INFLUENCE OF LIGHTING PROGRAMS ON THE PRODUCTIVITY OF RABBIT DOES OF TWO GENETIC TYPES

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ABSTRACT

The aim of this experiment was to study the influence of lighting programs on rabbit doe productivity, according to their genetic type and their physiological status at insemination. A total of 223 nulliparous rabbit does (genetic type '0067': 108, genetic type '0557': 115) were placed in rooms under different lighting programs: a continuous 8L:16D (group 8C); a continuous 16L:8D (group 16C) and a discontinuous program: 16L:8D (8L:4D:8L:4D, group 16D). Inseminations (1558) were carried out in eight series (every 42 days). The lighting program did not influence the does' viability and receptivity, nevertheless the '0067' does were more receptive under 16C than the '0557' ones (73.0 % *vs* 59.7 %). Females under 8C were more fertile than under 16C or 16D (82.7 % *vs* 75.5 % and 73.8 %, respectively, P=0.0155). On the contrary, the does under 16C or 16D had a significantly higher litter size at birth (total born, born alive, after elimination), at 28 days *post partum* (8.88 and 8.89 *vs* 8.07 for group 8C respectively, P=0.0096) and consequently a higher litter weight. Even though the lighting program did not influence the weights at 28 days *post partum*, the young rabbits from the '0067' mothers were significantly heavier under 16C or 16D. The genetic type did not influence doe viability. The '0067' does were more receptive (69,1 % *vs* 64.4 %, P=0.0493), more prolific at birth and until weaning (9.29 *vs* 7.94, P<0.0004) consequently they had heavier litters at weaning; whereas the '0557' does were more fertile (82.0 % *vs* 72.7 %, P=0.0004). Their global productivity at weaning varied slightly (3383 g *vs* 3338 g of weaned rabbits/A.I. for '0557' and '0067' does, respectively). The physiological status of the does highly influenced all their reproductive performance as well as growth of the young. In conclusion, for a 42 day reproduction rhythm using insemination and cycled production, the studied lighting programs did not greatly influence global productivity (3388 g, 3452 g and 3235 g of weaned rabbits per insemination for groups 16C, 16D and 8C, respectively). The lighting programs did not interact with the does' genetic type for fertility and prolificacy. Nevertheless, there is a differential sensitivity of photoperiod on litter weight depending on the does' genetic type. A constant 16L:8D is recommended for '0067' rabbit does to increase receptivity and young rabbit growth.

Key words: rabbit, lighting program, genetic effect, physiological status.

NTRODUCTION

Within the European latitude, HAMMOND and MARSHALL (1925) and BOYD (1986) reported that wild rabbits (*Oryctolagus cuniculus*), have a well-defined seasonal cycle of reproduction: most pregnancies occur between February and early August with a peak in May. This means that fertility is maximal for increasing day-length. WALTER *et al*. (1968) showed that 16L:8D of constant lighting all year round reduces the reproduction problems normally associated with decreasing day-length periods. Whereas this recommendation is followed by almost all breeders, SCHÜDDEMAGE (2000) has obtained opposite results: rabbit does under a constant 8L:16D produce + 5% of alive rabbits at birth, than those placed under a constant 16L:8D. Other authors have studied discontinuous lighting. UZCATEGUI and JOHNSTON (1990) conclude that Rex rabbits need at least 14h of continuous light to meet their reproductive potential, and discontinuous lighting schedules of 10, 12 and 14h are equally as effective as 14h of continuous light in promoting doe reproduction. ARVEUX and TROISLOUCHES (1994) observed an increase of productivity (+ 11.6%) when 16 hours of light were provided discontinuously *vs* continuously.

Since new breeding systems have been developed during these last fifteen years (artificial insemination, cycled production…), the aim of this study was, in these conditions, to answer the following three questions :

1) Does a constant 16L:8D lighting program allow a better rabbit productivity than a 8L:16D one?
2) For a 16L:8D lighting program, does a discontinuous light distribution allow a better rabbit productivity than a continuous one?
3) Since two genetic types of rabbit does are used, is there a genetic variability of the sensitivity to photoperiodism?

MATERIAL AND METHODS

The experiment was performed at INRA (Domaine Pluridisciplinaire du Magneraud, France) between May 2001 and May 2002.

Animal. A total of 223 nulliparous rabbit does were used: 108 'INRA 0067'' does (sire 'INRA 2066' and dam 'INRA 1077',) and 115 '0557' does (sire 5555: from a Rex line selected for more than ten years for fur production, a trait very sensitive to the photoperiod, and dam 'INRA 1077').

Photoperiodic conditions. During the fattening period, rabbit does were under a 8L:16D lighting program (from 8 a.m. to 16 p.m.). Three identical environmentally controlled rooms were placed under a different photoperiod : constant 8L:16D (light from 8 a.m. to 16 p.m.), constant 16L:8D (light from 8 a.m. to 24 p.m.) and discontinuous 16L:8D (light from 4 a.m. to 12 a.m., and from 16 p.m. to 24 p.m.). The schedules simulated a continuous 8-hour (8C), a continuous 16-hour (16C) and a discontinuous 16-hour (16D) lighting. In each room, on each side, 9 neon-tubes (white light) were placed in front of the cages at a 1.7 meter height. The mean of light intensity was measured in the centre of each cage (from 100 to 260 lux), at the rabbit eyes height.

Groups drawing up. Rabbit does were equally divided into 3 groups according to their genetic type, genealogies, light intensity inside the cage, the weight measured 21 days before being placed in the definitive room. A doe was definitively assigned to a group. In case of mortality or elimination, a young doe was assigned to the group of the doe it replaced.

Breeding system. The does were inseminated at the age of 17.5 weeks following a three-week adaptation period to the definitive lighting program. Eight series of artificial inseminations (A.I. - 2 batches at an interval of 6 weeks) were practised using heterospermic pools of Hyplus buck semen (Grimaud Frères). Prior to insemination, sexual receptivity of the does was tested in the presence of a buck. The ovulation was induced by the i.m. injection of 0.2 mL of Réceptal®. No hormone or biostimulation was used in this experiment to induce the does' receptivity. The litters were not standardised at birth, but young rabbits under a weight of 30 g were eliminated. Free suckling was applied. Two consecutive unsuccessful inseminations were followed by the doe's elimination. The animals were housed in individual flat-deck cages and fed *ad libitum* with a commercial pelleted diet containing 16.5% protein and 15.5% fibre. Water was provided *ad libitum*.

Registered parameters. The receptivity rate, fertility (number of kindling does/ number of inseminated does), litter size at birth, after elimination (adjusted), at 28 days (weaning) and the mean weight at 28 days were studied. The global productivity was measured by the weight of weaned rabbits/A.I.

Statistical analyses. Receptivity and fertility, were analysed as Bernoulli variables (range 0-1) by analysis of variance like classical continuous variables. The analysis of variance took into account the fixed effect of the lighting program (3 levels : 8C, 16C, 16D), the genetic type of the does (2 levels: '0067' or '0557'), the physiological status of the does (10 levels) and the interactions taken 2 by 2. The physiological status of the does considered at insemination: the parity: nulliparous (N), primiparous (P), or multiparous (M); the lactation stage: lactating (L+) or non-lactating (L-); the receptivity: receptive (R+) or non-receptive (R-). To study the receptivity, the fixed effect of the physiological status of the does was removed from the model. In a preliminary analysis, the batch effect was never significant and was removed from the model. The mean weight of weaned rabbits was analysed introducing the litter size at weaning as the covariable. Mothers or young rabbits' viability were analysed using a chi-square test. The results presented in table 1 are least square means.

RESULTS

In this analysis, 1558 inseminations were carried out in eight series of artificial inseminations. Since the reproduction rhythm was changed after the 8th insemination, litter sizes and weights at 28 days *post partum* of the last serie were removed from the analysis. Table 1 presents the reproductive performance and growth of the young according to the lighting program, the does' genetic type and the physiological status of does at the moment of A.I.

Does viability. The does viability, analysed by the number of initial nulliparous does still present at the 8th insemination did not vary significantly according to the lighting program (40.2%, 50.7% and 52.0% for groups 8C, 16C and 16D respectively), nor to the genetic type (45.3% and 49.6% for '0067' and '0557' rabbit does, respectively).

Receptivity. The lighting program did not influence the receptivity of the does at insemination (67.5%, 66.4% and 66.4%, for groups 8C, 16C and 16D respectively). The '0067' does were more receptive than the '0557' ones (69.1% *vs* 64.4%, P=0.0493). Nevertheless, there was a significant interaction between the effects of the lighting program and the does' genetic type, whereas the '0067' does were more receptive under 16C than the '0557' ones (73.0% *vs* 59.7%).

Fertility. Considering the variations of fertility according to the serie of inseminations, the lighting program and the does' genetic type, except for the '0067' does at the 4th A.I., no effect of the lighting program on fertility was evidenced. Nevertheless, considering now the analysis of variance (table 1), females under 8C were more fertile than under 16C or 16D (82.7% *vs* 75.5% and 73.8%, respectively, P=0.0155). The '0557' does were more fertile than the '0067' ones (82.0% *vs* 72.7%, P=0.0004).

The physiological status of the does at insemination highly influenced fertility varying from 35.4% (primiparous lactating non-receptive does) to 97.4% (multiparous non-lactating receptive does). The lighting program and the physiological status of the does interacted: 16D improved the fertility of primiparous lactating and receptive does, whereas 8C improved the fertility of primiparous non-lactating and non-receptive does as well as those of multiparous lactating and non-receptive ones (P=0.0036). The genetic type of does and their physiological status interacted: fertility was lower for the '0067' does when they were nulliparous non-receptive or primiparous and lactating (whatever their receptivity) or multiparous lactating and non-receptive (P<0.0001).

Litter size. The number of young rabbits at birth (total born, born alive, adjusted after elimination) and at weaning was significantly higher when the does were under 16C or 16D. At birth, '0067' rabbit does were significantly more prolific and the difference was maintained until weaning (9.29 *vs* 7.94, respectively, P<0.0001). Whatever the moment of observation, the litter size was highly influenced by the physiological status of the does at insemination (P<0.0001). The lowest litter size was obtained by nulliparous non-receptive does whereas the highest was obtained by multiparous non-lactating and receptive does. A significant interaction between the lighting program and the physiological status was observed on litter size at birth: primiparous does under 8C had a lower litter size at birth (total born and born alive).

Young growth. Even if weaned rabbits under 8C were lighter than those placed under 16C or 16D, the difference was not significant. As a consequence of the effect of lighting programs on prolificacy, the litter weight was higher for 16C or 16D (4577 g and 4663 g *vs* 4328 g for 8C, respectively). At weaning, on the mean weight and the litter weight, there was a significant interaction between the lighting program and the does' genetic type. Young rabbits and litters from the '0067' does were significantly heavier under 16 hours of light (4299 g, 4738 g and 4971 g for 8C, 16C and 16D, respectively, P=0.0002). The lighting program did not influence the mean weight of the young rabbits from the '0557' mothers.

The physiological status of the does highly influenced the litter weight at weaning, from 3596 g (nulliparous and receptive does) to 5200 g (multiparous lactating and receptive ones.

DISCUSSION

Using natural mating and a 31 day reproduction rhythm, WALTER *et al.* (1968) evidenced that the longer is the daily light duration, the higher is the sexual receptivity of rabbit does. The comparison of the does' receptivity of groups 8C, 16C and 16D did not confirm this conclusion. Whereas the fertility was improved under 8C, the litter size was improved under 16C or 16D. An increase in follicular growth could not be a physiological explanation of the prolificacy improvement, since under 16 hours of light, the does were not more receptive. On the contrary to SCHÜDDEMAGE (2000, reproduction rhythm: 33 days), in the present experimental conditions (reproduction rhythm: 42 days), a constant 16L:8D lighting program allowed to improve the productivity at weaning by + 4.7 % compared to a 8L:16D one (3388 g *vs* 3235 g of weaned rabbits/A.I.).

That experiment did not allow to confirm the interest of providing 16 hours of light discontinuously (+ 1.8 % *vs* 11.6 % for ARVEUX and TROISLOUCHES, 1994).

On fertility and prolificacy, the lighting programs did not interact with the does' genetic type. Nevertheless, there was a differential photoperiod sensitivity at weaning, on the litter weight and the mean weight, depending on the does' genetic type: the '0557' does were not influenced by the lighting program (environment of selection: 8C), but on the '0067' does (environment of selection: 16C), the litter weight was significantly increased by 16C or 16D. The '0557' does might have better lactation abilities and/or a better mother-young behaviour acting on the young growth whatever the lighting program. Moreover, a constant 16L:8D is recommended to '0067' does to increase receptivity and young rabbit growth.

Nulliparous, primiparous or lactating and non-receptive '0067' does were significantly less fertile than the '0557' does. This result indicates a marked antagonism between lactation and reproduction for the '0067' rabbit does. On the contrary, as a result of the intense selection on numerical productivity, the '0067' rabbit does were more prolific, leading to the same level of productivity at weaning (3338g *vs* 3383g of weaned rabbits/A.I. for '0557' does, respectively).

As evidenced by THEAU-CLÉMENT *et al.* (2003), the physiological status of does at A.I. highly influences the reproductive performance of does as well as young growth.

CONCLUSION

For a 42 day reproduction rhythm, using artificial insemination and cycled production, the studied lighting programs did not greatly influence global productivity. The lighting programs did not interact with does' genetic type for fertility and prolificacy,. Nevertheless at weaning, there is a differential sensitivity to photoperiod on litter weight and young weight depending on the does' genetic type. A constant 16L:8D is recommended for the '0067' rabbit does for an increased receptivity and young rabbits growth.

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Table 1. Influence of lighting programs, the does' genetic type and physiological status on rabbit doe productivity.

	Number A.I.	Fertility (%)	*Number of litters*	Total born	Born alive	Adjusted	*Number of litters*	Weaned	Mean weight (g)	Litter weight (g)
Mean	*1558*	79.2	*1240*	10.36	9.54	9.29	*1048*	8.47	544	4518
Residual s.d.		0.40		2.90	3.33	3.21		2.69	77	1006
R^2		0.36		0.27	0.21	0.20		0.21	0.63	0.34
Lighting program:		P=0.0155		P=0.0076	P=0.0165	P=0.0183		P=0.0096	NS	P=0.0165
8C	*502*	82.7^{a}	*414*	9.84^{a}	9.03^{a}	8.83^{a}	*342*	8.07^{a}	530	4328^{a}
16C	*524*	75.5^{b}	*408*	10.61^{b}	9.95^{b}	9.71^{b}	*342*	8.88^{b}	549	4577^{b}
16D	*532*	73.8^{b}	*418*	10.75^{b}	9.82^{b}	9.53^{b}	*364*	8.89^{b}	546	4663^{b}
Genetic type:		P=0.0004		P<0.0001	P<0.0001	P<0.0001		P<0.0001	NS	P=0.033
'0067'	*761*	72.7^{a}	*575*	11.42^{a}	10.42^{a}	10.10^{a}	*486*	9.29^{a}	541	4669^{a}
'0557'	*797*	82.0^{b}	*665*	9.39^{b}	8.78^{b}	8.60^{b}	*562*	7.94^{b}	542	4376^{b}
Physiol. status		P<0.0001		P<0.0001	P<0.0001	P<0.0001		P<0.0001	P<0.0001	P<0.0001
NL-R+	*283*	96.0^{ac}	*273*	9.34^{a}	8.20^{a}	7.94^{a}	*243*	7.36^{a}	464^{a}	3596^{a}
NL-R-	*84*	65.8^{e}	*59*	9.00^{a}	7.85^{a}	7.59^{ad}	*55*	7.35^{bc}	479^{a}	3700^{a}
PL+R+	*193*	73.7^{a}	*144*	10.90^{d}	10.08^{bcd}	9.91^{c}	*133*	8.96^{a}	521^{b}	4448^{d}
PL+R-	*83*	35.4^{ad}	*29*	10.09^{ad}	9.42^{abcd}	9.11^{abc}	*27*	8.45^{ab}	556^{bcd}	4489^{bd}
PL-R+	*78*	97.2^{a}	*76*	11.30^{bcd}	10.70^{bc}	10.22^{bc}	*66*	9.39^{c}	529^{bc}	4617^{b}
PL-R-	*24*	76.4^{b}	*18*	10.52^{abcd}	9.68^{abcd}	9.54^{c}	*15*	9.47^{b}	502^{ab}	4482^{bd}
ML+R+	*413*	89.5^{b}	*370*	11.53^{bc}	10.81^{bc}	10.52^{c}	*295*	9.42^{a}	594^{d}	5200^{c}
ML+R-	*282*	54.9^{f}	*159*	9.32^{a}	8.47^{a}	8.27^{ab}	*123*	7.68^{abc}	620^{e}	4919^{b}
ML-R+	*72*	97.4^{a}	*71*	11.57^{bd}	11.06^{b}	10.79^{c}	*65*	9.59^{a}	554^{c}	4877^{b}
ML-R-	*46*	87.2^{bcd}	*41*	10.44^{cd}	9.73^{c}	9.62^{c}	*26*	8.49^{a}	597de	4897^{bc}
Light x genetic type		NS		NS	NS	NS		NS	P=0.0016	P=0.0002
Light x Phys.stat.		P=0.0036		0.0203	NS	P=0.0420		NS	NS	P=0.0154
Gen. x Phys. stat.		P<0.0001		NS	NS	NS		P=0.0242	NS	NS

Within columns, means with different letters are significantly different P<0.05