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EFFECT OF LIGHT COLOUR AND REPRODUCTIVE RHYTHM ON RABBIT DOE PERFORMANCE

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Abstract: In this experiment the effects of the colour of light and reproductive rhythm on rabbit does' production was examined. The does (n=122) were first inseminated at the age of 16.5 wk and housed in 2 rooms. White coloured light was applied (W), in the first room, and blue lighting (B) was used in the second room. In both rooms, the does were randomly divided into 2 subgroups and inseminated using a theoretical reproductive rhythm (interval between parturitions) of 42 (42D) and 56 d (56D), respectively. Kits were weaned at 35 and 23 d of age in 42D and 56D subgroups, respectively. The rabbit does' performance was examined over 336 d (8 and 6 reproduction cycles in groups 42D and 56D, respectively). During the first gestation, the W rabbits had higher feed consumption (162 *vs*. 145 g/d, $P<0.05$) and during the whole period a larger body weight than the B does. The colour of the light did not influence the kindling rate and litter size ($P>0.10$). In contrast, individual kit and litter weights measured at 23 d of age was higher in the B group (451 *vs*. 435 g and 3611 *vs*. 3498 g, respectively; $P<0.05$). No significant differences were found for productivity index between the W and B groups. The kindling rate was more favourable in the 56D than in the 42D group (89.3 *vs*. 82.0%, $P<0.05$). The 56D does' body weight at kindling was larger than that of the 42D group (4474 *vs*. 4188 g, $P<0.001$). No significant effect of reproductive rhythm were found for litter size. Individual kit weight and litter weight at 23 d of age were slightly higher for the 42D group than the 56D (447 *vs*. 439 g, P=0.057 and 3598 *vs*. 3513 g, P=0.055). Kindling intervals of the 42D and 56D groups were 46.6 and 59.5 d, respectively ($P<0.001$). Body condition of does (measured by the TOBEC method) was higher in the 56D group at 4-5th parturition. Survival rate at the age of 336 d was slightly higher for 56D than 42D female (26 and 13% respectively, P=0.07). Based on the results, the blue colour could have a favourable effect on the litter weight as well as the individual weight of kits at 23 d (+3.2 and +3.7% respectively). It may be concluded that the effect of the colour of light merits further research. Comparing the two reproduction rhythms, extend reproductive rhythm and early weaning (group 56D) could be more favourable (condition, survival) from the animal welfare viewpoint but the productivity index (number of kits/doe/yr and kits' weight at 23 d/doe/yr) of the 42D group exceeded that of the 56D group by 19-23%, which has a high economical impact.

Key Words: rabbit does, light colour, reproductive rhythm, performance.

INTRODUCTION

The effect of the length of light period on rabbit production has been analysed by several authors (Maertens and Luzi, 1995; Mirabito *et al*., 1994; Theau-Clément *et al*., 1990; Virág *et al*., 2000). However, in our understanding, so far the effect of the colour of light on the rabbits' production has not been analysed. According to a free choice test, rabbits show higher preference towards

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light (white and yellow) colours than for darker colours such as green or blue (Gerencsér *et al*., 2009). Only limited information can be found describing this topic for other farm animals (cattle: Ádám *et al*., 1990; sheep: Casamassima *et al*., 1994; horse: Stachurska *et al*., 2002). In poultry, the effect of light colour on egg production, and size and body weight gain is well established (Rodenboog, 2001).

With the spread of artificial insemination (AI) and cyclic production, the most frequent insemination time for rabbit does occurs 11 d after parturition (Theau-Clément, 2007). Although European wild rabbits mate immediately after kindling (Hudson *et al*., 1996), due to the relatively small litter size and the several months resting period during winter, this practice does not overload the does. At the same time, from the animal welfare viewpoint of domesticated rabbits, less intensive reproductive rhythms were recommended (Castellini, 2007). It is claimed that as a result the body condition of rabbit does will improve, showing more pronounced oestrus, better pregnancy rates and lower mortality (Feugier and Fortun-Lamothe, 2006; Castellini, 2007).

The aim of our experiment was to analyse the effect of the colour of light (blue *vs*. white) and time of insemination after kindling (11 *vs*. 25 d) on long term rabbit does performance.

MATERIAL AND METHODS

The experiment was conducted at the Kaposvár University using Pannon White rabbit does. The rabbit does were randomly housed in 2 identical rooms. The cage base area was 580×385 mm and nest box size was 260×385 mm. In the first room, the customary white coloured light was applied (W group, n=59 does, 288 inseminations), while blue coloured light was used (B group, n=63 does, 304 inseminations) in the second room. The fluorescent tube specifications were white [FW 36W, colour code: 830, wavelength: 300-650 nm] and blue [Narva, LT 36W, colour code: 018, wavelength: 450 nm]. A 16L lighting program was used in both rooms. The luminous intensity measured in the middle of the cages was identical in both rooms (51±8 Lux).

Within both rooms, 2 further sub-groups were randomly formed: in the first group, the does were inseminated 11 d postpartum (reproductive rhythm of 42 d between parturitions: 42D group, n=61 does, 323 inseminations); in the second group, the does were inseminated 25 d after parturition (reproductive rhythm of 56 d between parturitions: 56D group, n=61 does, 269 inseminations). The 4^{th} and 8^{th} kindlings of the 42D does coincided with the 3^{rd} and 6^{th} kindlings of the 56D group at the 168^{th} and at the 336^{th} d (Figure 1).

Rabbit does were first mated at the age of 16.5 wk. They were inseminated with diluted semen (coming from a single buck) and at the same time were injected with 1.5 µg GnRH analogue (Ovurelin, Reanal) into their thigh muscle. Only those rabbit does which conceived after the first AI were considered in the analysis. After equalisation, at the first and latter kindlings every doe nursed a maximum 8 and 10 kits, respectively. Cross-fostering was practised only within

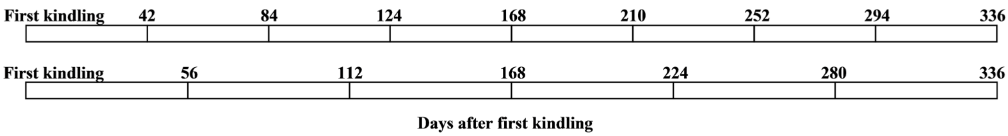

Figure 1: Theoretical kindling interval for the groups, where the does were inseminated 11 (upper line, 42D group) and 25 d (lower line, 56D group) after parturition.

the four groups. In the 42D group, the does could generally nurse their kits freely, but 3 d prior to AI controlled suckling was applied and the kits were weaned at the age of 35 d. In the 56D group, the kits were weaned 2 d prior to the AI at 25 d (at the age of 23 d). Does were culled due to conditional problems or if they did not conceive after 2 successive AI. The performance of rabbit does was examined over 336 d (8 and 6 reproduction cycles in groups 42D and 56D, respectively). The evolution of the body weight from 3 to 11 wk of age was also controlled for 249 growing rabbits (120 and 129 for 42D and 56D groups, respectively). The study was divided into 2 identical periods: the first period (from first weaning to first 168 d of performance) and second period (second 168 d of performance).

Rabbits were fed *ad libitum* a commercial pellet (11 MJ digestible energy per kg, 17.0% crude protein, 15.5% crude fibre). Water was available *ad libitum* from nipple drinkers.

The Total Body Electrical Conductivity (TOBEC) method was applied to estimate the body condition of the does. The measurements (E-value) were taken using EM-SCAN device (Model SA-3203-type) at the first AI of the does (at the age of 16.5 wk, n=26 and 27) and at the age of 44-45 wk (n=22 and 17, respectively in the 42D and 56D groups). The method was as described by Fortun-Lamothe *et al*. (2002). At the time of TOBEC measurement, the does were also weighed. The effects of body weight of the rabbits were accounted for E-values as covariates.

Calculation of productivity index was based on IRRG recommendations (2005). Numerical productivity (number of live born and weaned rabbits per inseminated doe) and overall productivity (weight of weaned rabbits per inseminated doe) were multiplied by number of theoretical AI per year.

Reproduction traits and productivity index were analyzed using a multi-factor analysis of variance. The applied model for the reproduction traits was the following:

$$Y_{ijk} = \mu + Col_i + Rr_j + Age_k + (Col \times Rr)_{ij} + (Col \times Age)_{ik} + (Rr \times Age)_{jk} + e_{ijk}$$

- μ is the general mean,
- Col_i the effect of the light colour (i = 1-2),
- Rr_j the effect of the reproduction rhythm (j=1-2),
- Age_k the effect of the does' age (k = 1-3),
- $(Col \times Rr)_{ij}$ the effect of interaction of level i of factor Col with level j of factor Rr,
- $(Col \times Age)_{ik}$ the effect of interaction of level i of factor Col with level k of factor Age,
- $(Rr \times Age)_{jk}$ the effect of interaction of level j of factor Rr with level k of factor Age,
- e_{ijk} is the random error.

The applied model for the productivity index was the following:

$$Y_{ij} = \mu + Col_i + Rr_j + (Col \times Rr)_{ij} + e_{ij}$$

Production traits of growing rabbits were analyzed using a one-factor analysis of variance. The applied model for the production traits was the following:

$$Y_i = \mu + Rr_i + e_i$$

The elements of the models are defined above.

The kindling rate and the survival of the does were compared by means of Chi-square test. All statistical analyses were conducted using SPSS 10.0 software package.

RESULTS AND DISCUSSION

Effect of reproductive period

Performance values at first kindling were lower for almost all traits (body weight of does and litter size and weight) than at the first or second production periods (Table 1). As expected, body weight of females at 0 and 23 d of lactation increased with the age (P<0.001) and litter performance (size and weight) was lower at first parturition than thereafter. Similar results were previusly reported in the literature (Szendrő and Maertens, 2001; Xiccato *et al*., 2004; Rebollar *et al*., 2009; Tuma *et al*., 2010).

There were no significant interactions either between reproductive period and colour of light, reproductive period and reproductive rhythm, or between colour of light and reproductive rhythm. Consequently, these effects were presented and discussed separately.

Effect of light colour

Those nocturnal animal species that are active during the dark period are generally unable to differentiate between colours, or exhibit limited colour vision. The European Wild rabbit is sensitive to blue and green. Their visual system consists predominantly of rods, also containing blue (λ_{max}=425nm) and green (λ_{max}=523nm) sensitive cones (Nuboer and Moed, 1983). According to a preference test, growing rabbits more frequently chose those cages which were illuminated by white or yellow coloured light compared to those where blue and green coloured lights were used (Gerencsér *et al*., 2009). Because rabbits are sensitive to blue and green, and their preference

Table 1: Effect of reproductive period on the rabbit does performance.

	Period				
	1st parturition	1st 168 d period	2nd 168 d period	SE	P-value
AI/kindling		1.19	1.16	0.02	0.590
Body weight of does at kindling, g	3903[a]	4349[b]	4567[c]	18	<0.001
Body weight of does at 23 d after kindling, g	4428[a]	4739[b]	4909[c]	16	<0.001
Litter size					
total	8.20[a]	9.25[b]	8.85[ab]	0.11	0.003
alive	7.86[a]	8.93[b]	8.61[ab]	0.11	0.003
at 23 d	7.38[a]	8.25[b]	8.15[b]	0.05	<0.001
Litter weight, g					
at birth (alive)	434[a]	568[b]	577[b]	6	<0.001
at 23 d	2971[a]	3622[b]	3804[c]	25	<0.001
Individual weight, g					
at birth (alive)	57.8[a]	65.2[b]	68.8[c]	0.5	<0.001
at 23 d	404[a]	442[b]	471[c]	3	<0.001

SE: standard error.

Table 2: Feed intake (g/d) from AI to first parturition in function of the colour of the light.

	Light colour			
Week of pregnancy	White	Blue	SE	*P*-value
1	221	217	4.03	0.609
2	183	171	6.69	0.39
3	157	116	7.04	0.003
4	88.9	75	5.59	0.217
1 to 4	162	145	4.24	0.037

SE: standard error.

is modified by the colour of light, their performance could be different in cases when white or blue light is applied. Nevertheless, the effect of the colour of light on performance of rabbit does was weak.

Table 3: Effect of light colour on 336 d production period of the rabbit does.

	Light colour			
	White	Blue	SE	*P*-value
No. of does at the beginning of the experiment	59	63		
No. of parturitions	288	304		
Kindling rate, %	83.3	87		0.170
Body weight of does at kindling, g	4371	4282	18	<0.001
Body weight of does at 23 d after kindling, g	4769	4698	16	0.002
Litter size				
total	8.84	9.02	0.11	0.344
alive	8.62	8.68	0.11	0.782
at 23 d	8.08	8.05	0.05	0.586
Litter weight, g				
at birth (alive)	543	550	6	0.713
at 23 d	3498	3611	25	0.036
Individual kit weight, g				
at birth (alive)	64.3	65.5	0.5	0.332
at 23 d	435	451	3	0.002
Numerical productivity				
No. of kits born alive/doe and AI	7.11	7.4	0.2	0.524
No. of kits at 23 d/doe and AI	6.66	6.84	0.14	0.556
Productivity index				
No. of kits born alive/doe and yr	53.7	55.9	1.7	0.493
No. of kits at 23 d/doe an yr	50.3	51.5	1.1	0.528
kits' weight (kg) at 23 d/doe and yr	21.6	22.5	0.5	0.333

SE: standard error.

Significant differences were found between AI and first kindling for the weekly feed intake (Table 2). Feed consumption during the third week and whole pregnancy (1st to 4th wk) was higher in the W group (*P*=0.003 and 0.037, respectively).

Results for the whole (336 d long) period can be seen in Table 3. The number of inseminations per kindling was low for both groups, and kindling rates of the W and B rabbit does were 83.3 and 87.0%, respectively. It should be taken into account that the kindling rate was favourable in both groups.

The body weight of W rabbit does was significantly higher compared to the B group both at kindling and at 23 d of lactation (*P*<0.001 and *P*=0.002, respectively). During the first gestation, the W rabbits had higher feed consumption (this trait was only measured during the first gestation) than B does. The feed intake of W does could probably be remained higher for the latter periods, which can explain how the body weight of the W does significantly exceeded that of the B group.

In both groups, similar values were recorded for the number of kits born in total, born alive and alive at 23 d. The colour of light does not seem to modify kindling rate and litter size. No significant differences were detected in litter and individual weight at kindling. However, the litter weight and the individual weight of the W rabbits exceeded that of the B group at 23 d (*P*=0.036 and *P*=0.002, respectively). As the litter size of the two groups was the same, the difference could be probably caused by the different milk yields of the B and W rabbit does.

Between the W and B groups no significant differences were found for numerical productivity and productivity index (Table 3), so the differences which were occasionally detected between the groups were not detected as significant on the pooled production parameters.

Effect of reproductive rhythm

Results of the 336 d long productive period are summarised in Table 4.

The kindling rate was significantly higher for the 56D than for 42D group (89.3 *vs*. 82.0%, *P*=0.005). The differences between the two groups were much smaller than reported in the literature (Feugier and Fortun-Lamothe, 2006; Xiccato *et al*., 2005; Castellini *et al*., 2006). The reason for this finding may be that inseminating the does two days after weaning (25 d *post-partum*) and the own early weaning had a positive effect on receptivity, so in the 42D group prior to insemination the nursing method was modified from free to controlled nursing with the aim of biostimulation. Based on our previous findings, this method was efficient in improving the kindling rate (Matics *et al*., 2004; Szendrő *et al*., 2005; Xiccato *et al.,* 2005).

At parturition, the does' body weight was higher in the 56D than in the 42D group (*P*<0.001), but at 23 d of lactation body weight of the groups did not differ. Similarly to our results, Feugier and Fortun-Lamothe (2006) reported differences between females inseminated at 11 d and weaned at 35 d with those inseminated at 25 d and weaned at 23 d. Castellini *et al*. (2006) recorded higher body weight in the groups inseminated at 27 d *post-partum*. The authors considered this result to be the consequence of a possible better body condition of the latter inseminated group's better condition.

Prolificacy at birth (total number of kits, born alive) and the number of kits at 23 d did not vary according to the reproductive rhythm. Litter weight at birth, at 23 d and the individual weight at 23 d of lactation were higher in 42D than in 56D group (*P*=0.006, *P*=0.057 and 0.055, respectively). Xiccato *et al*. (2005), Feugier and Fortun-Lamothe (2006) and Castellini *et al*. (2006) observed similar tendencies. It seems that the longer resting period after kindling could have a favourable effect on the kindling rate but not on the litter size and litter weight.

Table 4: Effect of reproductive rhythm [theoretical interval between parturition of 42 (42D) or 56 d (56D)] on rabbit does performance.

	Reproductive rhythm			
	42D	56D	SE	*P*-value
No. of does at the beginning of the experiment	61	61		
No. of parturitions	323	269		
Kindling rate, %	82.0	89.3		0.005
Body weight of does at kindling, g	4188	4474	18	<0.001
Body weight of does at 23 d after kindling, g	4747	4715	16	0.319
Litter size				
total	9.11	8.75	0.11	0.138
alive	8.87	8.51	0.11	0.283
at 23 d of lactation	8.09	8.04	0.05	0.815
Litter weight, g				
at birth (alive)	564	528	6	0.006
at 23 d of lactation	3598	3513	25	0.055
Individual kit weight, g				
at birth (alive)	65.6	64.2	0.5	0.117
at 23 d of lactation	447	439	3	0.057
Real kindling interval, d	46.6	59.5	0.5	<0.001
TOBEC (E-value)				
at first insemination	1646	1712	21	0.489
at 4-5th parturition	2770	2434	39	<0.001
Survival of does, %				
at 168 d	57	72		0.089
at 336 d	13	26		0.07
Numerical productivity				
No. of kits born alive/doe and AI	6.96	7.55	0.22	0.184
No. of kits at 23 d/doe and AI	6.4	7.13	0.14	0.006
Productivity index				
No. of kits born alive/doe and yr	60.5	49.2	1.7	0.001
No. of kits at 23 d/doe and yr	55.3	46.5	1.1	<0.001
kits' weight (kg) at 23 d/doe and yr	24	20.1	0.5	<0.001

SE: standard error.

As expected real kindling interval was 13 d shorter in 42D than in 56D group. Castellini *et al*. (2006) also found significant differences but, because of the weak pregnancy rate following insemination at 11 d, the difference between the two groups was only 8 d.

At the 4th-5th kindling, the E-value measured by the TOBEC method was significantly higher for the 42D compared to the 56D rabbit does. As the E-value measures the fat free body mass,

Table 5: The effect of weaning age (23 and 35 d of age) on the performance of growing rabbits.

	Weaning age			
	23d (56D)	35d (42D)	SE	*P*-value
No.	129	120		
Body weight, g				
3 wk	433	420	2	0.002
5 wk	891	954	6	<0.001
7 wk	1542	1503	7	0.005
9 wk	2171	2128	9	0.022
11 wk	2694	2632	12	0.01
Daily gain, g/d				
3-5 wk	38.6	41.1	0.3	<0.001
5-7 wk	46.1	42.9	0.4	<0.001
7-9 wk	45.1	44.0	0.3	0.126
9-11 wk	37.0	36.2	0.4	0.286
3-11 wk	41.8	41.2	0.2	0.179

Reproductive rhythm group (56D or 42D) in brackets. SE: standard error.

lower values indicate larger fat depots. This is obvious because the kindling interval of the 56D group is longer by 13 d so a longer period was available for regeneration. Moreover, the weaning age could also influence the results. Inseminating the does at 11 d and weaning the kits at 35 d, there is lactation and pregnancy concurrence in opposition with the extensive rhythms, which can affects energy deficit (Xiccato, 1996). In the 56D group there is not pregnancy and lactation concurrence; the longer dry period could be also favourable from an animal welfare viewpoint (Castellini, 2007), although the risk of doe fatness must be controlled.

Higher survival values (%) were observed at 168 and 336 d for the 56D group (P=0.089 and P=0.070). Castellini *et al*. (2006) found similar results, as the proportion of the replacement does was lower in the group inseminated at 27 d than in the other group where insemination took place at 11 d (60 and 80%, respectively). Higher survival (longevity) could be related to the better body condition (Castellini, 2007).

Based on the results, it can be calculated that in the 56D group the numerical productivity per AI was higher than that of the 42D rabbits (Table 4), and the difference for the number of kits at 23 d per doe and insemination was significant (7.13 *vs*. 6.40 respectively, P=0.006), which shows that application of an extensive reproduction rhythm improved the performance of the rabbit does. Contrary to the latter finding, the productivity index per year of the 42D group was higher by 19-23%, as a 33% difference was found for the yearly theoretical inseminations (the number of annual inseminations of the 42D and 56D groups were 8.69 and 6.52, respectively).

The differences were greater than those of Castellini *et al*. (2006). Similarly, in the current study small differences were found in the kindling rate, as the reinsemination 14 d later substantially influences the traits indicating the annual production (the differences in kindling/yr/doe and rabbits sold/yr/doe were 12.9 and 9.8%, respectively).

Early weaning affected the further performance of growing rabbits. Daily weight gain of young rabbits weaned at 23 d (56D group) was significant lower from 3 to 5 wk of age to that observed for those weaned at 35 d (45D group), reaching 5 wk of age with a clear body weight disadvantage (–7%; $P<0.001$). However, the following compensatory growth of kits weaned at 23 d from 5 to 7 wk of age lead to show both groups similar global daily weight gain from 3 to 11 wk of age. In any case, young rabbits weaned at 35 d had slightly larger body weight at 11 wk of age than those weaned at 23 d (+2%; $P<0.01$).

CONCLUSION

Although rabbits are nocturnal animals and therefore not as sensitive to the colour of light as those animals that are active during the light period, for some traits were found significant difference between the groups illuminated by white or blue light. Thus, the possible effect of the colour of light is worth further analysis.

An extended reproductive rhythm to 56 d between parturitions was favourable from an animal welfare viewpoint as the rabbit does had better body condition and showed higher survival rate. On the contrary, the differences in yearly production were far too great (19-23%) which could condition applying this system.

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