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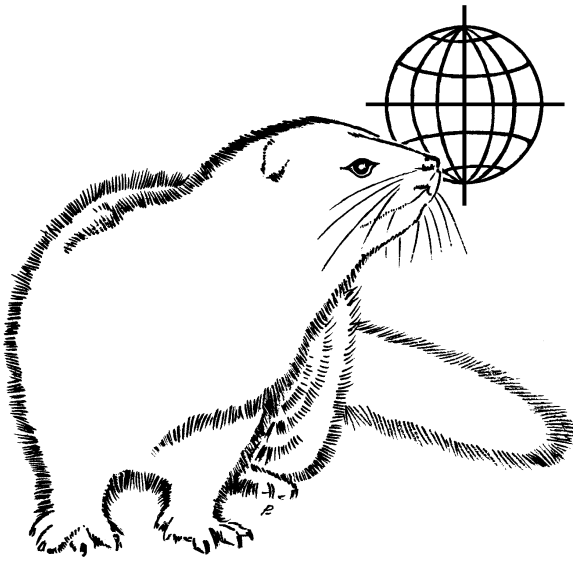

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Proceedings of the IX International Scientific Congress in Fur Animal Production

Edited by:

Dr. Berhard Benkel
Dr. Hossain Farid
Dr. Bruce Hunter
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Lora Harris

RP = Reviewed Paper
P = Paper

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Proceedings of the IX International Scientific Congress in Fur Animal Production

I: Satellite Symposium on Litter Size and Kit Survival

Edited by:

Dr. Bruce Hunter
Dr. Bruce Murphy
Lora Harris

I – 1 P

Introduction to workshop ´Litter size and kit survival´

B.K. Hansen
Department of Genetics and Biotechnology, Faculty of Agricultural Sciences, Aarhus University, DK-8830 Tjele, Denmark.
E-mail address: BenteK.Hansen@agrsci.dk

Introduction

Good reproduction is an important economic factor in fur production. This economic impact lies in the number of kits/pups per breeding unit at pelting time. This again depends on the number of offspring born and surviving until pelting.

During recent years, fur farmers have been very concerned about reproduction. After the steady progress made in mink production on this field until early 1990's the litter size per mated female has stagnated since 1995. In fox production, the litter average has been declining since early 1990's. Therefore we entitled this Satellite Workshop 'Litter size and Kit survival' as further research and new innovations in this area seem extremely necessary. We know that fur animals are born with a genetic potential, but it is the environment, that determines to what extent the genetic potential is utilized, and making progress needs optimizing both of these factors. In this workshop we aim to focus on three important areas: breeding, physiology and management aspects of 'Litter size and Kit survival' in order to increase our knowledge using the interaction across scientific fields.

Breeding

Modern breeding programmes for fur animals were developed in the 1980's and include estimation of breeding value (BV) for female fertility. The models for BV estimation have continuously been improved and are based on the most modern knowledge on this field. Even though the heritability of litter size is generally low, it has been possible to increase it by selection in many species. Good results have been achieved e.g. in pig production (Vernersen 2007a), where litter size counted at 5 days *post partum* has high priority as a breeding goal.

Litter size depends on the number of kits born and the number of kits survived. In fur animal production the litter is usually counted first time about 2-3 days *post partum* and the documented litter size is thus a result of the litter size at birth and the survival of the kits during the first 3 days. Earlier research has shown that it is possible to improve litter sizes at birth (Einarsson, 1987), at three weeks (Lagerkvist et al.1993), and at 42 days (Hansen & Berg, 2000) by selection. Percent survived kits in a mink litter has also been proved to be inherited (Hansen et al., 2008) as well as survival of offspring in other species (in pigs: Lund et al., 2002, Vernersen, 2007b, and in cattle: Norberg, 2008).

In spite of these encouraging research results, the current breeding strategies have not been able to improve reproduction in fur animals. In searching for reasons for this, we have to ask:

1. Are breeders not using BV for litter size in selection of breeding stock?
2. Does the litter index not have enough weight in the breeding goal?
3. What are the consequences for other traits, if litter size has high priority in selection?

One assumption is that litter size is negatively related to increased body size. On commercial farms mink body weight has lately increased in males 60g/year and females 30g/year (Sønderup, 1999).

Also, blue foxes are getting larger. Rimeslåtten (1976) reported that the average blue fox body weight at pelting was 6-7 kg, while Valaja et al. (2000) found that adult body weight of blue foxes exceeded 10kg. But is body size a

limitation for good reproduction? Comparing 114 different species Leitch and Billewicz (1959) found - the greater the dam weight - the greater the litter weight, but the body weight of each individual offspring in the litter was decreased.

Physiology

In physiological effects on reproduction we have to consider reproduction physiology including hormone development and activation, but also about metabolic physiology and especially the interaction between these two.

In all fur animal species our present production animals are much larger than they were for 10-20 years ago. This includes also a remarkable change in the fat-protein relation in the body. What do these changes mean for the sexual development, activation and maintenance of reproduction and maternal abilities of the dams?

Management

Today the management routines can be more finely controlled than was possible 5-10 years ago. Modern individual feeding systems allow exact control of animal condition and thus gives the possibility to affect the reproduction factors that are related to body condition. Flushing is an example of efforts to affect reproduction by feeding management but our knowledge about the possible effects of feeding strategy during growth period and immediately after pelting is still limited. For example the relation between energy balance during this period and reproduction functions is largely unknown. Here we probably can learn something from research with other production animals because all mammals have the same biological cycle: they are born, they grow, they get weaned, and continue to grow, and they reach sexual maturity, reproduce and, if female, go through lactation and so on.

I hope that during this workshop we will get a fruitful discussion between scientists from different fields and that this workshop will inspire you to cooperation and to include knowledge from other scientific areas in your future research.

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I – 2 P

Physiological constraints on litter size in mink

Pavine Lefèvre and Bruce D. Murphy
Centre de recherche en reproduction animale, Université de Montreal
St-Hyacinthe Québec Canada J2S7C6
E-mail address: bruce.d.murphy@umontreal.ca

Introduction

Reproduction in the mink displays characteristics present in carnivores, including protracted estrus, induced ovulation, embryonic diapause, and luteal function independent of the uterus. In addition, mink reproduction also exhibits unique characteristics, including an abbreviated mating season and a curious pattern of repetition of ovulation in the presence of embryos in the uterus. Bred mink can produce anywhere from none to as many as 20 kits. The number born to a female is influenced by the parental genome acting on a number of events in the reproductive process. The male contribution, in the form of sperm capable of fertilization, as well as environmental factors such as photoperiod and nutrition, complement maternal influences. Herein we discuss the physiological processes that constrain litter size.

Follicle Development

In mammals, it is accepted that the lifetime complement of follicles is present in the ovary at birth of the female. Follicles from this bank enter a growing pool, some of which are then recruited as preovulatory follicles from the population of antral follicles of 0.2 mm in diameter in the mink (Douglas et al., 1994). Follicle counts across a sample of 24 pastel mink revealed that the number of healthy antral follicles ranged from 177-352, and those capable of ovulating i.e. >0.7 mm in diameter, averaged 15/animal (Douglas et al., 1994). In other species, there is a strong influence of the parental genome on follicle populations, but little is known of the genetics of follicle development in mink. In litter bearing species, flushing (moderate feed restriction for periods of two or more weeks followed by feeding *ad libidum*) has been shown to increase the number of preovulatory follicles. Indirect evidence in mink suggest that the follicle population can be manipulated in this manner (Tauson & Forsberg, 1992), thus, the number of follicles developing may be a constraint on litter size.

Ovulation

As noted above, ovulation is induced in mink, and occurs 36-48 h after initiation of stimulation of the cervix by mating ((Enders, 1952; Hanssen, 1947)). Although mink display protracted coupling, the length of mating appears not to be a factor in induction of ovulation (Adams, 1981)). The peculiar pattern of repeated follicle development, culminating in the presence of a new wave of preovulatory follicles 6-7 days after mating, results in litters derived from multiple ovulations, a phenomenon known as superfetation. Superfecundation, where there can be more than one sire to a litter, also occurs, due to the same multiple ovulatory phenomenon. The number of follicles ovulated appears not to vary between first and second matings (Hanssen, 1947). Early studies using males of different colors demonstrated that mating causing the first ovulation was greatly underrepresented in the litters derived from matings spaced at seven or more days (Enders, 1952; Hanssen, 1947). Further investigation showed that the mating inducing second ovulation, but not ovulation per se, caused expulsion of the embryos from the first coupling (Adams, 1981). The mating pattern may therefore influence litter size.

Fertilization

Mink oocytes are fertilized in the oviduct between 50 and 60 h after initiation of mating (Enders, 1952; Hanssen, 1947). In uterine flushings to recover blastocysts we have frequently found unfertilized ova, suggesting that fertilization is not entirely successful. This, coupled with a high frequency of infertile males in ranch mink populations (as many as 15%), suggests that fertilization can be a physiological constraint on litter size.

Preimplantation embryo loss

The mink embryo develops to the blastocyst stage, and then undergoes an obligate arrest in development (Lopes et al., 2004). As noted above, 90% of the embryos derived from the first mating are not represented in the litter of multiple mated mink (Adams, 1981). This has led to the hypothesis that length of diapause is inversely related to embryo survival, and thus litter size. Studies on the use of extended photoperiod to induce precocious implantation generally support this view. Further, stress on the dam during the delay that precedes implantation can preclude embryo reactivation and result in failure of pregnancy (Daniel, 1971). Dopamine antagonists that induce prolactin secretion and provoke implantation reduce diapause to the minimum and synchronizing parturition. Limited experimentation has revealed that, while the frequency of successful gestation is increased by this treatment, litter size per female whelping did not change. Nonetheless, preimplantation mortality is judged to be a constraint on litter size.

Postimplantation embryo loss

In inspection of numerous mink during the postimplantation period it was not unusual to find that the most cranial implantation site on either uterine horn to be undergoing resorption. The causes of this postimplantation embryo loss are not known and are probably multiple. They appear unrelated to the number of embryos present in the uterus. Indeed, the birth of litters of up to 18 kits suggests that uterine space is not a limiting factor in successful gestation. The postimplantation mammalian embryo is susceptible to mortality, particularly in response to xenobiotics. As an example, several studies have demonstrated a dose-related post-implantation embryo loss following incorporation of various polychlorinated biphenyls into the feed of mink beginning prior to mating. The principal defects appear to be in the uterus, where uterine glands numbers and size are reduced (Backlin et al., 1997) and there is disruption of placental formation and function (Backlin & Bergman, 1995; Jones et al., 1997). In addition, antibiotics that interfere with folic acid synthesis or metabolism, including sulfonamides and folate antagonists, likewise result in postimplantation loss, primarily be interfering with the developmental trajectory of the embryo thereby rendering it nonviable. Clearly, the success of postimplantation gestation contributes to size of the litter.

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I – 3 P

Reduced litter size and percent kits alive is a consequence of selecting for high body weight

Bente Krogh Hansen and Peer Berg
Department of Genetics and Biotechnology, Faculty of Agricultural Sciences, Aarhus University, DK-8830 Tjele, Denmark.
E-mail address: BenteK.Hansen@agrsci.dk

Introduction

The number of kits weaned per dam is a trait of major economic importance in mink and fox production. However, during the last 10 years litter size per mated female mink has stagnated around 5.3, even though litter size is still selected for. In fox production the same picture shows up. The lack of increase in litter size might be caused by:
1) a reduced survival rate.
2) selection for correlated traits, particularly high body weight at live grading.

An unfavourable genetic correlation between body weight in September and early kit mortality was found in mink by Lagerkvist et al. (1994) and in foxes by Peura et al. (2007).

Due to selection the mink may differ compared to mink in the early 1990's, therefore it is important to confirm the genetic correlation between body weight and litter size and percent kits alive in mink (Hansen et al., 2008).

The overall hypothesis was that in mink:
1) Litter size and survival of kits are influenced by the dam´s genotype.
2) There is an unfavourable genetic correlation between female kit body weight and litter size and percent kits alive, respectively.

Materials and Methods

An univariate animal model with a maternal genetic effect, and an animal model with a maternal and a paternal genetic effect, were used to estimate the genetic variation in litter size and percent kits alive. In a subset including only yearlings, the genetic correlation between female kit body weight and litter size and percent kit survived were estimated.

Results

Litter size has a genetic variation of 4 to 12%. Percent kits alive has a genetic variation of 10 to 20%. Unfavourable genetic correlation was found for both litter size and percent kits alive to the kit body weight of females.

Conclusion

1) It is possible to improve litter size at weaning by selection, in relation to both litter size and survival of kits. However, the heritability is low and there is an unfavourable correlation to body weight.
2) Continuous selection for high body weight at live grading may result in a correlated decrease in number of kits at weaning due to both reduced litter sizes and reduced kit survival.

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I – 4 P

Feeding history affects cub survival of young breeding blue foxes (*Alopex lagopus*), a field study

Nita Koskinen[1], Anne-Helene Tauson[2], Juhani Sepponen[1] and Teppo Rekilä[1]
[1]MTT Agrifood Research Finland, Fur Animal Production, Kannus, Finland
[2] Faculty of Life Sciences, University of Copenhagen, Denmark
E-mail address: nita.koskinen@mtt.fi

Introduction

In recent years, selective breeding in blue fox farming in Finland has focused on producing large and heavy animals. At present blue foxes are given unrestricted feed during the growing – furring period, independent of dietary energy concentration. *Ad libitum* feeding hence often leads to animals being very fat or even obese at the time of pelting.

Fur farmers in Finland have been alerted since 1990, because the number of cubs born has not been as expected. Among first-year breeding blue foxes litter size has decreased during the years 1995-2007. Recent data suggest that blue fox vixens being selected for breeding purposes during the late summer, and then being reared on a restricted feeding regimen, have better reproduction results when compared to vixens reared on unrestricted feeding (Koskinen et al., 2006, Koskinen et al., 2007). Similar results were shown in Norwegian field studies (Sanson & Ahlstrøm 2005). These findings are in good agreement with previous findings in another seasonal animal, the mink (Tauson & Aldén 1984, Tauson, 1993).

The objectives of this field study were to determine if the time when blue fox females are selected for breeding and body conditioning affect the breeding result and to determine the correlation between body weight of artificially inseminated blue fox females, breeding results and cub survival.

Hypothesis: Restricted feeding during the growing-furring season has a positive effect on the breeding result and cub survival of first year breeding blue fox females.

Materials and Methods

The experiment was carried out in a private fur farm (Sillanpään Turkis Oy) in Veteli during July 2006 – July 2007. Experimental animals included 80 young, full-sibling blue fox females divided into two research groups according to the time of selection for breeding. The first group (E) included early females (n=40) maintained on a restricted feed program during the growing and breeding season. The second group (L) included late females (n=40) that were provided with unrestricted feed during the growing season but then fed restrictedly after November. The feeding of the group E was restricted to approximately 55% during the growing season compared to group L.

The animals were kept according to common farming practices in wire mesh cages, two animals per cage in the growing season. At the beginning of November full-sib pairs in group L were separated to individual cages. Females in group E were placed in individual cages at the end of December. The animals were fed with a commercial blue fox feed (Kaustisen Turkisrehu Oy). The females in group E were weighed when selected in July and in September. The females in both groups were weighed at the beginning of November, January, February and at the first artificial insemination.

The breeding result (litter size/inseminated female) was calculated when litters were 1 day, 10 days and 3-4 and 7 weeks old. Statistical analyses were carried out using SAS Enterprise Guide 3.0. Wilcoxon-Mann-Whitney test was used for comparisons of the litter sizes and weights between the experimental groups.

Table 1. Average weight (kg ±SD) and breeding result (cubs/inseminated female ±SD) of the artificially inseminated blue fox females in both groups during the trial.

	Weight, kg		
Time	Early (n=43)	Late (n=45)	P*
7th of November 2006	9.97±0.71	14.58±1.32	<0.001
2nd of January 2007	9.96±0.76	11.28±1.03	<0.001
7th of February 2007	9.14±0.62	10.26±0.85	<0.001
27th of February 2007	7.98±0.71	9.25±0.91	<0.001
At artificial insemination	7.70±0.88	8.55±0.92	<0.001
Breeding result (litter size/inseminated female)	n=35	n=38	
1 day	6.57±3.4	6.61±4.8	NS
10 days	4.43±3.3	2.97±3.5	<0.05
3-4 weeks	4.37±3.3	2.92±3.5	<0.05
7 weeks	4.31±3.2	2.92±3.5	<0.05

- NS = non-significant, P < 0.05 = significant difference between groups

Results and Discussion

At the first day of artificial insemination, mean weights in group E were 7.70±0.88 kg and in group L 8.55±0.92 kg ($p<0.001$). The weights of females in group E remained quite stable during the trial compared to the weights of females in group L. According to earlier studies obese females at the time of artificial insemination are poor breeders (Koskinen et al., 2006, 2007). The number of cubs per inseminated female was the same at parturition in both experimental groups: 6.57±3.44 and 6.61±4.79 in groups E and L, respectively. Ten days after parturition the number of cubs per inseminated female was 4.43 and 2.97 in groups E and L, respectively ($p<0.05$). The survival of the cubs during first ten days was better for vixens which were fed restrictedly during the growing-furring season. The difference in breeding result between groups until weaning remained almost the same as 10 days after parturition (Table 1).

Energy supply, body condition and reproductive processes are closely connected (Blache et al., 2003). The time when the young blue fox females (those in their first breeding season) are chosen for breeding is important. Therefore, feeding history and dieting of young blue fox females has a remarkable effect on cub survival and breeding result. The fact that litter size has decreased among Finnish blue foxes during the past few years may indicate that the present rearing routines are harmful for future reproductive performance. However, means of improving litter size/female need to be studied further in order to establish the right practices for selecting blue fox females for breeding, and for reconditioning vixens to the coming pregnancy and whelping period. Furthermore the connection between feeding history (e.g. energy and protein supply), body condition and the survival of the cubs needs to be investigated.

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I – 5 P

Female body condition and early kit mortality: A description from practice

Henrik Baekgaard, Peter Foged Larsen and Michael Sønderup
Danish Agricultural Advisory Service, National Centre | Fur Animals
E-mail address: hnb@landscentret.dk

Introduction

According to Gade & Malmkvist (2004), first year brown/glow females give birth to 9.5 (7.5 living) kits per litter on average. On the day after parturition, this number is reduced to 5.3 kits per litter. This loss of kits is also noticed on commercial mink farms, and is known as early kit mortality. In 2003 a study was initiated by Michel et al. (2005) where kits and females from farms with severe problems with early kit mortality were examined. They suggested obesity as the main factor to explain early kit mortality, because of dystoci. In addition Malmkvist (2005) found a tendency for body condition to influence the duration of the birth and the interval between kits. Due to these findings, which suggested that body condition is part of the problem, we initiated studies in 2006 and 2007. The aim of these studies was to describe the correlation between female body condition and number of both dead and living kits. We conducted the study on commercial mink farms.

Materials and Methods

In 2006 and 2007 we included 12 and 6 farms, respectively. Body condition of 3137 (2006) and 3878 (2007) first year brown/glow females were scored 4 times, late January, late February, late March and just before birth in late April. The scale used for measuring the body condition of the females was a 5 point scale (1 =thin, 3=medium, 5= very obese), developed by Rouvinen-Watt & Armstrong and described by Clausen (2005). Correlations were made between body condition of the female and both number of dead and living kits. The same person did all the scoring to ensure reproducible results (Kappa = 0.83). We did not include barren females in these studies.

Results

We found that females with a body condition score of 2 in late February had most living kits in 2007. The same tendency was seen in 2006 but was not statistically significant. Moreover we found a correlation between body condition in early February and number of living kits in 2007. In both 2006 and 2007 we found that females with a body condition score of 3 in late March had significantly more living kits 3 days post partum than females in category 4 and 5. In late April we found that females in body condition 4 had the most living kits on average in both 2006 and 2007. In both years we found that females in body condition 5 in late April had significantly more dead kits per litter than females in condition 3 and 4. Moreover we found that females that were scored slimmer in late April compared to late March had significant fewer living kits compared to females that stayed in or gained in body condition in the same period.

Discussion and Conclusion

These studies show that female body condition has an influence on the number of both dead and living kits 3 days post partum. We did, however, find that the strongest correlation was between body condition and number of living kits. The reason could be that the number of dead kits is strongly influenced by the time of counting and the appetite of the female. We found that females with a positive development in body condition from late February to late April, on average, produced more living kits per litter. Thus, it appears that a score 2 in late February,

score 3 late March and a score 4 in late April is the combination that on average results in the most living kits per litter. Moreover we found that females that gained 1 score in body condition from late March to late April (implantation and pregnancy) had significant more living kits per female. Based on these observations we conclude that body condition of the female is an important factor in relation to the phenomenon "early kit mortality" or kit loss.

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I – 6 P

Feeding during gestation in relation to litter size in mink

Steen Henrik Møller
Department of Animal Health, Welfare, and Nutrition, Faculty of Agricultural Sciences, University of Aarhus, Blichers Allé 20, P.O. Box 50, DK-8830 Tjele, Denmark.
E-mail address: Steenh.Moller@agrsci.dk

Introduction

During the last decade the energy allowance during the implantation period of female mink has increased by 25% (from 220 kcal to 295 kcal) on Danish mink farms. This increase has been based on the assumption that females fed more than necessary for maintenance during the implantation period will implant a higher proportion of the blastocysts and thereby give birth to larger litters than females fed at the maintenance level.

This assumption has been supported by an investigation of the average litter size and feed allowance during gestation on farms from a large Danish mink feed producer. The investigation suggested a positive correlation between feed allowance during the period from March 20th to April 10th and the subsequent litter size (Børsting & Hedegaard, 1998).

Experimental investigations of the subject have not been conclusive as both negative, no, and positive effects on litter size of high feeding intensity during implantation have been reported (Lund, 1992; Weiss, 1991; Kemp et al., 1993). However, due to an insufficient number of females, none of these results were significant. Therefore, I have tested the hypothesis that the observed farm variation in feeding intensity during implantation has no effect on litter size in mink.

Materials and Methods

The hypothesis has been tested on production data and in an experiment on private farms. Production data from 5 years (1994-1998) from a total of 135 farms receiving feed from a large Danish mink feed producer were analysed. Four characteristic feeding periods were defined:

1). Conditioning – January 5 to February 23.
2). Flushing – February 24 to March 20.
3). Implantation - March 21 to April 10.
4). Prenatal – April 11 to April 30.

The difference in kcal/mink/day between Flushing and Conditioning and between Implantation and Prenatal was calculated for each farm and year and used in the analysis of litter size.

The farm experiment involved individual feed allowance and litter size from 2,150 females in each of two groups fed according to two different strategies: either a small or a large difference in feed allowance between the Implantation and the Prenatal period.

Results and Discussion

The analysis of farm production data showed that litter size in brown mink increased significantly with higher energy allowance in the Implantation period compared to the Prenatal period ($P<0.01$), while the effect was small and insignificant in black mink. The farm experiment revealed that, at the individual level, a large difference in feed allowance between the Implantation and the Prenatal period decreased the number of barren females and increased the litter size at birth. Due to increased kit mortality, the difference in litter size was smaller at weaning.

In conclusion, the hypothesis that the observed farm variation in feeding intensity during implantation has no effect on litter size in mink was rejected, as brown females fed more than necessary for maintenance during the implantation period gave birth to larger litters than females fed closer to the maintenance level.

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I – 7 P

Development of mammary glands in mink

Steen Henrik Møller
Department of Animal Health, Welfare, and Nutrition, Faculty of Agricultural Sciences, University of Aarhus, Blichers Allé 20, P.O. Box 50, DK-8830 Tjele, Denmark.
E-mail address: Steenh.Moller@agrsci.dk

Introduction

Mink kits begin to eat solid feed and drink water around 4 and 6 weeks after birth, respectively. The milk production of the female is therefore one of the most important maternal properties. In order to define the best management procedures for preparing the females for a successful lactation, I have investigated mink mammary glands in different ways over many years. In this presentation, I focus on the time of development, activation and deactivation of mammary glands as well as ways to quantify the amount of active gland tissue in mink.

Materials and Methods

In order to describe the development of the mammary gland in mink females and identify periods of special interest 64 samples were biopsied from 24 anaesthetized Scanblack mink females at regular intervals from weaning through their first lactation. The percentage of parenchyma, connective tissue, fat, and other tissues was determined by microscopy (Møller, 1996).

The activity of individual glands was recorded several times during lactation in females with their own undisturbed litters as well as after adding foster kits 3 to 7 days post partum.

The amount of active gland tissue was measured in different ways, e.g. size, weight, and DNA content in relation to feeding intensity during the autumn and during the gestation period.

Results

At birth, parenchymal structures were already present in the skin near the teat. During the next 8 months development was very limited. The last 7 weeks before parturition, the parenchyma increased from below 15% to over 80% of the gland tissue. The main part of the parenchymal proliferation of the gland took place during the last 3 weeks of gestation (Møller, 1996).

The activity of individual glands was dynamic, and previously inactive glands were observed to be active at any time between day 3 and 12 post partum in females with their own litters as well as in females after addition of foster kits. The activation of glands was more frequent in females with more kits + foster kits than active glands, while inactivation of glands only occurred in females with more active glands than kits + foster kits.

At 5 days post partum, the total gland area per female was 21.0 cm^2 and the total gland weight was 19.5 g. At 42 days post partum the total gland area per female was 24.3 cm^2 and the total gland weight was 20.5 g. There was no effect of feeding regime during autumn and winter on gland weight, neither at 5 nor at 42 days post partum. The feed allowance during gestation did not affect the gland weight 5 days post partum while the average gland weight 42 days post partum was reduced by 25% in females on restricted feed allowance during gestation.

At 7 weeks post partum, the gland area measured on the shaved belly of females correlated well with the size and weight of the glands after dissection, while lactation had almost stopped in most females 8 weeks post partum and the gland area and weight were low.

Conclusion

The main part of the mammary gland tissue is developed during the last 3 weeks of gestation. Individual glands can be activated up to at least 12 days post partum and this was more frequent in females with more kits than active glands. The average gland weight 42 days post partum was reduced by 25% in females on restricted feed allowance during gestation. The gland area measured on the shaved belly of females is a good estimate of the size and weight of the glands up to 7 weeks post partum.

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I – 8 P

Genetics of early kit growth and maternal weight changes during pregnancy and lactation in mink

Bente Krogh Hansen and Peer Berg
Department of Genetics and Biotechnology, Faculty of Agricultural Sciences, Aarhus University, DK-8830 Tjele, Denmark.
E-mail address: BenteK.Hansen@agrsci.dk

Introduction

In mink, selection for high litter size gives a positive response (Einarsson 1987, Lagerkvist et al., 1993). In the line selected for high litter size at birth the body weight of kits was lower than in low line or control line (Einarsson 1987) and continued to be so even at pelting (Lagerkvist et al., 1994). Early kit growth depends on a genetic component and an environmental component. The genetic component can be divided into kits' own capacity for growth (direct effect) and the dam's genetic capacity to promote kit growth (maternal effect). The environmental component can be divided into the permanent environment, which is common to all litters of the dam and the specific environment, which is common to kits in one specific litter (Willham 1972). The dam's influence consists of her capacity for milk production and other maternal abilities. The heritability of maternal effect on early kit growth was found to be intermediate (h2 ≈ 0.3) at week four post partum (Hansen & Berg 1997). At this time the kits start to intake solid feed. Even though the dams increase feed intake significantly (Hansen 1999), they lose weight during the lactation period : on average 15% of the body weight at parturition (Hansen & Berg 1998).

Dam weight change during lactation has shown intermediate heritability (h^2 ≈ 0.15 to 0.38; Hansen & Berg 1998). Focusing on selection strongly on both litter size and maternal effect on early growth may therefore lead to increasing demand on lactating dams. To clarify this it is necessary to know the relationship between maternal traits to produce milk and take care of the kits and weight changes of the dam during lactation period. The objective of this study was to describe the genetic correlation between early growth of kits and weight changes of the dam during lactation.

Hypothesis

1) It is possible to improve maternal induced kit growth by selection
2) Weight changes of dam can be increased by selection for maternal induced kit growth
3) Weight change during pregnancy is related to development of mammary glands and therefore indirectly related to maternal induced kit growth.

Materials and Methods:

Data were from the black colour type in a selection experiment carried out in 1996 to 2001. The breeding goals were litter size (line 1), kit´s own capacity for growth (line 2) and the maternal ability to induce growth in kits (line 3). Recorded traits were Kit Body Weight at four weeks after birth (KBW) and Dam Weight Changes (DWC) - from 1 week to 4 weeks post partum (DWC-14), - from 4 weeks until weaning at 43 days post partum (DWC-4w) and - from 1 week until weaning (DWC-1w).
KBW and DWC during lactation were analysed by fitting bivariate linear mixed animal models. The DMU programme package (Jensen & Madsen, 1994) was used to estimate the variance components, using a REML algorithm.

Results and Conclusions

There were intermediate heritability estimates (h^2 = 0.3) for dam-induced kit growth until 4

weeks of age and afavourable genetic correlation between dam weight changes in the lactation period and dam induced kit growth. Positive genetic correlation between dam weight change in the pregnancy period and dam induced kit growth was also observed.

In conclusion:
1) It is possible to select for maternal induced kit growth.

2) It is possible to select for maternal induced kit growth without negative consequences for the dam

3) Dams that are genetically disposed for high weight gain during pregnancy are also genetically disposed to induce early growth in kits.

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I – 9 P

Protein restriction *in utero* – influence on metabolic traits and regulatory hormones in mink kits

Connie Frank Matthiesen[1], Dominique Blache[2] and Anne-Helene Tauson[1]
[1]Department of Basic Animal and Veterinary Sciences, Faculty of Life Sciences, University of Copenhagen, Grønnegaardsvej 3, DK- 1870 Frederiksberg C, Denmark
[2]School of Animal Biology, Faculty of Natural and Agricultural Sciences, The University of Western Australia, 35 Stirling Highway, Crawley WA 6009, Australia
E-mail address: aht@life.ku.dk

Introduction

The outcome of an intra-uterine protein malnutrition resulting in a metabolic programming or imprinting in the offspring may depend on when the malnutrition is imposed and whether it is imposed during certain sensitive time periods in the gestation (Lucas, 1991). It appears that an inadequate nutrient supply in each of these critical periods may cause a different metabolic programming response in the offspring. The objective of the present study was to investigate how *in utero* protein restriction affects growth, metabolic traits and regulatory hormones in mink kits during the first two months of life, a period of rapid growth.

Materials and Methods

Thirty two male mink kits were used in the present study. Out of these 16 (L) were exposed to *in utero* metabolic programming by feeding their dams a low protein gestation diet for three weeks in late gestation, whereas the dams of the remaining 16 kits (A) had been adequately fed during gestation. All animals were fed *ad libitum* and feed intake was recorded. The kits were divided into two feeding groups, each comprising 8 A and 8 L. One group was given a level of protein that met the requirements (A; 32% of metabolizable energy (ME) from protein) and the other was given an insufficiently low level of protein (L; 18% of ME from protein) for a three week period, starting at weaning when the kits were 7 weeks old. Respiration and balance experiments were performed by means of indirect calorimetry in an open-air circulation system with two kits in each cage. The following metabolic traits were calculated: respiratory quotient (RQ), heat production (HE), (ME) intake, retained energy (RE) and retained nitrogen (RN). The animals were killed at the end of the experiment for collection of blood and organ material. Plasma samples were analysed for IGF-1, cortisol, GH, leptin by radioimmunoassays (RIA). The statistical analyses of data were carried using the MIXED procedure in SAS.

Results and Discussion

The body (LW) and liver weights of kits fed the A diet postnatally were significantly higher ($P<0.001$) than those of kits fed the L protein diet, irrespective of *in utero* treatment. These results indicate that possible effects of *in utero* protein restriction on body weights and liver size were alleviated by an adequate protein supply during postnatal growth. This is consistent with findings on body weights for rats where an intra-uterine protein restriction also was alleviated by an accelerated growth postnatally when animals were adequately fed (Hales & Baker, 2001). The results indicate that the quantitative metabolism traits were more influenced by postnatal dietary treatment than *in utero* treatment (see Table 1).

Table 1. Animal live weights, liver weights and quantitative metabolism traits.

Variable	Treatment				RR[1]	P-value[2]
	AA	AL	LA	LL		
LW (g)	1033[a]	769[b]	985[a]	719[b]	98.96	<0.001
Liver (g · kg $^{-0.75}$)	37.41[a]	30.38[b]	36.74[a]	30.09[b]	2.44	<0.001
Liver (% of LW)	3.71[a]	3.25[b]	3.69[a]	3.28[b]	0.24	<0.001
RN (g·kg $^{-0.75}$ ·d^{-1})	2.06[a]	0.72[b]	2.45[a]	0.72[b]	0.42	<0.001
ME (kJ · kg $^{-0.75}$)	1438[a]	970[b]	1538[a]	959[b]	156.30	<0.001
HE (kJ · kg $^{-0.75}$)	797	611	822	737	223.45	NS
RE (kJ · kg $^{-0.75}$)	642[ab]	359[ac]	717 [b]	223[c]	222.98	<0.05
RQ	0.83	0.89	0.83	0.92	0.06	NS

[1] Square root of Residual, [2]Effect of treatment, Values with different superscripts (a, b, c) in a row differ significantly

Table 2. Plasma concentration of insulin-like growth factor 1 (IGF1), growth hormone (GH), cortisol and leptin.

Variable	Treatment				RR[1]	P-value[2]
	AA	AL	LA	LL		
IGF1 (ng·ml^{-1} ·kg $^{-0.75}$)	344.03	363.72	392.85	428.24	97.95	NS
GH (ng·ml^{-1} ·kg $^{-0.75}$)	22.71[a]	38.67[b]	24.10[a]	40.99[b]	14.72	<0.05
Cortisol (ng·ml^{-1} ·kg $^{-0.75}$)	19.65	11.36	8.92	7.40	10.87	NS
Leptin (ng·ml^{-1} ·kg $^{-0.75}$)	0.71[a]	0.99[b]	0.73[a]	1.05[b]	0.17	<0.001

[1] Square root of Residual, [2]Effect of treatment, Values with different superscripts (a, b, c) in a row differ significantly

Plasma concentrations of the measured hormones showed that the concentration of GH and leptin were significantly lower for kits fed the A diet postnatally irrespectively of intra-uterine treatment, results for GH being consistent with the higher ME intake on the A diet and those for leptin possibly reflecting a relatively lower fat retention for A than for L kits (See Table 2). In conclusion, these results suggest that *in utero* nutrition effects were not evident in 10 weeks old kits, but strong effects of postnatal dietary treatment were documented.

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I – 10 P

Review of factors associated with mink kit mortality

Dr. D. Bruce Hunter
Department of Pathobiology
Ontario Veterinary College
University of Guelph
Guelph, Ontario Canada NG 2W1
E-mail address: bhunter@uoguelph.ca

On commercial mink farms in North America the normal mortality rates between birth and weaning approach 20-25% of all kits whelped, if all losses are considered including aborted, stillborn and weak-born kits. Approximately half (50%) of these dead kits are stillborn and an additional 35% are due to a failure to nurse for a variety of reasons.

A normal healthy new-born kit should weigh greater than 11-12 grams. Kits with a birth weight of 9-11 grams have reduced viability and those under 8 grams generally do not survive. These kits are either late-term deaths *in utero* or they are born too small or too weak to nurse or compete with larger siblings. Undersized kits examined at necropsy often do not have pathological lesions and a specific cause of death may not be established (Schneider et al., 1993). Most of these are simply physically and physiologically underdeveloped kits.

Some of the most common reasons for these very early kit losses include dystocia, systemic infections, external trauma associated with dystocia and the mother physically pulling the kit, mothers lying on kits and suffocating them, anasarca, hypothermia (Harjunpää & Rouvinen-Watt, 2004) and congenital anomalies (Schneider et al., 1993). Occasionally, bacterial infections acquired at birth may cause infections of the neonatal skin gland over the neck resulting in abscesses and systemic infections often called "pimply kits". These infections can be observed as early as 1-2 days post whelp and are often associated with females with sub-clinical vaginitis at the time of whelp (Hunter & Prescott, 1988).

As mink kits reach 3-6 weeks of age, so-called "sticky kits" can occur both pre- and post-weaning. There are many causes for sticky kits. Affected mink kits generally have a fever and often have diarrhea. On Canadian mink farms *Campylobacter* is a common bacterial cause of kit diarrhea during the late pre-weaning and early weaning (Hunter et al., 1986). There are a number of viral causes of kit diarrhea including enteric calicivirus, corona virus, reovirus, astrovirus (Englund et al., 2002) and likely others that have not yet determined.

Over the past number of years we have identified an enteric calicivirus associated with pre-weaning diarrhea in mink. All cases examined were positive for calicivirus using RT-PCR to detect the calicivirus genome. Sequence analyses showed that the caliciviruses identified from diarrheic mink shared the highest similarities (approximately 70%) to Sapporo-like caliciviruses in humans and porcine enteric calicivirus . A total of 5 distinct enteric caliciviruses were identified from various farms, and their sequences differed by 8 to 21%. Fecal samples examined from clinically healthy mink were negative for calicivirus using the same RT-PCR. All cases were negative for corona virus using PCR and astrovirus using direct EM visualization of feces. We therefore

believe that enteric calicivirus is a major cause of pre-weaning diarrhea in Canadian mink.

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I – 11 P

Early pup mortality in blue fox (*Alopex lagopus*) – mechanisms and pathology

Gorm Sanson
Norwegian Fur Breeders' Association, Oekern Torgvei 13, 0508 OSLO, Norway.
E-mail address: sanson@norpels.noI

Introduction

Perinatal pup loss in the blue fox is a great challenge in modern blue fox breeding. Variance component estimates performed on the variance of pup loss from birth to 3 weeks (Sanson & Farstad, 2003) has given some perspectives. A model that tested the pup loss variance in 182.558 litters, showed that age of vixens was most important (46%), followed by owner (33%) and number of pups born (13%), respectively. The effect of age of vixen is well known, but far from fully understood. The large effect of owner shows that management and genetics are important explanations to variations in perinatal pup loss. The aim of this presentation is to highlight some of the mechanisms and pathology related to perinatal pup loss in the blue fox.

Mechanisms and Pathology

Steroid hormones

Blue fox vixens have similar blood concentrations of steroid hormones as described in bitches during pregnancy and parturition (Concannon et al., 1978; Valberg et al., 1992; Sanson et al., 2005). The fat soluble nature of the steroid hormones and the importance they play during heat, pregnancy, parturition and the onset of lactation should be given special consideration. What is the optimal nutritional status with respect to steroid hormones, to make a blue fox vixen perform her best during reproduction?

High numbers of stillbirths and weak born

Field studies in Norway have revealed as much as 40% of total pup losses are stillbirths or weak born pups (Sanson & Farstad, 2003; Sanson & Ahlstrøm, 2005). These pups have either died in very late pregnancy, during parturition, or just after parturition. Vixens with a sub-optimal nutritional status may have a higher risk of dystocia during parturition. The dystocia could be caused by the low level of blood calcium and blood glucose, making the vixen weak and dizzy during parturition. A sub-optimal nutritional status could also interfere with the corticoid hormones believed to be involved with the onset and propagation of parturition. This mechanism has yet not been fully investigated in the blue fox, but it is reasonable to believe that onset of parturition that is either too early or too late may cause dystocia-like problems, as well as delays during the propagation of parturition. The nutritional status of the vixens will also affect the unborn foetuses. In dogs, hypoglycaemic foetuses are more susceptible to systemic anoxia (Vannuci et al, 1980). Anoxia in the uterus may cause deaths in pups before and after parturition.

Pups with unknown cause of death

In Norwegian field studies, ~20% of autopsied pups did not provide any diagnosis for cause of death. Some of these pups may have suffered from anoxia. In dogs, thermoregulation is very limited in newborn pups, and dog pups may die within hours from hypothermia (Crighton, 1968). Anoxia and hypothermia may be very difficult to reveal at autopsy, but could be very important causes for early pup mortality in the blue fox.

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I – 12 P

Placental scars in barren mink females

Tove N. Clausen[1] & Anne Sofie Hammer[2]
[1]Danish Fur Breeders Research Center, Herningvej 112C, DK-7500 Holstebro
[2]Technical Univeristy of Denmark, The National Veterinary Institute, Hangøvej 2, DK-8200 Aarhus N
E-mail address: tc.pfc@kopenhagenfur.com

Introduction

In an investigation on the requirement of protein in the gestation period, Tauson et al. (2005) found that 17% of the metabolisable energy from protein (MEp) was too little compared to 32 MEp. Clausen et al (2007) found that 36 MEp or more during the period April 6 to April 26, seemed to be sufficient. To further investigate the consequences of low protein in the gestation period, we decided to euthanize all barren females from that investigation and look for implantation zones indicative of failed gestation.

Materials and Methods

In the period April 6 to April 26 females were fed different protein content from 20 MEp to 52 (20, 28, 36, 44 and 52 respectively). All barren females were euthanized July 10 and investigated for placental scars to see, whether the barren females had been pregnant and experienced a late termination of pregnancy or a not observed neonatal death. A total of 100 barren females were investigated.

Results and Discussion

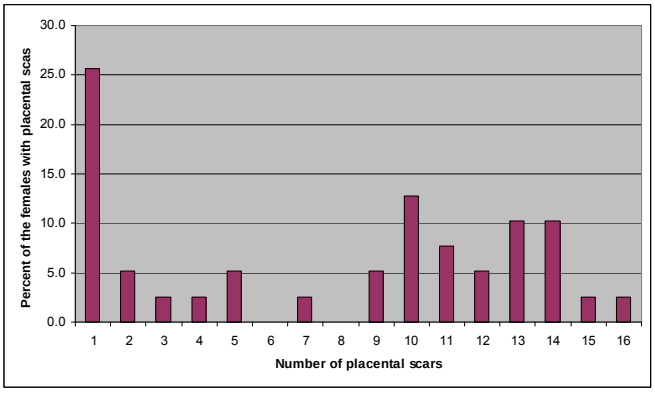
The results showed that a very low protein content in the gestation period reduced the number of liveborn kits, increased the number of dead kits at birth and increased the number of barren females (not significant) (Table 1). The highest percentage of females with placental scars was seen in the groups fed low protein (not significant). The results corresponds with investigations in pigs, where low protein in the feed increase the frequency of embryonic dead and foetal mummification (Rasbech, 1981).
Investigations of barren females in 2005 (not shown) showed that 26.7% of the barren females (n=15) had placental scars. The number of PS in the females with scars varied from 1 to 16 (Figure 1). Around 25 percent of the females were pregnant with only one embryo. In pigs, 4 embryos are necessary to maintain pregnancy. Around 50 percent of the mink had 10 or more embryos. In this case the load on the uterus may be too severe, and the embryos are aborted or reabsorbed after foetal death. In pigs the capacity of the uterus to nourish the foetus' are by some considered to be the limiting factor for survival of the foetus (Rhodes et al., 1991). Placental scars in females giving birth, has also been investigated. Hammer et al. (2008) found on average 2 placental scars more than the number of kits,when counting 2-3 month postpartum. 4 – 5 month and 6 – 7 month

Table 1. Influence of feed protein content in the gestation period on litter size, barren females and placental scars (Clausen et al., 2007).

MEp in the gestation period	Liveborn kits per litter	Dead kits at birth per litter	Barren females, %	% of barren females with placental scars
52	7.05	0.38	14.0	37.5
44	6.80	0.36	9.3	27.3
36	6.89	0.44	14.2	35.3
28	6.49	0.50	11.2	53.8
20	5.19	0.80	24.6	42.9

postpartum, the number of kits in the litter was higher than the number of scars. Females investigated > 12 month postpartum retained no placental scars (Hammer et al., 2008). Elmeros & Hammershøj (2006) found 0.4 placental scars more than the number of kits 1 – 3 month postpartum. In dogs, the investigation of uteri showed that 11 - 13% of the foetuses were dead and reabsorbed (Andersen & Simpson, 1973). In pigs 30 – 40% of potential piglets are lost before farrowing (Vonnahme et al, 2002). They reported a positive correlation early in pregnancy between number of embryos and ovulation rate, but in late pregnancy when uterine capacity becomes limiting they instead find a positive correlation between number of embryos and uterine horn length.

Figure 1. Number of placental scars in females with placental scars



Conclusion

Feeding low protein in the gestation period resulted in a nonsignificant increase in number of barren females and in number of the barren females with placental scars. From 27 to 54% of the barren females had been pregnant. Foetal death is especially seen in females with only one embryo or females with more than 10 embryos. The number of kits at birth is lower than the number of placental scars.

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I – 13 P

Observations of deliveries in mink: Potential for more kits

B. Houbak and J. Malmkvist
Department of Animal Health, Welfare and Nutrition, University of Aarhus,
Blichers Allé 20, Postbox 50, 8830 Tjele, Denmark
E-mail address: Jens.Malmkvist@agrsci.dk

Introduction

Litter size and kit mortality are both relatively high in the commercial production of mink, with most deaths occurring around parturition and during the first days of life. Based on several years of video recordings of mink births, we report that females give birth to in average 9.5 (7.5 live) kits. Most stillborns were fully developed, and thus the potential of having much higher litters is present.

This is a short summary of what is presently known.

Results and Discussion

We have found that:

1) Video recordings of births showed that the females gave birth to more kits than expected on the basis of the counting carried out on day 1 – 3 after birth.

2) Mortality peaked on day 0/day 1 (day 0 is the day of birth).

3) The majority of the still-born kits were fully developed.

4) The low mortality litters were characterised by markedly shorter deliveries compared with high mortality equally sized litters.

5) A range of maternal behaviour were observed and quantified from the recordings. Variation in kit survival was linked to some of these behaviours.

6) The duration of parturition in a line of wild mink averaged 6 h 00 +/- 28.3 min per litter (N= 46) (Malmkvist & Palme, 2008).

7) In one study, high mortality females had a longer duration of parturition (10 h 10 min (2 h 8 min) compared to low mortality females (5 h 15 min (1 h 2 min)) (p=0.034), giving birth to equal number of kits (Malmkvist et al., 2006).

8) Birth problems contributed to both impaired maternal behaviour and early kit mortality.

9) Lack of access to suitable nest building materials had a negative effect on the course of the parturition and early kit mortality.

10) An artificial nest alone or in combination with *ad libitum* access to straw tended to reduce maternal stress postpartum.

11) For kit vitality and survival, an artificial nest appeared as good as a nest of straw created by female, due to an improved in-nest climate postpartum.

12) Females with low and high lean scores after birth had more variable births, which is an indicator of birth problems.

Our on-going experiments focus on factors that affect the early kit mortality, in particularly how the birth environment is optimized to the high-

producing mink dams and how other factors affect the progress of parturition in mink.

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II: Genomics, Breeding & Genetics

Edited by:

Dr. Bernhard Benkel
Dr. Hossain Farid
Dr. Bruce Hunter
Dr. Bruce Murphy
Lora Harris

II-1

Featured plenary talk on Genomics

A moving landscape for comparative genomics in mammals; lessons from the Felidae

by:

Dr. Stephen O'Brien
Head, Genetics Section
Laboratory Chief, Laboratory of Genomic Diversity
National Cancer Institute

II-2 RP

Mapping the mink genome: techniques and current status

Razvan Anistoroaei[1], Hossain Farid[2], Bernhard F. Benkel[2], & Knud Christensen[1]
[1]Faculty of Life Science, University of Copenhagen, Grønneraardsvej 3, 1870 Frederiksberg C, Denmark
E-mail address: kc@life.ku.dk
[2]Nova Scotia Agricultural College, Truro, NS, Canada B2N 5E3

Abstract
Following the release of the first genetic map for the American mink (*Neovison vison*), efforts have been oriented towards further improvement of the map, genetic resource development, and comparative studies meant to aid the genetic research in this species. Over 270 mink microsatellite sequences were placed on a human-mink and dog-mink comparative map by BLAST analysis of mink sequences against these genomes (BLAST cut-off threshold = $1x10^{-5}$).

These microsatellites are a new resource of "mapped" markers for the American mink which can be used in linkage studies, fine mapping and positional cloning of QTL. Many of the microsatellite markers are derived from BAC clones (Benkel et al., unpublished). The BAC clones are an important step on the road to a complete genetic map of the mink. In the scanning process, high linearity between the human and dog genomic sequences has been observed. BLASTing mink against the dog genome has produced many more hits of higher quality compared to BLASTing mink against the human sequences, and the average hit is of double length in the dog compared to the human genome which indicates that the dog is much more closely related to the mink than is the human..

About 200 microsatellites are ordered in linkage groups on all chromosomes. These microsatellites will be used in the large Danish QTL project comprising more than 1000 F_2 mink in 20 sire families. The F_1-generation was a cross between the small American mink with short nap and the much bigger ordinary Danish Wild mink with a coarser coat. This project has been initiated by Foulum Research Center and is being run in collaboration with the Faculty of Life Sciences, Copenhagen University.

II-3 RP

Construction of a SNP map of the mink genome

Bernhard F Benkel[1], Razvan Anistoroaei[2], Hossain Farid[1] and Knud Christensen[2]

[1] *Nova Scotia Agricultural College, Dept. of Plant and Animal Sciences, P.O. Box 550, Truro, NS, B2N 5E3, Canada*

[2] *University of Copenhagen, Dept. of Animal and Veterinary Basic Sciences, Division of Animal Genetics and Bioinformatics, Gronnegaardsvej 3, 1870 Frederiksberg C, Denmark*

E-mail address: bbenkel@nsac.ca

Introduction

Traditionally, gene mapping or the localization of genes underlying traits of interest in complex species has been carried out by linkage mapping using microsatellite markers (Ellegren, 1992). The process of interval mapping using linkage analysis has been remarkably successful for genes underlying so-called simple or single gene traits. For example, the identification of candidate genes for over a thousand single gene inherited diseases in humans has relied on linkage mapping (see the OMIM database at: www.ncbi.nlm.nih.gov).

Microsatellite Maps: Microsatellite-based maps have been developed for a large number of species in addition to humans, including most farm animals (e.g. Barendse et al., 1994; Rohrer et al., 1999). Notably, as far as this report is concerned, the first generation microsatellite map of the mink genome has recently been completed (Anistoroiae et al., 2004).

SNP-based Maps: In the wake of technological advancements in the field of genomics, SNP-based maps have begun to replace microsatellite maps as the tools of choice for gene mapping in complex species. The advantages of SNP maps over microsatellite maps for genomics studies are many fold. For instance, SNP markers are highly abundant in the genomes of all complex species and are randomly distributed throughout the genome. In addition, a variety of platforms have been developed that facilitate automated, high throughput genotyping with SNPs at affordable costs. Moreover, SNP maps show promise for the identification of genes (aka quantitative trait loci) underlying the so-called *complex* traits; an area of study in which linkage maps have generally proven to be ineffective.

The utility of SNP maps for the positional localization of genes underlying traits of interest has resulted in the construction of high density SNP marker panels for a number of species. For example, Affymetrix (www.Affymetrix.com) currently offers genotyping for use with human resource populations based on a set of high density, whole genome coverage GeneChips. High density SNP mapping panels are also available for the mouse (Affymetrix; Illumina at www.Illumina.com) and chicken (International Chicken Polymorphism Map Consortium, 2004), and are currently under construction for a variety of species including most farm and companion animals.

Application of a Mink SNP Map

There are a number of factors that limit the growth and competitiveness of mink ranching in Nova Scotia, notably the susceptibility of animals to disease (especially Aleutian Disease), pelt color and quality, feed conversion, and reproductive efficiency. These factors are predominantly related to complex traits, i.e. characteristics that are controlled by several or more genes in interaction with the environment, and ones that are difficult to improve by

classical selection. In contrast, rapid improvement in such traits is possible through the use of DNA typing and marker-assisted selection. For example, whereas 25 years of conventional selection against porcine stress syndrome (PSS) in swine resulted in only marginal breed improvement, a period of several years was sufficient for its almost complete elimination from the Canadian swine herd once a DNA marker for PSS became available (O'Brien et al., 1993).

Consider the effect of Aleutian Disease (AD) on mink production, for example. Aleutian Disease is currently the most significant disease threat to the mink industry in Canada and worldwide. The cost of testing for Aleutian Disease in NS alone exceeds $400,000 annually. The presence of AD on ranches in Nova Scotia has resulted in the imposition of restrictions on the sale of breeding stock outside Canada's borders. Moreover, the practice of testing and culling positive animals, which has been practiced in NS for nearly a decade, has not succeeded in eradicating AD from the province's mink ranches. Clearly, an alternative technology needs to be developed for the control of AD.

Many mink breeders believe that AD appears more frequently in certain families than in others. The highly susceptible nature of Sapphire color phase mink and the much lower susceptibility of Pastel mink has been well documented (Bloom, 1975; Hadlow et al., 1983). Moreover, there is strong circumstantial evidence that even in heavily infected ranches, the infection rate never reaches 100%; not even for animals housed in adjacent cages. The identification of the genes underlying reduced susceptibility to AD in some individuals would provide a basis for the development of improved lines of mink, and the SNP-based comparative map, in turn, is the tool of choice for the identification of the genes underlying resistance to infection.

AD susceptibility is just one example of a trait where the SNP-based map could play a decisive role. In fact, any trait of interest to mink production, simple or complex, is amenable to molecular dissection using the SNP map, with the ultimate goal helping the industry to find efficacious, affordable technologies to ensure sustainability and increase its competitiveness by developing improved lines of mink through DNA marker-assisted breeding programs.

Map Construction

For the most part the map will be based on SNP markers developed through a process of "Minkifying" other genomes. This approach maximizes the exploitation of information from species related to the mink for which both extensively annotated complete genome sequence and some comparative genomics data are already available. For example, the human and dog genome sequences are already available and the sequencing of the cat, which is believed to be more closely related to the mink than the dog, is underway.

Although the mink SNP map will be based primarily on sequence tagged sites (STSs) for expressed loci within the mink genome, it will also incorporate the anonymous microsatellite markers from the mink linkage map. The reliance on expressed STSs for the backbone of the SNP map will facilitate back-and-forth navigation between the mink genome and the genomes of mammalian species that are either already available. Thus, the SNP map will serve as a vehicle by which the existing information from well studied species such as the human and mouse can be used to advantage for genetic improvement in a less well characterized species, i.e. the mink, via the process of comparative functional genomics. This approach facilitates full scale genomics research in the mink without incurring the prohibitive cost of a fully fledged mink genomics initiative. Once developed, the SNP map will become a powerful tool for genetic improvement in mink.

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II-4 RP

Polish vs. Danish chinchillas (*Chinchilla laniger* M.). An analysis of body conformation and reproduction performance in two populations

Lidia Felska-Błaszczyk[1], Małgorzata Sulik[1], Agnieszka Semik[1], Beata Seremak[2]
[1] *Department of Animal Anatomy, Laboratory of Fur Animals, Agricultural University of Szczecin, ul. Doktora Judyma 14, 71-460 Szczecin, Poland,*
E-mail address: lidia.felska-blaszczyk@biot.ar.szczecin.pl
[2] *Department of Animal Reproduction, Agricultural University of Szczecin, ul. Doktora Judyma 6, 71-460 Szczecin, Poland*

Abstract
The aim of the study was to analyse conformation of Polish and Danish chinchillas and verify whether their scores for this trait correlate with reproduction performance. The analysis involved 162 Danish and 169 Polish Standard females. The analysed traits included body size, colour, colour clarity, fur quality, litter size, weaning success, number of litters per female, pre-weaning mortality, and birth interval. On the whole, Polish chinchillas obtained poorer results compared with the Danish ones. Based on these results we cannot unequivocally state that with an improvement in conformation (higher conformation scores), reproduction performance of chinchillas deteriorates. Polish chinchillas do seem to follow this pattern; however, it does not apply to those imported from Denmark. Reproduction parameters amongst the Danish animals were better in those that achieved higher conformation scores. In order to improve both conformation and reproduction traits in the population of Polish chinchillas, it is advisable to cross Polish animals with Danish ones.

Introduction
Chinchilla farming started in Poland as early as 1956, and the quality of pelts has improved considerably over these 50 years (Sulik, 2003). Polish breeders now use prime quality animals for breeding, often evolved from their own intensive breeding programmes. New animals, however, are also imported from other countries where long-term chinchilla breeding and selection efforts have led to outstanding achievements reflected by superior pelt quality (Felska & Brzozowski, 2001).
The profitability of a chinchilla farm heavily depends on the quality of pelts and the production output. Thus, both qualitative (fur quality) and quantitative traits (reproduction performance) should be permanently improved. Litter size is the most important reproduction parameter, since it directly translates to the output of pelts. It has been observed that fertility is negatively correlated with the body size (Lagerqvist et al., 1994). Barabasz (2001) states that a high-yielding chinchilla (i.e. one that has excellent conformation) will achieve a lower fertility index on average compared with an animal of a lower genetic value of production traits. As a result of conformation improvement, reproduction parameters may deteriorate; this, however, remains to be confirmed through scientific study.
The aim of the study was to analyse conformation of Polish and Danish chinchillas and verify whether their scores for this trait correlate with reproduction performance.

Material and Methods
The study was carried out on one of Europe's largest chinchilla farms (Alex Chinchilla Farm, Nowogard, Poland) during the years 2002-2005. Conformation grading data and reproduction parameters were analysed for 331 Standard chinchillas, 162 Danish and 169 Polish females.

Table 1. Chinchilla conformation assessment scoring rules for each trait (Barabasz, 2001).

Traits	Meeting standard requirements	Defects:		
		Minor defects	Major defects	Disqualifying defects
Size and confirmation	4	3	2 - 1	0
Colour type	5	4 - 2	1	0
Clarity of colour	9	7	5 or 3	0
Fur quality	9	7 or 5	3 or 1	0
Belly	3	2	1	0

The six-month old chinchillas were graded for conformation by a licensed judge, and the appraisal included the traits of the current Chinchilla Conformation Standard of 1999 (Table 1).

The highest attainable score for conformation is 30. In either group, we analysed the following reproduction parameters: litter size, number of weaned offspring per litter, number of litters per female per year, pre-weaning mortality, and birth interval.

The resulting data were statistically processed using Statistica 7.1 PL software (StatSoft). Descriptive statistics included the mean (m), standard deviation (SD), coefficient of variability (V%), and mode (Mo). In order to test the differences between the groups, we applied two-way ANOVA and, where applicable, the Mann-Whitney test.

Results

A significant ($p<0.01$) difference was found in the total conformation score (Table 2). The mean score achieved by Danish chinchillas, 28.7 points, was higher compared with that by Polish, 27.4 points. The highest difference, however, can be observed when we compare the modes of the two data sets, which was 30 points (maximum score) for the Danish chinchillas and 27 points for the Polish ones. This implies that Danish chinchillas more frequently achieve the highest score for conformation. Danish chinchillas seemed more uniform in terms of conformation, as the coefficient of variability was lower for all the traits, as compared with Polish chinchillas. This may indicate a very high level of genotypic similarity of the imported animals.

Statistical analysis has not revealed significant differences between the groups in terms of reproduction performance (Table 3).

In Danish chinchillas, 3 out of 4 analysed reproduction parameters were highest in the best-conformation animals. These were the number of weaned offspring per litter (1.68), pre-weaning mortality (14.9%), and the number of litters per female per year (1.35). Litter sizes were highest only with lower conformation scores, i.e. 28 points (2.07). The lowest levels of the number of weaned per litter and pre-weaning mortality were recorded in the Danish chinchillas having the poorest conformation scores.

Table 2. Overall results of the conformation assessment of Danish and Polish chinchillas

Genetic group	n	m	Mo	SD	V (%)
Danish chinchillas	162	28.7**	30	1.31	4.55
Polish chinchillas	169	27.4**	27	1.34	4.92
Total	331	27.9	27	1.50	5.27

n – number of animals, m – mean, Mo – mode, SD – standard deviation, V% - coefficient of variability;
** – differences significant at $p < 0.01$.

Table 3. Reproduction performance parameters in relation to conformation score.

Reproduction performance	Conformation score (pts)	Danish chinchillas			Polish chinchillas			Total		
		m	SD	V%	m	SD	V%	m	SD	V%
Litter size	27	1.87	0.4	22.2	1.96	0.4	21.3	1.94	0.4	20.7
	28	2.07	0.5	22.8	1.88	0.4	22.4	1.97	0.4	23.0
	29	1.85	0.4	20.3	2.03	0.4	21.5	1.94	0.4	21.4
	30	1.96	0.3	18.1	1.96	0.6	31.0	1.96	0.4	21.6
	Total	1.95	0.4	21.4	1.95	0.4	22.2	1.95	0.4	21.8
Number of weaned offspring per litter	27	1.5	0.5	34.9	1.59	0.5	29.3	1.58	0.5	29.4
	28	1.63	0.4	27.2	1.57	0.5	30.2	1.6	0.5	28.7
	29	1.5	0.4	25.3	1.66	0.5	29.7	1.59	0.4	28.2
	30	1.68	0.5	27.4	1.58	0.6	40.1	1.66	0.5	54.7
	Total	1.6	0.5	29.5	1.6	0.5	30.0	1.6	0.5	29.8
Pre-weaning mortality (during nursing)	27	21.8	20.0	95.5	18.8	17.8	95.0	18.5	17.9	96.9
	28	21.4	14.2	66.4	17.8	17.5	98.7	19.4	16.1	83.1
	29	18.1	16.0	88.6	17.7	16.4	93.0	17.9	16.1	90.4
	30	14.9	15.9	106.4	19.7	19.0	69.1	16.1	16.7	103.7
	Total	18.1	16.2	89.5	18.1	17.2	95.0	18.1	16.7	92.4
Number of litters per female per year	27	1.26	0.5	39.6	1.32	0.5	37.9	1.3	0.5	37.9
	28	1.23	0.4	35.7	1.16	0.5	41.4	1.19	0.5	38.7
	29	1.21	0.4	32.2	1.17	0.5	39.0	1.19	0.4	35.6
	30	1.35	0.5	37.6	1.13	0.4	38.6	1.31	0.5	38.5
	Total	1.28	0.5	36.2	1.22	0.5	39.3	1.25	0.5	37.9

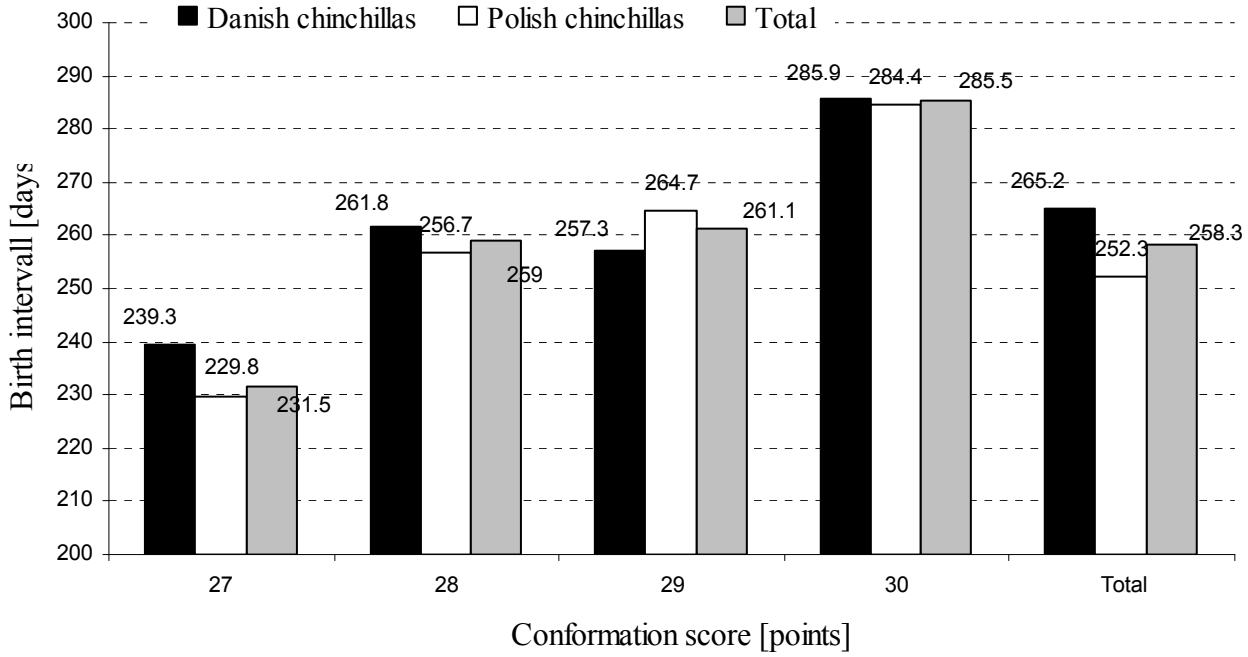
In the group of Polish chinchillas, the relationships between conformation scores and reproduction parameters were different. It was found that most indices were higher in the animals with poorer conformation. The highest number of weaned per litter, number of litters per female per year, and the optimum nursing mortality, 1.66, 1.31, and 16.1% respectively, were attained by the animals with the highest conformation scores. Danish chinchillas were characterised by generally better reproduction performance.

Figure 1 presents birth intervals in relation to conformation by genetic group. Although there were no significant differences, we may observe that this parameter is related to conformation. The lowest period was found in those with the lowest scores for conformation, 239 days in the Danish and 229.8 days in the Polish chinchillas, while the longest in the best chinchillas, with the highest conformation scores, irrespective of the genetic group, 285.9 days in Danish and 284.4 days in Polish animals

Discussion

Conformation analysis of both groups indicates that, despite the long-term tradition of chinchilla breeding in Poland, the animals still lack the quality observed in those imported from Denmark. Similar results were reported by Sulik (1994), who also found that Polish chinchillas achieved poorer scores for conformation (25.8 points) compared with Danish animals

Figure 1. Birth interval in relation to conformation score in Danish and Polish chinchillas



(27.8 points). When we compare these data, however, with those obtained in the presented study, progress is apparent, since both genetic groups achieved higher scores. A long-term growing trend for the conformation scores has also been observed by Socha and Anatolik (1998), and by Sulik (1998).

Socha and Olechno (2000) found that animal conformation scores depend on factors including, birth year, sex, and genetic group (origin) – as in our studies; however, the authors observed that Polish chinchillas rather than imported achieved better overall scores for conformation, ranging between 27.3 and 28.3 points, compared with a group of half-imports (26.8-28.3 points) or a group of imported chinchillas, which achieved the lowest scores for conformation (26.7-27.4 points). These results differ considerably from those obtained in our study.

Polish chinchilla breeders should continue to improve the quality of chinchilla pelts, which can primarily be achieved through conformation evaluation-based selection (Jeżewska et al., 1994; Socha & Anatolik, 1998; Barabasz, 2002; Sulik, 1998, 2003).

It seems that the relationship described by Barabasz (2001), i.e. that chinchillas with high production performance (high conformation scores) show worse reproduction performance, is more relevant in relation to the Poland-bred population of farm chinchilla. The Danish chinchillas with a high-quality conformation had also better reproduction parameters. This may imply that the latter group of animals are more stable both in terms of reproduction and body conformation. The solution which could lead to improvement of the chinchilla population in Poland is to cross the animals with Danish ones, which should result in both better conformation and improved reproduction.

Birth interval is a parameter that most quickly responds to various factors, such as age of chinchillas (Felska-Błaszczyk & Kaczmarek, 2006), or light intensity (Felska-Błaszczyk, 2005; Felska-Błaszczyk & Brzozowski, 2005). Birth interval was longer in those with better conformation results, which confirms the

opinion of Barabasz (2001), i.e. that chinchillas with better conformation scores had worse reproduction performance, longer birth intervals in this particular case.

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II-5 RP

Genetic parameters of feed efficiency and its relationships with feed intake, daily gain and animal size traits in Finnish blue fox (*Alopex lagopus*)

Riitta Kempe[1)], Ismo Strandén[1)], Minna Koivula[1)], Teppo Rekilä[2)], Nita Koskinen[2)] and Esa Mäntysaari[1)]

[1)]MTT Agrifood Research Finland, Biotechnology and Food Research, Biometrical Genetics, FI-31600 Jokioinen, Finland

[2)]MTT, Animal Production Research, Fur Animals, PL 44, FI-69101 Kannus, Finland

E-mail address: riitta.kempe@mtt.fi

Abstract

Feed is the biggest cost in fur animal production. Thus, daily feed intake (DFI), daily gain (DG) and feed efficiency (FE: DG/ DFI kg dry matter) should be taken into account in blue fox breeding programmes. The objectives of this study were to estimate genetic parameters for FE and related production traits. DFI and FE were measured during a test period from August to October in 1026 pairwise housed full-sibs. Individual body weights (BW), DG, grading size (gSI) and animal length were evaluated in 2076 foxes. Heritabilities for DFI, DG and FE were 0.24, 0.29 and 0.26, respectively. FE had favourable genetic correlation with DG (0.52) and DFI (-0.14), but unfavourable correlations with BW (0.14), gSI (-0.10) and animal length (-0.18). In conclusion, FE is a moderately heritable trait and selection for better FE and more precise feeding will reduce feed consumption and feeding costs and reduce environmental emissions. On the other hand, selection of better FE will favour faster growing, heavier animals, and it may have a negative impact on body length.

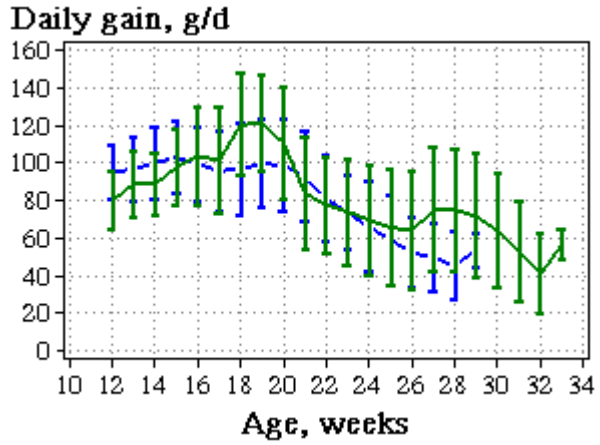
Introduction

During the last decade, the blue fox has been bred to be large and fat, because the price of the pelt is mostly determined by the size of pelt. At the same time, the feed prices and the amount of feed consumed per produced pelt have increased. Recently, increased attention to feed consumption has lead to the development and use of automatic feeding and feed recording systems, which make individual and precise feeding on each cage possible. Individual daily feed intake (DFI) recorded by the computer and animal's daily gain (DG) during growth period are vital information for estimation of feed efficiency (FE: DG/ DFI kg of dry matter). In the literature there are no studies on FE in blue foxes, but the possibility of increasing FE has been documented in other species. In a study of Sørensen (2002), the heritability of FE (DG/DFI) in the mink was 0.30. In pigs feed conversion ratio (DFI/DG) or residual feed intake are often used instead of FE (DG/DFI) and heritability estimates for these traits range from 0.15-0.40 (Mrode & Kennedy, 1993, Von Felde et al., 1996, Cai et al., 2008). The aim of this study was to estimate genetic parameters for FE and its relationships to DFI, DG, body weight, grading size and animal length in Finnish blue foxes.

Material and Methods

The experiment was carried out during 2005-2006 at the fur animal research station Kannus, MTT Agrifood Research Finland. The data consisted of 29 paternal progeny groups representing 2076 blue foxes. The number of dams was 241. Pedigree information for 1583 animals was obtained from the Finnish Fur Breeders Association. Blue foxes were born between May 6 and June 19. The foxes were on average 74 days old (57-91 days) in 2005 and an average of 84 days old (60-101 days) in 2006, at the beginning of the experimental period on August 15.

Figure 1. Daily gain (mean ±std) in Finnish blue foxes during growth period from August to pelting in 2005 (---) and 2006 (—).



After weaning, the foxes were housed according to common farming practices in wire mesh cages, one full-sib pair per cage. Forty per cent of the cages were situated in two traditional wire-netting sheds and sixty per cent in a hall. The foxes were fed according to normal farming practises so that they could utilise their full potential for growth. The average daily feed intake (DFI) of each full-sib pair was recorded once a day by automatic feeding machine regulated by Farm Pilot (Tved Maskinbyg, Denmark) from the Aug 15 until pelting. The daily ratio of each cage was pre-programmed into Farm Pilot based on feed intake and leftovers recorded before the daily feeding. The foxes were fed once a day by commercial standard diet delivered daily from the local feed manufacturer (Kannuksen minkinrehu Oy, Kannus, Finland).

Body weights (BW) were recorded six times during the experiment. The BW was measured at the beginning of the experiment (Aug 15) and again every three weeks (Sept 5, Sept 26,Oct 17/18, Nov 7/8) until pelting, when the final weight was obtained. Pelting and the measurement of body length (from nose to the beginning of tail) were done in November and December during weeks 47-48 in 2005 and during weeks 48-51 in 2006. Individual daily gain (DG g/d) for five different growth periods (1=15 Aug to 5 Sept; 2=Sept 5 to Sept 26; 3=Sept 26 to Oct 17/18; 4=Oct 17/18 to Nov 7/8; 5=Nov 7/8 to pelting) was calculated as the difference between BW at the end of period and BW at the beginning of the period, divided by the number of days in the period. DG was also calculated for the longer growth period from Aug 15 to Oct 17/18 ($DG_{Aug\text{-}Oct}$). DFI was measured as a cage average for a full sib pair. Feed efficiency (FE) of full-sib pairs was calculated as the ratio of total DG (g) to total DFI (kg dry matter) of a cage for corresponding periods as DG. Live animal grading traits were evaluated on November 7-16 in 2005 and on October 23-26 in 2006. For animal grading size (gSI) class 1 was the smallest and 5 was the largest.

(Co)variance components for different traits were estimated using the DMU program (Madsen & Jensen, 2000) that relies on restricted maximum likelihood (REML) method in variance component estimation. Animal model for variance component estimation was**:**

$$\boldsymbol{y = Xb + Wc + Za + e}$$

where $\boldsymbol{y}$ is vector of observations, $\boldsymbol{b}$ is a vector of fixed effects, and $\boldsymbol{c}$, $\boldsymbol{a}$ and $\boldsymbol{e}$ are vectors of random litter, animal/sib group and residual effects, respectively. For FE and DFI the random effect of animal was replaced by sib group. Matrices $\boldsymbol{X}$, $\boldsymbol{W}$ and $\boldsymbol{Z}$ are corresponding incidence matrices. Fixed effects for DG, BW, gSI and animal length were house-year, sex (two classes: male or female), pair (three classes: male-male, male-female or female-female pair), time of birth (four classes: 104-129, 130-144, 145-160 or 161-180 days from

Table 1. Heritabilities and their standard errors (diagonal), genetic correlations and their standard errors (upper triangle) and phenotypic correlations (lower triangle) of feed efficiency in five different periods (1-5).

	1	2	3	4	5
1	**0.08±0.02**	0.95±0.26	0.71±0.13	0.64±0.18	0.57±0.22
2	-0.13	**0.08±0.04**	0.81±0.29	0.84±0.21	0.78±0.28
3	0.14	-0.29	**0.10±0.04**	0.71±0.27	0.86±0.24
4	0.13	0.15	-0.24	**0.08±0.04**	0.94±0.36
5	0.02	0.09	0.04	-0.27	**0.08±0.04**

Periods: 1=15 Aug to 5 Sept; 2=Sept 5 to Sept 26; 3=Sept 26 to Oct 17/18; 4=Oct 17/18 to Nov 7/8; 5=Nov 7/8 to pelting

the beginning of the year) and age of dam (three classes: 1, 2 or ≥3 years). Fixed effects for FE and DFI were the same except that effect of sex was not included in the model. In order to calculate genetic and phenotypic correlations between the different traits a multitrait animal model was used and all the traits were taken asthe average of the sib group. Sex was not included in the multitrait model.

Random effects were assumed to be independent and normally distributed with mean zero. In addition, $\mathbf{var}(\boldsymbol{a}) = \boldsymbol{G}_0 \otimes \boldsymbol{A}$, where $\boldsymbol{A}$ is the numerator matrix and $\boldsymbol{G_0}$ is the additive genetic covariance matrix. Because the traits, which were taken as the average of a sib group, had reduced variance compared to the individual measurement, the appropriate changes were made to the inverse of the relationship matrix ($\boldsymbol{A^{-1}}$) as presented by Kovac & Groeneveld (1990).

Heritability (h^2) and proportion of litter variation (c^2) for a trait were calculated as $h^2 = \sigma^2_a/(\sigma^2_a + \sigma^2_c + \sigma^2_e)$ and $c^2 = \sigma^2_c/(\sigma^2_a + \sigma^2_c + \sigma^2_e)$, where σ^2_a, σ^2_c and σ^2_e are additive genetic, litter environment and residual variances for the trait, respectively.

Results and Discussion

Firstly, we wanted to study whether FE, DG and DFI during different growth periods are separate traits, and which period would be most suitable for further analysis of FE. DG was highest at the beginning of the growth period and started to decrease in October when the animals reached 20 weeks of age (Figure 1). The same trend was noted also in FE. DG started to decrease at the same age as reported in the study of Huhti (2005). Blue foxes reached their adult length by the middle of October and after that growth occured mainly through deposition of fat (Sirkko, 2000, Huhti, 2005).

Genetic correlations of FE between the first three periods, which were characterized as the fast growth period, were high (0.71-0.95) and the correlations between the first period and the two last periods (4 and 5) were lower (0.57-0.64) (Table 1). Therefore, FE in the first three periods can be considered as the same trait. FE measured from October until pelting may be partly different trait than FE measured during the fast growth period. In addition, heritabilities of FE estimated in different periods (1-5) were low (0.08-0.10). This was mainly due to large error variance in the short, three week periods. This and the fact that the genetic correlations between FEs in subsequent periods were high favored a longer measuring period for FE. Therefore, the whole period of fast growth from August to October - a total of nine weeks - was used in further analyses ($FE_{Aug\text{-}Oct}$).

Table 2. Number of observations (n), means, standard deviations (SD), estimated phenotypic variances (σ^2_P), proportion of litter variation (c^2) and heritabilities (h^2) for the studied traits in single trait analysis.

	n	Mean	SD	σ^2_P	c^2±s.e.	h^2±s.e.
gSI	2060	3.70	0.90	0.56	0.15±0.03	0.34±0.09
Animal length, cm	1805	71.4	3.01	6.31	0.08±0.04	0.52±0.12
BW_{Aug}, kg	2076	4.28	11.41	0.48	0.49±0.04	0.35±0.08
BW_{Oct}, kg	2069	10.68	1.56	1.55	0.25±0.04	0.42±0.10
BW_{Final}, kg	2058	13.61	20.14	2.88	0.14±0.03	0.50±0.10
$DG_{Aug-Oct}$, g/d	2072	106	16.59	217.60	0.17±0.03	0.29±0.09
$DFI_{Aug-Oct}$, g DM	1026	373	40.11	2347.09	0.14±0.03	0.24±0.05
$FE_{Aug-Oct}$, g/kg DM	1026	271	28.62	780.42	0.09±0.03	0.26±0.05

gSI=grading size, BW=body weight, DG=daily gain, DFI=daily feed intake, DM=dry matter and FE=feed efficiency

During the period of August to October, the heritability of $FE_{Aug-Oct}$ was fairly high (0.26), which should make genetic improvement possible through selection (Table 2). In the literature, FE heritabilities have not been estimated for blue foxes. However, the estimate for FE derived in the present study was within the range of estimates reported for mink and swine (Berg & Lohi, 1992, Mrode & Kennedy, 1993, Von Felde et al., 1996, Sørensen, 2002, Møller et al., 2004, Cai et al., 2008). $DFI_{Aug-Oct}$ and $DG_{Aug-Oct}$ had moderate heritabilities of 0.24 and 0.29, respectively. To our knowledge there are no published heritability estimates of DFI or DG for blue foxes. In mink, heritability estimates of DFI and DG were higher than in our study (Sørensen, 2002). Heritability estimates for DG in pigs range from 0.16 to 0.44 (Mrode & Kennedy, 1993, Von Felde et al., 1996, Cai et al., 2008). The heritability estimates for size traits were high. The highest heritability was obtained for animal length (0.52). Also the October BW and final BW had high heritabilities of 0.42 and 0.50, respectively. The heritability of animal's gSI (0.34) was much higher than in the study of Peura et al. (2004, 2005) but lower than that estimated by Kenttämies (2002). The main reasons for high heritability estimates in our study were the small number of animals in the study and a more controlled environment. The farm and grader were the same for all the animals.

Litter effect had a clear influence for all the traits studied (Table 2). Litter variation was the highest in BW (0.21-0.49) at the beginning of the growth period and it decreased when the animals grew larger. In gSI, $DG_{Aug-Oct}$ and $DFI_{Aug-Oct}$ the litter effect varied between 0.14-0.17. The proportion of litter variation was lowest in $FE_{Aug-Oct}$ and animal length (0.08-0.09).

Feed efficiency had favourable genetic correlation with $DG_{Aug-Oct}$ (0.52) and $DFI_{Aug-Oct}$ (-0.14), but unfavourable correlation with BW_{Oct} (0.14), gSi (-0.10) and animal length (-0.18)(Table 3). Selection for better FE will favour faster growing animals and may slightly decrease the feed required for a given rate of growth due to economically favourable negative genetic correlation between FE and DFI. However, the correlation between the traits was low, and therefore the indirect selection of FE by measuring DFI is not practical in blue foxes. Improved FE seems to have some negative impact on animal size, as the animals with better FE are heavier but their body length is shorter. In the present breeding program one does not

Table 3. Estimated genetic correlations and their standard errors (upper triangle) and phenotypic correlations (lower triangle) between feed efficiency (FE), daily gain (DG), daily feed intake (DFI), body weight (BW), grading size (gSI) and animal length in multitrait analysis.

	$FE_{Aug-Oct}$	$DG_{Aug-Oct}$	$DFI_{Aug-Oct}$	BW_{Oct}	gSI	length
$FE_{Aug-Oct}$		0.52±0.07	-0.14±0.05	0.14±0.05	-0.10±0.05	-0.18±0.05
$DG_{Aug-Oct}$	0.46		0.77±0.06	0.91±0.03	0.62±0.12	0.33±0.16
$DFI_{Aug-Oct}$	-0.26	0.73		0.95±0.02	0.78±0.11	0.49±0.17
BW_{Oct}	0.10	0.83	0.83		0.82±0.09	0.51±0.15
gSI	0.06	0.45	0.46	0.58		0.87±0.07
length	-0.07	0.30	0.39	0.45	0.55	

want to increase the size or fatness of the blue foxes, because there is an antagonistic correlation between animal size and fertility and between animal size and front leg pastern angle (Peura et al., 2004; Keski-Nisula, 2006).

Grading size had high genetic correlation with animal length (0.87) and BW_{Oct} (0.82)(Table 3). The genetic correlation between animal length and BW_{Oct} was 0.51. This was expected, because grading size represents the grader's general impression on animal size, which is influenced by length, BW and fatness of the animal. All the genetic correlations between size traits (gSI, BW_{Oct} and length) and $DG_{Aug-Oct}$ were positive ranging from 0.33 to 0.91. This means that selection for large gSI and heavy animals will favour faster growing animals.

The genetic correlations between size traits (gSI, BW_{Oct} and length) and $DFI_{Aug-Oct}$ rangedfrom 0.49 to 0.95 (Table 3). Also the genetic correlation between $DG_{Aug-Oct}$ and $DFI_{Aug-Oct}$ was high (0.77). Therefore, the selection of big, heavy, fast growing animals will increase DFI. Animal length and gSI had negative genetic correlations with FE. Therefore it seems that selection for longer animal and larger pelt size leads to poorer FE, and higher feed consumption, although genetic correlation is weak.

According to a study by Sørensen (2002), in mink, selection of better FE and DG may favour larger, obese and less active animals. Therefore the connection of FE and obesity traits of blue foxes needs to be studied. It is also known, that gSI has a large genetic correlation with pelt size (0.75) (Peura et al., 2005). As the price of pelts is determined by the pelt size and quality traits, the relationships between FE and pelt character traits requires further study.

Conclusions

FE is a moderately heritable trait and genetic improvement is possible through selection. As feed is the biggest cost in fur animal production, FE should be taken into account in blue fox breeding programmes. It is expected that better FE and more precise feeding will reduce feed consumption and feeding costs and reduce environmental emissions.

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Genetic parameters for litter size and grading traits in Finnish mink population

Minna Koivula, Ismo Strandén and Esa A. Mäntysaari
MTT Agrifood Research Finland, Biotechnology and Food Research, Biometrical Genetics, FIN-31600 Jokioinen, Finland
E-mail address: Minna.Koivula@mtt.f

Abstract
The main breeding goals in Finnish mink breeding have been improved fur quality, and increase in body size and litter size. Mink are usually graded before pelting to select suitable animals for breeding. Thus, grading information is commonly used for indirect selection of pelt characteristics. The aim of this study was to estimate variance parameters for grading and fertility traits. Data included observations from 99,861 animals. The pedigree file contained 148,425 animals. Animals were from 27 farms and observations were from years 1996 – 2004. Heritability estimates for litter size and grading traits varied from low to moderate (0.12 to 0.39). Genetic correlation between animal size and litter size was clearly unfavorable (-0.24) indicating that large animals tend to have low fertility (smaller than average litters). Other grading traits also had antagonistic relationship with litter size. Therefore, it could be reasonable to use information on correlated traits when selection weights for economically important traits are decided.

Introduction
The main breeding goals in Finnish mink (*Neovison vison*) breeding have been improved fur quality, and increases in body size and litter size. Fur animal recording in Finland is divided into three trait groups: fertility (litter size at two weeks post partum), grading traits (evaluated from live animals: animal size, color darkness, underfur density, color clarity, guard hair coverage and quality), and pelt character traits (measured from dried pelt: pelt size, color darkness, color clarity and quality). Mink are usually graded before pelting in order to select suitable animals for breeding. Thus, grading traits are commonly used for indirect selection of pelt characters in mink.

High reliability of the statistical model is important in the genetic evaluations. Heritability estimates have been calculated for many traits in mink (Kenttämies & Vilva, 1988; Lohi et al., 1990; Berg, 1993; Lagerkvist et al., 1993, 1994). As breeding involves simultaneous selection of several traits, information about genetic correlations between traits is also important. A strong positive genetic correlation has been reported between body weight and pelt length and a negative correlation between body weight and wool density (Lagerkvist et al., 1993). It has also been shown that an increase in animal size may cause a decrease in litter size due to unfavorable genetic correlation between these two traits (Lagerkvist et al., 1994). Rozempolska-Rucińsca (2004) has considered joint analysis of fertility and animal size in mink. Although variance components have been estimated for several traits, trait definitions in different mink populations are slightly different or not analyzed in the literature. Thus, no complete body of information on genetic (co)variance components between all the grading traits and litter size is available for the Finnish mink breeding programme.

The aim of this study was to re-estimate genetic parameters for grading and fertility traits in mink. One of the objectives was to provide new statistical models and variance components for the within farm genetic evaluation of mink in Finland.

Materials and Methods

Data was obtained from the SAMPO registry which is collected from fur farms by the Finnish Fur Breeders' Association. Data for variance component estimation was sampled from the full SAMPO data. In the end, the sample had observations from 99,861 mink from years 1996-2004. The pedigree contained 148,425 animals from 27 farms. Totally SAMPO data included 2,785,090 animals.

The studied traits were the litter size at first whelping and the grading traits. Litter size was recorded two weeks after whelping. The grading traits were scored by the farmer for young animals, mainly in October, on a scale from 1 to 5, where a score of 1 represented the poorest and 5 the best class. The means and standard deviations for the traits are given in Table 1. The average grading score for all traits should be ca. 3 in each farm each year. However, slightly higher scores are common (Table 1).

Fixed effects for the traits were studied with a general linear model by excluding random effects other than residual (SAS, 2004). Restricted maximum likelihood (REML) estimates of (co)variance components were calculated using DMU software (Madsen & Jensen, 2000). Five four-variate REML runs were carried out with an animal model. The statistical model was: $\mathbf{y} = \mathbf{Xb} + \mathbf{Wc} + \mathbf{Za} + \mathbf{e}$ where **y** is a vector of observations, **b** is a vector of fixed effects, and **c**, **a** and **e** are vectors of random effects for common litter, animal and residual, respectively, and matrices **X**, **W** and **Z** are corresponding incidence matrices. Fixed effects for the litter size were farm-year, time of birth for animal, and number of matings. For grading traits the fixed effects were farm-year, time of birth for animal, sex of animal, and age of dam. Random effects were assumed to be independent and normally distributed: $\mathbf{a} \sim N(\mathbf{0}, G_0 \otimes A)$, $\mathbf{c} \sim N(\mathbf{0}, C_0 \otimes I)$, $\mathbf{e} \sim N(\mathbf{0}, R_0 \otimes I)$. Heritability ($h^2$) and proportion of common litter variance (c^2) for the traits were calculated as $h^2 = \sigma_a^2/(\sigma_a^2 + \sigma_c^2 + \sigma_e^2)$, and $c^2 = \sigma_c^2/(\sigma_a^2 + \sigma_c^2 + \sigma_e^2)$, where σ_a^2, σ_c^2 and σ_e^2 were additive genetic, common litter environment and residual variances for the traits, respectively.

Estimates from the separate REML-runs were compiled to form additive genetic (G_0), litter (C_0) and residual (co)variance matrices (R_0) of order 7 by 7 using the method of expanded part matrices to ensure that the results remain positive definite (Mäntysaari, 1999). Genetic trends for litter size, animal size and quality were assessed by examining standardized breeding values (EBV). Breeding values were calculated with MiX99 (Strandén & Lidauer, 1999). The model used was the same as in the variance component analysis and the variances were the estimates obtained there. The data for EBV calculations was from the same farms as data for variance component estimation, but included years 1990-2004. In total, there were 161,846 animals total in the data file, and 208,636 animals in the pedigree file. Estimated breeding values were standardized so that animals born in 2000 had mean 100 and standard deviation 10.

Table 1. Number of observations (n), mean, standard deviation (SD) and coefficient of variation (CV) by trait.

Trait	n	Mean	SD	CV
Litter size	33942	5.48	2.09	0.38
Animal Size	90134	3.62	0.88	0.24
Color darkness	48108	3.43	0.84	0.24
Underfur density	61074	3.71	0.77	0.21
Guard hair coverage	62078	3.66	0.82	0.22
Color clarity	34607	3.58	0.98	0.27
Quality	74463	3.70	0.78	0.22

Results

Mean litter size in the first parturition was 5.5 pups and CV for the litter size was considerable, being 38% (Table 1). From the grading traits, most variation was found in color clarity (27%). Heritability estimates for the traits studied varied between 0.12 and 0.39 (Table 2). The

Table 2. Estimates of phenotypic variances (σ_p^2), additive genetic variance (σ_a^2), litter variance (σ_c^2), litter effect (c^2) and heritabilities (h^2) with their standard errors (SE) for the litter size and grading traits in Finnish mink.

Trait	σ_p^2	σ_a^2	σ_c^2	$c^2 \pm$ SE	$h^2 \pm$ SE
Litter size	4.06	0.495	0.040	0.01 ±0.009	0.12 ±0.008
Animal Size	0.48	0.109	0.049	0.10 ±0.007	0.23 ±0.004
Color darkness	0.43	0.169	0.034	0.08 ±0.003	0.39 ±0.017
Underfur density	0.35	0.059	0.031	0.09 ±0.008	0.17 ±0.004
Guard hair coverage	0.41	0.087	0.033	0.08 ±0.008	0.21 ±0.004
Color clarity	0.44	0.123	0.034	0.08 ±0.011	0.28 ±0.006
Quality	0.38	0.071	0.033	0.09 ±0.007	0.19 ±0.004

(0.12). For the grading traits, the highest heritability estimate was obtained for the color darkness (0.39) and the lowest for the underfur density (0.17). Although common litter effect was lower than heritability, being an average 0.08, the litter variance existed for most of the traits (Table 2).

Genetic and phenotypic correlations between the studied traits are presented in Table 3. In the present study, only correlations that were higher than $1.96 \times \text{SE}$ were considered to differ from zero. Genetic correlations between the litter size and all grading traits were negative. The strongest antagonistic relationship was estimated between litter size and animal size (-0.24). Grading quality had high genetic correlation with guard hair coverage (0.76), underfur density (0.50), but a slightly lower correlation with animal size (0.40), color darkness (0.32), and color clarity (0.31). Genetic correlation between color darkness and color clarity was moderate (0.44) as well as was the genetic correlation between underfur density and guard hair coverage (0.47). The phenotypic

Figure 1. Genetic changes in standardized estimates of breeding values by birth year for litter size (LS) and animal size (SIZE) and grading quality (QU) in Finnish mink.

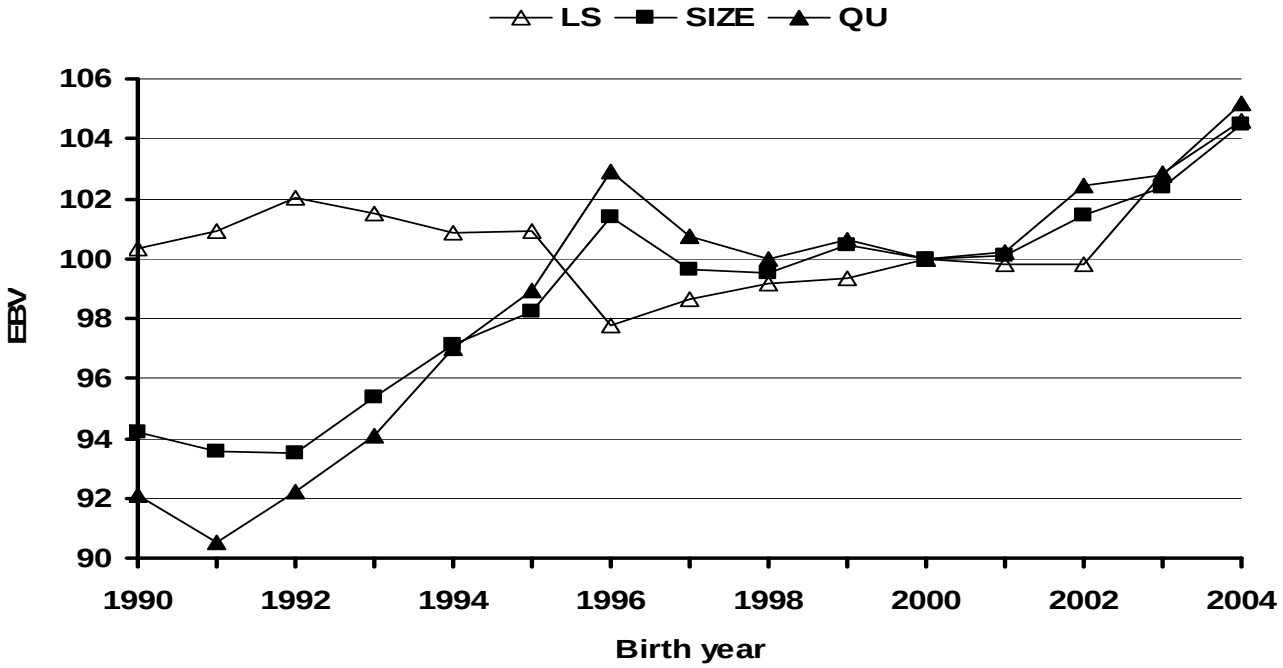

Table 3. Estimated genetic (above diagonal) and phenotypic (below diagonal) correlations for litter size and grading traits. Standard errors are in parenthesis. Traits are litter size (LS), animal size (SIZE) color darkness (DA), underfur density (DE), guard hair coverage (GC), color clarity (CL), and quality (QU). The genetic correlations differing more than 1.96 SE from zero are in bold.

	LS	SIZE	DA	DE	GC	CL	QU
LS		**-0.24 (0.04)**	**-0.17 (0.04)**	-0.07 (0.05)	-0.08 (0.04)	**-0.14 (0.05)**	**-0.18 (0.04)**
SIZE	-0.03		**0.07 (0.02)**	**0.10 (0.03)**	-0.02 (0.03)	0.02 (0.03)	0.40 (0.03)
DA	-0.03	0.06		**0.19 (0.03)**	**0.22 (0.03)**	**0.44 (0.02)**	**0.32 (0.03)**
DE	-0.01	0.11	0.09		**0.47 (0.03)**	**0.16 (0.04)**	**0.49 (0.03)**
GC	-0.02	0.09	0.15	0.36		**0.27 (0.03)**	**0.76 (0.03)**
CL	-0.02	0.08	0.33	0.15	0.24		**0.31 (0.03)**

correlations between grading quality and other grading traits were from moderate to high (0.31 to 0.63). In general, however, phenotypic correlations were lower than the genetic correlations.

Standardized estimates of breeding values show that in general, there has been a trend towards increasing litter size, animal size and quality (Figure 1). However, the increases in quality and animal size have been steeper than in litter size. Moreover, litter size decreased from 1992 to 1996, after which it was almost constant until year 2002. After year 2002 there has been a slight increase in the genetic trend of litter size.

Discussion

Profitability of mink production depends highly on reproductive performance. According to earlier studies, a large variation in heritability estimates of fertility traits was found among different mink populations (Lohi et al., 1990Lagerkvist et al., 1994; Socha, 2004). We estimated the heritability of litter size to be 0.12. In other studies, estimates for litter size in mink have usually ranged from 0.13 to 0.20 (Berg, 1993), but also lower estimates have been presented. Lagerkvist et al. (1994) estimated the heritability of total number of pups born to be 0.09 for mink, and Rozempolska-Rucińsca (2004) reported a heritability of 0.02 for the number of pups born. In other species heritability estimates have also been close to 0.10. For Finnish blue fox, for example, the heritability for the first litter size has been estimated to be 0.10 (Peura et al., 2007). In Poland heritability of litter size at birth in blue fox has been reported to be 0.20 (Wierzbicki, 2004). Serenius et al. (2004) estimated heritabilities between 0.07 - 0.11 for different litter size traits for Finnish Large white and Finnish Landrace pigs. Thus, the heritability estimate presented in this study is within the range reported in the literature.

Animal size is an important trait in fur production. Heritability for animal size was estimates at 0.23 in the present study. There exists large variation in heritability estimates for body size in mink. In studies analyzing traits based on subjective grading, heritability estimates for body size have varied from zero to 0.51, with an average around 0.20 (Berg, 1993; Socha, 2004). The highest heritabilities (range from 0.20 to 0.77) have been estimated for measurable size traits like body weight and body length (Berg, 1993; Lagerkvist et al., 1994; Socha, 2004). In blue fox, heritability estimates have ranged from 0.16 to 0.29 for the subjectively graded body size (Peura et al., 2005, 2007; Wierzbicki, 2004). Visual scoring of body size may be affected by the fatness of the animal, which may cause differences in heritability estimates.

Heritability estimates for other grading traits were found to be from low to moderate and correspond to results from other studies in mink (Lagerkvist et al., 1994). Likewise, studies on blue fox (Peura et al., 2005, 2007; Wierzbicki, 2004) have reported heritabilities close to those in our study. The common litter effect accounted for nearly 10% of the phenotypic variation in all grading traits. Thus, the litter environment influences fur quality.

Genetic correlation between animal size and litter size was clearly unfavorable indicating that larger animals have lower fertility (smaller litters). Other studies have also shown that increase in animal size may cause decrease in litter size due to unfavorable genetic correlation. Lagerkvist et al. (1993, 1994), and Rozempolska-Rucińsca (2004) found a low antagonistic genetic correlation between fertility and animal size in mink. In blue fox, Peura et al. (2007) observed an unfavorable genetic correlation between animal size and litter size. The average genetic trend in litter size has been slightly increasing. For animal size and grading quality, genetic trend has been upward as well. Thus, it seems that in spite of negative genetic correlation between animal size and litter size, there has been genetic improvement in both traits. However, if selection focuses continuously on increasing animal size, the genetic level of the litter size can be expected to decrease at some point. As the heritability of litter size is quite low, the phenotypic impact may be small and slow to appear.

Litter size also showed negative correlations with other grading traits, especially with color darkness, color clarity and grading quality. It seems that if selection for fur quality, color darkness or color clarity is based on single-trait evaluations, fertility of mink deteriorates. In order to guarantee improvement in all economically important traits, it is reasonable to use correlation information when considering selection index weights. Moreover, low heritability means low accuracy in breeding value estimation. Therefore, decisions on early selection for low heritability traits are associated with uncertainty. The use of correlated trait information would increase the accuracy of estimated breeding values. Therefore, the use of a multitrait model would be especially beneficial in the evaluation of fertility traits.

The only negative correlation, although not significant, among grading traits was estimated between animal size and guard hair coverage. Lagerkvist et al. (1994) also found that animal weight at autumn had slightly negative correlation with fur traits, especially wool density, but on the other hand a strong positive genetic correlation was reported between body weight and pelt length. They suggested that this negative interaction between animal size and fur traits could be due to the number of hair follicles being fixed. Thus when the animal gets bigger its skin stretches and fur will appear less dense.

Conclusion

There exists considerable genetic variation in litter size and grading traits. Thus, it is possible to change all traits by selection. Genetic correlations between the grading traits and litter size were antagonistic but low. Thus, it would be reasonable to take into account genetic correlations between the traits when selection weights are decided. In addition, litter size evaluations are likely to benefit from a multiple trait evaluation where traits with highest correlation to litter size are included.

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II-7 RP

Analysis of conformation traits in mink of standard and palomino colour types

Dorota Kołodziejczyk, Stanislaw Socha
Department of Breeding Methods, Poultry and Small Ruminent Breeding, University of Podlasie, 08-110 Siedlce, ul. B. Prusa 14. Poland
E-mail addres: socha@ap.siedlce.pl

Abstract
The present work was intended to analyze the factors that influence animal size and fur quality (colour purity, colour type, fur quality and total score) in mink (*Neovison vison* Sch.). The research considered standard and palomino colour types : 1400 animals were evaluated over three years. The analyses of variance of the traits proved statistically significant for year, colour type and animal sex on the majority of the analysed traits. The interactions of the following factors: the year, colour type and animal sex were statistically significant only for some traits. Proportionally, the highest mean characterised animal size (97% - 99%) and total score (96% - 97%), while maximum score was 100%. Coefficient of variability was the highest for animal size and fur quality (coat density and hair length) and ranged from 0 to 15%. The lowest values of variance coefficients were observed for total evaluation (from 2.2% to 5.9%). This demonstrates that the animals characterized by high parameters in some traits had low parameters in the others. Consequently, total evaluation equalized the animal values. The animals of the analysed breeding farm were characterised by very high parameters of fur traits as evidenced by the overall mean (18.43 points) and by numerous prizes obtained by the animals at the national shows.

Introduction
The mink is bred in many colour types. The traits that have significant influence on pelt price are: pelt size, colour, colour purity and fur quality (including hair density and length, as well as equilibrium of hue). Mink breeding has been recently very popular in Poland. The traits that are important in fur animal breeding are fur quality traits and animal size (Socha & Markiewicz, 2003). These are the traits that besides health and fecundity determine the economic result of mink production (Jeżewska & Maciejowski, 1986).

The present work aims to analyse the variance of animal size and fur traits in mink of standard and palomino colour types. The work is a continuation of the researches conducted in the Department of Breeding Methods, Poultry and Small Ruminent Breeding (University of Podlasie).

Materials and Methods
The research was conducted on a mink farm situated in northern Poland. Two colour types, standard and palomino, were analysed over three years (2004-2006). A total of 722 standard mink (163 males and 559 females) and 675 palomino mink (155 males and 520 females) were studied. The following traits were measured: animal size and body conformation (6 points), colour type (3 points), colour purity (5 points), fur quality (the length of hair and fur density – 8 points) and total score (the sum of points for all traits). The animals were evaluated when the fur is mature, according to the new rules (Wzorzec – Norm 1997). The whole evaluation was pointed. The maximum amount of points was 20. The animals that received 0 points for a trait were disqualified from further breeding. Only young animals, born during the grading year, were evaluated. Animal size is the weight in grams converted into points. For each of the analysed traits analysis of variance was performed and included as fixed effects the year

of evaluation, colour type and animal sex, as well as interaction between those factors. The estimates of the variance components were obtained using SAS/STAT (1998) procedure.

Results and Discussion

The analyses of variance of the traits showed statistically significant effects for the following factors: year, colour type and animal sex on the majority of the analysed traits. The interactions of those factors were statistically significant only for some traits. The year, colour type and animal sex did not have a statistically significant effect on animal size. Table 1 presents the arithmetic means and coefficients of variance for the traits analysed. It considers colour types and animal sex. According to the Norm, to obtain 6 points for animal size, the following weights are required: 2200 grams (males) or 1200 g (females) for standard mink; and 2300 g (males) or 1300 g (females) for palominos. The majority of the animals analysed obtained 5 or 6 points, which are the results close to maximum score (6 points).

Animal weight is an important production trait in mink; it influences the size and, consequently, the price of the pelt. Mink bred on farms are significantly heavier than wild or feral animals (Jeżewska & Maciejowski, 1981). Fur quality also depends on the sex of the animal. Male pelts are generally larger, with longer and thicker hair (Cholewa, 2000). Due to the fact that colour type (intensity of the colour) was not evaluated, all individuals scored 3 points in this category. Arithmetic mean of colour purity was higher in standard than in palomino type mink. Males received higher notes (more scores) in comparison with females in both colour types.

Fur colour is one of the traits that characterize beautiful pelts. Hair colour and the intensity of colour are conditioned by one type of brown pigment, melanin, distributed in the bark and medulla of the hair (Jeżewska & Maciejowski, 1986). Colour purity in mink is genetically conditioned and susceptible to environmental factors (Lorek et al., 1998).

The arithmetic mean of fur quality was slightly higher in palominos (5.21) than in standard mink (5.08). While evaluating this trait the following elements are considered: fur density, hair length and equilibrium of hue. The indicators of the quality of pelts destined for furs are: density, hair thickness, height and equilibrium of hue, composition, resilience, softness, colour, gloss, as well as protection from the cold and durability of the fur (Kuźniewicz & Filistowicz, 1999).

Hair density is one of the most important traits. The denser the hair, the more valuable is the pelt. Hair density influences the beauty of the pelt, its splendour, fur durability and protection from the cold. Dense and gentle hair, as well as uniform density of the fur, makes the fur look like velvet (Jeżewska & Maciejowski, 1986).

Variance coefficients of fur quality and colour purity ranged between 5% and 15% and were definitely higher in comparison with the variance coefficient of animal size and the total number of points. Higher variability was observed in palomino type and in females of both colour types.

Total score, which is the value most important for the breeder, is the sum of points for all traits. In the breeding farm analysed, the mink of both colour types obtained in average more than 18 points. Variance coefficients of total score ranged from 2.2% to 5.8%, depending on colour type. It indicates that this trait was most balanced.

Higher variability (higher variance) characterised standard colour type in

Table 1. Arithmetic means ($\bar{x}$) and variability coefficients (V) of traits in a herd of mink, depending on colour type and animal sex.

Traits	Colour type	Males		Females		Total	
		$\bar{x}$	V	$\bar{x}$	V	$\bar{x}$	V
Animal size & dimensions (body conformation)	Standard	5.99	1.30	6.00	0.00	6.00	0.67
	Palomino	6.00	1.47	5.99	1.47	5.99	1.29
	Total	5.99	1.00	5.99	1.00	5.99	1.00
Colour type (trait)	Standard	3.00	0.0	3.00	0.0	3.00	0.0
	Palomino	3.00	0.0	3.00	0.0	3.00	0.0
	Total	3.00	0.0	3.00	0.0	3.00	0.0
Colour purity	Standard	4.68	10.00	4.32	14.54	4.40	13.95
	Palomino	4.48	11.18	4.08	15.96	4.17	15.40
	Total	4.58	10.79	4.20	15.48	4.29	14.87
Fur quality	Standard	5.73	7.77	4.89	14.91	5.08	14.98
	Palomino	5.77	7.28	5.04	12.86	5.21	13.01
	Total	5.75	7.53	4.96	14.01	5.14	14.09
Total number of scores	Standard	19.41	2.61	18.22	5.94	18.48	5.95
	Palomino	19.25	2.26	18.10	0.55	18.36	5.58
	Total	19.33	2.48	18.16	5.75	18.43	5.78

comparison with palomino. The low variability of the total number of scores is due to the fact that the animals characterized by high parameters in some traits had low parameters in the others. (Socha & Markiewicz, 2003).

According to the model (Wzorzec – Norm, 1997) the maximum number is 20 points for all traits. In the breeding farm analysed in the period 2004 – 2006, the mink of standard andpalomino types obtained in average 17.93 – 19.47 points.

To sum up, the animals analysed were of very high quality. This is demonstrated not only by high scores obtained in evaluation of conformation, but also by numerous prizes gained at fur animals exhibitions in Poland. It is important to stress that the mink included in the study had traits of similar value between colour types. It is undoubtedly the result of a long-lasting and goal-oriented breeding work. The present study does not analyse genetic differences, apart from the difference between colour types. We may suppose that high evaluation of phenotypic traits of the animals originates from genetic base and the breeding values of animals also are high compared to the model requirements. On the other hand, the low phenotypic variation may indicate the narrowing of the genetic variability. It is obvious that an effective breeding work must take place in the optimum environmental conditions in order to guarantee the possibility of the entire manifestation of the genetic capacity of animals. Breeding work on fur animals is like the work on other animals composed of the following stages: estimation of utility value and breeding value, selection of breeder animals and the mating plans (Jeżewska & Maciejowski, 1986).

Conclusions

1. The following factors: year, colour type and animal sex had statistically significant effects on the majority of the analysed traits. The only exception was animal size, for which no statistically significant effect of the year or colour type was observed. In the majority of the traits higher means of the evaluation notes were obtained by males.

2. Animal size in points was similar in standard and palomino due to little discrepancy of the point system. The arithmetic mean of colour purity was higher in standard mink, while high arithmetic mean of fur quality characterised palomino type.

3. During the study period 2004 - 2006 the arithmetic means of animal size did not change. However, colour purity and fur quality deteriorated which caused the score totals to decline during the research (not presented in detail due to limited volume of the present work).

4. The animals studied demonstrated very good fur parameters. The overall mean was 18.43 points. It is proved by numerous prizes received by the studied animals at exhibitions and shows.

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II-8 RP

Effects of domestication and new technological possibilities in breeding practice: American mink (*Neovison vison* Schreber, 1777) as a model.

O.V. Trapezov
Institute of Cytology and Genetics, Russian Academy of Sciences Novosibirsk, Russia
E-mail address: trapezov@bionet.nsc.ru (work); o.trapezov@academ.org (home)

Introduction

What are the characteristic changes in the fur animals subjected to domestication? Domestication itself is the process whereby animals adapt to humans and conditions in captivity through a set of genetic changes (Ratner & Boice, 1975). We have already demonstrated behavioral changes, namely in their response to humans. Unconscious selection plays a key role in the domestication of fur animals. Fur farmers retain and breed for their own use and utility the calmest animals, and discard the vicious, without the deliberate intent to modify the genetic nature of their silver and polar foxes, mink, and sobols. For this reason, in the course of a short (in historical terms) time span of a hundred years or so, an uncontrolled genetic change in behaviour through successive generations has occurred in favor of a tolerant attitude towards the man-made environment (if not towards humans themselves, as the domesticated fur bearers were kept at arm's length) (Trapezov et al., 2004).

Another important feature of the domestication of fur animals is change in the coat color as compared to the wild type.

Under human protection, fur animals are no longer vulnerable to the effects of numerous noxious agents, such as wild competitors and carnivores. They are provided with food, warmth, shelter and vaccination to combat infectious diseases. This dampens the effects of natural selection as it occurs in the wild, and allows diverse hereditary changes to spread and accumulate.

For this reason, an early result of domestication is a considerable broadening of genetic variability as compared to the wild ancestors, which is was primarily due to the accumulation of the most different hereditary changes. In the wild, the viability of most mutations is low, and so they cannot spread in populations. In contrast, in animals raised and bred under human protection many mutations do not only survive, they are intentionally propagated to achieve an increase in numbers and to preserve the variant characters. This enables us to choose particular forms for further domestication and the subsequent application of artificial selection: man exercises his "power of selection" over characteristics that are manifestly useful.

The diverse coat color phases in domestic mink are immediately apparent. For example, spots of different colors are irregularly distributed all over the body in the domesticates (cows, goats, dogs, guinea pigs). This is never observed in wild animals, whose coat is of a uniform color (as in the ancestors of the above listed domesticates) or striped, or spotted in a regular patterns. Uniform gray is a genetically very complex coat color, with underlying mechanisms to distribute various color pigments regularly along the hair shaft. Moreover, uncontrolled accumulation of mutations frequently impairs the mechanism of pigment formation and the resulting coat becomes white.

To date, 35 coat color mutations have been recorded in mink. The entire preceding history of mink as a species has never witnessed such a diversity in the wild. In the American mink, which has been domesticated for a hundred

years, coat color mutations affected physiological features, vital functions, and brain biochemical properties so strongly that fur farms alone could ensure their evolutionary success (Voitenko & Trapezov, 2001).

Diversity of coat color could only be manifested in mink and foxes bred in captivity and maintained in favorable conditions. Mutations in coat color frequently decrease viability, but in man-made conditions they are quite compatible with life, moreover they were perpetuated and became the hallmark features of good breeding. No such diversity occurs in the wild fur animals in America, Europe, even Siberia. An original coat color pattern may be encountered in the wild, but its fixation demands artificially created favorable conditions.

The deaf white mink, and the platinum and white foxes carrying the lethal and semilethal gene, require the developments of specific breeding programmes in order to thrive.

Because of the lethal factors linked to different color phases, some combinations of these are lethal. Pups with these genotypes are born, but most of them die before adolescence. However, special breeding methods permit them to survive without any problems in captivity.

Domestication gives rise to the same coat color specificities in various species repeatedly involved in domestication

Figure 1. Domestication and homologous changes in coat color.

In conformance with the law of homologous series in hereditary variation (Vavilov, 1922), a coat color variability arose in fur animals subjected to domestication similar to the one observed in the traditionally domesticated animals: dogs, cats, rabbits, cattle, horses; even fowl. There exists a remarkable parallelism in coat colors, such as white spotting (or piebaldness), which is complete depigmentation (whiteness) in particular areas of the coat (Figure 1).

Selection for behavioral responses, i.e., selection for a particular functional state of the neurochemical mechanism, will cause corresponding changes in the regulation of the genetic processes under domestication. This might have contributed to the domestication of wild fur animals, while their behavioral reorganization might have been a product of the same genetic changes caused by selection targeted at domestication (Belyaev, 1969; Belyaev & Trut, 1981). This unconscious selection for domestication unidirectionally modifies in all animals subject to domestication the neurochemical mechanisms of the developmental regulatory systems, which in turn produce the same or phenotypically similar correlated responses in coat color. In other words, those same coat color features, which man revealed and historically fixed in the earlier domestic species (dogs, cats, cows, horses, cattle, fowl), manifested in fur animals subjected to domestication for a hundred years.

The results of many years of research conducted at the Institute of Cytology and Genetics (Novosibirsk, Russia) showed that mink behavior can be modified from wild to domestic provided that the experimental (starting) population includes individuals that are more docile, tameable, and amenable to domestication than others. One important piece of evidence for the capacity of wild mink to become domesticated was the inherited reorganization of behavior through breeding in captivity, or the

reorganization from nondomestic behaviour to domestic. Observations from the experimental fur farm of this institute supports the hypothesis that domestic or nondomestic behavior has a genetic basis (Belyaev, 1969; Belyaev & Trut, 1981).

Study of the domestication mechanisms contribute to a better understanding of coat color formation in fur animals, and accordingly facilitates the search for their control. In principle, variants of coat color can be derived from previously known mutations by taking advantage of domestic behavior.

How?

Let's proceed from the development of specific estimates of defensive reaction towards man in mink, using the "hand catch test". Three types of mink will be distinguished: aggressive, fear with avoidance of contact, and tame. The expression of both aggressive and domesticated reactions varied qualitatively, enabling these characteristics to be scored (Table 1).

The founding stocks selected for domestic and aggressive behavior was a population of farmed mink, 10,000 individuals in size.

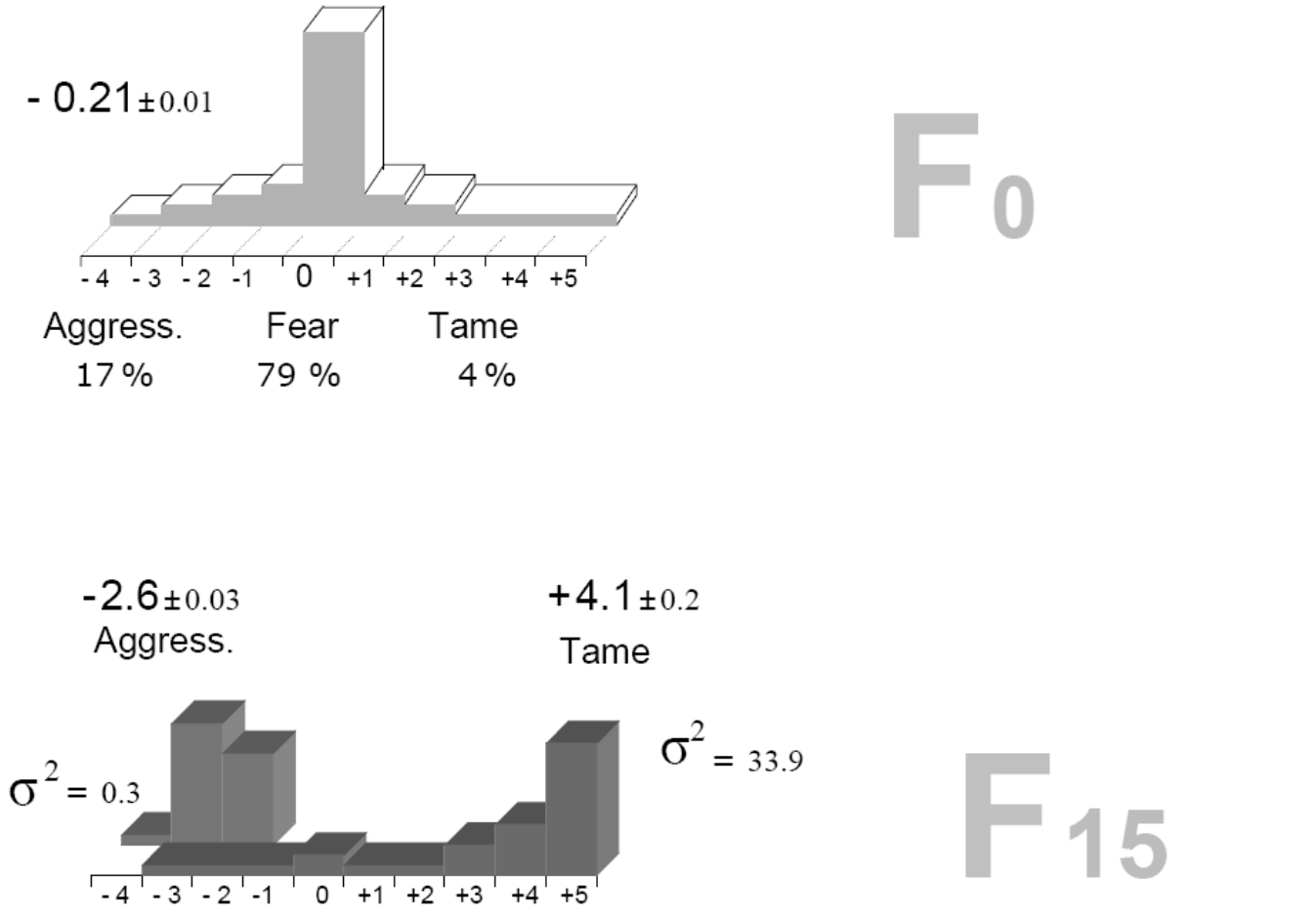
Selection-induced modification of defensive reaction towards humans

Two lines of standard mink were developed through behavior-targeted selection for 15 generations: one showing domesticated or tame reaction towards humans, the other,

Table 1. Scoring of behavioural responses to the hand-catch test.

Type of behaviour	Score	Mink's response.
Aggressive behaviour	-4	**Attack in response to human approach**. The mink vehemently responded to human presence about the cage, gnawing its bars, even before the cage is opened.
	-3	**Active attack outside shelter**. The mink instead of hiding promptly attacked the hand.
	-2	**Attack from the nest-box**. The mink jumped to the entrance of the nest box, hid in it to attack the gloved hand, bit it with considerable intensity.
	-1	**Fearful**. The mink retreated, hid in its nest box, gaping and baring its teeth, cried shrilly or hissed, its posture showed intense emotional stress.
Avoidance of contact	0	**Avoidance of contact.** The mink turned aside (slowly or rapidly) from a gloved hand.
Domesticated behaviour	+1	**Exploratory responses**. The mink calmly responded to the stretched hand, showed the exploratory response, sniffing the hand with quivering vibrassae.
	+2	**Calm response to contact**. The mink displays exploratory reactions when observer brings the tips of his fingers into physical contact with snout and throat.
	+3	**Active contact**. Before the cage is opened, the mink excitedly ran around, tried to thrust its face out of the bar to reach the approaching hand, infrequently "cooing". When the cage was opened, the mink got up, leaning against the open door, reached out for the gloved hand. Inside the cage, it actively sniffed about the gloved hand, and not infrequently leaned on it. When attempts were made to touch any part of its body, the mink dodged and freed itself.
	+4	**Allowed touch**. Mink was actively exploratory, played with the hand, but resisted attempts to handle it.
	+5	**Allowed handling**. These mink were unique among the farm population. They showed extreme domestic behavior, allowed handling without displaying fear or aggression

Figure. 2. The creation of two groups of cage breeding mink with aggressive and tame defensive behavior towards humans.

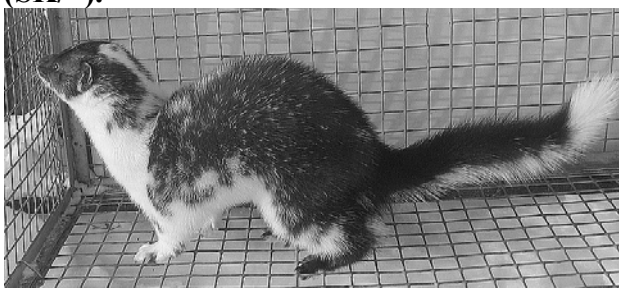


aggression (Figure 2). Interesting relationships between selection direction and variability in behavior were revealed in the course of selection for domestic and non-domestic behavior. Phenotypic behavior variability in selection for domestication is several times greater than that in selection for aggressiveness.

New technological possibilities.

Study of the domestication mechanisms contributes to a better understanding of coat color formation in fur animals and accordingly facilitates the search for their control. Taking advantage of domestic behavior, new, in principle, variants of coat color can be derived from the previously well known mutations. The Karelian dark brown mink will be provided as an example.

Figure 3. The Karelian dark brown mink (SK/+).

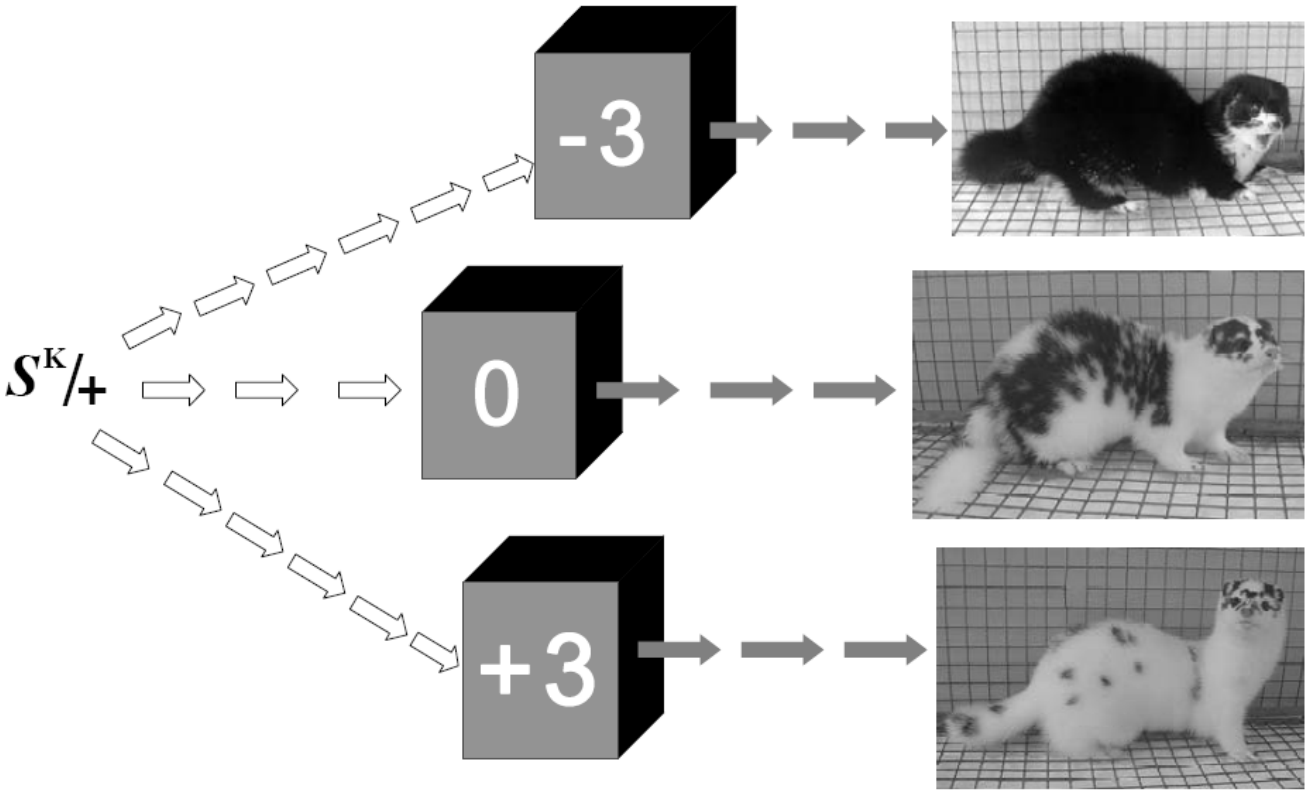


According to the classical description, the belly of the Karelian dark brown mink (SK/+) is

white, the back is all dark brown, and the forehead is dark brown with white spots. The sides are dark brown turning gradually to white. Gray hairs occur in the midst of pigmented (colored) areas (Iljina & Kuznetsov, 1983) (Figure 3).

Crosses between Standard dark brown females (+/+) showing different behavior and males of the Karelian dark brown mink (SK/+) yielded male and female offspring of entirely different coat colors (Figure 4).In the figure below, the mating scheme is given and also the outward appearance of the offspring of Karelian dark brown males (SK/+) mated with Standard dark brown females (+/+), showing aggressive (-3), fear (0) and domestic (+3) defensive reaction towards humans.

Figure 4. Genetic-behavioral principle of a new coat color formation in Karelian dark brown mink (SK/+).



1. When aggressive females (+/+) that show aggressive behavior (–3) are the sexual partner of Karelian dark brown males (SK/+), offspring fur of Karelian dark brown (SK/+) is extensively colored and spreads continuously over the back.

2. When females (+/+) that show fearful behavior (0) are the sexual partners of Karelian dark brown males (SK/+), kits among Karelian dark brown (SK/+)offspring are spotted.

Furthermore:

3. Standard dark brown females (+/+) that show tame behavior (+3) are used as sexual partners of Karelian dark brown males (SK/+). As Figure 4 shows, the higher is the score for domestic behavior, the more unusual (in comparison to the classical description) is the spotting pattern in offspring of Karelian dark brown (SK/+) mink.

Conclusions

What are the characteristic changes in the fur animals subjected to domestication?

1. We have already demonstrated that their behaviour changes in the first place, namely their response to humans. An important feature of the domestication of fur animals is change in the coat color of the wild type. In the wild, the viability of most mutations is low and they cannot spread in populations. In contrast, in the domesticates raised and bred under human protection many mutants do not only survive, they are even intentionally propagated to achieve an increase in numbers and to preserve the variant characters. This is never observed in the wild animals whose coat is of a uniform color (like in the ancestors of the above listed domesticates). To date, 35 coat color mutations have been recorded in mink. The entire preceding history of mink as a species has never witnessed such a diversity in the wild. 2. Domestication gives rise to the same coat color specificities in various species repeatedly involved in domestication. In conformance with the law of homologous series in hereditary variation, a coat color variability arose in fur animals subjected to domestication similar to the one observed in the traditionally domesticated animals: dogs, cats, rabbits, cattle, horses; even fowl.

3. Taking advantage of domestic behavior, in principle, new variants of coat color can be derived from the previously well known fur color mutations.

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II-9 P

Sequencing and nucleotide variation analysis of the mink leptin gene

I. Arju and A. Farid
Department of Plant and Animal Sciences, Nova Scotia Agricultural College, Truro, Nova Scotia, Canada
E-mail address: hfarid@nsac.ca

Introduction

Leptin is a peptide hormone which is mainly secreted by white adipose tissue and plays important roles in the regulation of appetite and energy balance. Leptin signals nutritional status to the central reproductive axis, which is particularly important in mink where hormonal control of reproduction is tightly linked with body fat reserve and availability of food. Sequence variations in the leptin gene have been associated with carcass composition, milk production and fertility traits in different mammalian species. The leptin gene is thus a valuable candidate for investigation as a molecular marker for fertility traits in the mink. The objectives of this study were to sequence the leptin gene in the mink and to identify nucleotide polymorphisms.

Materials and Methods

Sequences of the cat and the dog leptin gene were used to design primers for the amplification of this gene in the mink by the polymerase chain reaction (PCR). PCR products from two unrelated mink from each of black, brown, pastel, sapphire, and mink trapped in the wild were bi-directionally sequenced to detect nucleotide variations.

Results and Discussion

A 4738 bp segment of the mink leptin gene, consisting of the coding segment of exon 2 (144 bp), intron 2 (1867 bp) and exon 3 (2727 bp) was determined and submitted to GenBank (accession number EU755352). The 3'-UTR contained two mRNA destabilizing motifs (ATTTA). Comparison of the 504 bp coding sequence (CDS) of the mink leptin gene with those of 24 mammalian species whose complete CDS were available in GenBank revealed 93% (giant panda, dog, cat) to 74% (grey short-tailed opossum) nucleotide identity, and 96% (giant panda) to 70% (short-tailed opossum) amino acid identity.

Six single nucleotide polymorphisms (SNP), three polymorphic mono-nucleotide repeats and an 11 bp deletion/insertion were detected in intron 2, and 11 SNPs were revealed in the 3'-UTR of the gene. Fourteen of the SNPs were transitional mutations, consisting of nine pyrimidine to pyrimidine (C-T) and five purine to purine (G-A) substitutions. The SNPs in the 3'-UTR, which is rather long in the leptin gene (2367 bp), might influence mRNA stability and modify translation of the gene by creating or destroying microRNA target sites.

II-10 P

Molecular characterization of the Himalayan mink

Bernhard F Benkel[1], Kirsti Rouvinen-Watt[1], Razvan Anistoroaei[2], A Hossain Farid[1]
[1]Nova Scotia Agricultural College, Dept. of Plant and Animal Sciences, P.O. Box 550, Truro, NS, B2N 5E3, Canada
E-mail address: bbenkel@nsac.ca
[2]University of Copenhagen, Dept. of Animal and Veterinary Basic Sciences, Division of Animal Genetics and Bioinformatics, Gronnegaardsvej 3, 1870 Frederiksberg C, Denmark

Introduction

A rare color variant discovered on a mink ranch in Nova Scotia and referred to as the 'marbled' variety, carries a distinctive pigment distribution pattern resembling that found in some other species, e.g. the Siamese cat and the Himalayan mouse. We tested the hypothesis that the color pattern in question – mainly light coloration on the trunk with darker patches at the extremities – results from a temperature-sensitive pigment producing enzyme known as tyrosinase.

Materials and Methods

The bulk of the coding region for the tyrosinase gene of the 'marbled' mink was amplified by PCR and sequenced using a series of primer pairs adapted from work previous performed on the cat (Schmidt-Küntzel et al., 2005) and ferret (Blaszczyk et al., 2007) tyrosinase genes and used recently for the characterization of the albino mutation in the mink (Anistoroaei et al., in press).

Results and Discussion

The 'marbled' mink carries an amino acid substitution at a crucial histidine residue in exon 4 of the tyrosinase gene. The location of this substitution, H420Q, corresponds to the identical amino acid position that is also mutated in the tyrosinase gene of the Himalayan mouse, H420R (Kwon et al, 1989). Thus the 'marbled' mink is, in fact, the mink version of the Himalayan mouse.

The identification of the mutation underlying the Himalayan color variant is another step in understanding coat color variation in the mink. At the same time, it and the other temperature-sensitive variants may also help to shed some light on the relationship between structure and function in tyrosinase enzymes in particular, and in proteins in general.

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II-11 P

Modelling genetic effects of feed conversion ratio in group housed mink

Peer Berg and Bente Krogh Hansen
Department of Genetics and Biotechnology, Faculty of Agricultural Sciences, Aarhus University, DK-8830 Tjele, Denmark.
E-mail address: Peer.Berg@agrsci.dk

Introduction

Feed constitutes the largest cost in fur animal production. Mink production is based on a large cost in terms of feed, using up to 40kg of feed per pelt produced (Kopenhagen Fur 2005). Compared to other livestock species, the feed consumption is very large relative to the size of the animal at pelting. This is caused by the need to keep fur animals not only until a fixed body weight but until the winter pelt is matured. The potential for improving feed conversion (Feed consumption/Body weight gain) or feed efficiency (Body weight gain / Feed consumption) is large. However, fur animals are generally raised in groups of two or more. Thus feed consumption is only known per cage whereas body weight gain can be measured on individual animals.

The objective is to present strategies for estimating breeding values for feed conversion or feed efficiency in terms of both recordings needed and statistical models when feed consumption is measured per cage and body weight gain is measured individually.

Recording strategy

A simple strategy could be to place full- or half-sibs in one or several cages, and use data on feed conversion or feed efficiency per cage to predict breeding values of parents (progeny test). A drawback of this strategy is that individual breeding values are not calculated.

Another strategy could be to record feed consumption per cage and measure individual body weight gain on all cages, and use statistical models to predict breeding values for individual animals. The possibilities of using this strategy are described in more detail in the next section.

Models

Both feed conversion and feed efficiency of a cage can be written as a weighted average of feed conversion or feed efficiency of animals in the cage:

$$FC_{cage} = \sum_{i=1}^{n} \frac{WG_i}{WG_{cage}} \cdot FC_i$$

and

$$FE_{cage} = \sum_{i=1}^{n} \frac{FCO_i}{FCO_{cage}} \cdot FE_i$$

With n animals in a cage having feed consumption (FCO) and weight gain (WG). Subscript *cage* refers to the sum of all animals in a cage and i refers to individual animals. Feed efficiency is a weighted average of feed efficiency of animals in the cage where weights depend on their relative feed consumption. But the relative feed consumption is not known and thus this decomposition is not useful. In contrast, for feed conversion the weight is the relative weight gain of individuals and this is known.

Similarly feed consumption can be decomposed in terms of feed conversion as:

$$FCO_{cage} = \sum_{i=1}^{n} WG_i \cdot FC_i$$

Thus random regression models can be used to predict breeding values from models having the

above decompositions as fixed regressions to account for the average relationship and similarly as random regressions accounting for genetic relationships between animals to predict breeding values.

Conclusion

Either simple designs based on testing progeny groups and/or random regression models based on a decomposition of feed conversion or feed consumption can be used to predict breeding values for feed conversion but not feed efficiency.

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II-12 P

Optimal contribution selection in mink breeding schemes

Peer Berg
Department of Genetics and Biotechnology, Faculty of Agricultural Sciences, Aarhus University, DK-8830 Tjele, Denmark.
E-mail address: Peer.Berg@agrsci.dk

Introduction

Inbreeding might be a concern in finite populations under selection, as selection reduces the effective population size. Inbreeding causes inbreeding depression (Berg 1996) and a loss of genetic variation, possibly reducing future genetic progress. One way to mitigate this effect is to optimise the genetic contributions of breeding animals by selecting for maximal genetic gain given a constraint on rate of inbreeding (e.g. Meuwissen 1997; Grundy et al. 2000). Alternatively, one can select on a linear function of genetic gain and rate of inbreeding, where the rate of inbreeding is penalised by a cost factor (Berg et al. 2006). The objective of this study is to quantify the advantage of using optimal contribution selection in mink breeding.

Materials and Methods

Effects of implementing optimal contribution selection in mink breeding schemes were studied by stochastic simulation using the simulation software ADAM (ADAM 2008). Traits considered were litter size and body weight, and BLUP of breeding values was obtained from individual animal models. Optimal contribution selection was based on the method described by Grundy et al. (2000) implemented using an evolutionary algorithm (Berg et al., 2006). A set of weights (cost factors) on long-term inbreeding were considered in order to describe effects of alternative strategies. For comparison a breeding scheme based on truncation selection was simulated.

Results and Discussion

Optimal contribution selection is computationally time consuming. Computational costs can be reduced by pre-selecting animals within litters, without any effect on long-term genetic progress.

Results show that genetic response can be increased at a fixed rate of inbreeding by optimal contribution selection. Alternatively rates of inbreeding can be reduced at a fixed genetic gain using optimal contribution selection compared to truncation selection.

Conclusion

Optimal contribution selection can be implemented to either increase genetic gain at a given rate of inbreeding or reduce rate of inbreeding at a given response to selection.

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II-13 P

Genetic variability of the interleukin-6 gene in captive and wild mink

J. Donkor and A. Farid
Department of Plant and Animal Sciences, Nova Scotia Agricultural College, Truro, Nova Scotia, B2N 5E3, Canada
E-mail address: hfarid@nsac.ca

Introduction

Interleukin-6 (*il-6*) is an immunoregulatory cytokine with a wide variety of biological functions including stimulation of the acute phase response to infection and injury. Expression of the *il-6* gene is highly inducible in many cell types in response to a number of inflammatory stimuli, such as bacterial products, viral infection and stress. The objectives of this study were to sequence the *il-6* gene in the mink and identify polymorphisms which can be used to evaluate the potential role of this gene in the immune system response to infections.

Materials and Methods

A 4678 bp portion of the mink *il6* gene, consisting of the promoter region, five exons and four introns, was sequenced and submitted to GenBank (accession number EF620932). Four unrelated mink from each of black, brown, pastel, sapphire and mink that were trapped in the wild were bi-directionally sequenced for mutation detection. Another 82 animals from the five color types were also genotyped using RFLP-PCR, bringing the total number to 20 or 21 mink in each color type.

Results and Discussion

The 349 bp promoter region of the gene, which is highly conserved among several mammalian species, contained a TATA box, a CAAT box, and binding sites for the nuclear factor kappa (NF-kB), Sp/KLF, SRY/SOX, a CCAAT enhancer-binding protein (C/EBP), a cyclic-AMP response element (CRE) and an activator protein-1 (AP-1)/NF-E2 element. These elements presumably enable the promoter to act as a multifunctional sensor which responds to a wide range of environmental stimuli that control the immune and inflammatory responses. The 418 bp 3'-UTR of the gene contained seven mRNA destabilizing motifs (ATTTA) and the poly-A signal (AATAAA).

One exonic and seven intronic single nucleotide polymorphisms (SNPs) were detected by comparing the sequences of the 20 mink. Only two intronic SNPs were segregating at high frequencies, indicating that the level of nucleotide substitution in the mink *il-6* gene was low. Allele frequency distributions of the SNPs in the 20 or 21 mink in each color type showed no evidence of association with adaptation to captivity (wild *vs* captive) or immune competency (sapphire *vs* others).

A tetranucleotide repeat with $(TAAA)_5$ and $(TAAA)_6$ alleles was detected in the promoter region. The frequency of $(TAAA)_6$ allele was 0.0, 0.17, 0.25, 0.25 and 0.40 in the wild, black, pastel, brown and sapphire mink, respectively. This repeat was located five nucleotides downstream of the AP-1/NF-E2 transcription factor binding sites. The location of this variant and its allele frequency distributions in wild and captive mink suggest that $(TAAA)_6$ allele may have some selective advantage under farm conditions, possibly through the known effects of stress hormones on cytokine expression or the higher level of pathogen load on the ranch compared with that in the wild. Alternatively, the allele frequency difference could reflect differences in the origin of wild and captive mink that were used in this work.

A polymorphic $(CA)_n$, where n varied between 8 and 20 repeats, with 10 alleles was detected in intron 2. There were 4 alleles in black and 6 alleles in other color types, suggesting that despite many years of intense selection for adaptation to captivity and fur quality traits, the genetic variability of brown, pastel and sapphire was comparable with that in the wild mink, and that of black mink was only slightly lower. The SNPs and polymorphic microsatellites that were identified in this study provide the means of evaluating the *il-6* gene as a candidate for the immune response of mink to infection by various pathogens.

II-14 P

Genetic parameters of resistance of black mink to Aleutian mink disease virus infection

A. Farid[1], J. Fatehi[2] and D.G. Bishop[3]
1-Department of Plant and Animal Sciences, Nova Scotia Agricultural College, Truro, Nova Scotia, Canada
2-Centre for Genetic Improvement of Livestock, University of Guelph, Guelph, Ontario, Canada
3-Department of Engineering, Nova Scotia Agricultural College, Truro, Nova Scotia, Canada
E-mail address: hfarid@nsac.ca

Introduction

Aleutian disease is an important health issue for the mink industry worldwide. Currently, regular testing of mink for antibody against the Aleutian mink disease virus (ADV) by counter-immune electrophoresis (CIEP) and elimination of infected animals is the accepted control measure. Although this strategy has been effective in controlling the infection, it has not eliminated the virus from all mink producing countries. Development of the disease and severity of the diseases symptoms depend on the mink genetics, the strain of ADV and environmental factors. Differences among and within mink color types for response to infection by ADV has been reported, but the extent of genetic control of response to infection is not quite clear. The objective of this study was to estimate heritability of resistance to ADV infection in black mink under ranch conditions.

Materials and Methods

The experiment was conducted on an ADV-infected ranch in Nova Scotia, where the CIEP test has been used as a selection tool since the virus was detected on the ranch in 2001. A group of 100 yearling black females and 30 males that were CIEP negative in November 2005 were tested again in February 2006 (before breeding). One of the males was CIEP-positive and was used for breeding, but eight females that were seropositive in February were eliminated to prevent transplacental transmission of the virus. Two females died before breeding, and the remaining 90 females were bred with the 30 males in a single-sire mating scheme. Breeding females were CIEP tested in July, October and November, and kits were tested in August and November, 2006. Spleen samples were taken from dead kits after the August test, and the presence of ADV was tested by polymerase chain reaction (PCR). Data were analyzed using a multiple-trait animal model that included the CIEP test results of parents and kits, the fixed effects of sex and age at the time of testing (month), the animal's additive genetic effect (random) and the random error using the VCE5 software (Kovač and Groeneveld 2002).

Results and Discussion

The proportion of seropositive breeding females was 2.2%, 3.3% and 4.2% in July, October and November tests, respectively, and the proportions of CIEP-positive kits were 3.8% (n=416) in August and 20.9% (n=411) in November. Nine of the 11 kits that died between August and November were tested positive by PCR. These results suggest that while infection increased the chance of death in kits, the spread of ADV among adults was limited with no apparent adverse effect on their survival rate.

There were significant differences among sires for the percentage of progeny that became CIEP positive by August and November. In August, the 16 seropositive kits were the progeny of five sires. In November, the 86 seropositive kits were the progeny of 20 sires. None of the 116

progeny of nine sires that mated with 24 females were seropositive by November, while all the 8 progeny of the two females that mated with the CIEP-positive male became positive. Since the two dams that bred with the seropositive sire remained seronegative, it may be hypothesized that either ADV was transmitted by sperm or the male transmitted susceptible genes to its progeny. Estimates of heritability were 0.570± 0.044 and 0.492 ± 0.049 for the August and November tests, respectively, and the genetic correlation between the two measurements was 0.742± 0.051. The results suggest that resistance to ADV infection has a strong genetic component and thus the establishment of resistant lines of mink by genetic selection should be possible.

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II-14b P

Heterosis in mink

Bente Krogh Hansen[1)], Peer Berg[1)] & Peter Foged Larsen[2)]
[1)] Department of Genetics and Biotechnology, Faculty of Agricultural Sciences, Aarhus University, DK-8830 Tjele, Denmark.
E-mail address: BenteK.Hansen@agrsci.dk
[2)] The National Centre, Fur Animals, DK-8200 Århus N.

Introduction

The term heterosis, also known as hybrid vigor or outbreeding enhancement, describes the increased performance of crossbreds deviating from the parental average for a given trait (Nicholas, 1988). The greater the genetic diversity between two purebred populations; the greater the heterosis in hybrids between them (Nicholas, 1988). Heterosis occurs only if there is a non-additive gene action (e.g. dominance) for the character concerned (Nicolas, 1988; Falconer & Mackay, 1997). Heterosis is greatest in characteristics associated with the ability to survive or to reproduce.

In mink production, combination effects are often seen when animals of different colour types are crossed. In the context of reproduction and viability of mink kits, Lagerkvist & Lundeheim (1993) and Nielsen (2008) have reported increased litter size in the first generation of hybrid females.

The aim of this project was to confirm that heterosis exists for fertility and survival traits in mink by estimating the percentage of heterosis in alternative crosses, and to document that systematic crossbreeding, utilising heterosis, can be a valuable tool in mink production.

Materials and Methods

The effects of crossbreeding were studied on two farms in 2007 and 2008. On the research farm, 2065 litters were studied, while on a commercial farm 3400 litters were examined. On the research farm, the following traits were recorded for each individual animal: litter size at birth and at 2-3 weeks, kit survival, body weight, weight gain, pelt characteristics, feed conversion and temperament. The colour types used were wild/standard brown, standard black and palomino. On the commercial farm measurements included litter size and survival of kits as mean values of pure and crossbred lines. Colour types were regal white, standard brown and mahogany. Two-way crosses, three-way crosses and back crosses were performed to document heterosis and complementary effects.

Results

In the first crossbred generation we found no difference in body weight at grading between pure lines and the crossbred line.

However heterosis was found in litter size and percent kits alive in the litter. Preliminary analysis shows that heterosis results in 0.5 more kits per litter and 4 to 10% more kits alive in the litter.

Maternal heterosis was found for litter size, while both maternal and individual heterosis was found for percent kits alive in a litter.

Conclusion

Litter size and survival of kits in the suckling period can be increased by using crossbreeding.

Acknowledgements

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II-15 P

Profile of chromosome X in chinchilla (*Chinchilla laniger)* karyotype

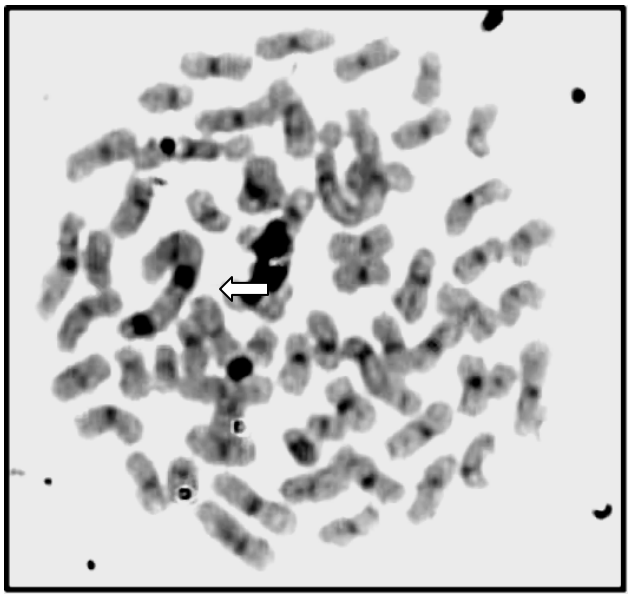
Marta Kuchta[1], Olga Szeleszczuk[1], Beata Łysek[2]
[1]University of Agriculture, Department of Anatomy and Animal Reproduction, al. Mickiewicza 24/28, 30-059 Krakow, Poland
[2]University Children's Hospital of Cracow, 265 Wielicka Street, 30-663 Krakow, Poland
E-mail address: rzszeles@cyf-kr.edu.pl

Introduction

Previous cytogenetics investigations conducted on chinchilla established the diploid chromosome number as 2n=62 [Hong et al., 1982]. Sex chromosome X was described as a metacentric with a p to q ratio of 44.5% and a relative length of 8.7 µm. Since the fifties, when the diploid number of human chromosomes was established, there have been dynamic developments in cytogenetics investigations and related investigative techniques. For chromosome identification of different animal species, banding techniques are now routinely used on a broad scale [Danielak, 1992].

The aim of this paper was the application of banding techniques GTG and CBG to the analysis of sex chromosome X structure in chinchilla standard.

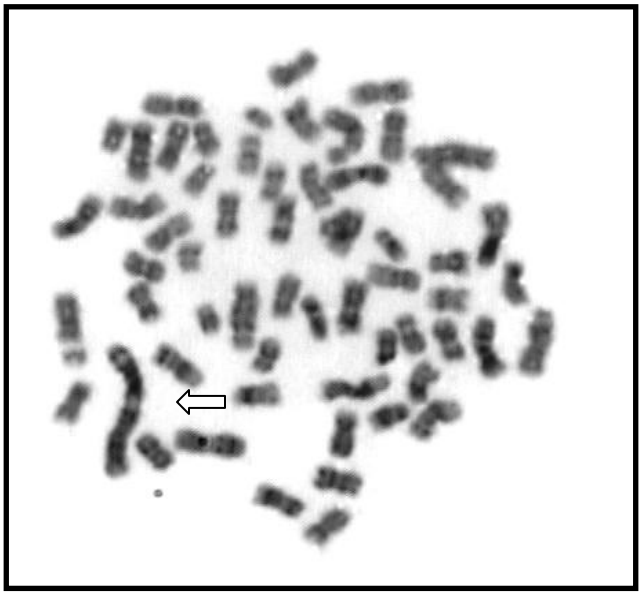
Photo 1. Metaphase plate of chinchilla (*Chinchilla laniger*) male 2n=64 stained using CBG



Materials and Methods

The investigations were conducted on bone marrow cells from 5 females and 5 males of chinchilla standard [Nomura et al., 1984]. Prepared chromosome slides were stained using the G bending technique [Wang & Fedoroff, 1972] as well as the C banding method [Summer, 1972]. Chromosome X was analyzed using the computer software Multiscan Base and Microsoft Office Excel 2003. Using the students t-test, comparison of means in males and females population was performed.

Photo 2. Metaphase plate of chinchilla (*Chinchilla laniger*) male 2n=64 stained using GTG



Results and Discussion

The analyses showed that in all 10 individuals tested, sex chromosome X is metacentric and is the largest of the chromosome set [Photo 1]. The characteristic trait of the G banding pattern

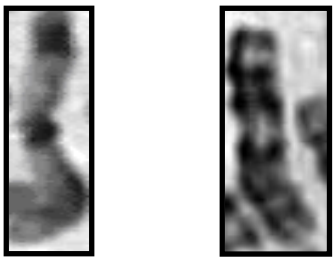
Table 1. Profile of sex chromosome X

Animals	Length of arm [µm]		p + q [µm]	p : q [%]
	p	q		
Female	3,324	3,312	6,62	50,11
Male	3,337	3,131	6,63	50,4
Mean	3,331	3,222	6,63	50,26

on the p arm of chromosome X is a positive telomere band and set of a few positive bands, whereas the q arm shows a wide centromere band divided into 3 positive bands [Photo 2].

All individuals had a clear and broad C band in the centromere region (centromere hetero-chromatin) and a clear telomere band [Photo 3]. In the majority of animals, heterochromatin is present only in the centromere region [Danielak, 1992; Kozubska-Sobocińska et al., 2006; Onderka et al., 2003].

Photo 3. Chromosome X



CBG **GTG**

There were no significant statistical differences between the arm measurement results of males and females (Table 1). Conversely, Hong et al. (2006) published that the p:q ratio was equal to 44.5%, and the length of the chromosome was 8.7 µm. This discrepancy in results could be the result of a difference in degree of spirality of the chromosomes, which is usually different for each metaphase slide.

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II-16 P

Effect of crossing wild type and standard black mink on litter size

V.H. Nielsen
Department of Genetics and Biotechnology, Faculty of Agricultural Sciences, Aarhus University, DK-8830 Tjele, Denmark.
E-mail address: vivih.nielsen@agrsci.dk

Introduction

The coat color of the standard black mink is attractive but reproduction in the black mink is inferior compared with reproduction in the brown color type. The present study examines the possibility of establishing a line of mink with reproduction performance similar to that of brown mink and a coat color as in standard black mink.

Materials and Methods

Animals: The design of the experiment is shown in Figure 1. Reciprocal mating of brown and black mink was performed in 1998. In 1999, mating was carried out within each of the lines 54 and 55. In 2000, these two lines were crossed. In the following years, mating performed within line 56. Selection in the lines was based on an index with the following weighing: 10% litter size, 20% quality, 20% clarity, 20% color, 25% weight, 5% against fur chewing.

Model: Litter size was analyzed using a model including line effect. Color was analyzed using a model with effect of line, sex and interaction between line and sex.

Results and Discussion

Litter size at first counting is significantly larger in the brown than in the black line – 6.2 in the brown line versus 4.2 in the black line. In 1998, the results indicated that larger litter size is obtained when the brown line is used as the maternal line. Heterosis due to non-maternal effects was estimated to be 0.2 kits per litter in the F_1–generation in 1998. In the F_2–generation in 1999, heterosis was 1.0 kit per litter. This heterosis is ascribed to a maternal effect plus half the heterosis in the F_1–generation. Heterosis is the counterpart of inbreeding (Falconer, 1989). Inbreeding in the founder lines – presumably primarily in the black line - thus most likely explains these results.

In 1998 heterosis for coat color was estimated to 0.3 unit. It was expected to be halved in the F_2–generation compared to the F_1–generation. However, in 1998 heterosis was estimated to be 0.4 unit. Interpretation of this result needs to consider the selection performed and that evaluation of fur quality is made within lines and years.

Conclusion

Crossing of wild type and standard black mink resulted in improved litter size compared to the black line, ascribed to inbreeding in the black mink and selection for litter size. The recording method for fur quality traits did not allow interpretation of the development of these traits.

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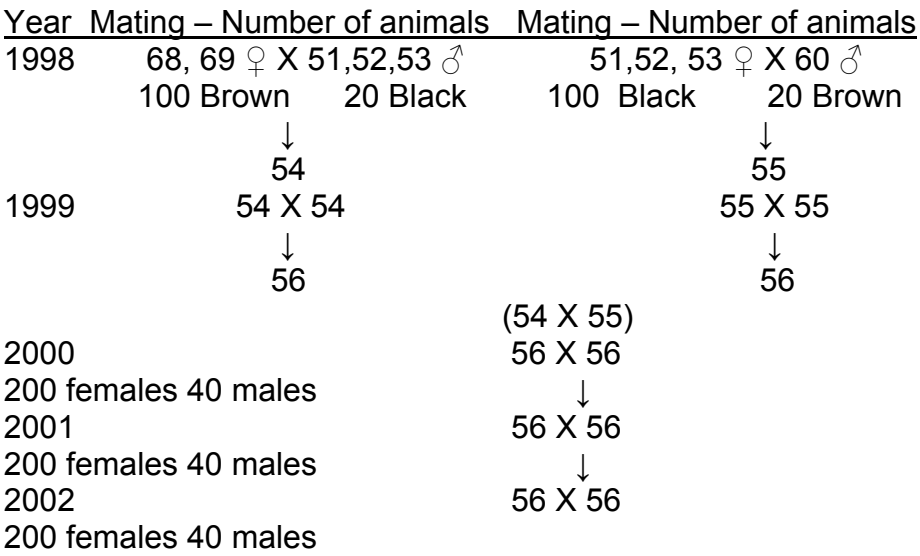
Figure 1. Reciprocal crossing of brown wild mink and Scanblack mink.



II-17 P

Total merit index as a selection criterion in the Polish blue fox farming

Heliodor Wierzbicki
Department of Genetics and Animal Breeding, University of Environmental and Life Sciences, Kozuchowska 7, 51-631 Wroclaw, Poland
E-mail address: heliodor.wierzbicki@up.wroc.pl

Introduction

Breeding schemes for the blue fox production mainly concentrate on pelt size, fur quality and reproductive performance. Pelt size has gained great economic importance since increasing pelt length has a strong positive effect on price (Filistowicz et al., 1999; Hansen & Berg, 2004; Wierzbicki, 2005). In the last 15 years, Polish fur breeders have put a lot effort into genetic improvement of this trait. Also in Finland, pelt size has been given priority in breeding programs (Peura et al., 2004). The second trait which is found among characters of great economic importance is litter size. According to Lagerqvist (1997), increased litter size substantially reduces production costs. However, the tremendous improvement in pelt size has been accompanied by deteriorated reproductive performance. It appears that pelt size is negatively correlated with litter size (Lagerkvist et al., 1994; Peura et al., 2004). Much attention is also paid to fur quality traits which are taken into account when selecting animals.

The overall efficiency of production is affected by traits included in the breeding objective. The traits combined into the aggregate genotype should be selected basing on the relative contribution of each trait to the overall efficiency of production (Goddard, 1998). An aggregate genotype to be improved, which is a function of additive genetic values of traits weighted by their economic values, is usually called the Total Merit Index (TMI).

Polish blue foxes are selected based on scores obtained during the grading of their phenotypes. In this type of selection the total score is the main criterion (expresses the value of aggregate genotype). Economic values of the traits included in the aggregate genotype are not taken into account when calculating the total score.

Materials and Methods

In order to replace the current method of breeding value (BV) evaluation by BLUP Animal Model (AM), the "FUTERKA" computer program has been developed. The computer system stores and organizes data collected on farm, which are subsequently used for BV estimation and construction of TMI. Annual inflow of new information on animal productivity and reproductive performance updates the computer data base. This makes the annual re-estimation of BV of breeding animals possible, and increases the accuracy of the BV estimation.

Results and Discussion

The "FUTERKA" computer system estimates BV using data collected on farm during grading (evaluation of conformation and fur coat traits) and evaluation of reproductive performance. Indices are calculated with the use of BLUP AM. After estimation of breeding value, EBVs are used for constructing TMI. The most important information on the estimation of BV of traits included into TMI and their economic weights is given in Table 1.

Table 1. Fixed and random effects in the animal model for estimation of breeding value, heritabilities and relative economic weights (REW) of the traits included into TMI

Trait	Effects included in the animal model					h^2	REW
	fixed			random			
	year x birth season	farm x year x birth season*	female age	additive genetic	common litter environment		
Litter Size	+	+/-	+	+	+	0.205	0.46
Body Size	+	+/-	-	+	+	0.289	0.15
Fur Quality	+	+/-	-	+	+	0.200	0.36
Color Type	+	+/-	-	+	+	0.325	0.03

*can replace year x birth season if BV of animals originating from more than one farm is estimated

TMI constructed for the Polish blue fox farming should become the main criterion used for the selection of breeding animals. This index which takes into account production circumstances (through economic weights) is a reliable tool to change the genetic merit of animals such that they produce more and high quality products under present and future economic circumstances.

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II-18 P

Preliminary analysis of polymorphism in the growth hormone locus in polar foxes (*Alopex lagopus*)

Magdalena Zatoń-Dobrowolska
Wroclaw University of Environmental and Life Sciences, Department of Genetics and Animal Breeding, Kozuchowska 7, 51-631 Wroclaw, Poland,
E-mail address: magdalena.dobrowolska@up.wroc.pl

Introduction

Growth hormone is one of the main factors influencing body size. This hormone plays an important role in prenatal body development and in growth of bones (Dennison et al., 2004, Esteban et al., 2007, Kirpensteijn et al., 2002). In many species growth hormone shows genetic variations associated with important production traits (de Faria et al., 2006, Ge et al., 2003, Pawar et al., 2007). Body size is one of the most important traits in foxes, because it is strongly correlated with pelt size. Categorization of pelts is also based on their length.

The main aim of this study was the application of the canine growth hormone gene sequence to the analysis of this locus in polar fox. The second goal of the study was to find the polymorphisms in this locus which can be used in the future to study associations between the polymorphism and body size as well as other economically important traits.

Materials and Methods

Blood samples of 72 polar foxes were used in this study. DNA was isolated from blood using the GenElute™ Blood Genomic DNA Kit (Sigma®). Primers for PCR were designed based on growth hormone sequence for the dog (GenBank accession U92533). PCR was carried out in a Biometria T-gradient thermocycler. PCR (25 µl final volume) using 12,5 µl REDTaq® ReadyMix™ PCR Reaction Mix, 10 pM of each primer and sterile water. The cycling temperature was as follow: one cycle at 95°C by 5 min; 95°C for 40s, 55°C for 40s; 72°C for 1 min for 40 cycles; followed by 72°C for 10 min. Polymorphisms were detected by RFLP using seven restriction endonucleases: *Alu*I, *Rsa*I, *Pst*I, *Sau3A*I, *BamH*I, *Apa*I and *Stu*I. PCR products (5µl) – were digested in a final volume of 16,5 µl. For all enzymes (except *Apa*I) restriction digests were incubated at 37°C (30°C for *Apa*I) for 3 hours. RFLP products were analyzed by electrophoresis on 2% agarose gel. The DNA sequences of selected samples were determined using a capillary automated sequencer, ABI 3100Avant.

Results and Discussion

For 12 individuals the dog sequence based primers failed to amplify polar fox DNA. For other samples, amplicons of about 530 bp were produced.

Out of seven restriction enzymes used, only two showed differentiation after RFLP: *Alu*I and *Apa*I. For 47 individuals the *Alu*I enzyme cut the PCR product into three different fragments. For 12 individuals the products after RFLP were cut into six fragments. Two of the restriction fragments were of similar size, making interpretation by gel electrophoresis alone difficult: however, sequencing results allows differentiation between the two. The ApaI enzyme showed two fragments as a result of electrophoresis in all but one individual. The anomalous individual showed three fragments visible by electrophoresis. In the future these two enzymes (*Alu*I and *Apa*I) will be used to analyze differentiation in a larger population of

polar fox in order to find possible associations with body size and other important traits.

Acknowledgements
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III: Reproduction

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III– 1 RP

Determination of gestational length in chinchilla (*Chinchilla laniger*) based on the presence of copulation plugs

Agnieszka Semik, Małgorzata Sulik, Lidia Felska-Błaszczyk
Department of Animal Anatomy, Laboratory of Fur Animals, Agricultural University of Szczecin, ul. Doktora Judyma 14, 71-460 Szczecin, Poland
E-mail addres: agnieszka.semik@biot.ar.szczecin.pl

Abstract
The aim of this study was to determine the duration of pregnancy in chinchillas, in both primiparous and multiparous females, considering the duration of gestations resulting from the postpartum oestrus based on a vaginal plug occurring after copulation. In all, 806 plugs were analysed, and the mean gestation length for all the studied females was 110.5 days. The range of gestation length was even wider than that reported in the literature. Gestation lengths in primiparous and multiparous females were similar. A longer duration of pregnancy was found in the females serviced in the postpartum oestrus. It is recommended that the breeders should look for copulation plugs, to more accuratly estimate the right service and expected whelping dates. This should provide better conditions for pregnant females and better reproductive management on the farm.

Introduction
The chinchilla is a mammal belonging to the order of rodents (*Rodentia*), superfamily *Hystricomorpha*, and the family *Chinchillidae*. It originates from the Andes (South America), and at present it is managed in captivity and farmed for beautiful and smooth fur (Gromadzka-Ostrowska, 1998).

When we look at the biology and anatomy of the chinchilla, we should expect that the reproductive potential of this species be much greater that that observed on a farm. In a female chinchilla, about 16 ovarian follicles develop, of which only 4 ovulate during oestrus. Theoretically, we might expect to have 4 kits in a litter. Larger sizes have happened on farms in Poland, some females having 5-6 young (Gromadzka-Ostrowska, 1998). Also Barabasz (2001) states that litter sizes reached 6 or even 7 kits; these however, are sporadic cases. According to this author, the average litter size in Poland at present is 1.6-2.5 young chinchillas. According to Neira et al. (1989), the most frequent litter consists of a single kit (47.2%), less frequently 2 kits (29.7%), 3 kits (7.6%), while litter size of 4 young is the least frequent event (0.6%). Lanszki (1996), however, reports the following distribution of litter sizes: 1 indiv., 26.8%, 2 indiv., 49.5%, 3 indiv., 23.9%, 4 indiv., 2.8% of litters.

As with the discrepancy among the litter sizes, multiple estimates of the gestation length can be found in the literature, which ranges from 105 to 118 days.

Formation of a copulation plug in the reproductive tract of a female, which is excreted from the organism after about 24 hours, is equally interesting and poorly understood phenomenon of chinchilla reproduction. The chinchilla male has highly developed follicular glands, which are most probably responsible for producing the gel substance that blocks the vaginal exit following copulation. Farmers that house chinchillas in cages on the net find the plugs of 15 mm in length and 3 mm in diameter under the cage of the female that has had a male visitor. A plug may mean that a copulation has taken place.

Table 1. Gestation period in chinchillas depending on their reproduction management systems

Females	Mean gestation period (days)	Max. (days)	Min. (days)
Primiparous	110.08	119	106[A]
Multiparous	110.70	120	101[A]
Total	110.50	120	101

A – difference significant at $p < 0.01$.

Chinchillas are managed in a system which allows the male to access a female at any time, which makes determination of gestation length difficult, since the date of the service is unknown. Thus, a plug under the cage may be a useful signal.

The aim of the study was to precisely determine the gestation length in the chinchilla using the copulation plug and to check whether gestation period differs between primiparous and multiparous females.

Materials and Methods

The studies took place on a chinchilla farm in the Zachodniopomorskie Voivodship, Poland, based on data collected in the years 2000, 2001, 2002, 2004, and 2006 (the data, however, do not constitute the complete annual report, since an analysis of each month of a year was not possible). In all, the observations were carried out over at total of 23 months across the years in question. We analysed gestation length, the number of live- and stillborn offspring per litter, with reference to primiparous and multiparous females, and to copulation during the postnatal oestrus. Each day, the female of the breeding stock were inspected and the presence of plugs was duly noted. Finding one was a mark for the onset of gestation.

The mean temperatures and humidities, respectively, were the following for each year:

- 2000: 19.14°C, 43,15%
- 2001: 20.51°C, 50.33%
- 2002: 20.24°C, 66.65%
- 2004: 16.69°C, 40.26%
- 2006: 18.07°C, 48.92%

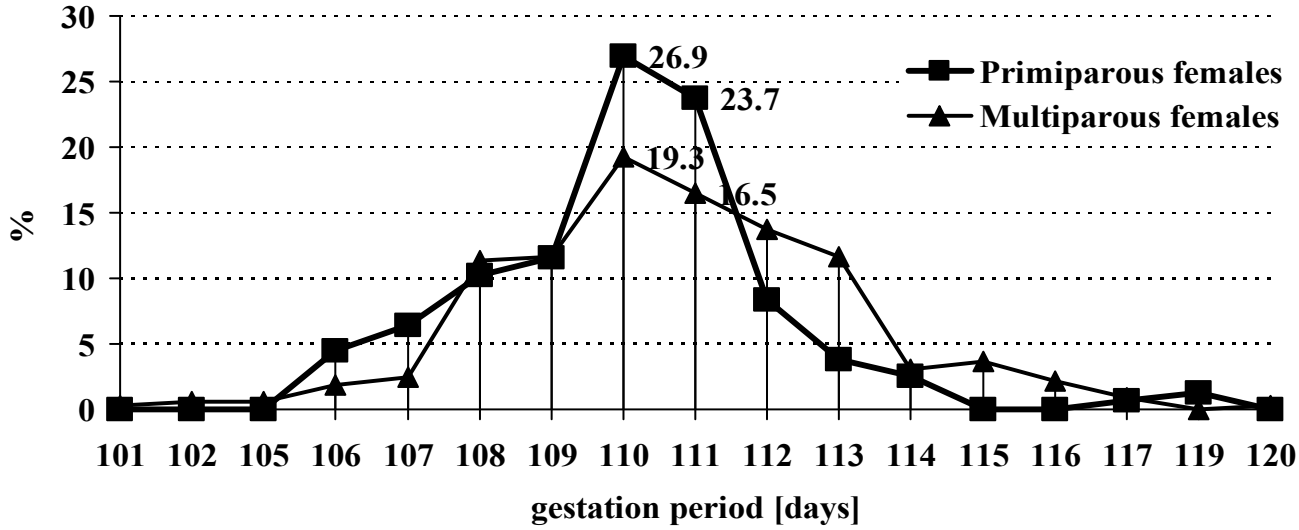
The animals under study remained in a uniform environment, with the photoperiod of 12 hrs of light , and were fed on complete feed pellets, hay, and water ad libitum.

Results and Discussion

Chinchilla farms employ a polygamous, colony breeding system, in which the male has a constant access to a female, moving between the females' cages through access passages, to which females are not allowed due to blocking collars fastened around their necks. This system, however, prevents exact determination of service dates, thus it is difficult to unequivocally state the date of conception. The only sign of copulation is the vaginal plug excreted by the female. Its role in reproduction is not fully understood. The opinion is that the plug prevents the female from copulating with another male. Nevertheless, the plug can be used to estimate the length of gestation, which has been attempted in this study.

The day the plug was found was assumed to be the first day of pregnancy. In all, we have analysed the presence of 806 plugs, of which 483 litters were confirmed, which represented 60.05% of the plugs. The analysis of the data on the reproduction has revealed that the mean gestation period (for primiparous and multiparous chinchillas together), based of the presence of the plugs found under the cages, is 110.5 days. The variability range of gestation has proved to be wider than that reported in the literature, i.e. from 101 to 120 days. According to Sotto (1993) and Jarosz and Rżewska (1996), the mean gestation period in the chinchilla is 111 days. Weir (1986) reported a similar

Figure 1. Percentage distribution of gestation length in primi- and multiparous females



gestation period, i.e. 110.8 days. Also Gromadzka-Ostrowska (1998) states that 111 days is the average gestation period (with 2 days deviation). Barabasz describes a slightly longer gestation period, i.e. 105-115 days, with the mean also 111 days. The wider range of gestation lengths has been stated by Spotorno et al. (after Hillyer, 2004), 105-118 days.

The gestation periods of primi- and multiparous females (Table 1) were, respectively, 110.08 and 110.70 days and did not show significant differences. Highly significant differences, however, were observed in the case of the minimum gestation period, which was 106 days in primiparous and 101 days in multiparous dams. Gestation period in the females serviced during the postnatal oestrus was slightly longer compared to that in both primi- and multiparous conceiving in other oestruses, and was 112.8 days.

When we consider the percentage distribution of gestation lengths (Figure 1) in primi- and multiparous females, we can see that they were similar and there was a normal distribution. The largest number of gestations lasted for 110 days (26.9%, primiparous, and 19.3%, multiparous females), followed by 111-day gestations (23.7%, primiparous, and 16.5%, multiparous females).

The mean number of the young (primiparous and multiparous females altogether) born live per litter was 1.84. We have not found significant differences between live-born offspring in primiparous and multiparous females, which were, respectively, 1.83 and 1.85. This result is similar to those given in the literature, e.g. Lanszki (1996) reports the mean litter size being 1.87. The potential of the species, however, is much higher, and the parameter attained on farms should be considered unsatisfactory. The loss as the proportion of stillborn offspring was found to be 4.19% and 9.09% for, respectively, primi- and multiparous females.

Conclusions

1. The studies has revealed that copulation plugs represent a good indicator of the time of service and conception of a female chinchilla, as more than 60% of gestations have been confirmed on this basis.

2. Using the presence of plugs allowed demonstration that a gestation in chinchillas lasts for 110.5 days on average, ranging from

Table 2. Breakdown of reproduction parameters

Females	Mean number of live-born offspring per litter	Percentage of stillborn
Primiparous	1.83	4.19
Multiparous	1.85	9.09
Total	1.84	6.64

101 to 120 days.

3. It has been also found that the distribution of gestation length is similar in primiparous and multiparous females.

4 Systematic monitoring for presence or absence of a copulation plug beneath female cages of the breeding stock is recommended in order to support estimated time of whelping.

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III – 2 RP

Optimization of hormonal stimulation of ovulation in the chinchilla

Beata Seremak[1], Malgorzata Sulik[2], Lidia Felska-Blaszczyk[2], Bogdan Lasota[1]
[1]Department of Animal Reproduction, Agricultural University of Szczecin, ul. Doktora Judyma 6, 71-460 Szczecin, Poland.
E-mail address: beata.seremak@biot.ar.szczecin.pl
[2] Department of Animal Anatomy, Laboratory of Fur Animals, Agricultural University of Szczecin, ul. Doktora Judyma 14, 71-460 Szczecin, Poland

Abstract
The aim of the study was to optimize hormonal stimulation of ovulation in chinchilla female using gonadotropic hormones during diestrus and to evaluate the stimulation efficiency using morphometrics and functional characteristics of the ovaries. Females from group I (PG 600 – dose 200 iu PMSG and 100 iu hCG) and from group III (200 iu PMSG and after 72 hours 200 iu hCG) had the heaviest ovaries while the lightest and smallest ovaries were found in the control group that did not receive any hormones. The results strongly suggest that fertility in chinchilla females can be improved by hormonal treatment.

Introduction
Methods of ovarian cycle stimulation include the use of hormonally active biochemical agents, natural or synthetic, that directly or indirectly stimulate gametogenesis. Over the recent years, considerable progress has been observed in the area of pharmacological control of oestrus and ovulation in livestock animals. However, the chinchilla is a species on which such methods have not been developed. Also, in the field of experimental research, only few reports that deal with the narrow area of hormonally stimulated sexual cycles in female chinchillas can be found.

The aim of the study was to optimize hormonal stimulation of ovulation in chinchilla female using gonadotropic hormones during dioestrus and to evaluate the efficiency of the stimulation by examining changes in morphometrics and functional characteristics of the ovaries.

Materials and Methods
The experiment was carried out on 20 adult chinchilla females split into four groups. The following hormonal combinations were used for the stimulation:
Group I: PG 600 (Intervet, Holland), dose: 200 iu PMSG and 100 iu hCG;
Group II: PG 600 (Intervet, Holland), dose: 100 iu PMSG and 50 iu hCG;
Group III: Serogonadotropin (Biowet, Poland) containing 200 iu PMSG and after 72 hours, Biogonadyl containing 200 iu hCG (BioMed, Poland).
Group IV: control group, 0.2 ml aqua pro injectione (Polfa, Poland).

The chemicals were administered intra-muscularly during dioestrus which was determined by vaginal smears. The mucus was collected using sterile and damp cotton-wool buds and smeared on sterile slides. Each specimen was fixed in a 96% solution of ethanol mixed with ether (1:1) for at least 30 minutes. The slides were then stained by means of Papanicolaou differential method and analyzed under a microscope to determine the distribution of cells coming from the different epithelial cell layers, oestrous cells – scales, as well as the presence of leukocytes.

Table 1: Ovarian length, width and weight measured in females from the 4 experimental groups.

Group	Length		Width		Weight	
	Right ovary	Left ovary	Right ovary	Left ovary	Right ovary	Left ovary
Group I	7.21±0.66	7.93±0.72	4.50±0.45	4.99±0.66	74.5±16.4	69.72±12.1
Group II	6.62±1.05	7.45±1.42	3.85±0.49	4.93±0.98	58.9±21.14	63.72±22.0
Group III	7.14±2.25	7.72±2.24	4.87±1.54	5.64±1.85	77.1±27.65	64.7±24.76
Control group	6.57±1.09	7.31±1.41	3.99±1.02	4.99±1.31	42.9±12.67	53.48±7.66

The efficiency of the treatments was evaluated by morphometric and functional modifications functional condition of the vagina, i.e. whether it was open or closed, as well as the quantity and texture of the mucus. Groups I and II were slaughtered in 6 days after the treatment, while group III and the control in 9 days after administration of the pharmacological agents.

Results and Discussion

Two gonadotropins were used for experimental stimulation: (1) pregnant mare serum gonadotropin (PMSG), which has a luteinizing effect, but also stimulates the development of ovarian follicles and the synthesis of oestrogens, as well as (2) human chorionic gonadotropin (hCG), which evokes ovulation and formation of corpora lutea. These hormones were tested in various combinations.

First, we estimated the efficiency of each hormonal treatment by examining the morphological characteristics of the ovaries. The ovaries were weighed and measured, and the presence of particular ovarian structures was investigated. Group I (PG 600 – dose 200 iu PMSG and 100 iu hCG) and group III (200 iu PMSG and after 72 hours 200 iu hCG) had the highest ovarian weights on average and the ovaries were largest compared to group II and the control group. The lowest ovarian weights and the smallest ovarian sizes were found in the control group, which had not received any hormones (Table 1).

in the ovaries in response to hormonal stimulation. We have also examined the We then investigated changes in ovarian functional characteristics in response to the different hormonal stimulations. We found single fresh corpora lutea as well as developing and mature ovarian follicles in ovaries among experimental groups females (Table 2). The best results were observed in groups I and III where we found mature follicles in most all females, as well as fresh CL in all females in group III and two females in group I.

Females of group II, which received half doses of the hormones, exhibited numerous maturing ovarian follicles in their ovaries. Four out of 5 females from the control group did not show any fresh ovulation sites but only tiny ovarian follicles were found and ovaries were considered anoestrous.

Those data lead to the conclusion that oestrus, followed by ovulation, can be induced by exogenous gonadotropin hormones. It also turned out that the best results were obtained when using either two separate treatments of PMSG and hCG (200 iu PMSG and 200 iu hCG) or a PG 600 in a high dose (200 iu PMSG, 100 iu hCG) treatment. Ovaries of these females contained a higher number of developing and mature ovarian follicles and corpora lutea compared to those from females treated with PG 600 in the dose of 100 iu PMSG and 50 iu hCG and control group.

Table 2 Morphological evaluation of the ovarian structures in each group after hormonal stimulation

Group	Female number	Follicles				Corpora lutea		Vaginal condition
		maturing		mature				
		Right	Left	Right	Left	Right	Left	
I	1	numerous	numerous	0	4	0	0	open
	2	numerous	numerous	1	1	0	0	open
	3	numerous	numerous	1	2	0	0	open
	4	numerous	numerous	2	5	2	5	open
	5	numerous	numerous	0	3	1	1	closed
II	1	numerous	numerous	0	0	0	0	closed
	2	numerous	numerous	1	0	0	0	closed
	3	numerous	numerous	1	1	0	0	open
	4	single	0	3	1	0	0	open
	5	numerous	0	0	0	1	0	open
III	1	numerous	numerous	0	1	2	2	open
	2	numerous	numerous	4	1	2	2	open
	3	numerous	numerous	4	8	2	1	open
	4	single	single	0	0	2	3	open
	5	numerous	numerous	5	7	1	0	closed
IV	1	4	0	0	0	1	0	closed
	2	single	single	0	0	0	0	closed
	3	0	single	0	0	0	0	closed
	4	numerous	numerous	1	0	1	1	closed
	5	numerous	numerous	0	0	0	0	closed

In contrast, one previous study revealed that ovulation was induced when the two gonadotropins were used simultaneously in chinchilla females (Weir, 1966). Similarly, Szeleszczuk and Jarosz (1995) demonstrated that PG 600 resulted in a higher efficiency of the oestrus and ovulation stimulation in the nutria. On the other hand, Kremer (1980) observed that ovulation is induced by a single administration of PMSG in dose response manner in sheep.

The hormonal treatments used in the present study demonstrate good efficiency of these methods in the chinchilla since growth and maturing of ovarian follicles was observed. However, some reports revealed that similar hormonal treatments may have negative effects on females from other species. Negative effects of PMSG were found by Karsch et al. (1997). These authors observed that administration of similar hormonal treatment resulted often in disorders of ovarian follicle maturation and sperm transport.

In addition, Cran (1993) and Bonsell-Hermereich et al. (1989) also induced ovulation using Serogonadotropin and Biogonadyl and observed that some follicles were malformed during maturation, resulting in cysts. The layer of granulosa cells was thin or absent, while internal sheath often formed a thick and luteinizing layer.

The results of the present study suggest that chinchilla female fertility may be improved by

hormonal treatments. Further studies are still required, mainly to investigate the hormone effects on the chinchilla global reproductive function as well as to determine optimal experimental conditions.

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III – 3 RP

Analysis of female fertility in mink of standard and palomino colour types

Stanislaw Socha, Dorota Kołodziejczyk, Ewelina Konopka
Department of Breeding Methods, Poultry and Small Ruminent Breeding, University of Podlasie, 08-110 Siedlce, ul. B. Prusa 14. Poland,
E-mail address: socha@ap.siedlce.pl

Abstract
The aim of the work was to analyze the factors that influence reproductive results in mink of standard and palomino colour types. Two basic reproduction traits of mink were analysed: number of kits born and number of raised pups. A total of 664 litters were studied over 3 years. The analysis of variance demonstrated a statistically significant effect of the colour type and the year of investigation on the number of kits born and raised. No statistically significant effect was found for female age. The mean number of born and raised pups was: 4.47 and 3.94, in standard, while in palomino it was slightly higher: 4.90 and 4.34, respectively. It was observed that the highest fertility was reached by one-year-old and two-year-old females, both of standard and palomino type, while the lowest fertility was attained by four-year-old females. In standard mink the highest percentage of the litters comprised those from the females that had 7 born and 6 raised pups in a litter. In palomino mink the most frequent were females that had 6 born and 5 raised pups in a litter.

Introduction
Reproduction is one of the basic life functions of animals. The mink has only one estrous cycle per year. Hansson in 1941 (Cholewa, 2000) demonstrated that reproduction in mink in the Northern Hemisphere starts in March. Litter size is one of the most important production traits in fur animal breeding. It depends on genetically coded species traits. The variability of litter quantity is caused by, among others, the following factors: female age, female condition, number of matings. The majority of research has demonstrated that size of the first litter is generally lower than the subsequent litters. This is due not only to genetic factors, but it also is impacted by external influence, such as additional lighting, improper feeding and other stressful factors. A breeder is undoubtedly interested in increasing fur animal fertility, but there is a selection priority in the hierarchy of importance of traits, with fur traits being most important. Little selection emphasis on reproduction is the cause of the lack of breeding progress in fertility traits in mink (Jeżewska & Maciejowski, 1986). Rozempolska-Rucińska et al. (2000) analysed the level of production in standard mink and demonstrated that highest fertility characterized the two-year-old females. Apart from the genetic basis, there is a significant influence of weather conditions and of management, especially feeding, on reproduction (Jeżewska & Maciejowski, 1986).
The aim of the work was to analyse the factors that influence reproductive results in mink of standard and palomino colour types.

Materials and Methods
Two primary reproduction-related traits were analysed: the number of pups born and the number of pups raised in mink of standard and palomino colour types. A total of 664 litters were studied over 3 years: 2005-2007. Statistical parameters of traits in herd: arithmetic mean and variability coefficient (which presents variability expressed in % in relation to the mean) were calculated according to standard statistical procedures. Analysis of variance was performed for each of the traits analysed on the basis of a mathematical model which included constant

effects: year, colour type and female age, as well as interactions between these factors.

Results and Discussion

The analysis of variance demonstrated a statistically significant effect of colour type and the year of investigation on the number of pups born and raised. No statistically significant effect was found for female age.

Tables 1 and 2 present a statistical description of the number of pups born and raised, in relation to the year, colour type and female age. The tables include arithmetic means (x) and variability coefficients (V). The highest means of pups born were achieved by two-year-old females of both standard and palomino colour types, and were: 4.87 and 5.08, respectively. The lowest means were observed in four-year-old females and were: 3.76 and 4.75 in standard and palomino, respectively. Similarly, the highest means of raised pups were achieved by two-year-old females of standard type (4.63) and by three-year-old females of palomino colour type (4.45), although these differences were not statistically significant.

Lorek (1996) reported that reproductive coefficients (the number of kits born and raised) are generally lower in primigravidas than in older females. Also Jeżewska & Maciejowski (1986) observed that the size of the first litter is generally lower than in subsequent litters. Then comes an increased followed by a decrease – generally after the third year.

However, Bernacka & Kubacki (1982) observed in standard mink that one-year –old and two-year-old females that had the highest mean number of pups born: 6.54 and 6.53, respectively, while the three-year-old females had the lowest mean number of pups born: 5.94 pups.

Other research conducted by Socha & Markiewicz (2001) in crossbred mink demonstrated that the highest statistically significant fertility was obtained by two-year-old females while the litter size in females older than two years decreased gradually. Also Lorek (1996) reported that introducing changes in genotype in a national population leads to improvement of reproduction coefficients in mink.

Socha et al. (2003) performed statistical analysis of the number of pups born and raised in relation to female age and observed that the highest mean fertility characterized two-year-old females of the following colour types:– mahogany–6.01, sapphire–4.06 and standard–3.52.

Table 1. Statistical description of the number of pups born in relation to the year, colour type and female age (N- number of litters, $\bar{x}$ – arithmetic mean, V- coefficient of variation). The means marked by different letters differ statistically significantly.

Year of research	Female age	Standard colour type			Palomino colour type			Total		
		N	$\bar{x}$	V	N	$\bar{x}$	V	N	$\bar{x}$	V
2005		59	3.52[a]	60.22	133	4.66[d]	45.34	192	4.31[b]	50.44
2006		87	4.44[b]	52.5	148	4.63[d]	50.38	235	4.56[d]	51.07
2007		101	5.05[c]	44.07	136	5.44[e]	42.07	237	5.28[c,e]	42.91
Total	1	149	4.51	48.80	203	4.82	45.14	352	4.69	46.48
	2	57	4.87	48.93	102	5.08	49.15	159	5.01	48.14
	3	28	3.82	69.45	72	4.97	44.02	100	4.65	50.96
	4	13	3.76	58.61	40	4.75	50.37	53	4.50	52.44
Total		247	4.47[f]	51.65	417	4.90[g]	46.44	664	4.74[f,g]	48.43

Table 2. Statistical description of the number of pups raised in relation to the year, colour type and female age (N- number of litters, $\bar{x}$ – arithmetic mean, V- variability coefficient). The means marked by different letters differ statistically significantly.

Year of research	Female age	Standard colour type			Palomino colour type			Total		
		N	$\bar{x}$	V	N	$\bar{x}$	V	N	$\bar{x}$	V
2005		59	3.10[a]	60.38	133	4.24[d]	46.81	192	3.89[b]	51.82
2006		87	3.58[b]	54.30	148	3.83[b]	52.66	235	3.74[b]	53.20
2007		101	4.74[c]	46.85	136	5.00[e]	44.62	237	4.89[e]	45.50
Total	1	149	3.81	52.04	203	4.27	49.69	352	4.07	50.85
	2	57	4.63	47.34	102	4.44	82.31	159	4.50	66.44
	3	28	3.67	73.78	72	4.45	40.06	100	4.24	49.29
	4	13	2.92	66.23	40	4.27	50.84	53	3.94	55.07
Total		247	3.94[f]	54.61	417	4.34[g]	51.40	664	4.19[f,g]	51.19

According to Szeleszczuk (2001), the litter size in one-year-old females is lower when compared with later years, then it decreases again in the sixth year.

The analysis performed demonstrates that coefficients of variation (CV) of the number of pups raised across the entire sample population of researched group were significantly higher in comparison with the coefficients of the number of pups born. In the research performed in the years 2005-2007 coefficients of variation in relation to female age and colour type of females were similarly elevated. For the mean number of pups born of the standard type, the CV ranged between 34.65% and 77.34%, and to palomino type ranged between 36.84% and 54.72%.

Socha & Markiewicz (2001) obtained similar results. They demonstrated significantly higher variability of the number of pups raised in comparison with the number of born.

Tables 3 and 4 present percentage distribution of the number of born and raised pups in relation to colour type. In standard mink the highest percentage of the litters resulted from the females that had 7 born and 6 raised pups in a litter. In palomino mink the most frequent were females that had 6 born and 5 pups raised in a litter. In the research herd of mink of both colour types there were also litters of 9, 10 and even 11 pups, but they were least frequent, and constituted 1.63%; 0.82% and 0.42%, respectively in standard colour type and 3.37%; 1.69% and 0.73%, respectively, in palomino colour type.

Table 3. Percentage distribution of litter size at birth in relation to colour type of mink.

Number of pups in a litter	Percentage of litters in relation to colour type	
	Standard	Palomino
1	0.80	0.47
2	17.00	12.23
3	14.97	11.03
4	10.52	11.51
5	12.95	13.90
6	14.57	18.70
7	17.40	17.26
8	8.92	9.11
9	1.63	3.37
10	0.82	1.69
11	0.42	0.73

Rozempolska-Rucińska et al. (2000) observed significant differences in the number of pups born and raised in a litter, which ranged from 0 to 13. Similar results were obtained by Sulik & Felska (2000) who demontrated that the

difference between the smallest and the largest litter was of between 1 and 13 pups. According to Jeżewska & Maciejowski (1986), most frequent litter size in mink is 4-6 pups, and the least frequent are litters of one pup, and, in addition, there are numerous litters of 15 pups.

Table 4. Percentage distribution of litter size of pups raised in relation to colour type of mink.

Number of pups in a litter	Percentage of litters in relation to colour type	
	Standard	Palomino
1	14.57	9.83
2	10.93	10.07
3	9.31	7.19
4	13.36	12.23
5	13.76	17.50
6	19.02	17.02
7	10.12	14.62
8	5.26	7.67
9	2.44	2.17
10	1.23	0.97
11	-	0.73

Conclusions

The analysis of results of reproduction in mink of standard and palomino colour type on a breeding farm leads the following conclusions:

1. The analysis of variance demonstrated a statistically significant effect of the colour type and the year of investigation on the number of born and raised pups. No significant effect, on the other hand, was found for female age.

2. The mean number of pups born and raised in a litter was the following: 4.47 and 3.94, respectively, in standard colour type and 4.90 and 4.34, respectively, in palomino colour type. It was observed that the highest fertility was reached by one-year-old and two-year–old females both of standard and palomino type, while the lowest fertility was reached by four-year-old females; although these differences were no statistically significant.

3. Coefficients of variation of the number of pups raised in the studied population were significantly higher in comparison with the coefficients of the number of pups born. In standard mink, the highest percentage of the litters was found in females that had 7 pups born and 6 pups raised in a litter. In palomino mink the most frequent were females that had 6 pups born and 5 pups raised in a litter.

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III – 4 RP

Analysis of reproduction performance under different mating systems in Sapphire and Wild mink

Malgorzata Sulik, Lidia Felska-Blaszczyk, Jadwiga Zołedziejewska, Agnieszka Semik
Department of Animal Anatomy, Laboratory of Fur Animals, Agricultural University of Szczecin, ul. Doktora Judyma 14, 71-460 Szczecin, Poland.
E-mail address: lidia.felska-blaszczyk@biot.ar.szczecin.pl

Abstract
The predisposition of the mink to genetic mutations within the fur colour trait has resulted in a large number of varieties derived by the breeders, which are also diverse in terms of reproduction. In the present study, our aim was to evaluate of the relationship between the number of repeated matings in the Wild and Sapphire varieties and gestation length, litter size. We have analysed reproduction performance of 4474 Wild and 1347 Sapphire females. It was found that no third repeated mating should be applied after 19 March, since it negatively influences the litter size for the Sapphire group. Gestation length did not affect significantly the litter sizes in the studied colour varieties. Sapphire mink were characterised by a smaller range of gestation lengths (41-65 days), as compared with the Wilds (35-75 days).

Introduction
The mink is a monoestrous species with a strongly pronounced photoperiodism. Compared to other livestock animals, the physiology of reproduction in the mink is less understood and more complex, which together means that various problems in mink breeding may be encountered. The most important issues include the lack of apparent heat symptoms, delayed implantation, different gestation lengths, as well as the fact that artificial insemination is constrained by provoked ovulation. During embryonic diapause in the mink, the blastocyst growth ceases and, after reactivation, resumes development (Desmarais et al., 2004). Insufficient length of photoperiod during pregnancy may result in extended diapause, which, as a consequence, results in an increased mortality of the embryos (Murphy & James 1974, reviewed in Lopes et al., 2004). The factors that also influence gestational length include feeding and temperature, as well as the atmospheric precipitation.
Over the last decade, an impressive development in mink farming has been observed in Poland. This is due to a great demand for pelts and high prices that are offered in the auction houses and also due to the excellent climate conditions in Poland, favourable for mink breeding. Most newly established farms manage large stocks of mink, no smaller than 10,000 to 20,000 females of breeding stock. In such large populations, proper reproduction is the key issue in terms of the profitability of the farm (Sulik et al., 2007). The predisposition of the species to genetic mutations within the fur colour trait has resulted in many varieties derived by the breeders. According to some authors (Sulik et al, 2007; Rozempolska-Rucińska et al., 2000; Socha & Markiewicz, 2001), the reproductive parameters are different depending on the colour variety and the age of a female.

Therefore we have undertaken the present study, which was aimed to evaluate the linkage between the number of matings per conception and colour variety versus gestation length and litter size

Material and Methods

The study was carried out on a mink farm located in the West Pomerania, Poland, in the years 2005-2006. The analyses included two colour varieties, dark- (Wild) and light-fur mink (Sapphire), which demonstrated considerable differences in the reproduction performance. Dates of mating, number of matings per conception, gestation length, and litter size were collected from 4474 Wild and 1347 Sapphire females (a total of 5821 animals). The data were analysed statistically be means of the Statistica PL software (StatSoft) using two-way ANOVA and the Duncan multiple range test.

Results and Discussion

The average litter size per female was 8.59 born and 6.85 weaned kits, independent of the colour variety. This result is much higher compared to what can be found in the literature, since many authors (Rozempolska-Rucińska et al., 2000; Socha & Markiewicz, 2001) report an average number of 4.31 born and 3.96 weaned offspring per litter.

It has been discussed what number of matings should be applied to obtain larger litters and increase survival rate of newborns. On the group we have analyzed, a group mating system has been implemented, which consisted in repeated mating of the same female with another strongly related male. One to four repeated matings were applied at 1, 2, 7, and 8 days in heat. This system follows the cycle of follicle maturation during the oestrus occurring in March (Hansson 1947, Murphy 1983, Wehrenberg et al., 1992). Occurrence of the oestrus and its intensity is linked to a longer photoperiod, with a 10-hour light day triggering the onset of the heat (Travis & Pilbeam 1980, Wahrenberg et al. 1992, Bishnupuri & Haldar, 2000). Under conditions of West Pomerania in Poland, darker-colour varieties, such as Wild, attain the successful conception soonest. Research has show that this variety produced litters from the first mating taking place on 1 March, while the Sapphires were successfully mated as late as on 4 March (Figure 1). With the early matings, the repeated mating was not applied until after another 7 days.

Figure 1. Relationship between mating date, matings per conception, and gestation length in Sapphire and Wild mink (in legend: I -one mating, II – two matings, III – three matings)

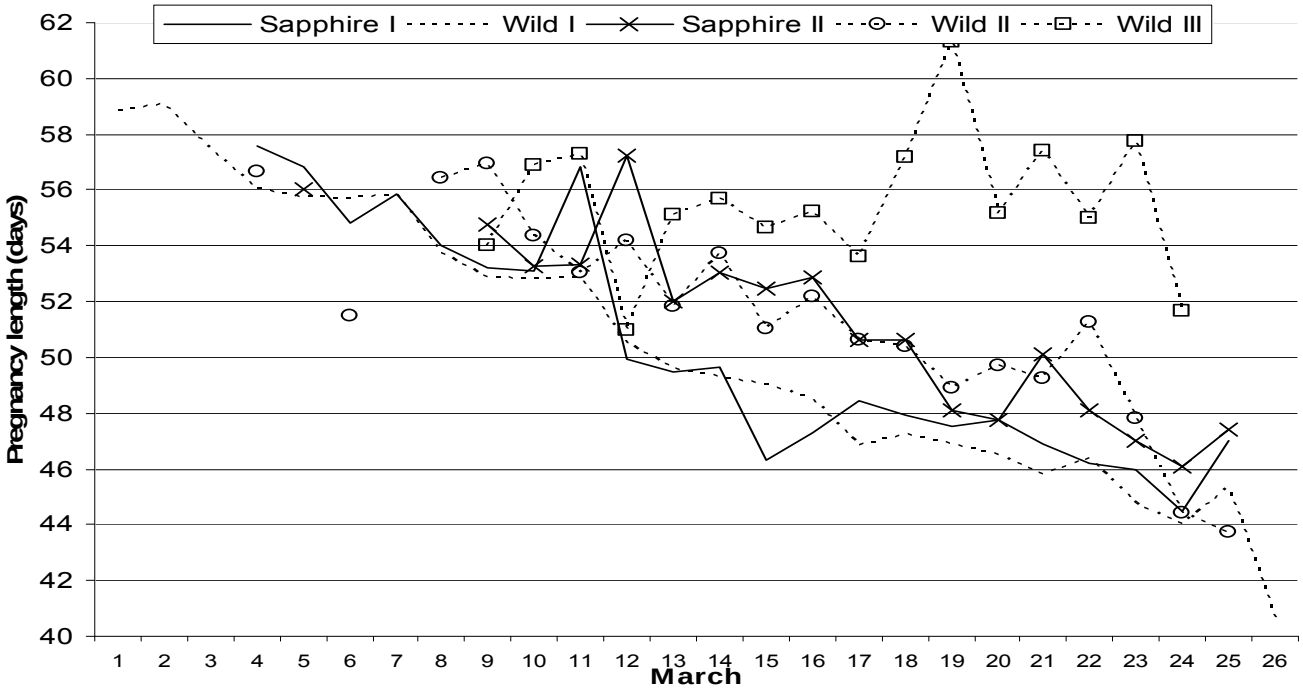


Table 1. Basic reproduction parameters in relation to matings per conception in mink

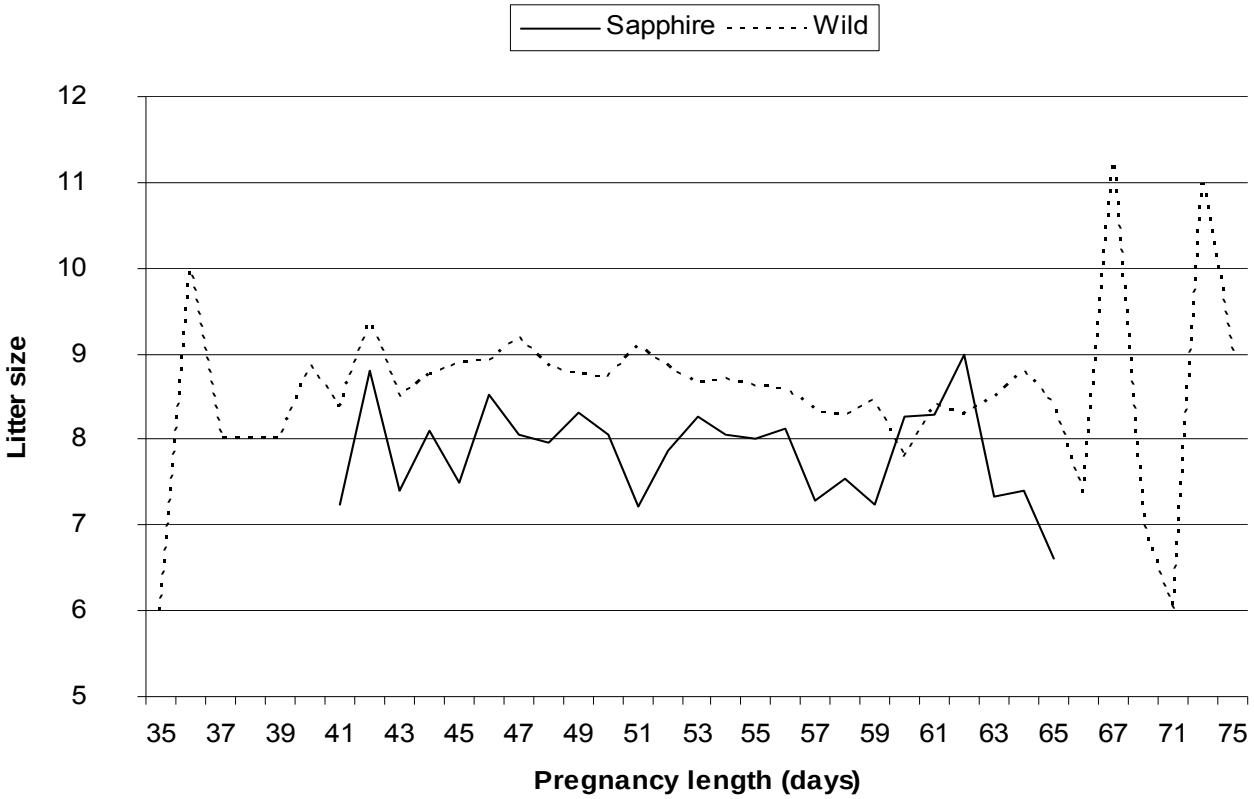
Colour variety (mean matings per conception)	Reproduction parameters		Matings per conception				
			1	2	3	4	Mean
Sapphire (1.92)	Litter size (indiv.):	born	8.10	7.89	6	-	7.9
		live-born	7.27	7.01	5.0	-	7.02
		weaned	6.42	5.79	5.5	-	5.84
	Percentage of females (%)		7.11	92.43	0.46	-	100
	Gestation length (days)		51.19	52.32	51.00	-	52.23
Wild (2.00)	Litter size (indiv.):	born	8.68	8.71	8.86	6.5	8.72
		live-born	7.42	7.71	7.86	6.0	7.70
		weaned	6.83	7.05	7.24	6.0	7.05
	Percentage of females (%)			75.8	12.18	0.1	100
	Gestation length (days)			51.30	55.53	56.00	51.90
Total (1.99)	Litter size (indiv.):	born	8.62	8.55	8.84	6.5	8.59
		live-born	7.41	7.58	7.85	6.0	7.59
		weaned	6.79	6.81	7.23	6.0	6.85
	Percentage of females (%)			78.45	10.27	0.15	100
	Gestation length (days)			51.49	55.49	56.00	51.90

Gestation length in mink is linked with the effect of delayed implantation of the embryo, the so called embryonic diapause. It has been estimated that gestation may take from 36 to 85 days, with the development of the foetus lasting 30 days (Murphy et al., 1983; Wehrenberg et al., 1992; Ferguson et al., 1996; Renfree & Shaw, 2000; Isakona et al., 2001; Thom et al., 2004). According to Bowness (1968), the mean gestational length in mink is 52.37 days. The present study has demonstrated that early matings extend the gestation to 59 days (herd average 51.9 days) for wild I group, and to 57 days for Sapphires having 4-7 days longer gestations resulting from matings on 11 March compared to other dates of mating. Figure 1 also demonstrates that application of three repetitions of matings has a significant effect on an extension of gestation, especially as the repeated mating took place after 19 March. Too long a diapause may lead to deaths of embryos, which in consequence results in smaller litters (Socha & Markiewicz, 2001; Sulik & Felska, 2000).

Table 2. Gestation length variability in mink in relation to matings

Matings	Sapphire		Wild		Total	
	Mean	SD	Mean	SD	Mean	SD
1	51.19	5.46	51.51	5.57	51.48	5.55
2	52.32	5.33	51.30	5.43	51.49	5.43
3	51.00	7.07	55.53	4.47	55.49	4.49
4			56.00	1.41	56.00	1.41
Total	52.23	5.34	51.84	5.51	51.90	5.48

Figure 2. Litter size in relation to gestation length in Sapphire and Wild mink



We found in this study that the Wild mink are characterized by a wider range of gestation lengths, 35 to 75 days, as compared with the Sapphire, 41-65 days; this, however does not affect the litter size. The Wilds had 1.7 young larger litters compared with the Sapphires (Table 1), irrespective to gestation length.

According to Socha & Markiewicz (2002), the largest litters are obtained from matings taking place after 15 March. In our studies, we have not seen such relationship in the Wild variety, while a slight trend of reduced litter sizes from matings after 13 March was apparent in the Sapphire mink.

Conclusions

- Repeated mating leads to increased litter sizes in mink; however, application of the third mating after 19 March may have a negative effect, i.e. a smaller litter size for the Sapphire, but not for the wild (Table 1).
- There was no correlation between gestation length and litter size in the studied colour varieties. Only in Sapphire have we observed a trend of smaller litters from matings carried out after 13 March.
- The Sapphires were characterised by a smaller range of gestation lengths (41-65 days) compared with the Wilds (35-75 days).

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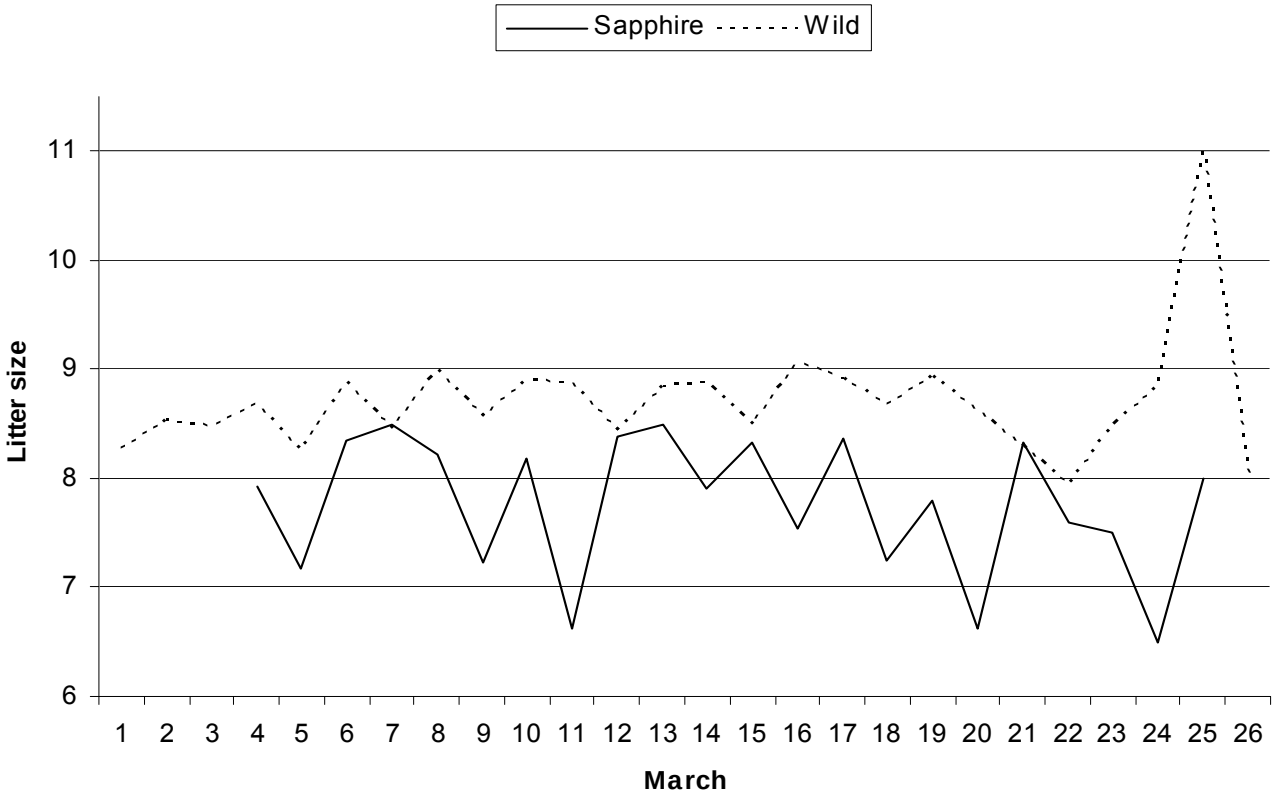
Figure 3. Litter size in relation to mating date in Sapphire and Wild mink



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III–5 RP

Trials to estimate factors affecting cub losses in the early suckling period in farmed Raccoon dog (*Nyctereutes pryocyonoides*)

Olga Szeleszczuk[1] Katarzyna Gala[1], Piotr Niedbała[2], Duśan Martin[3], Hieronim Żurek[4]
[1]University of Agriculture, Department of Anatomy and Animal Reproduction, Al. Mickiewicza 24/28, 30-059 Krakow, Poland
[2]University of Agriculture, Department of Animal Hygiene and Poultry and Fur Animals Breeding, Al. Mickiewicza 24/28, 30-059 Kraków, Poland
[3]Research Institute of Animal Production, Hlohovska 2, 949 92 Nitra, Slovak Republic
[4] Wladkowice Farm – owner, Poland
E-mail address rzszeles@cyf-kr.edu.pl

Abstract
The success of pup rearing is affected by a number of factors both hereditary and environmental. One of them is the health status and activity of the mammary glands in females during the lactation period. The aim of the investigation was to define the reasons for litters being destroyed by raccoon dog females during lactation. The health status of mammary glands was determined by cytological methods used for diagnosis of mastitis in cattle (KMT, WST and SCCs) with minor modification. The results of our investigation confirm the occurrence of different forms of inflammation of mammary gland in farmed raccoon dog females. This chronic disease is likely the trigger for mothers biting their pups.

Introduction

In recent years, an increase in mortality among newborn and cubs was noticed on farms of carnivorous fur animals (Szeleszczuk et al., 2004, Szeleszczuk & Niedbala 1999). The number of stillborn cubs and mortality during the first few days of life is much greater than all the losses recorded during the remainder of the rearing period (Szeleszczuk, 2002). The reasons of such great losses are diverse and complex. Mainly the females eat dead embryos, and dead newborn or suckling cubs, or those whose survival is unlikely (Kaleta & Brzozowski, 1989, Kowalczyk, 1970). This can be a positive reflex, such as sanitation; when they clean the nests in this manner to remove dead individuals, or as a defensive mechanism, manifested by catching the cubs in their muzzle and running away from a threat (Szeleszczuk, 1987, Twardon & Dejneka, 2001). Cannibalism can provide a lack of milk or inflammation of mammary gland, and in this condition, attempted suckly by the young can increase the pain (Dzieciol et al. 2006). During suckling the cubs cause pain, which can lead nervous females to bite their young, sometimes causing death (Kowalczyk, 1970, Twardon & Dejneka, 2001).

This paper examined the health status of mammary glands and their influence on the survival and rearing of young raccoon dogs.

Material and Methods

The investigations were carried out on foxes and raccoon dogs at the Wladkowice farm. Milk was collected from females destroying their litters (Group I – experimental) and rearing their litters (Group II – control). Milk from females destroying litters was collected within 7 – 14 days after kittening. At the same time milk was collected from females rearing litters. In females from group I, swelling, redness and tender nipples were observed. Cytological methods routinely applied in cows were used as an indirect method to assess the health status of the mammary gland. These methods were modified to adjust for differences in milk

Table 1 Number of somatic cells in milk defined by the Prescott – Breed method.

Group	Number of females	Number of somatic cells			
		Mean	SD	Minimum	Maximum
I	16	311 800	98 510	170 000	435 000
II	10	90 470	13 610	70 000	107 500

processing in raccoon dogs (Fithenakis 1995; Klosowska et al., 2005).
The California mastitis test TOK determines agglutination after mixing a drop of raccoon dog milk with a drop of Mastirapid reagent. Sodium lauryl sulfate in this reagent reacts with DNA present in milk leukocytes causing milk floccules, and an indicator, bromine-cresol purple, changes the tinge according to the pH of milk. A negative result has gray-bluish tinge, but milk from animals with suspected inflammation of mammary gland – all shades of violet. The severity of the mastitis can be determined according to a 5 point scale: "negative", "trace", "+", "++", "+++".

The Whiteside WST test consisted of stirring 5 drops of collected milk with 2 drops of 1N NaOH on a dark background and observing the reaction. The results are reading according to the scheme:

-negative result (-) – the mixture keep uniform color, it is opaque, without floccules (milk comes from healthy animals),
-questionable result (+-) – the mixture is white, still opaque, little floccules appear which do not tend to aggrege in small clusters, sometimes visible edge granulation

-positive result (+; ++; +++) – the mixture can be watery with a tendency to increased viscosity, floccules are clearly present (milk comes from animals suspected of inflammation).
The third test applied was milk somatic cell counting by the Prescott-Breed method (Pinkiewicz, 1975). In this method a milk smear was prepared on a glass slide, air dried, stained with test reagents and evaluated microscopically under oil immersion. Somatic cells were counted in three visible fields at the edge of smear, four center fields and three at the opposite edge in parallel line. The results were calculated according to the formula:

$$Q = z \times f$$

where Q – number of cellular elements in 1 ml of milk; z – number of cells from 10 visible fields; f – microscope optical coefficient with the use of ocular. Based on the number of cells in milk of healthy females, the norms for raccoon dog females were established.

In addition, according to the binding procedures, milk for bacteriology investigation was collected. Investigations were completed in the laboratory of Veterinary Hygiene Institute in Krakow (Procedure PN-EN ISO/IEC 17025 2005),

Results and Discussion
The reproductive results and proper rearing of the young are the most import factors in breeding results on the raccoon dog farm. The success of pup rearing is affected by a number of factors both hereditary and environmental. One of them is the health status and activity of mammary glands in females during lactation period.

The number of somatic cells defined by Prescott – Breed method in milk collected from females of raccoon dog is presented in Table 1. Healthy females (Group II) have an average of approximately 90 000 somatic cells per ml, but in females with suspected

Table 2. The results of Whiteside and CMT tests in females from group I

Females	Whiteside test	CMT test
A; B; C	+++	+++
D; E; F; H; I	++	++
J; K; L	+	+
M; N	Trace	+
O	Trace	Trace
P, T	-	Negative

inflammation of the mammary gland (*mastitis*), and which destroyed their litters (Group I), the number of somatic cells per ml was much higher, ranging from 170 000 to 435 000, with an average of 311 700/ml, as would be consistent with inflammation of the mammary gland.

In females A, B and C, inflammation of mammary gland was present and confirmed by positive reactions in the Whiteside test and the CMT (Table 2). In females M and N, the CMT test gave positive results indicating subclinical levels of *mastitis*, but the WST result was questionable. In female O, the presence of inflammation of mammary gland was not determinable, because the results of both tests were questionable. For precise confirmation of inflammation of mammary glands in these females, additional milk tests need to be done.

The results of bacteriological testing are presented in Table 3. In females A, B, C and E the S*treptococcus agalactiae* bacteria, was present. This is streptococcus from group B, which persists in an external environment and has a rather low sensitivity for antibiotics. It is an absolutely pathogenic germ, The most virulent of all streptococci which cause inflammation of mammary gland in cows, because its metabolism is the best adapted to conditions in this gland. It is highly contagious (Dzieciol et al., 2006; Ververidis et al., 2007). In female N the bacteria *Staphylococcus sp.* – especially important in causing inflammatory processes in animals (Twardon, 2000; Ververidis et al., 2007) – was detected.

Each disturbance regarding the time of milk secretion and maintenance of lactation duration is equally dangerous for mothers and for kids. Females having problems with mastitis and duration of lactation become aggressive and nervous. This behavior of the females can result in fighting and cannibalism in the cubs and may also lead to death by starvation. Chronic illness of the mammary gland in raccoon dog females is rarely noticed by owners in comparison to other diseases, even though it can cause irreversible local changes and serious general disturbances of the body. Mastitis can be caused by chemical or physical factors, but in the most cases its fundamental origin is infectious in nature (Twardon & Dejneka, 2001; Ververidis et al., 2007). It is characterized by an increased number of somatic cells in milk. Depending on different factors which favor the presence of inflammation of mammary gland and other phenomenon, mastitis can have different courses and different clinical presentations. Mastitis can be characterized in 4 different forms: latent infections, which may have pathogenic microflora present but normal somatic cells counts; subclinical mastitis, which may have pathogenic microflora present but only mild increase in somatic cell counts; clinical mastitis, which can present with systemic signs such as increased temperature of mammary gland, inflammation, painfulness, organoleptic changes in milk, bloody or purulent-bloody

Table 3. Results of bacteriological examination of milk coming from females suspected of mastitis (Group I)

Females	Detected bacteria
A, B, C	*Pantoae spp.; Proteus mirabilis: Streptococcus agalactiae*
E	*Streptococcus agalactiae*
D	*Streptococcus agalactiae: Enterobacter cloacae*
N	*Staphylococcus coagulase negative*
O,T	*Negative result*

secretion, and often abscessation of the gland. Finally, when is a lack of clear pathogenic symptoms, but there may be fimbriae and protein clots in the milk, the inflammation is termed subacute. When inflammation is unspecific (non-infectious) – and when symptoms indicate subclinical nature, there is a lack of results indicating infectious character of this threat.

The results of our investigations confirm the presence and existence of different forms of mammary gland inflammation in raccoon dog females. This chronic illness may account for death of litters by maternal biting, which causes enormous losses among sucklings during lactation. In the majority of investigated females which destroyed their own progeny, the inflammation of mammary gland was observed. From these females milk was collected and tested by WST and CMT, tests which are used to confirm the occurrence of inflammation of mammary glands in cows. In raccoon dog females, in the majority of cases these tests gave positive results. The number of somatic cells in milk from females which had bitten their young to death was higher in comparison than in milk of females which reared their young. The inflammation of mammary gland concerned usually individual nipples. Inflamed nipple glands are usually stiff, painful and red. In the material collected from females which has destroyed their litters, the bacteria *Streptococcus agalactiea* was detected, bacteria which is responsible for bovine mammary gland inflammation. Bacteria from the group of *Staphylococcus* was also detected, another bacteria responsible for bovine mammary gland inflammation, but in lesser degree (Klosowska et al., 2005).

Conclusion

In females destroying their young, inflammation of the mammary gland is often present, causing the mothers to become aggressive and to bite their young to death immediately if they try to suckle from painful nipples. It is very important to observe the nipples and mammary glands in female raccoon dogs, to detect changes, and to react to prevent losses again in the next season.

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III–6 P

Uterine global gene expression at embryo reactivation after embryonic diapause in the American Mink (*Neovison vison*)

Pavine L. C. Lefèvre[1], Danièle Beaudry[2], Marie-France Palin[2] and Bruce D. Murphy[1]
[1]Centre de recherche en reproduction animale, 3200, rue Sicotte, Saint Hyacinthe J2S 7C6, Qc, Canada.
[2]Centre de recherche et de développement sur le bovin laitier et le porc, 2000, rue Collège, C.P. 90, succ. Lennoxville, Sherbrooke J1M 1Z3, Qc, Canada.
E-mail address: pavine.lefevre@umontreal.ca

Background

Embryonic diapause is a reversible arrest of embryo development prior to implantation that occurs due to suppression of cell proliferation at the blastocyst stage. In the mink, embryonic diapause characterizes each gestation (Hanssen, 1947). The principal environmental signal that reactivates embryos is the increasing length of photoperiod and consequent increases in secretion of hypophyseal prolactin and ovarian progesterone (Murphy & James, 1974). Diapause and embryo reactivation are under maternal control and reinitation of development is associated with an increase in endometrial secretion into the uterine lumen (Murphy et al., 1981). Mink embryos in diapause cocultured with uterine cell monolayers *in vitro* are reactivated, providing further evidence that the resumption of embryo development is triggered by factors secreted by the uterus (Moreau et al., 1995).

The termination of the mink embryonic diapause is triggered by endometrial factors into the uterine lumen. The aim of our study was to identify the elements that initiate the resumption of embryo development after embryonic diapause.

Materials and Methods

We used suppressive subtractive hybrization (SSH) (Diatchenko et al., 1996) to generate a library of cDNA fragments differentially expressed between the diapause and reactivated states. Termination of embryonic diapause was synchronized by daily i.m injection of prolactin beginning at the vernal equinox. Uterine horn samples were collected from females in diapause (n=11) and from females at 3 (n=3), 5 (n=5) and 7 days (n=3) after the resumption of embryo development. Total mRNA was extracted from those uterine samples and reversed transcribed and SSH was performed on cDNA of the pool of the samples collected at 3, 5 and 7 days after embryo reactivation versus cDNA of samples collected in diapause. The identity of differentially expressed cDNA sequences from the SSH library was established using the BLAST program (NCBI). Candidate genes were selected according to their biological function and potential for implication in the implantation process, based on published information in other species. The differential expression pattern of those candidate genes was confirmed by real-time PCR. Finally, the temporal and spatial expression patterns of selected genes were respectively analyzed by real-time PCR and immunocytochemistry.

Results and Discussion

Among the 337 differentially expressed sequences in the library, 69% revealed high degrees of homology with known gene sequences listed in the GenBank database. Genes that are associated with regulation of gene expression, metabolism, cell cycle, signal transduction and transport functions in the uterus were among those found in the uterus during the resumption of embryo development. PCR analysis revealed that four selected

candidate genes were upregulated 3 days after the resumption of the embryo development: *growth and differentiation factor 3* (*gdf3), ornithine decarboxylase (odc), ornithine decarboxylase antizyme inhibitor (odcai)* and *spermidine/spermine N_1-acetyltransferase (ssat1)*. Immunohistochemistry revealed that GDF3, a member of the TGFβ superfamily (Jones et al., 1992), was weakly expressed in the luminal epithelium during diapause. In contrast, it is strongly expressed in the uterine luminal and glandular epithelium beginning at day 1 after embryo reactivation. *Ornithine decarboxylase*, *ODCai* and *SSAT1* are polyamine-related genes, and ODC is the rate limiting enzyme in polyamines biosynthesis (Wallace et al., 2003). Immunolocalization revealed that ODC protein is strongly expressed in the uterine luminal and glandular epithelium and also in the subepithelial stroma beginning at the time of embryo reactivation (day 1) compared to diapause.

Conclusions

Together, those results lead to the new hypothesis that GDF3 secreted by the uterine lumen acts alone or in concert with other factors to induce mink blastocyst reactivation at the time of termination of embryonic diapause. In addition, upregulation of polyamine–related genes reflects intense synthesis of polyamines in the uterus at embryo reactivation. These provide another potential factor to reactivate the embryo.

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III–7 P

Sampling of genetic material in sable, coypu and marmot males

Igor Plotnikov and Oleg Bespyatykh
Russian Research Institute of Game Management and Fur Farming, Russian Academy of Agricultural Sciences, 79 Engels Street, Kirov, 610000, Russia
E-mail address: bio.vniioz@mail.ru

Introduction

To preserve biodiversity and to increase selection progress and maximum use of genetic resources of valuable animals, it is necessary to carry out artificial insemination. Its development in present-day conditions is impossible without using cryotechnology. In fur-bearing animal breeding, the technology of artificial insemination was developed in Russia only for polar foxes and red foxes (Bautina & Pomytko, 1987). The use of this method for other species of fur-bearing animals was hindered by the problem of acquiring sperm of good quality that may be used for cryoconservation and insemination of females.

Materials and Methods

We studied the possibility of taking sperm from sable (*Martes zibellina* L., 1758) males 2-13 years of age weighing 1.3-1.6 kg (*n*=25), from coypu (nutria) (*Myocastor coypus* Molina, 1782) males 6 months of age weighing 3.5-3.9 kg (*n*=14) and from marmot (*Marmota bobak* Mull., 1776) males 2-10 years of age weighing 3.6-9.4 kg (*n*=17). Since we failed to take sperm from these by masturbation, we applied electroejaculation (Plotnikov & Bespyatykh, 2004). The electroejaculator electrode is a plastic rod with 4 current conducting rings. It was wetted in a physiological solution before introducing into the animal's rectum. The alternative current was first switched on with a low voltage (1V), then the current was gradually increased to 4-6 V. Current impulses and intervals between them were 3-5s. Electrostimulation was stopped after the end of the ejaculate secretion. Sperm was taken from the animals which had been previously immobilized.

Results and Discussion

The period of electro-irritation of nervous centers in animals from the moment of introducing the electrode to the moment when the first drops of ejaculate appear made up 3-8 min. In the majority of cases ejaculation took place when the electrode was introduced into the rectum as deep as 6-8 cm and the current at 4 V was carried to both pairs of current conducting rings. In this case the irritation of pudendal and external spermatic nerves occurred, and that resulted in ejaculation.

From sable males ejaculates were taken in 56% of cases, and they were white and grey in colour. The volume of ejaculate was 0.1-0.2 ml, spermatozoa concentration varied from 31 to 127 millions per ml, with their mobility equal to 4-6 points. From 16% of males only a secretion of accessory genital glands was extracted. It should be mentioned that in sables the whole amount of ejaculate was not extracted at one moment, but a gradual dripping of sperm was observed. In some males a rapid urination after sperm extraction took place, probably because of electro-irritation of nervous centers. So, a fractional collection of ejaculate may be recommended for taking a good-quality sperm. From coypu males ejaculates were taken in 50% of cases. They had white and grey colour. The ejaculate volume was on the average 0.2 ml, spermatozoa concentration varied within 70-90 millions per ml, their mobility equal to 6-7 points. From 21.4% of males the secretion of accessory genital glands was extracted. From

marmot males ejaculates were taken in 53% of cases. The volume of ejaculate was 0.25-1.2 ml, spermatozoa concentration varied from 46 to 555 millions per ml, with their mobility equal to 5-8 points. For obtaining ejaculate of high quality and eliminating stress in the animals, they must be deeply anesthetized. Otherwise the animal will respond to manipulations, and ejaculate will coagulate partially or completely.

Conclusions

We conclude that it is possible to extract sperm of good quality from sable, coypu and marmot males, and the sperm may be used for cryoconservation and insemination of females of respective species.

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Lora Harris

IV-1 RP

Perspectives on traditional and alternative feed ingredients in future fur animal production

Øystein Ahlstrøm[1], Anders Skrede[1] and Karl Shearer[2]
[1]Department of Animal and Aquacultural Sciences
Norwegian University of Life Sciences
P.O. Box 5003, 1432 Ås, Norway
[2]Aquaculture Protein Centre, Centre of Excellence, Ås,
Norway
E-mail address: oystein.ahlstrom@umb.no

Abstract
As carnivores and non-food producing animals, mink and foxes utilize and recycle locally produced animal waste by-products which have no other alternative use than destruction.

From the world pelt production the total fur feed production can be estimated to 3.3 million metric tonnes of wet feed in 2007. Today, the majority of pelt production takes place in Europe, USA and Canada, while China is the largest single producing country. In fur animal production, feed expenses account for 70% of total costs and low feed costs are therefore a key factor for profit. A wet feed based on traditional by-products from slaughterhouses and the fishing industry will still be the basis for economical feed production in the future. The price and availability of animal by-products will depend on several factors, such as the cost level in animal production, alternative use of by-products decided by national and international regulations and the price competition from an industry exploiting the same by-products for other purposes. Emerging alternative ingredients are scarce, while ingredients like meat-and-bone meal and acid preserved poultry by-products are likely to be important in future fur animal feed.

Fur animal feed production

Carnivorous fur-bearing animals require a certain amount of animal protein and fat in the diet, and fur animal feed production is therefore based on by-product ingredients of animal origin not meant for consumption by humans or food producing animals. Typically the by-products are raw, unprocessed parts of slaughtered animals and fish. A large portion of the animal by-products used as ingredient for fur animal feed has no alternative use other than destruction or incineration, and there is therefore little question that the transformation of these waste materials into valuable fur should be profitable for both fur breeders and for society. There is also an ecological interest in recycling the nutrients and energy from these by-products, instead of disposing of them in environmentally damaging ways. Nevertheless, the economy of fur production is dependent on high quality and low cost ingredients to be profitable on the international fur market where prices vary from one year to another. Feed costs may account for about 70% of the total production costs and low feed costs are therefore a key factor in economical fur production. Typical character traits of the fur animal feed production are therefore flexibility in use of ingredients and a search for new ingredients, preservation methods and production systems that make the production more cost effective. Wet feed is usually the most common and the most inexpensive type of fur animal feed and the storage time is only a few days for the ready made feed. Thus, the transport distance for the by-product ingredients (fresh, frozen stored, acid preserved) to the production plant cannot be too long. The feed

Table 1. Mink and fox production in 2007 (million pelts)

	Mink	Fox
Europe	33.1	2.5
USA and Canada	4.5	-
China	18.0	4.5
World	**55.6**	**7.0**

Information from Oslo Fur Auctions 2008

resources are therefore mainly collected within the country where the production takes place.

This system is economical and probably the most environmentally sound since transport costs are minimized. The main continent for fur production is Europe. Especially in the Nordic countries with Denmark on top have large productions, whereas China was the largest single producer of mink and fox furs in the World in 2007 (Table 1). The European Fur Breeders' Association (1999) estimated that fur animal feed production in the EU countries consumed 0,284 million metric tonnes of poultry by-products and slaughterhouse by-products, and 0,365 million metric tonnes of fish by-products yearly. A rough estimate of the total feed usage by 33.1 million mink and 2.5 million foxes in Europe in 2007 (60 kg feed per mink pelt, 120 kg feed per fox pelt) was 2.3 million metric tonnes. On a world basis using the same preconditions for feed consumption, the total production estimate would be 3.3 million metric tonnes for 2007. It has been calculated that only 68% of poultry slaughter weight, 62% of pigs and 52% of bovine animals and sheep and goats, is consumed directly by humans (EU Directive 1774, 2002). In the EU countries, by-products from slaughterhouses account for approximately 10 million tons every year. Similar value for caught wild fish in Europe is about 11 million metric tonnes of processed fish of which 4.3 million metric tonnes are by-products. In addition, fish farming is increasing rapidly, with 65 million metric tonnes per year versus 80 million metric tonnes caught wild fish globally, and 18 million metric tonnes are processed in Europe (FAO Fish Stat Plus, 2004), resulting in approximately 8.0 million metric tonnes of by-products. A major part of the by-product material is then transformed into a number of products such as human food, animal feed, cosmetics, pharmaceuticals and products for technical use such as biofuel. Compared to the amount of by-products in, or nearby the fur producing countries, fur animal feed production is a minor consumer and therefore one can expect that the supply of animal by-product ingredients continues to be adequate for the years to come.

Factors that could affect prices or availability of animal by-product for the fur feed production

A major competition in the market for similar by-products as consumed by the fur animal feed industry is the pet food industry. This competition could significantly affect the prices of by-products. The number of cats and dogs in Europe is estimated to be 50 millions and 40 millions, respectively (Petfood Forum, 2007). Corresponding numbers in USA are 75 millions cats and 60 millions dogs. Cat and dog food sales are still increasing in Europe and reached $14.47 billion dollars in 2007 (Petfood Industry, 2008). An estimate of production volume, if prices are set to $5 dollars per kg, would be about 2.9 million metric tonnes of mainly dry food. The sale of pet food in Europe has increased 40% between 2001 and 2007. Western Europe and North America is considered mature markets for pet food. Typical expanding markets for pet food are Eastern Europe, as well as other parts of the world with rising economies such as China, India, Vietnam, Korea, Mexico and Brazil. However, the competition for by-products between the petfood industry and the fur feed industry is reduced by the fact that they have different preferences for the type of by-product. Dry foods are dominating the petfood market for dogs and meals made of by-products account for a large part of their protein content.

Unprocessed by-products are cheaper, and since fur animal feed is moist feed, feed producer would accept and prefer unprocessed by-products as well as by-products with high fat content. Fat energy is the most important energy source in fur animal production, while carbohydrates are the main energy source in dry pet foods (Case et al., 2000).

Today's increasing prices of feed ingredients for food producing animals is due to the increasing demand in Asia. This will result in higher meat prices and probably higher prices for by-products. Present prospects show that costs in meat production will go up because of increasing prices of oil, fertilizer, micronutrients and scarcity of cropland and irrigation systems. Production of bio-fuel is also another factor that would reduce available cropland even more. A side effect of this development could be that meat-and- bone meal will be reintroduced as feed ingredient for meat producing animals in Europe to reduce the import of the approximately 3 million metric tonnes of soybean meal that has replaced the meat-and-bone meal since the ban in 1999. However, food safety and ethical concerns must be adequately addressed in this matter. If the ban is lifted or lifted for some specific meal types e.g. poultry meal, it is difficult to predict how this would affect the prices of by-products, but there is a chance that the slaughterhouse industry will get higher prices selling the by-products as raw material to the meat-and-bone meal industry than to fur feed producers. This may result in higher prices for slaughterhouse by-products for the fur feed production.

Meat consumption in Europe and especially Asia has been predicted to increase towards 2020 (Bradford, 1999), and consumption of farmed fish is also showing an increasing trend. The increased demand for animal protein will result in increased animal production, especially poultry meat and pork (FAO, 2006) and thereby more by-products. But this trend will probably also encourage the food processing industry to intensify efforts to minimize the amount of low value by-products suitable for fur animal feed. The value-added research activity to make by-products more valuable has been high the last ten years, especially on producing n-3 essential fatty acid concentrates from fish-by products for human consumption and for companion animals. Concentrated and defatted protein sources made of by-products of animal origin are also examples of typical value-added products that are only of moderate interest for the fur feed industry because of their high price.

Ingredients in fur animal feed

Traditional ingredients

Feed ingredients applied in fur animal feed can be divided into animal, vegetable and single cell sources. Within this classification the sources can be divided into protein, fat and carbohydrate sources dependent on the nutrient content (Rouvinen et al., 2005). A precise definition of a traditional ingredient is difficult to give, but it would largely comprise fresh, frozen stored, acid preserved or dried products of animal origin containing mainly protein and/or fat. In addition, some vegetable oils and carbohydrate ingredients from different kinds of heat treated cereal grain can be considered traditional. The novelty that qualifies an ingredient to be called alternative could be that it is coming from a new source, or a new processing or preservation technology has been applied, or simply that an existing ingredient applied in other animal feed production has become available at a favorable price for a certain period of time.

Fish and fish by-products

Fish and fish by-products are considered to be the main protein, fat and mineral (Ca, P, Na, Se, I) source in fur animal feed. Protein from fish has a high content of methionine, which is the first limiting amino acid for mink and foxes, and fish protein can be used as the sole protein source in fur animal diets (Skrede, 1978). Fish by-products also contain high amounts of other

essential amino acids, but the level will depend on which part of the by-product is used. Muscle protein has high essential amino acid content, while connective tissue and bone have a lower content. The fish species that are used are usually divided into those storing fat in the muscle tissue (e.g. salmon, herring, mackerel) and those storing fat in the liver (e.g. cod species, flounder). Another classification considers species used for human consumption and those not used (e.g. capelin). The traditional by-product is definitely the fresh or frozen stored filleting scraps from cod species, which have a stable protein content of 16-17%, low fat content (0.5%) and a high protein digestibility (90%) (Skrede, 1978).

By-products from oily species like salmon, herring, and mackerel are typically used in fur animal feed and contain higher fat levels (5-30%) than the cod species. The fat content will vary with the type of product, whole fish or by-product, and the time of the year the fish has been caught. The fat is an excellent source for n-3 fatty acids and fat energy in general. The fat, however, is highly susceptible to oxidation during storage without antioxidant protection and it has been shown that mink require more vitamin E when fed high levels of dietary fish oil (Brandt et al., 1990). Notable when applying frozen stored or fresh salmon by-products is that the muscle contains the color pigment astaxanthine, which has antioxidant effects that could give an extra protection to the animals. Raw herring by-products may contain the enzyme thiaminase that destroys thiamine and can induce deficiency (Evans, 1975). High levels of dietary thiamine are therefore usually applied to reduce this risk when using high levels of raw herring by-products.

Fish silage is acid preserved (pH 3-4) ground whole fish or by-products. Fish silage can be defatted and concentrated after acid preservation if the raw material is from e.g. salmon, but mainly plain products are applied to fur animals. The main advantage of fish silage compared with other preservation methods is the low preservation and storage costs. Mixtures of sulphuric acid and acetic acid, or solely formic acid are most commonly applied. When acid is added, a large part of the protein becomes hydrolyzed by the acid and by proteolytic enzymes if the viscera are included (Johnsen & Skrede, 1981). The nutrient content is mainly dependent on the raw materials used, but one important nutritional factor to be aware of is that tryptophan is partly destroyed by the acid and the content is therefore lower in fish silage compared with fish meal (Skrede & Kjos 1995). Low feed pH (<pH 5) may also exceed the metabolic acid-base balance capacity in mink resulting in acidosis (Poulsen and Jørgensen 1977). Fish silage can account for a large part of fur animal feed (30-35%), but it is recommended to be used at lower levels during the most sensitive nutritional periods such as the reproduction period (Rouvinen et al., 2005).

Fish meal is mainly made of fish species not used for human consumption. Typical nutrient content of a high quality fish meal is 70% protein, 11% fat, and 11% ash. Protein digestibility is high (82-92%), and dependent on the drying method and ash content. Meals with low ash content and meals that are dried at moderate temperature have the highest digestibility. Generally fish meal is considered to be a safe, stable product with high protein quality, no antinutritional factors and good storage stability.

Slaughterhouse by-products

Slaughterhouse by-products from livestock and poultry account for a large part of the fur animal feed. These by-products consist of viscera and other parts of the carcass not used for human consumption (digestive tracts, throats, lungs, blood, poultry necks, backs and feet). Slaughterhouse by-products supply protein, fat and minerals to the feed and enhance palatability. The by-products are applied in

various ways; fresh, frozen stored, acid preserved or as dry meal products such as meat meal, meat-and-bone meal, poultry meal or blood meal. The content and composition of protein and fat will vary with the species and with type of by-products. A rough average for fresh or frozen stored materials will be 10-25% and 5-30% for protein and fat, respectively. In general the amino acid composition is very good, but is considered poorer than for fish by-products due to the lower levels of sulfur containing amino acids (Murray et al., 1997). If the by-products contain large amounts of connective tissue or bones, the content of essential amino acids will be lower than in by-products containing more protein from soft tissue. Protein from connective tissue and bone will also have low protein digestibility, and high ash content is an indicator of low protein quality and digestibility. Fat level and fatty acid composition and fat digestibility are also dependent on the species and from which part of the animal the by-product originates (Rouvinen et al., 1989). Poultry fat is the most unsaturated and has the highest digestibility (94%), while pig fat (lard) and beef fat (tallow) are more saturated and have a digestibility of about 85% and 78%, respectively. Animal fat from by-products is the most important energy source in fur animal feed today.

The main challenge when using slaughterhouse by-products is to obtain and maintain satisfactory hygienic quality. Acid preservation is an applicable and cheap method, but as for fish silage, adverse effects on animals may occur if inclusion level is too high. Preservation with formic acid and benzoic acid has been shown to be successful in maintaining a stable product (Pölönen et al., 1997). Sulfuric acid and acetic acid are probably the most common method applied for preservation of poultry by-products used in Danish feed production.

Alternative feed ingredients

The type of ingredients used in fur animal feed has been quite stable over the decades, but inclusion levels may vary because of fluctuations in price. However, new and alternative ingredients turn up on the market from time to time. This occurs mainly as a result of new regulations limiting the use of particular by-products as feed for meat producing species. A good example of this is the ban of using meat-and-bone meal for food producing animals in 1999 in Europe. The regulation resulted in lower prices for meat-and bone meal and also raw materials for the meat-and-bone meal production were made available at low prices for the fur feed production. Meat-and-bone meal is considered a poor protein source, but because of current low price it can be used at moderate levels if other superior protein sources are added. Methionine supplement is also a possible way to improve the poor protein quality when using meat-and-bone meal.

A similar and even more promising ingredient is poultry by-products that have become a main protein source in European fur animal feed. The product is acid preserved or heat treated or both methods are applied. Acid preserved poultry by-products are a typical ingredient that fits well into fur animal feed containing equal parts of protein (15%) and fat (15%). Based on forecast of a considerable rise in poultry production towards 2020 (Bradford 2020), it is anticipated that poultry by-products could become even more dominating as ingredient in fur animal feed than it is today.

Vegetable

Vegetable protein sources such as soybean meals, pea meals, gluten meals, potato protein meals) can be used as a part of the protein supply in fur animal feed (Rouvinen 2005). Soybean products and pea products have been used with good results, but because of high prices as compared with more suitable animal protein sources one can hardly expect that any of these vegetable protein sources will have a permanent place in fur animal feed in the future.

Carbohydrates have an important role in fur animal feed as an energy source and to give proper consistency to the feed. The digestibility is dependent of the type of plant source which is mainly grain, and the heat treatment. Starch is the carbohydrate that can be utilized by fur animals and heat treatment is necessary to obtain adequate digestibility and to enable the product to absorb water. Several cereal grains and vegetables are applied (wheat, barley, oats, corn, pea, potato) and the product can be a mixture of two or three types of grain. Heat treatment is expensive and a future alternative to heat treatment could be enzyme treatment which is common in both poultry and pig feed production.

Single cell

Bacterial protein meal (Bioprotein) has shown to be a suitable protein source for production animals including the mink (Skrede et al., 1998). The future prospect for Bioprotein production is for the time being not clear so the product is not available on the market. Single cell plant protein (algae) products have been tested in digestibility experiments with mink showing promising results (Ahlstrøm, unpub.). Single cell protein sources can be used in the future if commercial production becomes successful and if the products are offered with similar price and properties as that of other comparable meal types of vegetable or animal origin.

Wet feed versus dry feed

If the fur industry is to keep its image of transforming low cost waste by-products with no better alternative use than destruction, into valuable fur, it is important to make sure that a large part of the feed is made up by traditional unprocessed animal by-products. This concept is used today, and so far the use of wet feed based on traditional animal by-products from the fishing industry and slaughterhouses are dominating because of low cost compared with the use of complete dry extruded feeds. Dry feeds have a more stable nutritional quality and obvious beneficial effects on reducing the risk of detrimental microbial growth. The transport and storage costs are also lower than in wet feed production. However, the processing costs are much higher in dry feed production. An important advantage in wet feed production is that it allows high short term flexibility in the choice of feed ingredients. Furthermore, high fat levels can be obtained much more conveniently than when producing dry feed. Dry feed production is a technically advanced process and to obtain high product quality there is little room for variation in the ingredient list or ingredient inclusion levels. High fat inclusion is particularly challenging when producing dry feed because the fat has to be completely absorbed into each kibble. Even though dry feed is highly recognized in other animal production and can be used with good results for fur animals, there is no indications that use of dry feed will increase in countries and areas where wet feed production is established, as in the Nordic countries.

Conclusions

Fur animal feed production relies on the use of low cost by-products of animal origin. A wet feed produced from traditional raw by-products from slaughterhouses and the fishing industry will still be the basis for economical fur animal feed production in the future.

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IV – 2 RP

Processing of animal by-products used in feed for fur animals – effect on nutritional value and hygienic quality

Christiansen, Mette Line E[1]. & Lassén, Tor Mikael[1],
[1]National Centre|Fur Animals, Danish Agricultural Advisory Centre,
Udkaersvej 15, Skejby, DK-8200 Aarhus N. Denmark
E-mail address: tml@landscentret.dk

Introduction

Feed for fur animals is mainly made of fresh animal by-products, dried protein of plant and animal origin, grain and vegetable oils and animal fat. Most of these by-products are available in equal amounts around the year, but the production of fur animal feed is not evenly distributed during the year and the main production is concentrated in the growing-furring period from July to pelting in November. Therefore the main part of the by-products must be stocked for a longer period and processed in order to maintain a good dietary quality until use. Some of the by-products have a high initial bacterial load and must be processed to remove harmful bacteria and to reduce the initial bacterial load. In this paper, different methods of processing animal by-products and in which way they will affect the stability and nutritional and hygienic value of the product will be discussed.

Mechanisms for spoilage of fresh animal by-products

The hygienic quality of wet mink feed is significantly influenced by the microbial contamination that has occurred in the feed ingredients. Feed ingredients like fresh animal by-products contain bacteria that cause decomposition as well as feed borne diseases such as salmonellosis, botulism and campylobacteriosis. The products belonging to the group of fresh animal by-products are fishery by-products, industrial fish, fresh blood from pig slaughterhouses and by-products from pig, chicken and cattle slaughterhouses. The high moisture content of these ingredients makes them susceptible to spoilage if not properly stored and handled. To ensure high feed quality, degradation and spoilage of feeds and feed ingredients must be prevented. Minimizing the survival and growth of microorganisms is the most critical step in ensuring that the hygienic quality of the feed is maintained. To do this one must understand and control the factors that affect microbial growth. (Jay, 2000).

The time microorganisms are allowed to grow in the by-product is crucial to how severe the spoilage will be. Normally there is a delay period (or lag phase) when the feed ingredient is contaminated. If conditions become optimal for the microbes present microbial growth proceeds rapidly into the next phase; the growth phase. During the growth phase the number of bacteria can increase from a single cell to one million bacteria in as little as six hours (Kangas & Juokslahti, 1975; Kangas et al., 1982). After the growth phase there is normally a period of diminished growth rates, as nutrients, moisture, and oxygen are exhausted or toxic end products accumulates. Hygienic quality will be best in by-products that are preserved or properly stored during the lag phase, before microbial growth begins. Delaying until the growth stage will give the microbes opportunity for rapid reproduction.

Feed ingredients used in fur animal feed have high moisture content and contain nutrients that will support the growth of a wide range of microorganisms. To reduce the microbial growth it is therefore necessary to manage the

other factors that influence microbial growth and feed decomposition, temperature, moisture, pH and oxygen (Jay, 2000).

Temperature is one of the most important factors affecting microbial growth, and microorganisms can be classified according to their optimum temperature range (Jay, 2000). Most spoilage bacteria grows at low temperatures (0 – 7°C), while most of the pathogenic bacteria grow in the area of 25-45°C (Jay, 2000). *Salmonella spp.,* which is present in both Danish and imported animal by-products, is one of these. Thermophilic microorganisms grow best at temperatures between 50 and 70°C, and temperatures below 30°C will usually slow or inhibit the growth. *Clostridium* bacteria, which cause botulism, belong to this group, but will also grow in temperatures as low as 15°C (Kangas & Juokslahti, 1975; Kangas et al., 1982).

Feed ingredients can also be preserved by controlling oxygen levels. The bacterium that causes botulism (*Cl. botulinum*) is an anaerobic bacterium. It will become a problem if a slaughter by-product is stored without oxygen at temperatures above 15°C (Kangas & Juokslahti, 1975; Kangas et al., 1982).

The pH of the by-product has a great influence on the survival and growth rate of microorganisms. Most bacteria grow well in a neutral pH range. Since the pH of raw unprocessed slaughter- and fishery by-products is usually 6.1 or higher, these by-products are susceptible to spoilage by a wide range of bacteria. Most pathogenic bacteria do not grow under pH 4.0 (Lassén, 2007).

Microorganisms also require water in order to survive and reproduce. Specifically, they require free or unbound water, i.e. water not bound to protein or carbohydrate. The amount of free water presented in a by-product is referred to as the water value (a_w). If the by-product has an a_w value of 0.5, half the water is bound and unavailable for use by the microorganisms. Most spoilage and pathogenic bacteria grows at a_w values over 0.91, however yeasts and moulds can survive and grow at a_w values as low as 0.6, which may result in growth of moulds in fish silage.

Preservations factors can interact to create a hurdle effect in which one factor will enhance the preservation effect of another factor (Leistner, 1995). For example, the effective pH for feed ingredients may be higher (i.e. less acid is required) if the feed ingredient has a low free water content or if it is chilled. However, interactions among factors can also make feed ingredients more susceptible to spoilage. Wet ingredients will spoil more rapidly than dried animal by-products, especially when the storage temperature is high. These types of interactions need to be considered when evaluating preservation and storage options for the animal by-products to be used.

Processing of animal by-products to improve or maintain hygienic quality

The initial bacterial load varies a great deal between animal by-products and is also influenced by the hygienic standards at the place of processing. Fresh blood from pigs collected with a hollow knife and obtained under sterile conditions may be kept sterile under Good Manufacturing Practice (GMP) conditions. Under GMP conditions, it also possible to maintain low bacterial load of fresh by-products from pig slaughterhouses, and there is no need for other treatment than keeping the by-products at +5°C. For example, viscera from chicken are a good source of digestible protein and energy, however, they contain high levels of bacteria and intestinal enzymes.

One objective of feed processing is to use temperature to kill microorganisms or reduce their growth rate. Chilling (0 to +4°C) or freezing (-20 to -25°C) will inhibit bacterial growth but will not kill most bacteria. To avoid microbial growth to start with, the entire batch of ingredients must be completely chilled to

refrigeration temperatures within 3 hours. The time it will take to reduce the temperature depends on the cooling system and surface to volume ratio of the by-product unit. During storage and transportation it is important to keep a constant temperature. If the temperature is allowed to increase both microbial growth and enzyme activity will resume. It is essential to maintain an unbroken cold-chain especially in warm weather or if the refrigeration period will be longer than 3 days.

Freezing is a common method of by-product preservation, which slows down both the decay of feed ingredients and most chemical reactions and makes water unavailable for bacterial growth, by turning water to ice. Feed ingredients may be preserved for several months by freezing. Long-term freezing requires a constant temperature of -20°C or below and it is also necessary to add antioxidants to all ground feed ingredients with a fat content higher than 3%. The time feed ingredients, especially fatty fish, can be kept in the freezer is further reduced considerably if the temperature in the freezer fluctuates. Fluctuations could occur due to a small gap in the freezer door or due to the addition of a large amount of thawed or unfrozen by-products.

Heating treatment (80°C) affects the quality of animal- and fishery by-products in several ways. Heating the material separates the fat from the tissue, allowing the production of fat and oils from chicken by-products and fatty fishery by-products. Mackerel by-products have a high fat content, which often reduces inclusion of the by-product in mink feed. However by heating the product, part of the fat can be removed by decanting. Excessive fat in chicken by-products can be removed in similar ways.

Cooking (100°C) fresh by-products will kill many pathogenic and spoilage microorganisms and improve the hygienic quality. However the by-products are not stable for further storage. Therefore the by-products have to be either frozen or acidified after cooking. Pressure-cooking at 133°C is used in the rendering industry to sterilize animal by-products with a high initial bacterial load. These by-products must also be frozen or acidified if they are to be stored for a longer period. The nutritional value is decreased when pressure-cooking is used as a processing method and the low digestibility of the protein will reduce the amount of by-product that can be used in the ready mixed feed.

Acid ensiling is an economical preservation method for fishery and poultry by-products and can be adapted either for short term or long term storage. It greatly reduces the risk of microbial spoilage and of problems that results from protein decomposition (ammonia and biogenic amines). However, acid preservation must take place as soon as possible after fish landing or slaughter. Decomposition will occur rapidly in these materials, and acid preservation will not reverse these processes. It is also critical to develop a consistent procedure that ensures adequate pH reduction for the ingredients that are to be ensiled. For some by-products, modified acid ensiling represents an option for preserving hygienic quality until the ingredient can be frozen or further processed. This is especially beneficial when fresh by-product ingredients are to be transported over long distances or in hot weather.

Effects of processing on hygienic quality and nutritional value

Processing influences the nutritional value of by-products and high inclusions acid in the feed reduces both palatability and feed conversion. As shown in Table 1 there is a great decrease in both palatability and digestibility, when fresh chicken by-products are processed in different ways. Cooking and pressure cooking have a great influence on both palatability and protein digestibility. Often it is observed that processing influences the digestibility of individual amino acids more than the protein digestibility. The actual digestibility of individual amino acids is not included in Table 1, but is described in each

Table 1. Total bacterial count, risk of growth of *Salmonella* and *Clostridium*, protein digestibility and palatability score of processed or unprocessed animal by-products used in fur animal feed.

Product	Bacteria count at 21°C (cfu/g)[1]	Risk for growth of: [2]		Protein digestibility (%) app.	Palatability compared to fresh product[3]
		Salmonella	*Clostridium*		
Fresh herring[4]	100.000	Low	Low	88	Higher
Preserved herring[5]	25.000	Very low	Very low	89	Low
Ensiled herring[6]	< 1.000	Zero	Zero	84	Lower
Fresh salmon[7]	500.000	Low	Low	88	Higher
Ensiled salmon[8]	< 1.000	Zero	Zero	84	Lower
Fresh chicken[9]	3.000.000	High	Moderate	87	Higher
Preserved chicken[10]	10.000	Zero	Low	91	Higher
Cooked chicken 100°C[11]	< 1.000	Zero	Low	80	Low
Sterilized chicken 110°C[12]	< 1.000	Zero	Zero	74	Low
Sterilized chicken 133°C Farmfood[13]	< 1.000	Zero	Zero	72	Lower
Sterilized chicken 133°C German[14]	< 1.000	Zero	Zero	69	Lower
Fresh slaughter by-products, pig low ash[15]	1.000.000	Moderate	Moderate	89	Higher
Fresh slaughter by-products, pig high ash[16]	1.000.000	Moderate	Moderate	72	Low
Sterilized slaughter by-products, pig 6% ash[17]	<1.000	Zero	Zero	85	Low
Sterilised slaughter by-products, pig 13% ash[18]	<1.000	Zero	Zero	76	Lower

[1] Based on typical analyses from the report from Voluntary Feed Control Denmark, [2] Based on risk analysis according to HACCP, [3] Based on palatability trials and observations, [4] F198, [5] F212, [6] F156 & F164, [7] F281, [8] F283, [9] F298, [10] F334, [11] F327, [12] F349, [13] F328, [14] F150, [15] F242&F240, [16] F317, [17] Based on in-vitro analysis, [18] F155 & F169.

of the references. The amino acid tryptophan is very sensitive for processing and both heating and acidifying may reduce both the content and the digestibility of this amino acid. Freezing does not generally influence the nutritional value of products, if fat oxidation is avoided.

Palatability is greatly influenced by processing. Fresh or frozen stored animal by-products have a high palatability in comparison to processed by-products. Low palatability of the feed may be a result of acidifying agents used to preserve a specific by-product or spoiled feed ingredients. Freezing has little or no effect on palatability. This occurs if enzyme activity is allowed to oxidize the polyunsaturated fatty acids.

Mink are very sensitive to the growth of some specific bacteria, *Clostridium botulinum*, being the most dangerous. In many countries, the mink population is vaccinated against Botulinum toxin type C, which is the most common. However in Denmark, mink have not been vaccinated, because fresh animal by-products are delivered with a temperature under +6 °C. These by-products are either immediately chilled to temperatures under +4°C or frozen immediately after slaughtering, which keeps the growth of both spoilage and pathogenic bacteria at a low level (Lassén, 2001). There is, however, always a risk for the fresh by-products to be contaminated with *Salmonella spp*.. This can only be avoided by heating the product or by adding acids to the product. However, mink is most sensitive to salmonella during pregnancy, especially to *Salmonella dublin*, and by-products with a potential risk to be contaminated with this specific bacteria should be excluded from the feed during pregnancy.

Conclusion

To prevent animal by-products from spoiling during short and long term storage, they must be processed or preserved. Proper handling during slaughter and chilling is essential to keep the by-products fresh and maintain high palatability and digestibility of nutrients. Freezing the by-products does not influence palatability or digestibility, but will not kill potential pathogenic bacteria. Ensiling fresh animal by-products does not influence digestibility but decreases palatability. Heat treatment kills pathogenic bacteria, but decreases both palatability and digestibility. Heat treatment should only be used for animal by-products with a high initial bacterial load. Proper handling of by-products combined with chilling, freezing and ensiling will provide the most efficient way of storing animal by products without decreasing palatability and digestibility.

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IV – 3 RP

Protein requirement for maintenance in adult male mink *(Neovison vison)*

Carsten Hejlesen[1)], Peter Sandbol[1)] & Niels Enggaard Hansen[2)].
[1)] Danish Fur Breeders Research Centre, Holstebro, Denmark.
E-mail address: ps@pfr.dk
[2)] University of Copenhagen, Faculty of Life Sciences, Department of Basic Animal and Veterinary Sciences

Abstract
Adult male mink were fed diets based on common ingredients, containing 15, 11 or 7% of the metabolizable energy from protein (MEp). Another two groups were fed a diet with either 15 or 7% of MEp where all the protein was based on Free Amino Acids (FAA). The average voluntary feed intake was lower with decreasing dietary protein content. The energy consumption was very low in this particular trial period. The energy requirement for maintaining constant weight was measured to be 153 kcal/kg$^{0.75}$ at 14° C and N (protein) requirement for maintenance was calculated to be 11.5% of ME. In summary, the data indicated that the N-balance achieved using FAA did not differ from regular diets.

Introduction
Nutrient requirement is divided between a requirement for maintenance and a requirement for production. This production may consist of pregnancy, lactation, body growth or hair growth. When determining the nutrient requirement for mink during different parts of their life cycle, it will therefore be of help to know the requirement for maintenance.

Initial work to establish the maintenance requirement using from 14.9 – 26.7% MEp (% of metabolisable energy from protein) was reported by Hejlesen (2004). It was concluded that the MEp requirement is below 14.9%. The present experiment was set up with the same design and the same amino acid (AA) profile as reported by Hejlesen (2004), but with lower MEp levels in order to more accurately determine the requirement.
In addition, it would be interesting to clarify if mink respond differently to dietary free amino acids (FAA) than to amino acids from protein ingredients. Therefore two parallel diets containing only FAA, as used by Hvam (2007), were included in the design.

Materials and Methods
Animals
Each treatment group was comprised of six adult male mink of the Brown/Glow colour type. During the experiment, the animals were housed in metabolic cages modified after Jørgensen (1973), at a constant temperature (14 ºC).

Feeds and Feeding
Three diets were made, based on common ingredients, and containing 15.0 (IP15); 11.0 (IP11) and 7.0% (IP7) of MEp respectively (Table 1). The corresponding levels of ME from carbohydrates (MEc) were 30.3; 31.4; and 32.6%.

The content of ME was calculated from table values, and consequently the increasing difference between apparent and true digestibility with falling protein content was not taken into account. Carbohydrates were calculated by difference (Dry Matter - Ash - Crude Protein - Crude Fat). Diet IP15 was made as in the earlier trial (Hejlesen, 2004). The AA content relative to lysine and apparently digestible AA per 100 kcal are also shown in Table 1.

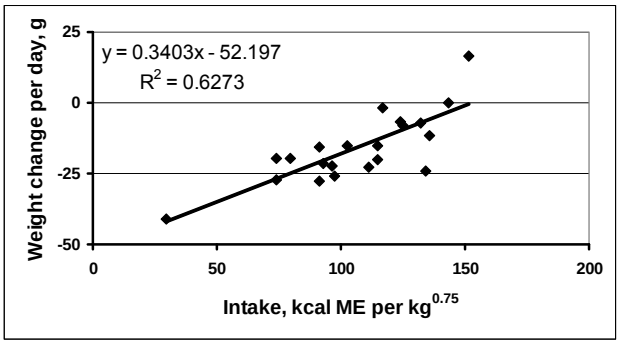
Table 1. Feed ingredient composition as fed, planned AA content, and calculated and analysed proximate composition.

Ingredient, %	IP15	IP15	IP15	IP11	IP7	FAA15	FAA7
Industrial fish, 8-12% fat	-	-	2.8	2.4	1.9		
Poultry offal	-	-	13.1	11.9	8.8		
Slaughter offal	-	-	16.9	14.6	11.4		
Barley /wheat, popped, 90%<0,5mm	-	-	3.8	3.4	2.6		
Feather meal	-	-	0.8	0.7	0.6		
Haemoglobin meal	-	-	0.2	0.2	0.2		
Peas, heat treated	-	-	2.9	2.5	2.0		
Potato protein meal	-	-	1.5	1.3	1.0		
Corn gluten meal	-	-	1.9	1.6	1.3		
Soya concentrate	-	-	0.4	0.4	0.3		
Soya oil	-	-	8.3	11.0	15.0	7.3	11.7
Lard, max 1.5% FFA	-	-	4.2	5.5	7.5	7.3	11.7
Corn starch	-	-	16.7	22.0	29.8	20.0	32.0
Vitamin & mineral premix	-	-	0.26	0.23	0.18	0.48	0.49
Cellulose	-	-	-	-	-	4.7	4.8
Water	-	-	26.0	22.5	17.5	52.1	33.7
Amino Acids							
	Relative	g App. Digest	%	%	%	%	%
Alanine	to Lysine	/ 100 kcal					
Arginine	101	0.204	-	-	-	0.48	0.33
Aspartic acid	103	0.208	-	-	-	0.49	0.34
Cysteine (HCL-salt)	132	0.267	-	-	-	0.63	0.44
Glutamic acid	24	0.049	-	-	-	0.17	0.12
Glycine	241	0.486	-	-	-	1.15	0.79
Histidine	107	0.217	-	-	-	0.51	0.35
Isoleucine	40	0.081	-	-	-	0.19	0.13
Leucine	74	0.149	-	-	-	0.35	0.25
Lysine (HCl-salt)	159	0.322	-	-	-	0.76	0.52
Methionine	100	0.201	0.02	0.02	0.01	0.61	0.42
Phenylalanine	82	0.166	0.26	0.23	0.18	0.39	0.28
Proline	84	0.169	-	-	-	0.40	0.28
Serine	110	0.222	-	-	-	0.52	0.36
Threonine	92	0.185	-	-	-	0.44	0.30
Tryptophan	72	0.145	0.04	0.03	0.03	0.34	0.24
Tyrosine	22	0.044	0.03	0.03	0.02	0.10	0.07
Valine	65	0.131	-	-	-	0.31	0.21
	100	0.201	-	-	-	0.47	0.33
Planned energy distribution, % of ME							
Protein							
Fat	-	-	15	11	7	13	6
Carbohydrate	-	-	55	58	60	56	60
	-	-	30	31	33	31	34
Content per kg dry matter, calculated							
Kcal, ME							
MJ, ME	-	-	5195	5397	5620	4963	5331
Crude protein, g	-	-	21.8	22.6	23.5	20.8	22.3
Crude fat, g	-	-	205	160	106	146	74
Ash, g	-	-	321	349	380	314	364
	-	-	27	22	18	10	10
Analysed content per kg dry matter							
Crude protein	-	-	199	157	113	145	75
Crude fat	-	-	327	347	386	264	330
Ash	-	-	18	15	11	4	4

The diets IP11 and IP7 were made by the addition of fat (1/3 of lard + 2/3 soya oil) plus pregelatinized corn starch to diet IP15 (Table 1).

The two FAA diets (FAA15 and FAA7) were composed to have an AA content and profile similar to diets IP15 and IP7.

Figure 1. Body weight change (g) as a function of energy intake (ME) during the collection period. An ME intake of 153.4 kcal/kg$^{0.75}$ is calculated as the requirement for maintenance at constant body weight for adult males.

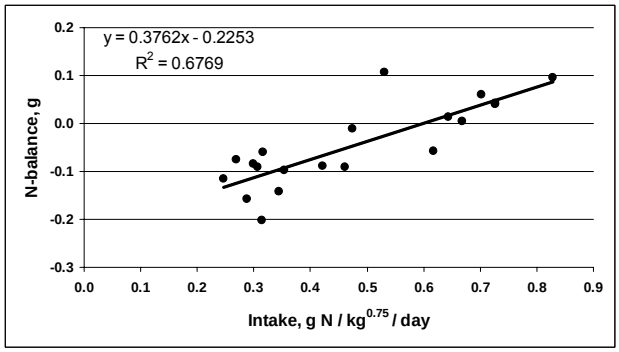


Upon calculation of the diet compositions, all AAs were assumed to have a purity of 98% and an apparent digestibility of 96%, with the exception of cystine and lysine, which were included as HCl salts, and therefore only had a purity of 69% and 78% respectively The animals were fed approximately 400 kcal ME per day on the IP feeds and approximately 300 kcal per day on the FAA feeds.

Measurements

Daily feed intake was measured. The trial lasted 11 days with a 7-day pre-period and a 4-day 24h quantitative sampling of faeces and urine. Faeces were stored at -18 °C until analyzed for dry matter, ash, crude protein and crude fat. Urine was collected in 500 ml plastic bottles containing approximately 60 ml of 5% H_2SO_4 to ensure a low pH. Urine in the feeding tunnel was absorbed with N-free filtration paper and put into the storage bottle. Each day in the collection period, the urine was transferred into 200 ml bottles and stored at -18 °C until analysis for crude protein. The animals were weighed before the trial, at the beginning of the sampling period and at the end of the trial, so body weight changes during the two periods could be calculated. Endogenous faecal nitrogen was calculated as 0.278 g of N per 100 g DM intake (Skrede, 1979).

Figure 2. N-balance (intake - faecal and urinary excretion) as a function of intake (g) pr kg metabolic weight.



Results

There was a good agreement between the calculated and the analysed content of CP in all diets. For fat, the agreement was good for the IPFAA diets, but for the FAA diets the analysed content was lower than expected. The analysed of ash content was generally lower than calculated (Table 1).

During the whole trial period, animals from, all groups had a markedly low feed intake : the reason for this is not clear. Therefore, period. 1 and period 2 males from groups IP15 and IP7, respectively were excluded due to unacceptably low feed intake. Similarly 4 and 3 males were excluded from groups FAA15 and FAA7. Because of the low energy intake, male weight was reduced by 10 to 22 g on average per group on daily basis. Based on the energy intake and the weight change during the collection period, the ME requirement for maintenance of constant weight could be calculated as 153.4 kcal/kg$^{0.75}$ at 14 °C (r^2=0.63) (Figure 1). Correcting for temperature (Chwalibog et al., 1979), this corresponds to 131.2 kcal/ kg$^{0.75}$ at 20 °C, which is identical to the value of 132 kcal/ kg$^{0.75}$ reported by Hejlesen (2004).

The energy intake decreased with decreasing MEp in the IP diets (Table 2) and was significantly different between IP15 and IP7. With the FAA diets, the highest intake was with

Table 2. Body weight, protein balance and digestibility data for the collection period, units/day

	IP15	IP11	IP7	FAA15	FAA7	p <
Males included, n	5	6	4	2	3	
Metabolic weight, $kg^{0.75}$	2.01^{ab}	2.04^{a}	2.02^{ab}	1.90^{b}	1.99^{ab}	0.0224
Weight change/day, g	- 11.4	- 10.1	- 22.3	- 20.9	- 15.5	ns
Per kg metabolic weight ($kg^{0.75}$)						
ME intake, kcal	115^{a}	108^{ab}	85^{b}	86^{b}	127^{a}	0.0273
N intake, g	0.72^{a}	0.51^{b}	0.29^{c}	0.41^{bc}	0.30^{c}	0.0031
Faecal N, g	0.14^{a}	0.12^{b}	0.08^{c}	0.05^{c}	0.06^{c}	0.0249
Endogenous faecal N [2)]	0.06^{ab}	0.06^{abc}	0.04^{c}	0.05^{bc}	0.07^{a}	0.0399
Apparent digestible N, g	0.58^{a}	0.40^{b}	0.21^{bc}	0.35^{cd}	0.23^{d}	0.0421
Urinary N, g	0.54^{a}	0.42^{b}	0.32^{c}	0.45^{ab}	0.36^{bc}	0.0321
N-Balance, g	0.04^{a}	$- 0.02^{ab}$	$- 0.10^{bc}$	$- 0.09^{bc}$	$- 0.12^{c}$	0.0450
Protein digestibility						
Apparent	80.6^{b}	77.0^{c}	73.2^{d}	86.6^{a}	78.5^{bc}	0.0148
True	89.3^{b}	88.0^{b}	88.6^{b}	98.5^{a}	101.7^{a}	0.0001

[1)] Average of body weight at start and finish as $kg^{0.75}$.
[2)] Calculated according to Skrede, 1978

the lowest MEp. Since about half of the animals fed these diets were excluded from the statistic, the results should be interpreted with caution.

Among the IP diets, IP7 differed significantly for most parameters because of both lower intake and the lower dietary N.content, The N intake with the FAA diets was less on an energy basis compared to the IP diets. This might have been compensated for by the higher N digestibility of the FAA diets. As expected, faecal N decreased with a decreasing MEp in the IP diets as a consequence of the lower N content in the feed and the lower feed intake. The FAA diets had the lowest faecal N among the five groups. The calculated faecal endogenous N in the FAA diets corresponded to the analysed faecal N. Therefore the true protein digestibility of the FAA diets was 98.5 and 101.7% for the FAA 15 and the FAA7 diets, respectively.

The calculated true protein digestibility of all the IP diets was significantly lower than in the FAA diets ($p<0.001$). Both for the IP and the FAA diets the apparent digestibility decreased with decreasing MEp ($p<0.02$). Furthermore, the urinary N decreased with decreasing MEp and N intake. The N-balance decreased with decreasing MEp for both the IP and the FAA diets. Only the IP15 diet gave a positive N-balance and the N-balance of all the other diets were significantly lower ($p<0.05$).

Discussion

For the IP diets, the energy intake was below maintenance and decreased with decreasing MEp in the interval from 15 to 7%. Earlier results have shown an increasing energy intake with decreasing MEp in the interval from 27 to 15% (Hejlesen, 2004). Other trials carried out during the same period have also shown large variations in feed intake and a generally lower intake. Recent trials at our institute indicate, that this may be a seasonal phenomenon.. The energy intake in the present trial was markedly lower at 15% MEp (115 kcal/ME/$kg^{0.75}$) than reported earlier by Hejlesen (2004) (161 kcal/ME/$kg^{0.75}$). The diet compositions at 15% MEp in both trials were close to identical,indicating that there may be other reasons for the low feed intake in the present experiment. It is worth considering whether the different trends in the two trials could be caused

by actual levels of specific amino acids, which could have stimulating or suppressing effects on feed intake.

From Table 2 it can be seen that zero N-balance should be found with an MEp between 11 and 15%. For the FAA diets, this was not the case. However, it seems very possible that this is caused by the generally low feed intake with these diets.

There is variation in the methods of expressing maintenance requirements for N (Burger et al., 1985, Hendriks et al., 1997). We have chosen to determine the N requirement for maintenance directly by plotting the N-balance as a response to the N-intake as described by Dempsey et al. (1985). The requirement is determined as the amount of N per animal and day, which, using an estimated apparent protein digestibility, can be converted to MEp. Using this method, the present data (Figure 2) shows a requirement of 0.6 g N / $kg^{0.75}$ (R^2=0.69). From the measured apparent protein digestibility of the IP diets and the corresponding N intakes (table 2) the apparent N digestibility at an intake of 0.6 g N / $kg^{0.75}$ can be calculated to be 78.5%. The calculation of the energy requirement for maintenance at 14°C (Figure 1) showed 153.4 kcal ME / $kg^{0.75}$. Consequently 0.6 g N / $kg^{0.75}$ corresponds to 8.6% of MEp.

Recovery of urinary N in balance trials is typically below 100% (Elnif, 1992, Wamberg et al., 1996 & Hejlesen, 2004). Figure 2 shows, that the balance is positive at a N intake higher than 0.6 g N/$kg^{0.75}$. Based on the results from Hejlesen (2004) it is reasonable to assume a urinary N recovery of 90% under similar conditions. Adjusted for this underestimation, the protein requirement for maintenance corresponds to 11.5% MEp.

A valid comparison of the FAA diets and the IP diets was compromised by the low feed intake particularly with the FAA diets. However, the inclusion of the FAA data in the above regression of N for maintenance did not change the estimate but only reduces the R^2 value from 69 to 68. This indicates, that FAA diets should give the same responses as IP diets.

Conclusion

The results indicate a decreased feed intake with decreasing MEp below 15%. There was a clear decrease in feed intake when all dietary protein was made up from FAA. It is calculated, that the protein (N) requirement for maintenance in adult mink males correspond to 11.5% of MEp at an energy requirement for maintenance of 153 kcal/$kg^{0.75}$ at 14°C (equivalent to 131kcal/$kg^{0.75}$ at 20°C).

The results further indicate that future N-balance trials can be carried out with FAA diets.

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IV-4 RP

DL- methionine supplementation to low protein diets in mink during the breeding season

Nita Koskinen[1], Jarmo Valaja[2], Ilpo Pölönen[3], Maarit Mohaibes[1] and Teppo Rekilä[1]

[1]MTT Agrifood Research Finland, Fur Animal Production, Kannus, Finland
[2]MTT Agrifood Research Finland, Monogastric Research, Jokioinen, Finland
[3]Laurea University of Applied Sciences, Natural Resources and Environment, Hyvinkää, Finland
E-mail address: nita.koskinen@mtt.fi

Abstract
The main aim of the study was to find out to what extent DL-methionine supplementation to a low protein diet affected breeding results in mink. Treatments were: Protein 25% of metabolizable energy (ME) supplemented with methionine 1 g per kg feed and Protein 35% of ME without methionine supplementation. Body weight, feed consumption, reproduction data, and some blood parameters were recorded. Plasma total protein was affected by the protein level of the experimental feeds. The breeding result 7 weeks after parturition was 0.54 and 3.66 ($p<0.001$) cubs per mated female in treatments Protein 25% and Protein 35%, respectively. The 35% level produced normal reproduction results for the farm, but the DL-methionine supplementation did not compensate for the low dietary protein content of the 25% Protein diet. This shows that the poor reproduction results with this diet was not because of deficient DL-methionine supplementation, but due low levels of both for dispensable and indispensable amino acids in general.

Introduction

The mink, as a strict carnivore and a seasonal breeder, needs high levels of dietary essential amino acids both in the growing-furring season and in the breeding season. The composition of protein in feed and protein requirements of animals has been in continuous focus in the scientific field and in practice. Raw materials rich in protein are the most expensive in fur animal feed and directly affect the price of the feed and thus the cost of fur animal production. Indeed there is no advantage in feeding animals more than the protein requirement for physiological, economical or environmental reasons.

Earlier feeding experiments showed that it was possible to decrease the protein recommendation during the growing-furring season of blue foxes (Dahlman et al., 2002; Koskinen et al., 2005). At the same time it was noticed that methionine was the first and critical essential amino acid for hair growth in blue foxes (Dahlman et al., 2002). Ideal protein for blue foxes and mink in the growing and furring periods have been investigated (Valaja & Pölönen, 2005, Sandbøl et al., 2004) but there is little information for the requirements of amino acids during the breeding season in blue foxes or mink. According to Fink (2001) feeding mink dams with high protein diets (39% vs. 55%) predisposes the lactating female to significant increases in metabolic rates and exposes them to oxidative stress. It is uncertain whether mink require high levels of dietary protein as dispensable amino acids or that low protein diets supplemented with essential amino acids such as methionine cover the requirement adequately for mink dams during the breeding season. The protein recommendation for breeding minks is 40% protein of ME (Finnish Fur Breeders' Association, FFBA 2007). The aim of the present study was to investigate the effects of low protein (protein 25% + DL

Table 1. Ingredients and analysed composition of the diets Protein 25% and Protein 35% during the experiment.

	Diets	
Raw material, %	**Protein 25 %**	**Protein 35 %**
Fish by-product	25.5	35.6
Chicken slaughterhouse offal	12.7	13.9
Slaughterhouse offal	12.7	13.9
Wheat starch	15.7	11
Fish meal	1	4.5
Molasses	1	1
Soya oil	2.2	1.8
Vitamin premix	1.5	1.5
DL-Methionine	0.1	0
Water	25.8	16
Arbocel®[a]	2	1
Analysed composition:		
Number of samples	3	3
pH	5.6	5.5
Dry matter (DM), g/kg	322	317
Ash, g kg DM	92	123
Crude protein, g kg DM	234	346
Fat, g kg DM	187	194
Carbohydrate, g kg DM	487	338
MJ kg DM	15.5	15.6
Metabolisable energy[b] (ME):		
Protein, % of ME	24.3	34.2
Fat, % of ME	43.1	43.9
Carbohydrate, % of ME	32.6	21.9

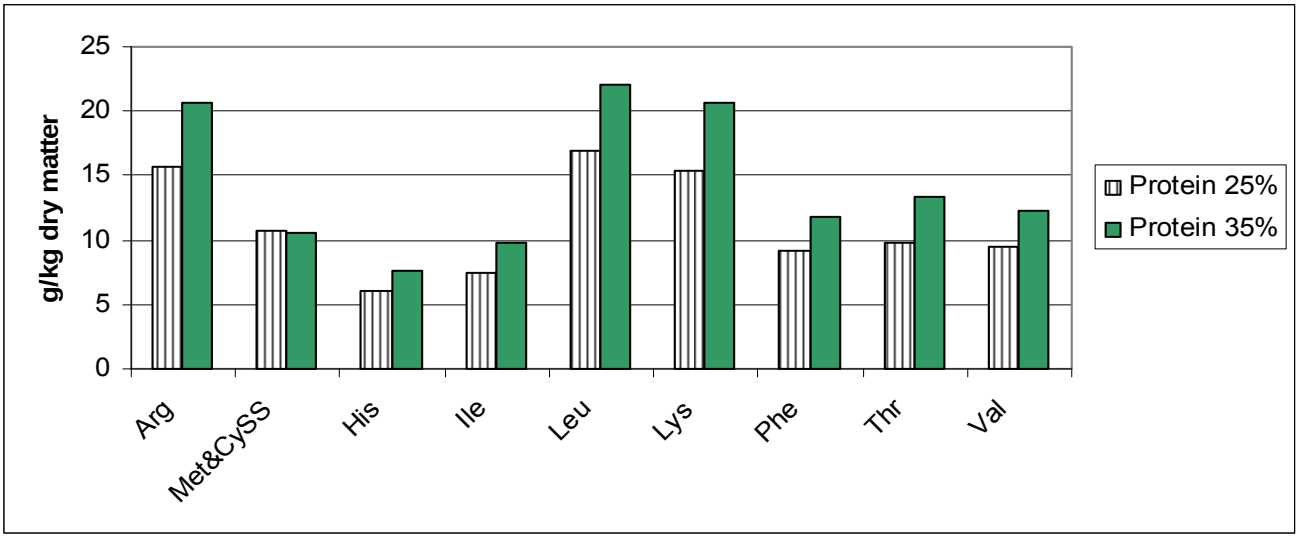
[a]Arbocel® was added to the feeds prior to feeding in order to improve the consistency of the feeds
[b]Estimated digestibility values for ingredients were used for calculation of metabolisable energy distribution

methionine and 35% of ME) diets during the breeding season on breeding result, body weight development of dams and some blood parameters.

Materials and Methods

The feeding experiment was carried out at the research station of MTT Agrifood Research Finland in Kannus 1.12.2004 - 27.6.2005. The protein contents of the two experimental diets were 25% and 35% protein of ME, but 25% diet was added DL-methionine to level the concentration of the 35% diet. The diets consisted of fish and chicken slaughterhouse-by-products, precooked wheat starch, fish meal, molasses, soya oil, Arbocel®, vitamins and minerals. The content of protein- and carbohydrate in experimental diets varied according to the treatment. For the rest the formula of the diets was equal to the recommendations of breeding season (FFBA 2005). Arbocel® was mixed to the feeds to adjust the consistence of the experimental feeds. The diets were isocaloric. DL- methionine was added to diet Protein 25% 1 g per kg feed in order to reach the same level of sulphur

Figure 1. Analysed amount (g / kg of dry matter) of essential amino acids in the experimental diets



containing amino acids as in 35% feed (Figure 1, Table 1).

Each experimental group consisted of 75 multiparous and 75 primiparous mink dams. Full-sisters from the same litter were assigned to both feeding groups in order to have the same breeding value in both groups. Animals were fed according to conventional fur farm practise. The offered and uneaten feed was weighed and feed consumption of each female was recorded.

Body weight of the females were recorded in December, January, March, April, June and July. The number of kits was recorded at the age of one day, one week and seven weeks. Body weights of kits were recorded one and seven weeks after parturition. At the beginning of June blood samples were collected before the euthanasia from twenty (Protein 25%) and ten (Protein 35%) barren mink dams. Blood alanine aminotransferase (ALT), aspartate amino-transferase (AST), creatine kinase, total protein, hematocrit (HCT), hemoglobin (HGB), the number of red blood cells (RBC) and white blood cells (WBC) were analysed. The implantation scars were counted from 20 barren females from both groups. The blood values were analysed and implantation scars were counted in order to solve the reason for barren dams. Statistical analyses were carried out using SAS Enterprise Guide 3.0. Wilcoxon-Mann-Whitney test was used for comparisons of the litter sizes and blood values between the experimental groups.

Results and Discussion

The average feed consumption of mink dams in both groups was similar during the 1st of December to 2nd of February and during the 1st of March until parturition. During the 3rd to 28th of February the dams were fed according to the body condition. Dams in group 35% were slightly heavier and thus were offered 120±4.0 g feed per day instead of 169±8.2 g per day in group 25%. The feeding between the parturition and weaning depended on the litter size and feed was offered unrestrictedly (Table 2).

The experimental treatment did not affect in the date of mating time and body weights did not differ between the groups at the beginning of the mating-period or three weeks after parturition. The average body weight of dams were 1.1 kg in both groups at mating.

Table 2. The mean feed consumption in g per day of mink (±SD = standard deviation)

Period	Protein 25%	Protein 35%
1st of December to 2nd of February	167±2.3	166±4.9
3rd to 28th of February	169±8.2	120±4.0
1st of March to 10th of April	173±8.6	170±7.7
11th to 30th of April	195±10.2	194±10.8

Nearly 98% of females were mated in both groups. After parturition, the experimental treatment revealed distinct differences in the number of barren dams: In the 25% Protein group, 49.3% of the females were barren, while in the 35% Protein group only 16.8% were barren. The kit mortality was also higher in the 25% Protein group; 31.9% of the females lost their litter as compared to only 6.3% in the 35% protein group. Furthermore, the litter size and the body weight of the kits were significantly higher with increasing protein content of the feed. The breeding result after 7 weeks after parturition was 0.54 and 3.66 ($p<0.001$) cubs per mated female in treatments Protein 25% and Protein 35%, respectively (Table 3).

Protein and amino acid content of mink feed during breeding season has significant connection to number of mink kits. The DL-methionine supplementation was not enough to ensure the normal development of embryos. Most probably there was a demand of total protein not any single amino acid in the group of low protein (25%).

Blood parameters were not significantly different between groups except HGB, HCT and total protein. HGB and total protein were significantly lower ($p<0.001$) in the Protein 25% group in comparison to the Protein 35%. However HGB was rather high in both groups 172.1 g/l and 186.6 g/l in groups Protein 25% and 35%, respectively. According to several researches the HGB values of mink females varies from 80 to 190 according to the period and physiological state (Fletch and Karstad, 1972; Gatti-Yorke, 2008). Plasma total protein was 67.1±1.0 g/l in group Protein 25% and 71.9±1.0 g/l in group Protein 35% ($p<0.001$). Plasma total protein was probably affected by the protein level of the experimental feeds. The HCT value was higher in group Protein 35% than in group Protein 25%. The HCT was 62±1.0 in group Protein 25% and 66±1.0 in group Protein 35% ($p<0.05$). Barren females were not suffering from anemia at the time of sample taking. The investigation of the implantation scars revealed that in group Protein 25% fourteen out of 20 females had been pregnant. In group 35% only eight out of 20 females had been pregnant. However in Protein 35% group 24 females did not whelp and in group Protein 25% 68 females did not whelp. In group Protein 25% mating frequency was similar as in group Protein 35%. but the females had more abortions during pregnancy, barren dams, and the kit survival was worse.

Skrede (1978) investigated the effect of protein level on female reproductive performance, preweaning growth and mortality of the progeny and found similar results in mink. Level of protein had no significant effects on overall mating and fertility performance but low protein level in feed affected on the number of born kits and on the kit mortality. In blue foxes, it has been found that the protein retention increases and is in the highest level during the last trimester (Valaja & Pölönen 2005). During the first trimester 33% protein of ME was adequate for pregnant blue foxes. During the last trimester protein retention was highest in group 39% protein of ME (experimental feeds were from 15 to 39% protein from ME). It is

Table 3. Number of mated, barren, weaned dams and dams which lost their cubs. Mean number of kits per mated female (n= number of dams) and mean weight of kits at the age of one and seven weeks. SD = standard deviation, P= probability value

	Protein 25 % mean±SD	Protein 35 % mean±SD	
No. of mated dams	138	143	
No. of barren dams	68	24	
No. of dams which lost their cubs	44	9	
No. of weaned dams	26	110	
No. of kits per mated dam:			**p-value**
1 day alive	0.75±1.4	4.03±2.7	<0.001
1 day all	1.20±1.2	4.75±4.8	<0.001
1 week	0.60±1.4	3.78±2.6	<0.001
7 weeks	0.54±1.3	3.66±2.6	<0.001
The body weight of the kits, g (1 week)	31±10	34±7	<0.01
The body weight of the kits, g (7 weeks)	328±64	389±56	<0.01

especially important to pay attention to the quantity and quality of protein and amino acids in feed during the last trimester of the pregnancy and the end of the breeding season in order to ensure good breeding results.

Conclusions

Protein levels 25% + Met and 35% of ME did not affect mating frequency, but the 25% + Met diet produced very poor reproduction results: abortions during pregnancy and poor kit survival. A poor reproduction result with this diet was not because of deficient DL-methionine supplementation, but due low levels of both for dispensable and indispensable amino acids in general. Current recommendation (FFBA 2007) for protein (40% protein from ME) in breeding season of mink is therefore valid. At least protein levels under 35% of ME should be avoided during pregnancy.

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IV-5 P

Iodine requirement for mink (*Neovison vison*).

Maria Sylvest Blæsbjerg[1], Niels Enggaard Hansen[2], Peter Sandbøl[1] & Mette Schulin-Zeuthen[1]

[1] *Danish Fur Breeders Research Center, Herningvej 112C, DK-7500 Holstebro, Denmark*

[2] *University of Copenhagen, Faculty of Life Sciences, Department of Basic Animal and Veterinary Sciences, Grønnegårdsvej 3, DK-1870 Frederiksberg C, Denmark*

E-mail address: msz@kopenhagenfur.com

Introduction

Toxic levels of iodine in mink diets has been investigated by Aulerich et al. (1978) and Jones et al. (1982). Travis et al. (1966) used 15% gullet trimmings in a mink diet. More than 1000 ppm of dietary iodine resulted in no whelping females while more than 80 ppm lead to a markedly reduced litter size (Aulerich et al., 1978; Jones et al., 1982). 20 ppm of iodine in the diet of pregnant females caused newborn kits to have enlarged thyroid glands (Jones et al., 1982). Females fed 10 ppm of iodine in the diet, showed no reproductive changes (Aulerich et al., 1978; Jones et al., 1982). The iodine requirement of mink has not been determined experimentally, but 0.2 ppm has been recommended on basis of other species (Wood, 1962). Recent trials with dogs (Löscher et al., 2000) and cats (Ranz et al., 2002) indicate that a simple balance study may be used to estimate the requirement. The hypothesis is that faecal iodine is independent of intake and that there is a positive correlation between intake and renal loss. A trial was set up with adult male mink, in order to estimate the iodine requirement for maintenance.

Materials and Methods

Two experiments were carried out: 1) a pilot study to clarify: A) are mink willing to eat the diets containing the low and high concentrations of iodine to be used in the balance study, and B) can the iodine levels in diets, faeces and urine be analyzed and 2) a balance study to estimate the requirement of iodine for adult mink.

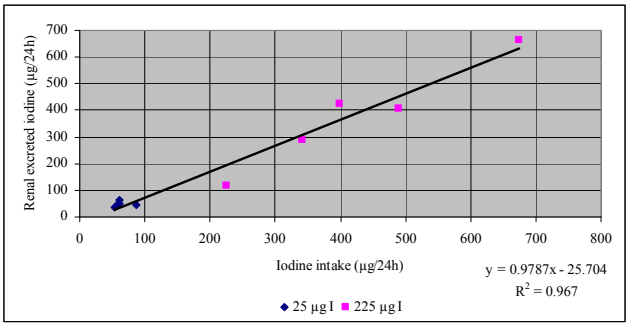
Five adult male mink of the colour type brown/glow were used per treatment in both studies. They were housed individually in balance cages (modified after Jørgensen & Glem Hansen, 1973) and had free access to water. They were fed 260 g of feed/day (115kcal/100g and 26% of dry matter) of a so-called synthetic diet (Sandbøl et al., 2007) containing 25, 75, 125, 175 and 225 µg iodine/100 kcal, starting with the lowest level. A trial period had 6 days of adaption and 24 hrs of quantitative urine and faeces collection. Feed consumption was recorded daily. Diets and faeces were analyzed for iodine and dry matter, diet leftovers for dry matter and the urine for iodine. On the seventh day the males were weighed before feeding.

Results

The pilot study

Renal iodine excretion depended on the intake (Figure 1). The mink ate sufficiently of the diets, and the methods of analysis gave reliable results for the dietary, urinary and faecal iodine within the levels used.

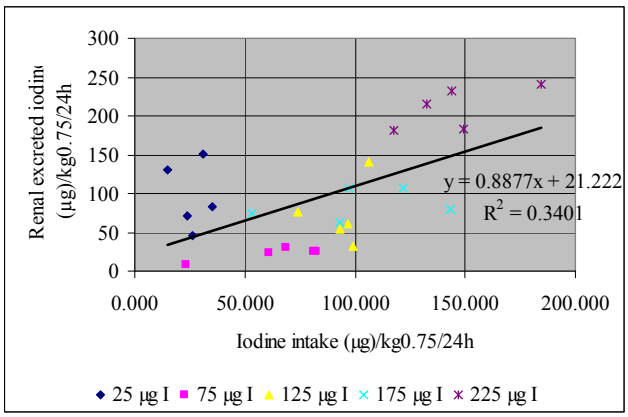
Figure 4: Individual values and linear regression of renal iodine (I) excretion in response to iodine intake.



Balance study

Due to analytical problems, iodine intake was based on calculated dietary content (Figure 2).

Figure 5: Individual values and linear regression of renal iodine (I) excretion in response to iodine intake.



Extrapolating the linear regression to zero feed intake gave a renal excretion of 21.2 µg iodine/kg$^{0.75}$/24 hours. The average faecal excretion of iodine was 3.7 µg/kg$^{0.75}$/24h. This resulted in an estimated iodine requirement for maintenance as 24.9 µg/kg$^{0.75}$/24h. The ambient temperature was 15.9°C.

Discussion

The high variability in dietary intake was likely due to the low pH in the diet (below 5.5). Some samples were below the detection limit (0.2ppm of iodine). Consequently, we used the calculated iodine intake to estimate the requirement. The estimate is relatively close to the requirement of cats at 20 µg iodine/kg$^{0.75}$/24h (Ranz et al., 2002). Conversion of the requirement to ppm, gives a value of 0.2 ppm of iodine, similar to the recommendations of Wood (1962). A requirement of 0.2 ppm is much lower than the toxic levels found by Aulerich et al. (1978) and Jones et al. (1982). Their lowest concentration in the diet was 10 ppm. This is 50-fold more iodine than the presently estimated requirement. However, no reduction in reproduction was observed at this level. At 20 ppm of iodine (100 times the norm) negative effects were observed with long-term feeding. This indicates that the mink has a high iodine tolerance, and is able to excrete the excess, until a toxic threshold is met.

Conclusion

We estimated an iodine requirement for mink at maintenance of 24.9 µg/kg$^{0.75}$/24h. However, this estimate may be inaccurate due to analytical difficulties. Therefore, the experiment should be repeated to achieve a more valid estimate.

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IV-6 P

Sodium requirement of mink throughout the production year

Tove N. Clausen[1] *& Birthe M. Damgaard*[2]
[1] *Danish Fur Breeders Research Center, Herningvej 112C, DK-7500 Holstebro*
[2] *University of Aarhus, Faculty of Agricultural Sciences, Department of Animal Health, Welfare and Nutrition, Blichers Allé 20, P.O. Box 50, DK-8830 Tjele*
E-mail address: tc.pfc@kopenhagenfur.com

Introduction

Salt (sodium chloride) is very important for the health of animals. If they do not get a sufficient amount of sodium (Na) they will reduce their feed consumption and lose body weight, plasma aldosterone and packed cell volume will be elevated, and urinary sodium excretion will be reduced (Yu & Morris, 1999). Consumption of too high amounts of Na likewise decreases feed consumption and body weight. Further the animals develop a dark diarrhoea, rough coat, crusty nose and eyes, and exhibit irritability in the early stages, and lethargy in the later stages (Restum et al., 1995). In the nursing period we usually add sodium chloride to the feed to prevent nursing sickness (Clausen et al., 1996; Clausen et al, 2002; Hartsogh, 1960). A change in feed raw materials from animal by-products to more vegetable products, where the content of Na is often very low, has made it necessary to reconsider the Na content in mink feed throughout the year.

Figure 1. Urinary Na content and blood aldosterone concentration in adult male mink fed different amounts of Na.

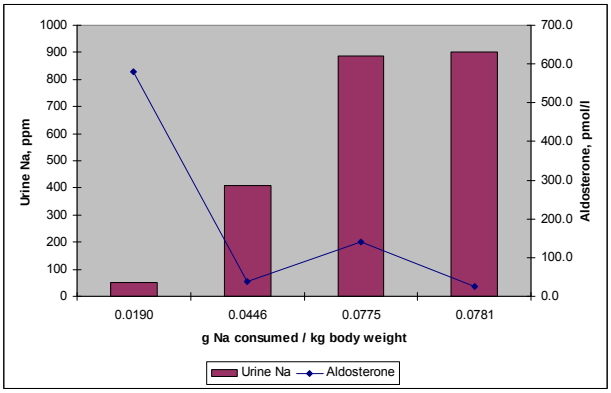
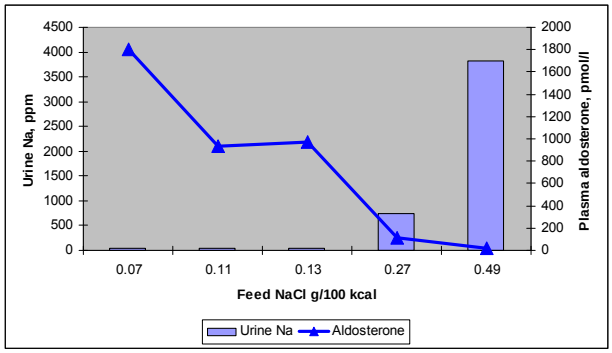


Figure 2. Urinary Na content and blood aldosterone concentration in male mink kits fed different amounts of Na.



Materials and Methods

Adult male mink: The investigation was carried out from April 11 to April 18. Four groups of 5 brown male mink were fed synthetic feed with different Na content (Analysed, Na g /100 kcal: 0.017, 0.037, 0.057, and 0.059).

Kits during early growth: Nine groups of 20 litters of black mink kits were included in the experiment from 6 to 10 weeks of age. Raw materials with a very low Na content were chosen for the experimental diet. The diet was supplemented with increasing amounts of NaCl (Analysed g NaCl/100 kcal: 0.07, 0.11, 0.13, 0.27, 0.49, 0.68, 0.86, 1.0, and 1.85).

Results and Discussion

Adult male mink: There was no significant differences in body weight between the groups. In all groups there was a decrease in body weight during the experiment probably due to the bad taste of the synthetic feed. At the end of the investigation urine samples were collected for

determination of Na content and blood samples were collected for plasma aldosterone analysis. The concentration of plasma aldosterone was very high and the concentration of urine Na very low in the group fed the lowest amount of Na compared to the other groups (Figure 1).

This corresponds to results from earlier investigations in mink and cats (Clausen et al, 1996, Yu & Morris, 1997; 1998; 1999). In the groups fed the diet supplemented with NaCl the concentration of urine Na was considerably higher and the concentration of plasma aldosterone was within normal range. So it seems that 0.019 g Na per kg body weight per day is too low for adult male mink whereas 0.0446 g Na per kg body weight appear to be sufficient to fulfil the Na requirement.

Kits during early growth: The kits were weaned at 6 weeks of age which may have affected the growth negatively, even though the kits were housed in groups of three. Regardless, there seems to be a tendency towards the lowest weight increase in kits that received a very low amount of Na and in kits that received a very high amount of Na. At the end of the investigation urine samples were collected for the determination of Na content and blood samples were taken for plasma aldosterone analysis from male mink kits from the five groups with the lowest Na content (Figure 2).

The concentration of plasma aldosterone was very high and the concentration of urinary Na was very low in the three groups fed the lowest Na level in the feed, indicating that the amount of Na was too low to fulfil the need of the kits. In the other two groups the concentration of urine Na was considerably higher and the concentration of plasma aldosterone was within normal range.

Table 1. Recommended NaCl content in Danish mink feed throughout the year.

Period	g Na / 100 kcal	g NaCl / 100 kcal	% NaCl *
Adult mink - Winter period	0.05	0.13	0.15
Nursing females	0.17	0.42	0.50
Growing kits 6-10 weeks	0.11	0.27	0.40
Growing - pelting period	0.03	0.08	0.15

* energy concentration: 120, 120, 150, and 200 kcal/100g

Conclusion

The results from these and earlier investigations (Clausen et al., 1996; Clausen et al., 2002) lead to the following recommendations regarding the NaCl content in the feed throughout the production year (Table 1).

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IV-7 P

Increasing water consumption by adding NaCl to mink feed

Tove N. Clausen & Peter Sandbøl
Danish Fur Breeders Research Center, Herningvej 112C, DK-7500 Holstebro
E-mail address: tc.pfc@kopenhagenfur.com

Introduction

One of the biggest disease problems in mink kits during June / July is related to the urinary tract (Hansen et al., 2008; Clausen, 2006). It is suggested that extra salt (NaCl) in the feed can make mink kits drink more and thereby urinate more; reducing the formation of urinary stones. On the other hand, too high levels of NaCl in the feed can be toxic. The symptoms of NaCl toxicity are reduced feed consumption and body weight, a dark diarrhoea, rough coat, crusty nose and eyes, irritability in the early stage, and lethargy in the later stages (Restum et al., 1995).

Materials and Methods

We used 6 groups of 5 black male mink kits each. From 10 – 12 weeks of age the kits were placed in individual balance cages and fed a basic feed supplemented with different amounts of NaCl (Table 1).

Feed and water consumption and urine production was recorded. Sodium concentration in the feed and urine was analysed by ICP, optical emission spectrometer (Optima 2100 DV)

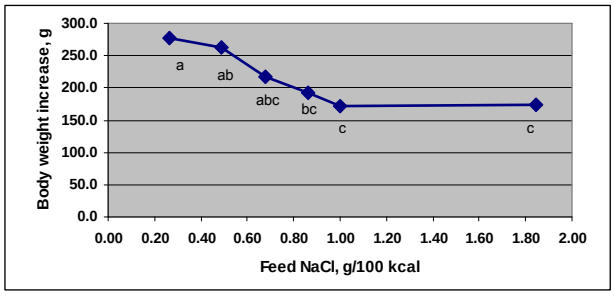
Table 1. Added NaCl, analysed sodium (Na) concentration and calculated NaCl content in the feed.

Added g NaCl / 100 g feed	**0.3**	**0.6**	**0.9**	**1.1**	**1.3**	**2.3**
Analysed g Na / 100 kcal	**0.11**	**0.19**	**0.27**	**0.34**	**0.40**	**0.73**
Calculated g NaCl / 100 kcal	**0.27**	**0.49**	**0.68**	**0.86**	**1.00**	**1.85**

Results and Discussion

Body weight gain: Body weight gain decreased with increasing NaCl in the feed (Figure 1). The best body weight gain was found in the kits receiving 0.27 or 0.49g NaCl / 100 kcal. At 0.68g NaCl / 100 kcal there was a decrease in gain and at 0.86g NaCl / 100 kcal and more, the gain was significantly lower. Our results are similar to those by Lund (1979), who also found reduced growth in black mink kits receiving around 0.68g NaCl / 100 kcal.

Figure 1. Body weight increase of mink kits from 10 to 12 weeks, at different NaCl content in the feed



Water consumption: Average daily intake of drinking water from June 29 to July 13 is seen in Figure 2. At 0.68 g NaCl / 100 kcal the water consumption increased and from 0.86g NaCl / 100 kcal the increase was significant. Kits receiving 1.85g NaCl / 100 kcal drank twice as much water compared to the kits getting 0.27 – 0.49g NaCl / 100 kcal. The average daily water absorption (drinking water + water from the feed ÷ water in the faeces), the drinking water intake and urine production from July 6 to July 13 (Figure 3), increased linearly with increasing

Figure 2. Average daily water consumption from June 29 to July 13 by mink kits fed diets with different NaCl concentration

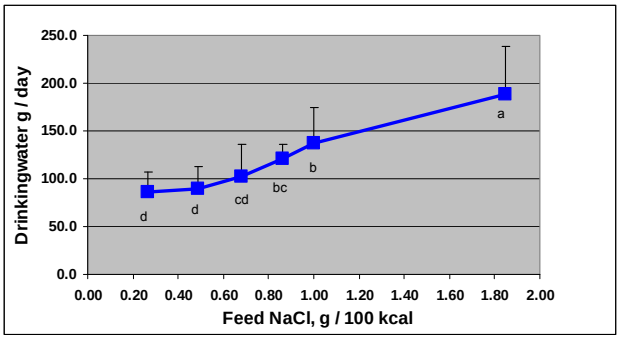


Figure 3. Average water absorption, drinking water intake and urine production in mink during July 6 to July 13

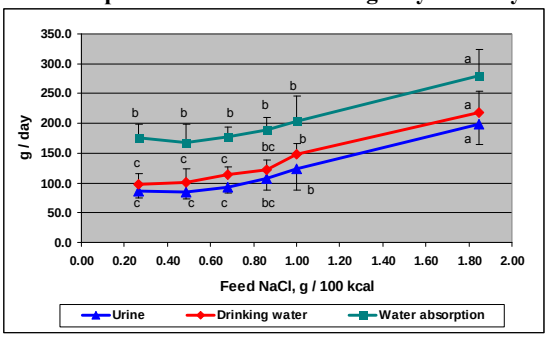
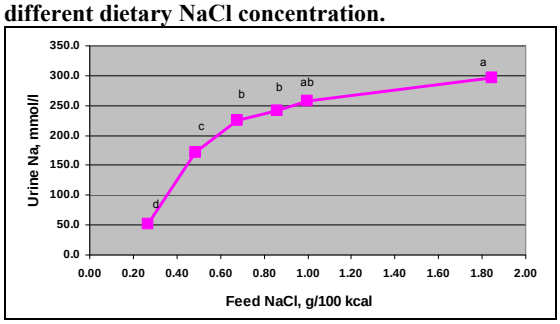


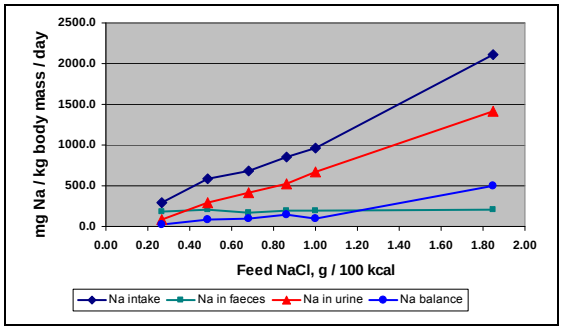
Figure 4. Na concentration in the urine of mink fed at different dietary NaCl concentration.



NaCl content in the feed above 0.68 g NaCl / 100 kcal.

Urine: With a high NaCl content in the feed, the kits excrete the excess Na by increasing the urinary concentration. There is however a limit to this concentration. In Figure 4 the limit is seen at 250 – 300 mmol Na / l. This corresponds with earlier investigations (Clausen et al., 2002). Above 0.68 g NaCl / 100 kcal in the feed the concentration of Na in the urine increased very slowly, and the kits would have to drink more water to get rid of the excess Na. This can be seen in Figure 3.

Figure 5. Na balance of mink fed at different dietary NaCl concentration



Na-balance: The Na-balance is shown in Figure 5. At the highest dietary NaCl concentration the kits could not get rid of the excess Na and probably would have developed intoxication symptoms with time. Faecal Na was independent of intake as also seen in cats (Yu & Morris, 1997).

Conclusion

More than 0.68 g NaCl / 100 kcal increase the water intake and urine production, but reduce the body weight gain in 10 – 12 week old mink kits.

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IV-8 P

Lipid and glucose metabolism in lactating mink (*Neovison vison*) - The effects of omega-3 long chain polyunsaturated fatty acid enrichment

Sarah Gatti-Yorke and Kirsti Rouvinen-Watt
Nova Scotia Agricultural College, Department of Plant and Animal Sciences,
P.O. Box 550, Truro, Nova Scotia, B2N 5E3, Canada
E-mail address: slgatti@nsac.ca, krouvinen@nsac.ca

Introduction

Mink nursing sickness is a metabolic disorder characterized by abnormally high blood glucose concentrations (Wamberg et al., 1992b). Omega-3 long chain polyunsaturated fatty acids (LCPUFA) improve insulin-stimulated glucose transport in white adipose tissue (Takahashi & Ide, 2000) and may have a role in the regulation of glucose homeostasis in lactating mink (Rouvinen-Watt, 2003). Omega-3 LCPUFA also have an impact on lipogenic gene expression by means of transcriptional regulation (Jump et al., 2005). The mink mammary glands have limited capacity for *de novo* fat synthesis, and the diet is known to alter mink milk fatty acid composition (Wamberg et al., 1992a). The goal of this research was to study the effects of dietary enrichment with omega-3 LCPUFA on body weight, body condition, litter size, and lactation physiology of mink dams and to examine the role of omega-3 LCPUFA in lipid and glucose metabolism.

Materials and Methods

One hundred (n = 100) yearling female mink of the standard black color type were used in this research from October until end of lactation (June). The mink were selected as sister pairs, which were randomly assigned to one of two dietary treatments. A basal diet supplemented with canola oil, served as the Control (n = 50), and the same basal diet supplemented with seal oil was used as the Omega-3 LCPUFA enriched diet (n = 50). The body weight, body condition score, and blood glucose concentration were measured at day 1, day 21 and day 42 of lactation. On days 1, 21 and 42, also 13 Control and 13 Omega-3 LCPUFA fed mink were sampled for blood, liver, adipose tissue, skeletal muscle, and mammary gland. The mRNA levels of lipoprotein lipase (LPL), glucose transporter 4 (GLUT4), and uncoupling protein 2 (UCP2) in selected tissues were determined using qRT-PCR.

Results and Discussion

The Control diet contained higher amounts of omega-6 fatty acid (FA), whereas the Omega-3 LCPUFA enriched diet had more total omega-3 FA, including EPA and DHA. No differences were observed in the body weights of the females due to the diet during October until April. On average the Omega-3 LCPUFA enriched group had the lowest blood glucose values in November (Control: 4.22 mmol/L, Omega-3: 4.06 mmol/L), whereas the highest values were reported in April (Control: 5.22 mmol/L, Omega-3: 5.52 mmol/L). There was a sudden increase in the blood glucose values from March to April for both diets, which indicates impaired glycemic regulation during gestation and may be attributed to increased glucose requirement in support of fetal growth (Herrera, 2000). During lactation, the blood glucose concentrations were significantly lower for the Omega-3 LCPUFA fed mink dams (P=0.050).

The mink on the Omega-3 LCPUFA enriched diet had significantly higher total omega-3 PUFA in the liver and the subcutaneous fat. When subject to rapid body fat mobilization, the mink first deplete the omega-3 PUFA, which results in a decreased omega-3/omega-6 ratio in

the liver and white adipose tissue (Nieminen et al., 2006). Both dietary fat sources used in the current study supported normal body fat mobilization for milk fat provision in the mink dams while maintaining a normal blood glucose concentration throughout the lactation period. However, the mink fed the Omega-3 LCPUFA diet maintained a significantly higher tissue omega-3/omega-6 PUFA ratio. There were no abnormal findings in the blood parameters and all mink dams were apparently healthy with normal litter sizes and litter weights. The Omega-3 LCPUFA enriched diet did not alter dam or litter performance in comparison to the Control diet.

There were no significant differences in the mammary gland and subcutaneous adipose tissue LPL gene expression due to the Omega-3 LCPUFA enrichment. Though there were no significant differences in the GLUT4 gene expression by dietary treatment, there was an increase in gene expression by day 42 of lactation ($P<0.001$), suggesting that at weaning the mink dams had an improved capacity for insulin-dependent glucose disposal by the skeletal muscle. In the subcutaneous adipose tissue, the UCP2 showed a trend for higher expression as a result of the Omega-3 LCPUFA enrichment ($P=0.087$). The improved blood glucose regulation observed in dams on the Omega-3 enrichment may possibly be attributed to the elevated UCP2 gene expression and the subsequently improved insulin signaling. The UCP2 up-regulation by Omega-3 LCPUFA may also be significant with regard to the mammary gland LPL expression as LPL is regulated by insulin action post-prandially (Sjaastad et al., 2003). Further studies are necessary to more closely investigate the relationship between dietary supplementation with Omega-3 LCPUFA, UCP2 and LPL gene expression in mink dams during lactation.

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IV-9 P

The effect of different protein and carbohydrate supply on protein and energy metabolism in early growth period of mink kits

Anne Louise Frydendahl Hellwing, Niels Enggaard Hansen and Anne-Helene Tauson
Department of Basic Animal and Veterinary Sciences, Faculty of Life Sciences,
University of Copenhagen, Groennegaardsvej 3, DK-1870 Frederiksberg C, Denmark
E-mail address: aflh@life.ku.dk

Introduction

The protein and amino acid requirements of mink kits during the transition from suckling to intake of solid feed, and in the early post-weaning period, are incompletely known. Mink kits suckled by dams fed a diet with 30% of the metabolisable energy (ME) from protein had a superior weight gain until four weeks of age than those suckled by dams fed diets with higher protein content (Fink et al., 2004, 2006). From four weeks of age, however, kits fed 30% of ME from protein had a lower weight gain than kits fed a diet with 45% of ME from protein (Tauson, unpublished). The objective of the present study was therefore to evaluate the effect of different protein and carbohydrate supply on protein and energy metabolism of mink kits in the early post-weaning growth period.

Materials and Methods

A total of thirty-two dams of the standard brown colour type with 7 kits each were fed four different diets from week four post partum. One pair of male kits from each dam was weaned between 5 and 6 weeks post partum. The kits were allocated to four blocks according to dietary treatment and time of birth. The diets were formulated with either 30% or 45% of ME from protein and either 15% or 25% of ME from carbohydrate. The four diets were labeled HPHC ((ME from protein:fat:carbohydrate) 45:30:25), HPLC (45:40:15), LPHC (30:45:25) and LPLC (30:55:15). The amino acid content of the HP diets met the Danish recommendations for mink in June and July whereas the LP diets only met the recommendation for July. The calculated amino acid contents of the LPHC and LPLC diets were almost the same. The diets were mainly based on fish offal, whole fish, poultry offal, heat treated barley and wheat, soy-bean oil and lard. Three balance and respiration experiments were conducted, starting when the kits were 5.5-6.5 (period 1), 9.5-10.5 (period 2), and 11.5-12.5 (period 3) weeks of age. In the first balance period two male kits were kept in each balance cage, but in periods 2 and 3 only one of the kits was used. Each balance period lasted four days, including a 22-hour respiration experiment carried out by means of indirect calorimetry in an open-air circulation system. Collection procedures, chemical analyses and calculations are described by Hellwing et al. (2005) and the respiration unit and calibration procedures are described by Chwalibog et al. (2004). Data were analysed using the GLM procedure in SAS. The model included effect of protein level, carbohydrate level, period, block and interactions effects between protein, carbohydrate and period. Results are presented as least squares means (LSmeans) of the interaction between protein and carbohydrate, and the root mean square error (RMSE) is given for each variable as a measure of variation. Pair-wise comparisons of LSmeans were made by using the PDIFF option, and effects were considered significant if $p<0.05$.

Results and Discussion

The weight gain was significantly higher on the LPHC diet (28.5 g/day) than on the LPLC diet (13.9 g/day) in the balance periods. Dry matter intake was 189, 169, 166 and 141 g/kg$^{0.75}$ on the HPHC, HPLC, LPHC and LPLC diets respectively, and the effects of protein and

Table 1. Main results from the nitrogen and energy metabolism measurements on growing mink kits (5-12 weeks of age) fed different levels of protein and carbohydrate.

	Diet1					P-values		
	HPHC	HPLC	LPHC	LPLC	RMSE	PRO (P)	CHO (C)	P*C
Weight gain (g)	21.5[a]	23.7[a b]	28.5[a]	13.9[c]	10.45	0.52	0.005	<0.001
Intake of dry matter (g/kg0.75)	189	169	166	141	24.85	<0.001	<0.001	0.59
N-metabolism								
Ingested nitrogen (g/kg0.75)	5.41	5.37	3.97	3.77	0.66	<0.001	0.39	0.57
Digested nitrogen (g/kg0.75)	4.24	4.24	3.05	2.78	0.49	<0.001	0.20	0.19
Retained nitrogen (g/kg0.75)	1.33[a]	1.29[a]	1.47[a]	0.87[b]	0.33	0.05	<0.001	<0.001
Apparent digestibility of N (%)	78.5[a]	79.0[a]	76.8[b]	73.7[c]	2.84	<0.001	0.03	0.003
Energy metabolism								
Metabolisable energy(kJ/kg0.75)	1133[a]	1133[a]	1221[a]	1011[b]	162	0.31	0.01	<0.001
Heat production (kJ/kg0.75)	833[a]	828[a]	836[a]	763[b]	78	0.06	0.02	0.04
Retained energy (kJ/kg0.75)	316	348	362	254	189	0.56	0.34	0.08
Apparent digestibility of energy (%)	79.5[b]	82.7[a]	81.8[a b]	71.3[c]	4.05	<0.001	<0.001	<0.001

1 HPHC (ME from protein:fat:carbohydrate 45:30:25), HPLC (45:40:15), LPHC (30:45:25) and LPLC (30:55:15)

carbohydrate level were significant.

The lower weight gain of the LPLC kits was observed in all balance periods and was partly caused by the lower daily intake of dry matter. The digestibility of nitrogen and energy were significantly lower on the LPLC diet than on the other diets. This also contributed to the poorer gain and resulted in lowest retention of nitrogen. The intake of metabolisable energy was the same on the LPHC, HPLC, and HPHC diets all being significantly higher than on the LPHC diet. The heat production was also significantly lower on the LPLC diet than on the other diets which could be an effect of the lower intake of metabolisable energy. The retention of energy tended to be lower (P=0.08) on the LPLC diet than on the other diets (Table 1). The poorer digestibility of especially fat on the LPLC diet was most pronounced in periods 2 and 3. The reason for this is unknown, but another study with 9 weeks-old mink kits in our laboratory indicates similar results (Matthiesen, unpublished). In conclusion, our results suggest that the protein and amino acid requirements of animals on the LPHC diets were sustained. The poor performance of the LPLC group needs further evaluation, but it can be assumed that the high fat content of this diet may have been a contributing factor.

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IV-10 P

Energy metabolism of growing blue foxes

Nita Koskinen[1], Anne-Helene Tauson[2], Juhani Sepponen[1] and Teppo Rekilä[1]
[1]MTT Agrifood Research Finland, Fur Animal Production, Kannus, Finland
[2]Faculty of Life Sciences, University of Copenhagen, Denmark
E-mail address: nita.koskinen@mtt.fi

Introduction

The blue fox (*Alopex lagopus*) is presently the most important species in fur farming in Finland. In recent years selective breeding programmes have focused on producing large and heavy animals. Ten years ago the average weight at pelting of blue fox vixens varied between 7 and 10 kg. Nowadays individuals weighing over 20 kg can be found. At present blue foxes are fed *ad libitum* during the growing – furring period. The blue fox exhibits seasonal fluctuations in feed intake and accretion of body fat, feed intake and body fat retention being very high during autumn and early winter if given free access to feed. Unrestricted feeding hence often leads to animals being very fat or even obese at the time of pelting. The accumulation of body fat may have dual purposes, both of crucial importance for animals living in the wild: first to provide insulation of the body and protection from excessive heat loss when ambient temperature is very low and second, to serve as an energy reserve in situations of scarcity.

The main objective of this project was to establish baseline data on the energy requirement of growing blue foxes, by measuring feed intake, energy expenditure, and protein and fat retention. This project is based on the main hypothesis that the energy requirement of the blue fox is strongly regulated by photoperiod, and that voluntary feed intake and energy expenditure reflect seasonal changes. Furthermore, it can be anticipated that very fat individuals, which have relatively less lean body mass, will have lower energy expenditure per kg metabolic body weight than lean individuals.

Materials and Methods

Animals, diet and treatment groups: Sixteen juvenile blue fox vixens were used. All animals were fed the same conventional fox diet. The average chemical composition of the diet was 37.8% dry matter, 1.9% ash, 11.7% crude protein, 8.7% fat and 15.5% carbohydrate as fed. The feed for the experiment was produced as one batch and stored frozen until use. The animals were allocated to four different treatment groups and given different energy supply: (1) *ad libitum*, target body condition "very high"; (2) 20 – 30% below the a*d libitum* group, target body condition "high"; (3) 35 - 45% below *ad libitum*, target condition "ideal mating condition";(4) 50 - 60% below the *ad libitum* group, target condition "lean". The differentiation of the energy supply was used in order to establish a population of animals with very different body condition/body fat contents.

Experimental techniques: The experiment was performed in five 7d balance periods (3d adaptation and 4d quantitative collection of faeces and urine), starting when the animals were about 10 weeks old and ending when the animals were about 30 weeks old. Each period included a 22 hr respiration experiment by means of indirect calorimetry in an open-air circulation system. Heat production was calculated according to the formula by Brouwer (1965). For a detailed description of the system, including

Table 1. Group means (±SE) for feed intake (g per day), animal live weight (kg) and feed efficiency (growth, g per feed intake, g per period) during the trial. p<0.01 = significant difference, NS= not significant

	Feed intake g d^{-1}	Live weight, kg	Feed efficiency
Group I	710±25.8	9.38±0.26	0.05±0.17
Group II	710±24.9	9.05±0.26	0.10±0.17
Group III	603±24.8	8.34±0.26	0.09±0.17
Group IV	494±24.8	7.60±0.26	0.07±0.17
p-values			
Group	<0.001	<0.01	NS
Period	<0.001	<0.001	<0.001
GroupXPeriod	NS	<0.001	NS

instrumentation, calibration and measurement procedures see Chwalibog et al. (2004).

During the balance periods the animals were kept in metabolic cages in an intensive animal care unit, under natural daylight conditions. Between balance periods the animals were kept under conventional farm conditions. The animals were weighed at the start and at the end of each balance period.

Statistical analyses were carried out using the repeated MIXED Model (SAS release 9.1) with treatment group (1-4), and period (1-5) as the main effects, and interactions between the main effects. The covariance structure was AR(1).

Results and Discussion

The results on mean feed intake, animal live weights and feed efficiency (g growth per g feed intake) during the trial are presented in Table 1. Mean live weights in groups were similar and ranged between 4.81 -5.09 kg at the beginning of the trial. Feed intake was affected by the group and by the period (p<0.001). At the end of the trial the mean weights in the groups were (1) 12.83 kg, (2) 12.52 kg, (3) 10.93 kg and (4) 9.23 kg. The final body weights in groups (1) and (2) were similar. The final weights in groups (3) and (4) differed from all the other groups (p<0.001). Feed efficiency was affected only by period (p<0.001). Feed efficiency was highest at the beginning of the trial (mean for all groups 0.15) and lowest at the end of the trial (mean for all groups 0.02). Animals were growing during the trial so the period had an effect on mean live weights in all groups. The feed consumption was different in the groups and the animals' live weight increased according to the energy supply. Further results on heat production, energy and protein metabolism will be presented at the congress.

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IV-11 P

Long-term effects of metabolic programming in one-year-old mink dams

Connie Frank Matthiesen & Anne-Helene Tauson
Department of Basic Animal and Veterinary Sciences. Faculty of Life Sciences University of Copenhagen.
Grønnegårdsvej 3, DK-1870 Frederiksberg C, Denmark
E-mail address: aht@life.ku.dk

Introduction

It is well recognised that *in utero* malnutrition or dietary restriction may cause long-term metabolic programming or changes in the offspring such as changes in the metabolism or increasing the risk of disease later in life (Lucas, 1998). The outcome of *in utero* malnutrition may depend on when it is imposed and whether this occurs during certain sensitive time periods called "critical windows" in gestation. These critical periods in development are periods of rapid cell division in a developing tissue (Langley-Evans, 2004). Inadequate nutrient supply in each of these critical periods may cause a different metabolic response in the offspring (Lucas, 1991). Collectively results from different animal models have indicated that *in utero* restriction or malnutrition may have long-term consequences in adult life. The objective of present study was to investigate how protein restriction during foetal life affects reproduction and energy metabolism in 1-year old mink dams.

Material and Methods

Sixteen mink dams which had been exposed to protein restriction *in utero* the last 14-19 days in late foetal life by feeding their mothers a low protein (L; 18% of metabolizable energy (ME) from protein) or adequate gestation diet (A; 32% of ME from protein) were used in the present experiment. Respiration and balance experiments were performed on these 16 female mink in their own first pregnancy and lactation by means of indirect calorimetry in an open-air circulation system. The mink dams were measured in the first (-28 days ±1.9) and last third (-7 days ± 1.5) of the true gestation, and in the second and fourth weeks of lactation (mink dam and kits).

Table 1. Nutrient intake and energy metabolism traits in pregnant and lactating mink dams.

	Stage in gestation		RR	Week of lactation		RR
	First third	Last third		2	4	
Days before parturition	-28±1.9	-7±1.5				
CP intake [g*kg$^{-0.75}$*d^{-1}]	25.2^{a}	19.1^{b}	5.0	34.3^{a}	54.7^{b}	7.0
Maternal A				33.5^{a}	50.6^{bA}	
Maternal L				35.1^{a}	58.8^{bB}	
Fat intake [g*kg$^{-0.75}$*d^{-1}]	8.6^{a}	6.5^{b}	1.7	11.7^{a}	18.7^{b}	2.4
Maternal A				11.5^{a}	17.3^{bA}	
Maternal L				12.0^{a}	20.1^{bB}	
RN intake [g*kg$^{-0.75}$*d^{-1}]	0.4	0.6	0.4	1.2^{a}	2.1^{b}	0.4
ME [kJ*kg$^{-0.75}$*d^{-1}]	831^{a}	695^{b}	163	1215^{a}	1949^{b}	242
Maternal A				1192^{a}	1816^{bA}	
Maternal L				1237^{a}	2082^{bB}	
HE [kJ*kg$^{-0.75}$*d^{-1}]	688^{a}	754^{b}	105	1124^{a}	1801^{b}	370
RE [kJ*kg$^{-0.75}$*d^{-1}]	189^{a}	-65^{b}	195	21	144	167

RR: Square root of residuals. Values with different superscripts (a, b, c) in a row within gestation or within lactation differ significantly (P<0.05). Values with different capital (A, B) superscripts within column differ significantly (P<0.05).

Table 2. Plasma concentration of insulin and IGF1 during gestation and lactation.

	Gestation		RR	Lactation		RR
Maternal *in utero* treatment	A	L		A	L	
Insulin [$\mu U*ml^{-1}$]	5.96	4.4	2.1	3.8^{a}	4.5^{b}	0.8
IGFI [$ng*ml^{-1}$]	42.9	38.5	6.3	52.6	54.3	9.9

RR: Square root of residuals. Values with different superscripts (a, b, c) in a row within gestation or within lactation differ significantly ($P<0.05$).

All dams were fed *ad libitum* on a conventional wet mink diet (percent of ME from protein, fat and carbohydrate; 47:41:12). The following metabolic parameters were calculated: respiratory quotient (RQ), heat production (HE), ME intake, retained energy (RE) and retained nitrogen (RN). Plasma samples were collected once during each balance period for analyses of insulin and IGF-1 by radio-immunoassays. The statistical analyses of data
were carried out using the MIXED procedure in SAS (Littell et al., 2006) with the repeated measures option in the gestation and lactation respectively. The auto regressive order 1 [AR (1)] covariance structure was fitted.

Results

The reproduction results were not significantly affected by the previous maternal protein restriction. However, the *in utero* protein restricted dams had one more liveborn kit per litter than the adequately treated. The protein restriction during foetal life caused no effect on feed intake or any of the measured energy metabolism traits in the pregnant one-year-old females (see Table 1). However, a tendency ($P=0.09$) for a higher plasma insulin concentration among animals exposed to A protein supply during foetal life than for those on L *in utero* protein supply was found (see Table 2). The foetal life L animals had a significantly higher intake of crude protein, fat, carbohydrates, digestible energy and ME than the A ones during the fourth week of lactation. The plasma concentration of insulin during lactation was significantly affected ($P=0.02$) by the previous maternal treatment with the A nourished dams having a lower plasma concentration than the L dams. The higher insulin concentration among *in utero* L treated animals during the fourth week of lactation reflected the higher energy intake during this period.

Conclusion

Long-term effects of protein malnutrition during foetal life were fairly limited in this study.
However, the results suggest that the dams malnourished *in utero* had a higher capacity for food intake during lactation, and that this was reflected in the higher plasma concentrations of insulin.

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IV-12 P

Palatability of a synthetic diet in mink (*Neovison vison*)

Mette Schulin-Zeuthen, Kirsten Hvam and Peter Sandbøl
Danish Fur Breeders Research Center, Herningvej 112C, 7500 Holstebro, Denmark.
E-mail address: msz.pfc@kopenhagenfur.dk

Introduction

In investigations that require exact control of dietary compositions, a diet mixed from pure amino acids has been applied (Sandbøl et al., 2007). However, in some trials dietary intake was low and fluctuating (Blæsbjerg et al., 2008). Previously, Hvam et al. (2006) showed that 'taste enhancers' increased the dietary intake of the mink. The purpose of Trial 1 was to determine the effect of increasing dietary levels of chicken breast on feed intake. In Trial 2, the purpose was to examine the effect of pH on feed intake by comparing a chicken breast-based semi-synthetic diet with a pH-regulated synthetic diet.

Materials and Methods

In Trial 1, 25 adult male mink of the Brown/Glow colour type were allocated in five groups with five mink in each. In Trial 2, 15 adult male mink were allocated in three groups. The animals were housed in balance cages for 10 days. On a daily basis, feed intake and feed remnants were recorded. In addition, one group received a diet flavoured with soya sauce. In Trial 1, 10%, 20% or 50% of the individual amino acids in the negative control diet (Table 1) were replaced with the respective amino acids originating from the chicken breast. One animal receiving the soy sauce diet refused to eat and was eliminated during the first days in trial. In Trial 2, dietary pH was balanced between the test diets by addition of $NaHCO_3$. The diets contained 0.56 MJ ME / 100 g diet. The energy distribution was 15:55:30 of ME from protein, fat, and carbohydrates, respectively, and the dry matter content was 23%. Daily rations of 260 gram (equalling 1.26 MJ ME) met the requirement of maintenance for adult male mink (Glem-Hansen and Chwalibog, 1978). In Trial 1, dietary pH was 4.10, 4.24, 4.30, 4.71 and 4.14, respectively. In Trial 2, dietary pH was 4.01, 4.74 and 4.68, respectively.

Table 1. Composition of the negative control diet (% of fresh weight).

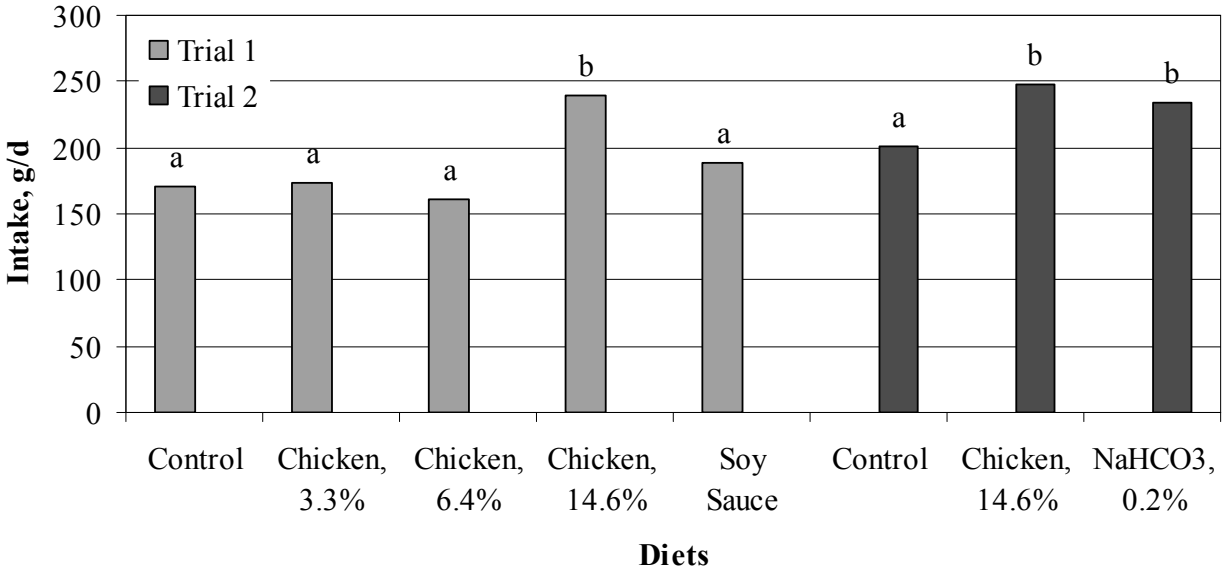
Ingredient	Composition, %
Methionine[1)]	0.227
Cystine	0.097
Lysine	0.354
Threonine	0.198
Tryptophan	0.060
Histidine	0.111
Phenylalanine	0.231
Tyrosine	0.179
Leucine	0.440
Isoleucine	0.204
Valine	0.275
Arginine	0.284
Glutamic acid	0.664
Glycine	0.296
Alanine	0.279
Serine	0.253
Aspartic acid	0.365
Proline	0.303
Corn starch	11.56
Cellulose	2.70
Soy oil	4.22
Lard	4.22
Vitamin premix	0.28
NaCl	0.06
Water	72.14

[1)] All amino acids are L-isomers
[2)] ME is metabolizable energy

Results and Discussion

Individual daily intakes varied a great deal between mink. Due to this fluctuation, the average intake of the last four days

Figure 6 Average feed intake of a synthetic diet with increasing inclusion of chicken breast (Trial 1 ■) and of a pH-regulated diet containing $NaHCO_3$ (Trial 2 ■). Dietary pH-values in control, chicken and $NaHCO_3$ diets in trial 2 were 4.01, 4.74, and 4.68. Different letters above columns denote statistical difference within trial.



was used for statistical calculations

The variation was lower in mink offered the highest level of chicken. The intake of this diet was significantly higher than that of the other four diets (Figure 1).The high dietary pH-value (Trial 2) significantly increased the intake of the diets compared to the negative control diet (Figure 1). The intake was not statistical different between the test diets.

Addition of $NaHCO_3$ or 14.6% chicken breast improved the dietary intake up to 95% of the offered diet compared to a dietary intake between 70 – 79% of the control diet. As addition of chicken to the diet did not increase dietary intake further than the addition of $NaHCO_3$ did, dietary pH appears to be more important for palatability than addition of raw meat. Which palatability enhancer to add depends on the purpose of the trial in question. The diets were designed to meet the daily ME requirement for maintenance in mink (Glem-Hansen & Chwalibog, 1978). A constant daily dietary intake of 95% must be considered sufficient to meet the requirement when offering a synthetic diet to adult male mink.

In conclusion, an addition of 14.6% chicken breast or 0.2% $NaHCO_3$ increased and stabilized dietary intake of a synthetic diet offered to adult male mink.

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IV-13 P

Amino acid digestibility of a synthetic diet fed to mink *(Neovison vison)*

Mette Schulin-Zeuthen & Peter Sandbol
Danish Fur Breeders Research Center, Holstebro, Denmark.
E-mail address: msz.pfc@kopenhagenfur.dk

Introduction

A synthetic diet has been designed where the protein fraction is entirely made up of individual amino acids (Sandbol et al., 2007). The amino acid composition of the diet is based on the ideal protein concept (Sandbol et al. 2004). It is assumed that pure amino acids are 96% digestible. To confirm this hypothesis, a digestibility trial was conducted with the purpose to determine the apparent digestibility of the individual amino acids used in the diet.

Materials and Methods

The trial was conducted with 4 adult male mink of the colour type Brown/Glow. The animals were housed in balance cages (modified after Jørgensen & Glem-Hansen, 1973). The animals were offered the diet (Table 1) in an adaptation period of 7 days followed by 4 days of collection. In the collection period, feed intake and feed leftovers were recorded daily. Faeces was collected daily and pooled for the days for each individual mink. Samples of feed and faeces were frozen at -18° C until analysis.
Apparent digestibility was calculated for the individual mink and amino acid according to the direct method as follows:

$$\text{Apparent digestibility, \%} = 100 * (AA_{intake} - AA_{faeces}) / AA_{intake}$$

where AA is the individual amino acid in grams. One animal with a low feed intake and a high faecal dry matter excretion was excluded from the calculations.

Table 2 Composition of the diet (% of fresh weight),and the calculated energy content and distribution.

Ingredient[1)]	Composition,% of diet
Alanine	0.239
Arginine	0.244
Aspartic acid	0.314
Cystine	0.083
Glutamic acid	0.571
Glycine	0.255
Histidine	0.095
Isoleucine	0.175
Leucine	0.378
Lysine	0.304
Methionine	0.195
Phenylalanine	0.198
Proline	0.260
Serine	0.217
Threonine	0.170
Tryptophan	0.051
Tyrosine	0.153
Valine	0.236
Corn starch	9.64
Cellulose	2.32
Soy Oil	3.62
Lard	3.74
Vitamin premix	0.24
NaCl	0.05
Water	75.94
Energy, calculated:	
ME[2)] MJ / 100 g	0.56
ME from protein, %	15
ME from fat, %	55
ME from carbohydrates, %	30
Dry matter, %	23

[1)] All amino acids are L-isomers
[2)] Metabolizable Energy

Table 3 Analysed content and calculated digestibility of amino acids. The results are means of 3 mink.

Amino acid[1)]	g/kg diet	Digestibility, %	SEM[2)]
Alanine	2.21	92	0.26
Arginine	2.41	94	0.20
Aspartic acid	3.09	92	0.10
Cysteine	0.53	74	0.97
Glutamic acid	5.58	94	0.20
Glycine	2.52	94	0.15
Histidine	0.99	92	0.15
Isoleucine	1.83	94	0.11
Leucine	3.76	95	0.11
Lysine	2.38	95	0.08
Methionine	1.78	98	0.08
Phenylalanine	2.14	95	0.07
Proline	2.64	92	0.19
Serine	2.15	89	0.39
Threonine	1.63	79	0.63
Tryptophan	0.51	89	0.30
Tyrosine	1.64	89	0.22
Valine	2.67	93	0.16

[1)]All amino acids are L-isomers
[2)] SEM = standard error of the mean

Results and Discussion

The apparent digestibility of the individual amino acids was for the majority between 89 and 95% (Table 2), which was slightly lower than the assumed 96%. The digestibility of methionine was slightly higher with 98%.

The digestibility of cysteine and threonine was 74% and 79%, respectively. The method used for determining the apparent digestibility implies that endogenous excretion is contained in the value. As a carnivore, the mink has a substantial endogenous excretion of enzymes involved in the digestion processes. However, Elnif and Hansen (2004) state that the reabsorption is very effective and therefore most amino acids will contribute little to the amount found in the faecal analysis. Low apparent digestibility can only be explained by their endogenous excretion for cysteine, threonine and aspartic acid (Elnif & Hansen, 2004). This supports our findings for cysteine and threonine.

A further contribution to the lower digestibility of cysteine, could be contamination of faeces with hair. However, the digestibility of other amino acids also abundant in hair (i.e. glutamic acid and serine) indicates that contamination with hair can be considered negligible.

Conclusion

In conclusion, digestibility of individual amino acids making up the entire dietary protein fraction was between 89 and 95%. Digestibility of cysteine and threonine was 74 and 79%, respectively.

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IV-14 P

Role of fatty acid synthesis in the mink fatty liver syndrome

Lei Sha[1, 2], Lora Harris[1], Morag Dick[1], Petteri Nieminen[3, 4], Anne-Mari Mustonen[3] and Kirsti Rouvinen-Watt[1]

[1]Department of Plant and Animal Sciences, Nova Scotia Agricultural College, P.O. Box 550, Truro, NS, B2N 5E3, Canada;

[2]Dalian University of Technology, Dalian 116024, China;

[3]Faculty of Biosciences, University of Joensuu, P.O. Box 111, Joensuu, FI-80101 Finland;

[4]Institute of Biomedicine, University of Oulu, P.O. Box 5000, Oulu, FI-90014, Finland

Email addresses: lsha@nsac.ca and krouvinen@nsac.ca

Introduction

Fatty liver syndrome (FLS) is a frequent pathological finding in mink and results from the accumulation of fat in the liver tissue (Hunter & Barker 1996). Mink develop FLS very quickly during a short period of starvation (Bjornvad et al., 2004). This has been shown to result in preferential mobilization of the n-3 polyunsaturated fatty acids (PUFA) causing an unfavourable n-3/n-6 PUFA balance (Nieminen et al., 2006). The altered n-3/n-6 PUFA ratio in the liver tissue may be important with regards to the activation of the endocannabinoid system. The activation of the cannabinoid receptor 1 (CB_1) in the liver is proposed to play a key role in increased lipid production. These effects are mediated by the upregulation of the lipogenic transcription factor sterol regulatory element-binding protein (SREBP)-1c and its associated enzymes acetyl-CoA carboxylase-1 (ACC-1) and fatty acid synthase (FAS) (Osei-Hyiaman et al., 2005). The objectives of this research project are to investigate the effects of feeding intensity, dietary fat source (n-3, n-6, n-9 polyunsaturated fatty acids, PUFA) and short-term fasting on the development of FLS in mink and if *de novo* liver fat synthesis plays a role in fat accumulation in the liver tissue in the mink.

Materials and Methods

Seventy-two (72) juvenile male and female standard dark mink were used in the trial. The mink were divided into three groups with three different diets containing 4.7% herring oil (n-3 PUFAs), soybean oil (n-6 PUFAs) or canola oil (n-9 MUFAs). Each diet was fed at 80% and 120% of the recommended dietary allowance (RDA) based on the metabolic body weight of the mink. The mink were fed 10 weeks from September to December 2007. Half the mink from each diet and feeding intensity were fasted for 5 days and the others were fasted for 14 hours before being anesthetized. The liver tissues were examined in triplicate for the mRNA levels of acetyl-CoA carboxylase-1 (ACC-1) with quantitative RT-PCR using 18S ribosomal RNA as a control. The data were analyzed using Proc Mixed in SAS with sex, oil and RDA as fixed effects and age of the mink as a random effect. A log transformation was carried out to achieve normality. The ACC-1 mRNA values presented are for the non-transformed data, while the P-values are reported for the log-transformed data.

Results and Discussion

There were no significant differences within the fasted mink due to the effect of sex, oil or RDA on the hepatic ACC-1 mRNA levels, whereas within the non-fasted mink a three-way interaction was found ($P = 0.07$).

As shown in Table 1, within the females fed at 80% RDA, when given the n-9 MUFA diet the hepatic ACC-1 mRNA levels differed significantly from the n-3 PUFA ($-6.13X10^{-6}$, $P=0.013$) and n-6 PUFA treatments

Table 1. Significant effects of oil, sex and RDA on the mRNA encoding for acetyl-CoA carboxylase-1 (ACC-1) in the liver of non-fasted mink (n = 36).

Planned Comparisons		Estimate (10^{-6})	SEM (10^{-6})	P-value
Effect of Oil	Females 80% n-3 vs. n-9	-6.13	1.896	0.013
	Females 80% n-6 vs. n-9	-6.50	1.896	0.009
Effect of Sex	80% n-3 Females vs. Males	-4.47	1.898	0.036
	80% n-9 Females vs. Males	5.13	1.898	0.040
Effect of RDA	Females n-9 80% vs. 120%	5.80	1.896	0.039

($-6.50X10^{-6}$, P=0.009). No other differences due to dietary fatty acid source were observed among the females. Significant sex difference was present for the mink fed at 80% RDA. The females had lower levels of ACC-1 mRNA in comparison to the males when fed the n-3 PUFA ($-4.47X10^{-6}$, P=0.036), whereas the females' levels were higher by $5.13 X 10^{-6}$ when fed the n-9 MUFA diet (P=0.040). Also, a significant RDA effect was observed among the female mink when fed the n-9 MUFA diet. The 80% group differed from the 120% RDA by $5.8X10^{-6}$ (P=0.039). In summary, oil, sex and RDA had significant effects on *de novo* liver fat synthesis as indicated by the mRNA encoding for ACC-1 in the non-fasted mink. The highest levels were observed in the female mink fed at 80% RDA with the n-9 MUFA diet.

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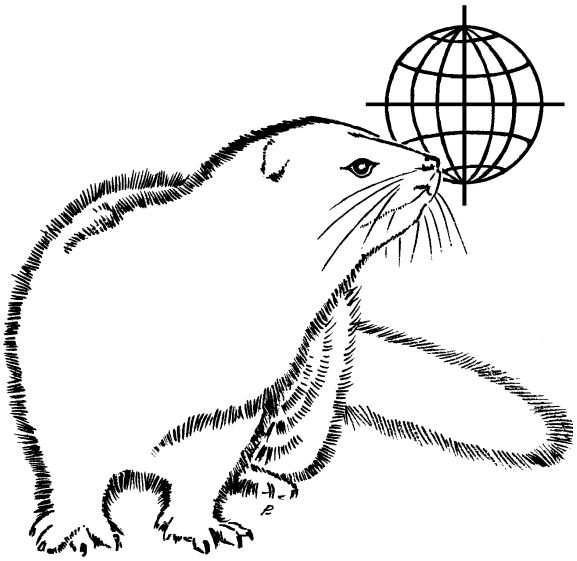

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V: Management

Edited by:

Dr. Bruce Hunter
Dr. Rouvinen-Watt
Lora Harris

V–1 P

Group housing of mink in flat and climbing cages

*J. de Rond * & G. de Jonge ***
** Research farm Edelveen Oudendijk 3A, 6744 PT Ederveen, The Netherlands.*
E-mail address: j.derond@edelveen.com
*** Rijn & Schiekade 89, 2311AN. Leiden, The Netherlands*
E-mail address:gerritdejonge40@gmail.com

Introduction

In response to continual pressure to improve welfare for farmed mink, a group housing system in enlarged cages was developed in the Netherlands (de Jonge, 1996), which allowed more space for individual mink. 15 years of experience with the new group housing system enables us to finally understand the economic impact, if not the welfare effects. Dutch mink breeders also introduced climbing cages, consisting of two cages above each other lodging four or five mink, on a large scale. Hence we researched the impact of this type of housing on pelt quality as compared to traditional pair-housing, then also studied the effects of larger groups, presence of the mother and varying sex ratio.

Materials and Methods

Mink were raised in groups (2 - 17 mink, with and without mother and in various sex ratios) and in pairs (controls) at the Spelderholt, from 1993 – 2000 and at Edelveen from 2004 - 2008. All were weaned at 11 weeks. Daily feed consumption was assessed during the growing period (i.e. from weaning until pelting). The amount of feed given to all controls and to all groups was weighed daily, for a total of five years at the two farms.

Pairs were raised in traditional mink cages (30 x 85 x 45 cm). Groups were housed in standard cages, connected vertically (flat cages) or horizontally (climbing cages) by 12cm wide holes in the walls. The housing density was two mink per cage plus one, as per the pre-2003 regulations.

The carcass was weighed before pelting, and the body length (Spelderholt) and pelt size (length of dried pelt as shipped) were measured. Pelt quality was evaluated by the auction houses and usually expressed as Saga and Saga Royal quality pelts as a % of all pelts. (In some years, pelts were scored on a 1 to 12 (good) scale by experts). Low grades are also expressed as % of all pelts.

Results

Food consumption: During the growing period), mink in pairs (controls) received approximately 1 kg more feed per mink than mink in groups, in each year of the study.

Pelt characteristics: Body weights of control males were about 100g higher than those of group-housed mink. Yearly body weight and pelt size averages from control males, males housed in groups of 4-5 in flat cages, and groups of 4-5 in climbing cages showed a body weight difference, but no pelt size difference. Group-housed male mink achieve the same pelt size as their 100-150g heavier control counterparts. No significant differences between body lengths were found, but the control mink yielded slightly but significantly shorter pelts than the group-housed mink.

The numbers of low grades varied stongly from year to year, with no consistent differences between the groups. Group- housed mink tended to yield better pelt quality than the control mink. No consistent differences between mink from flat and climbing cages were found. In our mink, as is often reported, pelt quality was always negatively correlated with pelting weight within groups of mink with the same body lengths, which would explain the higher quality pelts from the group-housed mink, who also have lower weights, and longer pelts.

Larger groups and sex ratio: Groups in larger cages, (up to 17 mink in 8 connected cages) developed well, but in groups of 6 – 16 mink per group there was an almost linear negative correlation between group size and pelting weight, and also between group size and pelt length. The presence of the mother promoted the weight and pelt length of the males slightly, with heavy male kits benefitting more than smaller ones. In groups of up to 5 mink, higher weight variation and a lower average weight are seen than in groups with only 2 males (de Rond, 2007,2008).

Table 1. Body weight and pelt length for group size and cage type, male mink

Cage type	standard cage			standard connected cage			climbing cage		
Group	Pair / 2 mink			Group / 4 or 5 mink			Group / 4 or 5 mink		
		weight	pelt size		weight	pelt size		weight	pelt size
year	n	g	cm	n	g	cm	n	g	cm
1994	351	2743	80,6	145	2742	80,9			
1995	208	2746	82,1	208	2690	80,0			
1996	133	2877	82,1	124	2800	82,0	50	2749	82,1
1997	71	2815	82,9	69	2752	83,3	61	2695	83,0
1998	40	2880	82,8	47	3034	85,1	32	2922	83,6
1999	71	2942	82,6	64	2912	82,4	54	2859	83,8
2004*	630	2852	12%				92	2754	14%
2005*	1150	2640	13%	80	2570	14%	413	2530	16%
2006	300	3115	85,8	130	3050	87,8	215	3030	88,5

*** pelt size = % 40 +30**

Welfare: Controls and group-housed mink produced about the same number of low-grade pelts, which strongly suggests that serious fighting was equally frequent. Mink in all size groups frequently huddled, and slept with as many mink in a nestbox as possible (up to 6 in ours).

Housing costs: Cost savings with group housing and climbing cages depends on local laws. In the Netherlands, a 30 cm wide cage may house two mink, while in the same width climbing cages, five animals are allowed at the moment. In 2013 four mink will be allowed in a climbing cage. Thus, climbing cages allow an animal density increase of 100 to 150% per m^2 compared to standard cages. Since the financial gain depends on several factors, such as the quality of the sheds, the watering and the manure removal system, we do not translate this 100 to 150% into exact profits. It is evident enough that climbing cages considerably reduce mink housing costs in The Netherlands.

Discussion

No differences in pelt quality were found between flat and climbing cages, making the space-saving climbing cages the self-evident choice for group housing.

Research at Edelveen, published in the Dutch minkbreeders magazine 'de Pelsdierenhouder', supports group housing. Controls ate moreand became heavier than mink in groups of 4-5. However, this weight difference did not make the control pelts longer : mink in groups yielded slightly longer pelts, and were slimmer. The energy balance may differ because mink in groups move more than mink in pairs, e.g. playing more with each other.. The smaller control cages may stimulate energy-consuming stereotyped behaviour, and larger groups of mink save more energy by huddling. It is apparent that housing in groups reduces feed costs and yields longer and better quality pelts, in groups of up to 6 mink. Since group housing improves both pelt quality and pelt length without increasing the number of low grades, these pelts must realize the highest prices in the auctions, but year to year price variations mask the differences between the experimental groups making an exact estimation impossible. Dutch minkbreeders, who have a good feeling for economics, came to the right decision when they decided to introduce group housing. In summary, considering the lower housing costs in combination with the better pelts, we conclude that group housing in climbing cages improve the economics of mink farming.

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V-2 P

Preventive microclimate control in the vicinity of mink in closed and open accommodations during extremely hot weather conditions in order to prevent heatstroke

Frans Kleyn van Willigen[1], Toine van Erp[1], Jan de Rond [2], Ties Peijnenburg[3]
[1] Animal Health Service
P.O. Box 9, 7400 AA Deventer, The Netherlands
[2] Research farm Edelveen, Dutch Fur Breeders Organisation,
P.O. 488, 6600 AL Wijchen, The Netherlands
[3]C.P.C Flevo, Nijverheidsweg 11, 3881 LA Putten, The Netherlands
E-mail address: f.kleyn.v.willigen@gddeventer.com

Introduction

In the period of July 14th-18th, 2007, more than 350 000 mink died as a result of heatstroke in the eastern part of Germany and in Poland. From an animal-welfare perspective, it is important to properly manage the microclimate in which the mink live, especially during extremely high temperatures and unpredictable humidity levels, and to modify this in such a way that mass deaths of animals can be prevented.

Heatstroke

Signs of heat stroke in mink are intense, rapid panting, wide eyes, salivating, staggering and weakness (Flournoy; Gaffin, 2002). Advanced heatstroke victims will collapse and become unconscious. The gums will appear pale and dry. The longer the body temperature remains at or above 41ºC, the more serious the situation. Kits before and just after weaning are more sensitive than adult mink. Fatter animals and males fall victim more often than slimmer ones and females.

Materials and Methods

A mink farm with functional microclimate control in northern Spain was visited in 2007. The traditional sheds and a hall are located 200 m above sea level and accommodate 8.000 female mink. The farm is situated in a valley and the buildings follow a north-south alignment. The inside of the hall and east side of the sheds catches the morning sun, while in the afternoon and early evening, the setting sun has an effect on the microclimate in the sheds. The roofs of the sheds and the hall have an open ridge and split-level construction with a height difference of approximately 80 cm, at 60 and 120 metres along its length. Along the length of the complete roof on the west and east side of the sheds and east side of the hall is a 1.2 metre cantilever awning made of fine-mesh windbreak netting constructed. A sprinkler system with copper nozzles providing an extremely fine mist, used in the poultry industry in hotter climates, are fitted 2 m above the cages at an angle, with 1.2 metre intervals along a length of 10 mm steel pipe. This system is fitted in the ridge of the sheds. A pump of 5.5 kWh generates 25 to 30 bars for 1600 nozzles in the hall. On hotter days (or those which are forecast to be hot) the system is activated from 10 a.m. to 5 p.m. A time-switch, set to intervals of 1 minute on and 2 minutes off, operates the sprinkler system. Depending on the weather conditions, the sprinkler intervals can be shorter or longer. Water is pumped from a 2500 litre reservoir, and kept at a constant temperature of 14ºC. After 6 p.m. the sun sets behind the hillside and the farm is then in shade. *Ad libitum* cool drinking water, supplied from an isolated system protected from the sun, is offered to the mink.

Table 1. Temperature and humidity levels in mink hall on hot days during the summer of 2007 (outside temperature 35-40ºC).

Date	31 July		4 August		5 August		14 August		15 August		26 August		27 August		28 August	
	temp.	humid.	temp.	humid.	temp.	humid.	temp.	humid.	temp.	humid.	temp.	humid.	temp.	humid.	temp.	humid.
Hour	ºC	%	ºC	%	ºC	%	ºC	%	ºC	%	ºC	%	ºC	%	ºC	%
7.00	19.4	85	13.9	75	17.5	58	14.5		24.3		23	86	25.7	72	21	
10.00	**23.1**	**85**	**21.8**	**38**	**27.5**	**60**	**21.5**		**27**	**36**	**29.8**		**29.2**	**68**	**29.5**	
10.30									30.1	47						
10.40									29	57						
10.45									28.2	66						
12.00			30.3	46	25.3	60	29.8		26.3	66	30.3	56	32.5	58	32.8	40
14.00	29.9	46	32.7	46									33.4	72	37.5	
16.00			30.4	46											35.2	54
18.00	29.2	46					29.3				29.2		31.5	82		
20.00			25.7	53			25.6				27.8					
21.00	23.7	51											25.8			

Results and Discussion

The positive effects of the atomisation activated at 10.00pm on cooling and stabilisation of the humidity of the microclimate (5ºC) in the hall are described (Table 1). A side effect of atomisation is the air-turbulence that is generated in the animals' surroundings. The open ridges reinforce the air-turbulence, since the ascended air can leave the sheds and the hall.

Cantilever of fine-mesh windbreak netting protect the minks against direct sun in fall in the morning and sunset. The total daily fluid requirement (litres per kg body weight) under condition of heat stress is as follows: no stress 0.05, mild 0.07, moderate 0.12, and severe 0.15 (Counotte, 2007). Stress levels will increase even more if temperature, humidity and exercise with great effort (Counotte, 2007; Case, 2001; Gaffin, 2002). In this situation, it will be necessary to provide the mink with an abundant supply of drinking water below 40ºC (Case, 2001;Counotte, 2007; Gaffin, 2002; Møller, 1988).

Conclusions

Controlling the microclimate (Wustenberg, 1988) in the vicinity of mink during extremely high outdoor temperatures (above 30ºC) in combination with extremely high humidity and without air movement reduces animal losses due to heatstroke. Induction of air movement around the animals by atomisation and an open roof ridge are important. Cantilever fine-mesh windbreak netting protects the mink and the drinking water supply against direct sun exposure in the fall. Unlimited fresh drinking water must always be available for the mink.

Acknowledgements

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VI: Behaviour & Welfare

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Dr. Bruce Hunter
Dr. Kirsti Rouvinen-Watt
Lora Harris

VI – 1 RP

Why should environmental enrichment be used to improve welfare on mink farms?

Georgia J. Mason
Canada Research Chair in Animal Welfare, Animal Science Department
University of Guelph, Guelph, Ontario N1G 2W1
Tel: +1-519-824-4120 x56804
Fax: +1-519-836-9873
Email address: gmason@uoguelph.ca

Abstract
The aim of this review paper is to present a general scientific and political argument for the greater enrichment of mink cages. I first give an overview of the animal welfare issues common to many husbandry systems, before assessing how mink farming compares with other sectors. I highlight two ways in which mink farming (like many other forms of farming) could be improved in welfare terms: in its use of restrictive feeding, and the barren, unenriched nature of many animals' cages (common in some countries, though now rare in others). I will also review in more detail what we know – both scientifically and practically – about specific possible enrichments for farmed mink. Even simple enrichments like wire cylinders, year-round straw, and lengths of rope may have marked effect on mink behaviour and welfare, and, especially in a climate where fur-farming seems to be scrutinised more closely and harshly than many other animal sectors, finding functional, cost-effective ways of enriching environments and reducing abnormal repetitive behaviours are to be encouraged.

Introduction
In this paper I first give a brief overview of the animal welfare issues common to many husbandry systems, before assessing how mink farming compares. I highlight two ways in which mink farming (like many other forms of farming) could be improved in welfare terms: in its use of restrictive feeding, and the barren, unenriched nature of many animals' cages. I review literature on other species to explain why this last is important in terms of both stress reduction and proper forebrain development, and then review the extent to which we see abnormal repetitive behaviour like stereotypic pacing on mink farms. In my plenary talk itself, and also a subsequent companion paper (Mason in prep.), I will additionally review in more detail what we know – both scientifically and practically – about specific possible enrichments for farmed mink. The aim of this present review is to present a more general scientific and political argument for the greater enrichment of minks' cages.

Welfare issues in captive animals: on a spectrum from 'good' to 'bad', where does fur farming sit?
Animal welfare relates to an animal's affective (colloquially, 'emotional') state: what it feels. Good welfare thus means experiencing positive emotional states and negligible suffering, while poor welfare entails experiencing severe or prolonged states of suffering (e.g., Dawkins 1980, 1990; Mason & Mendl, 1993). Worldwide, more than 22 billion individuals are currently kept by humans for food, for research, for companionship, and in zoos (cf. the few million farmed mink). For these animals, being housed very differently from how they would live if free or wild, is nearly ubiquitous. Although the aims and methods of these various husbandry systems differ, common welfare themes therefore recur. Veterinary expertise, scientific research and common sense all show, for example, that hygiene, vaccination regimes, nutrition, handling regimes, stress and genotype

have major effects on physical health – with animals that are in pain, nauseous, or otherwise in discomfort from disease or injury obviously having poor welfare. Being unable to maintain homeostasis, due to insufficient access to food, water or a suitable thermal environment, causes both psychological stress and welfare problems from impaired physiological functioning. Housing conditions which restrict movement and/or present little opportunity for naturalistic behaviours, are typically non-preferred by animals, induce stress, and cause the development of abnormal repetitive activities like stereotypic pacing and fur- or feather-plucking (all behaviours which I discuss in more detail below). Housing animals in groups, be they mothers with their offspring, or unrelated similar-age conspecifics, may help solve this problem, but often brings with it others: particularly competition for food, and aggression that subordinate animals cannot escape from. Finally, handling, transport and slaughter are often stressful processes for animals.

These welfare issues occur and recur in many systems from the familiar to the exotic: laboratory mouse breeding units, poultry farms, pig farms, even timber camps using working elephants – and a myriad others. These recurring welfare concerns have therefore prompted the 'Five Freedoms' (Brambell 1965) to become generally accepted tenets for ensuring good welfare, across a host of diverse systems; these are: (1) freedom from injury and disease; (2) freedom from hunger, thirst and malnutrition; (3) freedom from fear; (4) freedom from thermal or physical distress; and (5) freedom to express most 'normal' behaviors. These recurring welfare concerns also allow the exchange of ideas, opinions, techniques, data and welfare evaluations between scientists working on similar problems, even when the species and system they are studying varies.

Such exchanges would suggest that in many ways, a well-run mink farm compares extremely favourably with many other animal industries -- particularly with those in food animal agriculture (cf. Spruijt 1999; also SCAHAW 2001 and Pedersen et al., 2002; Hansen 2007), but arguably also with many research animal facilities, and even some (the most environmentally restrictive) forms of pet- and zoo animal housing. For example, infant mink are left with their mothers until they have transitioned to solid food (unlike piglets and calves, for instance); left physically intact (not castrated, branded, tail-clipped, tooth-clipped or given any other type of painful mutilation, unlike e.g. piglets, calves, lambs, laying hens, and many research rodents); and often housed with siblings beyond that. Overall kit mortality to weaning age has been estimated at between 20 and 35% (reviewed SCAHAW 2001); fairly similar to that seen in piglets without farrowing crates (reviewed Mellor & Stafford, 2004), and lower than rates seen in some bear and 'big cat' species in zoos (Clubb & Mason, 2003, 2007). Levels of fear are typically low. Mink cages give animals space to move, separate resting/nesting areas, and separation from their faeces (unlike typical poultry, pig and some dairy systems). Stereotypic behavior on mink farms is less prevalent than in say, tethered dry sows, isolated laboratory macaques, or even zoo-housed giraffes (surveyed in Mason & Latham 2004, Mason et al., 2007), and when mink are well-fed, it is also less time-consuming than that performed by many carnivore species in zoos (Clubb & Mason, 2003, 2007). Adult mink mortality rates are on average 2-5% per year (reviewed SCAHAW 2001); this contrasts with, say the 16-17% first and second litter sows that are culled for lameness (e.g. Gill, 2007; to give just one example; data from intensive dairy cattle or aviary laying hens would provide poorer contrasts still). Finally, mink are hardly ever transported (unlike the vast majority of food animals); and euthanasia is on-farm, and typically an extremely swift process.

So on a spectrum from 'good' to 'bad', where does fur farming (as best practiced) sit? 'Firmly in the middle' would be my judgment. Thus many millions or even billions or food animals would benefit if their housing and husbandry involved more of the attributes of a well-run mink farm, while millions or even billions of many other animals, from caged parrots to racing horses, arguably have welfare that is fairly similar. These comparisons are not here to induce complacency, but instead to illustrate that welfare issues are widespread across many systems, with mink farms far from standing out as 'worst offenders': indeed in certain ways, as highlighted above, mink farms are really rather good. There are, however, two notable ways in which mink farming fails to be better than other practices: in the restrictive feeding of breeding females, and in the barren, unenriched nature of most cages. I will focus primarily on the latter topic in the rest of this paper.

The restrictive feeding of breeding females

One of the most important welfare issues on mink farms is the restrictive feeding of breeding female mink, to 'condition' them over the winter. I will deal with this just briefly here. A major welfare issue for female broiler breeders and breeding sows (e.g. de Jong et al., 2003; Bergeron et al., 2006), in Europe at least it has long been recognized as, similarly, a major welfare concern for female mink. On mink farms, feed restriction greatly elevates stereotypic behaviour, increases animals' chances of dying over the winter, and also increases risks of 'greasy kits' once the litter is born (reviewed SCAHAW 2001). The best-researched solution to this problem is to use more graduated, gentle over-winter slimming (reviewed SCAHAW 2001); while new possible solutions include increasing the bulk of feed without increasing its energy content (e.g. reviewed SCAHAW 2001; also e.g. Damgaard & Hansen, 2004), and using a combination of weighing and feeding technology to help the precise feed levels needed by each individual animal be supplied and adjusted more appropriately (e.g. Sønderup & Bækgaard, 2005; Møller et al., 2007). Other potential solutions for the future might include finding ways to select breeding stock earlier in the fall (so that they can avoid being excessively 'fattened up' during this time; e.g. Møller et al., 2007), and perhaps selecting for animals whose fall growth involves less fat deposition. Reducing stereotypic behaviour (e.g. via enrichment) should also be beneficial – since it is the positive feedback between hunger and hyper-activity (with food deprivation triggering stereotypic activity, but stereotypic activity in turn using up energy reserves) that seems particularly likely to put some females on a 'knife-edge' over the winter. Last but least, where there is still a culture of *'if females aren't dying, they're not being slimmed hard enough'*, I seriously urge that this is dropped: it is unlikely that this belief is supported with actual evidence, and, more importantly, its ethical/welfare implications are impossible to defend. Overall, it is a moot point as to whether feed restriction for female mink is a more or less serious welfare issue than is the feed restriction of females in the pork and meat chicken industries. It is probably safest to conclude that it is serious issue in all three, and perhaps one that may best be reduced via more correspondence in the future between researchers trying to address this issue in all three sectors.

Lack of enrichment: why is this a problem in principle?

A second major welfare issue for farmed mink is the barren and unstimulating nature of their cages. Barren and unstimulating cages cause concern to the general public, but there is also now much scientific data as to their deleterious effects. An overview of these is given below.

First, barren, unstimulating environments may prevent natural activities that are essential for good welfare within the cage – if these are

prevented, animals display evidence of chronic stress (e.g. endocrine and immunological changes; e.g. Dawkins, 1990). Examples of such 'behavioural needs' are social contact for primates and many other group-living species (e.g. rats, horses); nest-building for peri-patrurient sows; climbing structures that allow vertical flight for some zoo animals (e.g. clouded leopards; some primates); and appropriate nests or shelters for laboratory rodents and also farmed mink. Second, barren, unstimulating environments prevent activities that are definitely rewarding when performed (e.g. Dawkins, 1990; Mason et al., 2001), even if the absence of these activities does not seem to cause chronic stress. Examples of such behaviours might include dust-bathing for hens, playing, copulation and maternal care in many species, and, some have argued (though see Mason in prep.), swimming in mink. Third, barren environments reduce welfare in an additional way: by making animals less resilient to stressful events that happen to them once they are removed from the cage. This reduced ability to cope has been best studied in laboratory rodents. Elevated anxiety if exposed to frightening situations outside the cage (as manifest in physiological responses, approach/escape behaviours, and even wound-healing rates) is seen when gregarious animals (e.g. rats; female mice; some hamster species) are isolation-housed. Similar effects are typically also seen when simple laboratory cages fail to be enriched with shelters and others forms of physical complexity (e.g. reviewed by: Olsson & Dahlborn, 2002; Smith & Corrow, 2005). Fourth, barren, unstimulating conditions compromise the development and functioning of the mammalian forebrain, as evidenced in physical indices such as reduced dendentric branching, as well as in cognitive indices like impaired learning (reviewed by e.g. Van Praag et al., 2000; Nithianantharajah & Hannan, 2006). This may perhaps not in itself be a welfare issue, but it does seem very likely to exacerbate a well-known sign of poor welfare: stereotypic behaviour (e.g. Mason, 2006; Tanimura et al., 2008). Stereotypic behaviour is the fifth and final reason to advocate environmental enrichment. 'Stereotypies' or 'stereotypic behaviours' have long been inter-changeably defined as repetitive, unvarying and apparently functionless behaviour patterns. Behaviour meeting these criteria is statistically associated with environments or husbandry practices that cause other signs of poor welfare (see meta-analysis by Mason & Latham, 2004), and statistically reduced in frequency by environmental enrichment (see meta-analysis by Swaisgood & Shepherdson, 2005).

Precisely how 'unvarying' or how 'functionless' an activity has to be for inclusion has led to debates as to what to label such behaviours as over-grooming, which involve quite variable motor patterns, or wheel-running which involves an enrichment. I have therefore suggested that the broad term 'stereotypic behaviour' be used instead to cover all 'repetitive behaviour induced by frustration, repeated attempts to cope and/or C.N.S. (brain) dysfunction' (Mason, 2006), with the term 'Abnormal Repetitive Behaviour' being used when we do not have data on biological causation. Many stereotypic behaviours specifically involve altered functioning of the forebrain's basal ganglia which cause behavioural symptoms such as 'perseveration' – the functionless repetition of evoked responses (e.g. reviewed Mason 2006; see also e.g. Tanimura et al., 2008).

Overall, it is currently unknown in general (let alone for mink *per se*) how the five effects of impoverished environments that I have listed here inter-relate. For example, is impaired brain function necessary for the emergence of stereotypic behaviour? Is the meeting of specific behavioural needs needed to reduce stereotypic behaviour, or to induce the 'out-of-cage' stress-protective effects of environmental enrichment? We do not know. One thing is certain, however:

there is a strong welfare case – as well as, pragmatically, a public relations case – for enriching barren cages.

Abnormal Repetitive Behaviour (ARB) in farmed mink

To start with the least well understood, and the least common form of ARB: occasionally large portions of the front part of the back and/or neck will be clipped of top hair, sometimes leaving only the head and back of the neck untouched. Pelt-clipping may be directed to the self or a cage-mate. In one study no pelt-chewing was observed in well-provisioned kits, only those experimentally fed at low intensities, and it also seems to be absent from wild pelts (reviewed SCAHAW 2001); although little is really known of the cause or welfare significance of this particular behaviour.

Another, more common form of mink ARB is tail-sucking or -chewing, which is typically self-directed and results in a clipped or bald tail-tip. Unlike locomotor stereotypic behaviour (see below), and possibly pelt-chewing (see above), tail-biting/-sucking does not seem to be reliably affected by feeding levels, but it does decrease with certain enrichments (Hansen et al., 2007) and increase if swimming enrichment is provided but then withdrawn (reviewed SCAHAW 2001, Vinke et al., 2008). It also seems to be absent from wild pelts (reviewed SCAHAW 2001). It is therefore probably best described as a true stereotypic behaviour, although much more work is needed as to biological causation. Its prevalence differs greatly across farms, e.g. as few as 10% of kits or more than 50% (Møller, 2000, cited by SCAHAW 2001), may have bitten or sucked tails by pelting time. Other assessments of tail-biting in adults show that as with kits, its prevalence varies greatly between farms (e.g. between 19% and 66%) and even between years (e.g. from 10% to 22% at the Research Center for Mink of the Dutch Research Institute for Animal Husbandry; de Jonge et al., 1986 cited by SCAHAW 2001).

Farmed mink commonly perform locomotor stereotypic behaviour, which typically involves pacing along the cage wall, vertical rearing in a cage corner, repetitive circling or nodding of the head/front half of the body, and/or repeatedly entering and leaving nest-box. Pacing (often called 'pendling' in Danish studies) seems to be the most common (reviewed SCAHAW 2001). This behaviour is, again, absent in the wild, as well as exacerbated by feed restriction, and also reduced by delaying weaning and some forms of environmental enrichment. Some instances also suggest underlying perseverative changes, or involve self-harm (for example, kits may transiently continue to stereotype for some seconds after the arrival of food, and adults may – albeit rarely – perform forms that involve repeatedly crashing down from the cage-top onto their backs; Mason, 1994; reviewed SCAHAW 2001). It is for these reasons that I class these as true stereotypic behavours, although precise biological bases are as yet unknown. Note that a subsidiary but important reason for aiming to reduce this behaviour in mink is that highly stereotypic lines are more vulnerable to over-winter mortality (SCAHAW 2001).

The degree to which adults stereotype in this way varies greatly. Some animals perform none, others perform them for over four-five hours a day. Thus during the seven hours before feeding, mink in some populations spend on average 49% of their time in the behaviour, while pre-feeding levels have been reported of between 4% and 32% on five different Dutch farms (reviewed SCAHAW 2001), and 13% - 35% on five different Danish farms (e.g. Møller & Hansen, 2001). In one survey, focusing on non-feed-restricted animals only, the mean level was under 10% of the day (Clubb & Mason, 2003, 2007). Females show

consistently higher levels than males (reviewed SCAHAW 2001). The prevalence of adult females with the behaviour also varies, averaging 98.3% on one site studied 61.6% on another, but under 10% on yet another. A range of 31–85% has also been reported for farms within the Netherlands (reviewed SCAHAW 2001).

Overall, ARBs including stereotypic behaviours thus have been common on mink farms, and are common still in more traditionally run establishments (though for exceptions and recent changes in Europe see e.g. Vinke et al., 2002; Jeppesen, 2004).

Discussion and Conclusions

Poor welfare is often presented by campaigning groups as a reason to single out fur farming. The HSUS, for example, states on its website that *'suffering is a common ingredient in all methods of procuring fur, from fur factory farming to trapping'*[1]. In condemning some of the worst practices seen worldwide (not least the skinning of animals that are injured but not dead), the HSUS and similar organizations are absolutely right: in countries where fur farming is completely unregulated, practices may occur which are simply indefensible. But another extreme by far are those farmers who work under regulation (in some countries meeting very specific legal husbandry requirements), and/or with a personal ethic that the animals in their care should not suffer. How do welfare standards on such farms objectively compare with the ways that food animals, research animals, pets and zoo animals are treated in those same countries? They are similar to many, and considerably better than some. There are therefore lessons that other sectors could learn from the mink industry.

However, by the same token there are lessons that even the most responsible elements of the fur industry need to learn from other sectors. Alleviating the hunger caused by food restricting breeding females is one. Enriching cages (and modifying other aspects of husbandry) to reduce stereotypic behavour, along with other benefits, is another. Some enrichment of cages is becoming standard practice in, for example, some Scandinavian countries, but in others (e.g. the US and Canada) it is far from the norm. Even simple enrichments like wire cylinders, year-round straw, and lengths of rope may have marked effect on mink behaviour and welfare (Jeppesen, 2004; Hansen et al., 2007; Mason, in prep.), and, especially in a climate where fur farming seems scrutinised more closely and harshly than many other animal sectors, finding functional, cost-effective ways of enriching environments and reducing ARB are to be encouraged.

[1] www.hsus.org/furfree/cruel_reality/, accessed July 20th 2008.

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VI-2 RP

Maternal behavior of chinchilla females changes during the first month after birth

Danuta Dzierzanowska-Goryn, Marian Brzozowski and Bartosz Pytlak
Department of Animal Breeding, Warsaw University of Life Sciences - SGGW
Ciszewskiego 8, 02-786 Warsaw, Poland
E-mail address: marian_brzozowski@sggw.p

Abstract
The behavioral activity of Chinchilla (*Chinchilla lanigera*) females and offspring was estimated during first month after birth. Five activity types were described: the females' own activity; the females' social activity; the females' maternal activity; own activity of offspring; social activity of offspring. It was observed that the number of maternal activity patterns decreased during estimated period. The number of individual activity patterns decreased during first two weeks then increased, whereas the number of social activity patterns increased during first two weeks after birth then decreased.

Introduction
Knowledge about the behaviour of chinchillas is important in order to increase the welfare of the animals according good codes of practice and law regulations. Any observed abnormal behavior patterns could be treated as precautionary signals informing about breeding problems on the farm, such as health, living conditions and feeding. There are several studies describing various aspects of animal behavior (Manning & Dawkins, 1998; Kaleta, 2003; Sadowski, 2003), but only a few are specific to chinchillas (Dzierzanowska-Goryn et al., 2005; Indulska, 2003). The aim of this study was to describe the maternal behavior pattern in chinchilla females during the first month after birth. This is the nursing period and determines the weaning results.

Chinchillas are animals with night-time activity and they are mostly resting and relaxing during the light period of the natural day (Barabasz, 2001; Dzierzanowska-Goryn et al., 2005). Maternity is a special period, when females have to be active all the time, even against their natural rhythm. After birth, the offspring needs the mother's attention and she is caring for and nursing her young nearly constantly. When the kits are older, they are more and more independent. By observing tendencies in the animals' activity (individual and social), we can describe the behavioral patterns of the females and her offspring after birth.

Materials and Methods
The studies were carried out on 9 females with litters with a total of 24 animals. Nest boxes are not used on chinchilla farms and the females give birth directly on the floor of the pen. The cages were made from wire mesh and it was possible to observe the animals' activity without disturbing them. The animals were observed during a 2-hour period, between 10:00 am – 2:00 pm every day from birth to 30 days post partum and all behavioral activity was recorded.

The following activities were observed:

- Individual activity: moving, eating, coprophagy, grooming, resting, sleeping, biting hard objects, playing with pellets, urination, defecation.
- Social activity: vocalization, resting together, cleaning each other, steeling pellets, following, escaping, imitating.
- Maternal activity (mother - litter interactions): feeding, cleaning, care, covering, observing.

The number of occurrence was recorded for each kind of activity and totaled per hour.

Figure 1. Chinchillas individual activity

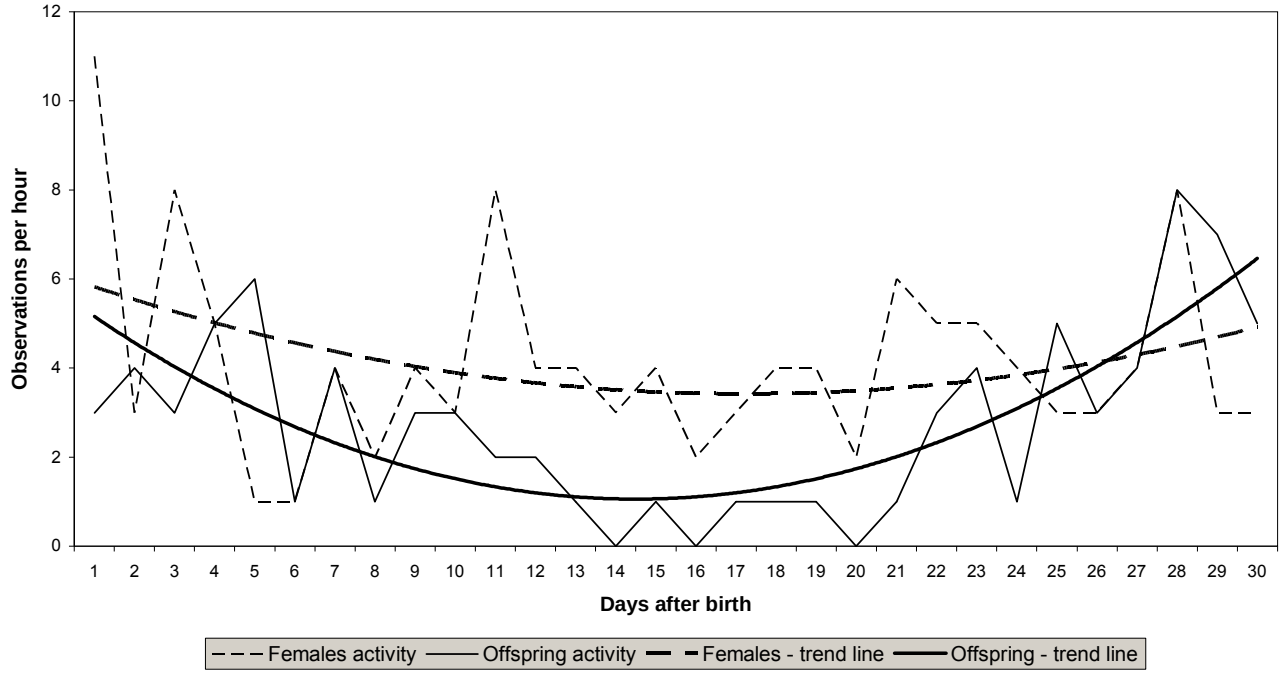


Figure 2. Chinchillas social activity

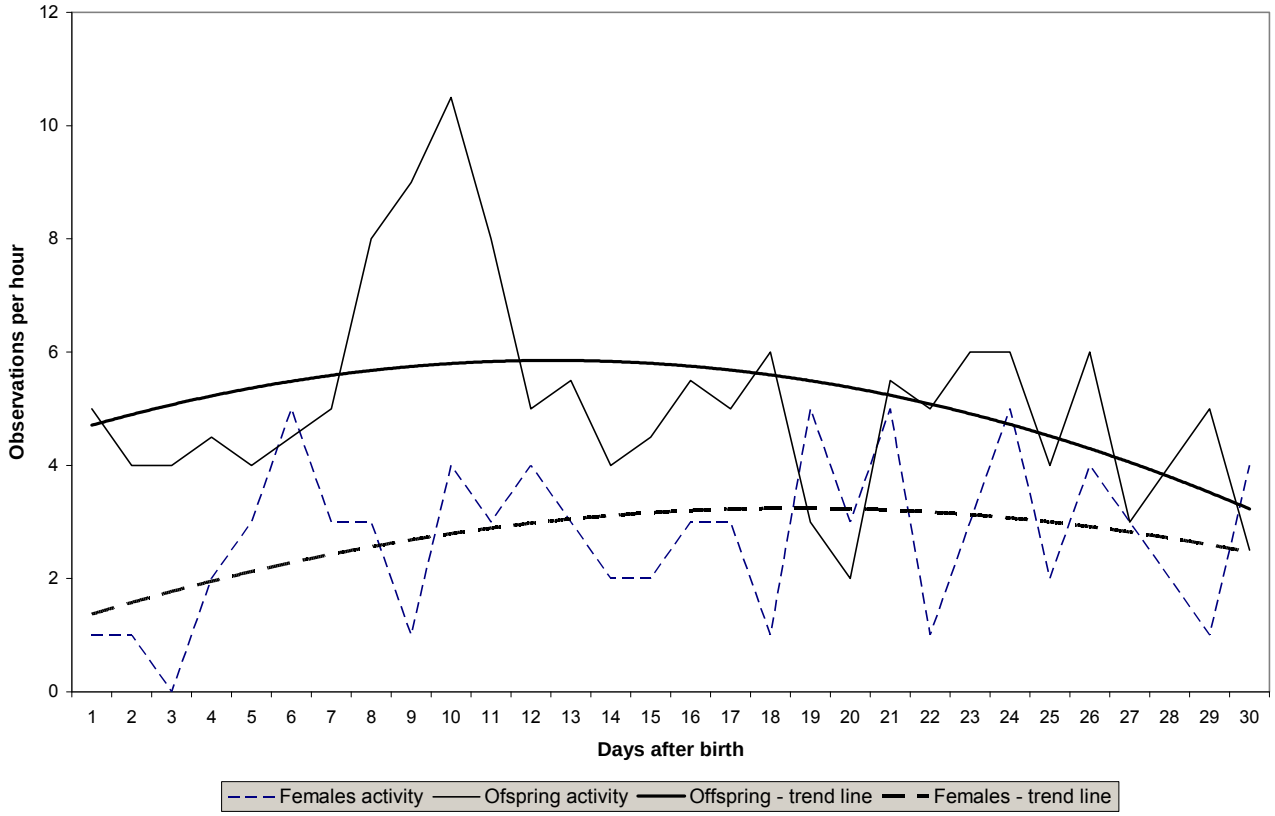
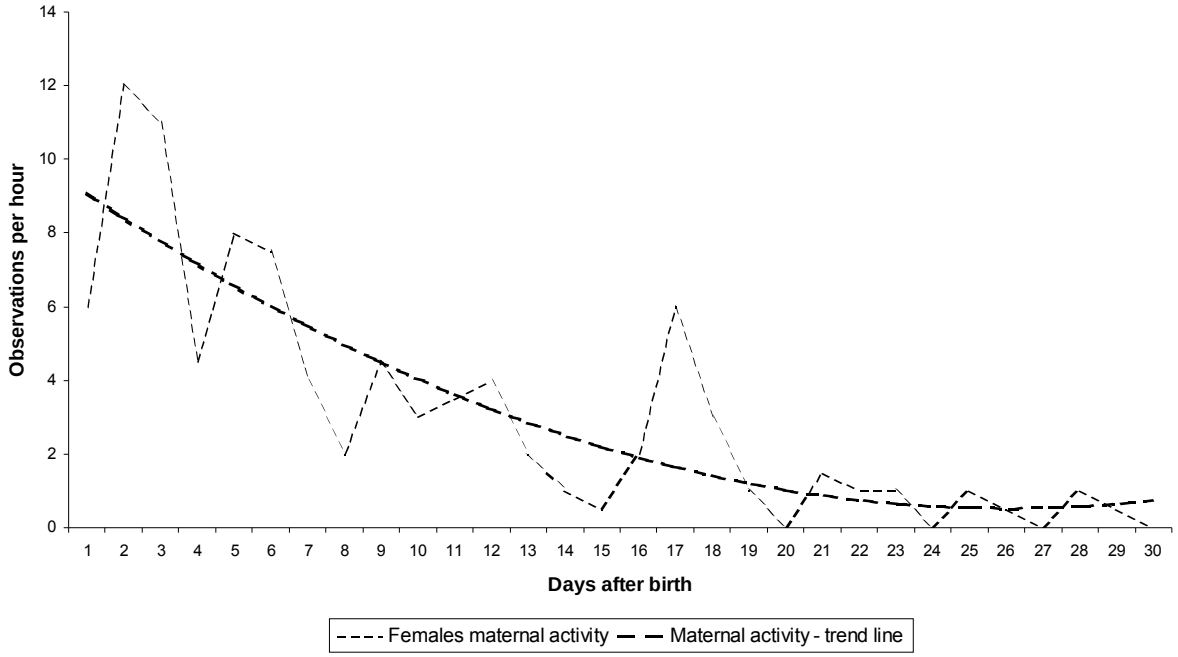


Figure 3. Chinchillas maternal activity



The results are presented as number of observed occurrences per hour and are averaged as estimated tendencies.

Results and Discussion

The results concerning the chinchillas' individual activity (females and offspring) are presented in Figure 1. The tendency line of the mothers and offspring individual activity during first month after birth looks like letter "U" with the lowest point at days 14-16 (Figure 1). The tendency line of social activity for mothers and offspring during first month after birth looks like letter "A" with the highest point at days 18-19 (females) and days 12-16 (offsprings, Figure 2). The females' maternal activity tendency line is the highest right after birth, then decreases up to day 31 (Figure 3).

In summary it can be seen, that the first week after birth is especially important. High activity of the females (nursing, protecting, care, cleaning young) and young chinchillas (learning all behavioral patterns as eating, escaping, grooming, playing) was observed during the first week. The end of the second week (days 14-15) was a turning point in the young chinchilla' activity. After this time their individual activity started to predominate over social interaction when they have to begin to take care of themselves. At the end of the 3rd week (days 18-20) the females' behavior changed also and more individual and even agonistic patterns (escaping) were observed in comparison to maternal and social behaviors.

Conclusions

In conclusion, five behavioural activity types were described: the females' own activity; the females' social activity; the females' maternal activity; the own activity of the offspring; and the social activity of offspring. It was observed that the number of maternal activity patterns decreased during the observation period. On the other hand, the number of individual activity patterns decreased during the first two weeks then increased, whereas the number of social

activity patterns increased during the first two weeks after birth and decreased thereafter.

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VI-3 RP

Production and welfare of Finn Raccoon (*Nyctereutes procyonoides*) in enriched-cage housing

Maarit Mohaibes, Nita Koskinen, Kirsi Kupsala and Teppo Rekilä*
MTT Agrifood Research Finland, Animal Production Research,
Silmäjärventie 2, FI-69100 Kannus, Finland
**E-mail address: maarit.mohaibes@mtt.fi*

Abstract
Traditionally Finn Raccoons are housed in male-female pairs during the growing-furring season. Biologically, Finn Raccoon is rather social compared to other farmed fur animals and therefore might benefit from housing in larger group. Group housing in two-tiered enriched-cages would be feasible and cost efficient in traditional fur-animal sheds. During the period from July to November, 100 enriched-cage housed and 100 standard-cage housed juvenile Finn Raccoons were studied to find out the effects of different housing systems on production and welfare. The cubs housed in the enriched-cages were heavier than those in the traditional-cages in the middle and at the end of the experiment. As well the organ masses were higher in the group of enriched-cage housed Finn Raccoons. The cortisol:creatinine-ratio did not differ between groups. We conclude that enriched-cage housing had no negative effects on production or welfare of Finn Raccoon in the present study. It is, however, important to analyse the data of fur quality evaluation and pelt prices before final recommendations can be made.

Introduction
The Raccoon dog *Nyctereutes procyonoides* originated from East-Asia and spread to the North-Eastern areas of the former Soviet Union in the 1930-1950s (Lavrov, 1971, in Kauhala, 1992). It was adopted from the wild to Finnish fur farms in the 1970s (Korhonen, 1988) and named Finn Raccoon. Already in the beginning of the farming trials it was noticed that Finn Raccoons were easy to handle, feed and breed in farm conditions. The Finn Raccoon has been farmed similarly to its relatives from the *Vulpes* and *Alopex* families, even though there are not many scientific studies related especially to welfare issues, such as barren cage environment, foot problems and diseases (European Commission 2001). Until now, ethological studies have been concentrated on the general activity (Korhonen 1988) with a single group-housing experiment (Ahola et al., 2007) in which group-housed animals were shown to stereotype less than traditionally raised animals. The Finn Raccoon is traditionally housed in male-female sibling-pairs, but as a social species it could benefit from group housing. This would also allow for species-specific need fulfilment due to the larger variation of social environment. The enriched-cage housing with cages in two tiers would offer a more diversified environment with the possibility for separation from the cage mates in case of aggressive behaviour.

Enriched-cage housing has also received interest from farmers because of its potential profitability. The enriched-cage consists of two similar size standard cages which are placed on top of each other and connected by an opening. This way it is possible to house a larger number of animals without enlarging the housing buildings, while the area requirements of animal protection laws are fulfilled. At the same time the animals are getting more social contact, their living area is increased and the cage-environment enriched. Enriched-cage housing has earlier been investigated in mink with positive results (Hänninen et al., 2008; Vinke et

al., 2004). The aim of the present study was to investigate the influence of enriched-cage housing on health, growth, production and stress level of the Finn Raccoon.

Materials and Methods

The present study was carried out on a commercial farm, of Kauppilan Turkis Oy in Lohtaja, Finland. The animals were fed *ad libitum* with fresh fur animal feed manufactured by a local feed kitchen. Straw was available for the animals during the whole experiment to satisfy the dietary fibre needs. Water was also available *ad libitum.* The health of the Finn Raccoons was checked daily. Altogether 200 juvenile Finn Raccoons were used in the experiment during the growing-furring season 2007. The experimental animals were divided into the two groups, which each consisted of 100 animals. The enriched cage group consisted of four animals per cage and the standard cage group consisted of two animals per cage. The enriched cage was made of two similar size standard cages placed on top of each other and were connected by an opening. There were platforms in both cages and the platform in the lower cage allowed the animals to climb into the upper cage. During the first week the animals housed in the enriched cages were prevented entry to the upper cage in order to get them used to defecating in the lower cage.

The animals were weighed at the beginning (July), middle (October) and at the end of the experiment (November). The final weighing was carried out in association with pelting. Urine was collected for a 24-h period in October from animals living in 10 cages per experimental group by urine-collecting pads placed under the cages. Cortisol:creatinine-ratio in the urine was measured to determine the stress level of the animals. The animals were killed by electro-execution at the end of the study. Fifty animals per group were dissected to measure the mass of heart, spleen, and adrenals, and the scars on the flesh side of the pelts were counted. The fur quality and prices of pelts will be evaluated by professional fur graders at the Finnish Fur Sales Ltd (Helsinki, Finland) during the autumn 2008.

Table 1. Growth indices and stress parameters in the Finn Raccoons between the experimental groups (mean±SD).

	Group		
Parameter	Enriched cage	Standard cage	P-value
Body mass in July (g)	4043±1030 n=95	4022±892 n=98	NS
Body mass in October (g)	13481±1609 n=95	12238±1312 n=98	<0.001
Body mass in November (g)	15636±2133 n=95	13515±1583 n=98	<0.001
Heart mass (g)	46.3±5.2 n=50	42.7±4.5 n=50	NS
Adrenal mass (mg)	289.0±42.0 n=50	259.7±48.1 n=50	NS
Spleen mass (g)	21.3±6.5 n=50	18.2±4.6 n=50	NS
Cortisol:creatinine-ratio	2.01±0.19 n=50	1.66±0.17 n=50	NS
Scars in pelts (number)	1 n=50	0 n=50	-

The growth-data was statistically analysed using the Proc Mixed (SAS for Windows release 9.1) with a model: $y_{ijk} = \mu + \tau_i + \varrho_{j(i)} + \varepsilon_{ijk}$, where μ is the overall mean, τ_i the effect of the treatment i, $\rho_{j(i)}$ the effect of the cage j in the treatment i and the ε_{ijk} is the error for animal k of the treatment i in the cage j. Organ masses were analysed by Proc Mixed model using body mass as covariate. The cortisol:creatinine -ratio was analysed using the Proc Mixed model without the effect of the cage j. The level of statistical significance was set at $p<0.05$.

Results

The animals in the enriched cages were significantly heavier than the animals in the standard cages in October and in November (Table 1.).

As well the heart, adrenal and spleen masses were higher in the animals housed in the enriched cages than in the animals housed in the standard cages, however after using the body mass as covariate the differences disappeared. In the beginning of the study in July there were no differences in the body masses between the groups. There were no significant differences in the cortisol:creatinine-ratio between the animals housed in the standard cages and the enriched cages. Only one scar from the flesh side of the pelt was found in an enriched-cage housed Finn Raccoon.

Discussion

In the wild, the Finn Raccoon might be the most social among the farmed fur-bearing animals (Siivonen, 1972; Sandell, 1989; Ward & Wurster-Hill, 1990; Kauhala, 1998), even though it is considered relatively solitary by some researchers (see Ikeda, 1986; Ward & Wurster-Hill, 1990). Group housing of Finn Raccoons seems to be quite promising (see e.g. Korhonen et al., 1986a, 1991a, Hänninen et al., 2002b). Our results showed no real signs of aggressions related to the large group-size in the enriched cages. Finn Raccoons formulate a social hierarchy in a group (Korhonen et al., 1991a), which may explain the low amount of aggressive behaviour observed (Korhonen & Harri, 1987b; Korhonen, 1988c).

In the current study, the animals in the enriched cage group were heavier in the middle (October) and at the end of the study (November) than in the standard cage group. This might be a result of higher social competition and increased appetite. Effect of group housing on production parameters and welfare of Finn Raccoon has been studied earlier in cages placed side by side. Hänninen et al.,(2002) reported that there were no differences in growth between the group-housed and traditional sibling-housed animals. Also Korhonen and Harri (1988) did not find any effects of group housing on growth of the Finn Raccoon. On the other hand, fur quality has been shown to be slightly worse in earlier group housing experiments (see Hänninen et al., 2002; Ahola et al., 2004). However, mechanical scuffing was assumed to be the reason when animals were entering from one cage to another through a small opening. The adrenal glands were heavier in the group-housed Finn Raccoons, and this was related to the stress induced by group housing (Hänninen et al., 2002). However, in the same experiment the pair-housed Finn Raccoons exhibited more stereotypic behaviour (Ahola et al., 2007). Opposite to previous findings, in the current study there were no differences between the groups in the mass of adrenals or the urinary corticol:creatinine –ratio, which are measures of the general level of stress.

Conclusions

It would be tempting to conclude that according to the better growth results, the enriched-cage housing is a better system for the Finn Raccoon that the traditional style housing. However, even if there was no sign of negative effects on any of the studied parameters it is important to include the results of the fur quality evaluation and pelt prices before final conclusions can be drawn.

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VI-4 P

Social preferences in relation to familiarity and age in silver fox females

Anne Kathrine Akre, Morten Bakken, Anne Lene Hovland
Department of Animal- and Aquacultural Sciences,Norwegian University of Life Sciences, P. O. Box 5003, 1432 Ås.
E-mail address: anne.akre@umb.no

Introduction

Foxes should possess the ability to recognise and distinguish conspecifics individually due to their flexible social structure. Determining foxes' social preference and how this influences their social behaviour towards different conspecifics at different ages may give us a better understanding on how to prevent foxes from exposure to possible social stressors when housed in groups.

Materials and Methods

The effect of familiarity on social preferences in young silver fox females and their motives for seeking social contact were studied in 14 silver fox female at the age of 9½ and 24½ weeks in a preference test where they could choose between a sister, an unfamiliar female or an empty cage. The position and behaviour of the females were recorded using instantaneous sampling every tenth minute for twenty-six hours.

Results and Discussion

There was a clear preference for seeking contact with a conspecific at 9½ weeks ($p<0.01$). The foxes did not differentiate between the familiar or unfamiliar stimulus ($p>0.05$), however there was a tendency to play more in front of the unfamiliar stimulus ($p=0.067$). No preference was seen for either of the stimuli provided to the foxes when 24½ weeks old, ($p>0.05$), but they were more aggressive towards the unfamiliar fox ($p<0.01$).

Conclusions

The motives for seeking contact as cubs were non-aggressive and possibly related to play motivation, whereas the aggressive behaviour displayed by juveniles towards the unfamiliar females indicates an increased competitive motivation.

VI-5 P

Intensive handling of mink (*Neovison vison*) dams during lactation reduces litter performance and weaning weight

Jennifer Dobson[1], Georgia Mason[2] and Kirsti Rouvinen-Watt[1]
[1]*Department of Plant and Animal Sciences, Nova Scotia Agricultural College, P.O.Box 550, Truro, Nova Scotia, B2N 5E3 Canada*
[2]*Department of Animal Science, University of Guelph, Guelph Ontario, N1G 2W1 Canada*
E-mail address: jadobson@nsac.ca, krouvinen@nsac.ca

Introduction

Gestational stress has been found to reduce maternal behaviour such as arched back nursing in rat dams (Smith et al., 2004). The behaviour of stressed rat dams is directed more often to digging, eating, drinking and resting rather than to their pups (Patin et al., 2002). Patin and colleagues (2002) suggest that this is the reason why the pups from stressed rat dams have a higher mortality and lower growth rate compared to controls. Reduced maternal care can also have detrimental effects on the adult offspring, causing them to be more fearful and also exhibit less maternal care (Francis et al., 2002). The objective of this study was to determine if the intensiveness of handling and blood sampling of mink dams during the lactation period affects the weight of the kits.

Materials and Methods

This study is part of a larger study that used four-hundred (400) breeder female mink with an even distribution of age (multi or primiparous) and colour (dark or pastel) over a two-year period to investigate the effects of resting bunks on body condition, the activation of the hypothalamic pituitary adrenal (HPA) axis, heat stress and oxidative stress and consequently glycemic control and reproductive performance of female mink. To determine the effect of the intensiveness of handling on the weight of mink kits, 304 mink females that whelped were blocked by the intensiveness of the blood sampling they received during the lactation period. These included: 128 Not Sampled (females that did not have a blood sample taken), 128 Sampled (females that had a drop of blood taken from one clipped hind limb toe nail for the measurement of blood glucose), and 48 Intensively Sampled (females that had multiple hind limb toe nails clipped to obtain five capillary tubes of blood and their rectal temperature measured). The MIXED procedure of repeated measures was performed using a model with blocks: Age (Multiparous or Primiparous), Colour (Dark or Pastel) and Blood Sampling Group (Non Sampled, Sampled and Intensively Sampled) as fixed effects with full interactions. Year was used as a random block and Litter Size a covariate. Statistical significance was set at $P<0.05$.

Results and Discussion

Using litter size and the number of male and female kits as covariates, there was a significant effect of the intensiveness of handling and blood sampling on the litter weight over the lactation period ($P = 0.0007$). The weaning weights of the litters from the Intensively Sampled females were significantly lower (1714.97±52.67) compared to the weaning weights of the litters from the mink dams who were blood sampled for glucose only (Sampled) (1887.09±36.09) and the mink dams who were not blood sampled (Not Sampled) (2097.46±39.96) during lactation.

The lower litter weights at weaning in the Sampled and Intensively Sampled groups compared to the Not Sampled group may be

attributed to the stress level of the dams. Similar outcomes have been observed in the silver fox (*Vulpes vulpes*), where female cubs from stressed vixens had a lower litter weaning weight and were less active compared to cubs from non stressed vixens (1660 ±42g and 1491± 40 g) (Bakken, 1998). The lower weaning litter weight may also be the result of reduced maternal care (Champagne & Meaney, 2006). A reduction in maternal care is mediated by changes in oxytocin receptor levels (Pedersen & Boccia, 2002). As a result of the stress from environmental adversity, rat dams reduce their level of maternal care as compared to control dams (Champagne & Meaney, 2006). Similarily, Bosch and collegues (2007) found that prenatally stressed rat dams nursed their pups significantly less than control dams.

Using litter weight as an indicator, it was determined that the intensiveness of handling and blood sampling during the lactation period is stressful to the mink dams. The mink dams that were not blood sampled during the lactation period had significantly higher litter weights at weaning compared to the females that had a blood glucose sample taken and the females that were handled more intensively with multiple blood samples taken at a time. Moreover, the females that only had a blood glucose sample taken had significantly higher litter weights at weaning compared to the females that were sampled for blood more intensively and also measured for rectal temperature. The results indicate that during the lactation period, blood sampling and prolonged handling of mink dams should be avoided in order to reduce the negative effects stress may have on maternal care.

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VI-6 P

Seasonal body weight, body condition score, blood glucose and stress level of female mink (*Neovison vison*) with or without access to resting bunks

Jennifer Dobson and Kirsti Rouvinen-Watt
Department of Plant and Animal Sciences, Nova Scotia Agricultural College,
P.O.Box 550, Truro, Nova Scotia, B2N 5E3 Canada
E-mail address: jadobson@nsac.ca, krouvinen@nsac.ca

Introduction

There are no previous studies outlining the effects of resting bunks on the body weight, blood glucose concentration, stress level and reproductive performance of female mink. Resting bunks may allow for the possibility of a less sedentary lifestyle. This could improve the body condition of the mink and also aid in glycemic control (Hynes et al., 2004). The bunks may also provide an occasional escape from the demands of lactation thereby reducing the excess mobilization of body reserves and uncontrolled gluconeogenesis associated with nursing sickness (Clausen et al., 1992). This may also reduce the level of oxidative stress, such as seen in humans with type 2 diabetes (Pitozzi et al., 2003). The alternative resting place and increased cage surface area provided by the bunks may also reduce stress from heat and crowding that occurs due to the close confinement of the dam and her growing kits in the nest box. The ability of the dam to escape from her kits may make the weaning process more gradual as in nature; this may be less stressful to both the dam and her kits (Dunstone, 1993). This research examined the effects of resting bunks on body condition, the activation of the hypothalamic pituitary adrenal (HPA) axis, heat stress and oxidative stress and consequently glycemic control and reproductive performance of female mink.

Materials and Methods

Four-hundred (400) breeder female mink with an even distribution of age (multi or primiparous) and colour (dark or pastel) were used for this study over a two-year period. Each year, half (100) of the cages were fitted with flexible plastic resting bunks, supplied for this research by UNIQ Farm Systems ApS (Hovervej, Denmark). Monthly measurements of body weight, body condition score (BCS) and blood glucose concentration were taken. The litter size, and kit weight and sex were determined on days 1, 21 and 42 post partum (PP). For the statistical analysis females were categorized as Barren, High Weight Loss (HWL, lost more than 20% of their body weight over the lactation period) and Regular Weight Loss (RWL, lost less than 20% of their body weight over the lactation period). For the determination of their stress level, 48 female mink (24 Bunk) were categorized as Handled and used to determine the rectal temperature, total number of protein bands using isoelectric focusing of serum samples, fecal cortisol metabolite concentration and comet assay score of leukocytes in whole blood samples at a base line measurement before bunks, day 1 PP and day 42 PP.

Results and Discussion

The bunks did not have a significant effect on the body weight, BCS, blood glucose concentration or the physiological stress response as measured by the rectal temperature, total number of protein bands, fecal cortisol metabolite concentration and comet assay score. There was a significant interaction effect of treatment and day (P=0.046), with a higher mortality rate in the HWL Control group (10.1%) on day 21 PP compared to that of the HWL Bunk group (5.8%). The Handled Bunk group had a marginally lower (P= 0.085) kit

mortality rate over the entire lactation period (27.2%) compared to the Handled Control group (37.8%). However, females in the RWL Bunk group had higher kit mortality on day 1 PP (19.72%) compared to the RWL Control group (10.96%) (P = 0.006). Using litter size and the number of male and female kits as covariates, the Handled Bunk dams had higher litter weights at weaning (1461.36±113.66g vs. 1843.40±115.84g) (P = 0.034) compared to the Handled Control dams, and 29% of the dams in the Handled Bunk group were also able to wean litters of 7 or more kits compared to only 16.7% of females in the Handled Control Group (P = 0.035).

The ability of the dam to raise her kits reflects the health of the dam. The lower kit mortality rate in the HWL and Handled Bunk groups may suggest that during the lactation period the bunks could have provided an escape from the demands of lactation allowing the dam to better care for herself and consequently her kits. This may also be reflected by the fact that more Handled Bunk females were able to wean litters of 7 or more kits. In the RWL Bunk group, climbing on and off of the bunks and possibly falling from the bunks during late gestation could have caused trauma to the fetuses, as seen in humans (Grossman, 2004), leading to a higher kit mortality on day 1PP. The lower litter weight at weaning in the Handled Control group may be attributed to the elevated stress level of these dams. In foxes and rats, stress and environmental adversity can lead to reduced maternal care and lower litter weight at weaning (Bakken, 1998; Champagne & Meaney, 2006). Due to the potential for increased neonatal mortality it is suggested that if resting bunks are going to be used, they should not be placed in the female's cages until 2-3 weeks after whelping.

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VI-7 P

Group housing of juvenile mink: effects on pelt length, general impression and price

Sari Hänninen[1], Ilpo Pölönen[2], Maija Lahti[3], Teija Pyykönen[1], Leena Ahola[1] and Jaakko Mononen[1]

[1]*University of Kuopio, Department of Biosciences, P.O.Box 1627, FIN-70211 Kuopio, Finland*
[2]*Laurea University of Applied Sciences, Uudenmaankatu 22, FIN-05800 Hyvinkää, Finland*
[3]*Finnish Fur Breeders' Association, P.O.Box 5, FIN-01601 Vantaa, Finland.*
E-mail address: sari.hanninen@uku.fi

Introduction

Group housing could be a potential way of enriching the housing environment of juvenile farmed mink. A larger cage system, required for a group of mink, makes it possible for all animals in the group to utilize a larger space, and also provides room for a more complex environment. Social contacts within the groups could also act as enrichment. Furthermore, by housing mink in groups of four in climbing cages, i.e. a standard cage with nest box and an extra cage built on top of it, twice as many mink can be housed in a certain floor area as compared to traditional pair housing. Consequently, savings in building expenses of mink barns are obvious. However, the welfare of group housed mink might be compromised (Hänninen et al., 2008, Pedersen et al., 2004), e.g. because of fighting and social stress, and the productivity of the mink could be worse due to poorer growth, or lower pelt quality and price. Therefore, research on group housing of mink is needed.

Material and Methods

We carried out four experiments to study the effects of group housing on pelt length, general impression and price in juvenile mink. In experiments 1 and 2, group housing (GH) in row cage systems where several standard mink cages were connected to each other was compared to traditional pair housing (PH) of mink in standard mink cages. In experiments 3 and 4, group housing of mink in climbing cages was compared to the traditional pair housing. The total N was 136, 156, 1356 and 444 mink in experiments 1-4, respectively. The analyses of pelt length and the ratio pelt price/average price in an auction (hereafter price ratio) were performed with linear mixed model. The price ratio was used instead of pelt price in order to correct for price differences between different auctions, colour types and sexes. General impression data were analysed either with Wilcoxon matched pairs test (row cage experiments) or Mann-Whitney U -test (climbing cage experiments) depending on the set-up in each experiment.

Results

There were no differences in pelt length between the GH mink (males 76±1 cm, 78±1 cm, 77±0 cm and 78±1 cm, females 63±1 cm, 64±1 cm, 64±0 cm and 63±1 cm, $\bar{x}$±SE, in Exp. 1, 2, 3 and 4 respectively) and PH mink (males 75±1 cm, 80±1 cm, 77±0 cm and 78±0 cm, females 61±1 cm, 64±1 cm, 63±0 cm and 62±1 cm) (for all comparisons: $p>0.05$). General impression was worse in the GH than PH mink in experiments 1 (6.2±0.4 vs. 7.7±0.3, $p<0.01$) and 2 (5.6±0.5 vs. 7.2±0.3, $p<0.05$), i.e. the row cage experiments. This difference was not seen in experiments 3 (6.4±0.1 vs. 6.6±0.1, $p>0.05$) and 4 (6.0±0.1 vs. 5.7±0.2, $p>0.05$) where the GH mink were housed in climbing cages. The price ratio did not differ between the GH and PH mink in experiments 1 (0.83±0.02 vs. 0.83±0.02, $p>0.05$) and 3 (0.93±0.12 vs. 0.93±0.15, $p>0.05$), whereas the GH mink had lower price ratio than the PH mink in experiments 2 (0.88±0.05 vs. 1.03±0.05,

$p<0.05$) and 4 (0.80±0.03 vs. 0.84± 0.02, $p<0.05$).

Discussion

Group housing seems to have no effect on pelt length. In row cage experiments, the general impression of the pelt was worse and the price ratio, to some extent, lower in the GH mink than in the PH mink. In climbing cage experiments, on the other hand, no difference in the general impression was observed, and the difference in the price ratio was not as remarkable as in the row cage experiments. In climbing cage systems these putative negative effects on pelt prices can possibly be compensated for by the savings in building expenses and possible timesavings in the daily farm labour. In conclusion, the results show that group housing especially in climbing cages is a feasible way of housing mink.

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VI – 8 P

Running in a running wheel substitutes for stereotypies in mink (*Neovison vison*) but does it improve their welfare?

Steffen W. Hansen & Birthe M. Damgaard
Department of Animal Health, Welfare and Nutrition, Faculty of Agricultural Sciences, University of Aarhus, Blichers Allé 20, Postbox 50, 8830 Tjele, Denmark
E-mail address: steffenw.hansen@agrsci.dk

Introduction

Many investigations have shown that restricted feeding increase the activity of mink and especially the performance of stereotypic behaviour (Damgaard et al., 2004). The presence of stereotypies is often assumed to indicate reduced welfare, but it is possible that a high level of appetitive fed searching behaviour in a limited area will enhance the development of patterns of movement that seem stereotypical. If this assumption is correct, we would expect that giving mink access to a running wheel would prevent the development of stereotypic behaviour, but would it also improve their welfare?

This experiment investigated whether access to a running wheel affects the development of stereotypies during restricted feeding and whether selection for high or low levels of stereotypy affects the use of the running wheel. Furthermore, the daily rhythm of stereotypies and wheel running activity were tested, and plasma cortisol concentrations were compared in stereotyping and non-stereotyping mink.

Materials and Methods

64 female mink selected for high or low levels of stereotypy were used. Half of the females were kept in standard cages each with access to a running wheel, whereas the other half had no access. The number of turns of the running wheel, behaviour, feed consumption, body weight and the concentration of plasma cortisol were measured during the winter slimming period, when the mink are given restricted feed.

Results and Discussion

The mink with access to a running wheel did not perform stereotypic behaviour, but stereotypic behaviour was observed in 24 out of 28 females without access to a running wheel during restricted feeding. Thus, the opportunity to use a running wheel reduces the risk of mink developing stereotypic behaviour in the cage. The mink selected for a high level of stereotypies had more turns in the running wheel than the mink selected for low levels of stereotypy (X_1=21.84; P<0.0001) and the females selected for a low level of stereotypy used the nest box more than the mink selected for a high level of stereotypy (X_1=17.54; P<0.0001). The results indicate that selection for or against stereotypy may be a more general selection for or against a high level of activity, and that mink with a high level of activity when housed in the normal standard cages have an increased risk of stereotypic behaviour. The number of turns in the running wheel peaked at the end of the slimming period and was at its lowest when the mink were fed *ad libitum* in the beginning of March. The body weight correlated negatively with the frequency of observed stereotypies (r = -0.51; P < 0.01) and the number of turns in the running wheel (r = -0.66; P < 0.01).

The results confirm that a high feeding motivation increases the stereotypic activity as well as wheel running activity and that both types of activity appear to be highly plastic and responsive.
Mink with access to a running wheel used the running wheel just as much as mink without

access to a running wheel performed stereotypies (Mink selected for high stereotypy: X_1=1.13; P<0.288), and the daily rhythms of the two types of activity were identical with a peak around feeding time ($F_{1,51.8}$=0.00; P = 0.96). No other behavioural differences between stereotyping and non-stereotyping mink were found and neither was there any difference in plasma cortisol concentration.

Conclusions

In conclusion, running in a running wheel substitutes for stereotypies in mink, but there were neither behavioural nor physiological indicators that the non-stereotyping individuals running in the running wheel had a better welfare than the stereotyping individuals without access to running wheels. Increased activity in the form of stereotypies or increased wheel running activity caused by reduced feeding may be a useful tool for feed management and assessment of welfare at farm level.

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VI – 9 P

Genotype affects maternal retrieval and ultrasonic vocalisations of mink kits

Birthe Houbak[1], Jens Malmkvist[1], Karin T. Clausen[2], Annemarie Surlykke[3]
[1]University of Aarhus, Department of Animal Health, Welfare and Nutrition,
[2]University of Aarhus, Department of Biological Sciences
[3]University of Southern Denmark, Institute of Biology
E-mail address: Jens.Malmkvist@agrsci.dk

Introduction

We know very little about the nature and function of mink kits' vocalisations. Therefore, the aim of the present study was to describe the kits' vocalisation when placed away from their warm mother, the protective nest, and their littermates. We investigated the influence of the vocalisations on maternal behaviour in terms of the dam's kit retrieval.

Materials and Methods

We used 58 one-year-old female mink (*Mustela vison*) of two genetic lines (colour type 'Palomino' n=23 and 'Black' n=35). All recordings were made during a standardised kit-retrieval test performed 5 days after birth, with equipment sensitive to sounds up to 100 kHz.

Results and Discussion

Our recordings demonstrated for the first time that mink kits produce complex ultrasonic vocalisation of up to 50 kHz. The call consists of long trains of multi-harmonic pulses with a relative long pulse duration (average 264-874 ms) and a high repetitions rate (0.6-2.3 pulses/s). Genetic line affected both kit vocalisations and maternal retrieval since Palomino kits had a higher variation in their pulse duration than Black kits ($p=0.023$) and Palomino dams had an impaired kit-retrieval compared to Black dams ($p=0.008$).

Conclusion

In conclusion, mink kits do produce ultrasonic vocalisation when away from their mothers and nests. Genotype influenced both the nature of kit vocalisation and maternal behaviour during a standardised kit-retrieval test.

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VI-10 P

The effect of environmental enrichment on farm mink in Sweden

Lena Lidfors[1], Heléne Lindberg[1] and Eva Aldén[2]
[1]Department of Animal Environment and Health, Swedish University of Agricultural Sciences, P.O. Box 234, SE-532 23 Skara, Sweden
[2]Department of Animal Welfare and Antimicrobial Strategies, National Veterinary Institute,SE-751 89 Uppsala, Sweden
E-mail address: Lena.Lidfors@hmh.slu.se

Introduction

The welfare of farmed mink has been heavily debated in Sweden over the last two decades. Reasons for reactions against mink farming include the perception of fur as a luxury product, and distaste for keeping wild animals in cages, exacerbated by the stereotyped behaviour exhibited by some caged mink. Over the years there have been several incidences of releases of mink from their cages and arson against two mink feed kitchens.

Swedish authorities in response to these problems have prepared extensive reports, the most recent of which investigated how to acceptably keep mink from both an animal welfare and an animal health point of view (SOU 2003:86). Sweden has also considered European findings on the same problem (European Commission, 2001).

In Sweden, the Animal Welfare Act §4 states "Animals shall be accommodated and handled in an environment that is appropriate for animals and in such a way as to promote their health and permit natural behaviour" (SFS 1988:534, SFS 2003:1077), and it also sets minimum standards for cage sizes and heights. An addendum to this act, proposed by the Ministry of Agriculture (Ds 2005:32), but voted down in Parliament in December 2006, stated "Mink raised for fur production shall be accommodated in a way so that that their need for movement, climbing, expressing their hunting behaviour and using time for other activities, and of being alone at periods are fulfilled. In addition mink shall have access to water to swim in."

The Swedish report (SOU 2003:86), which concluded that research to improve Swedish housing and management of mink, in order to reduce stereotyped behaviour and improve mink welfare is necessary, further outlined a four year PhD project which has been financed by SPR (the Research Fund within the Swedish Mink Farmers Association). This project was to investigate the frequency of stereotyped behaviour in the Swedish mink and the effects of environmental enrichment on the behaviour, health and fur quality of the mink.

Since 2004 two of the five larger investigations which have been conducted will be presented in this abstract, while two other studies will be presented in the abstract by Lindberg (2008).

Materials and Methods

Experiment 1: The aim of this study was to investigate which enrichments were most used by farmed mink when given several to choose from and the effect of the available enrichments on stereotyped behaviour and tail biting. The study was conducted on a private farm in Sweden during March and April 2004. A total of 20 10 month old silver-blue female mink were kept individually seven days in a row first either in a large enriched cage and then in a traditional cage (control) or vice versa in a cross-over design. The larger cage was 195 cm long and 80 cm deep, with wire mesh floor over one half and wooden floor on the other, two nest boxes, and six water nipples. The enrichments were a water bath, cylinders (one plastic and one wire mesh), shelves (one wood and one wire mesh), ropes, balls, branches and straw. The traditional cage was 30 cm long and 80 cm deep with wire mesh floor, one nest box and one water nipple. Both cage types were 40 cm high.

Experiment 2: The second study evaluated different enrichments in a standard cage system and the behavioural effects of these in female mink during the winter (December to April 2005). On two private farms (F1; F2) 150 eight month old black-cross females were housed individually in standard cages (80 or 90 x 30 cm, 40 cm high). The females were randomly allocated to one of the following treatments: wire net shelf, plastic cylinder, plastic ball, all three combined or no enrichments (control). Behaviours were recorded with one-zero sampling nine times during 10s each per month and individually on 75 females before and after feeding.

Results and Discussion

Experiment 1: There were significant differences in the percentages of recordings spent interacting with the different types of enrichments ($p<0,001$). Of their active time the mink used water bath 10.4%, shelves 4.8%, cylinders 3.2%, ropes 2.1%, balls 1.2%, straw 0.3% and branches 0.3%. Interactions with the enrichments were highest on day 1, which can be due to a novelty effect. Stereotyped behaviour was performed more frequently in the traditional cages (10%) than in the large enriched cage (1.4%, $p<0,05$). The type of stereotypies performed in the traditional cages were "circular" (43%), "pendling" (34%), "vertical" (15%), "acrobatic" (6%), "nest box" (1%) and "horizontal" (1%), whereas in the large enriched cages "circular" (89%), "pendling" (9%) and "vertical" (2%) stereotypies were performed. Tail biting was observed in two females when kept in the traditional cage.

Experiment 2: There was a significant effect of treatment on interactions with enrichments on both farms ($p<0.001$), where the highest percentage of recordings were found in cages with a shelf, followed by combined, plastic cylinder and ball. The mink interacted with enrichments 4.2% in F1 and 3.9% in F2. There was no significant effect of treatment on either farm on the percentage of recorded stereotyped behaviour (n.s.). The mink performed stereotyped behaviours 11.6% in F1 and 10.2% in F2. There was a significant effect of treatment on activity ($p<0.05$) in F2, but not in F1 (n.s.). In F2 mink with a shelf were less active than in the other treatments. Active behaviours were performed 28.8% in F1 and 20.9% in F2. There was a significant positive correlation between activity and stereotyped behaviour (F1; $p<0.001$, $r_s=0.29$, F2; $p<0.001$, $r_s=0.64$).

Conclusions

In conclusion stereotyped behaviour in female mink during the winter can be disrupted by giving them a highly enriched cage (see also Lindberg, 2004), whereas giving females that already have developed stereotyped behaviours enrichement in their standard cage does not appear to reduce stereotyped behaviour.

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VI-11 P

Effects of climbing cage and feeding strategy on behaviour and production in farmed mink

Heléne Lindberg[1], Eva Aldén[2], Steffen W Hansen[3] and Lena Lidfors[1]
[1]*Department of Animal Environment and Health, Swedish University of Agricultural Sciences, P.O. Box 234, SE-532 23 Skara, Sweden*
[2] *Department of animal welfare and antimicrobial strategies, National Veterinary Institute, SE-751 89 Uppsala, Sweden*
[3]*Department of Animal Health, Welfare and Nutrition, Faculty of Agricultural Sciences, University of Aarhus, Blichers Allé 20, P.O. Box 50, 8830 Tjele, Denmark*
E-mail address:Helene.lindberg@hmh.slu.se

Introduction

The development of sterotypies in farmed mink is influenced by the environment and by management routines such as the feeding strategy (Malmkvist & Hansen, 2001). Climbing cages could offer a better welfare for farmed mink because they provide a more complex environment when housing juvenile mink in groups, during the growing season and for singly housed adult mink during the breeding season. However, aggression may be a problem in group housing of juvenile mink. Hunger seems to be an important part of the development of stereotypies. Dietary fibres can reduce the feeling of hunger (Sparti et al., 2000), so by mixing dietary fibres, such as sugar beet pulp, into the feed stereotypies may be decreased.

Our studies aimed to investigate the influence of climbing cages, group housing and feeding strategy, on behaviour and production in farmed mink.

Materials and Methods

The studies were carried out at a private farm in the southwest of Sweden. In study 1 a total of 330 mink kits were housed, from July until November, one female and one male in standard cages, one female and one male, two female and one male or two female and two males in climbing cages. In study 2 a total of 360 females were singly housed in standard cages or in climbing cages from November until March. Direct observations were carried out and all pelts from the group housed mink were visually investigated for scars in November. From July until November all animals were fed *ad libitum* five days each month. From November until March all animals were fed with either restricted feeding, restricted feeding + 2% sugar beet pulp (dried) and 10% water or "*ad libitum"* (25% more energy then restricted).

Results and Discussion

The amount of stereotypies performed was low in all treatments, less than 1% of observed time, in juvenile mink. Neither the cage type (n.s) nor the group housing had any significant effect on the development of stereotypies. The cage type had no effect on stereotypies on breeding females either (n.s). The amount of performed stereotypies in breeding females average between 2,5% and 4,8% of the observed time.
The energy intake however affected the frequency of stereotypies in both juvenile mink and in adult mink. Stereotypies in juvenile mink were less frequently performed during the 5 days each month they were fed *ad libitum* ($p=0.01$). In breeding females, the frequency of stereotypies decreased when mink were fed "*ad libitum"* during 2 month compared to fed restricted or restricted + sugar beet pulp ($p<0,01$). Around flushing, all animals were fed feed with the same energy, the frequency of stereotypies were still lower in the animals

which had been fed "*ad libitum"* before flushing ($p<0,01$). No differences in pelt scars between group sizes were found (n.s.).

Conclusions

In conclusion, feeding strategy had an effect on stereotypies in both juvenile mink and in breeding females. An increase in cage size and complexity of the cage environment did not affect stereotypies, in juvenile mink or in breeding females. The amount of pelt scars did not increase in group sizes of 3 or 4 juvenile mink in our study, however, a potential increase in aggression should be considered when housing mink in groups.

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VI – 12 P

Does inactivity in the nestbox predict poor reproductive performance in mink?

Rebecca Meagher and Georgia Mason
Department of Animal & Poultry Science, University of Guelph
50 Stone Road East, Building #70, Guelph, Ontario, Canada N1G 2W1
E-mail address: rmeagher@uoguelph.ca

Introduction

Within a population of identically-housed animals, such as mink on a farm, individuals differ greatly in their behaviour. They range from spending most of the day performing stereotypic behaviour to becoming extremely inactive (Broom & Johnson, 1993). This may be linked to varying levels of stress; presumably somewhere within the range is a well-adapted phenotype associated with lower levels of stress. Stress is a concern not only for welfare but also for productivity, because it commonly impairs reproduction, both through physiological effects and through suppression of proceptive and receptive behaviours (Wingfield & Sapolsky, 2003).

While stereotypic behaviour has been well studied in this species, little attention has been paid to inactivity. This behaviour pattern could be normal (Hartley & King, 2003), reflecting positive welfare states such as calmness. However, it could also reflect negative welfare states such as 'apathy' (Broom & Johnson, 1993) or chronic fear (c.f. felids hiding: Carlstead et al., 1993). We hypothesize that individuals showing the most extreme levels of inactivity are experiencing stress, and consequently predict that their reproductive output will be comparatively low.

Materials and Methods

We conducted a preliminary study with 350 female mink on a commercial farm. Of these, 110 were primiparous, while the others ranged in age up to 4 years. Their colour types were Black, Demi (wild-type) and Pastel. Behavioural data were collected through scanning observations conducted pre-feeding over four days before mating began. Mink withdrawn inside the nestbox were considered inactive unless obvious movements were visible (e.g. grooming). We used litter size at birth and infant mortality as our measures of reproductive success. We also scored quality of nest-building, which was considered an aspect of maternal care. The relationships between these measures and inactivity were analysed using general linear models or logistic regressions where appropriate.

Results

Although most females were stereotypic, some spent up to 90% of the day inactive. The majority of inactive time was spent in the nestbox. Results were similar whether the measure used was total inactivity, inactivity in the nestbox, or all time in nestbox. Inactivity in the nestbox predicted small litter sizes at birth ($F_{1,331}$=6.89, P=0.009), and poorer nest quality before parturition, although the latter was only a trend ($F_{1,26}$=3.49, P=0.074). There was also a trend for a positive correlation with risk of some kit mortality between birth and weaning when all time in nestbox, rather than inactive time only, was used (P=0.087); a binary logistic regression was used for this analysis since mortality data were non-normal. Stereotypic behaviour was significantly inversely correlated with inactivity, but was a less consistent predictor of reproductive performance.

Discussion

The link between inactivity and poor reproduction may be due to excess body fat in these individuals; high body weight is associated with small litters, high kit mortality

and increased risk of barrenness in this species (Jeppesen et al., 2004). Alternatively, the observed relationship may be mediated by fear, which could elicit hiding in the nestbox and has been linked to decreased reproductive success (Korhonen et al., 2002). We are replicating this study to investigate these possibilities, as well as determining whether inactivity in different postures has different reproductive correlates. If specific forms of inactivity can be used to identify mink that are stressed, selective breeding to reduce these behaviours could increase productivity and likely improve welfare at the same time.

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VII: Health & Disease

Edited by:

Dr. Bruce Hunter
Dr. Bruce Murphy
Dr. Kirsti Rouvinen-Watt
Lora Harris

VII-1 RP

Health and disease in mink – past, present and future

Hans Henrik Dietz
Head of Departments, Assoc. Prof., DVM, PhD
Department of Small Animal Clinical Sciences &
Department of Large Animal Sciences
Faculty of Life Sciences, University of Copenhagen
16 Dyrlaegevej
DK-1870 Frederiksberg C, Copenhagen, DENMARK
E-mail address:hhd@life.ku.dk

Health and disease in mink is subdivided into 4 different sections briefly covering:
1. Definition of disease,
2. Disease problems in the past,
3. Present disease complexes, and
4. Future challenges.

1. Definition of Disease

Both from a philosophical and from a practical point of view it's interesting to work from a commonly agreed definition of disease. The following list only covers a brief aspect of definitions mainly reflecting who's setting the definitions.

Is disease defined by the opposite of health i.e. disease is equal to absence of health? This makes it easy to work mathematically with disease as it is now defined as a categorical variable, but immediately raises the need for a proper definition of health. However, this is a rather limited definition not taking into account that more than one disease may be present at a given time, and practically it is important to differentiate between morbidity and mortality as part of the disease definition.

A definition of disease which may be correct is simply an unbalance between health and disease, incorporating one or more disease agents like bacteria, virus, parasites and prions; but not necessarily taking into account that feed and production methods may significantly affect the animals' ability to sustain attacks from disease agents.

The animal owners will probably place poor production results, meaning reduced economic profit, high on their list of disease definitions. This raises the question whether disease in production animals in general primarily affects the animals or the owners. Society, including animal rights activists, may recognize animal welfare as a significant part of the definition of both health and disease.

A simple search on the WHO (World Health Organization) website reveals more than 17,000 hits on the words definition and disease, and CDC (Center for Disease Control and Prevention) lists more than 16,000 hits searching for the combination: definition of disease.

The Columbia Encyclopaedia (5th edition, 1993) defines disease as - Impairment of the normal state or functioning of the body as a whole or of any of its parts.

In conclusion it is important to define disease and health in any context where these terms are used.

2. Disease Problems in the Past

Examples of common disease problems in the past are Distemper, Mink Virus Enteritis,

Botulism, Haemorrhagic pneumonia (caused by *Ps. aeruginosa*), Aleutian Disease, "Yellow fat", nutritional muscle degeneration, urinary bladder stone formation, abortion due to Salmonella infection and parasite infestations.

When efficient vaccines became available in the 1950's distemper, virus enteritis, botulism and haemorrhagic pneumonia became controllable diseases. Intensive research in disease problems carried out in most of the fur animal producing countries helped improve the health status of fur animals and other production animals. A better general understanding of disease, higher standards in feed quality and improvements obtained through genetic research increased the economic output from the production and created a belief in better health through continued research. And last but not least, the availability of antibiotics at affordable prices changed animal production but also laid the foundation stone for new problems.

Effectiveness in production demands healthy and strong animals being fed prime quality feed, taken care of by skilled people, given effective vaccines and serviced by effective and capable advisors, laboratories and research institutions. All this began after World War II, and resulted in a greatly increased production effectiveness. However, disease was not eradicated.

3. Present Disease Complexes

A number of well known diseases are controlled but not eradicated. However due to disease eradication programmes primarily directed towards Aleutian Disease, good vaccination schemes and the availability of efficient antibiotics, a highly efficient fur animal production can be maintained and even continuously improved.

Research in general and genetic research in particular, should incorporate the creation of robust animals capable of sustaining external influence from changed feed composition, changed environment, changed climate and changed demands from the society. Disease has not been eradicated yet.

4. Future Challenges

Apart from keeping well known disease complexes under control one may expect to see more feed related disorders e.g. caused by a demand for the use of environmentally friendly feed products.
New contagious diseases may emerge either due to the introduction of known agents into animals now susceptible due to genetic changes or because hitherto unknown agents may emerge. Prion diseases are expected to be an issue immediately after diagnosis.

Diseases with a zoonotic potential may turn out to be devastating for the fur animal industry.
Lack of effective antibiotics basically caused my abuse of antibiotics may prove to be a major problem especially in production systems with a high basic use of antibiotics for non-disease related purposes.
Climate changes may potentially invoke a range of foreseeable and unforeseeable disease problems.

In conclusion, one way to improve an already very efficient production would be to further intensify national and international cooperation in research and exchange of knowledge e.g. by launching more international research programmes.

(For further information on Dr. Dietz's presentation, please follow the appropriate links from the Scientifur webpage, as follows:.)

http://www.ifasanet.org/scientifur_en_ligne.htm.

VII-2 RP

Mink health and disease: challenges and accomplishments, a Canadian perspective

D. Bruce Hunter
Department of Pathobiology, Ontario Veterinary College,
University of Guelph, Guelph, Ontario Canada N1G 2W1,
E-mail address: bhunter@uoguelph.ca

Introduction

The term health is used in many contexts. A livestock industry can be considered healthy if it can achieve good reproductive success and high livability, develop economical management systems, maintain animal welfare, practice sound environmental stewardship and develop and maintain strong markets. All of these factors collectively result in profit, contented neighbors, respect from the public and ultimately, sustainability.

The definition of health of an individual animal or a herd of animals is under continuous change. Modern definitions of individual animal or human health now recognize the importance of social and psychological well-being in addition to the traditional way of thinking about physical health. Any measure of a healthy industry must now include environmental stewardship, "good management practices" (GMP) and sustainability as integral components. The understanding of the strong and undeniable linkages between animal health, human health and environmental health has lead many to a transdisciplinary, ecosystem approach to thinking about animal and farm health.

Early Mink Industry

Animal health is tightly integrated with farm management practices, and management practices should be constantly evolving based on changing knowledge, applied common sense and technology. The early mink industry in Canada (circa 1866) started in Brantford, Ontario. An article by J. Mason Reynolds in the Grand Rapids (Michigan) Eagle, February 1870 (Bowness 1980) described this early ranch as follows (paraphrased): "the grounds contain an acre of land enclosed by a tight boarding six or seven feet in height and 2-3 feet into the ground. Within this is a pond which is fed by water piped from a nearby river. A breeding building was erected on one side of the enclosure containing a series of boxes or cages on the floor with wire gauze tops for light and air. At the back of each cage are two little bedrooms. Through the front runs a continuous trough furnished with a constant supply of running water. There is a small door at the back of the cage leading to the yard". This management system known as the "natural plan" was used into the early 1900s and likely seemed a logical way to raise mink at that time, and in fact has many characteristics that would appeal to animal welfare advocates today .. free run, access to water, choices of location and nesting areas etc. Yet these animals were not healthy, because farm managers at that time did not understand the aggressive behavioral characteristics of mink and lacked understanding of parasite cycles and routes of disease transmission.

In the early 1900's the mink industry developed in the Canadian provinces of Nova Scotia and Prince Edward Island, utilizing both this "natural plan" and a "colony plan" where mink were housed in communal groups with runway access to a source of running water. In 1911 the first "single pen housing system" was developed and was initially met with great skepticism. How could animals confined to cages be healthy? After considerable experiential research on suitable wire size and pen design to prevent adjacent animals from fighting, it was

found that this method of raising mink in individual pens greatly increased mink health and livability, revolutionized the industry and, with many modifications, is still used today. However, the industry continues to evolve. There have been significant gains in mink production. Litter sizes now regularly exceed 5 kits per litter and through genetic selection mink size has doubled. Pelt size is a significant economic factor at auction and selection for size will continue. Cage size and design is an important issue today and will be into the future to meet the requirements of modern mink production and satisfy an increasingly aware and critical consumer base.

Diseases in the early years involved traumatic injury (mostly fighting and cannibalism), and nutritional diseases (urinary calculi, steatitis, metabolic bone diseases, poor fur quality, freezing from poor body condition in the winter etc.) due to inconsistent and poorly formulated rations. In a booklet *Mink in Captivity* written by Dr. Law (1930), 4 of the 6 pages on mink diseases dealt with parasitic diseases, almost all relating to feeding practices and management.

Infectious Diseases

As mink farming became more profitable and farm and mink numbers grew, animal densities were greater and movement of animals between farms through sales and breeding stock purchase increased, infectious disease became more and more important. Canine distemper was identified in commercial mink in 1932 (Shaw) and became a dreaded disease wherever mink were commercially raised. In 1952 it caused losses of over 1700 animals on Ontario fur farms (Department of Lands and Forests Ontario 1952). Autogenous vaccines held limited success in stopping outbreaks and between 1949 and1952 Connaught Medical Research Laboratories (then University of Toronto) developed the first live viral vaccines for mink, and routine disease vaccination became part of herd health programs. In 1947, mink enteritis was identified in Fort William, Ontario and spread south in the early 1950's causing devastation on some farms. A viral etiology for this condition was recognized in 1949 (Schofield) and for a number of years killed vaccines were prepared for local ranchers through the Ontario Veterinary College. By 1958, vaccine production had been taken over by Connaught Laboratories, who also developed a toxoid to protect mink against botulism type C. Vaccines against these 3 dreaded diseases were available in various combinations and over the next number of years other vaccine manufacturers (e.g. United Vaccines, Schering Plough) produced mink vaccines. It is interesting that 50 years later (2008), due to fluctuations in demand, a shrinking mink industry and economic pressures on large biologic manufacturers, there is presently only one company with mink vaccines licensed in Canada and there is basically only one combination vaccine available for use in North America. Vaccine production and vaccine availability in appropriate combinations to ensure protection against these important diseases is a critical need in North America.

Aleutian Disease

Aleutian disease (AD) was first recognized in ranch-raised mink in the USA in 1946 and reported by Hartsough and Gorham (1956). A viral etiology was confirmed in 1962 (Karstad & Pridham). AD was identified as a problem in Canada in the late 1950's. Many farmers incorporated the Iodine Agglutination Test (AI) as part of a herd health program. The counter-immunoelectrophoresis (CIEP) test became available as a screening test in the early 1970's (Cho & Ingram 1972) but over the years, despite this excellent test and several initiatives by provincial and national mink organizations no standard industry-wide eradication program or AD-free certification program was developed. AD continues to be a serious and increasing disease problem throughout the North American mink industry. Researchers using new genetic

molecular technology are searching for selection criteria to identify disease resistant animals and new molecular techniques hold some promise for developing unique vaccines, but the industry has failed to aggressively tackle this problem through organized and regulated efforts both in consistently utilizing testing programs and in following basic principles in biosecurity. AD continues to be a serious risk to the success of the North American mink industry.

Through the 1960's and early 1970s submissions of furbearing animals through the Ontario Veterinary College fur animal pathology laboratory ranged from between 200-250 per year. The main causes of disease were quite similar to what we see today (2008). Aleutian disease was diagnosed quite regularly, canine distemper and virus enteritis still occurred sporadically despite available combination vaccines and encouragement of farmers to vaccinate regularly. Parasites, with the exception of an occasional coccidiosis problem in young mink, appeared to have been controlled. Urinary calculi, fatty livers, mastitis, nursing disease, a variety of bacterial pneumonic conditions and septicemias, and reproduction problems predominated. Increased efforts were placed on standardizing and improving feed ingredients and feed quality. Feed-related problems including the feeding of chicken wastes contaminated with stilbesterol (Enders & Merritts 1950), mercury toxicity from fish (Aulerich et al., 1974) and PCB contaminated fish from the Great Lakes (Auerlich et al., 1973) were identified. Herd health programs were developing along with great advances in nutrition, reproduction and breeding.

From the 1990s to the present time there have been significant advances in molecular technology and disease diagnostic capabilities. The development of PCR technology has been hugely beneficial in disease diagnosis and pathogen identification. PCR, sequencing capabilities and DNA technology has allowed researchers to tackle complex problems such as sorting out the complex etiologies of pre-weaning diarrhea, identifying differences in strains of pathogens and important virulence factors and in tracking pathogen movement through molecular epidemiology. The diagnosis of disease and understanding disease pathogenesis is being revolutionized with the ability to study gene regulation of inflammatory responses and metabolic functions. Microarray technology will allow simultaneous screening for large numbers of potential pathogens and greatly enhance the diagnostic process. All of these technologies however are tools to be used to enhance our capabilities to identify, understand and diagnose. To actually improve mink health and welfare the results of these efforts will have to be adapted and applied to on-farm situations.

Current Challenges

There are a number of challenges facing the North American mink industry that influence animal health services and research. The size of the industry is small (and shrinking) and spread out across the breadth of the USA and Canada. There is little infrastructure in the way of animal health expertise available to assist the industry. Although there is dialogue, good will and some communication between USA and Canadian industries and researchers, there is no formal, organized strategy to deal with health issues or promote and coordinate health research across borders. Diagnostic laboratories are far apart and see very few mink and therefore have limited expertise. Mink farmers have little confidence in the labs and are reluctant to spend money if there is no perceived emergency and therefore do not regularly submit samples, and so the cycle continues. Huge physical distances make developing infrastructure and designing and monitoring health programs difficult. On a global scale, the mink industry is small. Communication and cooperation among animal

health experts in the various mink producing countries needs to be improved.

North American mink farmers are fiercely independent and tend to make individual rather than communal decisions. Mink farmers have traditionally been reluctant to "buy into" structured programs such as mandatory AD monitoring or AD-free certification. Pressure to continually improve animal welfare will continue, and ranchers must not be slow to accept change. Recommended codes of practice for raising mink are being revised and the sections that deal with on-farm biosecurity and animal welfare should be strengthened. The North American mink industry needs to keep pace with other livestock commodity groups in disease surveillance and health promotion, including regulated on-farm, auditable biosecurity and welfare programs, or they risk losing consumer support.

Biosecurity is a huge issue in the North American mink industry. Farmers need to understand the connection between animal health, the environment and their own on- and off-farm activities. Pathogen movements, for example through wildlife reservoirs, people and animal movements, and feed sources , the importance of appropriate design and use of quarantine facilities, proper pre-purchase examination and disease screening of animals, appropriate waste disposal (of manure, feed, and carcasses), pest control, farm cleaning and disinfection, are all critical areas of biosecurtity and the basis of disease control.

Funding for health program development and implementation and funding for health research remains a significant challenge. These programs are an expensive investment in the future. The North American mink industry has historically removed itself from mainstream agriculture and has not attracted the number of researchers or the outside funding support that other commodity groups have benefited from. The mink industry has to find ways to fund targeted, high-quality research if the industry is to continue to progress. Partnerships among associations and researchers should be established and global research goals and cooperation should be the ideal.

Summary

Achieving animal health and farm health is complex. The short history presented in this paper provides only a brief snapshot of some of the animal health challenges that have faced the mink industry since its beginnings. The future holds many more in the areas of disease diagnosis, animal welfare, implementation of principles of animal health and farm biosecurity and very large challenges at the interface between sustainable farming, the environment and the community.

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VII-3 RP

Detection of Aleutian disease virus (ADV) antibodies in pre- and post-vaccinated mink kits

Steven Bursian[1] and Robert L. Stephon[2]
[1]Michigan State University, 2209C Anthony Hall, East Lansing, Michigan 48824 USA
[2]Scintilla Development Company LLC, 501 Grouse Drive, Bath, Pennsylvania 18014 USA
E-mail address: rlstephon@scintilladevelopment.com

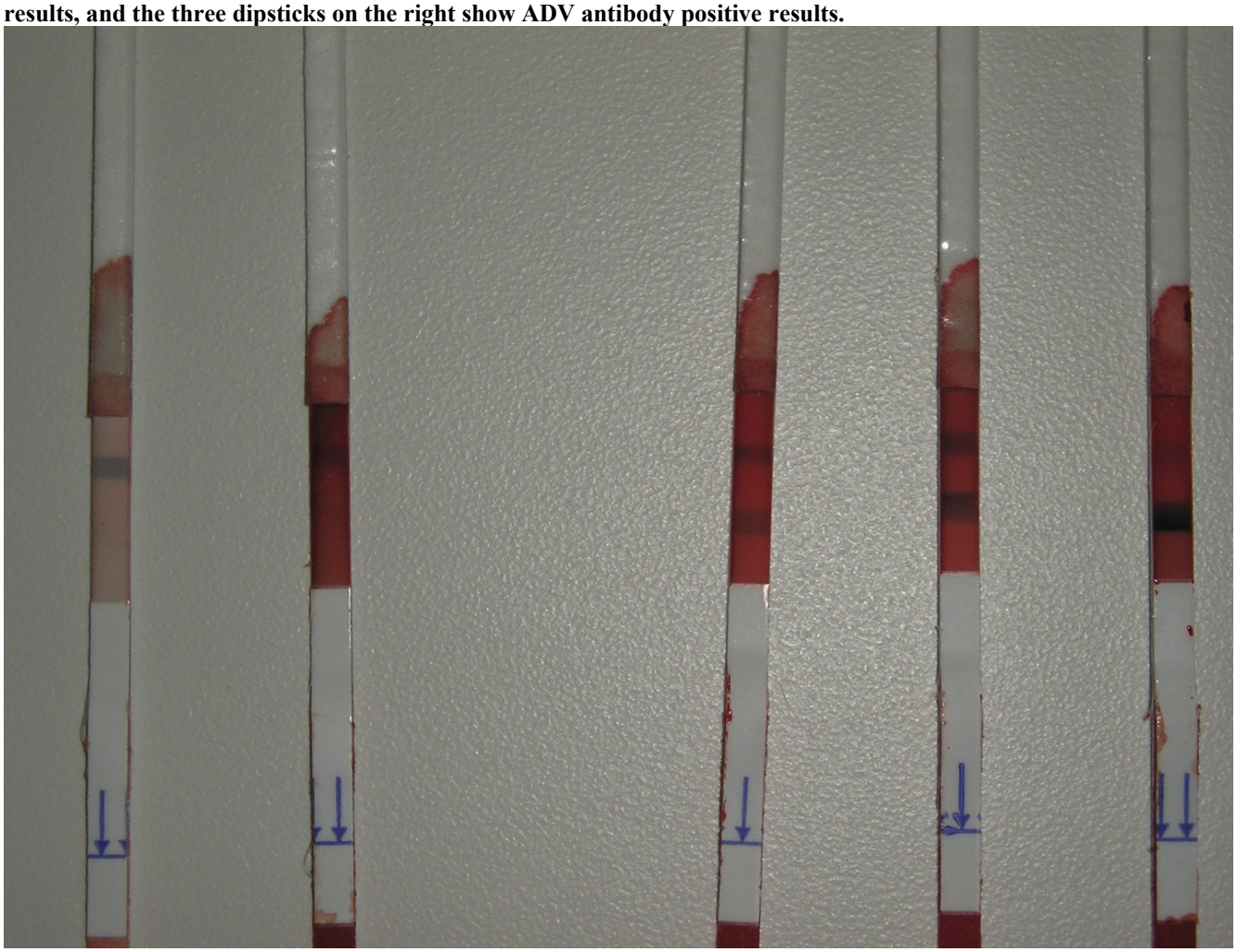
Abstract
The influence of vaccination on the detection of ADV antibodies in naïve mink was studied with the aim of determining whether immune responses to vaccine cell culture material may lead to false positive results. Mink kits were tested for ADV antibodies using a lateral flow immunoassay technique before and after inoculation with a combination vaccine for distemper, mink enteritis virus, and botulism. No false positive results for ADV antibodies were observed.

Introduction
Aleutian disease virus (ADV) is a readily transmitted parvovirus affecting the immune systems of mink (Porter et al., 1980) and often leads to mortality and reduction of pelt quality. The determination of ADV infection typically involves the detection of ADV antibodies by antigen-antibody interactions using an ADV viral extract produced in cell culture (Hahn, et al., 1977). Likewise, vaccines routinely used in the mink farming industry also contain some or all immunogens that are produced in cell culture. Residual cell culture debris can be recognized as foreign bodies and may cause formation of antibodies to that debris in mink. The present study was undertaken to determine whether mink produce antibodies against vaccine cell culture debris that can cause spurious ADV antibody result interpretations by binding to cell culture debris in ADV viral extract.

Materials and Methods
Materials: Distox-Plus vaccine containing the following: modified live distemper virus grown in chicken embryo tissue culture, inactivated mink enteritis virus grown in a feline cell line, *Clostridium botulinum* Type C-*Pseudomonas aeruginosa* bacterin-toxoid, aluminum adjuvant, gentamicin and amphotericin B as preservatives (Schering-Plough Animal Health); ADV antibody lateral flow immunoassay tests, sterile cotton-tipped swabs, 12 x 75 mm conical polypropylene tubes (5 mL capacity), and sample diluent (Scintilla Development Company LLC); natural dark mink kits (Michigan State University Fur Farm).

Methods: A total of 258 natural dark mink kits (*Neovison vison*) were weaned from their dams at approximately 6 weeks of age. The kits were housed in litters or partial litters of 2-6 mink per cage until 8 weeks of age then separated into pairs until 10 weeks of age. No mink kits were exposed to or injected with a vaccine or other immunogen before initial testing for ADV antibodies. Prior to vaccination at 10 weeks of age with Distox-Plus, and again at 26 days post vaccination, blood was collected by toenail clipping and tested for the presence of antibodies to ADV using a lateral flow immunoassay technique. All mink were tested on the same day both pre- and post-vaccination. When tested, some mink were caged singly and others remained paired. If mink were paired

Figure 1. Five ADV lateral flow immunoassay test results. The two dipsticks on the left show ADV antibody negative results, and the three dipsticks on the right show ADV antibody positive results.



they were of different sex for easy identification. Testing for ADV antibodies using the lateral flow immunoassay test proceeded as follows: a swab was placed against a fresh toenail wound so that the entire swab tip became soaked with blood sample. The swab was inserted into a 12 x 75 mm conical polypropylene test tube in a test tube rack with the swab tip facing the bottom of the tube. Four drops of sample diluent containing buffer and preservatives was added to each tube/sample. An ADV lateral flow immunoassay (dipstick) test was placed into each tube and the results visually interpreted after 15 minutes. A single blue-black line (control line) indicated a negative result for ADV antibodies and two lines (test and control lines) indicated a positive result for ADV antibodies.

Results and Discussion

All mink were found to be negative for ADV antibodies both before and after vaccination with Distox-Plus using the ADV antibody lateral flow immunoassay test.

The ADV antibody lateral flow immunoassay test contains a dried (lyophilized) submicron-size latex material labeled with Aleutian disease viral extract (Danish Fur Breeders' Association Laboratory, Glostrup, Denmark) identical to that used in counter-immunoelectrophoresis (Cho and Ingram, 1972), albeit prepared by a

proprietary method intended to potentiate specific ADV antibody-ADV antigen binding and to reduce potential interference from cell culture debris. When a liquid sample is introduced onto the sample pad of the lateral flow immunoassay test the labeled latex is rehydrated and any ADV antibodies in the sample bind to this material to form a conjugate. A nitrocellulose membrane in physical contact with the conjugate contains an immobilized anti-ADV antibody binding material at a discrete location called the test (T) line and, further downstream, also contains an immobilized latex binding material at a second discrete location called the control (C) line. As the conjugate flows through the membrane by capillary action it encounters first the T line and then the C line. If ADV antibodies are bound to the labeled latex, a portion of the conjugate will bind to the T line forming a visibly detectable signal. As the remainder of the labeled latex flows through the membrane it will bind to the C line regardless of whether the conjugate contains ADV antibodies. Development of both the T and C lines indicates a positive result for ADV antibodies and the development of the C line only indicates a negative result for ADV antibodies (see Figure 1). The C line serves to validate results and ensures that proper liquid flow characteristics govern result interpretation (Price and Newman, 1997).

Distox-Plus is a trivalent vaccine used to protect mink against distemper virus, mink enteritis virus, and botulism. The distemper and enteritis virus components of the vaccine are derived from chicken embryo tissue and feline cell cultures, respectively. Immunological reactions of vaccinated mink to the residual cell culture debris in the vaccine matrix may lead to the formation of antibodies to the debris, as well as to the desired immunogen. Likewise, Aleutian disease viral extracts used as the antigen reagent in counter-immunoelectrophoresis and the lateral flow immunoassay for the detection of ADV antibodies are also derived from cell culture. In practice, both techniques involve combining a biological specimen from the mink, potentially containing antibodies to cell culture debris, with the immunological reagent containing cell culture debris. The binding of anti-cell culture debris antibodies to cell culture debris, even in the absence of specific ADV antibody-ADV antigen interactions, may lead to the appearance of a positive reaction. Therefore, false positive results for ADV antibodies in immunoassay methods that use Aleutian disease viral extracts could present difficulties in the accurate determination of ADV infection in vaccinated mink.

Stimulation of the mammalian immune system causes formation of antibodies following exposure to a foreign substance of appropriate mass, for instance a virus, cell, or cellular component. In mink, ADV-specific IgM has been shown to appear within 6 days of infection, remaining detectable for approximately 85 days, and there is an elevation of ADV- specific IgG and IgA within 8-12 days after infection, with IgG levels generally increasing over the time of the disease course (*Porter, et al., 1984*). In this study we first established a negative ADV antibody baseline in unvaccinated mink housed in conditions typically found on fur farms and ranches. Following a full 26 days after inoculation with a vaccine material containing immunogens derived from cell culture, no false positive ADV antibody results were found using an immunoassay test that uses an ADV antigen, also derived from cell culture. The results demonstrate that, if antibodies to cell culture debris are generated in vaccinated mink, such antibodies do not lead to false positive ADV antibody results when using the ADV lateral flow immunoassay test.

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VII-4 P

A survey of Aleutian mink disease virus infection of feral American mink in Nova Scotia, Canada

A. Farid, P. Rupasinghe, J.J. Mitchell and K. Rouvinen-Watt
Department of Plant and Animal Sciences, Nova Scotia Agricultural College, Truro, Nova Scotia, B2N 5E3, Canada
E-mail address: hfarid@nsac.ca

Introduction

Aleutian disease (AD) is the most important disease problem for the mink industry in Nova Scotia, which is the largest producer of mink pelts in Canada. Despite many years of testing and elimination of the infected animals, and implementing disinfection and bio-security measures, the problem has persisted on several mink ranches in the province. One possible source of persistent infection or re-infection of clean ranches in Nova Scotia may be the feral or wild animal species, particularly mink, that carry the Aleutian mink disease virus (ADV) without showing overt signs of the disease. There is no information on the extent of infection of feral mink with ADV in Nova Scotia. The objective of this study was to survey the free-ranging mink population in Nova Scotia for ADV infection.

Materials and Methods

Spleen samples from 14 mink that were trapped in four counties of Nova Scotia (Kings, Colchester, Halifax and Yarmouth) were tested for the presence of the ADV by the polymerase chain reaction (PCR). Sequences of the conserved regions of the ADV genome from strains that are known to be circulating in Nova Scotia (Farid, unpublished) were used to design two pairs of primers for the PCR amplification. To ensure accurate identification, each sample was tested up to 16 times with various amounts of DNA.

Results and Discussion

Viral DNA was not detected in the samples from Kings County (n=2), while all the mink sampled from Colchester (n=2) and Halifax (n=6) Counties, and 3 of the 4 mink from Yarmouth County were infected with the virus. The presence of a high level of ADV-infected mink in Nova Scotia (78.6%), particularly in Colchester and Halifax Counties which were thought to be free of ADV, has important epidemiological ramifications, and may pose a serious threat to the captive mink and wild animal populations. Bio-security measures are needed to protect clean ranches from infection.

VII-5 P

Aleutian mink disease virus infection of mink ranches in Nova Scotia - a status report

A. Farid[1], G.G. Finley[2] and M.L. Zillig[1]
1-Department of Plant and Animal Sciences, Nova Scotia Agricultural College, Truro, NS, B2N 5E3
2- Veterinary Services, Hancock Veterinary Bldg, Nova Scotia Department of Agriculture, Truro, NS, B2N 5E3
E-mail address: hfarid@nsac.ca

Aleutian disease (AD) is endemic in Nova Scotia, Canada, particularly in Digby and Yarmouth Counties, in the south-western part of the Province, where approximately 80% of mink ranches are located. The high concentration of mink ranches in this region poses a great risk for the spread of the Aleutian mink disease virus (ADV) and presents a challenge to efforts to control the problem. The accepted procedure for the control of AD has been the elimination of infected animals identified by the counter-immune electrophoresis (CIEP) test, which has been performed in Nova Scotia since the mid 1970s, in combination with disinfection and bio-security practices. The objective of this study was to analyze the historical CIEP test results to evaluate the degree of success of the prevailing AD-control program in Nova Scotia.

The CIEP test, using commercial antigens, has been offered in Nova Scotia by the Quality Evaluation Division of the Nova Scotia Department of Agriculture since the mid 1970s, and in the Weymouth laboratory since 2003. Consent forms for the release of test results were signed by 71 ranchers, and data on 2,351,029 CIEP test results, covering the period of 1998 to 2005, inclusive, were analyzed. As approximately 140 licenses to operate a mink ranch have been issued in Nova Scotia in this time frame, about 50% of license holders participated in this study. All of the participating ranchers, except one, followed the test-and-kill strategy to control ADV on their premises.

The percentages of CIEP positive samples were 2.78, 5.74, 4.68, 4.31, 4.68, 2.94, 2.80 and 2.57 from 1998 to 2005, respectively, with the overall mean of 3.77%. Twenty-one ranchers (29.6%) tested their mink and eliminated the seropositive animals without interruption in the 8-year period examined in this study. The number of samples from these ranches (1,463,857) comprised 62.3% of the total samples tested, indicating that these ranchers have diligently been trying to control the disease. Of these ranches, only one in central Nova Scotia remained ADV-free for the entire period, one ranch cleared the virus and remained clean since 2001 (for 5 years), and three continued to have positive animals throughout the 8-year period. The other 16 ranches had mixed success in controlling the virus; seven were ADV-free for one to five years but became infected again and remained so until 2005, and CIEP-positive mink sporadically appeared in some years on the nine remaining ranches. Of the 21 ranches testing every year, 6, 9, 14, 14, 17, 19, 18 and 14 had some seropositive animals in 1998 to 2005, respectively, showing a high and increasing frequency of infected ranches. The incidence of seropositive animals on these ranches (excluding the one that remained negative throughout) was 2.2%, which is lower than that in the sample as a whole.

The number of ranches without a seropositive animal during the 8-year period was 21 (29.6%), but only one tested every year (mentioned above). Others sporadically tested a sample of their animals, usually those that are to be sold as

breeding stock. Eight of these ranches (11.2%) tested a sample of their animals in at least four of the eight years, and could be considered ADV-free with a high degree of certainty. On the ranch which did not eliminate its CIEP-positive animals, the incidence of seropositive mink was 84.7%, 84.4% and 80.6% in 2000, 2004 and 2005, respectively, with no apparent negative effect on animals' viability or productivity. By contrast, the incidence of seropositive animals on the 20 infected ranches with complete data for the 8-year period was less than 1% in 69.3% of the 160 year-ranch combinations, although a level of infection as high as 41.8% was observed.

The results strongly indicate that diligent implementation of the test-and-kill strategy has been very effective in reducing the level of ADV-infection within the ranches, although the proportion of ranchers unable to eliminate the infection remained rather high. This was particularly apparent in those 21 ranches which vigorously followed the control procedure where 90.0% still had some seropositive animals in certain years. The results also suggest that it would be possible for a ranch to remain free of ADV, even in Nova Scotia where the virus seems to be widespread. On the other hand, even after many years of the test-and-kill strategy, less than one third (29.6%) of the ranches in this sample are clean, which is not entirely encouraging.

These findings emphasize the need to clearly identify the reasons for continued infection and sources of re-contamination. The combination of variable response of the host to viral infection and bio-security failures are contributing factors. The high concentration of mink ranches in the south-western part of the Province where most of the infected ranches are located, and wild mammals which harbor the ADV make viral eradication a challenging task.

VII-6 P

Diskospondylitis in mink (*Neovison vison*): a preliminary study in Spanish mink farms

[1]R. Férnandez-Antonio, [2]M. López-Peña, [2]L.D. Faílde, [2]A. Barreiro, [2]L. Espino, [3]J. Astorga, [2]J. M. Nieto
[1]NUPE S.L., La Coruña
[2]Departamento de Ciencias Clínicas Veterinarias. Universidad de Santiago de Compostela. Lugo.
[3]Clínica Veterinaria Santa Cruz. La Coruña. Spain.
E-mail address: rf.antonio@colvet.es

Diskospondylitis is the main cause of paresis/paralysis in farmed mink in Spain. It has been associated with bacterial infections, mainly *Streptococcus sp.*. The aim of this study was to describe the clinical signs and the lesions observed in mink that developed diskospondylitis by means pathologic, radiographic and myelographic methods.

Paresis/paralysis of the extremities was found in 2 to 5 month-old mink (mainly between June and September) with mortality rates between 0.1%-1%. Also some sporadic cases were detected in adult mink during breeding season and after whelping.

Seven animals were necropsied for this study. Macroscopically, the degree of the lesions was variable and consisted of deviation of the spine at different levels. Some of them had a pale exudate around the site of the lesion. Lysis of the intervertebral disk and bony proliferation of the adjacent vertebral bodies were observed in association with sub-acute suppurative inflammation. Bacteriology results from the affected vertebrae were negative.

Radiographic lesions were identified in the cervical and/or thoracic region and they were characterized by lytic and proliferative bony changes with collapse of the intervertebral disk space. The number and severity of lesions varied but were usually located in one intervertebral disk affecting the two adjacent vertebral bodies.

Myelography and CT studies demonstrated the compression of the spinal cord in some of these animals.

High feed bacterial contamination appears as a possible predisposing factor as seems to have a feed dependence, being those feeds with low hygienic quality whose produce higher prevalence of this condition. A wider study about this pathology is currently in progress.

VII-7 P

Encephalitozoonosis in Spanish farmed mink (*Neovison vison*)

[1]R. Fernandez-Antonio, [2]M. López-Peña, [2]A. P. Losada, [2]L.D. Faílde, and [2]J. M.Nieto
[1]NUPE, SL, La Coruña
[2]Dpto Ciencias Clinicas Veterinarias, Facultad de Veterinaria de Lugo, Universidad de Santiago de Compostela. Spain.
E-mail address: rf.antonio@colvet.es

Cataracts in mink have been associated with clinical encephalitozoonosis in mink. This lesion in farmed mink in Spain is a sporadic finding affecting both kits and adults. Affected animals are pelted but new cases are observed each year in affected farms from January to May among breeding stock and during the growing-furring season among young kits.

Affected females usually have poor breeding results and there is high post natal kit mortality. Kits have impaired growth, poor hair cover and, in some cases, nervous signs (tremors and motor inco-ordination). Most of them die before weaning.

The condition was originally studied in 2004, when a farm reported an unusual prevalence. They had a peak of morbidity (5%) in November 2005 before pelting. The carcasses of several animals with these clinical signs were submitted for histopathologic diagnoses. In addition to cataracts, gross lesions were limited to the kidneys, as cysts and severe nonsuppurative interstitial nephritis. Histologically renal lesions consisted in a mesangioproliferative glomerulonephritis together with a subacute interstitial nephritis and tubular cysts. A few organisms similar to Encephalitozoon were seen in the epithelium and lumen of renal tubules using the Ziehl-Neelsen stain.The lesions in the nervous system were those of widespread non-suppurative meningoencephalomyelitis.

Hence, the clinical and pathological findings of these cases were consistent with encephalitozoonosis. Whilst not systematically proven, the epidemiological hypothesis has been that rodents are the reservoirs of the microorganism; under appropriate conditions they infect raw materials, whelping nest elements whilst they are stored or other farm stuff. This hypothesis has been useful for preventing the condition in affected farms.

The fact that most surviving offspring of affected females develop the condition and die before two months of age strongly suggest that there is also vertical transmission from the mothers to their litters.

VII-8 P

Pododermatitis in farmed mink (*Neovison vison*) in Spain

R. Fernández-Antonio[1], L.D. Fraílde[2], A.P. Losada[2], M. López-Peña[2], S. Vázquez[2], R. Bermúdez[3], M.I. Quiroga[2], and J.M. Nieto[2]
[1]NUPE, S.L. La Coruña.
[2]Departamento de Ciencias Clínicas Veterinaria.
[3]Departamento de Anatomía y Producción Animal. Universidad de Santiago de Compostela. Spain
E-mail address:rf.antonio@colvet.es

During 2006, 2007 and 2008, several mink were submitted to our department for necropsy with a history of superficial to deep ulcers on the foot pads, often covered by scabs and debris. The aim of this study is to describe the clinical features, the main macroscopic and microscopic lesions and to describe some epidemiological data.

Foot pad lesions were found mainly in adult female mink (more than 2 years old) and less frequently in young females and males (although young females became the most affected group after whelping). Lesions consisted of hyperkeratosis, necrosis, crusting and abscesses. Although sporadic cases were seen in many farms, the highest prevalence (between 1 and 5%) was observed in a cluster of genetically related farms; but the distribution of the condition in these farms did not follow a strict pattern linked with a particular genetic group.

Lesions were observed on the palmar and plantar surfaces of the metacarpal and metatarsal regions. Less often we saw similar lesions in the face, mainly in the nose and eyes. Microscopically follicular plugging, hyperkeratosis and folliculitis were common findings in the first stage of the lesion which evolved to severe ulcerations with a marked suppurative inflammatory response – abscesses.

Bacteriology performed on selected samples revealed the presence of *Staphilococcus intermedius.*

In this study we did not find any evidence of primary viral lesions but we could not discard a possible primary action of epithelial pathogenic virus, due to the advanced lesions that we observed. Our macroscopic and histo-pathological findings were in agreement with a bacterial infection. In this study we could not establish which factors predispose to these bacterial infections.

VII-9 P

Intestinal morphology and mucus layer in mink in relation to age, diet and health status

Mette Skou Hedemann, Helle Nygaard Laerke, and Birthe Marie Damgaard
University of Aarhus, Faculty of Agricultural Sciences, Dept. of Animal Health, Welfare and Nutrition, P.O. Box 50, DK-8830 Tjele, Denmark
E-mail address: Mette.Hedemann@agrsci.dk

Introduction

The mucus layer protects the gastrointestinal tract against harmful substances in the digesta. It obtains its gel-forming properties from mucin secreted by the goblet cells in the intestinal lining. Mucins have been shown to be implicated in the aetiology of several gastrointestinal diseases and as the synthesis and secretion of mucin is affected by a number of dietary substances, strengthening the mucus gel by dietary means may be a way to improve gastrointestinal health. Information on the mucus layer in the gastrointestinal tract of mink is scarce. The present project aimed to study the morphology of the small intestine and the area of the goblet cells, as an indication of the thickness of the mucus layer, in mink in relation to age, diet and health status.

Material and Methods

Three experiments were performed. In the first experiment 24 mink kits from eight litters were used. One mink kit from each litter was euthanized at 4, 6, and 8 weeks of age. The second experiment comprised 27 adult female mink that were fed three experimental diets differing in the content of sugar beet pulp (SBP) (0, 2.5%, and 4.9%, respectively) during 2 months. In the third experiment with 40 7-8 weeks old mink kits from 10 litters a challenge model for the susceptibility of post weaning diarrhea in mink kits was used. Half of the kits were orally challenged with *Escherichia coli O68* and the other half served as controls. One week post-challenge the kits were euthanized. In all experiments the mink were euthanized by an intraperitoneal injection of an overdose of pentobarbital. The abdominal cavity was opened and the entire gastrointestinal tract was removed. Samples for microscopy were taken at 25% and 75% of the small intestinal (SI) length and were transferred to a formalin solution (10% formalin, 5% glacial acetic acid, and 85% absolute alcohol) and processed for morphological measurements (villus height and crypt depth) and carbohydrate histochemistry (area of goblet cells on villi and in crypts, respectively) as previously described (Hedemann et al., 2006).

Results and Discussion

In mink kits, the villi got longer in the proximal part of the SI and shorter in the distal part while the depth of the crypts doubled during the period 4 to 8 weeks of age. This indicates that this is a period of extensive growth. An *E. coli* challenge caused a reduction of the crypt depth indicating that the growth of the intestine was affected. The addition of SBP to the diet did not affect SI morphology.

SBP has a high content of soluble dietary fiber and may influence the physico-chemical properties of digesta and the microflora and/or the fermentation pattern of the microflora. The area of mucins in the crypts in adult mink fed a diet containing 4.9% SBP was increased and tended ($P = 0.08$) to be increased on the villi in the proximal SI. The area of mucins increased in the crypts from 4 to 8 weeks of age but it decreased on the villi in the distal SI. Whether the latter increases the susceptibility towards bacterial infections remains unknown. The area of mucins is positively correlated to the

thickness of the mucus layer (Hedemann et al., 2008). As the mucus layer is assumed to protect against bacterial infections, increasing the thickness of the mucus layer by dietary means may improve the resistance against such infections.

In conclusion, the SI of the young mink is characterized by rapid growth which is seen in the morphological measurements. Challenging mink at this age with an *E. coli* infection reduces the growth of the intestine. In adult mink it is possible to influence the area of mucins by dietary means. Further studies are needed to show whether it is possible to feed mink kits a diet increasing the mucins staining area of the SI and whether this provides protection against post weaning diarrhea.

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VII-10 P

Body condition, liver fat and liver glycogen content of wild American mink (*Neovison vison*) in Nova Scotia, Canada

Jessicca Mitchell and Kirsti Rouvinen-Watt
Department of Plant and Animal Sciences, Nova Scotia Agricultural College,
P.O.Box 550, Truro, Nova Scotia, B2N 5E3, Canada
E-mail address: jlmittchell@nsac.ca, krouvinen@nsac.ca

Introduction

Ranch mink (*Neovison vison*) are capable of increasing their body fat stores significantly in the autumnal months resulting in the body mass consisting of about 38% body fat by December (Mustonen et al., 2005). During food scarcity the intra-abdominal fat stores are mobilized first while the subcutaneous fat stores are hydrolyzed more slowly in an effort to retain thermal insulation (Mustonen et al., 2005). Due to the long, lean body of the mink, they have a large surface area and thus a higher heat loss (Brown & Lasiewski, 1972). In the wild, this body shape enhances predatory ability by enabling the mink to enter the burrows and hiding places of their prey. Since ranch mink mobilize subcutaneous fat at a slower rate they are able to remain warm during wintertime food scarcity, where they have been observed to be more active, possibly in search of food (Mustonen et al., 2006). The amount of body fat is also linked to reproductive maturity, which is in part regulated by leptin, a hormone produced by the adipose tissue. The objectives were to determine the body condition and energy reserves of wild male and female mink in Nova Scotia during winter. This would establish reference data for the amount of body fat and liver fat and glycogen content found in free-ranging animals during seasonal food scarcity.

Materials and Methods

The following measurements were taken from 12 (9 male, 3 female) wild mink carcasses obtained from local trappers: body weight, body length, and weights of the fat depots using quantitative dissection. Liver fat content was analyzed according to Folch et al.,(1957) and liver glycogen concentration was determined using the Lo et al. (1970) method. The general linear models procedure in SAS was used to analyze the effect of sex on the response parameters.

Results and Discussion

The wild male and female mink differed significantly in both body weight and length (Table 1). This is a result of the sexual dimorphism where the males are close to double the size of the females. The results of the quantitative dissection of the adipose tissue depots showed that the total mass of the visceral fat depots represented less than 2% of the body mass of the wild mink (Table 1), whereas the largest amount of fat was found attached to the integument (hair, skin, and subcutaneous adipose tissue). The weight of the integument represented 21% and 30% of the body mass in male and female mink, respectively. Due to the semi-aquatic lifestyle of wild mink it would be desirable to maintain a certain amount of subcutaneous fat for body temperature regulation while swimming. This corresponds to findings on ranch mink which showed subcutaneous fat to be the least mobilized fat depot in fasting studies during both the summer and winter months (Mustonen et al., 2005; Nieminen et al., 2006). The liver fat content of the wild mink was on average 4.3%. During times of food deprivation, mink develop

Table 1. Body weight, body length and the weights of selected adipose tissue depots in male and female wild mink in Nova Scotia, Canada.

Parameter	Male	Female	P-value
Body weight, g	822.4±55.1	484.8±95.5	0.022
Body length, cm	37.4±0.4	31.7±0.6	<0.001
Omental fat, %BW	0.53±0.15	0.42±0.27	0.738
Mesenteric fat, %BW	0.54±0.09	0.80±0.15	0.189
Perirenal fat, %BW	0.33±0.12	0.34±0.21	0.977
Total visceral fat, %BW	1.50±0.36	1.67±0.62	0.815
Intermuscular fat, %BW	0.55±0.19	0.67±0.33	0.766
Integument, %BW	20.62±3.45	29.96±5.99	0.225

fatty liver syndrome as a result of triacylglycerol accumulation in the liver from rapid mobilization of their body fat stores (Mustonen et al., 2005). A liver with a fat content below 5% is considered normal. Liver glycogen levels were extremely low in the wild mink (males 0.11±0.04, females 0.26±0.07, P=0.10). Liver glycogen is utilized as an energy reserve and when starving, is the first energy source to be depleted. Therefore, the negligible liver glycogen levels are indicative of apparent food shortage. Found in two male specimens were infestations of giant kidney worms (*Dioctophyma renale*). The worms were present in the right kidney while one of the males also had five worms loose in the body cavity. Parasite infestation can greatly reduce the health of the host (Hunter & Lemieux, 1996). However, the other kidney can compensate to support function. These findings show that wild mink have exceedingly low body energy reserves during winter months. Subcutaneous fat is maintained for aquatic predation. All other fat depots and liver glycogen are minimal, which may affect the survival rates and decrease the reproductive success of individual mink.

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VII-11 P

Effects of fasting and re-feeding on the development of hepatic lipidosis in the American mink (*Neovison vison*)

Catherine Pal[1], Petteri Nieminen[2, 3], Anne-Mari-Mustonen[2] and Kirsti Rouvinen-Watt[1]
[1]Nova Scotia Agricultural College, Department of Plant and Animal Sciences, P.O. Box 550, Truro, Nova Scotia, B2N 5E3, Canada,
[2]University of Joensuu, Faculty of Biosciences, P.O. Box 111, FI-80101, Joensuu, Finland,
[3]University of Oulu, Faculty of Medicine, Institute of Biomedicine, Department of Anatomy and Cell Biology, P.O. Box 5000, FI-90014, University of Oulu, Finland
E-mail address: capal@nsac.ca, krouvinen@nsac.ca

Introduction

Fatty liver is a potentially fatal condition to which the American mink (*Neovison vison*) is at risk several times over the production cycle. These occur during autumnal fat deposition, prior to breeding, at parturition, and during mid-late lactation (Hunter & Lemieux 1996). Previous research has shown that fatty liver can develop in the mink in response to food deprivation (Bjornvad et al., 2004; Mustonen et al., 2005). Body weight (BW) variation occurs over the production cycle. However, fasting aggravates these normal metabolic responses resulting in the mobilization of body fat and lipid infiltration in the liver (Bjornvad et al., 2004; Mustonen et al., 2005). In humans, rapid BW loss is associated with an imbalance in the n-3/n-6 polyunsaturated fatty acid ratio and increased oxidative stress (Videla et al., 2004). These changes are believed to lead to the hepatic manifestation of the metabolic syndrome seen in the human non-alcoholic fatty liver disease and may be significant contributing factors to the development of nursing sickness in the mink (Rouvinen-Watt, 2003). It is not known how rapidly or to what extent lipid accumulation occurs in mink liver tissue during fasting and if the liver is able to regenerate after a period of re-feeding. The objectives of this study were to examine histologically the type and extent of lipid accumulation in the livers of mink in a controlled fasting experiment, to establish a time scale for the development of hepatic lipidosis, and to study liver recovery after normal feeding was resumed.

Materials and Methods

Sixty mink, with five males and five females per experimental group, were fasted for 0, 1, 3, 5, or 7 d. In addition, one group (RF) was fasted for 7 d followed by re-feeding for 28 d. The study lasted from Jan-Feb. At the end of each experimental regime the mink were weighed, anaesthetized, sampled for blood and euthanized. The livers were dissected and weighed. A liver sample was placed in 10% buffered formalin, processed for histology and stained using haematoxylin and eosin. The rest of the liver was stored in -80°C for the analysis of total lipid content according to Folch et al. (1957). The liver histology samples were examined using light microscopy and graded for the type and extent of lipidosis according to Brunt et al. (1999). The General Linear Models procedure in SAS was used to study the effects of sex, the fasting regime and their interaction on BW loss and liver fat content. Where significant differences existed, a multiple means comparison test (PDiff) was used to differentiate between the lsmeans ± SEM. The nonparametric data of liver histology were analyzed using the Fisher's exact test.

Results and Discussion

In comparison to the non-fasted controls, both males and females lost a significant amount of BW during 3-7 d of fasting, whereas the 1 d

group did not differ from control. Also, the RF group was not different during the preceding fast from the mink fasted for 7 d. On average, the females lost more% BW than the males ($P<0.001$). The mink in the 3-7 d fasted groups had higher liver fat content in comparison to the non-fasted control and the 1 d fasted mink ($P<0.001$). The liver fat percentages were 5.9±1.5, 6.4±1.5, 13.2±1.5, 19.2±1.5, and 19.7±1.4%, for the 0 d, 1 d, 3 d, 5 d, and 7 d groups. The livers showed recovery after the re-feeding period with the liver fat percent (5.3±1.6%) not differing from control. The histological evaluation showed significant differences among the experimental groups. In the 0 d and 1 d groups, 5 mink per group showed either none or mild macrovesicular lipidosis and 5 mink had moderate to severe macrovesicular lipidosis. In the 3 d group, 9/10 mink had moderate or severe macrovesicular lipidosis, and all mink in the 5 d and 7 d fasted groups showed moderate or severe macrovesicular lipidosis. The frequency distribution in the RF group was not significantly different from that observed in the 0 d and 1 d fasted groups. It is evident that fasting for as few as 3 d results in significant BW loss and the development of moderate to severe macrovesicular lipidosis in the livers as well as increased liver fat content. These findings are in agreement with previous studies on the effects of food deprivation in mink (Bjornvad et al., 2004; Mustonen et al., 2005). A period of re-feeding of 28 d after a 7-d fast resulted in return to near normal BW, liver fat percent, and liver architecture indicating recovery. Since the fasting-induced hepatic lipidosis has biochemical and morphological similarities with mink nursing sickness (Hunter & Lemieux 1996; Rouvinen-Watt, 2003) it could possibly be used as a model to study this metabolic syndrome. In practice, it would be important to monitor animals closely during the high risk periods and to find ways to encourage appetite in mink that have gone off feed as severe liver dysfunction, leading to mortality, can develop very rapidly.

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VII-12 P

Fur-bearing animals pseudomonosis control

A. N. Panin, V.I Ulasov, T. L. Chernichenko, and S. V. Lazarev
Federal University "All-Russian Quality and Standardization Centre of Animal Medications and Feed", Moscow, Russia,
LLC Biocenter, Moscow, Russia.

The idea that contagious diseases are often caused by common environmental inhabitants is a significant achievement and priority in domestic science (Terskiy V.I., 1958). *Pseudomonas aeruginosa* is one of the etiological factors of sapronosis.

In silver foxes and arctic foxes infection with *P. aeruginosa* often occurs via contaminated instruments or sperm during artificial insemination, or during natural breeding. The infection of mink kept in cages usually occurs in August-September, and presents as a hemorrhagic septicemia with mortality rates often exceeding 50% of the diseased animals. It is the males that are primarily affected. As for the laboratory animal species, the infection is "dead-end" and, as a rule, without any following "chain" transfer.

Infected soil and water are the storage and the source of *P. aeruginosa.* Here, the saprophyte is maintained, and possibly changes its serotype and sensitivity patterns to antibiotics and disinfectants. The bacteria are usually found in human and animal excrements, on body surfaces, as well as in feed, bedding, and in water. Isolates commonly are the same serotype as those pathogenic to animals. It is unclear what factors are necessary for the germ to become pathogenic for homeothermic animals. To our mind, the above-mentioned factors are important. Unsuccessful experiments on artificial reproduction of the disease in pigs, foxes and Arctic foxes confirm this idea.

The uncontrolled use of antibiotics that inhibit the development of competitive symbiotic microorganisms may contribute to the rapid proliferation of *Pseudomonas aeruginosa*, leading to infection in animals. Many *Pseudomonas aeruginosa* isolates have a high tolerance to most antibacterial preparations.

Quite often, the *Pseudomonas aeruginosa* is excreted along with the enteric bacteria and other opportunistic flora.

Pseudomonas aeruginosa is a rod-shaped gram-negative bacillus with rounded ends. It has weak glucose fermenting ability, is unable to breakdown mannitum and fibrin, or coagulate or dissolve gelatin. About 15% of the variants were unable, or slightly able to form small amounts of pyocyanine pigment. The virulence of different isolates of *P. aeruginosa* vary depending on the route of infection and the experimental animal species.

There is no definite correlation between the serologic variant of *P. aeruginosa* and the source, regarding the virulence factors related to different serovars. Generally, it is important to note that the fluctuations of LD_{50} between *P. aeruginosa* strains are rather high. The reference strains of *Pseudomonas spp*. (Habs's collection) showed the LD_{50} value for white mice fluctuating from 99 to 255 MIO microbial cells. Meanwhile, the maximum virulence was attributed to the strains with active mucus production and intensive pyocyanine pigment production (serovars 02, 04, 07, 09, 010 and 011); serovars 01, 03, 05, 06 and 012 races were less virulent.

With the help of the reference collection of diagnostic serovariant sera of *P. aeruginosa* and based on typing by agglutination spot tests on a glass, the following serotypes were determined. In pigs serotypes 02, 05, 06, 010 and 018 dominated. In cattle, silver foxes, arctic foxes and dogs, the serotypes varied depending on the area where the material was collected. Almost all the serotypes were present with the exception of 016 and 017. In mink, serotypes 05, 06, 08 and 011 dominated. Most isolates had low sensitivity to *Penicillin*, but were sensitive to *Gentamycin*.

Aldehyde and phenolic disinfectants were the most effective, providing that obligatory mechanical cleaning of the test objects to remove any organic material was done prior to application.

Among the various domestic and farm animals, specific prevention is only effective and reasonable in mink kept in cages. Vaccination using serotypes 05, 06, 08 and 011 in an optimal antigen ratio as part of the Bionor commercial vaccine is helpful in prevention of *Psuedomonas* infection.

Based on these findings, and considering the system of control measures used for *Pseudomonas* infection in our country, it is reasonable to perform the immunization of the minks only, using the associated vaccines containing an optimal range of serotypes. But, due to the variability of the serotype affinity, permanent monitoring for *Pseudomonas* in the environment and determination of their serotype combinations is necessary.

VII-13 P

Studies on the parasite effectiveness of the Polish enolphosphate – methylbromphenvinfos (IPO-63) – phosphate (Z, E) – 2 – bromo -1 - (2,4 dichlorophenyl) – vinyl – diethyl against fleas in Arctic (*Alopex lagopus*) and Silver foxes (*Vulpes vulpes*)

Kazimierz Sciesinski and Marian Brzozowski
Department of Animal Breeding, Warsaw University of Life Sciences - SGGW
Ciszewskiego 8, 02-786 Warsaw, Poland
E-mail address: marian_brzozowski@sggw.pl

Abstract
The investigations were carried out on the population of silver and Arctic foxes infected by an invasion of fleas (*Ctenocephalides canis*). Spraying with the aerozol form of methylbromphenvinfos (Polwet aerosol) was performed directly on the skin of animals. The treatment consisted in spraying the animals 2 times at the sites preferred by the parasites. The effectiveness of the aerozol form of methylbromphenvinfos (Polwet aerosol) was high (99%).

Introduction
Methylbromphenvinfos (IPO-63), i.e. phosphate (ZE) – 2 – bromo -1 - (2,4 dichlorophenyl) – vinyl – diethyl, belongs to the group of enolphosphates and was synthesized in Poland. Tha compound is characterized by a very low dermal toxicity and its absorption through the skin is 27-75 times lower than through the mucous membrane of the alimentary tract. On the basis of the index of acute oral toxicity of methylbromphenvinfos it was counted among the 2nd class of toxicity of poisons (Kolodziejczyk et al., 1977). The author established that the acute oral toxicity of methylbromphenvinfos for pigs was 459.3 mg/kg b.w. (range from 360.6 to 584.9 mg/kg b.w.). The administration of 4 mg/kg of methylbromphenvinfos with feed for 43 days did not cause changes in the activity of cholinesterase (ChE, AChE) (Sciesinski, 1981a).

The determination in pigs of the acute dermal toxicity (LD_{50}) of methylbromphenvinfos in our own investigations (Sciesinski, 1981b) showed that it reveals itself over the dose of 7.175 g/kg b.w. Methylbromphenwinfos proved to be highly effective against external parasites in farm animals (Sciesinski, 1984).

The objective of this research was to evaluate the efectiveness of methylbromphenvinfos in treating flea infestations in Arctic foxes (*Alopex lagopus*) and silver foxes (*Vulpes vulpes*).

Material and Methods
Methylbromphenvinfos and its commercial form Polwet aerozol contain the active substance which is phosphate (Z, E) – 2 – bromo -1 - (2,4 dichlorophenyl) – vinyl – diethyl. Polwet aerosol was supplied by the Institute of Organic Industry in Warsaw.

The presence of fleas (Ctenocephalides canis) was noted in silver and Arctic foxes over on their whole bodies. Fleas were controlled by the means of spraying with Polwet aerosol 2 times every 10 days. The dose of the drug was 1.5 mg/kg b.w.

Results and Discussion
Results of flea control in Arctic and silver foxes with the help of Polwet aerozol are presented in Table 1.

Table 1. Therapeutic properties of Polwet aerozol in flea (*Ctenocephalides canis*) control in Arctic and Silver foxes

No.	Treated animals	Insects	No. of animals	Mean body weight (kg)	Single dose of a.s. (mg/kg b.w.)	Mean effectiveness (%)
1.	Arctic foxes	fleas	48	7	1.5**	100
2.	Silver foxes	fleas	22	8	1.5	99

* a.s. - active substance

** two sprayings every 10 days

Polwet aerosol preparation containing 1% methylbromphenvinfos controlled fleas (*Ctenocephalides canis*) In Arctic and silver foxes in the concentration of 0.1% and the single dose of 1.5 mg/kg b.w. a.s. The effectiveness of the preparation in Arctic foxes was 100% and in Silver foxes was a little lower amounting to 99%. Methylbromphenvinfos in commercial forms has been used in cattle, sheep pigs as well as dogs and cats. By administering a proper therapeutic dose, a high drug effectiveness was obtained each time (Sciesinski, 1999).

Conclusions

Polwet aerosol containing methyl-bromphenvinfos as the active substance at the concentration of 0.1% and the dose of 1.5 mg/kg b.w. repeated 2 times every 10 days effectively controlled fleas (*Ctenocephalides canis*) in Arctic and silver foxes.

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VII-14 P

Effectiveness of one of the Polish preparations from the enolophosphate group – bromphenvinfos (IPO-62) phosphate (Z, E) – 2 – brom -1 - (2,4 dichlorophenyl) – vinyl – diethyl against scabies (*Sarcoptes scabiei v. canis*) in Arctic foxes

Sciesinski Kazimierz, Brzozowski Marian
Department of Animal Breeding Warsaw University of Life Sciences – SGGW
Ciszewskiego 8, 02-786 Warsaw, Poland.
E-mail address: marian_brzozowski@sggw.pl

Introduction

The objective of the investigation was to asses the effectiveness of one of the Polish preparations from the enolophosphate group – bromphenvinfos against scabies (*Sarcoptes scabiei v. canis*) in Arctic foxes. The assessment of various traits of bromphenvinfos (IPO-62, i.e. phosphate (Z,E)–2–bromo-1-(2,4 dichloro-phenyl)–vinyl–diethyl) was performed in many various research centres in Poland. On the basis of the investigations on oral acute toxicity performed in rats, the LD_{50} of that compound was marked and classified as the 2nd group of poisons (Majda, Chruscielska, 1974). The investigations carried out by Szuperski (1978) on bromphenvinfos did not show neurotoxicity. Further investigations on sub-acute, chronic, short lasting bromphenvinfos toxicity in rats (Kobes 1973), embryotoxicity (Dzierzawski and Minta 1976) as well as its teratogenicity (Fitko 1973) revealed, that the compound shows short lasting side effect on the organism of higher animals. A toxic oral dose (LD_{50}) for dogs amounts from 1780 to 3390 mg/kg b.w., and intraperitoneal from 75.2 to 169.1 mg/kg b.w. (Bronisz and Ochynski 1977). Our own investigations (Sciesinski 1973) showed that acute oral toxicity for swine amounts to 119.4 mg/kg b.w. in the blood plasma and organs.

The application of bromphenvinfos to pigs in the dose of 1 mg/kg does not decrease cholinesterase activity in the blood plasma or acetylcholin-esterase activity in blood erythrocytes (Sciesinski 1976a). Further investigations proved that the administration of bromphonvifos in the feed in the dose of 0.5 and 1.0 mg/kg for 12 months does not affect cholinesterase, aspartic and alanine transaminase, acid and alkaline phosphatase, lipase or lactate dehydrogenase levels in the blood plasma (Sciesinski 1976a). Investigations on the determination of acute dermal toxicity of bromphenvinfos in pigs showed that the application of bromphenvinfos in 25% acetone solution on the swine skin in 8 different doses within the limit from 119.9 mg/kg b.w. to 9.41 g/kg b.w. does not cause any clinical lesions (Sciesinski 1976b). Acute dermal toxicity appears above the limit of 9.41 g/kg b.w. As a result of further investigations (Sciesinski 1976b) on the determination of sub-acute dermal toxicity of bromphenvinfos in pigs, it was noted that the dose of 10 mg/kg b.w. of bromphonvinfos does not affect the cholinesterases (ChE and AChE). The investigations by Ochynski (1976) on the metabolism of bromphenvinfos labeled with C^{14} in rats and dogs revealed that after oral administration, bromphenvinfos is quickly absorbed to blood. Maximum radioactivity in the blood of both rats and dogs was noted in the second hour. Bromphenvinfos is removed mainly through kidneys and alimentary tract. 78% of the drug in rats and in 70% in dogs is eliminated within 24 hr after dosing.

The effectiveness of bromphenvinfos (Ipowet 5, Ipowet aerozol) against external parasites wasinvestigated in farm animals (cattle, sheep, pigs) and domestic animals (dogs, cats). The high effectiveness of the preparation was observed (Sciesinski 1999).

Materials and Methods

Ipowet 5 liquid was obtained from the Institute of Organic Industry in Warsaw

The appearance of scabies (*Sarcoptes scabiei v. canis*) was noted in Arctic foxes on the head, at

Table 1. Composition of the usable preparation Ipowet 5 liquid

component	%
Bromphenvinfos[1] 5 a.s. *	0.2 or 1
Rokacet R 40	1,5
Propylene glycol	37
Ethyl alcohol	up to 100

* a.s. active substance

[1] chemically active substance: phosphate(Z,E)-2-bromo–1-(2,4 dichlorophenyl)–vinyl–diethyl.

the base of auricle, on the ridge of the nose and also on the breast, body sides and limbs.

Scabies in Arctic foxes were controlled with the help of Ipowet 5 liquid, using solutions at the concentration of 0.2 and 1.0%, which were rubbed into the lesions 5 times at 3 days intervals. The drug dosage used was 3 to 15 mg/kg b.w..

Results and Discussion

The results of scabies control in Arctic foxes with the help of Ipowet 5 – liquid (bromphenvinfos at the concentration of 0.2% and 1.0%) are presented in Table 2.

Ipowet 5 liquid (i.e. bromphenvinfos) effectivelly controlled scabies in Arctic foxes at the concentration of 1% at a dosage of 15 mg/kg b.w. a.s. The procedure of rubbing pathologically changed sites was repeated 5 times at 3 day intervals. The effectiveness of control amounted to 100% of the treated animals. When the concentration and the dose were lower, 0.2% and 3 mg/kg b.w. a.s,. the effectiveness was only 25%. In the earlier investigations into the effectiveness of Ipowet 5 liquid against scabies in dogs, the obtained results were similar (Sciesinski 1999).

Table 2. Therapeutic properties of Ipowet 5 liquid in the control of scabies (*Sarcoptes scabiei v. canis*) in Arctic foxes

Animals (#)	Mean body weight (kg)	Concentration	Single dose a.s.* mg/kg b.w.	Animals healed (#)	Mean effectiveness (%)
10	7	1%	15	10	100
8	8	0.2%	3	2	25

* - a.s. active substance ** - Arctic foxes rubbed 5 times with 3 day intervals

Conclusions

Ipowet 5 liquid (bromphenvinfos) administered at the concentration of 1% and the dose of 15 mg/kg b.w. effectively controlled scabies (*Sarcoptes scabiei v. canis*) in Arctic foxes.

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Edited by:

Dr. Berhard Benkel
Dr. Hossain Farid
Dr. Kirsti Rouvinen-Watt
Lora Harris

VIII-1 RP

Sustainability of the fur industry

Larry Martin[1] and Tesfalidet Asfaha
George Morris Centre, 225-150 Research Lane
Guelph, Ontario N1G 4T2
E-mail address: larry@georgemorris.org

1. Introduction and Background

The international fur industry employs over one million people and generates fur sales of around $15 billion annually (IFTF, 2004). Both figures are growing.

The fur industry is also a source of controversy. On the one hand, some groups oppose it on animal welfare grounds, particularly since its products are generally regarded as luxuries. On the other hand, the 1999 United Nations conference on environment and development made sustainable production and consumption a central theme. It can be argued that fur production is sustainable since it uses by-products from other industries as its feed stock, and that many of these by-products would have little value and a high cost of removal absent this use.

These issues relate to the fur industry in general. Within the larger international industry there are also concerns about the Canadian component. Most of the producers in the industry are small, struggling to compete on price against China, the world's largest importer of fur pelts and leading exporter of fur garments. As fur is becoming more affordable and desirable to customers mainly because of the growth of incomes in developing countries, the Canadian fur industry needs to change with the pace of the global fur market to remain competitive and sustainable.

The concept of sustainability is a broad term. In terms of agricultural practices, two definitions of sustainability are fundamentally similar. It refers to:

- Agri-product systems that are economically viable, meet society's need for safe and efficacious foods and fibre, while conserving natural resources and the quality of the environment for future generations, or
- Agri-products systems that can indefinitely meet demands for food and fiber at socially acceptable economic and environmental costs.

Using either definition, sustainability incorporates the coordination of social, ecological and economic aspects. To us the practical aspects of the concept are:

- What is taken from the environment in production, or a reasonable substitute, is put back
- What is put back into the environment does no more harm than what was used
- Consumers demand and producers supply to them products that do not destroy the fundamental (air, water, soil) resources used in their production
- Producers supply products with the attributes consumers want
- Markets operate efficiently so that reasonably efficient (not all) producers can pay for the resources used in production (land, labour, management, capital) with the returns from the market place
- The foregoing conditions are met over time.

Purpose and Objectives

This paper was requested to obtain the perspective of authors outside the fur industry, who have experience at competitiveness and sustainability analysis, about the sustainability

of the fur industry. Its primary purpose is to make preliminary conclusions about the sustainability of the fur industry in general and the competitiveness of the industry in various countries. The specific purposes are:

- To understand the contribution of the fur industry towards sustainable production and consumption. This refers to the entire value chain: trapping, fur farming and feed use, production and recycling.
- Examine the industry's trend in market share, domestically and internationally.
- To identify alternative production technologies, marketing and branding strategies and pricing methods that are improving or can potentially improve domestic and international competitiveness of the industry as well as contribute towards sustainable production and consumption.

In organizing the paper, we have chosen to treat it as a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis with respect to the sustainability theme. For this application, it seems appropriate to focus first on the opportunities and threats, ie the external factors affecting the market.

2. Opportunities and Threats for the Fur Industry

Based on our observations, there are several opportunities and a few threats facing this industry.

Opportunities

They are somewhat interrelated, and most are being pursued. They include:

- **Income growth in Russia and China**

Given the nature of the raw product and most of its end uses, its market tends to be in temperate zone countries. Recent growth in consumer incomes, especially in China and Russia, puts fur potentially within the budget reach of millions of people who would have been unable to purchase it even a few years ago.

Even more than most agri-products, fur products tend to be purchased by higher income people. Therefore, income distribution is as or more important than average income growth. There is considerable evidence of very substantial growth in the number of people in the middle and upper income groups in both countries.

- **Product Flexibility and "Category Management"**

In the past, fur was perceived as being primarily for the very wealthy and many products emphasized that perception. More recently the industry is finding that there is a broader market for fur products with new products and new uses for fibre in competition with synthetic fibres from the petrochemical industry.

From our perspective, it would appear that the industry is beginning to evolve toward the category management structure seen in many industries such as wine or automobiles. In this structure, the supplying industry offers a broad line of distinct products with attributes and prices that appeal to a large number of segments. This often includes entry level products and then ranges up to very high quality and high priced products – Mercedes Benz, for example especially in Europe, clearly covers the range from efficient small entry autos, through taxies to touring sedans.

Product lines are usually built around age and/or income level of the various target market segments. However, segments also take into account other attributes. An obvious example is the recent introduction of hybrid autos for those who are concerned about the environment. Similarly, in Canada Mommessin wineries have

recently introduced very un-traditional packaging for their stalwart white and red wines. The packaging is fun, explains the product in terms understood by young people with little knowledge of wine. This is clearly meant to appeal to the new wine drinker – good, honest value provided in a way that will simplify life for the customer. We will be surprised if the company does not have a strategy developed to maintain the first timers and move them to higher priced product as they gain knowledge and experience.

The ability to provide product lines across various market segments simultaneously expands the current size of the market, and provides opportunity for continuing customers in the future.

The next three opportunities may be among the attributes that can be promoted to some market segments.

- **Fur Is a "Natural Product"**

A trend has developed among some consumers in favour of "natural" products. In the case of fur, major competition comes from synthetic products made from petrochemicals. When oil was plentiful and inexpensive, synthetics developed as relatively low cost alternatives to natural products. Going forward the trend to natural, notwithstanding the issues about animal rights, will have currency with a segment of the population.

- **Fur is a Renewable Resource**

A key aspect of the industry's opportunity is that it is a renewable resource. It is key because of the definitions above regarding sustainability. It's a little hard to argue that exploitation of non-renewable resources is sustainable. Clearly, by definition, using non-renewable resources means that something different will be needed when the resource is used up. The rate at which it is used up and the size of the remaining stock affects attitudes: with the widespread acceptance of the premise of "peak oil" in the past few years, it is clear that there is much more concern about that energy source running out. It affects the way many people feel about both renewable and non-renewable resources. A renewable resource provides a positive image, which is helpful in counteracting some of the mare negative images that have been associated with the fur industry.

- **Fur Production Uses Food Animal By-Products**

In line with the natural and renewable aspects of fur production is the fact that farmed fur production relies on by-products from meat, dairy, poultry and fish processing as a major feed source. Table 1 contains a summary of the estimated amounts of by-products that are fed to fur bearing animals in the EU and North America.

This would appear to be an opportunity to promote the industry because of developments with by-products, especially the meat industry. In short, the amount of by-products is rising and its alternative uses are declining. Because of issues such as BSE, regulators and market preferences are increasing the range of products that are not appropriate for human consumption. Similarly, fewer and fewer of these by-products can be fed to other species. The alternatives for these products are limited, if they are not used as feed. They can go to land-fills, or they can be rendered and the remains sent to land-fills. In either case, the energy and environmental costs of transporting and rendering them are quite high.

So, an advantage for the industry is that these

Table I. Summary of By-Product Use by Fur Farming in the EU and North America, 2002.

Amount of animal by-products fed yearly to fur animals in EU	Tonnes
• poultry processing	220,000
• fish and fish processing	365,000
• slaughterhouse	62,000
Amount of animal by-products fed yearly to fur animals in North America	200,000

Source: IFTF, 2004

by-products are used up. This still leaves the cost of dealing with manure and the fur industry's by-products, but it is less than what is fed.

Threats

These issues are important to the discussion of sustainability because of the issue of demand – i.e. an industry is not sustainable if there is insufficient demand for its products to pay for the resources used in its production. The following three issues, if not managed, can significantly affect demand.

- **Fundamental Issue of Exploitation of Animals**

There is a movement in society that is opposed to any kind of exploitation of animals, and it is probably growing. Some even oppose pets. Using them for fur is likely the most objectionable, as evidenced by bans on fur farming in some countries. On the other hand, it remains a small portion of the population, and is unlikely to significantly limit opportunities unless members of the industry engage in practices that put it in a bad light.

- **Animal Welfare**

As is evident from clicking on "fur" on the internet, the fur industry is a favorite target of animal rights activists. Everything from the nature of traps to pen sizes on fur farms to the process used to euthanize animals come under scrutiny. This is the next step from the issue of fundamental exploitation discussed above; i.e. it is acceptable to exploit animals, but if we do then we have a moral duty to treat them humanely in the process. This appears to be a basic belief that many humans hold. To break the implied moral pact is to cause consumers not to countenance the industry's practices by refusing to buy its products.

In this regard it is clear that many in the fur industry have invested heavily in research to help understand best practices. This shows the industry's commitment to welfare and the inconsistency in the oft-repeated accusation that it is more interested in maximizing profits than in the physical well-being of the animals. What evidence is there that the two issues are inconsistent? One is not likely to maximize profits if the practices used give rise to poor performance of the animals.

- **Pollution**

The final threat is the effects on the natural environment of production processes. It includes smells and runoff issues associated with manure and waste.

Trends in the Market

A number of market trends are quite suggestive of the progress of the fur industry in pursuing

Table 2. World production of mink pelts in thousand, 1998-2007.

Year	China	Denmark	Holland	USA	Poland	Canada	Others	World
1998	2,500	11,900	2,700	2,900	200	1,100	10,399	31,699
1999	3,000	10,500	2,700	2,800	400	1,200	9,290	29,890
2000	3,300	10,900	2,750	2,650	600	1,300	8,703	30,203
2001	3,700	12,200	3,000	2,570	800	1,400	9,145	32,815
2002	4,100	12,200	3,000	2,600	1,000	1,500	9,405	33,805
2003	6,000	12,200	3,100	2,550	1,100	1,700	9,650	36,300
2004	8,000	12,500	3,250	2,600	1,500	1,750	9,370	38,970
2005	12,000	12,900	3,300	2,700	1,800	1,900	9,690	44,290
2006	15,000	13,500	3,700	2,850	2,200	2,100	10,230	49,580
2007	20,000	14,000	4,300	3,000	2,800	2,300	11,190	57,590
% Δ (2006/07)	*33%*	*4%*	*16%*	*5%*	*27%*	*10%*	*9%*	*16%*
Average % Δ	*23%*	*3%*	*5%*	*0%*	*22%*	*8%*	*1%*	*7%*

the opportunities and offsetting the threats. Each is discussed below.

- **Public Opinion**

Several surveys over the past decade put fur in a generally favourable light (IFTF, 2004). For example:

- 86% of Americans support an individual's freedom to choose whether to wear fur (1996).
- 69% of Finnish people have a positive attitude to fur farming (1998).
- In the UK, 62% of people consider that it is environmentally sound to use natural fibres such as wool, silk, fur and leather (2000).
- 71% of Dutch people agree with the statement, "it makes in principle no difference for what reason you keep animals as long as you take care of their welfare" (2000).
- 67% of Dutch people believe individuals should have a free choice to wear fur (2000).
- 67% of Scottish people strongly agree with the statement "in principle, I find it acceptable that animals are kept on farms for any purpose, provided there is good animal welfare" (2001).
- 68% of Canadians know that the fur trade helps to support the livelihoods and cultures of people living in close harmony with the land (2001).
- In Norway, two thirds of people support fur farming (2003).

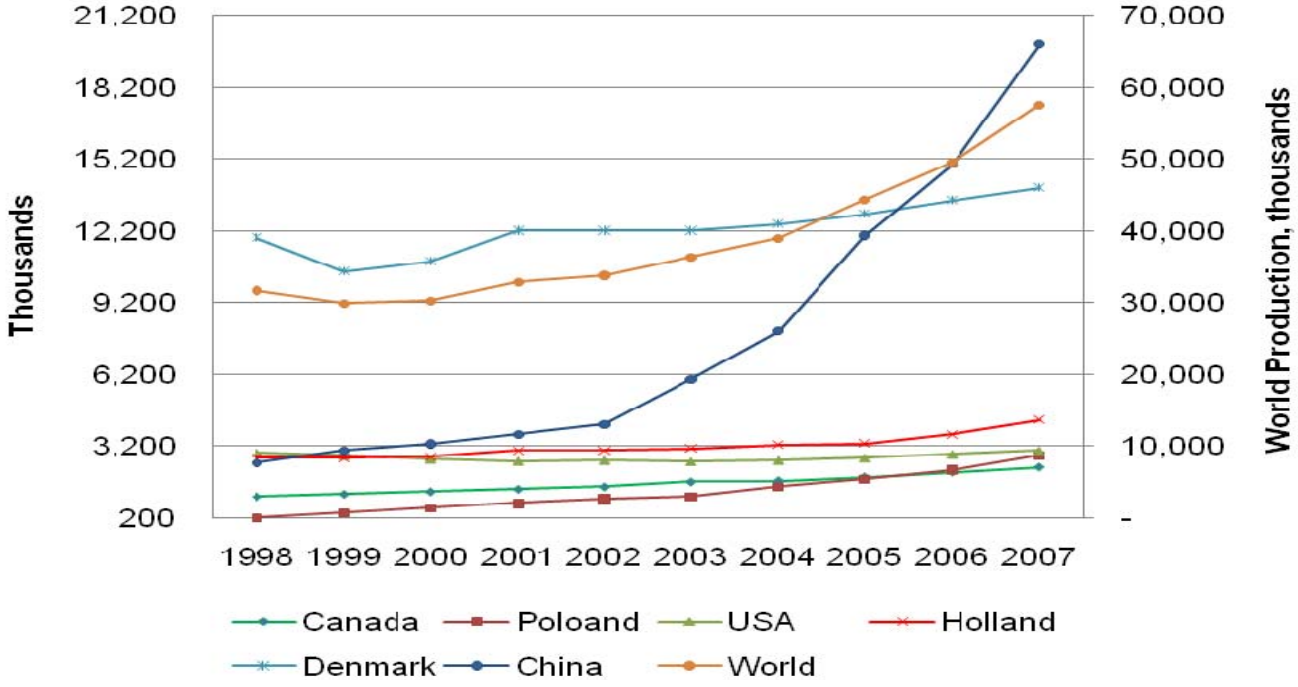
These results suggest that the industry has a sufficiently positive image to continue growth.

- **Growth in Sales**

The total value of fur sales reached 11 billion dollars in the early 2000's following a significant trend upward. We were unable to find total sales data past that time, but the following data show trends in volume of production of pelts and average prices for mink and fox for several producing countries.

Table 2 and Figure 1 show mink production by country since 1998. Of particular note is the fact that production rose in all countries except the United States, and it rose in almost every year. Average annual compound growth during the period was 7%, with China, Poland and

Figure 1: Mink production by country, 1998 – 2007.



Canada being above the average. The second factor to note is the rapid growth of China and Poland – China's production grew by a factor of 8, while Poland's increased 14 times from its base in 1998.

Graphing production, as has been done in Figure 1, gives a visual impression of the rate of growth in mink production. While most countries enjoyed linear growth, China's has been almost exponential. The latter also affects the shape of world production.

Table 3 and Figure 2 contain similar data for fox pelts. They show a different pattern. While world growth is similar at 8% annually, all of the growth has been in China – production has declined marginally in every other country, and China's declined in 2007.

In light of the growth in sales of furs shown above, the most compelling information is the price data shown in Table 4. While sales volumes were growing at compound rates of more than 20% between 1998 and 2008, prices for male mink and silver fox tripled and double for female mink. Changes of this magnitude can only be a result of very substantial increases in demand.

One has to conclude from these data that the fur industry has been able to successfully take advantage of the opportunities that exist in the market place, and have to date avoided the threats that were listed. That the trends have been upward for ten years indicates that the industry is quite sustainable.

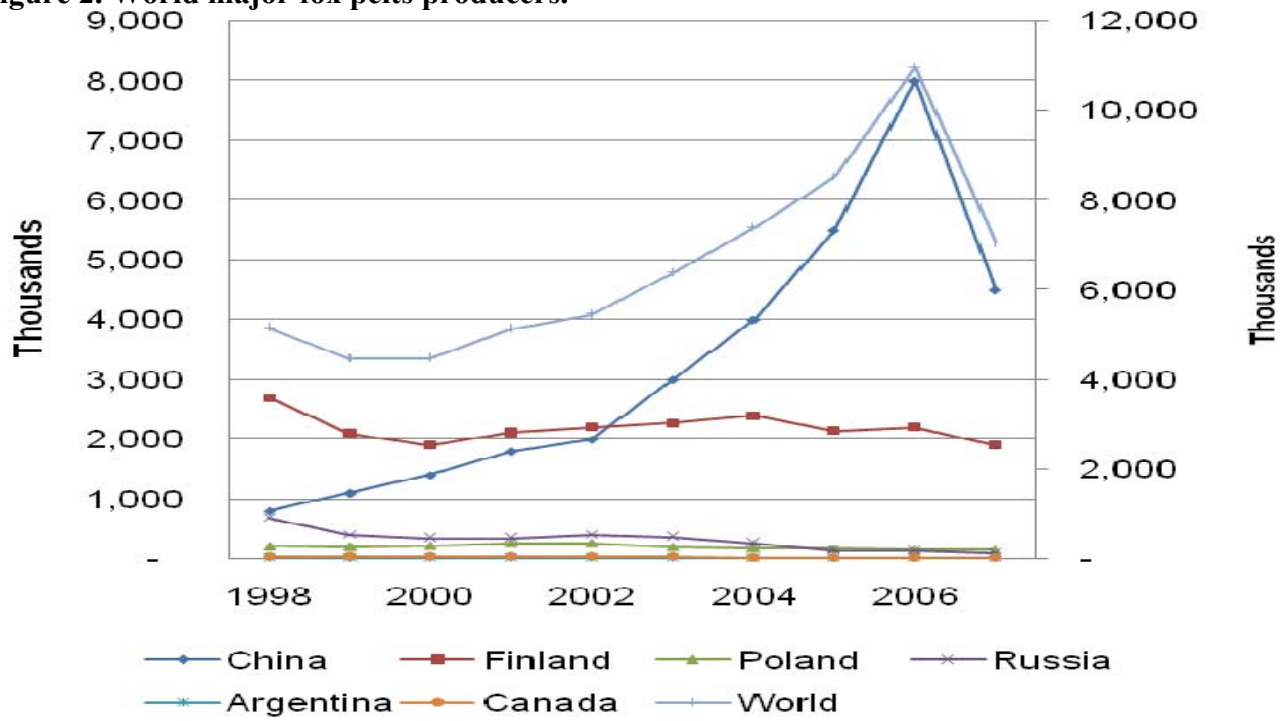
3. Strengths and Weaknesses of the Industry

In light of the opportunities and threats discussed above, what are the strengths and weaknesses of the fur industry going forward? These are discussed below.

Strengths

The fur industry appears to have several strengths. Here is what we see.

Figure 2. World major fox pelts producers.



- **Economic Weight**

The value chain of the fur industry is complex and has connections to a number of other industries. Our attempt to characterize it for farmed fur is in Figure 3. This shows the linkages within the fur industry and between it and other industries. It also indicates a large and growing economic presence for the industry.

The most recent data we could find on total world sales of furs was for 2002 when sales were estimated at $10.95 billion. Given that both volume and prices have trended upward since then, it seems conservative to estimate that

Table 3. World production of fox pelts in thousand, 1998-2007.

Year	China	Finland	Poland	Russia	Argentina	Canada	Other	World
1998	800	2,700	210	680	30	33	706	5,159
1999	1,100	2,100	200	400	23	35	617	4,475
2000	1,400	1,900	220	350	20	40	553	4,483
2001	1,800	2,115	260	350	20	40	547	5,132
2002	2,000	2,200	260	400	20	35	544	5,459
2003	3,000	2,275	200	370	20	30	502	6,397
2004	4,000	2,400	180	270	20	25	498	7,393
2005	5,500	2,150	170	150	20	25	499	8,514
2006	8,000	2,200	150	140	20	20	448	10,978
2007	4,500	1,900	150	100	20	15	370	7,055
% Δ (2006/07)	*-44%*	*-14%*	*0%*	*-29%*	*0%*	*-25%*	*-18%*	*-36%*
Average % Δ	*21%*	*-1%*	*-4%*	*-16%*	*-3%*	*-9%*	*-5%*	*8%*

Table 4. Ten year ranch fur average prices*.

	U.S. $		
Year	**Male Mink**	**Female Mink**	**Silver Foxes**
1999	25.67	20.3	34.73
2000	38.52	26.35	38.34
2001	37.57	25.66	54.44
2002	37.87	24.84	59.35
2003	33.27	22.91	74.71
2004	46.64	29.14	102.13
2005	54.59	34.97	64.54
2006	67.71	47.1	91.25
2007	52.38	34.32	104.02
2008	76.16	43.98	110.1
% Δ (2007/08)	***45%***	***28%***	***6%***

* Average prices include all pelts including lowgrades and breeders

sales now exceed $20 billion annually. The number of people employed in the industry exceeds one million. There are over 100,000 businesses in the world fur industry, including over 8,000 fur farms.

These figures add up to an industry with considerable economic weight. This can be translated into a considerable advantage. It means that lobbying efforts to governments will have credibility. It means that the industry can generate funds to make investments in its future in terms of information campaigns, training of its members and the like to respond to the potential threats and/or pursue its opportunities.

- **Excellent Infrastructure**

One cannot help but be impressed with the excellent set of fur auctions around the world that bring buyers and sellers together and coordinate the logistics of moving pelts to manufacturing facilities all over the world. These auctions bring buyers and sellers together, provide information to both about what the market wants and what is available, ensures that there is a relatively large amount of liquidity for market transactions, and transparency in pricing. They are willing and able to innovate in the marketing process if and as needed in the future.

- **Responsiveness to Market Demands**

In several respects, elements of the fur industry have shown responsiveness and willingness to respond to the market place and to society. The expansion of design and product development to a broader audience has already been mentioned as one example.

Another example is the ability of primary producers in the industry to adjust production processes to improve resource use and/or to respond to external criticisms. For example, the Canadian fur industry adopted several measures to ensure environmental sustainability. Important examples are:

- New manure handling equipment
- Computer controlled pelt processing equipment
- Computerized breeding records
- Guard fences around the entire farm to control the movement of animals and people
- Increased cage size
- Continuous research and testing of trapping systems to evaluate their consistency with an Agreement on

International Humane Trapping Standards (AIHTS).

Additionally, The Fur Institute of Canada supports several values relating to sustainability and resource conservation. The Institute supports:

- The sustainable use and conservation of renewable resources
- The continued improvement of animal welfare through ongoing research and the development of national and international trapping standards
- The conservation and management of natural resources based on scientific evidence and traditional knowledge
- Professionalism through continued education, licensing and research
- Respect for people, animals and the environment.

This shows that the fur industry not only understands but also feels obliged to the concept of sustainability and conservation of renewable resources.

Weaknesses

The most obvious weakness that we can see is that there are people in the industry who persist in using inhumane practices in the production and slaughter of animals. Not only do they likely reduce their own profitability, but they threaten the whole industry. Its opponents are strong, well financed and ruthless. It seems more than a little short sighted that some producers continue to invite trouble for the entire industry in this way.

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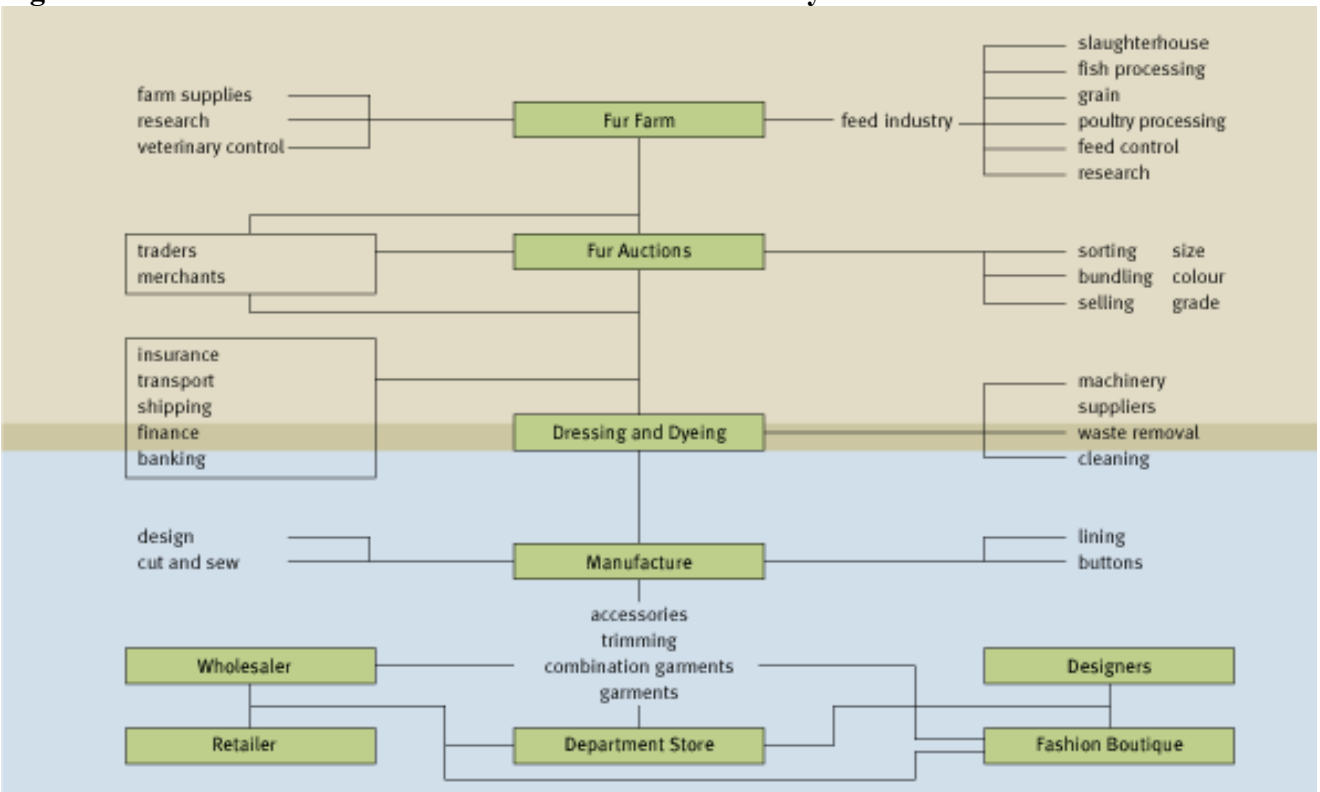
Figure 3. Schematic of the Value Chain for the Fur Industry



Source: (IFTF, 2004)

4. Tentative Conclusions.

To reach some conclusions, let's return to the several factors implicit in the definition of sustainability for an industry. We said there are six:

- What is taken from the environment in production, or a reasonable substitute, is put back
- What is put back into the environment does no more harm than what was used
- Consumers demand and producers supply to them products that do not destroy the fundamental (air, water, soil) resources used in their production
- Producers supply products with the attributes consumers want
- Markets operate efficiently so that reasonably efficient (not all) producers can pay for the resources used in production (land, labour, management, capital) with the returns from the market place
- The foregoing conditions are met over time.

In the case of at least farmed fur, there is likely very little taken from the natural environment because fur producers tend to feed by-products from animal agriculture. Similarly, manure and by-products from fur animal production can be applied back to the land, either directly or as rendered material.

It would appear from the rapid growth in production and rising prices over the past decade that by and large producers supply products with the appropriate attributes. At the same time, there is no evidence that what is being produced is doing irreparable harm to any natural system.

If there is an issue, it is with the concerns about animal welfare. Producers, suppliers, and producer organizations conduct research to improve these processes, and provide programs for producers to learn about and implement improved practices. Hence the majority of the industry is concerned about the sustainability of demand, when demand includes the humaneness of processes.

Humane treatment is both a threat and a weakness for this industry. Two suggestions come to mind that may assist the industry respond effectively to market demand. They are:

- Improve information flows in the value chain to encourage and reward the appropriate attributes - including production/killing processes. This can be accomplished by establishing pricing mechanisms that pay premiums for pelts that meet specific conditions. It logically follows that the products of pelts with premium characteristics also receive premium prices. This would be consistent with the concept of a family of brands intended to provide a series of product lines that reach various segments in the market place.

- As with meat animal industries, it may be appropriate for the fur industry to consider trace back systems that would monitor the conditions under which the product is produced and marketed against a set of protocols required to meet "label" approval. This would be an effective way to police the industry while, simultaneously promoting products produced under humane conditions.

VIII-2 RP *Please note: this is the final version of this paper. It has been changed from the IFASA congress proceedings printed in Scientifur 32 (4).*

Sustainability in mink production – A management perspective

Steen Henrik Møller
Department of Animal Health, Welfare, and Nutrition, Faculty of Agricultural Sciences, University of Aarhus, Blichers Allé 20, P.O. Box 50, DK-8830 Tjele, Denmark.
E-mail: Steenh.Moller@agrsci.dk

Introduction

Is mink production sustainable? If not, can we make it sustainable through management? and if yes, can management be useful in keeping mink production sustainable? If we ask European mink farmers whether mink production is sustainable the answer will probably be yes. If we ask the European general public whether mink production is sustainable the answer will probably be no, followed by some general expressions like:

"*The production of luxury goods like fur is a useless exploitation of resources better used otherwise"*

or

"*Keeping wild animals like mink in small cages is cruel to the animals and a disgrace to nature."*

I will focus on the meaning of the term sustainability, how this relates to the above mentioned critique of mink production and how the different views on sustainability relate to management. I will describe management of mink production and discuss to what extent farm management is related to or challenged by sustainability, and how we can develop management tools which take into account the need for further development of a sustainable mink production system.

What is sustainability in relation to mink production?

Although the concept of sustainability is widely used in agriculture as well as in society, there is no common understanding of the meaning of the term "sustainability". The term was used by the Brundtland Commission (1987, p.43) which coined what has become the most often-quoted definition of sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." The field of sustainable development can be conceptually broken into three constituent parts: environmental sustainability, economic sustainability and socio-political sustainability. On the other hand, Thompson (1997) emphasizes that research on sustainable agriculture should address the question of whether a given production is sustainable, by investigating the "resource sufficiency" or the "functional integrity" of agricultural production systems, particularly livestock farming systems. "The "resource sufficiency" approach directs attention to potential sources of total resource scarcity. The implicit values of the "functional integrity" approach lead us to look toward weak links in a system's ability to reproduce its essential elements" (Thompson, 1997).

What is management of mink production?

The management of livestock farming is generally described as an activity where the farmer decides the combination of production factors in a way that maximize his overall outcome or welfare, given the constraints. Many definitions with various emphases have been given of which the definition of "Farm / Horticulture Business Management" by Nix (1979) is one of the most often-quoted: "The science of organising and controlling the resources of a particular farm or holding so that they yield for the enterprise as a whole either the greatest continuous profit or that profit

which the farmer desires". My favourite definition stressing the dynamic, active, and uncertain nature of management and that the goal is often more than economic profit is given by Dillon (1980): "Farm management is the process by which resources and situations are manipulated by the farmer in trying, with less than full information, to achieve his goals".

Farm management is a continuing process, including compilation and analysis of data, planning the production towards a goal, implementation of the plan, and control of the output (Bernard & Nix, 1979). The control involves analyses of deviations from the plan or the goal, potentially leading to adjustments in the goal, the plan, or the implementation in order to reduce the deviation. Due to changes in agricultural values and the role of agriculture in the modern society, the goals of agriculture in general have shifted from maximizing the production over optimizing the productivity towards adaptation to a more sustainable way of production. These changes reflect the change in the role of agricultures in the society, from food supply to the entire production system including animal welfare, environmental impact and conservation of natural resources (Sørensen & Kristensen, 1992).

A feasible model of a mink farmer's management of the production is a cybernetic system. In this context the mink farm is organised as a production system defined by the animals, buildings, machines, land and labour, and a management system defined by feedback of information performed by the farmer (Figure 1) (Sørensen & Kristensen, 1992; Møller & Sørensen, 2004). It is an open system, as it produces animal products and by-products by use of controllable and uncontrollable inputs. By regulating the controllable factors the farmer tries to maintain production in harmony with the goal, while adjustments are needed when uncontrollable factors induce deviations from the goal. The interaction between the production system and the management system is illustrated in Figure 1. Management is seen as a chronological series of: 1) measurement of the production system's behaviour, 2) comparison with a goal or a plan, and 3) adjustment of controllable factors.

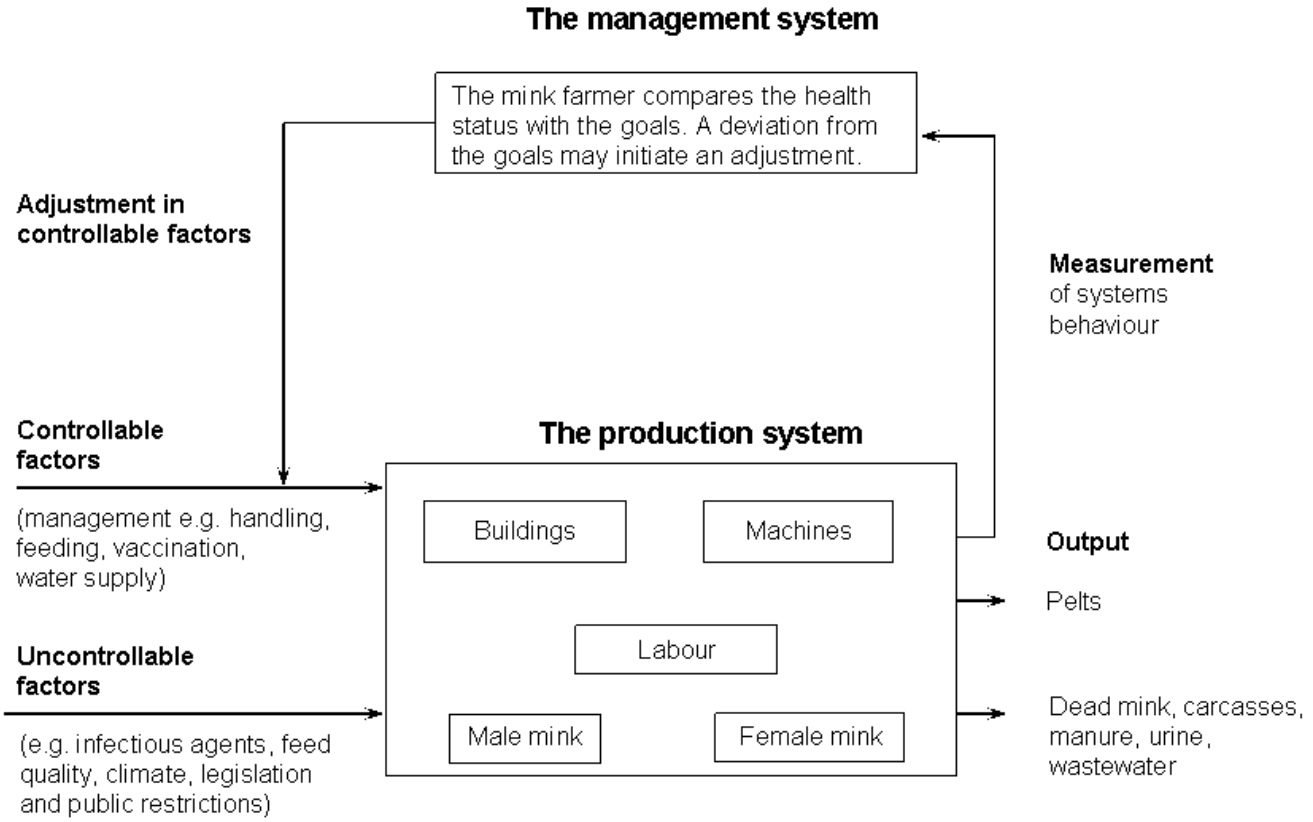
Sustainable mink management

The cybernetic systems model for farm management is very similar to the "functional integrity" approach, which also requires a systems view. Therefore, the management perspective of the sustainability of a mink farm can be investigated by the "functional integrity" of the farm as a cybernetic system. Sustainability of the mink production is then seen as the cybernetic system's ability to sustain itself. The system is not sustainable if the uncontrollable factors affect the systems behaviour to an extent where the controllable factors can not bring the production system back into a viable balance. Thus, the regenerative capacity of biological and social systems, i.e. the controllable factors, and the protecting capacity to bounce back from system insults, i.e. the uncontrollable factors, constitute the strategy of resilience of "functional integrity" (Thompson, 1997). In this context, mink production is sustainable if the factors controllable by management are sufficient to adjust for external threats from any uncontrollable factors (Figure 1).

Thus the farmer's perspective of sustainability will be "functional integrity" with focus on economy. However, the perspective of the outside society will be that of environmental and socio-political sustainability with focus on pollution and animal welfare, respectively. Consequently, both sets of perspectives should be incorporated into the management strategies of mink farmers.

In the following examples I will address the sustainability viewed from the perspective of the farmer as well as the society. In doing so, I

Figure 1. Sustainability of mink production as a cybernetic system conceptualized as the functional integrity of the system (modified from Sørensen & Kristensen, 1992; Møller & Sørensen, 2004).



focus on sustainable management in the mink production in relation to 3 topics that I have dealt with in my own research. These topics are: 1) animal welfare, 2) environmental impact, and 3) feed efficiency.

1) Animal welfare

Due to public regulation of mink production, animal welfare has for many years been part of farm management. However, from the mink farmer's perspective of "functional integrity" management has aimed at complying with regulations rather than improving animal welfare. For example, reducing welfare threats like pelt damage due to bite wounds, health problems and the fearfulness in mink has rather been part of management to reduce costs and ease handling of mink than to improve welfare in itself. If mink production is not socially or politically accepted, it will be at risk of being made economically unprofitable or banned. This has already been the case in several European countries, based on the public opinion of animal welfare in mink production. In Great Britain, mink production was banned in 2002 as it was not consistent with 'the public morality'. In several other European countries, regulation of housing conditions have been proposed or approved that will make fur animal production economically unsustainable. Some times this is almost the official purpose (e.g. legislation for foxes in Denmark), but more often regulations are intended to improve animal welfare (e.g. the Netherlands, Germany, Austria).

The welfare potential of mink

The welfare potential of mink is good in the normal farming situation because the typical production system does not include any severe

restrictions that endanger the welfare of the animals. In a typical production system the mink is:

1. Mated naturally and able to perform natural mating behaviour in the natural breeding season.
2. Provided with a nest box and nesting material, and thus able to perform unrestricted nest building behaviour.
3. Allowed to perform natural, unrestricted delivery of their kits without any behavioural restrictions.
4. Weaned when lactation is drying out, at the age best fulfilling the needs of female and kits. The production system does not impose any restrictions in choice of age at weaning.
5. Left intact with no physical restrictions or mutilations of the mink body.
6. Most often kept in social groups according to their need, that is singly from December and not more than one mink of each sex after September, which is the time of dispersal.
7. Killed just outside their cage. No transportation or waiting time prior to slaughter.
8. Pelted with very few physical injuries, wounds, bone fractures or clinical disorders at pelting time.
9. Housed in a way that enables effective and individual monitoring and observation of health and welfare.

The welfare of mink on Danish farms

As the term animal welfare is based on the animals' mental experiences, welfare cannot be measured directly but has to be assessed indirectly (Sandøe & Simonsen, 1992) through welfare indicators. Indicators relevant for an operational welfare assessment system should include system description, system application, animal health and animal behaviour (Sandøe et al., 1997). Measurements of health status and behaviour relate directly to the animals in question, whereas system description and system application may provide information on potential welfare problems and causes of impaired welfare. An operational welfare assessment system was developed by aggregating relevant indicators into a welfare indicator protocol in a "bottom up approach" (Rousing et al., 2001), in which, potential welfare indicators were evaluated step by step concerning their independent relevance, marginal welfare information value and applicability for on-farm studies (Møller & Hansen, 2000). Based on this three-step evaluation procedure, 36 welfare indicators were included in the protocol and applied to an evaluation of the animal welfare at farm level. Due to the strictly synchronised mink production, the welfare was evaluated within each of the tree major periods: 1) January to March; winter, flushing and mating, 2) April to June; gestation, birth, lactation and weaning, and 3) July to December; growth, selection and pelting.

Data collection involved five visits to each of six farms in which management routines, housing facilities and behaviour and health parameters were investigated. Methods and results are described elsewhere regarding temperament (Møller & Hansen, 2000) mortality, health status, and the cause of death (Dietz et al., 2000), and physical injuries and bite wounds at pelting (Møller, 2000).

Welfare assessment results

For each farm the data were aggregated into a welfare assessment report describing the background, purpose and content of the welfare evaluation, the overall results for the production year, and the detailed results of the four types of information in each of the three periods of the year. The welfare assessment in six private mink farms indicated 56 points where welfare was at risk. Each point was discussed with the farmers and at 30 points it was agreed that changes should be applied in order to improve the welfare of the mink. In 26 cases changes could be applied in order to avoid a risk. Thus, on

average on the six farms, the welfare assessment indicated five points out of the 36 indicators used in total, where changes should be applied. Most of these points were directly or indirectly related to management in terms of: 1) restricted feeding during winter leading to severe weight loss, stereotypy, and aggression, 2) too few cages to house al the kits in pairs, leading to placing of mink kits in groups (with more than one kit of each sex), aggression, and severe bite marks, or 3) a large number of mink per farm hand leading to inability to handle health or other problems appropriately. Once identified, these potential welfare risk factors and realized welfare problems can be avoided by relatively inexpensive and simple adjustments in management at the tactical and operational level.

Our "Welfare assessment system" was developed as an advisory or decision support tool for the specific mink farm. It should therefore provide the farmer with information that allows him to decide whether animal welfare is satisfactory in each production period. If this is not the case, the system should provide information on farm specific welfare problems, so the farmer can decide how to improve the welfare of the mink. A thorough description and discussion of the welfare impact of each indicator is crucial for the farmer's possibility to choose the best means to improve animal welfare on his farm, when needed.

Animal welfare, sustainability and management

Management of a sustainable mink production system should include the management needed in order to avoid threats and achieve socio-political sustainability. This would require that mink producers and their organizations can argue, demonstrate, and document that welfare problems are small and controllable, and that they are controlled in the mink production system. A management tool like the "Welfare assessment system" could fulfil such a requirement as the good welfare potential of the farm mink was realized at the farms investigated, if a few management-related risk factors were eliminated.

2) Environmental impact

Due to public restrictions on livestock farming systems, correct handling of manure has for many years been part of farm management. However, from the mink farmer's perspective of "functional integrity", management has mainly been aimed at complying with regulations.

The environmental impact of Danish mink

As carnivores, mink are fed a protein rich diet compared to other farm animals. Furthermore, the offal from the fish filleting industry used for fresh feed is rich in bone and phosphorus. Therefore mink fed a fresh, wet mink feed excrete a relatively high amount of N and P in the manure and urine, compared to most other farm animals. In Danish mink production, the amount of feed per pelt produced increased by 450 g each year, e.g. from 35.5 kg in 1995 (Møller, 1998) to 38.1 kg in 2003 (Møller, 2004), and 40.9 kg in 2007 (Møller, unpublished data).

Due to variation in feed consumption, litter size, and size of the mink, the excretion of N, P and K per female breeder varies from year to year. However, the general trend in Denmark has been an increase in the excretion of N and P and a fall in the excretion of K for the last 10 to 15 years (Table 1).

As the major proportion of nitrogen is excreted in urine, it is susceptible to evaporation. One important factor for the retention and use of the nutrients is therefore how the manure and urine are collected. With the development of slurry systems it has become possible to collect almost all the manure and urine, and furthermore to muck out often in order to reduce nitrogen evaporation.

Environmental impact, sustainability and management

Management of a sustainable mink production system should sustain society's acceptance of mink production as environmentally sustainable. If the environmental impact of mink production was declining, the mink farmers could more easily comply with present and future environmental regulations. In order to increase both the "functional integrity" and the environmental sustainability, mink farmers therefore should have direct incentives to reduce the environmental impact through their farm management.

3) Feed efficiency

To a large extent the feed resources used for mink feeding include offal from the fishing industry and abattoirs that have low alternative value. As far as these other industries are sustainable and produce sufficient offal for use in mink production, the production of mink feed can also be regarded as sustainable from the farmers "functional integrity" perspective as well as from the society's environmental and socio-political sustainability perspective. Furthermore, efficient use of the feed by the mink adds to the sustainability both in terms of economic prosperity as part of the farmers "functional integrity" and the society's environmental sustainability. Despite the variation in voluntary feed intake between individual mink, the daily amount of fresh feed has traditionally been the same for all male and female pairs of kits fed during the growing season. By distribution of feed leftovers to cages with no feed left, it was believed that a large part of the individual variation in feed intake was accounted for. However, this has turned out to be far from the truth, since the introduction of individual feeding systems has made true *ad libitum* feeding of mink possible.

For many years mink farmers have selected for body weight in order to maximize their economic outcome and the body weight increased by approximately 2.3% a year. At the same time, the amount of feed has increased by approximately 1.3% each year. Although this indicates some increase in feed efficiency, the full potential for reducing feed cost per pelt produced has not been applicable in practice. Technological development of hand held computers (PDAs) has made individual feeding of mink possible, and thus facilitated increasing feed efficiency by means of feeding management and selection.

Table 1. Standard values for N, P and K content in Danish mink feed, wasted feed and nutrients, deposited in the carcasses, manure and urine per mink dam and per pelt.

	N				P				K	
Year	1995	1999	2003	2007	1995	1999	2003	2007	1999	2007
g in feed	4898	4923	5420	5581	937	1077	958	1007	563	533
g wasted feed[(1)]	392	394	434	446	75	86	77	81	45	43
g ingested	4506	4529	4986	5135	862	991	881	926	518	490
g deposited	310	332	351	390	43	48	51	57	19	23
g excreted	4196	4197	4635	4745	819	943	830	869	499	467
g in manure	676	679	748	873	431	495	441	463	52	49
g in urine	3520	3518	3887	3872	388	448	390	406	447	418
g in total per dam	4588	4591	5069	5191	894	1029	907	949	544	510
g in total per pelt	879	857	959	971	171	192	172	178	101	95

[(1)] Feed waste is set to 8% (Nielsen, 1993).

Feed efficiency improved by management

The possibility of increasing the feed efficiency under different feeding strategies and selection criteria has been investigated in a four-year experiment. During the growth period lines of male+female pairs were fed either according to normal farm practice (unselected control=FF), *ad libitum* (selected for November weight = AL), or restricted (20% below *ad libitum* and selected for November weight = RF). A more thorough description can be found in Møller et al., 2006.

The kits responded to the different feeding regimes by significant differences in weight gain and feed efficiency. The individual *ad libitum* feeding resulted in the highest weight gain, feed consumption and feed efficiency in 2003. The restricted feed allowance in line RF reduced weight gain as well as feed consumption and thereby maintained the feed efficiency compared to line FF in 2003. In general, the difference between lines in 2003 was an effect of the feeding strategies applied, while the differences between 2003, 2004, and 2005 reflect the effect of selection (Figure 2). *Ad libitum* feeding alone thus increased the feed efficiency significantly by 9.2%, while the selection increased the feed efficiency by 8.1% in 2004 and by 8.2% in 2005 to a total significant difference of 25.5% in the *ad libitum* fed AL line compared to the Farm Fed control line (Figure 2). Restricted feeding alone did not increase feed efficiency significantly while selection increased the feed efficiency by 7.9% in 2004 and further by 17.4% in 2005 to a total significant difference of 26.5% compared to the Farm Fed control line.

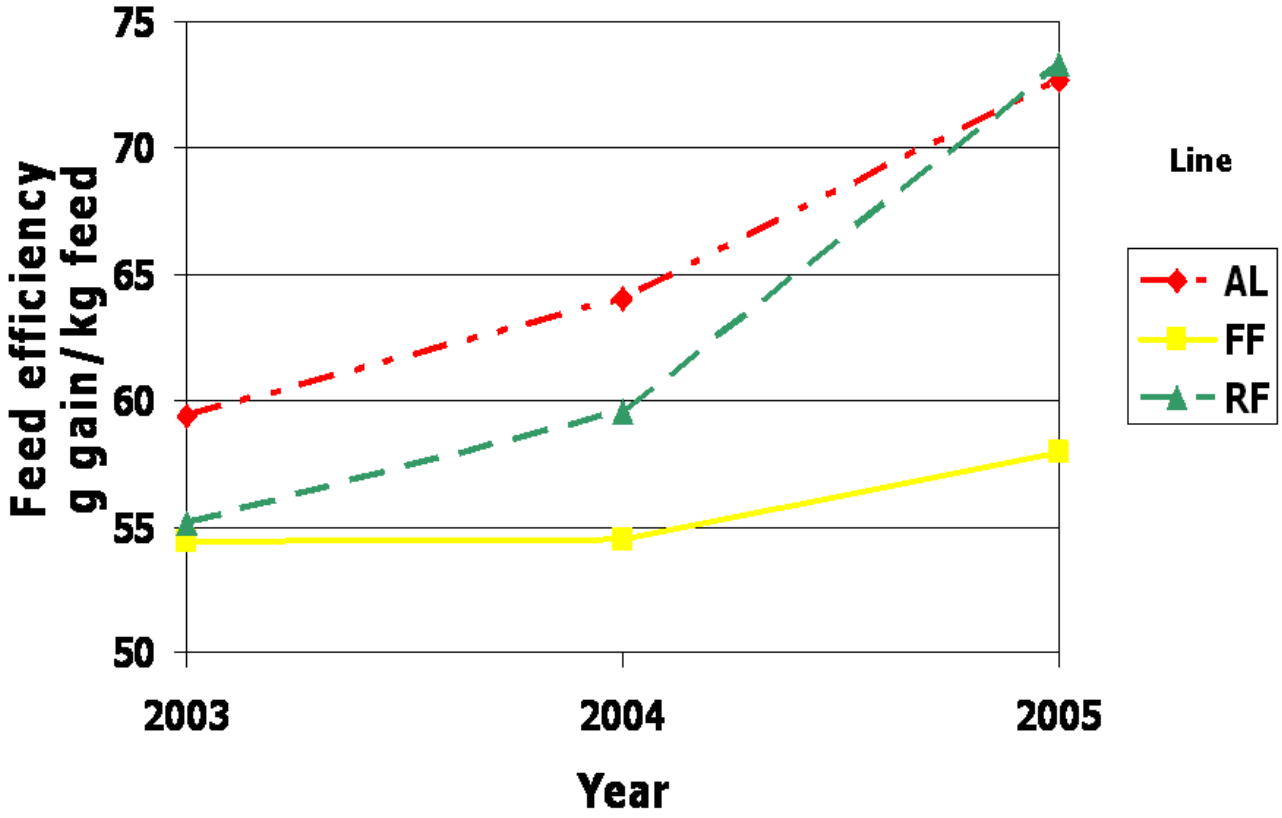
Feed efficiency, sustainability and management

Depending on the feeding regime and selection criteria applied, improvement of feed efficiency may result in all combinations from unchanged weight gain on 25% less feed to 25% higher weight gain on the same amount of feed. In any case the sustainability in terms of "functional integrity" of farm production will be improved as the farmer saves money and increases production and needs less land to spread the manure from a given production. The environmental sustainability will also be improved and thereby the socio-political sustainability of mink production is less at risk, relative to the amount of pelts produced.

Discussion

From a farm management perspective, mink farming is sustainable as long as it is profitable and legal. The farmer's primary management focus is economic sustainability and most farmers can manage the usual variation in uncontrollable factors in order to maintain the "functional integrity" of the production system. Other external uncontrollable factors such as political bans, economic depression or changes in fashion trends regarding fur are not manageable by the farmer. From society's perspective, mink production is accepted as long as it is generally regarded as having an acceptable environmental impact and as long as the mink are generally believed to have an acceptable welfare. Therefore, the public opinion and the political situation are not unaffected by the actual production on private farms. Unfortunately, one example of bad welfare or high environmental impact may have large effect compared to many farms without problems. Farm management is, therefore, indirectly important for political constraints that may be imposed by society, and thus for the socio-political sustainability of mink production. Farm management should therefore try to integrate the two different perspectives of sustainability: 1) the farmer's "functional integrity" perspective with focus on economy, 2) the society's perspective of environmental and socio-political sustainability with focus on environmental impact and animal welfare, respectively. In order to avoid external threats like political bans, welfare or environmental

Figure 2. Average feed efficiency in g weight gain per kg feed consumed for male + female pairs of kits from 12 to 26 weeks post partum (late July – late October) in line FF on farm feeding, line AL on *ad libitum* feeding and line RF on restricted feeding in 2003, 2004, and 2005 (Møller et al. 2006).



regulations that make mink farming economically unsustainable, it is paramount that mink producers and their organizations can document that welfare and environmental problems are generally small and controllable, and that they actually are controlled in the mink production systems.

In general, welfare and environmental impact are not prominent in farm management. As they have little direct effect on production they are usually included only in order to comply with public regulations. For example, the well documented negative effect on welfare in terms of more bite wounds (Pedersen et al., 2004; Hänninen et al., 2007), of more than one mink kit of each sex in the same cage after September has less negative effect on the pelt price than the positive economic effect of higher stocking density. Ironically enough, the public regulation imposed by the Council of Europe allows group housing of mink kits.

The socio-political sustainability of mink production should not be at risk as the mink have a good welfare potential, which, at the Danish farms investigated, seems to be realized in practice if a few management-related risk factors were eliminated. What might be lacking is for the mink farming community to agree on the choice and recommendation of management practices that are known not to put the welfare

at risk, and proper communication and documentation of this to the society at large. One example of this is the Norwegian "Action Plan: Animal Welfare in Fur Farming". Such initiatives will not only affect the socio-political sustainability in society but also the internal sustainability of fur farming in terms of functional integrity, as the norms and values of the mink farming community will be strengthened.

For the mink farmer to include environmental impact considerations into farm management, they should have direct effect on the production. As the Danish regulations are based on average "Standard Values" (Møller, 1998) the individual farmer has little incentive to include environmental aspects in farm management, as "functional integrity" of the production system is sustained when the regulations are followed. From the farmers "functional integrity" perspective, a political shift from "Standard Values" to farm specific calculation of environmental impact could increase management incentive drastically. For example, the effect of increasing the feed efficiency by means of feeding management and selection, as discussed below, would incorporate the environmental aspects parallel to the economic benefits in the farmers "functional integrity" perspective of management and thereby improve the environmental and socio-political sustainability of mink production as well. The results on feed efficiency demonstrate that the sustainability both in terms of "functional integrity" and environmental quality can be improved dramatically and fast by increasing the feed efficiency. Farm management thereby indirectly increase the socio-political sustainability of mink production, relative to the amount of pelt produced.

Hence there is a need for a systematic approach to the development of plans and goals for sustainable mink management at all time horizons and mainly in the area of socio-political sustainability.

Conclusions

- From a farm management perspective, mink farming is sustainable in terms of "functional integrity" as long as it is profitable and legal.
- The major challenge for sustainable mink production is political and social acceptance of mink production in terms of environmental impact and animal welfare. This acceptance is build only in part on the actual production and is thus only indirectly influenced by the management hereof.
- The perspective of sustainability differs between the mink farmer's view of "functional integrity", focusing on economy, and society's view of environmental and socio-political sustainability focusing on environmental impact and animal welfare.
- For the most part, the management of a mink farm is not or is only indirectly related to or challenged by sustainability seen as the "functional integrity" of the mink production system.
- At farm level, management is the most important factor for the welfare and environmental impact of the mink, and thus for the environmental and socio-political sustainability. Therefore management tools for assessing and controlling animal welfare and environmental impact are important instruments in keeping the farm level of mink production sustainable in the eyes of society.

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VIII-3 RP

The outlook for environmental management in the Nova Scotia fur industry

Gordon W. Price
Department of Engineering, Nova Scotia Agricultural College,Truro, Nova Scotia, Canada. B2N 5E3
E-mail address: gprice@nsac.ca

Abstract
As social and legislative pressures increase to protect and conserve natural capital, producers will continue to face higher costs of production. Moreover, agricultural costs of production are becoming more intricately linked to the provision of environmental goods and services, such as nutrient and environmental management, which are currently not associated with many cost recovery mechanisms.

Historically, a strong fur industry has existed in the Digby and Yarmouth Counties of Nova Scotia, Canada. Positive economic rewards over the past decade has led to rapid growth – more than 89% increase in mink since 2001 - of this industry in Nova Scotia. However, the industry is also facing greater challenges toward environmental sustainability due to restrictions in availability of land and allowable uses for land in Digby and Yarmouth. In addition, there is growing concern that current resource and waste management practices in the Nova Scotia fur industry are not adequate to address the environmental sustainability challenges being faced.

As economic and environmental sustainability become integral components of modern agricultural systems, the challenge will be to explore non-traditional mechanisms to manage organic wastes and develop new value chain opportunities that will mitigate against increases in cost of production.

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