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# Reproductive Performance of Rabbit Does and Productivity of their Kits in Response to Colour of Light

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## ABSTRACT

The information in the literature on the effect of light colour on productive and reproductive performances of rabbit production is scare. It was suggested that evaluation of the light colour's effect on the rabbit production can be perspective. This study aimed to evaluate the effect of florescent (FL) and red (RL) compared with Natural Light (NL) on reproductive performance of rabbit does and growth performance of their kits. Total of 75 mature California does were divided into three groups (25 in 5 replicates for each) in separated rooms. Control does were exposed to natural day light (G1), while those in G2 and G3 were exposed to artificial fluorescent or red lights, respectively for 16L/8D regime. Kindling Rate (KR), Gestation Period (GP) and Litter Size (LS) of does as well as weight (LW), Viability Rate (VR) and gain of kits was recorded at birth and weaning for three consecutive litters. Blood samples were collected pre-insemination for the $2^{nd}$ parity from 10 does in each group for determination of melatonin, FSH and oestrogen concentration in plasma. Values of KL, reproductive index of does, LS, VR and LW of kits at birth and LS, VR, weight and gain of kits at weaning were the highest ($p<0.05$) and GP was the shortest ($p<0.05$) for RL does. Artificial lights (FL and RL) increased ($p<0.05$) melatonin, FSH and oestrogen concentrations. In conclusion, using industrial red light resulted in increasing reproductive performance of rabbit does and weight and viability of their kits.

**Key words:** Rabbit does, red and florescent lights, fertility, melatonin, follicle stimulating hormone, oestrogen

## INTRODUCTION

Some studies have been conducted on the influence of light on rabbit's health and rabbit activities and these are almost exclusively concerned with the duration of lighting and seldom with light intensity. The practical recommendations on lighting are based more on observations in rabbitries than on experimental findings. Exposure for 14 to 16 h a day favors female sexual activity and fertilization. Breeders use either sunlight (in rabbitries with windows) or artificial lighting for one or two hours a day to satisfy the young rabbits' needs, at a set time so as not to disturb caecotrophic behavior. Most breeders use industrial warm white (Lich and Hung, 2008).

It is important to consider the following elements when the artificial light is the only source of illumination in a rabbit shed: light intensity level, day length, evenness of illumination of all cages and the colour of light emitted by the lamps (Barabasz, 2001). In rabbit breeding the 42-day reproduction rhythm (inseminating the does 11 days after kindling) is wide-spread. During the increasing stage of lactation the hormones regulating milk production prevent the production of hormones regulating reproduction resulting weak receptivity (Theau-Clement, 2007). Nowadays several investigations are being conducted in order to find natural methods replacing hormonal treatments applied for oestrus and ovulation synchronization. The effect of lighting schedule (length) on the rabbit production was analyzed by several authors (Virag *et al.*, 2000). In this respect, many investigators reported favorable effects of longer lighting (biostimulation) prior to insemination on reproductive performance of rabbit does (Maertens and Luzi, 1995).

In poultry the effect of light colour on the egg production, egg size and weight gain is well established (Rodenboog, 2001). However, scarce literate can be found describing this topic for cattle (Adam *et al.*, 1990), sheep (Casamassima *et al.*, 1994) and horse (Stachurska *et al.*, 2002). Despite rabbits are active during the dark period and are less sensitive for the colour of the light, studying its effect has a raising interest. According to various studies the rabbit's visual system which consist predominantly of rods, also contains blue-(425 nm) and green-(520 nm) sensitive cones (Juliusson *et al.*, 1994). According to the literature the rabbits perceive the red light (its wavelength) less compared to other light colours. Recently, Gerencser *et al.* (2008) analyzed the effect of the light colour (blue vs. white light) on Pannon White rabbit does. Also, Gerencser *et al.* (2009) evaluated the preference of growing rabbits for cages with different light colours (white, yellow, blue or green).

A certain level of light intensity is a signal to start or stop the synthesis of melatonin which is also responsible for reproduction processes. Melatonin controls the synthesis and secretion of the hypothalamus hormones which regulate the secretion of pituitary hormones responsible for ovulation (Udała and Błaszczyk, 1999). Pineal gland stopping melatonin secretion triggers a release of the hypothalamus hormones (Malpaux *et al.*, 1999). In addition, reproductive activity is stimulated by oestrogen and inhibited by progesterone in ovariectomized does (Hudson *et al.*, 1990). Sexual receptivity tends to be related to the estradiol levels in pseudopregnant does (Caillol *et al.*, 1983) and a direct relation between oestrogen and sexual receptivity of rabbits during the post-partum period has been reported by Elsaesser (1980).

The objective of the current work was to study the effect of florescent and red lights as compared to natural light on reproductive performance of does and growth performance of their kits.

## MATERIALS AND METHODS

The experimental work was carried out in a private Rabbit Production Farm in Zian Region, Dakahlyia governorate, Egypt, during the period from June 2010 to September 2010.

**Animals, housing and management:** Total of 75 mature California rabbit does (8-10 mo of age and 3.5-3.85 kg body weight) as well as 19 fertile California rabbit bucks (10-13 mo of age and 4-4.25 kg body weight) were used in this study. All animals were healthy and clinically free of external parasites.

All does and bucks were housed in a naturally ventilated building and kept individually in flat deck cages (50×60×40 cm) equipped with automatic water dispensers and only for does with internal nest boxes.

Animals received *ad libitum* a commercial diet (10.5 MJ of metabolazable energy per kg, 18.5% CP and 12.5% CF according to their physiological condition. Drinking water was available from nipple drinkers. Average of ambient temperature and relative humidity in Zian Region during the experimental period is shown in Table 1.

Table 1: Average of ambient temperature (°C) and relative humidity (%) during different months of the experimental period

| Experimental month | Ambient temperature (°C) | | Relative humidity (%) | |
|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum |
| June | 23.53 | 33.50 | 38.00 | 85.82 |
| July | 24.53 | 35.00 | 41.00 | 90.00 |
| August | 26.41 | 38.93 | 46.94 | 96.00 |
| September | 25.64 | 35.50 | 44.03 | 96.00 |
| Average | 24.75±0.312 | 35.35±0.457 | 42.25±0.603 | 90.82±1.139 |

Does were kept under the same management system in three separated rooms according to the experimental design, however, all bucks were kept under similar normal conditions. Cages and nest boxes were cleaned and disinfected regularly before each kindling. Urine and feces dropped from the cages on the floor were cleaned every day in the morning.

**Experimental design:** The experimental rabbit does were divided into three treatment groups (25 does in each) and each group was allotted into five replicates. Each group of does was kept in three separated identical rooms. In the room of the control group, does were exposed to the light of day (natural light) for 14-16 h during the experimental period (G1). While in two separated rooms of G2 and G3, natural light of the day was prevented by insulation windows with black curtains. Does of G2 and G3 were exposed to artificial fluorescent light (cool white) and industrial lighting (red light or warm white light) for 16 h a day, respectively. All lighting regimes (16L/8D) were applied for three consecutive litters. The amplitude of day length varied from a minimum of 14 h to a maximum of 16 h; the onset and end of lighting was controlled by an electronic clock.

Fluorescent 120 cm tube lamps (cool white light) have a blue tint and are supposed to mimic the color of light reflected from a clear sky. These tend to have a "cold" appearance. However, industrial normal cub lamps (red light) have a red tint and are supposed to mimic the color of light reflected from sun radiation.

Characteristics of the light were following: fluorescent light (cool white): 40 W, wavelength: 400-475 nm and red light (warm white), 60 W, 600-650 wavelength. Luminous intensity-independently of the light colour - measured at the middle of the cages ranged between 40-70 lux.

**Reproductive management:** On day of mating, each doe was transferred to the cage of buck and returned back to her own cage after mating. Each doe was palpated 12 days thereafter to diagnose pregnancy and those failed to conceive were returned to remate. On day 27 of pregnancy, the nest boxes were supplied with wooden straw to help the doe in preparing a worm comfortable nest for the kits of her litter. Does were mated 11 days after parturition for the next litter. After parturition, the size of the litter (total and live) was recorded and rabbit kits were weaned up to the age of 35 days.

**Blood samples and hormonal assay:** Within three days after the 1st parturition, blood samples were taken from 10 does in each experimental group pre-insemination for the 2nd parity. Blood samples were collected by puncture of the ear vein into heparinized clean test tubes and immediately centrifuged (4000 g) for 15 min. Then, plasma was separated and stored at -20°C until hormonal assay.

Concentration of melatonin in blood plasma was determined using commercial kit (Biosource, Belgium) according to Pintor *et al.* (2001). Plasma concentrations of FSH were determined in duplicate by RIA, using commercial kit (Harbor UCLA Medical Center, CA, USA) according to Ubilla *et al.* (1992). Also, oestrogen (estradiol 17-β) was determined using commercial kit (DIAGNOSTIC AUTOMATION, INC.) according to Ashby *et al.* (1980).

**Data recorded:** Within 12 h after kindling of each litter, the total number of rabbit kits was calculated. Dead kits were removed and size and weight of live kits were recorded after birth and at weaning. Kindling rate (the number of kindled does per number of mated does x 100) was determined. The viability rate (the number of live kits per total number of borns x 100) and length of gestation period (day) were also calculated. Reproductive Index (RI) was calculated as the following:

$$RI = \text{Total litter size at birth} \times \text{kindling rate} \times \text{viability rate at birth}$$

**Statistical analysis:** Data obtained in this study regard to gestation period, litter size, live body weight and hormonal concentration were analyzed using the Statistical Analysis System version 9.1.3 for Windows (SAS, 2004). One way ANOVA (GLM) was used to perform the effects of treatment on different traits. Multiple rang test (Duncan, 1955) was employed to test statistical differences among means at $p<0.05$. However, Kindling and viability rates were analyzed using Chi Square Analysis.

## RESULTS AND DISCUSSION

**Reproductive performance of rabbit does:** Results presented in Table 2 show significant ($p<0.05$) effect only for the red light on reproductive performance of does in terms of Kindling Rate (KR) and Gestation Period Length (GPL). Does exposed to red light significantly ($p<0.05$) exhibited higher KL (77.3 vs. 53.3%) and shorter GPL (31.1 vs. 31.9 d) than those exposed to natural day light (control). However, KL and GPL of does exposed to florescent light did not differ significantly from the control ones.

On the other hand, Litter Size (LS) of does at birth (total and live) and viability rate of their kits at birth significantly ($p<0.05$) increased by artificial lights as compared to the natural light.

Table 2: Effect of colour of light on reproductive traits of rabbit does

| Item | Natural light | Color of light<br>Fluorescent light | Red light | ±SEM |
|---|---|---|---|---|
| **Reproductive performance of does** | | | | |
| Kindling rate (%) | $53.30^{b}$ | $68.00^{ab}$ | $77.30^{a}$ | - |
| Gestation period (day) | $31.90^{a}$ | $31.60^{a}$ | $31.10^{b}$ | 0.16 |
| **Litter performance at birth** | | | | |
| Litter size (total) | $4.72^{c}$ | $5.68^{b}$ | $7.64^{a}$ | 0.27 |
| Litter size (live) | $3.40^{c}$ | $5.00^{b}$ | $7.36^{a}$ | 0.33 |
| Viability rate (%) | $70.70^{b}$ | $87.70^{a}$ | $96.50^{a}$ | - |
| Average kit weight (g) | $58.10^{b}$ | $60.30^{b}$ | $63.40^{a}$ | 0.86 |
| Reproductive index/doe | $1.80^{c}$ | $3.40^{b}$ | $5.70^{a}$ | 0.39 |

$^{a, b \text{ and } c}$: Means within the same row having different superscripts are significantly different at $p\leq0.05$

However, the rate of increase was significantly ($p<0.05$) higher for red than florescent light. Moreover, average weight at birth significantly ($p<0.05$) increased for kits produced from does exposed to red or florescent lights (63.4 and 60.3 g, respectively) as compared to the control kits (58.1 g, Table 2).

Based on the results of KL and LS of does and viability rate of their kits at birth, reproductive index was significantly ($p<0.05$) the highest for does exposed to red light (5.7/doe), moderate for those exposed to florescent light (3.4/doe) and the lowest for the control ones (1.8/doe, Table 2).

In accordance with the detected increase in kindling rate of rabbits exposed to red as compared to florescent light in this study, Gerencser *et al.* (2008) found higher pregnancy rate (87.0%) for rabbit does exposed to blue light than those exposed to white light (82.0%). In disagreement with the present study, the later authors found no significant differences were observed in litter size and individual weight of kit (as total and born alive at birth) between rabbit does exposed to white and blue lights.

According to the present results, color of light (red vs. florescent lights) seems to modify the reproductive performance of rabbit does. According to many authors, females housed in well-illuminated cages deliver and raise litters of larger sizes (Garcia *et al.*, 1989). Females obtaining the lowest amount of light displayed the worst reproduction performance (Felska *et al.*, 2002).

**Litter performance of kits at weaning:** Data shown in Table 3 reveal that LS at weaning was significantly ($p<0.05$) higher for does exposed to red light (6.04/litter) than florescent light (4.12/litter) and both was significantly ($p<0.05$) higher than the control does (2.40/litter). However, weaning rate of kits was significantly ($p<0.05$) higher for both artificial lights than the natural light (81.1 and 82.1% for red and florescent lights vs. 70.6% for natural light).

Regarding litter weight, live weight and gain per kit or litter at weaning was significantly ($p<0.05$) the highest for kits of does exposed to red light, followed by florescent light and the lowest for the control ones (Table 3). Such results may indicate the highest litter performance and litter weight of kits produced and reared by does exposed to red light.

The impact of colour of light (red or florescent lights) on litter weight at weaning as proved in this study was supported by Gerencser *et al.* (2008), who found that individual weight of kit on day 23 was larger ($p = 0.009$) in the blue than white group. Contrary, no significant differences were observed in litter size (born alive at 23 day of age) between rabbit does exposed to white and blue lights. Such trend may reflect favorable effects of red light on growth performance of kits during suckling period. Young rabbits do not really need light, but 15 to 16 h per day do no harm. Many breeders use either sunlight (in rabbitries with windows) or artificial lighting for one or two hours

Table 3: Effect of colour of light on litter size of rabbit does and weaning rate and weight of kits at weaning

| | | Colour of light | | |
|---|---|---|---|---|
| Item | Natural light | Fluorescent light | Red light | ±SEM |
| **Litter performance at weaning** | | | | |
| Litter size | 2.40[c] | 4.12[b] | 6.04[a] | 0.23 |
| Weaning rate (%)* | 70.60[b] | 82.10[a] | 81.10[a] | 4.58 |
| **Litter weight at weaning (g)** | | | | |
| Kit weight at weaning | 447.00[c] | 501.00[b] | 514.80[a] | 3.72 |
| Weight gain(/kit) | 388.90[c] | 440.70[b] | 451.40[a] | 3.21 |
| Weight gain( /litter) | 1072.00[c] | 2064.10[b] | 3109.40[a] | 5.47 |

[a, b and c]: Means within the same row having different superscripts are significantly different at $p \leq 0.05$. * Based on live kits

Table 4: Effect of color of light on melatonin, follicle stimulating hormone (FSH) and oestrogen (E2) concentrations in blood plasma of rabbit does

| | | Colour of light | | |
|---|---|---|---|---|
| Hormone | Natural day light | Fluorescent light | Red light | ±SEM |
| Melatonin (pg $mL^{-1}$) | $8.58^{c}$ | $16.76^{b}$ | $24.46^{a}$ | 0.26 |
| FSH (ng $mL^{-1}$) | $5.64^{c}$ | $14.00^{b}$ | $17.12^{a}$ | 0.61 |
| Oestrogen (pg $mL^{-1}$) | $11.66^{c}$ | $13.38^{b}$ | $15.46^{a}$ | 0.12 |

a, b and c: Means within the same row having different superscripts are significantly different at $P \leq 0.05$

a day to satisfy the young rabbit needs, at a set time so as not to disturb caecotrophic behavior. A much weaker light (5 to 10 lux) can be used for young rabbits (Lich and Hung, 2008).

In other domesticated farm animals, the effects of several light colours were investigated by some researchers. In broilers, Arockiam *et al.* (2001) found that the feeding behaviour was substantially modified by the blue light. Also, Rodenboog (2001) observed that weight gain of broilers improved by the blue light especially during the latter part of the fattening period. Similar studies for mammals are scarce on cattle i.e. (Adam *et al.*, 1990), sheep (Casamassima *et al.*, 1994) horse and (Stachurska *et al.*, 2002).

Such differences between rabbits and other species may be due to that the active period of the rabbits is the dark period. Consequently the recognition of colours can also be different than that of the other species (Kelber and Roth, 2006).

**Hormonal profile of rabbit does:** Hormonal data presented in Table 4 show that artificial lights (florescent and red) increased ($p<0.05$) plasma concentrations of melatonin, Follicle Stimulating Hormone (FSH) and oestrogen (E2) as compared to natural light. The observed increase by red light was higher ($p<0.05$) than that of florescent light. Generally, plasma concentration of melatonin, FSH and oestrogen was the highest ($p<0.05$) with red light and the lowest with natural light. According to the present results, both artificial lights reflected increasing all studied hormonal concentrations, being the highest on FSH, moderate on melatonin and the lowest on E2 (Table 4).

It is of interest to note that increasing FSH concentration as affected by artificial lights was associated with increase of melatonin and followed by increased concentration of E2. Lincoln and Maeda (1992) reported that FSH increased in response to melatonin treatment in the ram. Melatonin is a neurohormone secreted by pineal gland that mediates lightness±darkness signals to synchronize cellular physiology with the photoperiod (Bartness and Goldman, 1989). Melatonin also affects processes such as cell proliferation and differentiation (Benitez-King *et al.*, 1990). Reiter (1981) describes the route of innervation for photoregulation of the pineal gland. As light strikes the retina of the eye, a neural signal travels via the optic nerves to the suprachiasmatic nuclei.

Receptors for melatonin have been characterized in the hypothalamus and pituitary of the rabbit (Stankov *et al.*, 1991). Melatonin implants in the mediobasal hypothalamus of the ram caused a significant increase in prolactin (Lincoln and Maeda, 1992). Melatonin is another hormone implicated as a mediator of reproduction in the horse (Argo *et al.*, 1991; Aurich *et al.*, 1997; Peltier *et al.*, 1998). Melatonin secretion by pineal gland was determined to be circadian in nature with elevated levels occurring during the night in the equine (Kilmer *et al.*, 1982; Guerin *et al.*, 1995). Melatonin is negatively influenced by photoperiod in rats (Quay, 1963; Wurtman *et al.*, 1964), sheep (Rollag and Niswender, 1976; Karsch *et al.*, 1986) and cattle (Sanchez-Barcelo *et al.*, 1991).

A certain level (intensity) or colour of light is a signal to start or stop the synthesis of melatonin which is responsible for reproduction processes. According to Medina *et al.* (1999), light intensity is a factor that affects pineal gland metabolism. Melatonin is produced in darkness, while light inhibits the process (Medina *et al.*, 1999). Melatonin controls the synthesis and secretion of the hypothalamus hormones which regulate the secretion of pituitary hormones responsible for ovulation (Udała and Błaszczyk, 1999). Pineal gland stopping melatonin secretion triggers a release of the hypothalamus hormones (Malpaux *et al.*, 1999).

Reproductive activity is stimulated by oestrogen and inhibited by progesterone in ovariectomized does (Hudson *et a1.*, 1990). Sexual Receptivity (S.R.) tends to be related to the serum estradiol levels in pseudopregnant does (Caillol *et a1.*, 1983) and a direct relation between plasma E2, mean levels and high or low S.R. rabbits during the post-partum period, has been reported (Elsaesser, 1980).

The increased plasma E2 concentration 1-3 days after parturition are probably related to the follicular growth and increase of the follicle steroidogenic activity that occurred between the last days of pregnancy and the first day after parturition (Osteen and Mills, 1980). Also, Ubilla *et al.* (1992) observed high plasma FSH levels around day 5 after parturition in lactating rabbits. High follicular estradiol-17$\beta$ concentration, as well as, low atresia rate were observed in rabbits that accept mating (Lefevre and Caillol, 1978). Light length affects the hypothalamus-pituitary axis and consequently hormonal release (Theau-Clement *et al.*, 1995).

The visible red light has a wavelength of about 650 nm. At sunrise and sunset, red or orange colors are present because the wavelengths associated with these colors are less efficiently scattered by the atmosphere than the shorter wavelength colors (e.g., blue and purple). A large amount of blue and violet light has been removed as a result of scattering and the long wave colours, such as red and orange, are more readily seen.

Despite rabbits are active during the dark period and are less sensitive for the colour of the light, studying its effect has a raising interest. According to various studies the rabbit's visual system which consist predominantly of rods, also contains blue-(425 nm) and green-(520 nm) sensitive cones (Juliusson *et al.*, 1994).

In conclusion, using industrial red light in rabbitries with lighting regimen of 16 L/8D resulted in increasing reproductive performance of rabbit does and weight and viability of their kits during the suckling period.

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