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Effects of communal rearing and group size on breeding rabbits' post-grouping behaviour and its relation to ano-genital distance

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Abstract

Group housing is becoming the standard for many farm animal species, as it is seen as a more welfare friendly way of keeping gregarious animals. Aggression between female breeding rabbits currently obstructs the implementation of group housing for this species. Lack of social experience during the rearing period may be one reason why breeding rabbits can act (excessively) aggressive when grouped as adults. To study this, we either reared breeding rabbits with their same-litter siblings and mother only ("litter-only") or reared four litters and their mothers together from 18 days of life on ("communal rearing"). The litter-only rabbits were born from individually housed mothers, whereas the communally reared rabbits

were born from mothers that were group housed during the last three weeks of gestation. After their first kindling, female rabbits from both rearing strategies were housed in groups of four or eight individuals (at an equal space allowance per doe) to assess rearing and group size effects on post-grouping behaviour. Within both treatments we also measured the ano-genital distance at birth (an indicator of masculinization) and studied its relation to adult agonistic behaviour. Communal rearing and larger groups were expected to decrease agonistic behaviour and wounding, whereas rabbits with a longer ano-genital distance were expected to show more offensive agonistic behaviour. The first two hypotheses were not confirmed. Communally reared and litter-only rabbits did not differ significantly in the frequency of their offensive or defensive agonistic behaviour directly post-grouping, or in the severity of wounds sustained in the first three days after grouping ($P>0.10$). Communally reared rabbits sniffed/groomed their pen mates less often than litter-only rabbits ($P<0.05$). A tendency for a higher frequency of offensive agonistic behaviour in larger groups was found ($P<0.10$) and the decrease in defensive agonistic behaviour over time that was observed for the smaller groups was lacking in the larger groups. The third hypothesis was confirmed: female rabbits with a greater ano-genital distance at birth showed more offensive agonistic behaviour upon grouping as adults ($r_s=0.5$, $P<0.05$). When this relation was studied within the separate rearing strategies, it was only confirmed within the communal rearing treatment, possibly suggesting that prenatal social stress increased both ano-genital distance and aggression. To conclude, communal rearing and larger groups did not decrease agonistic behaviour in breeding rabbits, whereas ano-genital distance measurements may be useful when selecting less aggressive breeding rabbits (although this method may be specifically applicable to communally reared rabbits).

Keywords: Agonistic behaviour; Social behaviour; Pre-natal effects; Masculinization; Early experience; Group housing

1. Introduction

Over the last decades there has been a trend towards group housing for many farm animal species. Adult female breeding rabbits are still almost exclusively housed separately from each other, but the interest in group housing is increasing. However, one of the problems in group housing of breeding rabbits is that they can be quite aggressive towards each other, leading to a high percentage of wounded animals (Andrist et al., 2013). Semi-group housing systems for breeding rabbits have been developed in an attempt to decrease aggression. In such systems, breeding rabbits are separated shortly before parturition until several weeks later, to be grouped again afterwards until shortly before their next kindling. This means that they cannot fight and wound each other at the time of the reproductive cycle they are most likely to do so. Also, they cannot kill or wound each other's litters when these are still very young, immobile and vulnerable (a behaviour observed both in wild (Kunkele, 1992; Rodel et al., 2008) and commercial breeding rabbits (Szendro and Mcnitt, 2012)). However, post-grouping aggression and wounding are still common in these semi-group systems (Buijs et al., 2015; Rommers et al., 2014).

One reason why female breeding rabbits show high levels of aggression when grouped may be that the breeding rabbits used for group housing experiments are generally bred in individual systems themselves. This means that during their pre-reproductive phase they are only exposed to their own mother and same-litter siblings. This may not prepare them sufficiently for regrouping with unrelated animals at a later age. However, if group housing is combined with current management practices, this will lead to frequent regrouping as does that do not become pregnant upon insemination are currently moved to different production groups (in order to inseminate them again at an earlier time than those that did become pregnant). Even the introduction of one unfamiliar individual in an otherwise stable group can lead to an increase in aggression towards both the unfamiliar animal and the resident rabbits (Farabollini et al., 1991). In pigs it has been shown that exposure to non-littermates prior to weaning can decrease post-weaning aggression, accelerate post-weaning hierarchy

formation and decrease skin lesions (D'Eath, 2005; Kutzer et al., 2009). It is unknown if similar effects can be achieved for rabbits, but if so, rearing them in a communal system (thus exposing litters to each other at an early age) could facilitate the successful implementation of group systems for adult breeding rabbits. Pre-weaning exposure to non-littermates is unlikely to cause conflict between young rabbits as these are generally non-aggressive (Verga et al. 2006) and show a strong tendency to huddle rather than to avoid each other (Princz et al. 2008).

Alterations in group size may also affect aggressive behaviour. If space allowance per animal is kept constant, larger groups will have more space available in total, which would allow individuals to withdraw further from aggressive conspecifics. This could be expected to reduce agonistic behaviour. Conversely, larger groups have more hierarchy positions to resolve, which may call for increased agonistic behaviour in larger groups (Arey and Edwards, 1998). Research on the effects of group size on aggression in captive breeding rabbits is currently lacking and therefore we formulated our group size hypothesis based on existing knowledge obtained in a highly experimental and wild setting, respectively. Non-breeding adult laboratory rabbits tested in pairs are less aggressive when their first pairing occurs in a larger pen (Valuska and Mench, 2013) and research on wild populations suggests that female rabbits are more aggressive in smaller groups (Myers et al., 1971). Together, this would suggest that in larger groups breeding rabbits should be expected to show less aggression, assuming that behaviour in highly experimental and wild setting can be extrapolated to breeding rabbits in a husbandry setting.

A third way to reduce aggression could be to select less aggressive animals for group housing. To do so, a reliable pre-grouping indicator of adult aggression would be required. In this study, the use of ano-genital distance at birth was evaluated for this purpose. This was based on the knowledge that masculinization of female rabbits due to their intra-uterine position increases ano-genital distance (Banszegi et al., 2010) and that in other species the

same process leads to increased adult aggression (Cohen-Bendahan et al., 2005; Gandelman, 1980).

To study the effects of previous social experience on the behaviour of adult female breeding rabbits, two rearing strategies were used. “Litter-only” rabbits were reared with littermates and their mother only and housed individually as sub-adults (as is commercial practice). “Communally reared” rabbits were reared in groups of four litters and their mothers from 18 days of age on and were housed in groups as sub-adults. After their first kindling, rabbits from both rearing strategies were housed in groups of either four or eight rabbits and their litters, at an equal space allowance per breeding rabbit. The communally reared rabbits and rabbits from larger groups were expected to show fewer agonistic interactions and sustain fewer wounds than litter-only rabbits and rabbits from smaller groups. Individuals with a shorter ano-genital distance at birth were expected to initiate fewer agonistic interactions when grouped as adults.

2. Methods

All procedures were approved by the ILVO ethical committee for the use of animals in research. Table 1 gives an overview of housing and procedures which are clarified further in the next sections.

2.1 Parent stock and juvenile experimental rabbits

Maternal parent stock (Hycole, Marcoing, France) was selected after the weaning of their first litter (when 29 weeks old). Parent stock that was to produce experimental rabbits for litter-only rearing was housed in single-doe cages, whereas parent stock intended to produce rabbits for communal rearing was housed in semi-group pens.

These two housing systems, and their effects on behaviour and welfare of the parent stock, have been described in more detail in (Buijs et al., 2014; Buijs et al., 2015). Briefly, single-doe cages (Meneghin s. r. l., Povegliano, Italy) had 0.4 m^2 floor space and 0.1 m^2 platform space, representing the modern commercial standard. Each cage housed one breeding rabbit and her litter. Semi-group pens (Van der Vinne, Brucht, The Netherlands), had 2 m^2 floor space, one 0.6 m^2 platform, and housed four breeding rabbits and their litters (Figure 1). Three days before kindling these pens were divided into four units by adding partitions. The four units had an equal floor space and platform space, and housed one breeding rabbit and her litter to avoid aggression in the first period following kindling. On the day of birth, each litter was standardized to ten kits by cross-fostering within rearing treatment and removal of non-viable kits (as is commercial practice). When the litters were 18 days old the partitions of the semi-group pens were removed, allowing communally reared litters and their parent stock to interact. Breeding rabbits were barred from access to the nest-boxes from this day on (to provide a safe haven for the kits in case of attacks by adults). Separations underneath the platform offered options for partial physical and visual withdrawal.

Prior to the birth of the experimental rabbits, the parent stock had kindled twice in these housing systems. The same does were used during all three reproductive cycles except when these did not become pregnant upon insemination, in which case they were replaced. A different group composition was used in each reproductive cycle (i.e. all parent stock of communally reared rabbits was unfamiliar with each other when grouped), but parent stock always stayed within the same housing type. Parent stock was moved to new cages or pens 31 days after kindling, thus weaning the litters which remained in the system.

During this first phase we measured the ano-genital distance and birth weight of the experimental rabbits. On the day of birth new rabbits were collected as soon as detected, placed underneath a heat lamp to avoid cooling and the ano-genital distance was determined using digital callipers (Absolute Digimatic, Mitutoyo, Kruibeke, Belgium). Three measurements were made on each individual, which were subsequently averaged. However, if the three measures were not within 0.25 mm of each other the measure was repeated and the average of the second set of measurements was used (unless these were once again not within 0.25 mm, in which case the measurement was discarded). Subsequently the rabbits were weighed, chipped for electronic identification and returned to the nest.

2.2 Experimental rabbits in the pre-productive period

The experimental rabbits (Hycole × Hycole) were selected from the parent stock's fourth litter. To create approximately equal space allowances per rabbit remaining in the system after weaning, 6 rabbits were left per cage for the litter-only rearing strategy, whereas 32 rabbits per pen were left for the communal rearing strategy (i.e., 833 vs. 813 cm^2/rabbit). At 10 weeks of age, all males were removed.

From 12.5 weeks of age on, communally reared rabbits were housed in groups of four animals in the semi-group pens described previously. All four animals per group had previously been reared together in the same pen. Litter-only rabbits were housed in the same pens, but for this rearing strategy the pens were divided into four equal units allowing individual housing (0.5 m^2 floor space + 0.15 m^2 platform space per rabbit). All walls were made of wire, thus rabbits from both strategies were in continuous visual, auditory and olfactory contact. Water and access to a simple cage enrichment (a wooden gnawing block) was provided ad-libitum, as was a commercial pelleted rabbit feed (except from 32 to 56

days and from 70 to 118 days of age when feed was limited to prevent enteropathy and obesity, respectively).

Measures collected during the pre-reproductive phase (behavioural tests) are reported in Buijs and Tuyttens (2015).

2.3 Housing and management of experimental rabbits in the reproductive period

Seven days prior to insemination partitions were placed in the communally reared rabbits' pens allowing individual housing to avoid infertility due to mounting-induced pseudo-pregnancy (Rommers et al., 2006). These were removed two days after insemination (Table 1). Three days prior to kindling the communally reared rabbits were separated again, to avoid aggression in the immediate post-kindling period. At this time, non-pregnant breeding rabbits were removed from the experiment. Also, all rabbits were moved to different individual units in such a way that when the partitions were removed when their litters were 18 days old, all breeding rabbits were grouped with unfamiliar conspecifics. From this moment on, all experimental rabbits (i.e., both communally reared and litter-only reared) were group housed. Six groups were formed per rearing strategy (three groups of four and three groups of eight) by removing either three or seven partitions (thus, creating pens of 2x1 m and 4x1 m). Two straw rolls were supplied per pen, intended as environmental enrichment. Feed and water were available ad libitum.

Behaviour was analysed using overhead cameras. In each pen, two adult rabbits were observed continuously during the first two hours directly after grouping (all rabbits had been marked using non-toxic animal dye prior to grouping to facilitate individual recognition). Rabbits were selected in such a way that their pre-grouping locations (i.e., the location of

their separate unit within what would become the group pen upon removal of the separators) were as distributed as possible. The frequencies of offensive agonistic behaviour (attacking, fighting, chasing, threatening), defensive agonistic behaviour (fleeing and withdrawing), resting in bodily contact (focal and any other adult pen mate sitting/lying in contact for at least 20 s) and social sniffing/grooming (focal sniffing or allo-grooming an adult pen mate) were recorded. Manipulation (focal scratching an adult pen mate or pulling its fur, skin or ear) was recorded, but not analysed due to its low occurrence.

Immediately prior to grouping and three days after grouping, the number and severity of wounds on each of the 72 adult rabbits was scored to assign each rabbit to a wound category based on the increase of lesions. Animals were categorized on a 0-3 scale according to (Rommers et al., 2014) (0: no increase in lesions, 1: one to four additional short superficial lesions, 2: one to four additional long superficial or short deep lesions, or at least five additional short superficial lesions, 3: at least one additional deep long lesion, or at least five additional long superficial or short deep lesions).

2.4 Statistical analysis

All analyses were performed in SAS 9.4. The effect of maternal housing on female offspring's birth weight and ano-genital distance were analysed in a linear model with maternal housing as the only independent variable. Behaviour was analysed using a generalized linear model assuming an underlying Poisson distribution. Rearing strategy, group size, hour and their interactions were included as fixed factors and rabbit and pen as random factors. Wound categories were analysed using a cumulative logistic model with rearing strategy, group size and their interaction as fixed factors and pen as a random factor. Spearman correlations were used to assess the relation between physical characteristics at birth (ano-genital

distance and weight) and post-grouping agonistic behaviour. As the rearing treatment may influence these associations, we also evaluated these within the two treatments separately.

3. Results

3.1 Birth weight and ano-genital distance

Maternal housing tended to affect birth weight (P=0.055): rabbits born in the semi-group system (i.e., those that would later be used for the communal rearing treatments) were slightly heavier than those born in single-doe cages (62 vs. 58 ± 1.5 grams). Rabbits born in semi-group housing had longer ano-genital distances than those born in single-doe cages (1.3 vs. 1.1 ± 0.05 mm, P=0.024).

3.2 Behaviour

Offensive agonistic interactions were more than twice as frequent in the first as in the second hour after grouping (9.9 ± 1.6 vs. 3.9 ± 0.7 interactions/rabbit/hour, $F_{1,23}$=98, P<0.0001, Figure 2) and tended to be more frequent in groups of eight than in groups of four animals (8.6 ± 1.9 vs. 4.5 ± 1.1 interactions/rabbit/hour, $F_{1,23}$=3.8, P=0.064). No other main effects or interactions reached significance (P>0.10).

Defensive agonistic behaviour was influenced by a rearing strategy*group size*hour interaction ($F_{1,20}$=6.8, P=0.017). Only meaningful post-hoc pairwise comparisons were made (i.e. between pairs that had 2 out of 3 of the interacting variables in common). Groups of four rabbits showed more defensive agonistic behaviour in the first than in the second hour after grouping. This time effect within groups of four was most pronounced in the litter-only groups. In addition, during the 2nd hour rabbits from litter-only rearing showed more defensive

agonistic interaction when housed in groups of eight than when housed in groups of four (all P<0.001, all other pairwise comparisons P>0.05).

The frequency of resting in bodily contact was not influenced by any of the variables or their interactions (all P>0.10). Social sniffing/grooming was influenced by a rearing strategy*group size*hour interaction ($F_{1,20}$= 8.2, P=0.010). Only meaningful post-hoc pairwise comparisons were made (i.e. between pairs that had 2 out of 3 of the interacting variables in common). Social sniffing/grooming was more frequent in the 1st than in the 2nd hour for all rearing*group size combinations. Within the 1st hour, litter-only rabbits had more social contacts than communally reared rabbits. Within the 2nd hour, groups of eight litter-only rabbits had more social sniffing/grooming than groups of four litter-only rabbits or groups of eight communally reared rabbits.

3.3 Wounds

None of the tested variables or their interactions had a significant effect on the wound categories (P>0.10, Table 2).

3.4 Association between birth characteristics and adult behaviour

The analysis including rabbits from both rearing strategies showed that rabbits with a longer ano-genital distance engaged in more offensive and less defensive agonistic behaviour (and tended to engage in bodily contact and social sniffing/grooming less often) when they were grouped as adults (Table 3). Although birth weight and ano-genital distance were correlated, birth weight itself was not associated with agonistic behaviour.

Associations were also analysed within each rearing strategy separately. Within the litter-only treatment no significant associations between birth characteristics and agonistic behaviour were found. In contrast, in the communal rearing treatment rabbits with a longer ano-genital distance displayed less defensive agonistic behaviour and tended to display more offensive agonistic behaviour (Table 4).

4. Discussion

Based on literature from other species (D'Eath, 2005; Kutzer et al., 2009), we hypothesized that, when grouped after their first kindling, communally reared rabbits would be less aggressive and sustain fewer wounds than rabbits that had been reared with their own litter only. This hypothesis was not substantiated. Numerically communally reared rabbits even engaged in more offensive agonistic behaviour, but this effect did not reach significance. Communally reared rabbits did show less social sniffing/grooming in the post-grouping period. This may indicate that they were either more careful when approaching unfamiliar conspecifics or less interested in doing so due to being more used to meeting unfamiliar conspecifics. It is possible that agonistic interactions between the experimental rabbits' mothers during the rearing period caused social stress for the experimental rabbits, resulting in more anxious animals. Even though the mothers were extremely rarely observed to direct agonistic behaviour towards the experimental rabbits (Buijs et al. 2015), agonistic interactions between the mothers may still have affected the young.

Alternatively, the behavioural differences may not stem from the way the rabbits were reared, but from their prenatal environment. Communally reared rabbits were born to parent stock housed in semi-group housing. This meant that this parent stock was exposed to unfamiliar conspecifics during gestation (i.e., parent stock was grouped when their previous litter was 18 days old, at which time they were already 7 days pregnant with the litters included in the

present experiment). In contrast, the parent stock of the litter-only rabbits was kept in individual housing. Exposure to unfamiliar conspecifics is a potent stressor in rabbits (Noller et al. 2013) and in other species social stress during gestation is known to affect the offspring's behaviour and endocrine system. For instance, prenatal social stress increases testosterone levels in female guinea pigs (Kaiser and Sachser, 2005). The longer ano-genital distances we observed in the offspring of group housed mothers (as compared to offspring of individually housed mothers) suggests that a similar process occurred in our rabbits as ano-genital distance is testosterone dependant (Banszegi et al. 2010). Increased testosterone levels induce agonistic behaviour in dominant rabbits (Briganti et al. 2003), and may thus explain the numerically higher frequency of offensive behaviour in our communally reared rabbits. Exposure to unfamiliar conspecifics during pregnancy can also decrease social activity in female offspring (Marchlewska-Koj et al., 2003; Brunton, 2013), which may explain the lower levels of sniffing/grooming in our communally reared rabbits. The exact mechanisms through which prenatal stress affects behaviour are not fully clear, but research suggests that maternal steroids play a decisive role and both the maternal pituitary adrenocortical and sympathetic adrenomedullary system are likely involved (Kaiser and Sachser, 2005; Brunton, 2013).

In the present study pre- and postnatal effects on behaviour could not be distinguished. Future research may focus on the effects of communal rearing of rabbits whose parent stock has not been exposed to unfamiliar conspecifics during pregnancy. This could also clarify if the lack of differences in agonistic behaviour in the present study was due to counteracting pre-natal and post-natal effects, as it is possible that a positive effect of increased social experience during rearing was obscured by a negative effect of higher stress levels in the pre-natal environment. Also, further research into more enriched housing systems that improve rabbits' feeling of safety during the pre- and postnatal period may contribute to improved welfare.

The rabbits were only observed directly after grouping. Both previous research (Andrist et al., 2013; Buijs et al., 2015) and the decreased number of agonistic interactions in the second hour of the present study suggest that most agonistic behaviour occurs directly after grouping. This makes the post-grouping period an appropriate timeslot to focus on. Although it is possible that treatment differences that would occur later on were overlooked in this study, the lesion scores that were given three days after grouping support the behavioural data: no effect of previous rearing strategy on wounding was found. The high percentage of wounded breeding rabbits emphasizes that whilst aggression is mainly restricted to the period directly following grouping, it can still have an important impact on welfare.

Larger groups resulted in a tendency for more offensive agonistic behaviour. Also, the number of defensive agonistic interactions in the larger groups did not decrease between the first and second hours as they did in smaller groups (although offensive agonistic behaviour did decrease over time in the larger groups). This was the case even though space allowance per rabbit was equal in all systems and as an effect, animals housed in larger groups had more space available per group allowing them to withdraw further from aggressors. As such, the finding that wild female rabbits are more aggressive in smaller groups (Myers et al., 1971) cannot be extrapolated to the period following grouping of breeding rabbits in captivity. Instead, it seems likely that the increase in offensive agonistic behaviour was due to the fact that more hierarchy positions had to be resolved in the larger groups (Arey and Edwards, 1998).

In line with our hypothesis, rabbits with longer ano-genital distances at birth showed more offensive agonistic behaviour when grouped as adults. The longer ano-genital distances observed in communally reared rabbits (as compared to rabbits from litter-only rearing) suggest that prenatal social stress can masculinize female rabbits, as previously shown for

other species (Kaiser and Sachser, 2005). Masculinization can lead to increased aggression (Cohen-Bendahan et al., 2005; Gandelman, 1980). As such, ano-genital distance may be a useful indicator for selection of rabbits that are more suitable for group housing, which may be because it allows selections of rabbits whose mothers were more able to cope with their social grouping. This would also explain why the association between ano-genital distance and agonistic behaviour wasn't confirmed in the rabbits from litter-only rearing (whose mothers weren't grouped during pregnancy). Alternatively, it is possible that the association only appears when rabbits with different ano-genital distances have previously learned to adjust their behaviour when meeting unrelated animals (as the litter-only rabbits had not had this opportunity yet when we made our observations immediately after their first grouping). A negative correlation between offensive and defensive agonistic behaviour was also found in the communally reared rabbits, but not in the litter-reared ones. Again, this could be an indication that the roles (aggressor or victim) became clear more quickly in rabbits that had been raised communally, although this did not cause aggressors to cease their offensive agonistic behaviour immediately. If ano-genital distance is to be used as a selection tool, further analysis on the most appropriate way to assemble groups is needed, as from the current experiment it cannot be deduced whether it is the absolute distance that is of importance, or the distance relative to that of the other conspecifics

5. Conclusion

Communally reared rabbits born to group housed mothers were not found to show less agonistic behaviour or to receive fewer wounds than rabbits experiencing conventional pre- and post-natal conditions. To clarify if this was the result of counteracting pre- and post-natal effects further research is necessary. Post-grouping offensive agonistic behaviour tended to be more expressed in larger groups. Rabbits showing more offensive agonistic behaviour after their first post-kindling grouping could be identified at birth, based on their longer ano-

genital distance. The usefulness of this method may be limited to communally reared rabbits, however.

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Figure 1. Photograph and schematic overview of a semi-group pen for four rabbit does during the group phase.

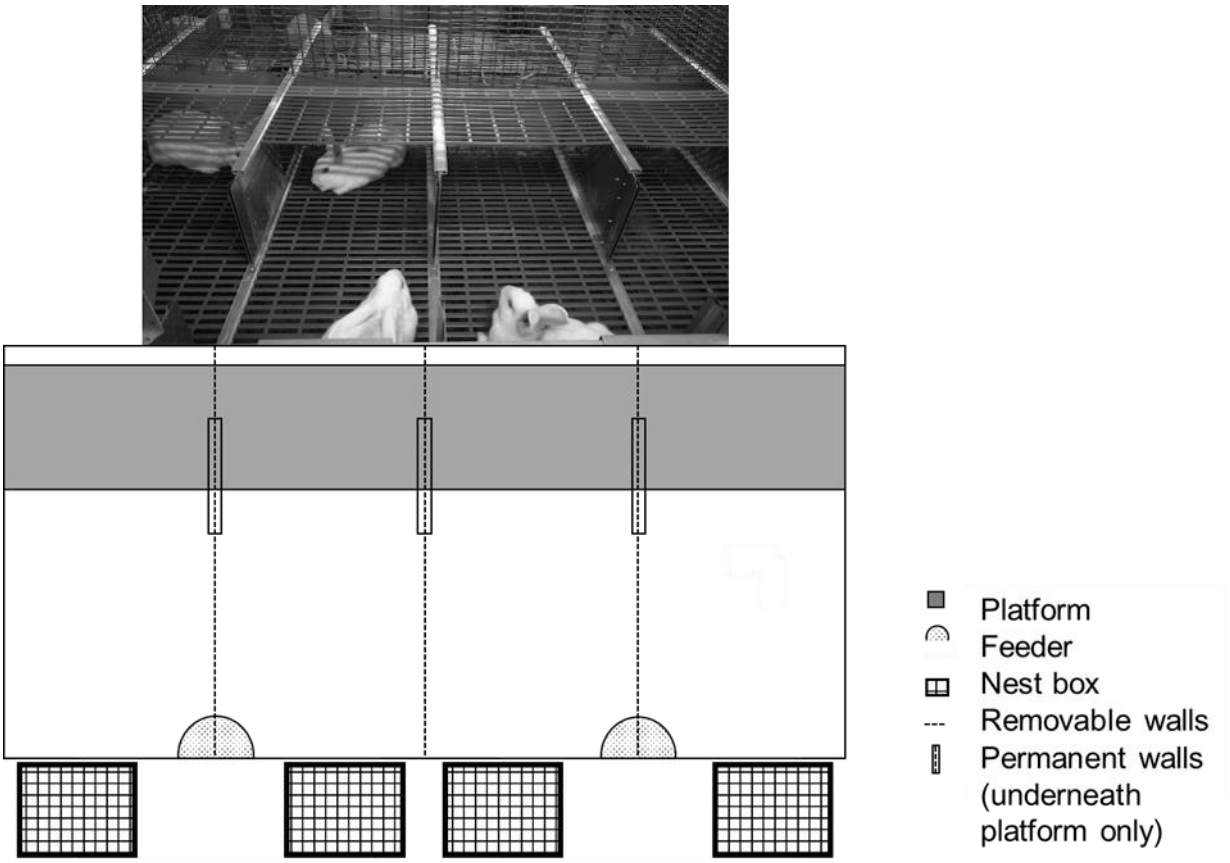
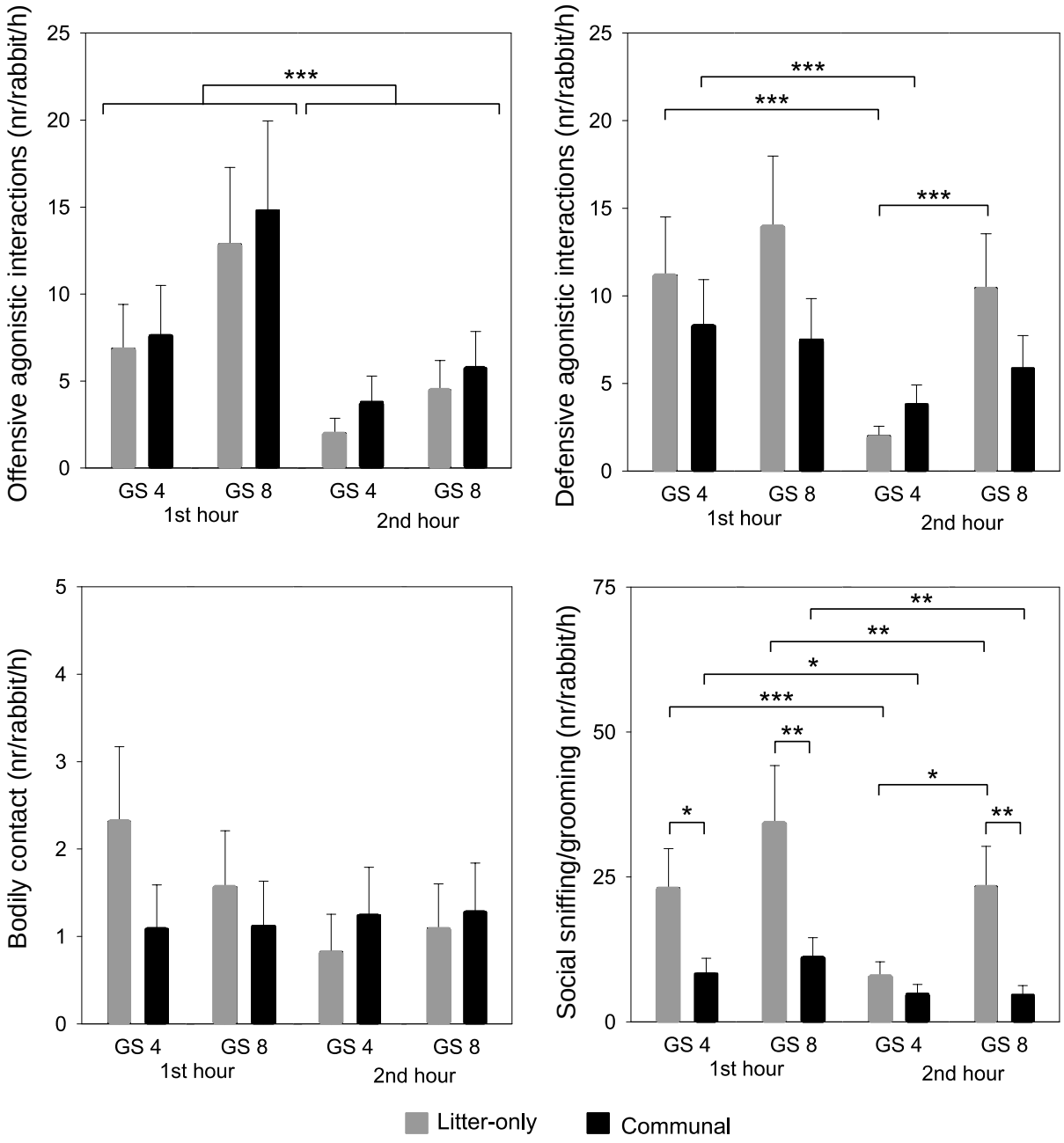


Figure 2. Frequencies of behaviour. GS = group size.



Age (wk)	Treatment Communal rearing	Litter-only rearing	Procedures
-7 to -4	P.stock[1] individual[2]	P.stock individual[2]	Insemination of p.stock
-4 to -1	P.stock in groups of 4[2]	P.stock individual[2]	Weaning of the litter previous to exp. rab.[3]
-1 to 2	P.stock individual with own litter of exp. rab.	P.stock individual with own litter of exp. rab.	Ano-genital distance exp. rab Birth weight exp. rab Insemination of p.stock
2 to 4	P.stock in groups of 4 with 4 litters of exp. rab.	P.stock individual with own litter of exp. rab.	
4 to 12	Exp. rab in groups of 4 litters	Exp. rab. with same-litter siblings	Weaning by removing p.stock Removal of males
12 to 16	Exp. rab in groups of 4 rabbits	Exp. rab individual	Exp. rab. moved to new pen
16 to 17	Exp. rab individual	Exp. rab individual	Insemination of exp. rab.
17 to 21	Exp. rab in groups of 4 rabbits	Exp. rab individual	
21 to 24	Exp. rab individual[4]	Exp. rab individual[4]	Kindling of exp. rab. Insemination of exp. rab.
24 to 27	Exp. rab in groups of 4 or 8 with their litters	Exp. rab in groups of 4 or 8 with their litters	Behavioural observations Wound scoring

Table 1. Summary of housing and procedures for the different treatments. During the highlighted phases, communally reared rabbits (or their parent stock) had more exposure to unfamiliar rabbits than litter-only rabbits.

[1] P.stock = parent stock

[2] With their own litter previous to the experimental litter for part of this period

[3] Exp. rab = experimental rabbits

[4] With their own litter for part of this period

Rearing strategy	Group size	Wound category			
		0	1	2	3
Litter-only	4	36.4	18.2	36.4	9.1
	8	21.7	34.8	34.8	8.7
Communal	4	25.0	41.7	33.3	0.0
	8	30.4	30.4	30.4	8.7

Table 2. Raw percentages of breeding rabbits in each of the wound categories, per rearing strategy and group size

	Birth weight	Offensive Agonistic	Defensive agonistic	Bodily contact	Social sniff/groom
Ano-genital	**0.59**	**0.51**	**-0.57**	-0.38	-0.43
distance	**0.005**	**0.020**	**0.007**	0.091	0.054
	21	**21**	**21**	21	21
Birth		0.34	-0.27	-0.15	**-0.42**
weight		ns	ns	ns	**0.042**
		24	24	24	**24**
Offensive			**-0.75**	-0.09	0.23
agonistic			**<0.001**	ns	ns
			24	24	24
Defensive				0.27	-0.01
Agonistic				ns	ns
				24	24
Bodily					0.23
contact					ns
					24

Table 3. Spearman correlations (r_s, p-value, nr) between birth characteristic and behaviour (dataset including rabbits from both rearing strategies). ns: P>0.10.

	Ano-genital	Birth weight	Offensive agonistic	Defensive agonistic	Bodily contact	Social sniff/groom
Ano-genital distance		0.48 ns 11	-0.02 ns 11	-0.19 ns 11	0.04 ns 11	-0.5 ns 11
Birth weight	0.44 ns 10		0.17 ns 12	-0.06 ns 12	-0.1 ns 12	-0.37 ns 12
Offensive agonistic	0.57 0.084 10	0.41 ns 12		-0.36 ns 12	-0.01 ns 12	0.57 0.054 12
Defensive agonistic	**-0.79** **0.006** **10**	-0.5 0.099 12	**-0.85** **0.001** **12**		0.01 ns 12	0.11 ns 12
Bodily contact	**-0.64** **0.045** **10**	-0.03 ns 12	-0.27 ns 12	0.4 ns 12		0.14 ns 12
Social contact	-0.1 ns 10	-0.15 ns 12	0.39 ns 12	-0.14 ns 12	0.37 ns 12	

Table 4. Spearman correlations (r_s, p-value, nr.) within rearing strategies (above diagonal: litter-only, below diagonal: communal rearing). ns: P>0.10.