. After kindling, the litters were standardised to 9 kits at first cycle (parturition) and to 10 kits in the following ones.

Additional traits included the time life of rabbit does (days from first AI to 4th weaning or dead or elimination), number of kindlings and weaned litters, as well as the total and annual number of live born, weaned and slaughtered kits.

Daily milk yield was measured using 26 rabbit does (13 of each housing system evaluated) at second or third cycles, weighing the does before and after kits' suckling. Milk yield during first and second weeks of lactation were measured 4 d a week, between Tuesday and Friday, and every day from 15th to 25th days. To prevent free nursing, kits were contained in closed nest boxes between nursings from kindling to 18 d of age and allocated to a separate cage from 18 to 25 d. In collective pens, the kits were separated into another cage and cages were grouped together after 18 d of age. During the milk production evaluation, doe feed intake was measured from kindling to 18th day of lactation (K-18L) and separately recorded doe and litters feed intake from 18th to 25th day of lactation (18L-25L). For feed intake determination, the litters were kept in other cages.

Statistical analysis

All traits were analysed by ANOVA using the Statgraphics Centurion program, considering two different housing systems (collective pens *vs.* individual cages). The number of kits was used as a covariate to analyse litter weight at birth. The value of 5% ($P<0.05$) was considered the level of significance. In the analysis of live born kits, total kits born and litter weight at kindling, the cycle order (1 to 4) and their interaction were added as model factors. For BW, feed intake and PFT of rabbit does, and litter size and weight analyses, the cycle order and the period inside the cycle (0, 18 and 28 d of lactation) and their interactions were added as model factors. For milk production analyses, the cycle order and the day of lactation (1 to 25), and their interactions were added as model factors. Means were compared with least significant difference (equilibrated groups) or Scheffe (not equilibrated groups) tests.

RESULTS

Rabbit does' traits during the experiment are described in Table 1. Considering the period prior to the first AI, the rabbit does housed in collective pens had lower growth than those housed in individual cages (-5 g/d; $P<0.01$), and thus reached their first insemination with lower BW (–203 g; $P<0.01$). However, considering all the experimental periods, there were never differences in the doe BW.

The development of feed intake of rabbit does and litters throughout the cycle was as expected in both groups (Table 1), being lower the day before kindling and higher at 18L-W, but the feed intake in individual cages was higher than in the collective pen in period 27P-K (+12 g DM/d; $P<0.05$) and in the 18L-W period (+27 g DM/day; $P<0.001$), except in the first cycle (Figure 3).

There were no differences between housing systems for PFT (Table 1). For all cycles, the PFT increased during the lactation period ($P<0.001$), except for the first cycle when the rabbit does in the collective pens lost PFT at the 18L-W period (–0.38 mm) but maintained PFT in individual cages (Figure 4). It was observed that the thickness of the perirenal fat declined as the cycles advanced ($P<0.001$) in both groups.

Reproductive performance and total productivity of rabbit does are shown in Tables 2 and 3, respectively. The number of inseminations to get a doe pregnant was higher in collective pens ($P<0.05$), while the number of days to achieve a new pregnancy was similar for both housing systems (Table 2).

The litter size at kindling was similar between the housing systems (live and total born kits). The weight of the litter at kindling and the individual weight of live born kits were higher in individual cages (+25 and +3.00 g, respectively; $P<0.05$).

Table 1: Traits for rabbit does during the experiment in different housing systems.

Traits of rabbit does	COL	SE_{COL}	IND	SE_{IND}	*P*-value
Daily weight gain before first insemination	12.7	1.28	18.1	1.28	0.0046
BW at first insemination (g)[1]	3669	47.93	3872	47.93	0.0045
Average BW (g)[2]	4306	22.2	4329	18.9	0.4429
Feed intake (g DM/day)					
W-27P	194	4.77	191	4.17	0.5282
27P-K	142	4.92	154	4.17	0.0417
K-18L	384	4.93	373	4.20	0.0504
18L-W	499	4.92	526	4.17	<0.001
Perirenal fat thickness at first insemination (mm)	7.27	0.10	7.30	0.10	0.8202
Average perirenal fat thickness (mm)[2]	6.43	0.04	6.49	0.03	0.2016

[1]covariable= Initial weight ($P<0.001$).

[2]All evaluation days, all cycles.

COL: rabbit does housed in collective pens; IND: rabbit does housed in individual cages; SE: standard error of the means; DM: dry matter; BW: body weight; W-27P: period from weaning to 27th day of pregnancy; 27P-K: period from 27th day of pregnancy to kindling; K-18L: period from kindling to 18 d of lactation; 18L-W: period from 18 d of lactation to weaning.

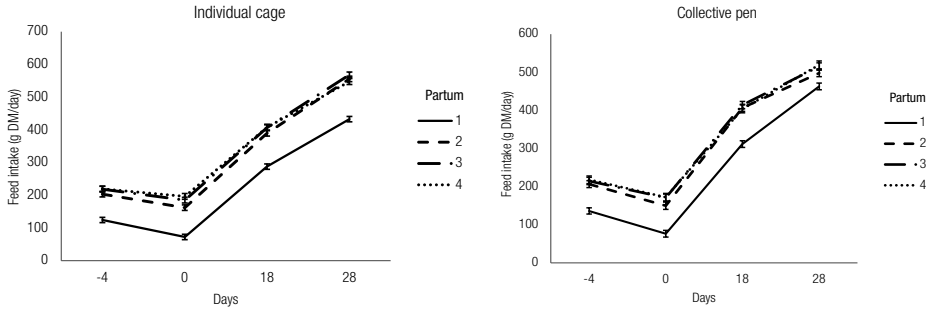

Figure 3: Feed intake (g dry matter/d) of rabbit does and litters from weaning to 27 d of gestation (–4), 27 d of gestation to kindling (0), kindling to 18 d of lactation (18) and 18 d of lactation to weaning (28) during four cycles (partum)).

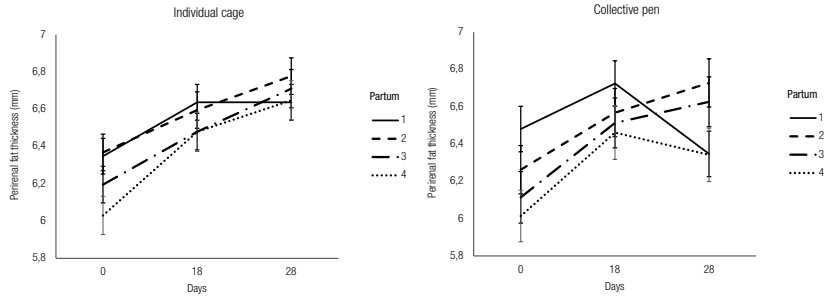

Figure 4: Perirenal fat thickness (mm) of rabbit does at the kindling day (0), 18 d of lactation (18) and 28 d of lactation (28), during four cycles (partum).

At 18 and 28 d, the litter size was higher in individual cages ($P<0.05$), but there were no significant differences in litter weight and the average kit weights at weaning was the same (582 g).

The lifetime productivity of does in the collective system was lower (–35 d), although the difference was not significant (Table 3), and there were no differences in the number of kits weaned per doe between the housing systems. However, does from collective pens produced a lower number of kits at kindling and at weaning than rabbit does

Table 2: Reproductive performance of rabbit does in different housing systems.

Traits	COL	SE_{COL}	IND	SE_{IND}	*P*-value
No. of AI to get pregnant	1.43	0.06	1.24	0.06	0.039
Days to get pregnant	18.30	1.69	17.39	1.40	0.680
Liveborn kits	10.08	0.46	10.54	0.39	0.457
Total born kits	10.86	0.39	11.07	0.33	0.690
Litter size at 18 d	9.38	0.08	9.59	0.07	0.026
Litter size at weaning	9.24	0.08	9.49	0.07	0.026
Weight of liveborn litter (g)[1]	595	20.8	620	17.7	0.024
Weight of individual liveborn kit (g)[1]	57	1.08	60	0.91	0.017
Weight of litter at 18 d of lactation	2802	59.5	2815	50.3	0.819
Weight of litter at 28 d of lactation	5369	29.5	5527	50.3	0.200
Weight of individual weaned kit (g)	582	8.1	581	6.8	0.9285

[1]covariable= litter size ($P<0.001$); AI= artificial insemination.

COL: rabbit does housed in collective pens; IND: rabbit does housed in individual cages; SE: standard error of the means.

Table 3: Total productivity of rabbit does in different housing systems considering 4 cycles and the projection for 1 yr.

Traits	COL	IND	SE	*P*-value
Time in the assay (d)	147	182	14.98	0.103
Number of kindlings per doe	3.2	3.8	0.21	0.048
Number of weanings per doe	3.1	3.7	0.22	0.046
Number of liveborn kits per doe	35.0	39.6	2.72	0.212
Number of weaned kits per doe	30.7	35.4	1.86	0.062
Number of liveborn kits per doe year^{-1}	63	73	4.77	0.109
Number of weaned kits per doe year^{-1}	56	66	3.18	0.025

COL: rabbit does housed in collective pens; IND: rabbit does housed in individual cages; SE: standard error.

housed in individual cages ($P<0.05$). Consequently, when the values were considered on an annual basis, rabbit does in individual cages produced more weaned animals (+10 and +9 kits; $P<0.05$) than does in collective pens.

The average milk production and feed intake from kindling to 25 d of lactation were similar in both groups, but there were some differences between groups in each cycle (Table 4). The rabbit does ate more feed and produced more milk at third cycle than in the second one in the individual cages, achieving the highest milk production ($P<0.05$), but in collective pens the increase in feed intake at third cycle was lower and milk production did not increase. The feed intake of rabbit does during the K-18L period was similar in both groups, but during the 18L-25L period the rabbit does housed in the collective pens showed a smaller increase in feed intake than in the individual cages (+37 *vs.* +88; $P<0.05$). A higher feed intake for kits ($P<0.01$) was observed from individual cages. The regrouping of rabbit does and kits caused a reduction ($P<0.05$) in milk yield at day 19 (Figure 5).

DISCUSSION

In the process of adaptation to the new housing system, the animals in collective pens had a slower growth rate that those housed in individual cages. This slower growth was probably caused by a chronic stress associated with the displacement and reluctance to eat according to their hierarchical position. However, the adaptation process to new conditions seemed to be temporary, because these animals regained weight after the first insemination. This trend was also reported by Buijs *et al.* (2015), who realised that animals housed in collective pens lost more BW only at the first cycle. Mugnai *et al.* (2009) and Zomeño *et al.* (2018) observed similar results and did not detect differences between the BW of the animals housed in individual cages and collective pens during the whole trial period.

There were differences in the feeding behaviour of rabbit does, mainly related to the order of reproductive cycles. When the parity order increases, the feed intake increases too. The period 27P-K is critical and characterised by a

Table 4: Milk production (g/d) and feed intake (g dry matter/d) of rabbit does and kits in different housing systems and parturitions.

	Collective	Individual	SE	*P* group	*P* cycle	*P* gxc	*P* gxp
Milk production of does							
Cycle 2	231^{ab}	225^{a}	4.65	0.667	0.015	0.040	0.101
Cycle 3	233^{ab}	243^{b}	3.95				
Feed intake of does							
K-18L	392^{a}	377^{a}	11.34	0.353	0.008	0.398	0.029
18L-25L	429^{b}	465^{c}	11.34				
Feed intake of kits							
18L-25L	5.0^{a}	6.8^{b}	0.44	<0.010	0.218	0.218	-

^{a,b,c} Means within a trait not sharing any superscript are significantly different at $P<0.05$.

K-18L: period from kindling to 18 d of lactation; 18L-25L: period from 18 to 25 d of lactation

SE: standard error; P group: *P* value for the two housing system; *P* cycle: *P* value for second or third cycles; *P* gxc*: P* value of interaction between groups and cycles; *P* gxp*: P* value of interaction between groups and periods.

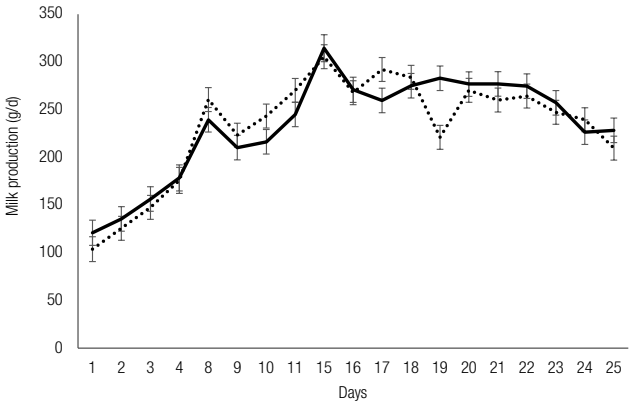

Figure 5: Milk production of rabbit does housed in collective pens and individual cages from first to 25th day of lactation. ·····: Collective; ——: Individual.

lack of appetite (Figure 3). However, the individualisation of rabbit does allocated to collective pens after 21 d together can stimulate their nesting behaviour and contribute to the lower level of feed intake of rabbit does housed in pens during this period (Table 1), which contributes to the lighter litter weights at partum (Table 2). After kindling, collective rabbit does increased their feed intake more than the individual ones during 18 d of lactation, but the regrouping of animals reduced this increment. This lower feed intake in collective pens after regrouping seemed to affect daily milk yield, and consequently the growth of their litters (Zomeño *et al.,* 2018).

In our investigation, there were no differences for milk production between rabbit does housed in individual cages and collective pens (Table 4), nor differences in litter weights during lactation. There was only a reduction in milk yield immediately after regrouping of animals (day 19) housed in collective pens (Figure 5), probably due to an increase in stress related to aggressive behaviour (Rommers and De Greef, 2018), which could increase the blood level of stress-related substances.

Attention should be given to the difference between feed intake of rabbit does observed for 19L-25L and K-18L periods between groups. In individual cages, the difference obtained was +88 g, and in the collective pens it was only +37 g. It is suggested that the period after regrouping is very stressful and this affects the feed intake level but not milk production. Mugnai *et al.* (2009) and Zomeño *et al.* (2018) found higher milk production in collective pens, although these studies only evaluated the first 16 d of the lactation. In addition, kits from individual cages ingested more feed during 19L-25L period.

An adequate mobilisation of lipid reserves is a key point for the reproductive success of rabbit does (Pascual *et al.,* 2004). During the first cycle, the rabbit does still have limited feed intake capacity and thus mobilise greater amounts of fat reserves to meet the huge demand of energy for milk and for their own growth. These circumstances could explain the fall in the PFT after day 18, but only in the first reproductive cycle in both groups (Figure 4) (–0.01 and –0.38 mm for individual cages and collective pens, respectively). This finding could explain the lower number of rabbit does that became pregnant eleven days after first kindling and the PFT recovery of non-pregnant ones. The PFT in successive parturitions increased from 18 to 28-d in individual cages (+0.19 mm), but not in collective pens (+0.04), which could affect the next cycles of rabbit does. Cervera *et al.* (2017) found a lower PFT in rabbits housed in collective pens with values higher than those observed in this experiment (7.0 *vs.* 6.7 mm).

The option of collective pens seemed to decrease the total reproductive rates (Table 2 and 3). Rommers *et al.* (2006) associated the lowest reproductive performance in collective pens to pseudopregnancy, confirmed by a higher level of progesterone in the blood of these animals. Mugnai *et al.* (2009) pointed out that in addition to the pseudopregnancy state, the reduced fertility may be due to the increased concentration of prolactin and corticosteroids in rabbit does under stress situations. Moreover, both authors perceived a lengthening of the kindling interval in collective pens. In

our research, does required a greater number of AI and, consequently, fewer kindlings per rabbit doe in collective pens was observed. These results could corroborate this statement. During the experiment it was common to observe some rabbit does trying to mate with each other when they were together. On the other hand, Cervera *et al.* (2017) did not perceive an increase in the number of inseminations to pregnancy when does were raised in collective pens.

The litter size and the number of days to achieve a new pregnancy were similar in both groups. This seemed to indicate that the housing system did not influence these traits. Maertens and Buijs (2016), Cervera *et al.* (2017) and Zomeño *et al.* (2018) reported similar results for the number of kits born per litter between different housing systems. A heavier litter weight of liveborn kits observed for the individual cages seems to be related to the higher feed intake in the period 27P-K, providing more nutrients towards pregnancy of these rabbit does.

The present results for litter size at 18 and 28 d between individual cages and collective pens were similar to the findings of Maertens and De Bie (2017) and Zomeño *et al.* (2018). However, Cervera *et al.* (2017) observed a higher number of kits in individual cages at the same age. Different results obtained by these researchers could be due to greater competition among the kits after the regrouping of the rabbit does. Likewise, weaker kits can be the result and it seems that this effect is higher or lower depending on the experimental conditions considered. All values of both housing systems are satisfactory from a productive point of view and similar to those reported by Mikó *et al.* (2014), Maertens and Buijs (2016) and Cervera *et al.* (2017) and better than those presented by Mugnai *et al.* (2009).

The total productivity traits are very important for rabbit farm management. It is noted that a clear trend was a shorter life in collective pens and a reduction in the number of kindlings and weanings, mainly due to a high number of culled rabbit does early in their reproductive life, as also observed by Mugnai *et al.* (2009). In our research, more rabbit does completed the four parturitions in individual cages compared to those in collective pens (76 *vs.* 52%) and a lower number of them were culled before 2nd parturition (8 *vs.* 32%). The lower number of kindlings in collective pens also seems to be influenced by a possible incidence of pseudopregnancy, as also noted by Mugnai *et al.* (2009). When the number of weaned kits are considered annually, the collective pens produces fewer kits, as verified by Mugnai *et al.* (2009) and Maertens and Buijs (2016).

CONCLUSIONS

Rabbit does housed in collective pens had lower weight gains before first insemination, but recovered in the following cycles. The feed intake in the 4 d before kindling was lower in does housed collectively and this contributed negatively to kit weights at birth. The regrouping of lactating rabbit does into collective pens caused a lower feed intake of rabbit does and a lower feed intake of litters.

The housing system did not modify the PFT or litter size at birth, but litter size at weaning was lower in collective pens. In addition, milk production was similar between housing systems, but the regrouping caused a steady decrease in milk production in rabbit does housed in collective pens. Likewise, fertility rates and the total number of weaned kits per year decreased in collective pens.

Further research on housing systems is needed to formulate new recommendations.

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