Ann. Anim. Sci., Vol. 13, No. 4 (2013) 797–805, DOI: 10.2478/aoas-2013-0054

EXTRA LIGHT DURING PREGNANCY IMPROVES REPRODUCTIVE PERFORMANCE OF MINK (*NEOVISON VISON*)*

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Abstract

The aim of this study was to determine the effect of artificially extended daylight applied during pregnancy on reproductive performance in farmed mink. The material consisted of 536 female Black (or "short NAP") mink aged 2 years. To analyse the reproductive performance, we selected females mated twice during the period 13 to 17 March. Energy-saving bulbs of 11 watts each (equivalent to traditional 60-watt bulbs) were placed above the cages of the females. The experiment involved two groups of females: the control group (n = 258) were females kept under natural daylight throughout pregnancy; the females of the treatment group (n = 278) were additionally subjected to extended photoperiod – up to 16 hours of light per day, applied from 20 March to 15 April. Selected reproduction indicators were analysed among the groups. The extended daylight applied during pregnancy of mink positively influenced many of the analysed indices. The duration of diapause and related total length of gestation decreased, the litter size – both at birth and at weaning – significantly increased. Pre-weaning mortality of young and the proportion of non-breeding females slightly decreased as a result of the treatment, which from the practical point of view might be seen as a beneficial effect; however, these parameters are shaped by other factors than photoperiod. The whelping season was both commenced and completed earlier among females subjected to extra light during pregnancy, which improved the organization of work on the farm. Artificial illumination of pregnant mink in Poland's climate can be applied with great success and introducing this treatment to the mink breeding technology on a permanent basis should be seriously considered.

Key words: American mink, artificial lighting, breeding, litter size, gestational length

Mink farming in Poland has gained in importance in recent years. The growth is so rapid and intense that, as a result, Poland has lately become the world's third

*This work was financed from statutory activity.

largest producer of mink pelts, and the American mink is now the most common fur animal farmed in Poland.

The American mink is a seasonally breeding mustelid with induced ovulation occurring mostly between 36 and 72 hours *post coitum* (Venge, 1973; Wehrenberg et al., 1992). After ovulation, the ruptured Graafian follicle forms the corpus luteum, which functions as an endocrine gland and secretes progesterone – the hormone responsible for embryonic implantation and fetal development. Compared to other mammals, however, the corpus luteum in the mink produces smaller amounts of progesterone. Therefore – despite the fact that the first mating has led to fertilization – new oocytes will mature and, if mating is repeated, ovulation will occur again and new eggs will be fertilized. Females demonstrate two to four periods of oestrus at 6- to 8-day intervals (Wehrenberg et al., 1992). There are two to four such cycles of egg maturation in the mink. This cyclical character of female mink reproductive biology gave way to the development of multiple-mating breeding practice (Ślaska and Rozempolska-Rucińska, 2011).

Phenologically, photoperiod represents one of the breeding timing cues and is the most powerful seasonal cue, since it allows preparations well ahead of breeding; phenological events in many organisms can be induced by photoperiodic manipulation (Visser et al., 2010). The oestrus of the mono-oestrous mink in the northern hemisphere occurs in March and is elicited by an increasing amount of daylight. At a certain point (10 hours of sunlight per day), the photoperiod triggers ovarian growth and egg maturation at the level of the hypothalamo-pituitary-gonadal (HPG) axis (Hammond, 1951; Pilbeam et al., 1979; Wehrenberg et al., 1992). Photoperiodism in animals has been extensively studied and the effects of photoperiod on the HPG axis are well described (Visser et al., 2010).

Light has also another implication for the mink reproduction, in the form of diapause. The fertilized egg develops to the stage of blastula and remains inactive until embryonic implantation. This embryonic dormancy may last up to 49 days *post coitum*. According to Sundqvist et al. (1989), who presents a comprehensive review on mink reproductive biology, there is much evidence for photoperiodic control of the egg implantation process. In the mink, as in many mammals, the pineal gland mediates the effects of photoperiod on the reproductive activity, including embryonic implantation. Increasing day length elicits sufficient secretion of prolactin, leading to the termination of diapause (Sundqvist et al., 1989). Gestational length in mink ranges from 36 to more than 80 days, with an average of 51 days (Stevenson, 1945; Bowness, 1968). According to Song et al. (1998) the diapause itself lasts from 6 to 55 days.

It is commonly accepted that delayed implantation has evolved as a solution allowing timing of birth to the season of best possible living conditions (usually spring, the season of good weather followed by a usually food-abundant summer). From the practical point of view, however, one might simplify that both diapause and embryo implantation are temporally linked with the changing length of the light phase of day (Amstislavsky and Ternovskaya, 2000; Lopes et al., 2004). The importance of controlling diapause results from the fact that – as reported by Franklin (1958) – the longer the diapause, the higher embryonic mortality and, in consequence, smaller litters. Both the check in the embryonic development and a considerable variability in litter sizes usually pose problems to the breeder; however, these biological peculiarities may also bring hope for some improvement of the key breeding parameters.

Reproductive performance in mink farming depends on many environmental and genetic factors. For example, selection for coat colour may result in improved pelt quality, though at a cost of other traits, including reproduction parameters (Ślaska et al., 2009; Felska-Błaszczyk et al., 2010). Nevertheless, significant improvements in breeding performance still can be achieved if the breeder implements a properly designed mating system (Ślaska and Rozempolska-Rucińska, 2011) and creates a good environment for the mink (Socha and Markiewicz, 2002).

Many authors report that the average litter size in mink ranges from 5 (Amstislavsky and Ternovskaya, 2000; Socha and Markiewicz, 2002) to 6, or even 7 kits (Sulik and Felska, 2000; Felska-Błaszczyk et al., 2010). Our direct observations of mink breeding on farms in Poland often revealed that litters can be much more numerous, reaching up to 15 kits. This information means there is a great potential hidden in this parameter of mink reproduction.

Extended illumination of female mink during pregnancy is a treatment that can improve reproduction parameters of the herd. It has been applied since the beginning of the 20th century by ranchers in North America (Hansson, 1947), where farming of this species has a much longer tradition than in Poland; however, in Poland this treatment has not been applied so far. Breeders in Poland often complain that the whelping season is extremely long, which impedes the workflow on the farm. The issues of reduced fertility of females, extended gestational lengths, and reduced litter sizes, which seem to haunt Polish mink breeders, stood behind our decision to undertake studies on the efficiency of application of an additional factor to enhance productivity, i.e. lighting of pregnant females.

The aim of this study was to determine the effect of extended daylight during pregnancy on the reproductive performance in mink.

Material and methods

The experiment was conducted on a commercial mink farm in West Pomerania, Poland, in 2010. The material comprised 536 females of Black variety, also called short NAP, aged 2 years. All the females were mated twice during 13 to 17 March. The animals were housed in identical cages under double-row multipurpose sheds used for both males and females of the breeding stock, as well as for offspring nursing. All the mink remained under the same management conditions. The animals were fed according to current standards (Gugołek and Barabasz, 2011). Semi-liquid feed based on fish and chicken was supplied three times a day, automatically dosed by a machine feeder directly on top of the cage. Each animal received the same ration of feed of the same quality.

Lamps equipped with 11-watt energy-saving bulbs (710 lumens of light output, equivalent to traditional bulbs of 60 watts) were placed above the cages of the females. The bulbs were installed at a height of 220 cm, at intervals of 270 cm, in the middle of the feed aisle, i.e. over each breeding unit (consisting of 5 groups of 8 females each and 1 group of 8 males).

The analysis involved two groups of females – one group, 258 females, were housed under natural daylight throughout pregnancy (control group). The second group, 278 females, were placed under conditions of extended daylight – up to 16 hours of light per day – applied from the date of mating completion until 15 April (treatment group).

The following reproduction parameters were analysed:

– total gestational length (period from the date of first copulation until parturition),

– diapause length (total gestational length minus 36 days, i.e. 6 days from fertilization until embryo transition into dormant state and 30 days from implantation until birth),

– litter size at birth (the total number of kits per litter, fecundity),

– live-born percentage (proportion of live-born kits per litter),

– litter size at weaning (number of kits weaned from litter),

– pre-weaning mortality (percent mortality of kits during maternal nursing),

– non-breeding females percentage (proportion of anoestrous, putatively infertile females, which were mated but failed to give birth),

– distribution of births (temporal whelping distribution, grouped in the following time intervals: 28 April to 4 May, 5 to 11 May, 12 to 18 May, and after 18 May).

Statistical analyses of the results were performed using the R language and environment for statistical computing (R Development Core Team, 2011). Due to a lack of normality and homoscedasticity of variances among the data (using the Shapiro-Wilk test and Bartlett test), we used the Wilcoxon rank sum test to estimate the significance of differences in the reproduction parameters (including distribution of births), and Pearson's chi-squared test for non-breeding female percentages among the groups.

Results

Length of gestation and diapause

Table 1 shows the length of gestation and diapause depending on the lighting conditions. Additional illumination during pregnancy resulted in a positive effect, since both the diapause and, consequently, the total length of pregnancy, were reduced. Pregnancy in control animals lasted 52.49 days, whereas gestational length in females that remained under 16-hour daylight was 50.54 days. Both differences were highly significant ($P<0.01$, see Table 1 for details).

Table 1. Gestational length and length of diapause by illumination conditions during pregnancy

Trait	Group	Mean (days)	SD	V%	Range
Gestational length	Control	52.49 A	4.07	7.76	46–67
	Treatment	50.54 A	3.24	6.41	42–60
	Total	51.50	3.80	7.37	42–67
Diapause length	Control	16.49 B	4.07	24.70	10–31
	Treatment	14.54 B	3.24	22.29	6–24
	Total	15.50	3.80	24.50	6–31

A, B – data with same letters differ highly significantly, Wilcoxon rank sum test: W = 16812.5, P = 0.00000134.

Litter size and pre-weaning mortality

Table 2 presents the data on litter size at birth, live-born percentage per litter, litter size at weaning, and pre-weaning mortality rate. Statistically significant differences ($P<0.01$, see Table 2) were noted among groups in litter size at birth and at weaning. Females that were subjected to additional lighting during pregnancy gave birth to – on the average – one more kit, compared to those remaining in natural light conditions. It must be stressed that litter size at weaning strongly depends on the initial value (i.e. litter size at birth); also, live-born percentage did not differ among the groups. Neither did pre-weaning mortality rate, since there is no biological background that would allow associating post-natal period of life with light during gestation and pre-natal period of life.

Non-breeding females and extra light

As expected, the number of females that failed to give birth – putatively infertile – was not changed significantly as a result of the treatment. Among the treatment females, non-whelping females percentage (18.60%, n = 48) was slightly lower (by 2.62 percent point), as compared to the control (21.15%, n = 59); the difference, however, was non-significant (Pearson's chi-squared test $\chi^2 = 0.7846$, $P = 0.3757$).

Table 2. Litter size at birth, live-born percentage, litter size at weaning, and pre-weaning mortality by illumination regimes applied during pregnancy

Trait	Group	Mean	SD	V%	Wilcoxon test	
					W	P-value
Litter size at birth	Control	6.12 A	2.78	45.46	18392.0	0.00
	Treatment	7.13 A	2.67	37.62		
	Total	6.61	2.78	41.99		
Live-born percentage	Control	89.40	19.72	22.05	24137.5	0.28
	Treatment	90.30	20.01	22.16		
	Total	89.86	19.85	22.09		
Litter size at weaning	Control	4.80 B	2.63	54.73	18980	0.00
	Treatment	5.57 B	2.79	50.18		
	Total	5.18	2.74	52.82		
Pre-weaning mortality (%)	Control	21.77	29.38	134.96	23390.5	0.75
	Treatment	21.23	29.64	139.58		
	Total	21.51	29.47	137.04		

A, B – differences significant at $P<0.01$.

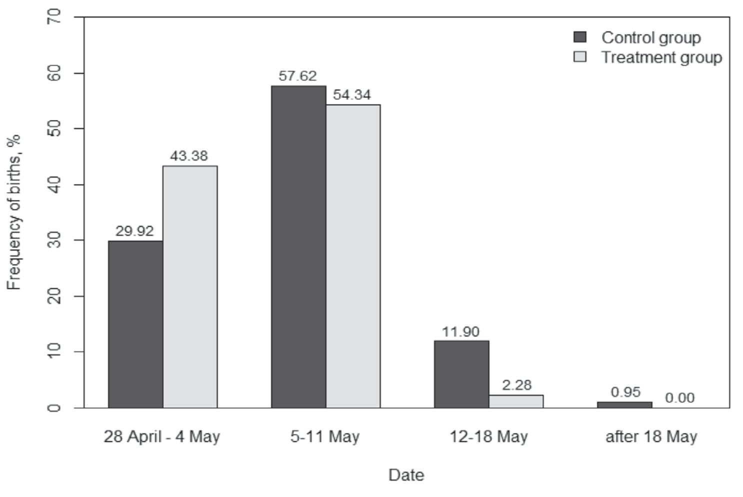

Figure 1. Distribution of births depending on the illumination applied throughout pregnancy

Distribution of births

Figure 1 shows the distribution of births depending on the lighting conditions. Prolonged daylight during pregnancy resulted in the fact that more females (almost 14%) gave birth during the first period, i.e. from 28 April to 4 May, as compared with the control. Another outcome is that the females ended births earlier, as all litters were born before 18 May. On the other hand, females that remained in natural light conditions still gave birth after 18 May. The effect of additional illumination on birth distribution was significant (Wilcoxon rank sum test with continuity correction, W = 29240, P-value = $1.027 \cdot 10^{-6}$).

Discussion

The experimental 16-hour light programme has led to some improvements in reproduction. First of all, it resulted in shorter gestation, which is a very positive effect, since – as many authors state – the shorter the pregnancy, the greater the litter size (Franklin, 1958; Felska-Błaszczyk et al., 2008; Felska-Błaszczyk et al., 2012). Pregnancies in this group of females lasted from 42 to 60 days. Studies by other authors, e.g. Hansson (1947) or Allais and Martinet (1978), also demonstrated beneficial effects of additional lighting on pregnant mink. These authors conclude that shorter pregnancies under such light regimes are due to a more rapid increase in the level of blood progesterone, which accelerates embryonic implantation in the uterine wall and thus leads to earlier birth.

The range of diapause lengths observed in our experiment, 6 to 24 days, is much narrower compared to that reported by Rose et al. (1986), i.e. from 5 to 55 days. Even females housed under natural light conditions in our experiment did not demonstrate such long diapause, as it lasted 10 to 31 days in this group. The average length of diapause in light-treated females was 14.54 days, which was a better result compared to those obtained by other authors. Murphy et al. (1983) reported that the average length of diapause was 23.7 days, and Song et al. (1995) reported 19 days. The results revealed by these authors are worse even than those attained by females in our control group, which exhibited 16.49 days of diapause on average.

An increase in the litter size was another beneficial effect of artificial lighting of pregnant mink. Treatment females gave birth on average to one more kitten, as compared to females remaining under the natural photoperiod. This effect represents the fundament for a very positive economic improvement. Researchers have noted very early that prolonged illumination during pregnancy increases litter sizes in mink (Hansson, 1947; Hammond, 1951). In a study by Klochkov and Zhelezova (1980), who posthumously examined pregnant females sacrificed on day 30 of gestation, more embryos were found in females which during pregnancy remained in artificial lighting conditions, compared to those kept under natural light.

Although other reproduction parameters in our experiment, such as live-born percentage, pre-weaning mortality, or percentage of infertile females, were also slightly improved, the differences were statistically non-significant. It must be stressed that this may have been expected, as there is no biologically based linkage between light conditions and post-natal parameters, such as weaning rate.

Another effect of the artificial illumination that is worth mentioning is the distribution of parturitions. It was found that more than 97% of the females which remained in pregnancy in a 16-hour lighting programme gave birth before 11 May. On the other hand, 87.5% control females whelped during the same period, i.e. approx. 10% less. Such distribution is a very desirable effect, since it greatly improves the workflow on the farm. The sooner all females are ready with births, the better, since it is associated with a variety of manipulations, including introduction of a new feeding scheme.

We conclude that 16-hour daylight applied to pregnant mink positively influenced the major part of the analysed parameters of reproduction. It resulted in a decreased duration of diapause and – consequently – reduced total length of gestation and, hence, significantly larger litters. Females started parturitions earlier and ended earlier, which improved the workflow on the farm. Artificial illumination of pregnant mink in Poland's climate can be applied with great success and introducing this treatment to the mink breeding technology on a permanent basis should be seriously considered.

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Accepted for printing 6 III 2013

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Dodatkowe światło w okresie ciąży poprawia wskaźniki użytkowości rozrodczej u norki (*Neovison vison*)

STRESZCZENIE

Celem pracy było określenie wpływu wydłużonego dnia świetlnego w okresie ciąży na wyniki rozrodu norek. Materiał badawczy stanowiły 536 samice norki odmiany czarnej, tzw. short NAP, w wieku 2 lat. Do analizy użytkowania rozrodczego wybrano samice kryte dwa razy, w okresie od 13 do 17 marca. Nad klatkami z samicami zostały umieszczone żarówki energooszczędne o mocy 11 W (odpowiada to żarówkom tradycyjnym o mocy 60 W). Analizą objęto dwie grupy samic – jedna grupa 258 samic przebywała w warunkach naturalnego oświetlenia przez cały okres ciąży (grupa kontrolna), a druga grupa – 278 samic od 20 marca do 15 kwietnia przebywała w warunkach wydłużonego do 16 godzin na dobę dnia świetlnego (grupa doświadczalna). W każdej grupie analizowano wybrane wskaźniki rozrodu. Wprowadzony w czasie ciąży norek 16-godzinny dzień świetlny wpłynął korzystnie na dużą część analizowanych wskaźników rozrodu. Zmniejszyła się długość trwania diapauzy i związana z tym całkowita długość ciąży, znacznie zwiększyła się liczba urodzonych i odchowanych młodych w miocie. Śmiertelność młodych w okresie odchowu i procent samic, które nie rodziły uległy nieistotnym statystycznie zmianom. Samice poddane doświetlaniu wcześniej zaczęły i wcześniej zakończyły porody, co usprawniło organizację pracy na fermie. Sztuczne doświetlanie ciężarnych samic norek w warunkach klimatycznych Polski może być stosowane z dużym powodzeniem, a więc należy poważnie zastanowić się nad wprowadzeniem tego zabiegu na stałe do technologii chowu norek.