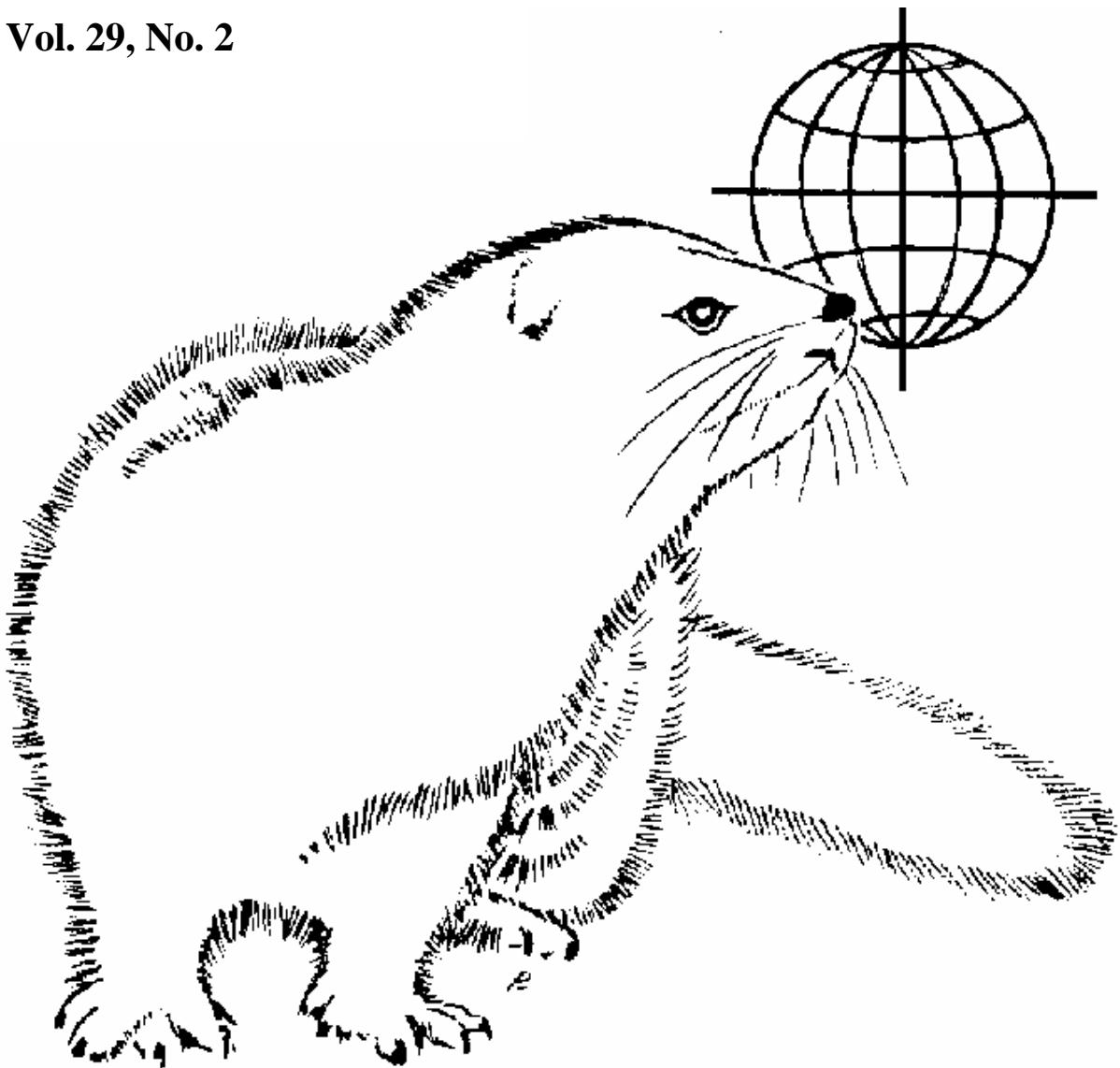


SCIENTIFUR

SCIENTIFIC INFORMATION IN FUR ANIMAL PRODUCTION

Vol. 29, No. 2



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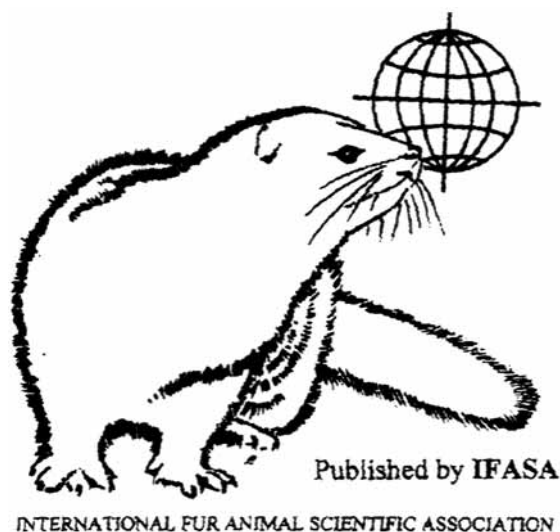
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Notes from the Group of Editors

This issue of *Scientifur*, which is the second issue of Volume 29, contains a vast number of abstracts of fur animal articles published in various periodicals.

A well-attended meeting on “Research in relation to future mink breeding” was held at the Danish Institute of Agricultural Sciences on 22 September 2005. The abstracts of this meeting are also included in this issue of *Scientifur*. Furthermore, the issue includes a mention of the thesis by Pernille Maj

Svendsen on “Stereotyped behaviour and welfare in mink (*Mustela vison*)” as well as that by María Díez León on “Farmed carnivores & Stereotypy establishment in fur farmed mink (*Mustela vison*)”

For future issues of *Scientifur*, we invite our readers to submit proceedings, articles for reviewing, short communications, abstracts and letters on fur animal production.

On behalf of the
Group of Editors

Birthe Damgaard

Digging in farmed blue foxes: Essential or not?

H.T. Korhonen, L. Jauhiainen, L. Kokkonen, T. Rekilä

The objective of this study was to establish the extent to which digging is essential for farm-bred blue foxes (*Alopex lagopus*). At weaning, juvenile foxes were divided into five experimental groups (N = 12 males/group): 1) a control group (Control), without any digging substrate; 2) a sandbox group (SB-1), with in-cage sandboxes from 8 weeks (weaning) onwards; 3) a digging plate group (DP-1), with in-cage plates from 8 weeks onwards; 4) a sandbox group (SB-2), with in-cage sandboxes available for three weeks (Sept 6-Sept 26) from age of 15 weeks onwards; and 5) a digging plate group (DP-2), with in-cage plates available for three weeks (Sept 6-Sept 26) from age of 15 weeks onwards. Sandboxes provided the full range of digging but plates only sham digging. Before deprivation, the time the sandbox (SB-1) group spent digging averaged 5.0±5.3 min/day (mean SD). Two days after the end of deprivation, a significant rebound effect was noted, and digging amounted to 16.3±11.9 min/day (P<0.01). Two weeks later, the digging frequency declined, returning to the initial, pre-deprivation level (P<0.01). Two days after deprivation, the time spent on scratching increased from the pre-deprivation level (2.5±3.8 min/day) to 8.1±7.0 min/day (P<0.05). Consequently, the initial scratching level was regained two weeks after the end of deprivation. Digging by SB-2 foxes amounted to 80.0±43.5 min/day two days after their first access to sandboxes and was still at the same level three weeks later. Digging by DP-2 animals amounted to 1.3±3.5 min/day two days after their first access to plates but had ceased altogether three weeks later. In SB-1, amount of stereotypies increased during the later part of deprivation (P<0.05) but then declined after re-access to sandboxes (P<0.05). In DP-2 animals, access to digging plates reduced (P<0.05) the amount of stereotypies but re-deprivation tended to increase them. In other groups (DP-1, SB-2), no changes in stereotypies were found. In SB-1 animals, the cortisol:creatinine ratio increased after the beginning of deprivation (P<0.05) and remained high even after re-access to sandboxes. In other groups, the cortisol:creatinine ratio remained constant throughout the study. Our results support the conclusion that digging is mainly innate in character, but that it is not highly essential for

farmed blue foxes with no experience of sand digging before 15 weeks of age.

Annals of Animal Science, 2004: 4, 405-419, 4 figs, 2 tables, 33 refs.

Comparative apparent total tract digestibility of major nutrients and amino acids in dogs (*Canis familiaris*), blue foxes (*Alopex lagopus*) and mink (*Mustela vison*)

S. G. Vhile, A. Skrede, Ø. Ahlstrøm, K. Hove

Major nutrient and amino acid digestibilities were evaluated in experiments with dogs (*Canis familiaris*), blue foxes (*Alopex lagopus*) and mink (*Mustela vison*) using seven extruded diets containing different protein sources. Four dogs (German shepherd), four blue foxes and four mink were offered each of the experimental diets to determine apparent total tract digestibility. Average digestibility of crude protein (CP) in blue foxes and mink was similar, and lower than the corresponding value in dogs (0.834 and 0.831 v. 0.864) (P < 0.001). CP digestibility in blue foxes showed significant correlations with dogs and mink (P < 0.05), while no significant correlation was observed between dogs and mink. Average digestibility of most amino acids was significantly lower in blue foxes than in dogs (P < 0.001), whereas mink digested most essential amino acids at the same level as did dogs. Most non-essential amino acids were digested at a significantly lower rate in the mink than in the dog and the blue fox (P < 0.001). There were significant correlations in the digestibility of most amino acids between dogs and blue foxes, and between blue foxes and mink (P < 0.05). Correlations were significant between dogs and mink for the digestibility of most essential amino acids (P < 0.05) but not significant (P > 0.05) for several non-essential amino acids. Average digestibility of crude fat was high and similar among the species studied: 0.968, 0.967 and 0.959 in dogs, blue foxes and mink, respectively. Average digestibility of starch ranged from 0.971 in mink to 0.998 in dogs; significantly higher in dogs than in blue foxes and mink, and significantly higher in blue foxes than in mink (P < 0.001). It was concluded that digestibility determined with mink, blue foxes or dogs may be used to predict digestibilities in the other investigated species. However, both the

characteristics of the protein sources as well as the individual amino acid studied will influence the difference in digestibility among the species.

Animal Science, 2005: 81, 141-148, 1 fig., 5 tables, 29 refs.

Effects of different feeding strategies during the winter period on behaviour and performance in mink females (*Mustela vison*)

B.M. Damgaard, S.W. Hansen, C.F. Børsting, S.H. Møller

Female mink used for breeding are slimmed during the winter to best prepare them for flushing immediately before the mating season. However, intensive and long-term slimming has a number of negative consequences e.g. a significant increase in stereotypies. The purpose of the study was to examine the effects of three different feeding strategies on the female's body weight and behaviour during the winter as well as examine the effects of the feeding strategies on the reproduction results and physiological parameters. The three different feeding strategies were ad libitum (ADL) feeding from 16 October to 16 February, ad libitum feeding but with a substantial (SUB) diet from 22 December to 16 February, and restricted (RE) feeding from 16 October to 16 February. Thereafter, the three groups were fed according to the same feeding strategy. The study included a total of 180 female mink. Behavioural observations were made by focal sampling in December, January, February, and March. The females were weighed approximately every second week from August to March. During the lactation period, the females were weighed at parturition, and 2, 3, 4, and 7 weeks after parturition. Blood samples were collected in November, February, March, May, and June for clinical-chemical analysis. Fifty-three per cent of the females fed restrictively (RE) were observed carrying out stereotypies compared to 27% of the females fed ad libitum (ADL, SUB). The study has demonstrated that it was possible to reduce the body weight of the females by feeding them a low-energy feed, and that this treatment did not lead to an increase in the incidence of stereotypies in mink. The body weight was lower

for stereotypic than for non-stereotypic females from the age of 4 months.

Applied Animal Behaviour Science, 2004: 89, 163-180, 3 figs, 3 tables, 45 refs.

Anticipatory activity and stereotypical behaviour in American mink (*Mustela vison*) in three housing systems differing in the amount of enrichments

C.M. Vinke, R. van den Bos, B.M. Spruijt

The present study aimed to measure anticipatory activity in farmed mink (*Mustela vison*) to study the effects of the presence of environmental enrichments in three housing systems differing in cage structure and in the amount of enrichments. In studies on laboratory rats, anticipatory activity is used as a parameter for potentially stressful conditions of different housing systems: enriched housed rats were less sensitive to sucrose-rewards than standard housed rats as shown by a lower anticipatory reactivity suggesting less stressful conditions.

Anticipatory activity in 36 adult female mink was elicited in a Pavlovian paradigm with tasty cat food as reward in January 2002. This Pavlovian paradigm was followed by an observation of stereotypical behaviour in February 2002. The Pavlovian paradigm and the observations of stereotypical behaviour were preceded by observations on juvenile mink behaviour (7–11 weeks of age) in the Summer of 2001.

The results of this study show (1) that mink juveniles in the most enriched system had more variable behaviour suggesting better coping potentials and (2) that mink, just like rats, can be trained to anticipate on reward. However, in contrast to the behavioural results of the juveniles, no significant long-term effects of the additional enrichments were found as measured by anticipatory activity and stereotypical behaviour, suggesting no differences between the experimental housing systems in terms of stress.

Applied Animal Behaviour Science, 2004: 89, 145-161, 5 figs, 1 table, 37 refs.

Behaviour in suckling mink kits under farm conditions: effects of accessibility of drinking water

A.-L. Brink, L.L. Jeppesen, K.E. Heller

Mortality in mink kits held under conventional farm conditions is believed to be related to dehydration and at least partially to thereby associated competitive aggression. In this study we demonstrated that licking saliva from the commissure of the dam's lips might serve to complement the kits' fluid supply in a period of relative water deficit and that increasing drinking activity is correlated with reduced aggression. Moreover, we found that easier accessibility of drinking water under farm conditions decreases saliva licking. We suggest that measuring enhanced saliva licking may be used as a possible parameter to detect the risk for dehydration in an early stage. Herewith possible competitive aggressive interactions between the kits for water can be reduced.

Applied Animal Behaviour Science, 2004: 89, 131-137, 1 fig, 1 table, 16 refs.

Short-term fasting induces intra-hepatic lipid accumulation and decreases intestinal mass without reduced brush-border enzyme activity in mink (*Mustela vison*) small intestine

C. R. Bjornvad, J. Elnif, P.T. Sangild

For many mammalian species short-term fasting is associated with intestinal atrophy and decreased digestive capacity. Under natural conditions, strictly carnivorous animals often experience prey scarcity during winter, and they may therefore be particularly well adapted to short-term food deprivation. To examine how the carnivorous gastrointestinal tract is affected by fasting, small-intestinal structure, brush-border enzyme activities and hepatic structure and function were examined in fed mink (controls) and mink that had been fasted for 1–10 days. During the first 1–2 days of fasting, intestinal mass decreased more rapidly than total body mass and villus heights were reduced 25–40%. In contrast, tissue-specific activity of the brush-

border enzymes sucrase, maltase, lactase, aminopeptidase A and dipeptidylpeptidase IV increased 0.5- to 1.5-fold at this time, but returned to prefasting levels after 6 days of fasting. After 6–10 days of fasting there was a marked increase in the activity of hepatic enzymes and accumulation of intra-hepatic lipid vacuoles. Thus, mink may be a useful model for studying fasting-induced intestinal atrophy and adaptation as well as mechanisms involved in accumulation of intra-hepatic lipids following food deprivation in strictly carnivorous domestic mammals, such as cats and ferrets.

Journal of Comparative Physiology, B, 2004: 174, 625-632, 4 figs, 1 table, 38 refs.

Comparison of the tyrosine aminotransferase cDNA and genomic DNA sequences of normal mink and mink affected with tyrosinemia Type II

S.R. Leib, T.C. McGuire, D.J. Prieur

Type II tyrosinemia, designated Richner-Hanhart syndrome in humans, is a hereditary metabolic disorder with autosomal recessive inheritance characterized by a deficiency of tyrosine aminotransferase activity. Mutations occur in the human tyrosine aminotransferase gene, resulting in high levels of tyrosine and disease. Type II tyrosinemia occurs in mink, and our hypothesis was that it would also be associated with mutation(s) in the tyrosine aminotransferase gene. Therefore, the transcribed cDNA and the genomic tyrosine aminotransferase gene were sequenced from normal and affected mink. The gene extended over 11.9 kb and had 12 exons coding for a predicted 454-amino-acid protein with 93% homology with human tyrosine aminotransferase. FISH analysis mapped the gene to chromosome 8 using the Mandahl and Fredga (1975) nomenclature and chromosome 5 using the Christensen et al. (1996) nomenclature. The hypothesis was rejected because sequence analysis disclosed no mutations in either cDNA or introns that were associated with affected mink. This suggests that an unlinked gene regulatory mutation may be the cause of tyrosinemia in mink.

Journal of Heredity, 2005: 96, 302-309, 4 figs, 3 tables, 50 refs.

Behaviour of mink kits and dams (*Mustela vison*) in the lactation period

A.-L. Brink, L. L. Jeppesen

This study describes the development of the behaviour of mink kits and dams from the fourth to the eighth respectively seventh week after delivery. The study is based on scan observations of 72 mink dams and their kits at a conventional Danish mink farm. The kits started eating when they were about 30 d old. Drinking started almost 2 wk later. During these 2 wk there was a peak in the licking of saliva from the dam and of the inter-litter agonistic behaviour. A causal relationship between experienced thirst and agonistic behaviour is suggested. The kits' sucking declined to only 5% of the time budget in the seventh week and the stereotypy frequency of the dams increased to about 4% of the time budget. It is suggested that some dams are frustrated by the forced cohabitation with their nutritionally independent kits already in the seventh week and that this should be taken into account when deciding time of weaning.

Canadian Journal of Animal Science, 2005: 85, 7-12, 2 figs, 1 table, 23 refs.

Digestibility of protein, amino acids and starch in mink (*Mustela vison*) fed diets processed by different extrusion conditions

K. Ljøkjel, M. Sørensen, T. Storebakken, A. Skrede

An experiment was carried out to evaluate the effect of different extrusion processes on digestibility of a fish-meal-based diet fed to mink. The feed was processed in a twin-screw extruder with the exit temperatures of the meal of 100, 125 or 150°C. Feed production was carried out three times, using different extrusion conditions to achieve the target temperatures. An untreated meal mixture was included as a control diet. True digestibilities of crude protein and total amino acids were lower for diets extruded at 125 and 150°C than for the control ($P < 0.05$). Digestibilities of crude protein, total amino acids, and the amino acids alanine, arginine, aspartic acid, cysteine, glutamic acid, histidine, isoleucine, leucine, lysine and valine decreased when increasing extrusion temperature from 100 to 125°C ($P < 0.05$), a further increase in temperature

did not influence digestibility ($P > 0.05$). The highest reduction was seen for cysteine (6.8 percentage units). Starch digestibility was increased by extrusion, but there was no effect of temperature ($P > 0.05$). Digestibilities of crude protein, total amino acids, alanine, arginine, aspartic acid, glutamic acid, glycine, proline, histidine, lysine, tryptophan and valine were affected by the processing method ($P < 0.05$), which by multivariate analysis, was revealed to be associated mainly with processing parameters: revolutions per minute, conditioner temperature, die temperature and feeding rate. Digestibility of starch was influenced mainly by the addition of water.

Canadian Journal of Animal Science, 2004: 84, 673-680, 1 fig, 4 tables, 47 refs.

European mink-polecat hybridization events: Hazards from natural process?

T. Lodé, G. Guiral, D. Peltier

Determining the significance of hybridization events raises essential issues both in conservation and in evolutionary biology. Here, we report a genetic investigation of sympatric polecat and endangered European mink populations. Although the two species were morphologically very similar, the European mink and the polecat were easily discriminated from allozymes and microsatellites and showed a high level of private alleles (effective number of alleles: mink=1.45 and polecat=3.09). Nevertheless, the allozymic polymorphism remained lower in the European mink (4 loci, 10.5%) than in polecat (9 loci, 23.7%). Similarly, from microsatellite data, the polymorphism only reached 36% at 0.99 in the European mink; whereas in the polecat, the polymorphism reached 82% at 0.99. Natural hybridization events between two native species were detected. Because of the low fertility of hybrids, interbreeding could be regarded as producing "hybrid sink" that leads to a progressive assimilation of mink by polecat. Nonetheless, pure mink populations inhabited streams in western France, and hybridization events were only detected in areas where mink were rare and now presumed disappeared. Rather than revealing the poor efficiency of the specific recognition system, our results suggest that

hybridization is associated with the scarcity of mating partners.

Journal of Heredity, 2005: 96, 89-96, 2 figs, 4 tables, 56 refs.

Efficacy of a commercial mycotoxin binder in alleviating effects of ochratoxin A, fumonisin B1, moniliformin and zearalenone in adult mink

S.J. Bursian, R.R. Mitchell, B. Yamini, S.D. Fitzgerald, P.A. Murphy, G. Fernandez, G.E. Rottinghaus, L. Moran, K. Leefers, I. Choi

The addition of nutritionally inert adsorbents to mycotoxin-contaminated animal feed has been a popular approach to decreasing toxicity in animals and carryover of mycotoxins from contaminated feed to animal by-products. Some studies suggest that esterified glucomannan derived from the cell wall of *Saccharomyces cerevisiae* is effective in reducing the bioavailability of at least some of the mycotoxins occurring in contaminated feed. Because cereal grains are important components of ranch mink diets, mycotoxicoses in mink is a potential problem faced by mink ranchers. We conducted a series of studies to determine if inclusion of a commercially available esterified glucomannan in ranch mink feed was effective in alleviating clinical signs indicative of exposure to ochratoxin A, fumonisin B1, moniliformin or zearalenone in adult mink. In 4 separate trials, mink were fed diets that contained 2.5, 5 or 10 mg ochratoxin A/kg feed, 200 mg fumonisin B1/kg feed, 20 mg moniliformin/kg feed, or 30 mg zearalenone/kg feed with or without 2 g esterified glucomannan/kg feed. Male mink fed diets containing ochratoxin A had significantly decreased feed intake as well as renal lesions characteristic of exposure to that mycotoxin. Inclusion of the esterified glucomannan did not ameliorate these effects. Male mink exposed to fumonisin B1 had increased urinary sphinganine concentration, which was not significantly reduced by the mycotoxin adsorbent. Male mink that consumed moniliformin-contaminated diets had characteristic ultrastructural changes in the heart that were not reduced in severity by the esterified glucomannan. Female mink exposed to zearalenone had increased uterine weight, which was not reversed by inclusion of commercial mycotoxin binder in the contaminated

feed. The results of this study suggest that a commercial esterified glucomannan was generally ineffective in alleviating effects indicative of exposure to ochratoxin A, fumonisin B1, moniliformin and zearalenone in mink.

Veterinary and Human Toxicology, 2004: 46, 122-129, 8 tables, 53 refs.

Adaptations to fasting in the American mink (*Mustela vison*): carbohydrate and lipid metabolism

A.-M. Mustonen, T. Pyykönen, T. Paakkonen, A. Ryökynen, J. Asikainen, J. Aho, J. Mononen, P. Nieminen

The aim of this study was to investigate whether the actively wintering American mink *Mustela vison* is strictly dependent on continuous food availability or if it has evolved physiological adaptations to tolerate nutritional scarcity. Fifty farm-bred male minks were divided into a fed control group and four experimental groups fasted for 2, 3, 5 or 7 days. The rate of weight loss was several-fold higher (1.5–3.2% day⁻¹) in the mink than recorded previously in larger carnivores utilizing passive wintering strategies. The minks remained normoglycaemic, although their liver glycogen stores and glucose-6-phosphatase activities decreased during fasting. Adipose tissue constituted approximately 36% of their body mass after 7 days of food deprivation. Intra-abdominal fat, especially retroperitoneal but also mesenteric adipose tissue, were the most important fat depots to be hydrolyzed, but the ability of the mink to utilize its body lipids during fasting may be limited. The increased liver size, hepatic triacylglycerol accumulation and increases in the activities of plasma aminotransferases indicated liver dysfunction. Food deprivation also affected the red blood cell indices, and the blood monocyte and lymphocyte counts decreased suggesting immunosuppression during fasting. The results of the present study suggest that the mink has not evolved sophisticated adaptations to wintertime fasting.

Comparative Biochemistry and Physiology, Part A, Molecular and Integrative Physiology, 2005: 140, 195-202, 5 tables, 46 refs.

High leptin in pregnant mink (*Mustela vison*) may exert anorexigenic effects: a permissive factor for rapid increase in food intake during lactation

A.-H. Tauson, M. Forsberg, A. Chwalibog

The role for leptin in food intake regulation in the mink, a polytocous seasonal breeder with altricial young, was investigated in pregnant and lactating dams and data were related to quantitative energy metabolism measurements and plasma concentrations of other important metabolic hormones. A total of nine mink dams were measured in consecutive 1-week balance periods, each including a 22 h measurement of heat production by means of indirect calorimetry, and blood was sampled at weekly intervals throughout gestation and during lactation weeks 1-4. Intake of metabolisable energy (ME) was high and energy balance was positive until the first third of true gestation. During mid- and late gestation ME intake decreased ($P < 0.001$) while heat production remained almost constant, resulting in negative energy balance and the loss of body weight. From late gestation until lactation week 4, ME intake increased by 3.5 times, but weight loss continued. Plasma concentrations of leptin were approximately doubled during the last two-thirds of true gestation ($P < 0.01$), demonstrating a clear gestational hyperleptinaemia. Concentrations declined rapidly after parturition and then remained stable. Insulin was independent of leptin, with low concentrations coincident with hyperleptinaemia. Also, concentrations of thyroid hormones declined during gestation, probably reflecting the low food intake. Hyperleptinaemia concomitant with low ME intake, negative energy balance and mobilisation of body reserves suggested an anorexigenic effect of leptin in pregnant mink. This suppression of food intake in late gestation might be permissive for the rapid increase in food intake occurring after parturition.

British Journal of Nutrition, 2004: 91, 411-421, 3 figs, 2 tables, 66 refs.

Lipoprotein lipase in the kidney: activity varies widely among animal species

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Much evidence points to a relationship among kidney disease, lipoprotein metabolism, and the enzyme lipoprotein lipase (LPL), but there is little information on LPL in the kidney. The range of LPL activity in the kidney in five species differed by >500-fold. The highest activity was in mink, followed by mice, Chinese hamsters, and rats, whereas the activity was low in guinea pigs. In contrast, the ranges for LPL activities in heart and adipose tissue were less than six- and fourfold, respectively. The activity in the kidney (in mice) decreased by >50% on food deprivation for 6 h without corresponding changes in mRNA or mass. This decrease in LPL activity did not occur when transcription was blocked with actinomycin D. Immunostaining for kidney LPL in mice and mink indicated that the enzyme is produced in tubular epithelial cells. To explore the previously suggested possibility that the negatively charged glomerular filter picks up LPL from the blood, bovine LPL was injected into rats and mice. This resulted in decoration of the glomerular capillary network with LPL. This study shows that in some species LPL is produced in the kidney and is subject to nutritional regulation by a posttranscriptional mechanism. In addition, LPL can be picked up from blood in the glomerulus.

American Journal of Physiology – Renal Physiology, 2004: 287, F1131-F1139, 6 figs, 1 table, 39 refs.

Juvenile farmed mink (*Mustela vison*) with additional access to swimming water play more frequently than animals housed with a cylinder and platform, but without swimming water

C.M. Vinke, J. van Leeuwen, B.M. Spruijt

The opportunity to perform play behaviour may be an important ontogenic activity that stimulates

behavioural variability and may enhance an individual's coping capacity later in life. Play behaviour in juveniles may be enhanced by the presence of cage enrichments relevant to the animal's motivations and natural behavioural repertoire. The present study aimed to investigate play behaviour in juvenile farmed mink reared and housed with the cage enrichments standard for the Dutch housing system (ie a cylinder and platform) and in an experimental group of animals with the same standard enrichments but with additional access to swimming water. Juvenile mink with access to swimming water played significantly more in the main cage than mink reared and housed with the cylinder and platform but without swimming water. The results suggest that swimming water presents the animals with biologically relevant stimuli that directly or indirectly influence the development of play behaviour. Specific implications for the animals' long-term welfare are discussed. Future studies should elucidate the effects of juvenile play on the occurrence of abnormal behavioural patterns in adulthood more precisely and more thoroughly.

Animal Welfare, 2005: 14, 53-60, 5 figs, 3 tables, 32 refs.

Genetic neighbourhood and effective population size in the endangered European mink *Mustela lutreola*

T. Lodé, D. Peltier

Genetic neighbourhood and effective population size (N_e) are critical factors when determining the potential survival of threatened species. Carnivores have intrinsically small effective numbers, because, as top predators, they show low densities. The European mink, *Mustela lutreola*, is one of the most endangered carnivores in the world and has suffered continual decline and local extinctions. The genetic neighbourhood, area within which adults could randomly mate, averaged $N_a = 31.7$ km diameter, allowing that population size within the neighbourhood area only ranged from $N_b = 6.1$ to 22.8 animals. Although the population size was assessed in one of the main mink populations in the world, this neighbourhood size is far below the values regarded as critical in literature. However, in contrast with recent propositions, the ratio N_e / N

only ranged between 0.09 and 0.19, estimates close to the average recognised by Frankham [(1995) *Genetic Research* 66: 95–107] for wildlife populations. In the context of the challenge to conserve this endangered carnivore, the studied neighbourhood provided crucial information suggesting both a low neighbourhood size and severe disturbance of breeding exchanges, emphasising the dramatically threatened status of the European mink.

Biodiversity and conservation, 2005: 14, 251-259, 2 figs, 41 refs.

Outbreak of dermatophytosis in farmed mink in the USA

R.J. Bildfell, O.R. Hedstrom, P.L. Dearing

Dermatophytosis (ringworm) is a common problem in many mammalian species but has been only rarely documented in mink (*Mustela vison*). This short communication describes the diagnosis and treatment of an outbreak of dermatophytosis on a large mink ranch in Oregon, USA. In contrast to other reports of ringworm in mustelids, large numbers of kits (over 700) were affected, and the degree of pelt damage could have resulted in significant economic loss.

The Veterinary Record, 2004: 155, 746-748, 4 figs, 8 refs. Abstracted by Scientifur.

Expression of vascular endothelial growth factor isoforms and receptors Flt-1 and KDR during the peri-implantation period in the mink, *Mustela vison*

F.L. Lopes, J. Desmarais, N.Y. Gévry, S. Ledoux, B.D. Murphy

Expression of vascular endothelial growth factor (VEGF) isoforms and its receptors, Flt-1 and KDR, was investigated during the period of peri-implantation in mink, a species that displays obligate embryonic diapause. Uterine samples were collected during diapause, embryo activation, and implantation from pseudopregnant and anestrous animals and analyzed by semiquantitative reverse

transcription polymerase chain reaction and immunohistochemistry. The abundance of mRNA of VEGF isoforms 120, 164, and 188 was highest during late embryo activation and at implantation. VEGF protein was localized to the glandular epithelium at all stages of peri-implantation, whereas the luminal epithelium lacked VEGF reactivity during diapause. Endometrial stroma and luminal and glandular epithelia were positive for VEGF in implanted uteri. The invasive trophoblast cells of the implanting embryo were intensively stained. High levels of VEGF mRNA in pseudopregnant uteri indicates that VEGF upregulation leading to implantation is dependent upon maternal rather than embryonic factors. The abundance of the two receptors, KDR and Flt-1, increased in the uterus during implantation. Low levels of the receptors in pseudopregnant uteri compared with those containing activated or implanted embryos indicates that the embryo regulates receptor expression. These results demonstrate VEGF and VEGF receptor expression during early gestation in mink and suggest that maternal and embryonic input regulates different aspects of the angiogenic process.

Biology of Reproduction, 2003: 68, 1926-1933, 4 figs, 2 tables, 46 refs.

Relationship of the hormone-sensitive lipase-mediated modulation of cholesterol metabolism in individual compartments of the testis to serum pituitary hormone and testosterone concentrations in a seasonal breeder, the mink (*Mustela vison*)

O. Kabbaj, S.R. Yoon, C. Holm, Jack Rose, M.L. Vitale, R.-M. Pelletier

The role of cholesterol differs in the two compartments of the testis. In the interstitial tissue, cholesterol is necessary for the synthesis of testosterone, whereas in the seminiferous tubules, membrane cholesterol content in developing germ cells will influence the gametes' fertility. Here we evaluate the hormone-sensitive lipase (HSL) modulation of the cholesterol metabolism in each compartment of the testis. Two HSL immunoreactive bands of 104- and 108-kDa were detected in Western blots performed with polyclonal anti-human HSL antibodies in the interstitial tissue

(ITf)- and seminiferous tubule (STf)-enriched fractions generated from testes harvested at 30-day intervals during puberty and, in the adult mink, during the annual seasonal reproductive cycle. Epididymal spermatozoa expressed a 104-kDa HSL isoform, and HSL was active in these cells. Immunolabeling localized HSL to interstitial macrophages; Sertoli cells, where its distribution was stage specific; spermatids; and the equatorial segment of spermatozoa. Total HSL protein levels, specific enzymatic activity, and free cholesterol (FC):esterified cholesterol (EC) ratios varied concomitantly in STf and ITf and reached maximal values in the adult during the period of maximal spermatogenic activity. In STf, HSL-specific activity correlated with FC:EC ratios but not with triglyceride levels. In STf, high HSL-specific activity occurred concomitantly with high FSH serum levels. In ITf, HSL-specific activity was high during periods of low serum prolactin levels and high serum testosterone levels. The results suggest that 1) modulation of cholesterol metabolism in individual testicular compartments may be regulated by HSL isoforms expressed by distinct cells; 2) interstitial macrophages may be part of a system involved in the synthesis of steroid hormones and in the recycling of sterols in the interstitium, whereas in the tubules, recycling could be ensured by Sertoli cells; 3) there is distinctive substrate preference for testicular HSL; and 4) HSL may be the only cholesterol esterase in this location.

Biology of Reproduction, 2003: 68, 722-734, 10 figs, 68 refs.

Immunophenotypic and functional effects of bunker C fuel oil on the immune system of American mink (*Mustela vison*)

J.A. Schwartz, B.M. Aldridge, J.L. Stott, F.C. Mohr

The relationship between exposure to environmental contaminants and immunotoxicity in vulnerable marine species is unknown. In this study, we used American mink (*Mustela vison*) as a surrogate species for the sea otter to examine the immunotoxic effects of chronic exposure to a low concentration of bunker C fuel oil (500 ppm admixed in the feed for 113–118 days). The mink immune system was monitored over time by flow cytometric analysis for alterations in the immunophenotype of blood

lymphocytes and monocytes and by mitogen-stimulated proliferation assays for changes in peripheral blood mononuclear cell function. Fuel oil exposure caused a mild, yet significant ($P < 0.05$) increase in the absolute numbers of specific peripheral blood lymphocyte subsets (CD3+T cells) and monocytes, an increase in the level of expression of functionally significant cell surface proteins (MHC II, CD18), and an increase in mitogen-induced mononuclear cell proliferative responses. This heightened state of cellular activation along with the increase in specific cell surface protein expression on both the innate and adaptive immune cells is similar to the pro-inflammatory or "adjuvant-like" effect described in laboratory models of polycyclic aromatic hydrocarbon exposure in other species. These results show the benefits of using a controlled laboratory model for detecting and characterizing subtle petroleum oil-induced perturbations in immune responses. In addition this study establishes a framework for studying the effects of environmental petroleum oil exposure on the immune system of free-ranging marine mammals. Expansion of these studies to address biological significance is warranted.

Veterinary Immunology and Immunopathology, 2004: 101, 179-190, 4 figs, 1 table, 35 refs.

Transfer of European mink (*Mustela lutreola*) embryos into hybrid recipients

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The European mink is considered as a highly endangered Mustelidae species. The objective of this study was to explore the intriguing possibility of embryo transfer from European mink to closely related Mustelidae recipient females. To overcome interspecies pregnancy failure, embryos of European mink (*Mustela lutreola*) were transferred into hybrid females obtained after mating of European polecat (*Mustela putorius*) males and European mink (*M. lutreola*) females and vice versa. A total of 32 blastocysts were surgically flushed from the uteri of nine European mink donors and surgically transferred into six pseudopregnant hybrid recipients. One of the recipients received a single embryo and did not whelp. The remaining five

recipients each received five to eight embryos and delivered kits. The overall success rate was 50% (16 kits/32 transferred embryos). For both male and female offspring, the average birth weight was lower in ET group when compared with naturally bred control population of European mink. The postnatal mortality rate was significantly higher in ET group as compared to controls: only 9 of 16 kits survived past the first week. At 10 days of age, the average weight for male offspring from the ET and control groups did not differ, although differences still persisted at this age for female offspring. At 3 months of age, the weight of male and female offspring in the ET group did not differ from European minks born after natural mating. We propose that transfer of European mink embryos to hybrid recipients be considered as a new experimental tool within the framework of ex situ approach conservation of this aboriginal European mustelid.

Theriogenology, 2004: 62, 458-467, 2 tables, 43 refs.

Nutrient digestibility of commercial dog foods using mink as a model

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Nutrient composition and digestibility are of crucial importance for health and well being of animals. Although great attention is paid to nutritional quality in the marketing of dog foods there is usually limited or no independent information on digestibilities. The most highly recognized dog food brands claim to have optimum nutritional quality and high digestibility. In Norway, these brands are usually the most expensive and they offer a set of dog food products with a specific nutrient composition intended for dogs in different life stages. These brands are often sold in pet shops and through veterinaries and they are well recognized by dog owners. Low-priced dog food brands typically have one or two products and they are sold in grocery store chains or sold locally directly from the producer.

The objective of this study was to compare digestibility of six expensive dry dog food brands [high price (HP)3] with six low price dog food

brands [low price (LP)] sold in the Norwegian market.

Journal of Nutrition, 2004: 134, 2141S-2144S, 5 tables, 9 refs.

Potential impact of an exotic mammal on rocky intertidal communities of northwestern Spain

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Being the interface of sea and land, the coast can be invaded by introduced species coming from either of these two worlds. Recent reviews of coastal invasions emphasize the human-mediated transport of non-indigenous marine plants and invertebrates, forgetting the potential role of invaders of terrestrial origin. By studying the diet of the introduced American mink (*Mustela Vison*) on a rocky shore of southwestern Europe, we draw attention the potential impact on intertidal communities of exotic species coming from inland. We analysed 199 mink faeces collected in August 1997 and August 1999 in Baiona, a coastal and urban area of northern Spain recently invaded by minks. The diet of the species was based almost exclusively on crabs (45.5% of individual prey) and fish (53.3%). Most crabs were marbled crabs (*Pachygrapsus marmoratus*) and most fish were adult blennies (*Coryphoblennius galerita* and *Lipophrys pholis*). Given its energy requirements (about 1250kJ/day), a single mink will consume during the month of August approximately 945 blennies and 496 crabs. Although we lack accurate data on mink abundance, a cautious estimation (4 mink/km before dispersal), supported by field observations, suggests that predation in August may reach 3780 blennies and 1994 crabs per km of shoreline. This predation pressure could affect the numbers of blennies and (less probably) crabs, indirectly benefiting the populations of their prey, that is, sessile invertebrates and snails. More field research is needed, but our results suggest that an exotic non-marine top predator such as the American mink could affect intertidal communities in Eurasia.

Biological invasions, 2004: 6, 213-219, 1 fig, 1 table, 40 refs.

***Toxoplasma gondii* infection in Polish farmed mink**

E. Smielewska-Los, W. Turniak

The aim of this study was to determine the seroprevalence of *Toxoplasma gondii* antibodies in Polish farmed mink according to way of feeding as well as to confirm the role of toxoplasmosis in reproductive losses in mink farms. The serological examinations were carried out on 961 mink randomly selected from 12 Polish farms. Blood sera were examined for the presence of *T. gondii* antibodies with the use of the latex agglutination test. The examinations for the presence of *T. gondii* in organ tissues were performed on five neonatal mink kits with the use of immunofluorescence method. In total 133 (13.9%) out of 961 examined mink had *T. gondii* antibodies. In large farms the seropositivity was lower (2.9%), than in small farms (26.33%) ($P < 0.001$). Significant difference was found in seroprevalence according to way of feeding. In farms feeding fish, percentage of seropositivity was lower (2.2%), than in farms based on non-frozen slaughter offal (43.4%). Titres of *T. gondii* antibodies were usually lower than 120 IU/ml. Using the immunofluorescence method, *T. gondii* was detected in impression smears from liver and brain of two neonatal mink kits derived from one seropositive female.

Veterinary Parasitology, 2004: 122, 201-206, 1 table, 22 refs.

Cloning and sequencing of *cnf1* from *Escherichia coli* incriminated in mink and bovine colibacillosis

S.M. Horne, J.L. Goplin, C.W. Giddings, N.W. Dyer, L.K. Nolan

Colibacillosis is responsible for significant losses to the mink and cattle industries. Previous work in our laboratory and by others has suggested that possession of *cnf1*, the gene encoding cytotoxic necrotizing factor (CNF1), may contribute to the virulence of isolates of *E. coli* from mink and cattle. The *cnf1* gene from *E. coli* isolated from a mink with colisepticaemia and a bovid with scours was amplified and cloned as a 3.5 kb fragment, and the fragment was sequenced. The *cnf1* sequences from

the mink and bovine isolates of *E. coli* were compared to each other and to *cnf1* sequences of *E. coli* from urinary tract and diarrhoea-associated infections of humans. The difference was only 7 nucleotides between the *cnf1* sequences of the mink and bovine isolates of *E. coli*, which translated into 7 differences in amino acids. The *cnf1* sequence of the mink isolate of *E. coli* had 15 nucleotide differences from the *cnf1* sequences of the human isolate of *E. coli* (GenBank X70670), which translated into 11 differences in amino acids between these proteins. The *cnf1* sequence of the bovine isolate of *E. coli* had 14 nucleotide differences from the *cnf1* sequence of the human isolate of *E. coli* (GenBank X70670), which translated into 10 differences in amino acids between these proteins. The highly conserved sequences of the amino acids of CNF1 proteins make them a promising target for detection and control of the CNF1-producing *E. coli* involved in disease among various host species.

Veterinary Research Communications, 2004: 28, 103-112, 2 figs, 1 table, 19 refs.

Near-infrared evaluation of wet mink diets

M. White, K. Rouvinen-Watt

Near-infrared spectroscopy (NIRS) is a relatively new technology in the determination of chemical constituents in compound (complete) feeds. The current paper reports on the application of NIRS to the measurement of dry matter (DM), crude protein (CP) and crude fat (CF) in wet diets for mink and the development of a calibration to predict these chemical constituents. In total, 287 typical wet mink feeds were collected from commercial mink ranches located on the south shore of Nova Scotia, Canada, to provide a large representative sample population. After population structuring, using CENTER and SELECT software (ISI) during calibration development, there were 73 samples remaining in the calibration. All feeds were analyzed by standard reference methods (primary) and then scanned (secondary) with a scanning monochromator NIR, model 5000 (NIRSystems Inc.), to develop a global calibration to predict DM, CP and CF. The "best fit" treatment for the calibration was a modified partial least squares analysis with a standard normal variate (SNV) correction for scatter, a derivative math

treatment of 1, 4, 4, 1 to remove particle size interference while scanning segments 1108–2492 skipping every 8 nm for prediction of DM, CP and CF. Standard error of calibration (SEC, g kg⁻¹), proportion of explained variance (RSQ), and standard error of cross-validation (SECV, g kg⁻¹) for DM, CP, and CF were; 11.9, 0.92 and 14.3; 11.3, 0.96 and 17.5; and 20.0, 0.92 and 22.5. Two external validation sets were used to evaluate the accuracy of the calibration with standard error of prediction (SEP), ranging from 12.7 to 19.5 g kg⁻¹. Based on the results of the data reported the use of NIRS technology in the nutritional evaluation of complete wet diets for mink is feasible. The most promising future use for this NIRS application is as on-line quality control in a central feed kitchen.

Animal Feed Science and Technology, 2004: 111, 239-246, 1 table, 18 refs.

The development of homeothermy in mink (*Mustela vison*)

S. Harjunpää, K. Rouvinen-Watt

In mink (*Mustela vison*) kits newborn mortality is very high. One of the major causes of death is hypothermia. The objectives of this study were to observe the development of thermoregulation in mink kits, and their ability to maintain their body temperature during the postnatal period (1–50 days of age). Based on the kit's body weight (BW), and rectal and ambient temperature measurements during cold (+4 °C) and warm (+40 °C) exposures, a homeothermy index (HI) and cooling and warming rates were calculated. No significant differences in the body temperatures were found between the kits and the dam after 36 days of age. The kits were able to maintain homeothermy by 22 days of age (HI 90%). The body cooling rate was 0.88±0.04 °C min⁻¹ on day 1 but only 0.35±0.03 °C min⁻¹ at 22 days of age. The body WR was lower: day 1, 0.85±0.04 °C min⁻¹ and 0.22±0.03 °C min⁻¹ at 22 days of age. All measured and calculated thermophysiological variables were significantly influenced by BW and age of the kit.

Comparative Biochemistry and Physiology, Part A, Molecular and Integrative Physiology, 2004: 137, 339-348, 5 figs, 1 table, 37 refs.

The influence of temperature on the activity and water use of farmed mink (*Mustela vison*)

C.P.B. Hansen, L.L. Jeppesen

Submerging in water is used by many species as a behavioral mechanism to reduce body temperature, and farmed mink have been shown to increase their swimming activity during summer months. Therefore we investigated whether a maintained, seasonally independent, high ambient temperature would lead to more swimming in farmed mink. Twelve mink were housed in a temperature controlled room and subjected to two periods of four different temperatures (8, 16, 24 and 32 °C) with each temperature lasting 4 days.

Although some types of activities changed with changes in temperature, the total level of activity was not affected. At high temperatures, the mink did not show any increase in either swimming or stereotyped behavior. It is concluded that within the limits of the experiment, mink will not use submerging in water as a thermoregulatory mechanism.

Animal Science, 2003: 76, 111-118, 2 figs, 4 tables, 28 refs.

Reproductive toxicity of ergot alkaloids in mink

C. Sharma, R.J. Aulerich, J.A. Render, T. Reimers, G.E. Rottinghaus, K. Kizilkaya, S.J. Bursian

Ergot alkaloids are synthesized by fungi of the Claviceps family that infect rye as well as other cereals and grains. Since a portion of the ranch mink diet is cereal, mink are at a risk of being exposed to ergot alkaloids. This study was performed to determine the reproductive toxicity of ergot alkaloids derived from ergot-contaminated oats in mink. Four groups of 12 female mink each were fed diets containing 0, 3, 6 or 12 ppm ergot alkaloids from 2w prior to the breeding season until the kits were approximately 33-d old (133 d). Females were mated with untreated males. Ergo talkaloids caused a transient decrease in feed consumption, but body weights were unaffected. The gestation period of the mink in the 6 ppm group was longer compared to controls. The number of mink whelping varied significantly with 9 mink whelping each in the

control and 3 ppm groups compared to 4 mink in the 6 ppm group and 1 in the 12 ppm group. Ergot alkaloids had a significant effect on kit survivability with no kits surviving in the 12 ppm group. Serum prolactin was significantly depressed in the 3 ergot alkaloid groups compared to the control group. This study indicated that ingestion of ergot alkaloids at 3 ppm or higher resulted in reproductive toxicity in mink.

Veterinary and Human Toxicology, 2002: 44, 324-327, 3 tables, 31 refs.

Surgical transfer of in vivo produced farmed European polecat (*Mustela putorius*) embryos

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Surgical embryo transfer of farmed European polecat (*Mustela putorius*) was investigated as part of an ex situ preservation project. The long-term objective of the project is to develop effective technology for ex situ conservation of the European mink (*Mustela lutreola*), which is a highly endangered aboriginal European species. Twenty European polecat females, which served as a model species for the European mink, were humanely killed 4–9 days after first mating and embryos were recovered from oviducts and uteri. Donor–recipient pairs ($n=16$) were generated by mating the donors ($n=20$) once a day for 2 consecutive days with fertile males and by mating the corresponding recipients ($n=16$) on the same days with vasectomized males. An embryo recovery rate of 70% (200 recovered embryos/284 corpora lutea) was achieved from 20 donors. Morulae and blastocysts were recovered between Days 5 and 9 after first mating and were regarded as the best developmental stages for uterine embryo transfer. A total of 172 embryos were transferred surgically under general anaesthesia into the ovarian third of the left uterine horn of 16 recipients with a thin glass capillary. Eleven recipients (69%) produced 72 pups equivalent to an average success rate of 42% (72 pups/172 transferred embryos). The average litter size was 4.5 (range 0–9). These results with this model species, farmed European polecat, demonstrate the potential of embryo transfer as an effective method for the preservation of the endangered European mink (*M. lutreola*). These

species are closely related and have a similar reproductive physiology. However, success of applying embryo transfer in conserving European mink is still dependent on further studies both into its reproductive physiology and developing of improved flushing techniques for anaesthetized donors and the successful transfer of frozen-thawed embryos.

Theriogenology, 2002: 57, 2167-2177, 4 tables, 41 refs.

In vitro digestibility based on fish crude enzyme extract for predication of feed quality in growth trials

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Biochemical structure of protein (reactive SH content, content ratio of SH/S-S and concentration of D-Asp as % of total (D+L)-Asp indicating digestibility of dietary protein was changed under different processing conditions. Based on fish crude enzyme extract, in vitro digestibility of different fish materials processed under different conditions correlated positively with reactive SH content and content ratio of SH/S-S and negatively with D-Asp concentration. In vitro digestion of different experimental feeds, based on Atlantic salmon crude enzyme extracts, was studied in association with growth trials in order to investigate its value as a criterion for industrial strategy in predicting feed quality. Crude enzymes were extracted from the pyloric caeca before feeding. Significant differences in in vitro digestibility between the experimental feeds were observed whereby there would be differences in feed conversion efficiency within 3 months of feeding. There were associations between the in vitro digestibility and other parameters for dietary quality, such as mink digestibility and the biochemical structure parameters of the dietary protein due to different processing conditions. Crude enzyme extracts from rainbow trout and European seabass were also used for in vitro digestibility study of different experimental feeds by standardising trypsin activity to that of Atlantic salmon crude enzyme extract. The results indicated that different fish species have different digestion

ability to the same feed types, and the effective time for feed utilisation and growth is dependent on fish sensitivity and the extent of difference in digestibility between the feeds consumed as observed in the Atlantic salmon trials. For the species investigated, sensitivity ranking of the enzymes to feed quality under the condition studied was Atlantic salmon > rainbow trout > European seabass. The results indicated that in vitro digestibility study of experimental feeds using pyloric caecal crude enzyme extract from a specific species at an age of interest could be a practical, quick and reliable method for testing feed quality in growth trials. By standardising the crude enzyme extract with regards to trypsin activity, the in vitro digestibility values could be comparable not only within the same species but also between different species.

Journal of the Science of Food and Agriculture, 2002: 82, 644-654, 6 figs, 2 tables, 34 refs.

Validation of a cell culture bioassay for detection of petroleum exposure in mink (*Mustela vison*) as a model for detection in sea otters (*Enhydra lutris*)

M.H. Ziccardi, J.A.K. Mazet, I.A. Gardner, W.M. Boyce, M.S. Denison

Objective: To validate a luciferase bioassay, which is based on a recombinant mouse hepatoma cell line, for the detection of exposure to petroleum in mustelid species.

Animals: 122 American mink (*Mustela vison*) and 15 sea otters (*Enhydra lutris*).

Procedures: Mink were exposed to Bunker C fuel oil or Alaska North Slope crude oil externally as a single exposure or internally via low dose concentrations in their ration for 6 months. Serum samples were analyzed for cytochrome P450 1A1 induction by quantification of luciferase activity in the bioassay. Mink liver specimens were also evaluated for cytochrome P450 1A1 induction by quantification of ethoxyresorufin-o-deethylase activity. Serum collected from exposed and unexposed sea otters was also analyzed using the luciferase bioassay.

Results: Serum samples from mink externally exposed to petroleum had significantly increased luciferase activities at 1 week after exposure. Serum samples taken at later time points or from mink exposed to either product in the ration did not cause significant luciferase induction. Samples from otters exposed to petroleum had significantly higher luciferase induction as compared with samples from otters not exposed to petroleum at 2 and 8 ears after the spill. Cytochrome P450 1A1 activity in liver specimens collected from mink that were internally exposed through diet was significantly increased at the conclusion of our study.

Conclusion and clinical relevance: The luciferase bioassay is a sensitive and specific method for determining recent exposure to petroleum in mink. The lack of luciferase activity in serum samples collected from mink greater than 1 week after experimental exposure was likely attributable to lower overall petroleum exposure in our trial, compared with natural exposures.

American Journal of Veterinary Research, 2002: 63, 963-968, 4 figs, 1 table, 37 refs.

Ammonia emission and nitrogen balances in mink houses

S. Pedersen, P. Sandbøl

Ammonia emissions from mink houses were measured over two seasons for growing kits in a two-row open-sided building with slurry gutters (385 mm wide). In the first season, a layer of sand was placed below the cages, and in the last season a layer of chopped barley straw on sand, to serve as a collector for urine and faeces dropped outside the gutter. When the slurry was removed weekly in the houses with slurry gutter and sand layer, the ammonia emission was 0.59 g [N] per animal per 24 h at 6°C and 1.15 g [N] per animal per 24 h at 16°C. By covering the ground area below the cages with a layer of chopped barley straw, renewed weekly, the nitrogen loss increased with the time since the latest renewal of the straw. One week after renewal of straw and removal of slurry, the emission amounted to 0.70 g [N] per animal per 24 h at 6°C and 1.44 g [N] per animal per 24 h at 16°C.

Nine-week nitrogen balance measurements were carried out in three sections over the second season. When a layer of chopped barley straw on the ground area was renewed once a week, about 45% of the nitrogen in the consumed feed was collected in the slurry gutter by emptying the gutter twice a week. About 19% was collected in straw beneath the cages, about 5% was deposited in the carcass, about 20% evaporated, and the rest, about 11%, was assumed to be collected in the sand layer below the cages.

Biosystems Engineering, 2002: 82, 467-477, 6 figs, 4 tables, 6 refs.

Application of N-PCR for diagnosis of distemper in dogs and fur animals

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The immunofluorescence test, routinely used for laboratory diagnosis of canine distemper virus (CDV) in Poland, is not sufficiently sensitive and specific. Therefore, the application of reverse transcriptase polymerase chain reaction (RT-PCR), nested PCR (N-PCR) and Southern blot hybridization for detection of phosphoprotein (P) gene of CDV in peripheral blood mononuclear cells (PBMCs) or internal organs of dogs and fur animals was the aim of these studies. The optimal parameters for two-step PCR were elaborated for reference strains of distemper virus and used for testing biological samples collected from dogs, foxes, ferret and mink with spontaneous distemper. PCR product of 1069 bp was obtained in one out of 10 dog blood samples, three out of 14 homogenates of internal organs of dogs and one out of five homogenates of internal organs of fox. Reamplification with the use of CDVa and CDVb primers demonstrated the 429 bp fragment in six samples, negative by PCR: two samples collected from dogs, two from foxes, one from mink and one from ferret. The specificity of N-PCR was confirmed by Southern blot hybridization. We conclude that two-step PCR is sensitive and specific method for diagnosis of CDV infection.

Veterinary Microbiology, 2002: 88, 95-103, 4 figs, 11 refs.

Decline in endangered species as an indication of anthropic pressures: the cases of European mink *Mustela lutreola* western population

T. Lodé, J.P. Cormier, D. le Jacques

Populations of threatened species, especially predators at the top of the food chain, may be affected by anthropic pressures. The endangered western population of European mink *Mustela lutreola* has shown a large decline over 50% of its natural range. *M. lutreola* disappeared from north-western France between 1984 and 1997 and the decline was associated with an increase in mustelid trapping, changes in watercourse quality, and habitat modifications due to agricultural practices. The pattern of decline showed a fragmentation restricting the minks into very small areas. Trapping was the first known cause of mortality. Although feral American mink *Mustela vison* may compete with autochthonous carnivores, *M. lutreola* has disappeared from streams before the introduction of the American species, suggesting that competitive inter-actions were not responsible. Furthermore, American mink has never been found or has remained rare in 62.4% of the area from which *M. lutreola* has disappeared. During the 25 last years, permanent grassland surfaces were reduced by 40% whereas fodder culture increased by 470%, causing considerable habitat changes. Furthermore, 55.7% of water courses were classified as being of bad quality or polluted. Therefore, our data suggests that a conjunction of intensive trapping, alterations in water quality and habitat modification was critical for the European mink's decline. Although there are difficulties in ascribing specific cause to distribution changes in a top-predator, this decline can be regarded as an indication for anthropic pressures on natural habitats.

Environmental Management, 2002: 28, 727-735, 5 figs, 2 tables, 50 refs.

Effects of dietary exposure to environmentally relevant concentrations of weathered Prudhoe Bay crude oil in ranch-raised mink (*Mustela vison*)

K.J. Beckett, R.J. Aulerich, L.K. Duffy, J.S. Patterson, S.J. Bursian

The purpose of the present study was to determine the effects of prolonged ingestion of weathered Prudhoe Bay crude oil (WPBCO) using concentrations of oil that could be encountered in the environment by wild mink. A ranch-raised strain of American mink (*Mustela vison*) was used as an animal model to represent a wildlife species that occupies a high trophic level and consumes prey affected by environmental contaminants, such as crude oil. Mink, as an indicator species of environmental contaminant exposure and ecosystem health, are approved by the U.S. Environmental Protection Agency and recognized by the National Academy of Science as a preferred toxicological model, and can be studied in a controlled laboratory situation. By exposing post-natal mink in the late stages of development to non-lethal doses of weathered crude oil, we investigated the impacts on various parameters including haematology, serum clinical chemistries, and tissue pathology, including neuropathology.

Based on the results from this study, 1000 ppm WPBCO will not cause extensive clinical chemistry changes in the short-term. Anemia and immune effects should be monitored under laboratory conditions because multiple stressors that are present in the natural environment might elicit compounded long-term impacts on an animal's physiological state, and eventually lead to population effects. More neurological and gestational exposure studies should be conducted to investigate offspring of female mink fed oil-contaminated diets.

Bulletin of Environmental Contamination and Toxicology, 2002: 69, 593-600, 2 tables, 21 refs. Abstracted by *Scientificur*.

Investigation of repeated vaccination as a possible cause of glomerular disease in mink

S.J. Newman, R. Johnson, W. Sears, B. Wilcock

The search for antigens capable of causing immune-complex-mediated glomerulonephritis continues. Modified live-virus vaccines commercially available for veterinary use are a possible source. In this study, repeated vaccination of mink with live-virus vaccines was investigated as a model for vaccine-

induced glomerular injury. Three groups of 10-wk-old mink, 15 per group, were vaccinated once with 4-way vaccine against distemper, *Pseudomonas aeruginosa* infection, botulism and mink viral enteritis. Subsequently, all mink in each group each were vaccinated either with the 4-way vaccine, a monovalent canine distemper vaccine, or saline. Glomerular function was assessed at 2-wk intervals by determining the urinary protein:creatinine (P:C) ratio. Kidney sections taken at necropsy, 20 wk after the 1st vaccination, were examined by light and immunofluorescent microscopy for deposition of immunoglobulin and complement. There was no statistically significant difference between the treated and control groups based on average urinary P:C ratio medians. Light microscopic changes were detected in glomeruli, but Fisher's exact test showed no significant differences between any of the treatment groups. Deposition of immunoglobulin but not complement was significantly more frequent ($P < 0.05$) in the glomeruli of animals that received multiple injections of the 4-way vaccine than in the glomeruli of those given only the monovalent canine distemper vaccine or saline. These findings suggest that repeated vaccination may increase the glomerular deposition of immunoglobulin. Further studies are required to determine if the increased deposition of immunoglobulin contributes to the development of glomerular damage and to identify the antigens driving production of the deposited immunoglobulin.

Canadian Journal of Veterinary Research, 2002: 66, 158-164, 3 tables, 29 refs.

Body-weight changes are clearly reflected in plasma concentrations of leptin in female mink (*Mustela vison*)

A.-H. Tauson, M. Forsberg

The mink is a seasonal breeder with a propensity for seasonal fatness, and it is very responsive to changes in energy supply. The objectives of the present study were first, to validate a multi-species leptin assay for mink (*Mustela vison*) plasma, and second, to evaluate how plasma leptin and insulin concentrations responded to energy restriction and body-weight loss and refeeding with restoration of body reserves. The study was performed with six very fat yearling females (initial mean body weight

1451 (SD 119) g, i.e. approximately 300 g more than for a female in normal body condition). The animals were fed in restricted amounts (about 35 % metabolizable energy requirement for maintenance) in order to reach a very lean body condition. The target weight of 800 g was reached after about 1 month of restriction. The animals were then re-fed ad libitum until almost complete weight recovery. Blood samples were taken on days 1, 24, 34 (end of restriction), 44, 55 and 71 (end of experiment) and analysed for plasma concentrations of leptin and insulin. Three females were mated on day 44. Leptin and insulin concentrations mirrored each other and clearly reflected changes in body weight. Significant ($P < 0.001$) Pearson correlation coefficients of 0.75 (leptin–insulin), 0.72 (leptin–body weight) and 0.59 (insulin–body weight) were found. Two of the three females that were mated gave birth to normal litters. It was concluded that the leptin assay yielded acceptable results for animals with body weight:fat content within the range investigated here, and that plasma leptin reflected body fat mass.

British Journal of Nutrition, 2002: 87, 101-105, 1 fig, 29 refs.

Stereotypic behaviour and tail biting in farmed mink (*Mustela vison*) in a new housing system

C.M. Vinke, N.C. Eenkhoorn, W.J. Netto, P.C.J. Fermont, B.M. Spruijt

Farmed mink are known for showing stereotypies and tail biting, behaviours that are mostly viewed as indicators of reduced welfare. Among the factors that are often described as being relevant for the welfare of mink are food management systems, age at weaning, and type/presence of nest boxes and bedding. In the present study of commercially farmed mink, all of these factors have been integrated in one housing system. The occurrence of stereotypies and tail biting were observed at six Dutch mink farms, which differed from one another with respect to the number of modifications and the time since the introduction of these modifications. On each farm, 60 non-lactating female mink were observed during winter and 50 lactating female mink (with kits) were observed during summer. Mink on the farm with the most modifications spent 4.1% and 0.8% of their time performing stereotypies in winter and in summer, respectively. Mink on the

farm with the least modifications spent 32% and 10.9% of their time performing stereotypies in winter and in summer, respectively. The occurrence of stereotypic behaviour in winter gradually increased as feeding time approached. This gradual increase was not observed at the farm with the least modifications. In general, mink spent less time performing stereotypies in summer than in winter. No clear differences were found between the farms for the occurrence of tail biting in relation to the modifications of the new system, although one farm showed a lower percentage (4%) of tail biters during summer. In conclusion, the farms that had introduced more modifications into their husbandry system housed animals showing less stereotypic behaviour. The results of this field study demonstrate an inverse relationship between the number of modifications and the occurrence of stereotypies; because of the experimental design, however, a causal relationship is not implied. Further work is required to investigate the impact of each measure both in isolation and in the integrated system under more carefully standardised conditions.

Animal Welfare, 2002: 11, 231-245, 4 figs, 3 tables, 52 refs.

Ra-226 in bone of mink (*Mustela vison*) and otter (*Lutra Canadensis*) taken near U workings at Elliot Lake, Canada, and from reference areas, with calculation of transfer parameters

T.J. Dewit, V. Clulow, N.K. Dave, M.A. Mirka, G.H. Parker, N. Peterson-Schaffner

In our study of environmental radioactivity of the Elliot Lake region, ²²⁶Ra levels in local mink and otter bones (sampled in 1986 and 1997) were compared to others taken from areas without U operations. These comparisons provide insight into ²²⁶Ra levels in mammalian secondary consumers in an ecosystem containing U mines and mills (compared to control levels) and change related to decline of U operations (by comparison of levels in tissues sampled at different times); neither line of investigation has received attention in the past.

The lack of significant decline in bone ²²⁶Ra levels in either species during the study period (during which U operations wound down then ceased)

indicates inertia in the ecosystem. Clearly, change in radionuclide content of food items or water has not yet been of sufficient magnitude, or of sufficient duration, to be reflected in the tissues of the two secondary consumers examined.

Further understanding of the movement of radionuclides through the ecosystem in the area of U workings at Elliot Lake will require an examination of all food items of the mink and otter including other mammals, reptiles, amphibians, and aquatic invertebrates. Such study, in turn, could provide a greater empirical estimation and understanding of relationships within various food chains, using the sensitivity and precision associated with radionuclide measurements. In addition, the fate of a once-industrialized ecosystem may provide pointers for planning, operating, and closing of resource extraction and refining operations in the future.

Bulletin of Environmental Contamination and Toxicology, 2002: 68, 878-884, 1 fig, 1 table, 24 refs. Abstracted by Scientifur.

Astrovirus epidemiologically linked to pre-weaning diarrhoea in mink

L. Englund, M. Chriel, H.H. Dietz, K.O. Hedlund

Diarrhoea and excessive secretion from the cervical apocrine glands in young, suckling mink kits is a well-known, but poorly defined, syndrome often referred to as "sticky", "greasy", or "wet" kits. We have performed a case-control study, at farm level as well as at mink kit level, in Denmark and Sweden to investigate whether enteric virus infections may be a risk factor in the development of pre-weaning diarrhoea. Tissue samples from the enteric tract of 180 sacrificed mink kits were analysed histologically. Faecal contents were examined by electron microscopy (EM). Astrovirus was detected in abundance and found to be a significant risk factor both at farm level (OR=21.60, p<0.001) and at mink kit level (OR=7.95, p<0.001). Other factors, i.e. low body weight, coccoid bacteria adherent to the enteric villi, and presence of calicivirus were also shown to increase the risk of pre-weaning diarrhoea, although with less impact than astrovirus.

Veterinary Microbiology, 2002: 85, 1-11, 2 figs, 1 table, 27 refs.

Cats differ from mink and ferrets in their response to commercial vaccines: a histologic comparison of early vaccine reactions

E.E. Carroll, R.R. Dubielzig, R.D. Schultz

Early histologic changes in lesions at vaccine sites were compared in cats, mink, and ferrets. Twenty-four 4-month-old cats, 20 4-month-old mink, and 20 12-month-old ferrets were vaccinated with three rabies virus vaccines, two feline leukemia virus vaccines, alum adjuvant, and saline. Injection sites were excised at selected time points up to 21 days postvaccination. Histologic examination of the tissue revealed significant differences among the cats, mink, and ferrets in the local response to the commercial vaccines. When compared with ferrets and mink, cats had more lymphocytes in response to all three rabies vaccines. Production of fibroblasts, collagen, and macrophages differed among the three killed aluminum-adjuvanted vaccines in cats but did not differ significantly in mink or ferrets. Cats produced fewer binucleate cells than did mink or ferrets in response to the two adjuvanted leukemia virus vaccines. Differences seen in early tissue response of cats to commercial vaccines may be related to the increased predisposition of cats to vaccine-associated sarcomas.

Veterinary Pathology, 2002: 39, 216-227, 6 figs, 4 tables, 46 refs.

Distribution of tyrosine aminotransferase activity in mink (*Mustela vison*)

D.J. Prieur, J.R. Gorham, R.K. Wood

The distribution of the enzyme tyrosine aminotransferase in tissues of mink, *Mustela vison*, was investigated. High levels of enzymatic activity were detected only in liver, documenting the hepatic-specific nature of this enzyme in this species. Further studies disclosed that tyrosine aminotransferase is not absent from non-hepatic tissues because of the lack of the use of a stabilized buffer, sensitivity to temperature, or due to the presence of an inhibitor. Collectively, these results suggest that the enzymatic assay of tyrosine

aminotransferase will be unlikely to be an efficacious approach for identifying mink that are heterozygous for the autosomal recessive deficiency of this enzyme that is common in dark mink.

Comparative Biochemistry and Physiology, Part B, Biochemistry and Molecular Biology, 2001: 130, 251-256, 4 tables, 22 refs.

Productive infection of a mink cell line with porcine endogenous retroviruses (PERVs) but lack of transmission to minks *in vivo*

V. Specke, R. Plesker, C. Coulibaly, K. Boller, J. Denner

Porcine endogenous retroviruses (PERVs) are considered a special risk for xenotransplantation because they are an integral part of the porcine genome and are able to infect cells of numerous species including humans *in vitro*. Among these cells, the mink lung epithelial cell line Mv1Lu could be productively infected with PERV. Provirus integration was detected by PCR, expression of viral proteins was shown by immunostaining and reverse transcriptase was detected in cell supernatants. PERV produced from mink cells could infect both, uninfected mink Mv1Lu cells and uninfected human 293 cells, with considerably higher virus production by human cells. Typical type C retroviruses were observed in PERV-infected mink cells using electron microscopy together with numerous multivesicular body (MVB)-like structures containing small virus-like particles, not present in uninfected mink cells. These MVBs could be stained with PERV-specific serum. In an attempt to establish a small animal model, PERV grown on mink cells was inoculated into adult and newborn American minks. Neither antibody production against PERV nor integration of viral DNA or production of viral proteins in tissues of different organs could be detected 12 weeks post virus inoculation, indicating that PERV infection had not occurred.

Archives of Virology, 2002: 147, 305-319, 7 figs, 1 table, 35 refs.

Caspase activation is required for permissive replication of Aleutian mink disease parvovirus *in vitro*

S.M. Best, J.B. Wolfenbarger, M.E. Bloom

Aleutian mink disease parvovirus (ADV) is distinct among the parvoviruses as infection *in vivo* is persistent, restricted, and noncytopathic. In contrast, infections with other more prototypic parvoviruses, like mink enteritis virus (MEV), are acute, cytopathic, and characterized by permissive replication *in vivo*. Although apoptosis results in the death of cells acutely infected by parvoviruses, the role of apoptosis in ADV infections is unknown. Permissive infection of ADV resulted in apoptosis of Crandell feline kidney (CrFK) cells as indicated by TUNEL staining, Annexin-V staining, and characteristic changes in cell morphology. Pretreatment of infected cells with caspase 3 or broad-spectrum caspase inhibitors prevented apoptosis. In addition, treatment of infected cells with these inhibitors caused a 2 log₁₀ reduction in the yield of infectious virus compared to untreated cultures. This block in replication preceded substantial viral DNA amplification and gene expression. However, inhibitors of caspases 1, 6, and 8 did not have this effect. MEV also induced caspase-dependent apoptosis following infection of CrFK cells, although production of infectious progeny was not affected by inhibition of apoptosis. Thus, permissive replication of ADV *in vitro* depended upon activation of specific caspases. If ADV infection of cells *in vivo* fails to initiate caspase activation, the requirement of caspase activity for replication may not be met, thus providing a possible mechanism for persistent, restricted infection.

Virology, 2002: 202, 224-234, 8 figs, 1 table, 55 refs.

Effects of petroleum on mink applied as a model for reproductive success in sea otters

J.A.K. Mazet, I.A. Gardner, D.A. Jessup, L.J. Lowenstine

Ranch-reared mink (*Mustela vison*) were used as a model in an experimental trial to investigate the potential effects of exposure to two petroleum

products on sea otters (*Enhydra lutris*). Mink were exposed either dermally on one occasion 60 days prior to breeding or via low level contamination of their diets daily from 60 days prior to breeding (January 1994) until weaning of kits (June 1994). For dermal exposure, we placed mink in either a slick of Alaskan North Slope crude oil (n = 24) or bunker C fuel oil (n = 24) on sea water or sea water alone (n = 10) for 1 min. For dietary exposure, we fed mink rations containing 500 ppm of either Alaskan North Slope crude oil (n = 24) or bunker C fuel oil (n = 24; control, n = 15). The number of liveborn kits did not differ significantly among mink exposed dermally (5.0 kits/female for crude oil and 6.5 kits/female for bunker C fuel oil) and unexposed controls (5.3 kits/female). However, only 2.3 and 0.7 kits were produced per female for those exposed through the diet to crude oil and bunker C fuel oil, respectively. Females with reduced reproductive success had no clinical signs of toxicosis or behavioral abnormalities. In addition, kits of females exposed through the diet had poor survival to weaning. Once mature, kits born to females exposed to bunker C fuel oil in the diet had significantly reduced reproductive success (3.4 kits/female) although their only exposure to the petroleum products was *in utero* or during nursing. Therefore, it is possible that sea otter populations consuming contaminated food sources or colonizing previously oiled habitats will have reduced reproductive success.

Journal of Wildlife Diseases, 2001: 37, 686-692, 2 tables, 18 refs.

Detection of Aleutian disease antibodies in feral American mink in southern England

N. Yamaguchi, D.W. MacDonald

Fourteen of 27 American mink (*Mustela vison*) trapped in the upper Thames region were positive for anti-Aleutian disease antibodies. This demonstration of the occurrence of this viral disease in a feral American mink population suggests that it could threaten populations of at least two protected mustelids, the otter (*Lutra lutra*) and the polecat (*Mustela putorius*), and may also play a role in the apparent decline of local mink populations in Britain.

Veterinary record, 2001: 149, 485-488, 1 table, 44 refs.

Effect of a valine residue at codon 352 of the VP2 capsid protein on *in vivo* replication and pathogenesis of Aleutian disease parvovirus in mink

M.A. McCrackin-Stevenson, J.M. Fox, J.B. Wolfenbarger, M.E. Bloom

To determine whether a group of 3 genetic differences in the nonstructural protein (NS1) or 1 genetic difference in the structural protein (VP2) of Aleutian disease parvovirus (ADV) is responsible for an increase in the *in vivo* replication and pathogenicity of G/U-8, a chimera of ADV-G (nonpathogenic) and ADV-Utah (pathogenic), compared with G/U-10. **ANIMALS:** 32 eight-month-old female sapphire mink (*Mustela vison*). **PROCEDURE:** Chimeric viruses were constructed, propagated *in vitro*, and used to inoculate mink. Antiviral antibody responses, presence of serum viral nucleic acid, and serum gamma globulin concentrations were monitored for 120 days following inoculation. Histologic examination of the liver, kidneys, spleen, and mesenteric lymph nodes was performed after necropsy. **RESULTS:** A chimera containing only the 3 amino acid substitutions in NS1 did not elicit measurable responses indicative of replication or pathogenicity in inoculated mink. Serum antiviral antibody responses, frequency of detection of viral nucleic acid in serum, gamma globulin response, and histologic changes in mink inoculated with chimeras containing a valine residue at codon 352 (352V) of VP2 capsid were increased, compared with values from mink inoculated with chimeric viruses that did not contain 352V. **CONCLUSIONS AND CLINICAL RELEVANCE:** A valine residue at codon 352 in the VP2 capsid protein of ADV affects *in vivo* viral replication and pathogenicity. This amino acid may be part of an incompletely defined pathogenic determinant of ADV. Further characterization of the pathogenic determinant may allow future development of focused preventive and therapeutic interventions for Aleutian disease of mink.

American Journal of Veterinary Research, 2001: 62, 1658-1663, 3 figs, 2 tables, 27 refs.

Aleutian mink disease parvovirus: implications for companion ferrets

M.A. McCrackin-Stevenson, L. Gates, J. Murray, M.E. Bloom

Aleutian mink disease parvovirus (ADV) causes disease in mink and ferrets and can infect such related animals as raccoons, weasels, fishers, martens, and striped skunks. Severe Aleutian disease (AD) in adult mink is characterized by viral persistence, high levels of antiviral antibody (which is ineffective at eliminating the virus), and immune-complex disease. Death results when virus-antibody immune complexes deposit in the kidneys, producing immune-mediated glomerulonephritis. Ferrets infected with ADV are usually asymptomatic and maintain a low antibody titer, but severe disease can occur. Ferrets with clinical signs of AD may have chronic wasting disease (similar to that seen in mink) or neurologic disease (most often manifested as posterior paresis or paralysis).

Compendium, 2001: 23, 178-185, 2 figs, 1 table, 55 refs.

Some comments on the review of Nimon and Broom on the welfare of farmed mink

C.M. Vinke

Fur-farming is a politically sensitive issue today. Therefore, discussions on the welfare situation of commercially farmed fur animals may be particularly valuable. The aim of this Short Communication is to address some issues, in addition to those covered in the review of Nimon and Broom on the welfare of farmed mink (*Animal Welfare* 1999, 8: 205-228), that may have received too little attention. This Short Communication addresses domestication and animal welfare, indispensable resources and behaviours of farmed mink, and the use of negative and positive indicators of welfare in research on farmed mink.

Animal Welfare, 2001: 10, 315-323, 62 refs.

Parvovirus infections in wild carnivores

A. Steinel, C.R. Parrish, M.E. Bloom, U. Truyen

Various parvoviruses infect carnivores and can cause disease. In this review article the knowledge about infections of free-ranging or captive carnivores with the feline parvoviruses, feline panleukopenia virus, and canine parvovirus, including the antigenic types CPV-2a and -2b, as well as Aleutian disease of mink virus and minute virus of canines are summarized. Particular emphasis is placed on description of the evolution of canine parvovirus which apparently involved wild carnivore hosts.

Journal of Wildlife Diseases, 2001, 37, 594-607, 2 figs, 100 refs.

Chronic toxicity of dietary 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin to mink

J.R. Hochstein, J.A. Render, S.J. Bursian, R.J. Aulerich

Mature female natural dark mink (*Mustela vison*) were fed 0.0006 (control), 0.016, 0.053, 0.180, or 1.40 ppb 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) for 131-132 d to ascertain the chronic toxic effects of TCDD in mink, including reproduction. Consumption of the 1.4 ppb TCDD diet resulted in lethargy, bloody stools, and 16.7% mortality. Final mink body weights were inversely proportional to the dietary TCDD concentrations. Due to subnormal mink breeding, definitive effects of TCDD on mink reproductive performance were not ascertained; however, there were significant dose-dependent decreases in kit (young mink) birth weight and survival from birth to 3 w of age in the groups that had reproduction. There were also significant differences in adult mink white blood cell counts, plasma total solids, serum iron, phosphorus, albumin, total protein, total CO₂, cholesterol, osmolality, and anion gap concentrations, and alanine aminotransaminase activity between the various dietary groups. During the latter stages alopecia and thickened, deformed, and elongated toenails were observed in the adult mink fed 1.4 ppb TCDD. At termination the mink fed 1.4 ppb TCDD had ascites, gastric ulcers, intestinal hemorrhages, depletion of adipose tissue, and mottled and/or discolored livers, spleens, and kidneys. Focal

lymphocytic meningitis in region of the olfactory bulb was present in 42% of the mink fed 1.4 ppb TCDD. These results confirmed the high sensitivity of mink to TCDD and revealed a toenail abnormality not previously reported for mink fed TCDD.

Veterinary and Human Toxicology, 2001: 43, 134-139, 4 tables, 30 refs.

The welfare of farmed mink (*Mustela vison*) in relation to behavioural selection: a review

J. Malmkvist, S.W. Hansen

Animal welfare is a major issue in Europe, and the production of mink, *Mustela vison*, has also been under debate. One common method of solving animal welfare problems is to adapt the environment to fit the behavioural needs of the animals. In comparison with other forms of husbandry, the mink production environment has remained relatively unchanged over the years and provides for some of the most obvious needs of mink. Whether today's typical housing conditions adequately meet the welfare requirements of mink is currently a topic of discussion. An alternative approach to improving welfare is to modify the animals so that they are better adapted to farming conditions. In large-scale animal production, handling of the individual can be a sporadic event, making an animal's inherent characteristics for temperament and adaptability important factors to consider with respect to its resultant welfare.

In this review we present and discuss experiments on behavioural selection for temperament, and against undesirable behaviours, such as fur chewing, in mink. Fur chewing behaviour can be reduced by selection, apparently without any negative effects, whereas only a little is known about the nature and consequences of selecting against stereotypic behaviours. Long-term selection experiments have shown that it is possible to reduce fearfulness in farmed mink. Using a relatively simple test, it is possible for farmers to add behavioural measurements to their normal selection criteria and thereby improve the welfare of farmed mink.

Animal Welfare, 2001: 10, 41-52, 5 figs, 61 refs.

Detection and molecular characterization of cultivable caliciviruses from clinically normal mink and enteric caliciviruses associated with diarrhoea in mink

M. Guo, J.F. Evermann, L.J. Saif

Enteric caliciviruses are emerging pathogens responsible for diarrhea or gastroenteritis in their respective hosts. In this report, mink enteric caliciviruses (MEC) were detected in feces from diarrheic mink by both immune electron microscopy (IEM) and RT-PCR using a broadly reactive primer pair (p289/290) targeting the highly conserved RNA polymerase regions of the enteric caliciviruses, Norwalk-like viruses (NLVs) and Sapporo-like viruses (SLVs). The MEC possess classical caliciviral morphology with typical cup-shaped depressions on the viral surface. Sequence analyses based on nucleotide and predicted amino acid (aa) sequences of the RT-PCR products indicated that MEC is most closely related genetically to SLVs of humans and animals. The MEC shared the highest aa identities (64-71%) in the RNA polymerase region with both human SLVs and the porcine enteric calicivirus (PEC) Cowden strain SLV, indicating that MEC may belong to an individual genogroup or subgroup in the SLV genus. The MEC shared only limited aa identities in the RNA polymerase region with vesiviruses (40-51%) and NLVs (29-33%). The RNA polymerase regions of the cultivable, non-enteric mink caliciviruses (MCV) were also amplified by RT-PCR using the primer pair Pol1/Pol3 based on sequences of vesiviruses, and the primer pair p289/290. Sequence analysis indicated that these MCV shared higher aa identities in the RNA polymerase region with vesiviruses (58-81%) than with SLVs (43-51%) including the MEC, lagoviruses (35-37%) and NLVs (27-35%), suggesting that they are most closely related genetically to vesiviruses. The MEC associated with diarrhea in mink are morphologically similar to but are genetically distinct from the cultivable MCV and likely represent a new member of the SLV genus.

Archives of Virology, 2001: 146, 479-493, 2 figs, 2 tables, 43 refs.

An outbreak of toxoplasmosis in farmed mink (*Mustela vison* S.)

R.K. Frank

A large Wisconsin mink (*Mustela vison*) farm experienced an outbreak of toxoplasmosis in the spring of 1999 following an outbreak of canine distemper during the previous fall. Major clinical signs for pregnant females included reduced feed consumption, abortions, and stillborn kits; kits < or =3 weeks old experienced ataxia and mortality. Of 7,800 females, 1,976 (26%) lost their entire litter either from abortion or neonatal mortality. Kit mortality from 7 days to 3 weeks of age was 3,300, and overall kit mortality attributed to the toxoplasmosis outbreak was 10,408. Six neonatal mink kits, 12 3-week-old kits, and 2 adult female mink were submitted to the University of Minnesota Veterinary Diagnostic Laboratory for diagnostic workup. Gross postmortem lesions were limited to empty stomachs (12 of 12 kits) and pale livers (4 of 12 kits) for the 3-week-old kits. Major microscopic lesions included interstitial pneumonia, encephalitis, encephalomalacia, and myocarditis. Toxoplasmosis was diagnosed by microscopic lesions, microscopic lesion distribution, and the detection of *Toxoplasma gondii* tachyzoites by immunohistochemistry. This is the first detailed report of an outbreak of toxoplasmosis in mink in the United States.

Journal of Veterinary Diagnostic Investigation, 2001:13, 245-249, 1 fig, 2 tables, 22 refs.

Porcine endogenous retroviruses: *in vitro* host range and attempts to establish small animal models

V. Specke, S.J. Tacke, K. Boller, J. Schwendemann, J. Denner

Using transgenic pigs as the source of cells or organs for xenotransplantation is associated with the risk of porcine endogenous retrovirus (PERV) transmission. Multiple proviruses are integrated into the genome of all pigs, and virus particles, some of

which are able to infect human cells, are released from normal pig cells. In order to evaluate the potential risk posed by the transmission of PERVs, *in vitro* infection studies were performed as a basis for small animal as well as non-human primate models. *In vitro* infectivity was demonstrated for permanent cell lines and primary cells from a wide range of species. Productive infection was shown using reverse transcriptase (RT) assays and RT-PCR for mink, feline and human kidney cell lines, primary rhesus peripheral blood mononuclear cells (PBMCs), and baboon spleen cells and PBMCs as well as for different human lymphoid and monocyte cell lines and PBMCs. In an attempt to establish a small animal model, naive guinea pigs, non-immunosuppressed rats, rats immunosuppressed by cyclosporin-A and immunosuppressed rats treated with cobra venom factor were inoculated with PERVs produced from porcine kidney PK-15 cells, infected human 293 kidney cells and mitogen-stimulated porcine PBMCs. Animals were also inoculated with PERV-producing PK-15 and 293 cells. No antibodies against PERV and no provirus integration were observed in any of the treated animals. This suggests that productive infection of these animals did not occur in this experimental setting.

Journal of General Virology, 2001: 82, 837-844, 3 figs, 2 tables, 36 refs.

Effect of lactic acid fermentation of wheat and barley whole meal flour on carbohydrate composition and digestibility in mink (*Mustela vison*)

G. Skrede, S. Sahlstrøm, A. Skrede, A. Holck, E. Slinde

Wheat and barley whole meal flours (WMFs) were subjected to treatment by fermentation, autoclaving, and fermentation followed by autoclaving. The WMFs were analysed for chemical composition, formulated into wet diets (282 g kg⁻¹) and fed to adult mink (*Mustela vison*) for determination of total tract digestibility of total starch, total carbohydrate, crude protein and fat. Fermentation of WMF/water mixtures inoculated with a *Lactobacillus* sp. (strain AD2) was performed at

30°C for 16 h. Autoclaving was carried out for 60 min at 120°C. Fermentation increased colony-forming units (CFUs) to about 108 g⁻¹ and lowered pH to 3.7–3.8 in both WMFs. All carbohydrate parameters were affected by type of cereal, and were, except for total starch, affected by treatment. Levels of total dietary fibre and β-glucans decreased by fermentation in both WMFs. The decrease in total β-glucans from 33.5 to 18.4 g kg⁻¹ in barley WMF, was mainly restricted to the soluble fraction. Glucose levels in barley WMF increased simultaneously from 0.6 to 12.3 g kg⁻¹. The main effects of autoclaving were increased levels of total dietary fibre, maltose, and increased hydration capacity. With fermentation prior to autoclaving, increases in levels of the fibre fractions and maltose were prevented while hydration capacity prevailed as an effect of autoclaving. Compared with fermentation alone, the combined treatment increased damaged starch levels and hydration capacity. Digestibilities of total carbohydrate, crude protein and fat were significantly higher for wheat than for barley. Fermentation had no effect on digestibility of total starch or total carbohydrate of wheat, but increased digestibility of total starch of barley significantly from 0.742 to 0.880, and of total carbohydrate from 0.457 to 0.616. Autoclaving had no significant effect on digestibility of total starch and total carbohydrate of wheat. Digestibility of total starch and total carbohydrate in barley increased significantly after autoclaving. Total starch and total carbohydrate digestibility of both wheat and barley were significantly enhanced by combined fermentation and autoclaving compared with fermentation alone. Compared with autoclaving alone, combined fermentation and autoclaving promoted no significant improvement of total starch and total carbohydrate digestibility in wheat, whereas total carbohydrate digestibility in barley increased from 0.605 to 0.672. Fat digestibility was slightly improved by both fermentation and autoclaving. Autoclaving of cereals reduced significantly the faecal dry matter contents of mink. This effect could be counteracted by preceding fermentation. In conclusion, lactic acid fermentation of wheat and especially barley provided chemical changes of benefit for carbohydrate digestion in the mink.

Animal Feed Science and Technology, 2001: 90, 199-212, 3 tables, 35 refs.

Serogroups and antimicrobial susceptibility among *Escherichia coli* isolated from farmed mink (*Mustela vison Schreiber*) in Denmark

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Escherichia coli is commonly found in outbreaks of diarrhoea in mink during the production season although its role as a primary causal organism remains unclear. The present study was undertaken to determine the serogroups and antimicrobial susceptibility of *E. coli* isolates from healthy and diarrhoeic mink. Rectal swabs were taken from healthy and diseased animals, on six different farms, once at the onset of disease and again approximately 2 weeks later. The swabs were subjected to bacteriological investigation; a total of 210 *E. coli* were isolated, 98 from healthy animals and 112 from diseased. All isolates were serotyped and MICs were determined for nine antimicrobial compounds. Non-haemolytic isolates numbered 147, whereas 63 were haemolytic. Both haemolytic and non-haemolytic isolates were isolated from both healthy and diseased animals.

A wide range of serogroups was detected, the most frequent being O2 (11.0%), O78 (11.0%), O153 (7.1%), O25 (5.7%), O6 (4.8%), and O15 (4.8%), but diarrhoea was not associated with specific serogroups. All isolates were sensitive to enrofloxacin, neomycin, gentamicin and colistin. In contrast, considerable variations in susceptibility were found among the six mink farms, for tetracycline (0–46.4%, average 21.9), ampicillin (2.9–50.0%, average 23.3), spectinomycin (8.0–35.7%, average 21.9), sulfamethoxazole (8.6–57.7%, average 30.0) and trimethoprim (0–35.7%, average 9.5). Resistance to tetracycline was statistically more prevalent among haemolytic than among non-haemolytic strains.

In conclusion, serogrouping and haemolysin testing failed to identify any association with diarrhoeal disease and antimicrobial resistance was highly variable between different mink farms.

Veterinary Microbiology, 2001: 79, 143-153, 3 tables, 22 refs.

Plasma leptin and thyroxine of mink (*Mustela vison*) vary with gender, diet and subchronic exposure to PCBs

P. Nieminen, H. Hyvarinen, R. Kakela, J. Asikainen

Female minks (*Mustela vison*) fed diets based on freshwater, marine or mixed fish were exposed to 1 mg of polychlorinated biphenyls (PCBs) a day for 21 weeks. The plasma leptin and thyroxine concentrations and the glucose-6-phosphatase and glycogen phosphorylase activities in the liver were measured at the end of the experiment. The plasma thyroxine concentrations were significantly higher in the group exposed to PCBs. The mean plasma leptin concentration and glucose-6-phosphatase activity was the highest in the group that had the lowest body-mass index (BMI). The glycogen phosphorylase activity was the highest in the freshwater fish-control group. The results suggest that the amount of fat in the body of the female minks is not the only determinant of the plasma leptin levels, but the leptin levels seem to rise with a lowered BMI unlike in rodents or humans. The positive correlation between the leptin levels and the glucose-6-phosphatase activity suggests increased gluconeogenesis with high leptin levels. Subchronic exposure to PCBs seems to have no effect on the plasma leptin levels or the glucose-6-phosphatase activities, but it elevates significantly the plasma thyroxine levels with a mechanism that remains unknown.

Comparative Biochemistry and Physiology, Part A, Molecular and Integrative Physiology, 2000: 127, 515-522, 1 figs, 3 tables, 44 refs.

Dynamics of connexin 43 levels and distribution in the mink (*Mustela vison*) anterior pituitary are associated with seasonal changes in anterior pituitary prolactin content

M.L. Vitale, J. Cardin, N.B. Gilula, M.E. Carbajal, R.M. Pelletier

Because in mammals the anterior pituitary lacks innervation, we investigated whether gap junctions

established between selected cells within the gland are part of an intrapituitary mechanism to ensure physiological synchronization of cells involved in the control of hormone secretion. We report here the dynamics of anterior pituitary connexin 43 (Cx43)-gap junctions throughout the mink (*Mustela vison*) annual reproductive cycle and its relationship with the anterior pituitary prolactin (PRL) content that parallels variations in serum PRL levels documented in the literature. We found that PRL anterior pituitary levels were maximal in spring and during lactation and that they were minimal in autumn and winter. Anterior pituitary Cx43 levels were maximal during periods of high PRL secretion. During these periods, Cx43-positive gap junctions localized to stellate-shaped cells occupying the center of anterior pituitary follicles and to the rounded cells occupying the remaining follicles. Connexin 43-positive gap junctions were also observed between adjacent follicles. During periods of low PRL pituitary content, Cx43-positive gap junctions localized to the stellate cells but not to the cells of the remaining follicles. Moreover, Cx43 labeling was undetected between adjacent follicles. To assess between which cells within the mink anterior pituitary the Cx43 gap junctions were established, the different anterior pituitary cell populations were separated by a discontinuous Percoll gradient, and Western blot analyses of each cell population using Cx43 antibodies were performed. The immunoblots showed a Cx43 immunoreactive band associated with the cell layer enriched in S-100-positive, stellate-shaped cells. The result was confirmed by fluorescence microscopy studies that showed that Cx43-mediated gap junctions were established preferentially between the cultured S-100-positive, elongated cells. The results show that in mink stellate cells, the junctional machinery associated with the Cx43 protein varies in synchrony with the anterior pituitary PRL content throughout the mink annual reproductive cycle. It is suggested that the Cx43 gap junctions on the stellate cells play an important role in the synchronization of cellular activity within selected follicles of the anterior pituitary, thus contributing to the control of PRL secretion during the annual reproductive cycle.

Biology of Reproduction, 2001: 64, 625-633, 6 figs, 1 table, 44 refs.

Effects of variations in dietary protein levels on hair growth and pelt quality in mink (*Mustela vison*)

P.V. Rasmussen, C.F. Børsting

The effect of different and shifting dietary protein levels on hair growth and the resulting pelt quality in mink was studied. Two groups of pastel female mink were fed either 59% (high protein, HP) or 40% (low protein, LP) of metabolisable energy (ME) from protein during pregnancy and lactation. Shortly after weaning, kits from females fed the LP diet were put on a new LP diet (21% protein of ME). Kits from females fed HP were randomly distributed to four experimental groups fed a new HP diet (34% protein of ME) and three of these groups were shifted to diets with 21% protein at different times during June until September. Skin biopsies were taken at 4, 6, 23 and 29 wk of age. Histological techniques and computer-assisted light microscopy were used to determine the ration of activity (ROA) of underfur and guard hairs, respectively, defined as the number of growing hairs as a percentage of the total number of hairs. The hair fibre length and thickness were determined by morphometric methods and correlated with fur properties of dried pelts judged by sensory methods. It was documented that 40% of ME from protein during pregnancy and lactation was sufficient for mink kits to express their genetic capacity to produce hair follicles. In males, a reduced protein level from the age of 15 wk or 22 wk until pelting disturbed moulting, indicated by a low ROA of underfur hairs at 23 wk, and consequently reduced the growth and development of the winter coat. A constantly low protein level from conception until the age of 29 wk did not disturb moulting, but led to a reduction of primeness and especially of the underfur length and fibre thickness of the winter coat. A low protein level from the age of 9 wk only reduced the thickness of the underfur fibres. Hair growth, final fur volume, and general quality of the winter coat of males were influenced negatively and to the same degree in all groups fed the LP diet in part of the growth period. The number of underfur hairs per area (hair density) of the winter coat was not influenced by the dietary treatment meaning that the protein content of 21% of ME in the LP diet was

high enough for the mink to express its genetic capacity to develop hair follicles. However, this low protein content led to a reduction of hair fibre length and hair fibre thickness of the underfur. Overall, this study demonstrated that hair growth and hair properties in pelts are very dependent on the dietary protein supply in the period from 22 wk of age until pelting, irrespective of the supply in the preceding periods.

Canadian Journal of Animal Science, 2000: 80, 633-642, 8 tables, 25 refs.

Body composition in mink (*Mustela vison*) kits during 21-42 days postpartum using estimates of hydrogen isotope dilution and direct carcass analysis

H.N. Layton, K.I. Rouvinen-Watt, S.J. Iverson

We compared carcass analysis and hydrogen isotope dilution methods to measure total body water (TBW) and body composition in a small altricial carnivore, the mink. Dilution space (D) of mink at 21–42 days of age ($n=20$), was determined after subcutaneous administration of tritiated water. The same animals were then used to determine TBW and body composition by carcass analysis and to derive predictive empirical relationships between TBW and total body fat, protein and energy. A separate validation set of 27 kits was used to test the accuracy of predicting body composition from TBW. D overestimated TBW by a consistent and predictable 4.1% ($R^2=0.999$, $P<0.001$). Our estimates of fat, protein and energy content, using equations derived from TBW, were not significantly different than those obtained from direct carcass analysis ($P>0.980$) in either the initial or validation set of mink. TBW was shown to decrease from 81 to 76% and total body protein to increase from 14 to 19% of LBM of the kits from 21 to 42 days of age. Although a rapidly changing hydration state was apparent in neonates, we conclude that when this is taken into account, accurate estimates of body composition can be obtained from hydrogen isotope dilution.

Comparative Biochemistry and Physiology, Part A, Molecular and Integrative Physiology, 2000: 126, 295-303, 3 figs, 2 tables, 31 refs.

Proliferation of periodontal squamous epithelium in mink fed 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (TCDD)

J.A. Render, J.R. Hochstein, R.J. Aulerich, S.J. Bursian

Teh maxilla and mandible from 2 adult female mink fed 5.0 ppb 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) for 6 mo were grossly unremarkable, but histologically had nests of squamous epithelium within the periodontal ligament. There was osteolysis of the adjacent alveolar bone.

Veterinary and Human Toxicology, 2000: 42, 85-86, 1 fig, 10 refs.

Observations on thermoregulatory ontogeny of mink (*Mustela vison*)

K. Rouvinen-Watt, M. Harri

(1) We measured cooling rate for neonatal mink during a 10 min coldroom (3.9°C) exposure and subsequent warming rate during a 20 min incubator (37.2°C) exposure, the behaviour of the kits and the changes in their pelage between 1 and 46 d of age, in an attempt to monitor the ontogeny of their thermoregulatory capacity. (2) Body weight of the 1 d old kits averaged only 12.8±2.3 g ($n=4$), but they gained weight rapidly reaching 226.1±28.3 g (males, $n=4$) and 207.6±16.1 g (females, $n=4$) at 30–31 d of age, and 562.3±43.2 g (males, $n=3$) and 435.7±35.5 g (females, $n=4$) at 45–46 d of age. (3) Body cooling rate (C_{rate} (°C/min); $n=80$) was affected by the age (between 1 and 31 d), BW, initial rectal temperature (T_{r0}), and sex of the kits, in addition to their body posture (P_{cold} , 1=extended, 2=curled-up) during coldroom exposure. C_{rate} (°C/min) = $-0.34 - 0.02age - 0.002 BW + 0.05 T_{r0} - 0.06sex - 0.20P_{cold}$ ($R^2=0.75$). (4) Body warming rate (W_{rate} (°C/min); $n=80$) was influenced by the age² and rectal temperature of the kit after the coldroom exposure (T_{r10}). W_{rate} (°C/min) = $1.24 + 0.0002age^2 - 0.04T_{r10}$ ($R^2=0.76$). (5) Kit fur fibre length increased from 5.45±0.63 mm (males, $n=2$) and 6.20±0.20 mm (females, $n=3$) at 22–23 d of age to 9.43±1.44 mm (males, $n=4$) and 8.70±1.89 mm (females, $n=4$) at 30–31 d of age, and to 12.93±0.47 mm (males, $n=3$) and 11.38±0.41 mm (females, $n=4$) at 45–46 d of

age, the growth averaging about 0.26 mm per day. (6) Under normal circumstances newborn mink kits are hypothermic. Their thermoregulation develops only gradually and is dependent on increase in body mass, insulation and behavioural thermoregulation. Their strategy of survival is based on the ability to withstand hypothermia and on the nutrition and warmth provided by the dam.

Journal of Thermal Biology, 2001: 26, 9-14, 6 figs, 13 refs.

Studies on influenza viruses H10N4 and H10N7 of avian origin in mink

L. Englund

An influenza A virus, A/mink/Sweden/84 (H10N4), was isolated from farmed mink during an outbreak of respiratory disease, histopathologically characterised by severe interstitial pneumonia. The virus was shown to be of recent avian origin and closely related to concomitantly circulating avian influenza virus. Serological investigations were used to link the isolated virus to the herds involved in the disease outbreak. Experimental infection of adult mink with the virus isolate from the disease outbreak reproduced the disease signs and pathological lesions observed in the field cases. The mink influenza virus also induced an antibody response and spread between mink by contact. The same pathogenesis in mink was observed for two avian influenza viruses of the H10N4 subtype, circulating in the avian population. When mink were infected with the prototype avian H10 influenza virus, A/chicken/Germany/N/49, H10N7, the animals responded with antibody production and mild pulmonary lesions but neither disease signs nor contact infections were observed. Detailed studies, including demonstration of viral antigen in situ by immunohistochemistry, of the sequential development of pathological lesions in the mink airways after aerosol exposure to H10N4 or H10N7 revealed that the infections progress very similarly during the first 24 h, but are distinctly different at later stages. The conclusion drawn is that A/mink/Sweden/84, but not A/chicken/Germany/N/49, produces a multiple-

cycle replication in mink airways. Since the viral distribution and pathological lesions are very similar during the initial stages of infection we suggest that the two viruses differ in their abilities to replicate and spread within the mink tissues, but that their capacities for viral adherence and entry into mink epithelial cells are comparable.

Veterinary Microbiology, 2000: 74, 101-107, 26 refs.

Intestinal transport of monosaccharides and amino acids during postnatal development of mink

R.K. Buddington, C. Malo, P.T. Sangild, J. Elnif

Intestinal development is typically studied using omnivores. For comparative purposes, we examined an altricial carnivore, the mink (*Mustela vison*). In mink, intestinal dimensions increase up to 8 wk after birth and then remain constant (length) or decrease (mass) into maturity despite continuing gains in body mass. Rates of glucose and fructose transport decline after birth for intact tissues but increase for brush-border membrane vesicles (BBMV). Rates of absorption for five amino acids that are substrates for the acidic (aspartate), basic (lysine), neutral (leucine and methionine), and imino acid (proline) carriers increase between birth and 24 h for intact tissues before declining, but increase after 2 wk for BBMV. The proportion of BBMV amino acid uptake that is Na⁺-dependent increases during development but for aspartate is nearly 100% at all ages. Tracer uptake by BBMV can be inhibited by 100 mmol/l of unlabeled amino acid, except for lysine. BBMV uptake of the dipeptide glycyl-sarcosine does not differ between ages, is not Na⁺-dependent, and is only partially inhibited by 100 mmol/l unlabeled dipeptide. Despite the ability to rapidly and efficiently digest high dietary loads of protein, rates of amino acid and peptide absorption are not markedly higher than those of other mammals.

American Journal of Physiology, Regulatory, Integrative and Comparative Physiology, 2000:279, R2287-R2296, 10 figs, 1 table, 26 refs.

Can spectroscopy in combination with chemometrics replace minks in digestibility tests?

P.L. Dahl, B.M. Christensen, L. Munck, E.P. Larsen, S.B. Engelsen

One of the most relevant but expensive methods of assessing the quality of fish meal is the physiological digestibility test with minks. The purpose of this study was to determine whether spectroscopic and chemical analyses evaluated with chemometrics can replace minks in digestibility tests. The spectroscopic methods used were the two complementary techniques of fluorescence emission and near-infrared reflectance. The investigation included 54 samples of high-quality fish meal ranging from 89.6 to 93.9 on the mink digestibility index. The investigation also included determination of seven quality parameters in the fish meal to substantiate the spectroscopic models on the mink digestibility. These quality parameters include the content of protein, oil, water, water-soluble protein, ash and the biogenic substance cadaverine as well as the titration value. The study demonstrates that the mink digestibility could be predicted from combining the two reference quality parameters oil and ash with a correlation coefficient of 0.89. The best spectroscopic calibration models on the mink digestibility resulted in a correlation coefficient of 0.94 and a prediction error of 0.5 using the near-infrared spectral ensemble and a correlation coefficient of 0.92 and a prediction error of 0.5 using the fluorescence spectral ensemble. In addition, the seven reference quality parameters could be predicted from the spectroscopic ensembles with good precision.

Journal of the Science of Food and Agriculture, 2000: 80, 365-374, 6 figs, 5 tables, 17 refs.

Immunohistochemical confirmation of *Sarcocystis neurona* infections in raccoons, mink, cat, skunk, and pony

J.P. Dubey, A.N. Hamir

In the central nervous system of 2 raccoons, 1 cat, 1 pony, 2 mink, and 1 skunk, protozoa previously thought to be *Sarcocystis*-like reacted positively to *Sarcocystis neurona*-specific antibodies in an

immunohistochemical test. In addition, *S. neurona* was identified in the brain of another skunk. These observations indicate that *S. neurona* is not confined to opossums and horses.

Journal of Parasitology, 2000: 86, 1150-1152, 1 table, 26 refs.

Silkiness in brown mink pelts characterized with optical methods

P.V. Rasmussen, J. Dyck

In mink production, silkiness refers to a silky fur surface. The sensory evaluation of silkiness may be based on information perceived by the eyes and the hands. Silkiness is assumed to depend on hair fiber properties such as guard hair straightness, glossiness, and smoothness. Our objective was to characterize the dorsal surface of brown mink pelts by means of optical variables and relate these to the visual grades of silkiness, thereby forming some objective criteria of silkiness. Two groups of brown male mink pelts (winter coat) that originated from a selection trial with a focus on silkiness were used. The pelts came from a basic (Group 1992) population and a selected (Group 1994) generation. Group 1992 was graded visually on a scale from 1 to 6 (most silky); Group 1994 was graded on a scale from 1 to 8 (most silky). With goniophotometric, nondestructive methods, the reflectance from each pelt surface was measured describing the angle-dependent distribution of reflection in the shape of angular reflectance curves. The measurements were performed along (w-reflectance curve) and across (c-reflectance curve) the guard hairs. The w-curve included a maximum assumed to be related to silkiness. Specular gloss, indicated by the maximum reflectance (s) in the direction of mirror reflection, was positively correlated with silkiness. For Group 1994, $s = 72.94 + .49 \times \text{silkiness}$; $r^2 = .33$, $P = .0003$. Correspondingly, an area representing specular (S) plus diffuse (D) reflectance (S + D) under the curve was positively correlated with silkiness. A decreasing band width of the w-curve at 90% of maximum specular reflectance (w90) was related to an increase of silkiness (Group 1992: $r = -.50$, $P < .01$). Furthermore, both $s/w90$ and $(S + D)/w90$ were positively correlated with silkiness (Group 1992: $r = .49$, $P < .01$ and $r = .51$, $P < .01$, respectively). Measures of contrast gloss involving

relations or differences between specular and diffuse reflectance were not suitable. From our results, a high degree of specular gloss, indicated by *s*, explained and was related to an essential part of silkiness and general sensory quality of the pelts investigated. Also, *s* was relatively easy to measure. Thus, even if the objective variables did not correlate perfectly with visual judgments, *s* was considered to be the most usable objective variable in characterizing silkiness.

Journal of Animal Science, 2000: 78, 1697-1709, 8 figs, 6 tables, 35 refs.

Epizootiological investigations of canine distemper virus in free-ranging carnivores from Germany

K. Frölich, O. Czupalla, L. Haas, J. Hentschke, J. Dedek, J. Fickel

Canine distemper virus (CDV) infects a broad range of carnivores. To assess whether wild carnivores may play a role in the epidemiology of CDV in domestic dogs in Germany, the seroprevalence of CDV was determined. In sera from red foxes (30 of 591 (5%)) and stone martens (2 of 10 (20%)) antiviral antibodies were detected using a neutralization assay, whereas sera of raccoons, two mink, one pine marten and one raccoon dog were negative. In foxes, there was a significantly higher prevalence in urban and suburban compared to rural regions. When testing lung and spleen tissue samples (fox, badger, stone marten, polecat, raccoon dog) 13 of 253 (5.1%) foxes, 2 of 13 (15.4%) stone martens and 2 of 6 (33%) badgers were virus positive using RT-PCR. Phylogenetic analysis based on partial sequences of the F gene revealed a distinct relatedness to canine CDV isolates. Together, the data support the concept of transmission of CDV between domestic dogs and wild carnivores.

Veterinary Microbiology, 2000: 74, 283-292, 2 figs, 2 tables, 24 refs.

Biochemical and morphological diversity among folliculo-stellate cells of the mink (*Mustela vison*) anterior pituitary

J. Cardin, M.E. Carbajal, M.L. Vitale

The folliculo-stellate (FS) cells are agranular cells of the anterior pituitary whose origin and function are still a matter of debate. This study examined the presence, topography, and morphological characteristics of FS cells in the mink anterior pituitary throughout the annual reproductive cycle. The S-100 protein was used as a FS cell marker. Immunoperoxidase labeling on tissue sections demonstrated the presence of two types of S-100 positive cells. Type 1 cells were stellate-shaped cells whose nuclei were localized near the center of pituitary follicles. In this type, S-100 labeling was strong in anterior pituitary sections obtained during spring, a period characterized by high prolactin pituitary content and low gonadotropin pituitary content. Type 2 cells were rounded cells occupying the periphery of the follicles. During periods of low prolactin pituitary content and high gonadotropin anterior content the type 2 S-100 positive cells formed aggregates of several cells. The total number of S-100 positive cells was constant during these two periods of the annual reproductive cycle, suggesting that type 1 and type 2 may reflect different morphological and physiological states of the same cell. Of the two subunits, α and β , that, combined, form three different dimeric S-100 proteins, mink FS cells expressed mostly the β subunit. FS cells also expressed the glial fibrillary acidic protein (GFAP). In culture, $8 \pm 3\%$ of anterior pituitary cells were S-100 positive. Cultured S-100 cells were elongated, polygonal, or rounded. The S-100 labeling accumulated in the cytoplasm around and within the nucleus, whereas it was weak in pseudopods and large cytoplasmic vacuoles. The presence of pseudopods suggests that cultured FS cells could migrate. The vacuoles may be related to the phagocytic activity ascribed to these cells. Some FS cells presented membrane blebbing and peripheral vesicles that were immunopositive for S-100 and that may indicate a secretory activity.

Cultured FS cells possessed actin filaments organized as a peripheral network; a few actin cables were also observed running across the cytoplasm. Pseudopods depicted a highly organized actin network. The microtubules of FS cells expanded throughout the cytoplasm. The intermediate filaments expressed by cultured FS cells were GFAP and vimentin. GFAP labeling was punctate and vimentin was organized as filaments. All cultured S-100 cells were positive for vimentin, suggesting a mesenchymal origin for the cells, and all cultured S-100 positive cells were positive for GFAP, suggesting a neuroectodermal origin. In conclusion, S-100 positive cells are heterogeneous with respect to cell shape and expression of S-100 subunits in the mink anterior pituitary. The presence of morphologically different S-100 positive cells is modified in accordance with the endocrine status of the animal, suggesting that FS cells may be involved in the modulation of the anterior pituitary endocrine activity in the mink.

General and Comparative Endocrinology, 2000: 120, 75-87, 6 figs, 2 tables, 44 refs.

Evaluation of changes in hematologic and clinical biochemical values after exposure to petroleum products in mink (*Mustela vison*) as a model for assessment of sea otters (*Enhydra lutris*)

J.K. Mazet, I.A. Gardner, D.A. Jessup, L.L. Lowenstine, W.M. Boyce

Objective: To determine the effects of petroleum exposure on hematologic and clinical biochemical results of mink and to identify variables that may be useful for making management decisions involving sea otters (*Enhydra lutris*) that have been exposed to oil in their environment.

Animals: 122 American mink (*Mustela vison*).

Procedures: Mink were exposed once to a slick of oil (Alaskan North Slope crude oil or bunker C fuel oil) on seawater or via low-level contamination of their daily rations.

Results: In the acute phase of exposure, petroleum directly affected RBC, WBC, neutrophil, and lymphocyte counts, fibrinogen, sodium, calcium, creatinine, total protein, and cholesterol

concentrations, and alanine transaminase, creatine kinase, alkaline phosphatase, and γ -glutamyltransferase activities. Aspartate transaminase, alkaline phosphatase, γ -glutamyltransferase, and lactate dehydrogenase activities and cholesterol concentration also varied as a result of chronic low-level contamination of feed.

Conclusion and clinical relevance: Our results are in agreement with reports that attribute increased alanine transaminase and alkaline phosphatase activities and decreased total protein concentration to petroleum exposure in sea otters during an oil spill. Sodium, calcium, creatinine, cholesterol, and lactate dehydrogenase may be valuable variables to assess for guidance during initial treatment of sea otters exposed to oil spills as well as for predicting which petroleum-exposed sea otters will reproduce following an oil spill. Measurement of these variables should aid wildlife professionals in making decisions regarding treatment of sea otters after oil spills.

American Journal of Veterinary Research, 2000: 61, 1197-1203, 4 tables, 19 refs.

Proliferation of maxillary and mandibular periodontal squamous cells in mink fed 3, 3', 4, 4', 5-pentachlorobiphenyl (PCB 126)

J.A. Render, R.J. Aulerich, S.J. Bursian, R.F. Nachreiner

This report characterizes squamous cell proliferation in young farm mink (*Mustela vison*) fed a diet supplemented with 0.024 ppm 3,3',4,4',5-pentachlorobiphenyl (polychlorinated biphenyl [PCB] congener 126). One to 2 months of dietary exposure to PCB 126 resulted in gross lesions of the upper and lower jaws consisting of mandibular and maxillary nodular proliferation of the gingiva and loose teeth. The maxilla and mandible of the PCB-treated mink were markedly porous because of loss of alveolar bone. Histologically, this osteoporosis was caused by proliferation of squamous cells that formed infiltrating cords. This report clearly documents the fact that the environmental contaminant PCB 126 can cause osteoinvasive squamous proliferation in young mink, although the dose used in the present study was 7 and 36 times

higher than what is typically encountered in contaminated bird eggs and fish, respectively.

Journal of Veterinary Diagnostic Investigation, 2000: 12, 477-479, 5 figs, 19 refs.

Genetic characterization of feline parvovirus sequences from various carnivores

A. Steinel, L. Munson, M. Van Vuuren, U. Truyen

Infections with viruses of the feline parvovirus subgroup such as feline panleukopenia virus (FPV), mink enteritis virus (MEV) and canine parvovirus (CPV-2) [together with its new antigenic types (CPV-2a, CPV-2b)] have been reported from several wild carnivore species. To examine the susceptibility of different species to the various parvoviruses and their antigenic types, samples from wild carnivores with acute parvovirus infections were collected. Viral DNA was amplified, and subsequently analysed, from faeces or formalin-fixed small intestines from an orphaned bat-eared fox (*Otocyon megalotis*), a free-ranging honey badger (*Mellivora capensis*), six captive cheetahs (*Acinonyx jubatus*), a captive Siberian tiger (*Panthera tigris altaica*) and a free-ranging African wild cat (*Felis lybica*). Parvovirus infection in bat-eared fox and honey badger was demonstrated for the first time. FPV-sequences were detected in tissues of the African wild cat and in faeces of one cheetah and the honey badger, whereas CPV-2b sequences were found in five cheetahs and the bat-eared fox. The Siberian tiger (from a German zoo) was infected with a CPV-type 2a virus. This distribution of feline parvovirus antigenic types in captive large cats suggests an interspecies transmission from domestic dogs. CPV-2 sequences were not detected in any of the specimens and no sequences with features intermediate between FPV and CPV were found in any of the animals examined.

Journal of General Virology, 2000: 81, 345-350, 1 figs, 3 tables, 28 refs.

Effects of early weaning and housing conditions on the development of stereotypies in farmed mink

L.L. Jeppesen, K.E. Heller, T. Dalsgaard

Female mink pups were weaned at 6, 8 or 10 weeks of age and subjected to two different housing conditions. They were either kept together with a single male sibling in traditional mink cages (30×45×90 cm) or housed socially with all littermates in an alternative system consisting of three adjoining traditional cages (90×45×90 cm). All cages were supplied with nest boxes. At 5 months of age, the siblings were removed leaving the females socially isolated in the two different cage systems. Females' stereotypies were quantified by repeated scanning observations under the social housing conditions immediately before removal of the siblings, and again at the age of 7 and 9 months, when the animals had stayed solitary in the two systems for 2 and 4 months. Solitary females showed significantly more stereotypies than females under social housing conditions in both cage systems. Stereotypies were more frequent in the smaller traditional cages. Stereotypies declined from 7 to 9 months of age among solitary animals in traditional cages but not in alternative cages. Early-weaned solitary females in traditional cages showed more stereotypies than later-weaned animals, but only when measured at the age of 7 months. It is suggested that early weaning, individual housing and small cages promote the development of stereotypies in farmed mink. The influence of early weaning on stereotypies seems to decline with age, while effects related to individual housing and small cages appear to be more persistent.

Applied Animal Behaviour Science, 2000: 68, 85-92, 4 figs, 26 refs.

Effect of dietary glycine and benzoate level on benzoate metabolism in mink (*Mustela vison*), blue fox (*Alopex lagopus*), and racoon dog (*Nyctereutes procyonoides*)

I.J. Pölönen, K.H. Partanen, T.K. Jalava, V.F. Toivonen

Three 2 x 4 factorial experiments were carried out from August to September with 30 juvenile male

mink, 24 raccoon dogs, and 24 blue foxes to investigate the effect of dietary glycine supply (low or high) on the efficiency of these species to excrete hippuric acid with incremental benzoate intake (0, 1, 2, or 4 mmol/kg BW). For mink, two additional treatments with 1 or 2 mmol/kg BW of ethyl benzoate were included. A basal low-glycine diet was formulated to meet the minimum protein requirements of fur animals (30% of ME). This diet was supplemented with 0 or 3 g/kg of glycine, or with 0, 1.0, 2.07, or 4.15 g/kg of sodium benzoate for mink and blue foxes, and with 0 or 4.5 g/kg of glycine and 0, 1.58, 3.17, or 6.34 g/kg of sodium benzoate for raccoon dogs, respectively. Two additional diets with .76 or 1.53 g/kg of ethyl benzoate were made for mink. Fecal and urinary benzoic and hippuric acid excretion were measured for 3 d. The 24-h recovery of [¹⁴C]benzoic acid injected intraperitoneally was measured from urine, the liver, and the kidneys. All animals appeared healthy and no clinical signs of benzoate overdose were observed. Dietary benzoate level did not affect ADFI or ADG in any species. Glycine supplementation lowered ADFI in mink. The majority of ingested benzoates were absorbed from the gut (over 95%), except in blue foxes, which excreted 6 to 15% of ingested benzoates in feces with incremental increases in benzoate intake. Urinary free benzoic acid excretion accounted for 10% of the ingested benzoates in blue foxes but less than 5% in mink and raccoon dogs. When benzoate intake was 1 mmol/kg BW, mink, blue foxes, and raccoon dogs excreted 71, 77, and 34% of ingested benzoates as hippuric acid in urine, respectively. With higher benzoate intakes, urinary hippuric acid excretion decreased quadratically with mink to 20%, and linearly with blue foxes and raccoon dogs to 45 and 16%, respectively. The hippuric acid pathway appears to be the principal route of benzoate elimination in the mink and blue fox, whereas, in the raccoon dog, other pathways appear to be more important. In mink, the elimination of ethyl benzoate did not differ from that of sodium benzoate. Because glycine conjugation is the primary route of benzoate elimination, it is recommended that benzoate content in fur animal feeds should not exceed 1 g/kg feed on an as-fed basis.

Journal of Animal Science, 2000: 78, 976-986, 1 figs, 4 tables, 30 refs.

Effect of heat treatment of soybean meal and fish meal on amino acid digestibility in mink and dairy cows

K. Ljøkjel, O.M. Harstad, A. Skrede

Commercial solvent extracted soybean meal (SBM) and fish meal (FM) subjected to additional moist heat for 30 min at 120 or 130°C were investigated in terms of amino acid (AA) composition, total tract digestibility in mink, rumen and total tract digestibility in dairy cows of crude protein (CP) and individual AA. Heat treatment of SBM at 130°C caused significant reduction of the content of Arg, Lys and Cys by 4.1, 8.2 and 12.5%, respectively. Digestibility in mink of CP and most AA was significantly reduced after heat treatment of SBM at 120°C and further at 130°C. The digestibilities of Cys, Asp and Lys, which were the most severely affected AA, declined with 12.3, 10.9 and 8.8 percentage units, respectively, after treatment at 130°C. Heat treatment of FM at 120°C caused reduced digestibility of CP and His, Ile, Lys, Met, Asp, Glu, Gly, and Ser, while heat treatment at 130°C reduced total tract digestibility of CP and all AA in mink. Digestibility of Asp and Cys were most affected after heat treatment at 130°C with reduction of 17.9 and 11.4 percentage units, respectively. Rumen degradability of CP and all AA was significantly lowered by heat treatment of SBM. Met and Glu were the most affected AA, with a reduction of degradability after 16 h rumen incubation of 62.1 and 58.0 percentage units, respectively, after treatment at 130°C. Heat treatment of FM at 120°C caused declined rumen degradability of CP and total AA, although not to the same extent as for SBM. There was no additional effect on rumen degradability of treatment at 130°C of FM. Rumen degradation of Glu and His, the most affected AA, in FM was reduced with 25.1 and 20.3 percentage units, respectively, following heat treatment at 120°C. Ruminant total tract digestibility of CP and AA was not significantly affected by treatment for either of the protein sources. Additional heat treatment of SBM reduced the rumen degradability of protein and AA more than treatment of FM, while for the nonruminant mink, total tract digestibility of SBM and FM was reduced similarly following heat treatment.

Animal Feed Science and Technology, 2000: 84, 83-95, 6 tables, 39 refs.

Nonsuppurative meningoencephalitis associated with Aleutian mink disease parvovirus infection in ranch mink

N.W. Dyer, B. Ching, M.E. Bloom

Severe nonsuppurative meningoencephalitis associated with Aleutian mink disease parvovirus (ADV) infection was observed in adult ranch mink. Brain lesions included severe, locally extensive to coalescing lymphoplasmacytic meningoencephalitis with accompanying gliosis, satellitosis, and mild extension of inflammation into the leptomeninges. ADV was identified in mesenteric lymph node, spleen, brain, and liver of affected mink by polymerase chain reaction techniques. Sequences of the ADV isolate (TH5) revealed 2 unique residues in the region of the viral genome that determines pathogenicity. These findings suggest that certain strains of ADV may preferentially cause disease in the nervous system. ADV infection should be considered in the differential diagnosis of neurologic disorders in mink.

Journal of Veterinary Diagnostic Investigation, 2000: 12, 159-162, 3 figs, 24 refs.

A comparative study of a new rapid and one-step test for the detection of parvovirus in faeces from dogs, cats and mink

J. Esfandiari, B. Klingeborn

A one-step immunochromatographic test, based on the use of monoclonal antibodies, was developed for the detection of canine parvovirus (CPV) in dog faeces. In addition to canine parvovirus the test can also be used for the diagnosis of infections with viruses causing parvovirus enteritis in cats (feline panleukopenia virus) and mink (mink enteritis virus). Four hundred and forty-three faecal samples were evaluated by comparative testing between this one-step test and three different enzyme-linked immunosorbent assays (ELISA) in Sweden, Denmark and The Netherlands. The result of the evaluation showed an overall relative sensitivity and specificity of 95.8 and 99.7 %, respectively. Furthermore, the comparative testing of 83 dog samples in Germany between the one-step test and an immune electron microscopy (IEM) agreed to 85.5 %. The sensitivity and specificity were 83.9

and 88.9 %, respectively. These results show that the one-step test is a rapid, simple, reproducible and sensitive diagnostic test for the detection of parvovirus in faecal samples of dogs, cats and mink.

Journal of Veterinary Medicine, Series B, 2000: 47, 145-153, 4 figs, 7 tables, 10 refs.

Optimal behaviour sampling and autocorrelation curve: modelling data of farmed foxes

L. Jauhiainen, H.T. Korhonen

Behavioural investigations frequently make use of video recordings. In a typical study, behaviour is recorded during a 24-h period using instantaneous sampling, a method whereby consecutive samples taken from the same animal are autocorrelated. This study sought to model the autocorrelation function and to evaluate the optimal sampling interval for recording periods of different length in farmed blue foxes. The data were based on video recordings. The autocorrelation was found to have two components: short-range and long-range. The range of the short-range component was from 2-4 min, implying that an animal continues the same operation without interruption for several minutes. The duration of the long-range component was from 20 to 75 min and was affected by the animal's mental state. The optimal sampling interval was not the same for all the behaviours studied and, moreover, depended on the length of the recording period. If the recording period lasted for 3 to 5 days, the optimal sampling interval was from 10 to 15 min; if, however, there was only one recording day, the optimal sampling interval was from 4 to 6 min.

Acta Ethologica, 2005: 15, 13-21, 2 figs, 3 tables, 34 refs.

**Meeting at the Danish Institute of Agricultural Sciences, Research Centre Foulum,
on 22 September 2005 on the subject**

'Research in relation to future mink breeding'

Internal Report 2005, no. 227 (in Danish)

The focus of the meeting was on presenting new ideas, research results and projects of relevance in relation to future mink production and breeding. The presentations hosted were based on studies carried out at the Danish Institute of Agricultural Studies, the Danish Fur Breeders' Research Center, the Royal Veterinary and Agricultural University, Copenhagen, and at Kopenhagen Fur. The presentations were divided into the following four categories: 1) the research and production challenges facing the Danish mink breeders in a global perspective, 2) the survival and health of mink kits, 3) feed efficiency, and 4) future initiatives. Approximately 155 farmers, advisers, researchers and others participated in the meeting. Below are the abstracts of the presentations hosted:

Survival of mink kits is inherited

B.K. Hansen

Survival of mink kits is inherited. Results from 2410 scanblack in the period from 1996 to 2001, show that 76% of liveborn kits survive until pelting. About 17% of the liveborn kits die during the suckling period. Of weaned kits 89% survive until pelting. Survival of kits depends on kit's own traits to survive and the mother's traits to take care of the kits so they survive. Kit's own ability to survive measured as number of kits alive in percent of liveborn kits in total has a heritability of 0.14 to 0.18. The dam genetic ability to promote the survival of kits has a heritability of 0.12 for the number of kits survived until pelting as percent of weaned kits. The heritability of litter size is low and varies from 0.02 to 0.12.

Meeting at DIAS, Research Centre Foulum, 22 September 2005 on the subject 'Research in relation to future mink breeding'. Internal Report 2005, no.

227 (in Danish). 6 pp, 4 tables, 9 refs. Author's abstract.

Metabolic traits of mink dams selected for high kit body gain

C.F. Matthiesen

A previous selection of mink dams (*Mustela vison*) either for maternal capacity to promote kit growth, (M-Line; Maternal traits), or for kits own capacity for growth until weaning (K-line; Kit capacity) has initiated the present investigation of the quantitative metabolism of the two selection lines. Significant ($P < 0.001$) interactions between line and period were found for heat production (HE) of the lactating dams. Likewise, there was an interaction ($P = 0.04$) between line and period for retained energy (RE) during the lactation period. These interactions might explain why the M-line dams maintain their body weight considerably better than expected in the light of the strain of a high milk yield.

Meeting at DIAS, Research Centre Foulum, 22 September 2005 on the subject 'Research in relation to future mink breeding'. Internal Report 2005, no. 227 (in Danish). 7 pp, 3 figs, 2 tables, 1 ref. Author's abstract.

Effects of nest building in farm mink

J. Malmkvist

Different types of nesting materials are used in the production of farm mink (*Mustela vison*). However, the effects of e.g. nest building activity by females

around parturition and the best nest environment have not been investigated into great detail, even though the early kit mortality is considerable. The purpose of the present study was to investigate whether the possibility to build a nest affects the course of birth in mink, stress and behaviour of females in relation to early kit mortality. Data included glucocorticoid metabolites in faeces from females before and after giving birth, temperature and humidity in nests, degree of nest building behaviour, direct observation of birth durations and interbirth intervals from video recordings, autopsy of all dead kits, individual weight of kits day 1 and 7 after birth, and maternal behaviour, in terms of keeping the litter together and the kit retrieval test. Preliminary results shows that lack of nest building possibility may have a negative impact, since it tended to increase the variation in interbirth interval between kits. After parturition, females with only wood shavings had a higher level of a glucocorticoid metabolite, as an indicator of a higher level of stress, in comparison to females with access to straw and/or an artificial nest.

Meeting at DIAS, Research Centre Foulum, 22 September 2005 on the subject 'Research in relation to future mink breeding'. Internal Report 2005, no. 227 (in Danish). 12 pp, 2 figs, 3 tables, 10 refs. Author's abstract.

Feeding during the flushing and gestation periods – effects on litter size and health in mink

S. Møller, I.C. Klaas

Based on the assumption that mink fed ad libitum during the implantation period will implant a high proportion of the blastocytes present and thereby give birth to large litters, the energy allowance during the implantation period of female mink has been increased to much more than the need of approx. 200 kcal/female/day in many Danish mink farms. This assumption is contradicted by the few experiments performed on the subject. High energy allowance during implantation often leads to low energy allowance in the latter part of gestation, and thereby increase the risk of pre-weaning diarrhoea in the kits. Data from 5 years (1994-1998) and 135 private mink farms on the feeding strategy in the winter, mating and gestation periods at farm level, the number of females and reproduction in Brown,

Black and Other colour types was made available from a large Danish feed plant. 125 farms had also filled in an annual questionnaire on the prevalence of pre-weaning diarrhoea. The litter size in different colour types were analysed, using a mixed linear model including the difference in kcal/female/day between the Flushing and Conditioning period, between the Implantation and Prenatal period as well as herd size, colour type and year. The analysis showed a significant increase in litter size of 0.36 kits per 100 g difference in feed allowance between the Flushing and Conditioning period ($P < 0.0001$) and with increasing herd size ($P < 0.05$). The difference in energy allowance between the Implantation and Prenatal periods had no significant effect on litter size ($P = 0.39$). Furthermore, the litter size differed significantly between colour types ($P < 0.0001$) and between years ($P < 0.05$). The risk factors for pre-weaning diarrhoea were tested in a univariable logistic regression model with farm as repeated effect between years. Two hazards for pre-weaning diarrhoea at farm level were identified: 1). Severely restricted feeding during the winter followed by a high energy allowance during the flushing period. A difference between the Flushing and Conditioning periods of 90 kcal/female/day at farm level increases the risk ($OR = 3.03$; $p = 0.01$). 2). A high energy allowance during the implantation period and the first part of the gestation period followed by a drastic decrease in the later part of the gestation period. By each kcal/female/day in difference between the Implantation and Prenatal two periods the risk of pre-weaning diarrhoea at farm level increases by $OR = 1.013$ ($p < 0.05$). A difference between the two periods of 90 kcal/female/day at farm level increases the risk by $OR = 3.20$.

Meeting at DIAS, Research Centre Foulum, 22 September 2005 on the subject 'Research in relation to future mink breeding'. Internal Report 2005, no. 227 (in Danish). 10 pp, 1 fig, 2 tables, 26 refs. Authors' abstract.

Survival and well-being of kits from birth to weaning

C. Hejlesen

In extreme situations the dietary composition can affect the death rate of mink kits in the

period from birth to weaning. But as mortality is affected by many factors that are not related to the dietary composition it is often impossible to pinpoint dietary compositions as the cause.

If the well-being of the kits from birth to weaning is expressed as growth, the dietary composition does affect their well-being. Reducing the percentage of metabolizable energy (ME) from protein compared to the prevailing level in practice of approximately 50% does increase the weight of the kits 28 and 42 days after parturition. It is concluded that the female's protein requirement (% of ME) for milk production is 30% of ME until 28 days after parturition. The protein requirement for optimal growth from 28 days after parturition and onwards hasn't finally been established, but is shown to be within the range of 34 – 45 % of ME.

Meeting at DIAS, Research Centre Foulum, 22 September 2005 on the subject 'Research in relation to future mink breeding'. Internal Report 2005, no. 227 (in Danish). 8 pp, 1 fig, 4 tables, 19 refs. Author's abstract.

Feeding during the flushing and gestation periods – effects on litter size and health in mink

S.H. Møller, V.H. Nielsen, B.K.Hansen

Most farmed mink in Denmark are fed close to the average ad libitum intake during the growth period, based on feed leftovers at farm, shed or row level. Variation in voluntary feed intake between male + female pairs is ignored apart from the distribution of feed leftovers to cages without feed left over from the day before. Technological development has facilitated individual feeding and thus the possibility for true ad libitum feeding of mink. The variation in voluntary feed intake, weight gain and feed efficiency was studied in 3 lines of male + female pairs of Scanbrown mink kits fed ad libitum (AL), restricted (RF) or farm fed (FF) according to normal practice during 15 weeks from 12 weeks of age in July to 26 weeks of age in November. The feed allowance was adjusted 3 times a week based on feed leftovers registered Monday, Wednesday and Friday. The average feed intake, weight gain and feed efficiency was highest in the (AL) line and lowest (FF) line after one generation of selection for body weight in November. The average feed

efficiency was 64, 60 and 55 g/kg feed in line AL, RF and FF respectively. Of the total increase in feed efficiency of 17 and 9 % in the AL and RF lines in 2004 compared to the control line FF 8 percentage points could be attributed to the selection in both lines. Compared to the normal feeding practice, individual ad libitum feeding provides the opportunity to utilise the full potential of the mink kits for growth and feed efficiency, and thereby for effective selection for these traits. Selection for body weight increase the feed efficiency by the same magnitude under both ad libitum and restricted feeding. The feeding strategy and selection criteria applied will determine whether the increased feed efficiency results in bigger mink or in reduced feed consumption.

Meeting at DIAS, Research Centre Foulum, 22 September 2005 on the subject 'Research in relation to future mink breeding'. Internal Report 2005, no. 227 (in Danish). 10 pp, 3 figs, 5 tables, 7 refs. Authors' abstract.

Can feed efficient breeding animals be found?

P. Berg

As feed is the largest cost in mink production, a genetic improvement will contribute to the general efficiency of mink production. Feed consumption per cage can now be recorded automatically. Thus feed efficiency or feed conversion ratio can be calculated per cage. But to effectively select for feed utilization there is a need to compute individual breeding values. Feed conversion ratio is a weighted mean of the feed conversion ratio of the two animals in the cage, the weights being the relative gain of the total gain in the cage. This allows for modelling individual genetic effects for feed conversion ratio (random regression model) where individual breeding values can be predicted. In data from lines selected for feed conversion ratio we found genetic variation in feed consumption and feed conversion ratio, a high genetic correlation between respectively feed consumption and feed conversion ratio in the two sexes. In addition, it was shown that the genetic effect (breeding value) for feed conversion ratio can be computed for individuals, when feed consumption is recorded per cage and gain is recorded individually.

Meeting at DIAS, Research Centre Foulum, 22 September 2005 on the subject 'Research in relation to future mink breeding'. Internal Report 2005, no. 227 (in Danish). 7 pp, 1 fig, 1 table, 8 refs. Author's abstract.

Standard cages and climbing cages – advantages and disadvantages

S.W. Hansen, J. Malmkvist

Group-housing makes it possible to increase the number of animals and thus improve profitability. At the same time, the individual mink may benefit from more space, provided that the actual liberty of action is not restrained by the other mink in the cage. Furthermore, a large cage makes it possible to increase complexity, which is an advantage with regard to the welfare of the animals, e.g. several studies have demonstrated group-housing results in a reduction of tail chewing/tail sucking. However, the mink is a solitary animal, and consequently increased aggression is a documented problem in mink kept in groups. Furthermore, group-housing makes it more difficult for the farmer to monitor the welfare of the individual mink in that it becomes difficult to observe the appetite and the consistency of faeces of the individual animal. Future studies should elucidate when and in which situations aggression is seen in mink (competition for feed, nest boxes, territory), the possibilities of reducing the level of aggression by means of more expedient cage environments (nest boxes, possibilities of escape and occupation), the level of aggression within colour type, and the possibilities of selection against aggression. Recent studies have demonstrated that it is possible to reduce the level of fur chewing/fur sucking, stereotypic behaviour and physiological stress in mink kept in conventional production cages by enrichment of the cages. However, the challenge of finding an applicable occupational material that remains of interest to the mink and that can last the scratching and biting of the animals still needs to be met. At the same time, it is concluded that the cage environment is more

important to the welfare of mink than is the size of the cage.

In further studies on effects of enrichment and social housing we stress the importance of an adequate experimental design to differentiate the effects of e.g. feeding regime from the effects being studied. Also the history of the animal (genetics plus environmental effects) must be taken into account when planning experiment, with the attempt to show effects on behaviour and welfare measures).

Meeting at DIAS, Research Centre Foulum, 22 September 2005 on the subject 'Research in relation to future mink breeding'. Internal Report 2005, no. 227 (in Danish). 12 pp, 40 refs. Authors' abstract.

FurMap

V.H. Nielsen

Mapping of genes provides new possibilities for genetic improvement of fur quality traits in mink. Mapping of genes requires a detailed gene map with a large number of markers. The genetic markers are microsatellites which exhibit large variation and genes which are useful in comparative gene mapping. Both establishment of a gene map and mapping of genes are performed in a 3-generation QTL-population. The population is established by crossing lines which are phenotypically and genetically very different for the traits involved. The mapping is obtained by combining information from the genetic markers with phenotypic recordings in the population.

Meeting at DIAS, Research Centre Foulum, 22 September 2005 on the subject 'Research in relation to future mink breeding'. Internal Report 2005, no. 227 (in Danish). 6 pp, 5 figs, 5 refs. Author's abstract.

Stereotyped behaviour and welfare in mink (*Mustela vison*)

Master's thesis in biology

by

Pernille Maj Svendsen

**Stereotyped behaviour and welfare in mink
(*Mustela vison*)**



M.Sc. THESIS
PERNILLE MAJ SVENDSEN
AUGUST 2005

August 2005

Supervisors:

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Biological Institute
University of Copenhagen

Department of Animal Health and Welfare
Research Centre Foulum
Danish Institute of Agricultural Sciences

The thesis is the result of a project carried out in collaboration with two institutions: Animal Behaviour Group, Biological Institute, University of

Copenhagen, and the Department of Animal Health and Welfare, Research Centre Foulum, Danish Institute of Agricultural Sciences (DIAS).

The first part of the project (data collection) was conducted at DIAS in Foulum under the supervision of Steffen Werner Hansen.

During the second part of the project I worked at the Animal Behaviour Group in Copenhagen, where the data analyses and the subsequent writing took place under the supervision of Leif Lau Jeppesen.

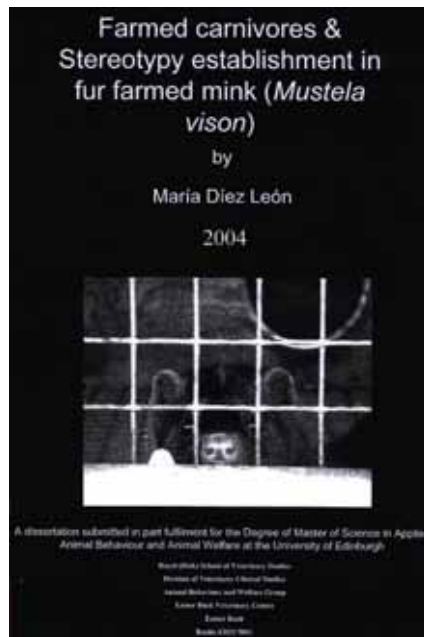
The thesis consists of two article manuscripts based on the same data set. Manuscript I focuses on the

question of possible welfare consequences of selection for and against stereotyped behaviour in mink. The manuscript is expected to be submitted to Applied Animal Behaviour Science once the experiment has been repeated during fall 2005 to verify the results. Manuscript II focuses on the variation in stereotyped behaviour. It is intended to be submitted to Applied Animal Behaviour Science.

**Farmed carnivores & Stereotypy establishment in fur farmed mink
(*Mustela vison*)**

by

María Díez León



**A dissertation submitted in part fulfilment for the Degree of Master of Science in Applied
Animal Behaviour and Animal Welfare at the University of Edinburgh
2004**

Royal (Dick) School of Veterinary Studies
Division of Veterinary Clinical Studies
Animal Behaviour and Welfare Group
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The results from this study suggest that, in general, mink motivation to stereotype is stronger than motivation to explore. The study also confirms the fact that hunger is not the only motivation to stereotype. The ease of interruption, apart from being related to the degree of establishment of the

population, seems to depend on the properties of the interruptor, as all the mink in the experiment were interrupted with the stimulus employed. This further confirms the importance of the qualities of the enrichments employed in i.e. zoos and of water for mink in particular. The new measures of

establishment proposed – location and form of the stereotypy – need of further study as this experiment did not show any conclusive findings.

The experimental design of this study presented a number of limitations:

- The study only accounted for mink of one year old. In order to study establishment properly, a range of ages would have been preferred
- Due to the time assigned for the experimental part of the dissertation, the study had to be carried out in summer months. This time of the year is not the best one to observe stereotypies as most of the females are pregnant. For this reason, only barren females were studied, limiting the results to that particular population.
- I would have been desirable not to censor the time of observation after the interruption, as this measure influenced all the statistical analysis employed and did not permit to study the real latency times for some of the observations.
- It would have been wise to study other measures of establishment as well as the ease of interruption (e.g. harder to abolish with environmental enrichment).
- For practical reasons, the type of behaviour interrupted was not decided prior to the experiment. Doing so would have taken out more variability from the sample, and therefore is advisable for future studies.

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