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ANALYSIS OF BODY WEIGHT IN VARIOUS COLOR VARIETIES OF AMERICAN MINK (*NEOVISON VISON*) AND THE RELATIONSHIP BETWEEN FEMALE BODY WEIGHT AND REPRODUCTIVE PERFORMANCE

Beata Seremak[1], Lidia Felska-Błaszczyk[2]

[1]Department of Animal Reproduction Biotechnology and Environmental Hygiene, West Pomeranian University of Technology, Klemensa Janickiego 29, 71-270 Szczecin, Poland
[2]Department of Animal Anatomy, West Pomeranian University of Technology, Klemensa Janickiego 33, 71-270 Szczecin, Poland

ABSTRACT

The aim of the study was to analyze the body weight of different color varieties of breeding mink and to assess the relationship between the body weight of females and the reproductive indexes obtained. The research material consisted of 3499 one-year-old American mink females of five color varieties: White Regal, Standard Black, Pearl, Silverblue and Black Cross. Six body-weight ranges of female mink were distinguished. The following were analyzed within each range: pregnancy length, fertility, average number of kits born in a litter, average number of kits born alive in a litter. It was also examined whether there was a relationship between the color variety and the average body weight of females attained during the pre-mating body condition adjustment. There were statistically significant differences in the body weight of the analyzed color varieties of mink. It was also found that the body weight of females obtained in the period of breeding preparation influences the resulting reproductive performance. Higher body weight positively influences fertility, while animals of an average body weight produce larger litters of kits.

Key words: mink, body weight, reproduction, color variant, fertility

INTRODUCTION

A variety of coat color types in the American mink farmed today is a result of decades of selective breeding conducted on mink farms. Not only do the resulting mink varieties differ in the color of the coat and breeding performance, but also in the average body weight and other traits. For example, it has been found that the minks of different color varieties may exhibit different morphological features of the skull [Baranowski et al. 2014], may differ in the size of the heart or in the structure and shape of the coronary vessels [Baranowski and Żuk 2019, Baranowski and Żuk 2020]. The apparent significant inequalities in the body weight of the mink of different colors result from genetics rather than from the environment, as housing and feeding conditions of the farm are the same [Liu et al. 2011, Do and Miar 2020]. The annual production cycle on a mink farm consists of four stages different in terms of feeding regime, which is adjusted to current energy and nutrient requirements of the animals [Bis-Wencel 2006, Bielański et al. 2013]. One of these is the breeding-preparation season, when a restrictive feeding regime applies. Prior to slaugher, however, the animals are fed intensively in order to obtain higher body weights and gain in fatness, which guarantees larger pelts without compromising the fur quality parameters (such as hair height, density etc.). During this time, animals are selected for the breeding stock. Due to the intensive feeding, excessive body weight and body fat deposition may affect both the mink intended for slaughter and those selected for breeding. Such a situation is a problem in term of reproduction performance; there is a cost in the form of deteriorated breeding results [Felska-Błaszczyk et al. 2017, Felska-Błaszczyk and Seremak 2020], hence restrictive feeding applied in order to bring the animals to the so called breeding condition.

Beata Seremak beata.seremak@zut.edu.pl

Many authors express an opinion that the optimal body condtion is the key factor in terms of the reproductive success of the herd [Boudreau 2012, Boudreau et al. 2014, Felska-Błaszczyk et al. 2017, Bis-Wencel et al. 2018, Felska-Błaszczyk and Seremak 2020]. Well designed restrictive feeding regime using reduced energy feeds, followed by the flushing period preceeding the mating season, has a positive effect on the reproductive performace of both males and females [Tauson 1988, Tauson 1993]. Despite the feeding restrictions, care schould be taken to properly balance the food ration, eliminating deficiencies that may be detrimental to the reproductive perfomance [Tauson et al. 2000]. The proper breeding condition of the body can be achieved if the process of weight reduction is prolonged [Korhonen 1990]. Slimming of the animals should start as early as in November or December and must be carried out in an individual way, being adjusted to the current body weight of the particular animal as well as to the weather conditions of the given year. Large-scale farming systems is a real challenge when it comes to the individual approach to the animals, which requires experienced workers and consumes a lot of labor.

The common practice of maximally rapid slimming of the animals shortly before the copulation period, as can be observed on many farms, is an error which may lead to fatty liver, one of the more frequent causes of deaths [Dick et al. 2014], as well as to an increased mortality of young mink associated with the occurrence of the preweaning diarrhea (the so-called "sticky kits", see Birch et al. [2018]) or the inanition referred to as nursing sickness. The factors of this sickness include suboptimal body condition of the female prior the mating season (too obese or, contrary, emaciated) or stress resulting from labor and lactation [Rouvinen-Watt 2003]. Another important problem related to the inadequate preparation of females for reproduction is the abnormal development of the mammary gland. According to Clausen and Dietz [2000], females that had been fed too intensively had a problem of overproduction of milk in relation to the litter's needs, which led to milk retention, swelling and inflammation of the mammary gland and to female's reluctance to suckle the kits due to pain.

Due to the fact that body weight during the mating season is important for reproductive condition, and that the color varieties of mink differ in body structure, the aim of the study was to analyze the body weight of various color variants of mink during the mating period and to assess the effect of body weight of females of various colors on their reproductive performance.

MATERIAL AND METHODS

The experiment was carried out on a mink farm located in northern Poland. The animals on the farm were housed in sheds and fed according to generally accepted standards. The ration consisted of a semi-liquid feed based on chicken and fish, fed directly to the cages with an automatic feeder. The research material consisted of one-year-old female American mink of five color varieties: White Regal, Standard Black, Pearl, Silverblue and Black Cross (Table 1). Each of the females was weighed by briefly letting the animal into a trap cage and placing it on a scale. Body weight measurements were made two weeks before the copulation period, i.e. during the preparation of females for reproduction using restrictive feeding regime. During the mating period, females selected for analysis were mated 3 times, in the period from March 1 through 7, according to the scheme 1 + 2 + 7 (mating on days 1, 2 and 7 of the month).

Table 1. The number of female mink in the experimental groups within individual color varieties

Color variety	Number of females
White Regal	680
Standard Black	626
Perl	1012
Silverblue	685
Black Cross	501
Total	3504

For the purposes of the experiment, the mink were grouped into 6 body-weight ranges:

- $\leq$ 0.79 kg, Group I,
- 0.8–0.99 kg, Group II,
- 1.0–1.19 kg, Group III,
- 1.2–1.39 kg, Group IV,
- 1.4–1.59 kg, Group V,
- $\geq$ 1.6 kg, Group VI.

Using individual farm records, the following were analyzed for females within particular weight ranges: fertility, average litter size and average live-born litter size. It was also determined whether there was a relationship between the color variety and the average body weight of females attained shortly before the mating period.

The datasets were processed using the Statistica 13PL package and a spreadsheet. The mean, standard deviation and standard error were used as descriptive statistics of the results. In the case of fertility, the non-parametric Kruskal-Wallis test was used to compare multiple trials of independent groups. Tukey's parametric RIR test for unequal group sizes and two-way ANOVA were applied to determine the significance of differences between the means of individual reproductive indices. The analysis was based on the followinf linear model:

$$Y_{ij} = \mu + w_i + c_j + e_{ij}$$

where:

Y_{ij} – trait level,
μ – population mean,
w_i – effect of female body weight,
c_j – effect of female color variety,
e_{ij} – random error.

RESULTS

The body weight of females of five color varieties was analyzed (Table 2). The data shows that White Regal females were characterized by the lowest average body weight, 1.02 kg, and the heaviest were Black females, 1.37 kg, and silverblue, 1.26 kg. There were significant differences in body weights between all the analyzed color varieties of mink, which was statistically significant at $P \leq 0.01$.

The analysis of the percentage of mink in individual weight ranges (Fig. 1) reveals that the body weight varies within the color varieties. The white regal variety was characterized by the highest percentage, 46.33%, of animals belonging to Group I and II; however, no animals from Group VI were recorded. The heaviest animals were Silverblue and Black Cross, where the most specimens belonged to Group III, IV and V. Within these color varieties, the largest number of animals weighing more than 1.6 kg, i.e. from the VI weight range, was recorded.

The joint analysis of all the animals (Fig. 2) shows that the greatest number of individuals with a body weight of 1 to 1.19 kg and 1.2 to 1.39 kg, i.e. belonging to Groups III and IV. The lowest percentage of mink was recorded in the extreme ranges. And so in the first range (Group I) it was 1.57%, while in Group VI it was 2.80% of the animals.

Data on fertility and litter sizes depending on the color variety are presented in Table 3. As a result of the analysis, it was shown that the highest percentage of fertile mink (i.e. those that gave birth) was noted for the Silverblue color variety, 93.43%, and for the Black Cross, 90.82%, so in the heaviest animals. Silverblue females also gave birth to largest litters and the most live born kits in a litter, on average 7.05 and 6.71 kits, respectively. The smallest percentage of females completed was recorded in the lightest females – in the white regal variety 76.47% and in the standard black variety, 76.20%. At the same time, in the white regal variety, the lowest value of born and live born pups was found, 6.14 and 5.69 individuals per litter, respectively.

Data on the percentage of bearing mink females by body weight (Table 4) differ in relation to the color variant. Since the groups varied in size, we analyzed only groups of more than 20 individuals, whereas smaller groups (below 20 minks) were marked with asterisk (*) and have not been incuded in the process of resulting data analysis. Looking at the data in Table 4, one can con-

Table 2. Average body weight of female mink within individual color varieties

Color variety	N	Mean body weight, kg	SD	SE
White Regal	680	1.02**	0.17	0.006
Standard Black	626	1.13**	0.15	0.006
Perl	1012	1.19**	0.19	0.005
Silverblue	685	1.26**	0.19	0.007
Black Cross	501	1.37**	0.19	0.008
Total	3504	1.18	0.20	0.003

**Means in the columns differ significantly at $P \leq 0.01$.

Table 3. Fertility, total litter size and number of live-born kits per litter by color variety

Color variety	N	Bearing females	Fertility, %	Average total litter size ±SE	Average live-born kits per litter ±SE
White Regal	680	520	76.47	6.14^{AB} ±0.11	5.69^{ABC} ±0.11
Standard Black	626	477	76.20	6.51^{C} ±0.09	5.86^{Dab} ±0.10
Perl	1012	868	85.77	6.88^{B} ±0.06	6.11^{AEa} ±0.07
Silverblue	685	640	93.43	7.05^{ACD} ±0.08	6.71^{BDE} ±0.08
Black Cross	501	455	90.82	6.47^{CD} ±0.10	6.13^{CEb} ±0.10
Total	3504	2960	84.66	6.61 ±0.03	6.10 ±0.04

A, B, C… – means in columns marked with the same letter differ significantly: upper case at $P \leq 0.01$, lower case at $P \leq 0.05$.

Table 4. Fertility, total litter size and number of live-born kits per litter by color variety in relation to body weight

Color variety	Weight range	Number of females	Bearing females	Fertility, %	Total liter size		Live-born per litter	
					mean	SE	mean	SE
White Regal	I	42	26	61.90	6.36	0.36	6.11	0.35
	II	273	211	77.29	6.00^{AC}	0.16	5.67^{A}	0.16
	III	251	196	78.49	6.22^{B}	0.16	5.79^{B}	0.17
	IV	95	71	74.74	6.56	0.24	5.73	0.26
	V	19*	16*	84.21	5.68	0.46	4.79	0.49
	VI	–	–	–	–	–	–	–
Standard Black	I	6*	2*	33.33*	7.01*	1.15*	7.00*	1.15*
	II	106	75	70.75	6.75	0.19	6.25	0.21
	III	321	239	74.45	6.49	0.13	5.90^{C}	0.13
	IV	172	128	74.42	6.49	0.19	5.60^{D}	0.22
	V	21	18	85.71	5.27	0.53	4.77	0.55
	VI	–	–	–	–	–	–	–
Perl	I	5*	4*	80.00*	6.23*	0.61*	5.34*	0.74*
	II	145	124	85.52	6.92	0.15	6.32	0.16
	III	386	333	86.27	7.03^{C}	0.11	6.43	0.11
	IV	360	314	87.22	6.71	0.11	5.84^{E}	0.12
	V	96	78	81.25	6.83	0.18	5.88	0.19
	VI	20	15	75.00	6.59	0.47	5.40	0.47
Silverblue	I	2*	2*	100*	8.00*	0.00*	7.00*	0.00*
	II	53	50	94.34	7.23	0.29	6.92	0.30
	III	228	207	90.79	7.27^{AB}	0.14	6.91^{ABCDE}	0.14
	IV	233	217	93.13	6.95^{a}	0.15	6.61^{a}	0.15
	V	144	139	96.53	6.85	0.18	6.52	0.19
	VI	25	25	100	6.40	0.48	6.28	0.49
Black Cross	I	–	–	–	–	–	–	–
	II	17*	14*	82.35*	6.26*	0.36*	6.19*	0.39*
	III	104	96	92.31	6.71	0.18	6.51	0.18
	IV	216	196	90.74	6.69	0.14	6.23	0.15
	V	111	99	89.19	6.16	0.22	5.63	0.22
	VI	53	50	94.34	6.06	0.34	5.71	0.35
Total	I	55	34	61.81	6.42	0.26	6.02	0.26
	II	594	483	81.31	6.59	0.08	6.18	0.09
	III	1290	1071	83.02	6.76	0.06	6.25	0.06
	IV	1076	926	86.06	6.71	0.06	6.14	0.06
	V	391	341	87.21	6.54	0.10	5.91	0.10
	VI	98	90	91.84	6.28	0.22	5.70	0.22
Grand total		3504	2960	84.66	6.61	0.03	6.10	0.04

* Smaller subgroups (n < 20) ignored in analyses.
A, B, C… – means in columns marked with the same letter differ significantly: upper case at $P \leq 0.01$, lower case at $P \leq 0.05$.

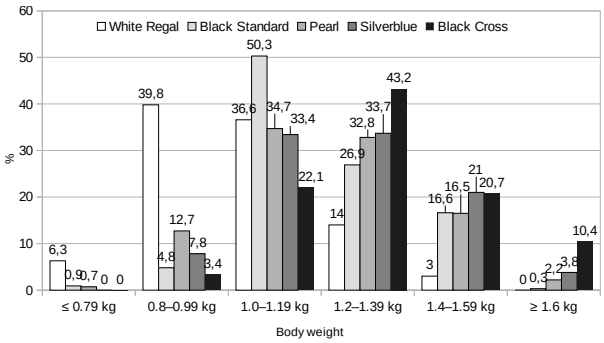

Fig. 1. The percentage of individual weight ranges by color

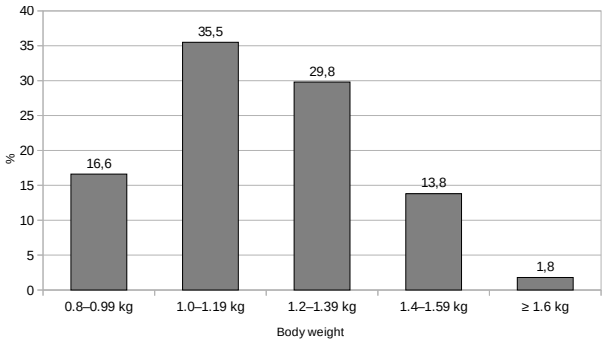

Fig. 2. Percentage of the individual mink weight ranges

clude that, regarless of the color variant, heavier females were more prolific, with most cases located in groups V and VI, i.e. above 1.4 kg of body weight (except for the Perl femals, were the highest fertility was observed in group IV, that is between 1.2 and 1.39 kg). The lowest fertility was noted in the lightest females, which was the case for nearly all the studied color variants. This relationship is more clearly visible in females, regardless of the color variety, where the lightest females achieved only less than 62% fertility, whereas the heaviest females attained nearly 92%.

Analyzing the fertility of females of particular color varieties in relation to the body weight, one can note that the highest rates do not occur in the heaviest females, but in females with an average body weight, which ranges from 0.8 kg to 1.39 kg, i.e. groups II through IV. Most often it was group III, i.e. females weighing from 1 kg to 1.19 kg (in varieties: Pearl, Silverblue and Black Cross). On the other hand, the lowest fertility was recorded in the heaviest females in all color varieties under study. There were several statistical differences at $p < 0.01$ in the number of kits born in the litter between the lowest values, attained by the White Regal females, and the highest values of this trait, observed in Silverblue and Pearl. In the number of live born per litter, there were also a few statistical differences at the level of $p < 0.01$ between the lowest values of White Regal females, Standard Black and Pearl and the highest values attained by Silverblue. Silverblue females were characterized by the highest mean of born and live born young per litter, 7.27 and 6.91 kits, respectively, in the weight range III among all weight ranges and all color varieties selected for the analysis.

If we omit the color variety, with only the weight ranges taken into account, it can be confirmed that the highest numbers of born and live born young, respectively 6.76 and 6,25 kits, were obtained from females with an average body weight in the range III (1 to 1.19 kg); the lowest values of these indices were recorded in the heaviest females, in the weight range VI (above 1.6 kg), 6.28 and 5.70 kits, respectively, born and live born.

DISCUSSION

The studies indicate a large variation in body weights in mink of different color varieties. The females were managed under the same conditions and fed the same feed in the same amount, which means that the differences in the body weight are predominantly genetically determined. Baranowski et al. [2014] and Baranowski and Żuk [2019, 2020] report on the anatomical differences between the color varieties of mink, including the structure of the skull and heart (with coronary vessels). As stated by Liu et al. [2017] and Do and Miar [2020], differences in the body weight of mink of different color varieties are visible already at a very young age, because their growth curve differs significantly – some mink grow faster and mature faster while others grow and mature more slowly. The heritability coefficient of body weight is 0.43 in females and 0.48 in males, so it is a trait with an average level of heritability [Thirstrup et al. 2017, Cai et al. 2018].

Korhonen [1990] argued that between December (reaching peak body weight) and March (mating season), minks lost an average of 16% of their body weight. As a result of selection, new color varieties of mink have appeared over the recent years, and the body weight of farmed mink increased. According to Boudreau et al. [2014] and Bis-Wencel et al. [2018], selection for largest possible skins often leads to obesity and fatness in mink, and consequently to reproductive problems. Also, Tinggaard et al. [2012] showed that females that were too obese gave birth to smaller litters than those in the normal body condition. In the above studies, the general analysis of fertility of females by color variety (without division into weight ranges) showed that Silverblue females included the highest percentage of females that had produced offspring, 93.43%. The second highest result of 90.82% was recorded for females of the Black Cross variety. Both these varieties belong to the heavier mink.

In contrast, the lowest fertility was found in Standard Black and White Regal females with lower body weight, 76.20% and 76.47%, respectively. In the case of the White Regal females, this percentage was higher than that

presented by Bielański et al. [2005], who noted 33% of sterile females (67% fertility) in their research. It should be emphasized that the fertility results obtained on the farm were high compared to other farms. And so, the average number of kits born for the Silverblue variety was 7.05 individuals and differed from the average attained on other farms; these were shown in a report by Ślaska et al. [2009], where the mean litter size was 6.20. For this color variety, a low level of juvenile deaths was also noted. This confirms the results obtained by Karimi et al. [2018], who found that selecting mink for higher litter weights at birth can effectively improve the survival rate and the number of live mink kits on farms.

This study reveals that females with a higher body weight achieve higher fertility rates (fewer sterile females) but lower fertility (born and live born kits per litter). The fact that heavier females are less fertile has already been demonstrated by Lagerkvist et al. [1993]. Similar results were obtained by Felska-Błaszczyk and Seremak [2020], who found that females in a very heavy and obese condition had higher fertility but less numerous litters. The authors also found that heavier females show less stereotypical behavior [the so-called fur-chewing]. Looking at the results obtained in this study and those obtained in previous studies [Felska-Błaszczyk and Seremak 2020], it can be concluded that it is better for females not to have too low body weight, because such females are characterized by low fertility rates and not too high fertility (litter sizes).

The analysis of the influence of the color variety on the condition of female American mink confirmed the hypothesis that the multiplicity of color varieties is reflected in the diversity of body sizes of the animals. This necessitates the need to differentiate food ration depending on the given color variety. A similar relationship was confirmed by Socha and Kołodziejczyk [2006].

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CONCLUSION

Undoubtedly, the period of body condition adjustment before the reproduction season is a very important moment on the farm, and if the farmers keep to certain rules, the reproductive performance will grow and, indirectly, the effectiveness of breeding will improve. The presented results confirmed the hypothesis that the body weight of females attained during the preparation for breeding has an impact on the resulting reproductive performance. Higher body weight positively influences fertility, while animals with lower weight (but not the lowest) produce larger litters of kits. It was found that the multiplicity of fur color variants is reflected in the variety of their body weight.

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ANALIZA MASY CIAŁA RÓŻNYCH ODMIAN BARWNYCH NORKI AMERYKAŃSKIEJ (*NEOVISON VISON*) ORAZ OCENA ZALEŻNOŚCI POMIĘDZY MASĄ CIAŁA SAMIC A UZYSKIWANYMI WSKAŹNIKAMI ROZRODU

STRESZCZENIE

Praca miała na celu analizę masy ciała różnych odmian barwnych norek hodowlanych oraz ocenę zależności pomiędzy masą ciała samic a uzyskiwanymi wskaźnikami rozrodczymi. Materiał do badań stanowiło 3499 jednorocznych samic norki amerykańskiej pięciu odmian barwnych: biała regal, standard czarny, perła, silverblue i czarny krzyżak. Wyodrębniono 6 przedziałów wagowych samic norek, dla każdego z nich przeanalizowano: długość ciąży, płodność, średnią liczbę urodzonych szczeniąt w miocie, średnią liczbę żywo urodzonych szczeniąt w miocie. Określono również, czy występuje zależność pomiędzy odmianą barwną a uzyskaną średnią masą ciała samic w czasie trwania okresu kondycjonowania zwierząt. Stwierdzono duże różnice w masie ciała analizowanych odmian barwnych norek, które zostały potwierdzone statystycznie. Stwierdzono również, iż masa ciała samic uzyskiwana w okresie przygotowania do rozrodu ma wpływ na uzyskiwane wyniki rozrodcze. Wyższa masa ciała korzystnie oddziałuje na parametr płodności, natomiast wyższą średnią urodzonych młodych charakteryzują się zwierzęta ze średnią masą ciała.

Słowa kluczowe: norka, masa ciała, reprodukcja

Beata Seremak https://orcid.org/0000-0003-0917-0607
Lidia Felska-Błaszczyk https://orcid.org/0000-0002-3765-5954