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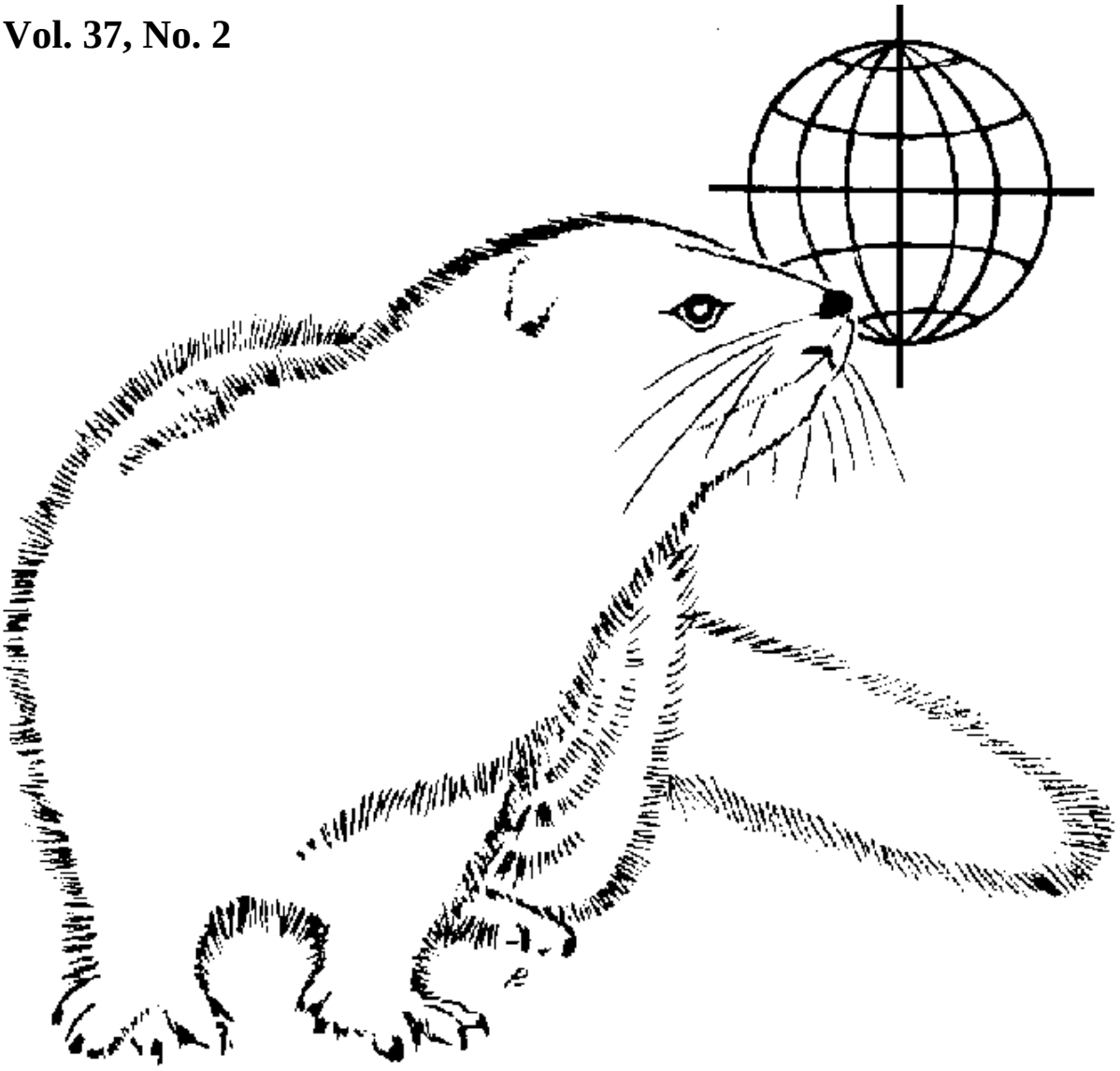

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INTERNATIONAL FUR ANIMAL SCIENTIFIC ASSOCIATION

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SCIENTIFUR is the contact link between fur animal researchers all over the world and serves as an outlet for scientific and other communication between researchers and others who are interested in the production of fur bearing animals. As such **SCIENTIFUR** contains reports of scientific and applied nature as well as abstracts of information published elsewhere and information regarding congresses, scientific meetings etc.

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Vivi Hunnicke Nielsen **Tel: +45 2219 1351**
SCIENTIFUR
P.O. Box 14
DK-8830 Tjele, Denmark **E-mail:** Scientifur@agrsci.dk

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Steen H. Møller **Tel: +45 8715 7926**
IFASA **Fax: +45 8715 4249**
P.O. Box 14
DK-8830 Tjele, Denmark **E-mail:** IFASA@agrsci.dk

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Regional Scientifur Representatives
USA: Dr. Jack Rose: E-mail: rosewill@isu.edu
Finland: M.Sc. Nita Koskinen: E-mail: nita.koskinen@mtt.fi
Iceland: Advisor Einar Einarsson: E-mail: einare@krokur.is
The Netherlands: Ing. Jan deRond: E-mail: info@edelveen.com
Poland: Dr. Robert Głogowski: E-mail: robert_glogowski@sggw.pl

International Fur Animal Scientific Association (IFASA). Board of directors:
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Dr. Bruce D. Murphy (Past President): E-mail: murphyb@MEDVET.Umontreal.CA
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Dr. Marian Brzozowski. E-mail: brzozowskim@delta.sggw.waw.pl
Dr. Timo Mikkola. E-mail: timo.mikkola@profur.fi

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Notes from the Editor

The aim of Scientifur is to report scientific work within fur animal production. Thus, Scientifur publish full articles as well as short communications. Scientifur also brings abstracts of scientific publication published elsewhere. This volume of Scientifur contains abstracts from the Danish Fur Breeders Research Center's Annual Report 2012, which report results from scientific work within behaviour, breeding and reproduction, nutrition and feeding, health, and management.

This volume of Scientifur also contains abstracts or links to abstracts dealing with e.g. studies of reproduction traits in different mink colour types, the effect of breeding for conformation traits in mink, dietary protein levels influence on hair growth and pelt quality in mink and environmental enrichment's effect on behaviour in caged mink. The abstracts are distributed under the headings: Breeding, genetics and reproduction, Nutrition, feeding and management, Behaviour and welfare, and Health and disease.

Attention is drawn to the 11th World Conference on Animal Production (WCAP 2013) held in Beijing, China October 15 to 20 2013. A session entitled "Other Livestock Production; Fur animal production: Fox, mink, and deer" is held at the conference.

Vivi Hunnicke Nielsen
Editor Scientifur

Faglig Årsberetning

2012

Kopenhagen Forskning

Annual Report

2012

Kopenhagen Research

REPORTS ON: BEHAVIOUR

Selection by means of behavioural criteria for adaptation of mink to group housing

L.L. Jeppesen

Juvenile mink housed in groups of four perform more fighting behaviour than juvenile mink housed in pairs. The fighting behaviour reduces the welfare of the mink and results in damages on the fur side of the skins and bite marks on the leather side of the skins. Here it is examined whether the frequency of fights following immediately after feeding (feed fights) can be used as criterion for selection against all spontaneous occurrences of fighting and by that potentially also against the damages that are caused by the fighting. Selection for or against feed fights was carried out in two lines (aggressive respectively peaceful line) in three generations. There were more feed fights and more spontaneous fights in the aggressive line as compared to the peaceful line in all generations. However, the frequency of feed fights increased from generation to generation in both lines and the frequency of spontaneous fights decreased from generation to generation in both lines. In addition, the frequency of serious damages on the fur side of the skins and bite marks on the leather side of the skins was not influenced by the selection. It is therefore concluded that feed fights is not a useful criterion for selection against general aggression and damages / bite marks. As opposed to feed fights, spontaneously occurring fighting behaviour correlates well with the bite marks on the leather side and with the location of the mink in the cages. Spontaneous fighting should, therefore be a better criterion for selection against damages and welfare threatening aggression. Based on the very infrequent occurrence of this kind of fighting it is, however, difficult to make use of as a practical selection criterion. In this project the feed was allocated 'individually' to the groups of four juveniles based upon the remains of feed on the cage in the morning. Following this feeding routine it showed up that the juveniles in the aggressive line got less feed and weighed less than the juveniles in the peaceful line. A possible explanation could be that the dominant animals in the aggressive line kept the lower ranking animals away from the feed to a larger extend that the dominant animals in the peaceful line and therefore left more feed at the cage which in turn led to the allocation of less feed.

Annual Report 2012: 7-14. Kopenhagen Research, Denmark

Feeding related enrichment reduces abnormal behaviour in mink

J. Malmkvist

Feeding farm feed with coarser structure – i.e. < 42 mm relative to the same type of feed with structure < 8 mm (ordinary farm feed) – (1) reduces the already low amount of stereotypic behaviour in November, (2) reduce tail-chewing in females, combined with that (3) these females are slimmed more (4) resulting in an increased stress hormone concentration during the winter season. Mink's use of biting-ropes in the cages is linked to the feeding situation/management. Mink use biting-ropes mostly prior to feeding and the wear and tear of biting-ropes increase with the restrictive feeding of females during the winter season. As the females are given vast amount of feed prior to mating, the use of biting-ropes is reduced back to normal. Biting-ropes in the cages reduced the occurrence and severity of fur-chewing in both males and females, housed in cages with a platform and permanent access to straw.

Annual Report 2012: 15-21. Kopenhagen Research, Denmark

Feeding at sunset in active period can reduce stress in breeding females during winter

J. Malmkvist

Feeding of breeding females at sunrise, when they naturally are active, result in (1) efficient sliming combined with (2) a lower baseline stress hormone concentration. No statistical differences were evident on the occurrence of stereotypic behaviour and fur-chewing measured prior to mating. The daily feeding 4 hours later tended to increase the general activity of the breeding females. The late fed females (4 hours after sunrise) had a higher occurrence of abnormal behaviour such as scratching on the cage-wire. The experimental mink were all housed in the same type of cages with a platform and permanent access to straw, and they were individually feed regulated after body condition. The results indicate that the timing of

feeding may have importance for welfare in breeding females during winter, as it may be beneficial to fed early during the day in this period with restricted access to feed.

Annual Report 2012: 23-27. Kopenhagen Research, Denmark

REPORTS ON: BREEDING AND REPRODUCTION

Sampling of mink semen

B.K. Hansen, K. Gautason, M.S. Blæsbjerg, M. Sønderup, H. Bækgaard

The male mink is crucial for the reproduction result of the farm, due to the genes he gives to the offspring and within each year due to his willingness to mate and the quality of the semen. These results derive as a part from a larger project concerning body condition of mink males during the winter period. Samples were collected on four farms, altogether from 315 males, one sample per male. The team has got valuable experience of necessary tools and procedures to collect samples of semen. The results showed that using one sample for each male is not enough to judge the fertility of the male and to exclude him from breeding.

Annual Report 2012: 29-33. Kopenhagen Research, Denmark

Correct body condition of mink males results in more dam mated and reduced barren percentage

B.K. Hansen, M. Sønderup, K. Gautason, H. Bækgaard, V. Weiss

Male body condition is graded according to scale 1 to 5 (5 = most fat). To get most dams mated and have a lower percentage of barren dams the condition of mink males should follow the pattern 3-2-2-3 from December to March. The body condition of mink males is observed on 9 farms during the winter 2011/2012. Grading results of altogether 7000 males were collected; mating results from 3300 males were used. The males were graded 4 times: Mid-December, in the beginning of January, mid-February and mid-March. The results show that most females were mated and the barren percentage was lowest, if the body condition of males was as follows: In mid-December should the body condition be 3 as the highest and in the beginning of January body condition 2. The condition should be kept on this level or increased a bit towards mid-February, where after the body condition should increase to 3 until mid-March just before remating.

Annual Report 2012: 35-42. Kopenhagen Research, Denmark

Inbreeding and heterosis in a six generation mink population

J.P. Thirstrup, V.H. Nielsen, P.F Larsen, C. Pertoldi

Litter sizes in a cross between brown and black mink were observed through six generations. The analyses showed significant effect of mink line and year as well as interaction between line and year. After adjusting for year and line we found significant increase in litter size in the second and third generation after crossing. Thereafter the litter size dropped to a level comparable to the mean litter size of the midparent. Results of this analysis indicates that heterosis has a positive effect on litter size in the first generations after crossing, but the positive effect decreases within a few generations if the lines are maintained without supplement - especially if the populations are small. The heterosis was mainly caused by an increase in litter size compared to the black parental line. This indicates that the black line was affected by inbreeding before crossing.

Annual Report 2012, 43-49. Kopenhagen Research, Denmark

REPORTS ON: NUTRITION AND FEEDING

Water binding capacity of fibres

K. Meldgaard, P.F. Larsen

It is necessary to know a fibres water binding capacity before adding it to a feed in order to get the right consistency. To obtain more information about different fibre products ability to absorb water, as well as the time a fibre uses to absorb water, on-going studies have been conducted on the research farm. Eleven fibres and one feedbinder were investigated using two different methods. In method

1 the fibre samples were mixed with water and in method 2 with both water and minkfeed for 10 minutes. The samples were placed on a cage net and evaluated after 10 minutes, one hour and 24 hours. In method 1 the desired result was obtained, when there was no water drip after 24 hours. In method 2 the desired result was obtained when the sample sank between 0.5-1.0 cm under the cage net 24 hours after mixing. The eleven tested fibres and one feedbinder had a water binding capacity from three to twenty times its own weight. The absorbing time for eight of the tested fibres and one feedbinder was less than 1 hour after mixing and tree fibres had an absorbing time on more than 1 hour. No difference in the water binding capacity for the tree fibres tested in both methods was found, which make both methods applicable and comparable.

Annual Report 2012: 51-54. Kopenhagen Research, Denmark

Effect of feed fibres on uptake of drinking water in mink kits

T.N. Clausen, L. Tinggaard, K. Hvam, P.F. Larsen

The purpose of the investigation was to study the effect of different fibres on water balance in 8 weeks old mink kits. We used 48 brown male mink kits distributed in 6 groups, one control group and 5 groups with different fibres / feedbinders. Sugar beet pulp (1,5 %), Quellmix 70/30 (1,3 %), Feed binder T95 (0,6 %), Cellulose (1,5 %) and Vivapur (0,5 %) were investigated.
None of the fibres / feedbinders had any negative effect on kit body growth in the investigation period. All of the products increased the water consumption through the feed and reduced the need of drinking water. There were no negative effect on mineral balance with these products at the applied concentrations.

Annual Report 2012: 53-62. Kopenhagen Research, Denmark

The cholin requirement of mink

M.S. Hedemann, T.N. Clausen, P.F. Larsen

Two experiments were conducted to examine whether choline chloride and soy lecithin are equally good as choline sources and whether the concentration of free choline in plasma is changed when the amount of choline in the feed is changed both in mink kits and full grown males. Mink kits were fed synthetic diets with either choline chloride or soy lecithin as choline source. Four levels of choline was examined (400, 1000, 2500 and 4000 mg choline/kg feed). Mink kits had higher feed intake and growth when soy lecithin was used as source of choline. The concentration of free choline in plasma was only increased in mink kits fed the highest amount of choline in the feed. The concentration of betaine increased with increasing level of choline in the feed. Full grown mink were fed four levels of choline chloride (40, 400, 1000, 5000 mg/kg feed) in a synthetic diet. The amount of choline in the feed did not affect the feed intake and growth. The concentration of free choline in plasma did not differ between the groups and the concentration of betaine was only increased in mink fed a diet containing 5000 mg choline/kg feed. The choline concentration in plasma is not a good indicator of choline status in mink. In mink kits the betaine concentration in plasma can be used as an indicator for choline status. The experiment with mink kits furthermore showed that choline chloride is a more easily available choline source than soy lecithin for mink kits.

Annual Report 2012: 63-68. Kopenhagen Research, Denmark

Nobacithin and Choline Chloride to mink kits in the growth period

T.N. Clausen, T.M. Lassén, P.F. Larsen

To investigate the effect of choline addition on fat infiltration in the liver at pelting, two levels of Choline Chloride and Nobacithin was tested in mink from the beginning of September until pelting.
Four groups of 130 brown males and females were used. From September 1st Choline Chloride was added up to 450 ppm vs. 750 ppm in two groups, in one group Nobacithin was used instead of soya oil. Choline Chloride and Nobacithin had no effect on the liver fat content at this level of protein (24 MEp). Nobacithin however had a negative influence on skin size and quality probably due to a reduced taste of the feed.

Annual Report 2012: 69-75, Kopenhagen Research, Denmark

Reduced dietary protein content to mink in the growing-furring period - The effects of supplement of choline chloride and Nobacithin on blood and liver parameters and health

B.M. Damgaard, P.F. Larsen, V.M. Thorup, T.N. Clausen

The purpose of the project was to investigate the effects of dietary supplement of choline chloride and Nobacithin to low dietary protein content on blood and liver parameters and health in mink in the growing-furring period. Five groups of each 275 male and female brown mink kits were included in the study. One control group was fed high dietary protein content during the growing-furring period. Four groups received reduced dietary protein content from August. Two groups with reduced dietary protein content were supplied with choline chloride (300 ppm and 600 ppm, respectively) to a dietary content of choline chloride of 450 ppm and 750 ppm, respectively. In one diet with low protein content Nobacithin replaced soya oil. The liver content of fat and free fatty acids was higher in mink fed a low dietary content of protein from August than in mink fed high dietary protein content during the growing-furring period. The investigated supplement of choline chloride and Nobacithin had no positive effects on the liver content of fat. The plasma content of ALAT seemed at pelting useful as biomarker for the liver content of fat. Supplement of Nobacithin decreased the plasma content of cholesterol. The mortality rate was low for all experimental groups and there were no differences in mortality rate between the groups.

Annual Report 2012: 77-82. Kopenhagen Research, Denmark

Protein reduction in the mating period

T.N. Clausen, P.F. Larsen

The need for protein to mink in March was investigated in four groups of each 260 females. The protein content was varied from 30 to 45 MEp in the period Feb 22 to April 6. The results showed equal litter size at birth, but more dead kits at birth was observed in the group with the lowest protein content.

Annual Report 2012: 83-88. Kopenhagen Research, Denmark

Reduced protein to mink kits in the growth period

T.N. Clausen, T.M. Lassén, P.F. Larsen

The purpose of the investigation in the growing and furring period was to reduce the protein content in the feed from the middle of July to pelting. In the investigation were used 5 groups of 150 black male mink kits and 3 groups of 130 brown male mink kits. The kits were feed different amounts of protein (from 24 to 32 MEp) and amino acids from July 15 to pelting.
Low protein increased the skin length in brown mink but not in black. Skin quality in black mink was reduced lowering protein content to 24 OEp. Skin quality in brown was not significantly affected, but the density of the skins were reduced in the low protein group compared to the control group.

Annual Report 2012: 89-95, Kopenhagen Research, Denmark

Reduced protein to mink kits in the growth period 2010 had no effect on skin size and quality in the offspring at pelting in 2011

T.N. Clausen, P.F. Larsen

The purpose of the investigation in the growing furring period was to study whether a significant reduction in protein in the growing period 2010 had any negative effect on the offspring performance at pelting the following year. To the investigation 4 groups of brown/glow male and female offspring was used whose parents had been fed varied amounts of protein as low as 21.5 MEp from July to pelting the previous year.
No effect was found on skin size and quality 2011 in offspring from animals fed down to 21.5 MEp in the growing furring period 2010.

Annual Report 2012: 97-99. Kopenhagen Research, Denmark

Selection of mink kits performing well on low protein diet. Growth period 2011 and reproduction period 2012

T.N. Clausen, P.F. Larsen

It is very important that mink are healthy and perform well on the feed we produce, and it is necessary to select the animals that perform best under the given conditions. July 2011 we started two selection groups that will be followed for several generations. One control group fed a protein level corresponding to the level at Danish feed kitchens in 2009 and one fed a 15 % protein reduction compared to the 2009 level.
The first growing and furring period showed a reduction in skin quality but longer skins in the selection group. The first reproduction period showed the same litter size in control and selection groups but a few more dead kits at birth and a tendency to more dead females in the selection group with reduced protein level.

Annual Report 2012: 101-109. Kopenhagen Research, Denmark

The protein supply during gestation affects the quantitative metabolism traits and bodyweights of F_2 progeny in mink (*Neovison Vison*)

C.F. Matthiesen, A-H. Tauson

The knowledge about the need for nutrients in the pregnancy and for fetal growth is still relatively limited in mink. However, it is known that malnutrition during gestation may affect subsequent generations. The purpose of this study was to investigate if the quantitative energy metabolism in F_2 offspring (male offspring) was affected by their mothers' protein supply in fetal life and their own protein supply in fetal life. In addition, also to investigate the males' response to a low and a sufficient level of protein in the growing season. It can be concluded that energy retention, substrate oxidation of protein and carbohydrate and body weight at 50 weeks of age were influenced by a significant interaction between protein supply in fetal life of both the males themselves and their mothers.

Annual Report 2012: 111-114. Kopenhagen Research, Denmark

Protein provision during fetal life affects birth weight of the F_2 progeny in mink (*Neovison vison*)

C.F. Matthiesen, A-H. Tauson

The knowledge about the need for nutrients in pregnancy and for fetal growth is still relatively limited in mink. However, it is known that particularly the protein level may have important implications for pregnancy and reproduction in subsequent generations. The purpose of this study was to investigate whether first-year females (F_1) that had been exposed to low protein supply during fetal life development were influenced by this low protein feed in their first reproductive period. The protein restriction in the females fetal life resulted in a higher birth weight among their offspring (F_2) and a numerically higher number of stillborn kits. Additionally, females exposed to low protein levels in late fetal life and fed a low protein level in their own gestation had significantly lower heat production than the control group, indicating that they can adapt to the current feeding.

Annual Report 2012: 115-118. Kopenhagen Research, Denmark

Low protein provision in mink (*Neovison vison*) during late gestation – *Effect on reproductive performance, and both development and metabolism of the progeny throughout the first year of life*

K. Vesterdorf

Energy- and nutrient restriction *in utero* causes metabolic adaptations, which may have adverse effects on health in adult life. Particularly protein provision impacts fetal development in carnivore species, such as mink, however, the long-term response to protein restriction in mink having been exposed to protein restriction *in utero* is unknown. The objectives of the present study were to implement a level of protein restriction during late gestation in mink, which causes metabolic adaptations in mink offspring, yet without affecting reproductive performance. Further, to study the effects of fetal protein restriction on the response to long-term adequate or low protein provision from weaning until 50 weeks of age in male mink offspring. It is concluded that fetal protein

restriction resulted in metabolic programming, evidenced by modifications to the hepatic proteome, which were still evident in yearling male mink. Supplying mink with a diet below the protein requirement during growth affected the protein and lipid metabolism, resulting in reduced growth, low ME intake, hepatic lipidosis, and increased body fat mass, regardless of fetal dietary treatment. Exposure to a post-weaning diet in excess of that experienced *in utero* was linked to modifications in the abundance of hepatic enzymes associated with the development of Type-2 diabetes in adult life. The present findings suggest that lifestyle changes towards nutrition in excess of that experienced *in utero* may have adverse effects on health in adult life, thus providing clues about how protein deficiency in early life may modify the metabolism and hence susceptibility to disease.

Annual Report 2012: 119-131. Kopenhagen Research, Denmark

REPORTS ON: HEALTH

Investigation of a ”mink wasting syndrome” at a Danish feed plant

M.S. Hansen, T.K. Jensen, J. Kjeldsen, T.M. Lassén, P.F. Larsen, M. Chriél

Here we present the preliminary results from an ongoing research project regarding a mink wasting syndrome. In July 2012, there were reports from several mink farms on the finding of unthrifty mink kits, where normal growth had stalled and the kits lost weight without evidence of clinical disease. The syndrome was called “mink wasting syndrome” (MWS) and appeared to primarily occur at customers of Sydvestjysk Pelsdyrfoder (FC 406). In order to determine the extent of the problem and find the cause of the syndrome, a pilot study was launched. The study included examinations of the feed from FC 406, including analysis of the content of mycotoxins (DON, ZEA and ochratoxin A) and biogenic amines (histamine), which showed high amounts of histamine. In addition, a questionnaire was launched among the customers of the feed plant and mink veterinarians. This showed that the affected farms on average found 2.2 wasted mink per 100 breeding females and that MWS accounted for 41.3% of the dead mink in September. Furthermore, 50 extremely wasted mink, 50 moderately wasted mink and 50 control mink were autopsied. There was significant difference in the weight of the animals between the groups, gender (males are at greatest risk of becoming wasted) and color types (MWS is mainly seen among black mink). Based on the preliminary pathological studies there are no indications that the syndrome has an infectious etiology or is caused by specific poisonings. Whether the presence of biogenic amines in the feed is the cause of the MWS has to be investigated further.

Annual Report 2012: 133-139. Kopenhagen Research, Denmark

Diarrhea and enteritis in mink – characterization of lesions, *in situ* identification of pathogens and implementation of new diagnostic methods

T.K. Jensen, M.S. Hansen, M. Chriél

Diarrhea and enteritis commonly affects mink after weaning and until pelting, but our current knowledge about the causes of these diseases is limited. Here, we present the first results from a research project which aims to bring new knowledge on present diarrheal and enteric diseases in Danish mink. Based on the results new diagnostic methods for relevant pathogens will be implemented.

Annual report 2012: 141-143. Kopenhagen Research, Denmark

Preliminary results of pathological examinations of foot ulcers in farm mink (*Neovison vison*)

N. Bonde-Jensen, M.M. Lassus, A. Jespersen, H.E. Jensen, A.S. Hammer

Since the mid 90ies there have been reports of outbreaks of foot ulcers (ulcerating pododermatitis) in farm mink. During the pelting season November 2012, the paws of 1159 mink originating from four Danish mink farms were examined and all gross lesions were recorded, with the purpose of evaluating the prevalence of foot ulcers. The survey was carried out as part of a 3-year project concerning wounds in mink. Foot ulcers were not found. The results showed that 55,1% of the mink included in the study had paws without gross lesions

and 44,9% of the mink had one or more paws with gross lesions classified as hair loss, thickened skin (hyperkeratosis) or crusts. The lesions were classified as mild. The lesions were primarily limited to a circular area of varying size in the metatarsal area proximal to the main paw pad on the hind legs.

Annual Report 2012: 145-147. Kopenhagen Research, Denmark

Preliminary results of microbiological investigations of paw ulcers in farm mink (*Neovison vison*) in Denmark

M.M. Lassus, B. Ålbæk, H.E. Jensen, A. Jespersen, A.S. Hammer

Ulcerating pododermatitis affecting the paws of mink has been reported from several fur producing countries. Several types of bacteria have been associated with these lesions in mink, but there is still little knowledge about the etiology, pathogenesis and effective treatment of the disease. More knowledge about which bacteria are associated with ulcers in mink and the role of individual species of bacteria is necessary in order to optimize and target the prophylaxis and treatment of different types of ulcers.
In this study samples and data were collected from the paws of mink (n=35) from four mink farms at pelting time in November 2012. The study also included samples form an outbreak of ulcerating pododermatitis on Iceland (n=4) and from sporadic cases of ulcerating pododermatitis on farms in 2012 (n=15). The samples were analyzed by conventional cuture methods. The investigation was performed as part of a 3-year project concerning skin lesions in mink. Here we report the results of microbiological cultivation methods. PCR-analysis and Fluorescens *In Situ* Hybridization (FISH) were also performed (results of these investigations are not included in this report).

Annual Report 2012: 149-152. Kopenhagen Research, Denmark

Interview study regarding hemorrhagic pneumonia in mink

C.M. Salomonsen, A.S. Hammer

Mink farmers who witnessed an outbreak of hemorrhagic pneumonia associated with *Pseudomonas aeruginosa* on their mink farm in autumn 2009 to 2011 were asked to answer a questionnaire to recover possible shared experiences. The results showed a mortality ranging from below 1 % to 56 % with the highest mortality among males. In 74 % of the outbreaks the weather in the week before the outbreak was defined as “not sunny”. A fourth of the farmers experienced sporadic spread of the disease on their farm which is important to consider when performing vaccination on the farm.

Annual Report 2012, 153-156. Kopenhagen Research, Denmark

Seasonal variation of the presence of skin ulcerations in farmed mink pups (*Neovison vison*)

A. Jespersen, T.N. Clausen, H.E. Jensen, A.S. Hammer

In order to develop a classification system for clinical evaluation, skin ulcerations were registered on mink collected in two periods of 2012 and morphological descriptions of skin ulcers were recorded. In June 2012 a total of 787 mink pups were collected from six farms, including Kopenhagen Farm and the experimental facility farm of the University of Copenhagen, The Faculty of Health Science (Taastrup). In October 2012 additional 1186 mink were collected from 12 farms, all situated in Jutland. The mink were either found dead or were euthanized due to injury or disease. Skin ulcerations were systematically recorded.
There was considerable variation in morphology as well as localization of ulcerations. The results showed a tendency of ulcerations to be located primarily on the front parts of the body and in the head in the month of June and mainly on the rear parts of the body and on the tail in the month of October. Tools for classification of skin ulcerations in mink and records of the prevalence of the

identified types of ulcers may be applied for evaluation and handling of wounds in practice, but they will also enable research targeted at the prevention and treatment of specific types of ulcers.

Annual Report 2012: 157-162. Kopenhagen Reseach, Denmark

Investigation of the prevalence of the fur problem "wet belly" in farm mink (*Neovison vison*) at pelting

S. Sommerlund, S. Bertelsen, A.S. Hammer, N.C. Kyvsgaard

The fur problem “Wet belly” is a well-known problem in production of mink skin. The prevalence of “Wet belly” among Danish mink pelted in November has not been investigated recently. This study was designed as a “cross-sectional study” from macroscopic findings, registered by necropsy of 1593 apparently healthy mink spread among seven Danish mink farms in November 2011. Wet belly” was only detected among male kits where it was a frequent finding, with a prevalence of 35%. The prevalence of “wet belly” among male mink kits varied very much between the farms (1- 56%). It was not possible to establish any association between “wet belly” and urinary tract disease. Farms with a significantly lower prevalence of “wet belly”, differed themselves by consequently discarding breeding males with the fur problem. The prevalence of urinary tract diseases among mink being pelted in November was very low at all farms (0-2 %). The results of this study indicates a significant potential in more focus on “Wet belly”, through research, surveillance and inclusion of the fur problem as an exclusion criteria in the selection of breeding males.

Annual Report 2012: 163-167. Kopenhagen research, Denmark

Gross pathological and radiological findings in four male mink (*Neovison vison*) with severe malformation of the baculum

A.S. Hammer, A. Jespersen, H. Elvang-Jensen, S. Bertelsen

A total of 1186 farm mink found dead or euthanized on 12 Danish mink farms during October 2012 were collected and gross pathological findings were systematically recorded. In five male mink the baculum (penile bone) were found to be absent or malformed. In four mink the baculum was absent or severely reduced in size. In one mink the baculum had an abnormal bend in the middle of the bone. The five mink were collected from two farms (three from one farm and two from another). Three of the mink were examined radiologically and histopathologically. Here we present the preliminary findings in these mink. Based on the nature of the malformations it is assumed that affected mink would not have been able to breed successfully. Since this investigation only included mink that died or were euthanized on the farms, the malformation may be present in otherwise clinically healthy mink. The finding of more than one mink with similar malformations on the same farm, suggest that the malformations might have a severe impact on reproduction results on affected farms. The cause of the malformations is unknown. During 2013 male mink will be collected from these farms and others in order to further investigate the disease entity.

Annual Report 2012: 169-172. Kopenhagen Research, Denmark

REPORTS ON: MANAGEMENT

Dividing big litters at 6 weeks of age reduces number of bites among mink kits

T.N. Clausen, P.F. Larsen

Investigation on the effect of dividing big litters (6 kits and more) of brown mink at 6 weeks of age. The 4 – 5 biggest kits in the litter were moved to a cage with their siblings. Bite was registered and some of the litters were weighed.
The results showed that weaning big kits from big litters day 42 after birth reduced the incidence of bites, without any influence on kit body growth. Bite was mainly observed in big litters (more than 6 kits) and most often on female kits. Male kits were mainly bitten in the ear region, whereas female kits most often had bite in the neck region. Female kits with bite weighed less than their female litter mates, whereas male kits with bites weighed the same as their male littermates. Not all kits in the litters with bites were bitten, most often 1 to 2 kits in a litter.

We observed 2.5 times more litters with bite marks among undivided litters than among divided litters. This means that dividing litters at day 42 after birth reduced bite frequency with 60 %.

Annual Report 2012: 173-176. Kopenhagen Research, Denmark

The risks of physical injuries increases when mink are kept in groups

S.W. Hansen, S.H. Møller

Does aggression in Danish mink production occur more often in mink kept in groups than in mink kept in pairs? The question was examined on four farms, by comparing the number of deaths, removals of animals, wounds and bite marks in brown mink kept in groups and mink kept in pairs (male + female). Through several years, the four farms had practiced group housing in parts of the farm. The result showed that it is possible to keep mink in groups with a low occurrence of deaths and wounds. However, the result also showed that the occurrence of deaths, wounds and bite marks can become high and that we still do not know which factors are involved when things go wrong. On the contrary, we have proved that the number of bite marks are bigger in mink kept in groups than in mink kept in pairs and thus the risk of injuries are highest when mink are kept in groups.

Annual Report 2012: 177-181. Kopenhagen Research, Denmark

Increasing the number of hours without feed is not a useful tool to avoid obesity in the autumn in juvenile mink selected as breeders

S.H. Møller

This investigation shows that mink juveniles increase their feed ingestion per hour, when the feed allowance is less than ad libitum. Consequently the number of hours with no feed left before next feeding is difficult to use as a management tool for restricted feeding as at least 9 hours without feed is needed in order to reduce feed intake – and more hours are needed for females than for males to produce the same effect. There seems to be an upper limit in feed intake around 20 g per hour for a couple (one male and one female) juvenile mink in the same cage. This limit can be used to calculate the hours without feed needed in order to reach a given restricted feed allowance.

Annual Report 2012: 183-187. Kopenhagen Research, Denmark

Effect of slurry channels to collect urine and faeces in mink farming

K. Meldgaard, P.F. Larsen

In practical mink farming slurry channels collect the majority of urine and faeces under the cages. However, no studies have previously focused on the exact ratio of urine and faeces collected by the slurry channels. Therefore the aim of this study was to develop a new method that could collect urine and faeces in specific sections under the cage. The second aim was to determine how much of the total urine and faeces the slurry channel collects, and third to study differences in where the mink depose urine and faeces among young mink housed in pairs, single housed female mink and single housed male mink including seasonal variations. Two different collection chutes were developed to register urine and faeces in 8 specific sections under six standard cages. Every 24 hours, urine and faeces was collected and weighted to quantify the amount.
The study showed that the slurry channels collect the majority of the urine and faeces. Results from the three groups in the study period showed that young mink housed in pairs depose 94.5% of the urine in the slurry channel, whereas female and male mink depose 96.1% and 88.5 % of the urine in the slurry channels, respectively. In conclusion the two collection chutes can both be used to define where the mink depose urine and faeces.

Annual Report 2012: 189-192. Kopenhagen Research, Denmark

BREEDING, GENETICS AND REPRODUCTION

Plasma concentrations of progesterone and testosterone in pregnant mink (*Neovision Vision*) depend on fur-color variety of the female

L. Felska-Błaszczyk, B. Lasota, B. Seremak, N. Zielińska-Zygmunt

The aim of this study was to determine plasma concentrations of progesterone and testosterone in blood collected on different dates from pregnant mink of different color varieties.
Blood was collected from fourteen pregnant female mink: sevenWild-type Standard Brown females and seven Black females, so called short NAP or Velvet. Blood was collected seven times – the first time before the matings, and the last time in about three weeks before birth. Hormone concentrations were determined by fluorescence immunoassay using the Delfia kits (PerkinElmer, Turku, Finland). Plasma concentrations of progesterone and testosterone differed significantly between collection dates. Significant differences in the concentrations of the hormones were determined also in relation to the color variety of pregnant mink. The concentrations of both studied hormones in the blood plasma of pregnant mink were positively correlated.

Acta Sci. Pol., Zootechnica, 2012: 11(3): 11–20

http://www.aqua.ar.wroc.pl/acta/pl/main.php?p=8&sub=0&act=10&s=9&no=376&lang=pl

Influence of gestation length and multiplicity of mating encounters in different color varieties of the American mink (*Mustela Vison*) on selected parameters of reproductive performance

L. Felska-Błaszczyk, B. Seremak, B. Lasota, J. Sobczyk

The aim of this study was to analyze the effect of gestational length and multiplicity of mating encounters on selected reproductive parameters within several color varieties of the mink. The material comprised the breeding results of 1285 American mink females of three color varieties: Sapphire, Silverblue, and the Scanbrown. The highest fertility and the highest number of live born and weaned per litter were achieved by Silverblue females. Within all the analyzed gestational length intervals in each color variety, the pregnancies with a length of 45 to 55 days were dominant (78.1% for Sapphire, 75.78% for Silverblue and 64.75% for Brown), while the lowest percentage (3.17% for Sapphire, 6.88% for Silverblue and 3.25% for Brown) represented the pregnancies lasting up to 44 days. The study shows that with an increase in the length of gestation litter sizes become smaller, which is consistent with reports of other authors conducting similar research on this group of animals. We observed an increase in the average litter size with an increase in the number of mating encounters within all analyzed mink color varieties.

Acta Sci. Pol., Zootechnica, 2012: 11(3): 21–30

http://www.aqua.ar.wroc.pl/acta/pl/main.php?p=8&sub=0&act=10&s=9&no=376&lang=pl

Missense polymorphisms in the MC1R gene of the dog, red fox, arctic fox and Chinese raccoon dog

J. Nowacka-Woszuk, S. Salamon, A. Gorna, M. Switonski

Coat colour variation is determined by many genes, one of which is the melanocortin receptor type 1 (MC1R) gene. In this study, we examined the whole coding sequence of this gene in four species belonging to the Canidae family (dog, red fox, arctic fox and Chinese raccoon dog). Although the comparative analysis of the obtained nucleotide sequences revealed a high conservation, which varied between 97.9 and 99.1%, we altogether identified 22 SNPs (10 in dogs, six in farmed red foxes, two in wild red foxes, three in arctic foxes and one in Chinese raccoon dog). Among them, seven appeared to be novel: one silent in the dog, three missense and one silent in the red fox, one in the 3'-flanking region in the arctic fox and one silent in the Chinese raccoon dog. In dogs and red foxes, the SNPs segregated as 10 and four haplotypes, respectively. Taking into consideration the published reports and results of this study, the highest number of missense polymorphisms was until now found in the dog (9) and red fox (7).

J Anim Breed Genet., 2013: 130(2):136-41

http://www.ncbi.nlm.nih.gov/pubmed/23496014

Three-dimensional positioning of B chromosomes in fibroblast nuclei of the red fox and the chinese raccoon dog

B. Kociucka, J. Sosnowski, A. Kubiak, A. Nowak, P. Pawlak, I. Szczerbal

Cytogenet Genome Res., 2013: 139(4): 243-249

http://www.ncbi.nlm.nih.gov/pubmed/23485799

Effects of methylmercury on epigenetic markers in three model species: mink, chicken and yellow perch

N. Basu, J. Head, D.H. Nam, J.R. Pilsner, M.J. Carvan, H.M. Chan, F.W. Goetz, C.A. Murphy, K. Rouvinen-Watt, A.M. Scheuhammer

Comp Biochem Physiol C Toxicol Pharmacol., 2013: 157(3): 322-27

http://www.ncbi.nlm.nih.gov/pubmed/23481557

Population viability analysis of American mink (*Neovison vison*) escaped from Danish mink farms

C. Pertoldi, S. Rødjajn, A. Zalewski, D. Demontis, V. Loeschcke, A. Kjærsgaard

The American mink (*Neovison vison*) was introduced to Danish fur farms in the 1930s. An unknown number of mink have managed to escape these farms over the years. Today feral mink are found in the wild in most parts of Denmark. A population viability analysis (PVA) was performed using VORTEX, a stochastic population simulation software, to 1) predict the viability and potential population expansion from different sizes of founding populations of farm escapees, 2) investigate which parameters mostly affect the viability, 3) assess the effects of continuous escapes on the feral populations and how the feral populations are affected by management programs, and 4) discuss eradication strategies and their efficiency in management of the feral American mink population in Denmark. The simulations showed that juvenile mortality had the greatest effect on population viability followed by fecundity, adult mortality, and initial population size. Populations supplemented yearly by escapees all reached the carrying capacity and gained genetic variability over the years. Harvesting was modeled as the yearly number of mink caught in Denmark. Most of the simulated harvested populations crashed within few years after the first harvesting event. This indicates that the feral number of mink in Denmark is sustained due to supplements from mink farms and no true feral population exists. To manage the number of feral mink in Denmark it is essential to prevent escapees. The eradication effort would be most effective if focused on late summer and autumn when juvenile mink leave the maternal territory.

J Anim Sci., 2013: 91(6): 2530-2541

http://www.ncbi.nlm.nih.gov/pubmed/23478820

Analysis of effectiveness of breeding work and estimation of genetic and phenotypic trends of conformation traits in selected varieties of coloured American mink

D. Kołodziejczyk, S. Socha

The objective of the study was to analyse the effectiveness of breeding for conformation traits in American mink as well as estimate genetic and phenotypic trends in the traits. Minks of the standard, pastel and palomino varieties were examined. They were raised at two breeding farms situated in north-western Poland. The analysis included a 10-year period of breeding and was performed on 3583 animals. Assessment was made of mink body weight, size, colour purity and fur quality as well as total point score.

Using the statistical package SAS, genetic parameters were determined for each trait in addition to phenotypic and genetic trends. Average values of the traits calculated for individual years were used to determine phenotypic trends whereas genetic trends were determined based on breeding values estimated by the BLUP method.

Of the traits analysed, fur colour purity tended to be the most prone to selection. The heritability of this trait was 0.33. The strongest genotypic associations were between mink body weight and body size (0.74), the phenotypic correlation of the traits being much lower than the genotypic one (0.21). The difference may indicate that there was a substantial influence of genetic factors on the traits analysed.

Genetic trend lines for conformation traits reflected an increasing tendency, which may indicate that selection for the traits was effective. Unlike genetic trends, phenotypic trends were relatively stable, their lines displaying a downward tendency, however. This, in turn, indicates a need to change the selection system and methods of breeding work on farms.

Electronic Journal of Polish Agricultural Univesities, 2012: 15(3): 7 pp.

http://www.ejpau.media.pl/volume15/issue3/index.html

NUTRITION, FEEDING AND MANAGEMENT

Effects of different dietary protein levels and DL-methionine supplementation on hair growth and pelt quality in mink (*Neovision vision*)

H.H. Zhang, Q.K. Jiang, W.L. Sun, C. Xu, B. Cong, F.H. Yang, G.Y. Li

The effect of different dietary protein levels and DL-methionine (Met) supplementation on hair growth and the resulting pelt quality in mink was studied. Four groups of male mink were fed with four isocaloric diets containing 32% (P32), 24% (P24), 16% (P16) or P24+Met (0.8%) crude protein of dry matter (DM) from September to December. Skin biopsies were taken at the pelting. Histological techniques and computer-assisted light microscopy were used to determine the ratio of activity (ROA) of under hairs and guard hairs respectively. The results showed that when the dietary protein level reduced from 32% to 16%, body length, number and diameter of under hairs and guard hairs of minks declined, and pelt length and pelt weight of minks decreased significantly ($p<0.05$). These parameters were similar between P32 and P24 with Met supplementation ($p>0.05$). The hair follicle density of the winter coat was not influenced by the dietary protein levels and Met supplementation ($p>0.05$). Low-protein diets content led to a reduction of hair follicle developing to next phase. It was documented that 24% crude protein of DM with Met supplementation during growing-furring period was sufficient for minks to express their genetic capacity to develop hair follicles and achieve the prime fur characteristics. Overall this study demonstrated that hair growth and hair properties in pelts are very dependent on the dietary protein and Met supply in the growing-furring period of minks.

J Anim Physiol Anim Nutr., (Berl), 2012: [Epub Sept 30]

http://www.ncbi.nlm.nih.gov/pubmed/23020079

BEHAVIOUR AND WELFARE

Environmental enrichment reduces signs of boredom in caged mink

R.K. Meagher, G.J. Mason

Animals housed in impoverished cages are often labelled 'bored'. They have also been called 'apathetic' or 'depressed', particularly when profoundly inactive. However, these terms are rarely operationally defined and validated. As a negative state caused by under-stimulation, boredom should increase interest in stimuli of all kinds. Apathy (lack of interest), by contrast, should manifest as decreased interest in all stimuli, while anhedonia (loss of pleasure, a depressive symptom) should specifically decrease interest in normally rewarding stimuli. We tested the hypotheses that mink, a model carnivore, experience more boredom, depression-like apathy, or anhedonia in non-enriched (NE) cages than in complex, enriched (E) cages. We exposed 29 subjects (13 E, 16 NE) to ten stimuli categorized a priori as aversive (e.g. air puffs), rewarding (e.g. evoking chasing) or ambiguous/neutral (e.g. candles). Interest in stimuli was assessed via latencies to contact, contact durations, and durations oriented to stimuli. NE mink contacted all stimuli faster ($P=0.003$) than E mink, and spent longer oriented to/in contact with them, albeit only significantly so for ambiguous ones (treatment*type $P<0.013$). With stimulus category removed from statistical models, interest in all stimuli was consistently higher among NE mink ($P<0.0001$ for all measures). NE mink also consumed more food rewards ($P=0.037$). Finally, we investigated whether lying down while awake and stereotypic behaviour (both increased by NE housing) predicted these responses. Lying awake positively co-varied with certain measures of increased exploration. In contrast, stereotypic 'scrabbling' or locomotion (e.g. pacing) did not. Overall, NE mink showed no evidence of apathy or depression, but instead a heightened investigation of

diverse stimuli consistent with boredom. This state was potentially indicated by spending much time lying still but awake (although this result requires replication). Boredom can thus be operationalized and assessed empirically in non-human animals. It can also be reduced by environmental enrichment.

PLoS One, 2012: 7(11): e49180

http://www.ncbi.nlm.nih.gov/pubmed/23155462

Effects of selection for behavior, human approach mode and sex on vocalization in silver fox

S.S. Gogoleva, I.A. Volodin, E.V. Volodina, A.V. Kharlamova, L.N. Trut

This study presents a first direct comparison of vocal type, call rate and time spent vocalizing among Unselected, Tame and Aggressive strains of silver fox (*Vulpes vulpes*) in three modes of human approach (Provoking, Approach-Retreat, and Static). Also, it provides a first comparison of male and female vocal output in the Provoking test. Vocal types were found strain-specific irrespective of the fox sex or the test. Males had higher call rates and spent shorter times vocalizing than females. These results support the evidence of genetic-based emotional states, triggering vocal behavior in silver fox strains, and suggest sex dimorphism in vocal activity toward humans.

J Ethol., 2013: 31(1): 95-100

http://www.ncbi.nlm.nih.gov/pubmed/23525128

Complex housing environment for farmed blue foxes (*Vulpes lagopus*): use of various resources

T. Koistinen, H.T. Korhonen

The present study was designed to measure the use of various, simultaneously available resources in a complex housing environment in juvenile blue foxes. Twelve blue fox sibling (male-female) pairs were housed in two-section experimental cages from the age of 8 weeks until the age of 7 months (from June to December). Each experimental cage was furnished with two platforms, a nest box, a sand box and a wooden block. This housing set-up provided the foxes with social contact, and an opportunity for oral manipulation, scratching and nesting, as well as the choice of staying on a solid floor material or on an elevated location. The foxes' behaviour was recorded at three time points during autumn (September, November and December). The foxes used all available resources. The most utilised resource was the nest box, possibly because it could be utilised in several ways (as a shelter, an elevated location, an object for scratching and for oral manipulation). The foxes also stayed more in the cage section containing the nest box than in the cage section containing a sand box. The foxes rested much on the cage floor, but they also used the interior of the nest box and elevated locations for resting. Social contact often occurred during resting. Thus, the nest box and elevated location, in conjunction with social contact seem to be valuable while resting. While active, the foxes utilised the cage floor and roof of the nest box instead of the platforms. Scratching, digging and an interaction with the wooden block were seldom observed. Activity occurred mainly on the 'empty' cage area. In conclusion, all studied resources provided blue foxes with a distinct value, as they all were used in the complex housing environment. The nest box is used most and for most variable behaviours.

Animal, 2013: 12: 1-8. [Epub ahead of print]

http://www.ncbi.nlm.nih.gov/pubmed/23481620

HEALTH AND DISEASE

Detection of mink enteritis virus by loop-mediated isothermal amplification (*LAMP*)

J. Wang, S. Cheng, L. Yi, Y. Cheng, S. Yang, H. Xu, Z. Li, X. Shi, H. Wu, X.Yan

J Virol Methods., 2013: 187(2): 401-405

http://www.ncbi.nlm.nih.gov/pubmed/23183142

Comparison of destructive periodontal disease in blue iris mink to PCB 126-induced mandibular and maxillary squamous epithelial proliferation in natural dark mink

R.M. Ellick, S.D. Fitzgerald, J.E. Link, S.J. Bursian

Mink (*Mustela vison*) exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)-like chemicals have been reported to develop mandibular and maxillary squamous cell proliferation that results in the destruction of alveolar bone and eventual tooth loss. This jaw lesion has been reported in wild mink collected from areas contaminated with TCDD-like compounds and is a potential biomarker for exposure to these chemicals. The blue iris strain of domestic mink is prone to develop severe periodontal disease, which results in destruction of bone and tooth loss that is grossly similar to the lesion induced by exposure to TCDD-like chemicals. A histological assessment of jaws from blue iris mink and natural dark mink exposed to 3,3',4,4',5-pentachlorobiphenyl (PCB 126) was done to determine whether the oral lesions are similar. The jaw tissue from the blue iris mink had lesions indicative of lymphoplasmacytic gingivitis and osteomyelitis, caused by inflammation entering the dental sulcus, while the jaw tissue from the mink exposed to PCB 126 exhibited squamous epithelial proliferation. Therefore, it was determined that the tooth loss and bone destruction seen in these mink are of different origin despite the similarity of the gross clinical signs.

Toxicol Pathol., 2013: 41(3): 528-31

http://www.ncbi.nlm.nih.gov/pubmed/22910675

Calodium hepaticum (Nematoda: Capillaridae) in a red fox (*Vulpes vulpes*) in Italy with scanning electron microscopy of the eggs

F. Macchioni, L. Chelucci, L. Guardone, W. Mignone, M.C. Prati, M. Magi

Calodium hepaticum (Bancroft, 1893) Moravec, 1982 (syn. Capillaria hepatica) is a cosmopolitan capillariid nematode, infecting mainly rodents and occasionally other mammals, including humans. Reports of C. hepaticum in canids are rare and the present one is, to the best of our knowledge, the first reported case in a red fox (*Vulpes vulpes Linnaeus*) in Italy. Scanning electron microscopy (SEM) examination of the eggs of C. hepaticum allowed a precise description of the egg morphology, which is one of the most relevant specific characteristics of capillariid nematodes. The egg shell showed a fibrous beam-like network which differs from that of the eggs of closely related trichinelloid species. This characteristic can be useful especially in case of spurious infection, when misdiagnosis among different trichinelloids species can occur.

Folia Parasitol (Praha), 2013: 60(2): 102-4.

http://www.ncbi.nlm.nih.gov/pubmed/23724729

Measurement repeatability of tibial tuberosity-trochlear groove offset distance in red fox (*Vulpes vulpes*) cadavers

J.E. Miles, B.R. Jensen, J. Kirpensteijn, E.L. Svalastoga, T. Eriksen

Objective-To describe CT image reconstruction criteria for measurement of the tibial tuberosity-trochlear groove (TT-TG) offset distance, evaluate intra- and inter-reconstruction repeatability, and identify key sources of error in the measurement technique, as determined in vulpine hind limbs. Animals-12 red fox (*Vulpes vulpes*) cadavers. Procedures-CT images of each hind limb in intact cadavers were obtained; at 1-week intervals, 3 reconstructions were performed that were based on 1 plane passing through the centers of the femoral head and medial condyle and parallel to the caudal femoral condyles, 1 plane aligned with the femoral trochlea, and a third orthogonal plane. Randomized and anonymized reconstructions were assessed for TT-TG offset distance with a single-image technique by 1 observer, and inter-reconstruction repeatability and intra- and inter-reconstruction measurement repeatability were assessed via the repeatability coefficient and intraclass correlation coefficient. Results-Multiplanar reconstructions of hind limb images were repeatedly made to within a few degrees of each other. Intra- and inter-reconstruction repeatability for TT-TG offset distance measurement was good. Repeatability was most affected by accurate identification of the tibial tuberosity and femoral trochlea landmarks. Conclusions and Clinical Relevance-Results obtained from vulpine hind limb CT images indicated that reconstructions can be made with a high degree of repeatability when based on strictly defined and applied criteria. The TT-TG offset distance has potential as an objective assessment of alignment of the distal portion of the quadriceps mechanism; its use as an aid in case selection for corrective femoral osteotomy among dogs with medial patellar luxation warrants investigation.

Am J Vet Res., 2013: 74(6): 888-94

http://www.ncbi.nlm.nih.gov/pubmed/23718657

Dietary exposure of mink (*Mustela vison*) to fish from the upper Hudson River, New York, USA: effects on organ mass and pathology

S.J. Bursian, J. Kern, R.E. Remington, J.E. Link, S.D. Fitzgerald

Environ Toxicol Chem., 2013: 32(4): 794-801

http://www.ncbi.nlm.nih.gov/pubmed/23293106

Seasonal emaciation cause tissue redistribution and an increased potential for toxicity of lipophilic pollutants in farmed artic fox (*Vulpes Lagopus*)

L.B. Helgason, H. Wolkers, E. Fuglei, O. Ahlstrøm, D. Muir, E.H. Jørgensen

Environ Toxicol Chem., 2013: [Epub ahead of print April 18]

http://www.ncbi.nlm.nih.gov/pubmed/23606128

Morphology of the transverse ligament of the atlas and the alar ligaments in the silver fox (*Vulpes vulpes var*)

M. Kupczynska, K. Barszcz, P. Janczyk, M. Wasowicz, N. Czubaj

Recent new anatomical and histological features of craniocervical junction in dogs and cats were described providing evidence of differences between the carnivore species. No information on these structures in foxes exists.
Two parts of the alar ligaments were found. A longer one aroused from dens of axis to the internal (medial) surface of the occipital condyles and was called apical part. A shorter part originated from the entire length of the lateral edge of the dens of axis and terminated on the internal wall of the vertebral foramen of atlas and thus was called the lateral part. The transverse ligament of the atlas was widened in the mid region, above the dens of axis, and thickened at enthesis. Periosteal fibrocartilage was detected in the transverse ligament of the atlas at the enthesis, and sesamoid fibrocartilage was present on periphery in the middle of the ligament.
The craniocervical junction in foxes differs in part from other carnivores such as dogs and cats but resembles that of mesaticephalic dogs. The sesamoid and periosteal fibrocartilage supports the transverse ligament of the atlas whereas the alar ligaments have no cartilage.

BMC Vet Res., 2013: 9:64

http://www.ncbi.nlm.nih.gov/pubmed/23557095

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