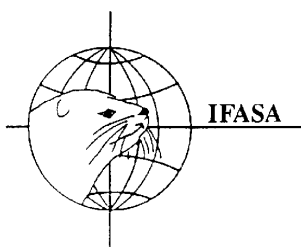
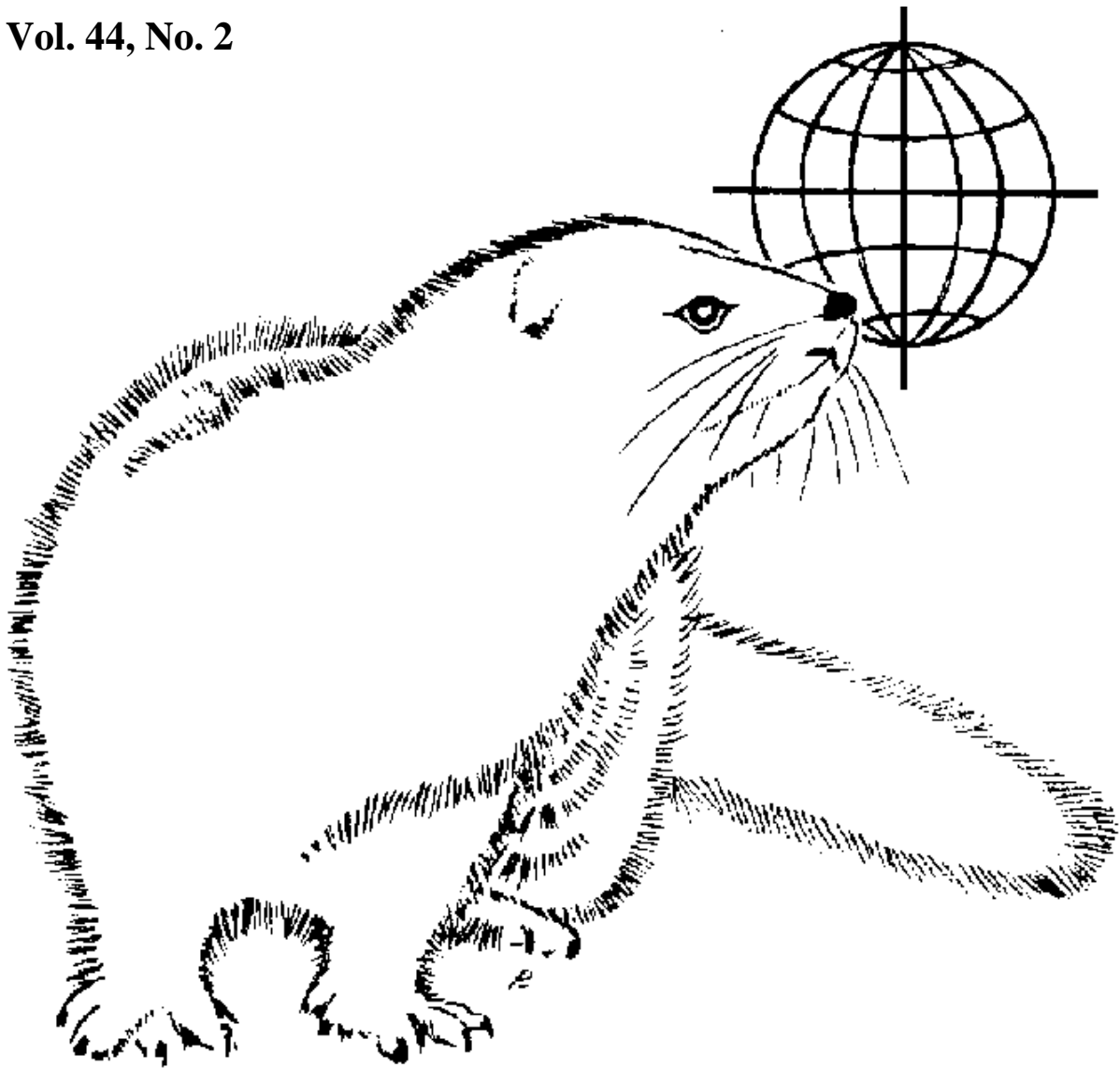


SCIENTIFUR

SCIENTIFIC INFORMATION IN FUR ANIMAL PRODUCTION

Vol. 44, No. 2



INTERNATIONAL FUR ANIMAL SCIENTIFIC ASSOCIATION

SCIENTIFUR scientific information for those involved in fur animal production is published by the International Fur Animal Scientific Association (IFASA).

SCIENTIFUR is the focal point for fur animal researchers all over the world and serves as a platform for scientific and other communication among researchers and others who are interested in the production of fur bearing animals. As such **SCIENTIFUR** contains reports of both basic and applied research as well as abstracts of publications published elsewhere and information regarding congresses, scientific meetings etc. A reference in Scientifur does not imply an endorsement by IFASA of the content, views or conclusions expressed.

SCIENTIFUR is published as four issues per year (one volume).

SCIENTIFIC ARTICLES. Papers forwarded can be published in Scientifur. The scientific content of the article is the sole responsibility of the author(s)

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SUBSCRIPTION: Free of charge: <http://www.ifasanet.org>

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INDEXING: Titles that have been published in SCIENTIFUR are covered in an electronic SCIENTIFUR INDEX.

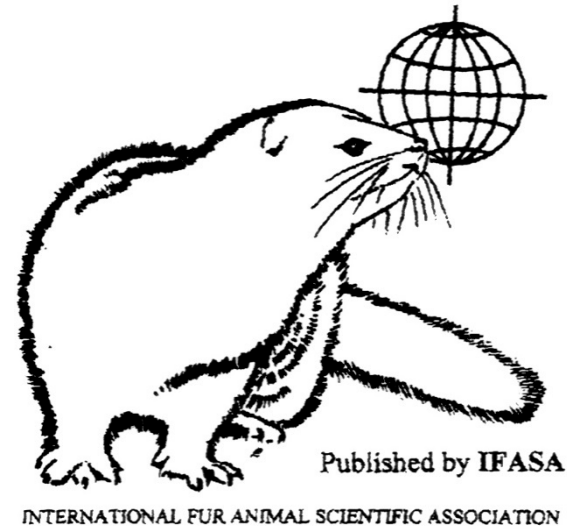
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SCIENTIFUR
ISSN 0105-2403
Vol. 44, No. 2



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Notes from the Editor

The spread of coronavirus COVID-19 worldwide has caused serious human, social and economic challenges. At present, we do not know the long-term consequences of this tragic global health pandemic. As a matter of course, the fur industry is also affected. This has meant that fur auctions have been cancelled or postponed. Exhibitions have been cancelled as well. In the societies, many people work from home as required by many authorities or governments and video conferencing is now used to a far greater extent in working relationships. Similarly, digital solutions are being sought for the conduct of upcoming auctions. This is a responsible solution that helps ensure the health of both customers and employees and helps support the economy in this area.

In 2020, the XII International Scientific Congress in Fur Animal Production will be held in a collaboration between the International Fur Animal Scientific Association (IFASA) and the Polish Society of Animal Production (PSAP). The congress will be held in Warsaw in Poland from 25 to 27 August. For further information, please consult: <https://ifasa2020.pl/>.

The IFASA Congress is an important forum for researchers in fur animal production to gather to present and discuss recent research and outline research to address future challenges.

I encourage all researchers with interest in fur animal production to participate in this important event. Important topics are welfare and behaviour, breeding, genetics and reproduction, nutrition, feeding and management, health and diseases, and environmental impact of fur farms. Please note that deadline for **registration** with a low fee has been extended to **15 June 2020**. Deadline for submission of **manuscripts and short communications** has been extended to **April 17, 2020**.

Colour mutants are important in fur animal production. I am thrilled to bring a publication about a new brown colour mutant in Blue Fox (*Vulpes lagopus*) discovered by an attentive Finnish breeder in this issue of Scientifur. The 2019 Annual Report from Copenhagen Fur Research is also published in this edition.

The results of a study, referred to in this issue of Scientifur indicate that Vitamin E supplementation improves the antioxidative status in mink dams and enhances the immune functions, decreases pre-weaning mortality and enhances weaning weight of the kits. The results of a study in blue fox indicate that the protein content in feed for adult foxes can be reduced when the low protein diet is supplemented with methionine.

Vivi Hunnicke Nielsen

Editor Scientifur

A New Brown Colour Mutant in Blue Fox (*Vulpes lagopus*)

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Abstract

A new brown colour mutant was identified in blue fox (*Vulpes lagopus*) and named *arctic burgundy*. Homology was demonstrated with the mutant *burgundy* in silver fox (*Vulpes vulpes*). The inter species type produced by crossing with silver fox *burgundy* was named *burgundyfrost*

Key words: Blue Fox, *Vulpes lagopus*, colour mutant, *arctic burgundy*, *burgundyfrost*

Introduction

Brown fur colour is known in both silver fox (*Vulpes vulpes*) and arctic fox (*Vulpes lagopus*). Several genes causing brown fur colour are observed in silver fox. In arctic fox, a brown arctic pearl mutant was born in 1978 in Norway on the farm of Heggem brothers. A similar type appeared in 1985 in Finland on Nahkala's farm. These two types are caused by the same gene or its allelic forms. Brown arctic pearl was the only brown type of *Vulpes lagopus* until 2016 when the farmer Erkki Hannula in Alavieska, Finland discovered 4 brown individuals in a blue fox litter of 10 cubs.



Fig. 1. The colour of *arctic burgundy* cubs is pale brown (Photo: Vesa Sorvari)

A new mutant

During the years following 2016, experiments by Erkki Hannula and his neighbouring farms showed that matings between brown individuals always produced 100 % brown cubs but that mating of brown and blue fox produced 100 % blue fox coloured cubs.

The results led to the conclusion that the brown colour was caused by a recessive autosomal gen. The theory was further confirmed by the results received when mating blue fox coloured offspring from brown x blue fox matings, either with each other or with brown individuals. These experiments gave both brown and blue fox coloured cubs, thus confirming that the blue fox coloured individuals were carrying the brown gene.

The new mutant contra arctic pearl

In the next step, the relationship between the brown arctic pearl mutant and the new mutant was clarified by matings between these two types. In all cases, these matings produced only blue fox coloured cubs and thus showed that these two brown types are caused by different genes.



Fig. 2. A blue fox at the back and the mutant type *arctic burgundy* in front. (Photo: Göran Sten)

Phenotypic features

As cub, the colour of the new type is pale brown (Fig. 1). Like in blue fox, the underfur in prime winter coat gets lighter but the mutant is well distinguished from blue fox due to the brown tips of guard hairs, which make a brown veil over the pelage (Fig. 2). The brown colour is most prominent on the head, especially behind the ears (Fig. 3). The underfur is pale bluish grey.



Fig. 3. The brown colour is most prominent on the head of the colour mutant *arctic burgundy* (Photo: Göran Sten)

Inter species hybrids with the new type

The new mutant is interesting also when producing inter species hybrids. It has been tested with most brown mutants of *Vulpes vulpes*. Most mating combinations produced only bluefrost offspring, but in matings with the silver fox *burgundy* mutant, only 100 % brown frost type cubs were observed. This means that the genes for these two types are homologous. As cubs, the colour is almost similar with the brown blue fox type, the white tip of the tail, however, identifies the frost cubs clearly (Fig. 4). The adult winter coat is darker but a large variation in the shade of the colour is obvious (Fig. 5).



Fig. 4. Brown blue fox mutant (*arctic burgundy*) on the left and inter species hybrid with silver fox (*burgundyfrost*) on the right. (Photo: Vesa Sorvari)

The name of the new mutant

The earlier known brown mutant arctic pearl is proved to be homologous with the Polish pastel type

of silver fox (*Vulpes vulpes*). The offspring between Polish pastel and arctic pearl gives pale brown pelts, which have been marketed under the name *amberfrost*.



Fig. 5. *Burgundyfrost* pelts (Photo: Sonja Gerke)

Based on the above reported experiments it is confirmed that this brown type is a new mutant in *Vulpes lagopus*. The mutant is named *arctic burgundy* and the inter species type produced by crossing with silver fox *burgundy* type is named *burgundyfrost*. (The names have been confirmed by the Breeding Committee for Fur Animals, Nordic Association of Agricultural Scientists).

BREEDING, GENETICS AND REPRODUCTION**Baboon bearing resemblance in pigmentation pattern to Siamese cat carries a missense mutation in the tyrosinase gene**

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An infant hamadryas baboon exhibiting an albino phenotype-white body hair and red eyes-was born to parents with wild-type body color. Pigmentation on some parts of its body surfaced during childhood and progressed with age. This baboon in adulthood has gray hair on parts of its body, such as the tail, distal portion of the legs, and face, with the remainder being white. This pigmentation pattern resembles that of the Siamese cat and the Himalayan variants of the mouse and the mink. The distinguishing phenotypes in these animals are known to be caused by a temperature-sensitive activity of tyrosinase, an enzyme essential for biosynthesis of melanin. We sequenced all the five exons of the tyrosinase (*TYR*) gene of this albino baboon, which were amplified by PCR, and found a base substitution leading to alteration of the 365th amino acid from Ala to Thr. Tyrosinase requires copper as a cofactor for its enzyme function. It has two copper-binding sites, the second of which contains His residues in positions 363 and 367 that are critical to its function. Thus, p.(Ala365Thr) due to a mutation in the *TYR* gene is a likely candidate for the cause of the albino phenotype in this baboon.

Genome. 2020 Feb 13:1-5.

Doi: 10.1139/gen-2020-0003. Epub ahead of print.

Comparison of the structure of chinchilla sperm isolated from semen and from the tail of the epididymis

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Reprod Domest Anim. 2020 Jan 27.

Doi: 10.1111/rda.13646. Epub ahead of print.

NUTRITION, FEEDING AND MANAGEMENT**Effects of dietary vitamin E supplementation on the reproductive performance of yearling female mink (*Neovison vison*) fed wet fish-based feed**

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Anim Reprod Sci. 2020 Feb; 213:106270.

Doi: 10.1016/j.anireprosci.2019.106270.

Epub 2019 Dec 28.

Evaluation of Growth Curve Models for Body Weight in American Mink

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Modelling the growth curves of animals is important for optimizing the management and efficiency of animal production; however, little is known about the growth curves in American mink (*Neovison vison*). The study evaluated the performances of four three-parameter (Logistic, Gompertz, von Bertalanffy, and Brody), four four-parameter (Richards, Weibull, Bridges, and Janoscheck) and two polynomial models for describing the growth curves in mink. Body weights were collected from the third week of life to the week 31 in 738 black mink (373 males and 365 females). Models were fitted using the *nls* and *nlsLM* functions in stats and minpack.lm packages in R software, respectively. The Akaike's information

criterion (AIC) and Bayesian information criterion (BIC) were used for model comparison. Based on these criteria, Logistic and Richards were the best models for males and females, respectively. Four-parameter models had better performance compared to the other models, except Logistic model. The estimated maximum weight and mature growth rate varied among the models and differed between males and females. The results indicated that males and females had different growth curves as males grew faster and reached to the maximum body weight later compared to females. Further studies on genetic parameters and selection response for growth curve parameters are required for development of selection programs based on the shape of growth curves in mink.

Animals (Basel). 2019 Dec 20; 10(1). pii: E22.
Doi: 10.3390/ani10010022.

Ileal and total tract digestibility and nitrogen utilisation in blue fox (*Vulpes lagopus*) fed low-protein diets supplemented with DL-methionine and L-histidine

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To formulate low-protein diets for blue foxes with sufficient amounts of amino acids (AA), AA digestibility and AA requirements of the animals are crucial information. Therefore, a digestibility and nitrogen (N) balance trial was conducted with 20 blue foxes to determine the macronutrient and AA digestibility and N utilisation in low-protein diets supplemented with DL-methionine (Met) and L-histidine (His). In addition, plasma urea and plasma AA were measured. The diets were designated as P24 (control), P20, P20M, P16M and P16MH and contained energy from digestible crude protein (DCP) at 24%, 20% or 16% of total dietary metabolisable energy (ME). The 20% protein level was fed with or without Met and the 16% protein level was fed with Met and with or without His. The apparent total-tract digestibility (ATTD) of crude protein linearly decreased with decreasing dietary protein level. The ATTD of dry matter, organic matter and crude carbohydrates increased when wheat starch was added as a replacement for protein.

The apparent ileal digestibility (AID) and ATTD methods were compared to determine the AA digestibility. The decreasing dietary protein supply decreased the ATTD of most of the AA: threonine, tryptophan (Trp), valine, alanine (Ala), aspartic acid (Asp), glutamic acid, glycine (Gly), proline (Pro), serine (Ser) and total AA. The AID of the AA was constant between diets. Diverging AA showed higher or lower digestibility when determined in the AID or ATTD methods. Isoleucine, lysine, Met, Ala and tyrosine showed higher levels of AID. Arginine, His, cysteine (Cys), Trp, Asp, Gly, Pro and Ser showed higher levels of ATTD, which may reflect the net loss of these AA in the large intestine. Met and His supplementation improved the ATTD and AID of the AA in question, respectively, but did not affect the other variables examined. N retention did not differ between diets and renal N excretion decreased with decreasing protein level; thus N utilisation improved. It was concluded that the protein supply and AA composition in low-protein diets with supplemented Met were adequate for adult blue foxes, since the lower protein supply improved N utilisation and did not affect N retention. However, His supplementation failed to reach the designed level and therefore showed no clear results.

Arch Anim Nutr. 2020 Mar 11:1-19.
Doi: 10.1080/1745039X.2020.1716655.
Epub ahead of print.

Dietary variation in Icelandic arctic fox (*Vulpes lagopus*) over a period of 30 years assessed through stable isotopes

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Identifying resources driving long-term trends in predators is important to understand ecosystem

changes and to manage populations in the context of conservation or control. The arctic fox population in Iceland has increased steadily over a period of 30 years, an increase that has been attributed to an overall increase in food abundance. We hypothesized that increasing populations of geese or seabirds were driving this growth. We analyzed stable isotopes in a long-term series of collagen samples to determine the role of these different resources. The isotopic signatures of arctic foxes differed consistently between coastal and inland habitats. While $\delta^{15}\text{N}$ displayed a non-linear change over time with a slight increase in the first part of the period followed by a decline in both habitats, $\delta^{13}\text{C}$ was stable. Stable isotope mixing models suggested that marine resources and rock ptarmigan were the most important dietary sources, with marine resources dominating in coastal habitats and rock ptarmigan being more important inland. Our results suggest that seabirds may have been driving the arctic fox population increase. The rapidly increasing populations of breeding geese seem to have played a minor role in arctic fox population growth, as rock ptarmigan was the most important terrestrial resource despite a considerable decrease in their abundance during recent decades. This study shows that a long-term population trend in a generalist predator may have occurred without a pronounced change in main dietary resources, despite ongoing structural changes in the food web, where one species of herbivorous birds increased and another decreased.

Oecologia, 2020 Feb; 192(2): 403-414.
Doi: 10.1007/s00442-019-04580-0.
Epub 2019 Dec 21.

Were ancient foxes far more carnivorous than recent ones?-Carnassial morphological evidence

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Crown shape variation of the first lower molar in the arctic (*Vulpes lagopus*) and red foxes (*Vulpes vulpes*) was analyzed using five groups of morphotypes. Carnassial morphologies were compared between the species and between spatially and temporally distant populations: one Late Pleistocene (n = 45) and seven

modern populations of the arctic fox (n = 259), and one Late Pleistocene (n = 35) and eight modern populations of the red fox (n = 606). The dentition of Holocene red foxes had larger morphotype variability than that of arctic foxes. The lower carnassials of the red fox kept have some primitive characters (additional cusps and stylids, complex shape of transverse cristid), whereas the first lower molars of the arctic fox have undergone crown shape simplification, with the occlusal part of the tooth undergoing a more pronounced adaptation to a more carnivorous diet. From the Late Pleistocene of Belgium to the present days, the arctic fox's crown shape has been simplified and some primitive characters have disappeared. In the red fox chronological changes in the morphology of the lower carnassials were not clearly identified. The phyletic tree based on morphotype carnassial characteristics indicated the distinctiveness of both foxes: in the arctic fox line, the ancient population from Belgium and recent Greenland made separate branches, whereas in the red foxes the ancient population from Belgium was most similar to modern red foxes from Belgium and Italy.

PLoS One. 2020 Jan 10; 15(1): e0227001.
Doi: 10.1371/journal.pone.0227001.
eCollection 2020.

Functional anatomy of the middle and inner ears of the red fox, in comparison to domestic dogs and cats

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J Anat. 2020 Feb 18.

Doi: 10.1111/joa.13159. Epub ahead of print.

Anomalous Fluorescence of White Hair Compared to Other Unpigmented Keratin Fibres

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Int J Cosmet Sci. 2020 Mar 27.

Doi: 10.1111/ics.12614. Epub ahead of print.

HEALTH AND DISEASE

Dose response of black American mink to Aleutian mink disease virus

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Immun Inflamm Dis. 2020 Mar 13.

Doi: 10.1002/iid3.290. Epub ahead of print.

Detection, genetic, and codon usage bias analyses of the VP2 gene of mink bocavirus

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Mink bocavirus 1 (MiBoV1), a novel virus detected from the feces of domestic minks in China in 2016, may be related to gastrointestinal diseases. However, its prevalence and genetic characteristics are poorly described. In this study, we examined 192 samples collected from minks in the major mink industry province from northern China. PCR results showed that 10 samples (5.2%) were positive for MiBoV1,

and 60% of MiBoV1-positive samples were co-infected with Aleutian mink disease virus or mink circovirus. MiBoV1 was detected in six serum samples. Sequence analysis demonstrated that the VP2 gene of MiBoV1 was highly conserved and had low viral diversity over the VP2 region and unique nucleotide mutations. Phylogenetic analysis of the VP2 sequence demonstrated that MiBoV1 strains formed two clades and were grouped with California sea lion bocavirus, Canine bocavirus, and Feline bocavirus. Codon usage analysis revealed that most of the preferentially used codons in MiBoV1 were A- or U-ended codons, and no evident codon usage bias was found. This study provides evidence that MiBoV1 has a low prevalence in Jilin and Hebei provinces in China. Moreover, it contributes information regarding the expansion of the limited mink bocavirus sequence and determines the codon usage bias of the VP2 gene for the first time. Epidemiological surveillance is necessary to understand the importance and evolution of MiBoV1.

Virus Genes. 2020 Feb 4.

Doi: 10.1007/s11262-020-01738-4.

Epub ahead of print.

Genetic characteristics of canine distemper viruses circulating in wildlife in the United States

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Canine distemper virus (CDV) is a highly contagious disease of wild and domestic mammals. Maintenance of CDV among wildlife plays an important role in the disease epidemiology. Wild animals, including raccoons (*Procyon lotor*) and gray foxes (*Urocyon cinereoargenteus*), serve as reservoirs of CDV and hamper the control of the disease. Recently, we discovered that at least three different CDV lineages (America-3 [Edomex], America-4, and America-5) that are genetically different from the available vaccine strains are circulating in domestic dogs in the United States. Because wildlife serve as a reservoir for the virus, it is important to determine if wildlife play a role in the maintenance and spread of these lineages. To determine the genetic characteristics of circulating strains of CDV in wildlife in various geographic regions in the United States, we studied the nucleotide sequences of the hemagglutinin (H) gene of 25 CDV strains detected in nondomestic species. The species included were free-ranging wildlife: three fishers (*Martes pennanti*), six foxes, one skunk (*Mephitis mephitis*), 10 raccoons, two wolves (*Canis lupus*), and one mink (*Neovison vison*). Strains from two species in managed care, one sloth (*Choloepus didactylus*) and one red panda (*Ailurus fulgens*), were also evaluated. Phylogenetic analysis of the H genes indicated that in addition to America-3, America-4, and America-5 lineages, there are at least two other lineages circulating in US wildlife. One of these includes CDV nucleotide sequences that grouped with that of a single CDV isolate previously detected in a raccoon from Rhode Island in 2012. The other lineage is independent and genetically distinct from other CDV strains included in the analysis. Additional genetically variable strains were detected, mainly in raccoons, suggesting that this species may be the host responsible for the genetic variability of newly detected strains in the domestic dog population.

J Zoo Wildl Med. 2020 Jan 9; 50 (4): 790-797.
Doi: 10.1638/2019-0052.

Seroprevalence of Echinococcus spp. and Toxocara spp. in Invasive Non-native American Mink

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Invasive non-native species can become reservoirs of zoonotic pathogens and cause their spread during colonization, increasing the risk of zoonoses transmission to both wild hosts and humans. American mink (*Neovison vison*) are considered an important invasive mammal species responsible for carrying endoparasites. The aim of our study was to evaluate the role of feral American mink as a possible transmission vector of *Echinococcus* spp. and *Toxocara* spp. in wildlife. We analysed the frequency of American mink exposure to both parasites, the spatial distribution in Poland, and the variability over time on the basis of specific antibody presence using ELISA and Western blot. Alimentary tract analyses revealed that American mink do not serve as definitive hosts for these parasites. Altogether, 1100 American mink were examined. The average seropositivity for American mink was 14.2% for echinococcosis and 21.7% for toxocarosis; dual-seropositivity was detected in only 6.0%. Seroprevalence of both parasites differed between study sites and significantly increased over time in *Toxocara* spp. Thus, our study revealed that free-living American mink are exposed to parasites and likely to be involved in the maintenance of both *Echinococcus* spp. and *Toxocara* spp. in the wild as paratenic hosts.

Ecohealth. 2020 Jan 27.

Doi: 10.1007/s10393-020-01470-3.

Epub ahead of print.

Emergence of an Eurasian avian-like swine influenza A (H1N1) virus from mink in China

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Vet Microbiol. 2020 Jan; 240:108509.

Doi: 10.1016/j.vetmic.2019.108509.

Epub 2019 Nov 22.

Two genetically similar H9N2 influenza viruses isolated from different species show similar virulence in minks but different virulence in mice

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The H9N2 influenza virus has been frequently endemic in poultry, infected mammals and humans and has threatened public health. It is therefore imperative to understand the molecular mechanism enabling this virus to jump from avian to mammalian species. In this study, two H9N2 influenza viruses were isolated from the same region in eastern China but from different hosts; one was isolated from mink and named A/Mink/Shandong/WM01/2014(H9N2)(WM01), while the other was isolated from chicken and named A/Chicken/Shandong/LX830/2014(H9N2)(LX830).

Sequencing and phylogenetic analysis showed that both H9N2 influenza viruses had similar genetic backgrounds. The results of infection in minks suggested that both viruses caused significant weight loss and pathological changes in the lungs. Mouse infection showed that LX830 was nonpathogenic in mice, but WM01 resulted in 25% mortality and pathological changes in the lungs, such as severe edema and diffused inflammation of the interalveolar septa. Comparison of the full genomes of both H9N2 influenza viruses showed 52-nucleotide-synonym mutations in 8 gene segments and 7-nucleotide-antonym mutations, resulting in 7 amino acid (AA) substitutions distributed in the PB1, PA, NA and M gene segments. None of these mutations did affect splicing of the M and NS gene segments at the nucleotide level or minor open reading frames (ORFs), such as PB1-F2 and PA-X. Phylogenetic analysis showed that both H9N2 influenza viruses belong to the prevalent epidemic genotype in Asia. Keywords: H9N2 influenza virus; chicken; minks; pathogenicity; phylogenetic.

Acta Virol. 2020; 64 (1):67-77.
Doi: 10.4149/av_2020_109.

Co-infection of H9N2 influenza virus and *Pseudomonas aeruginosa* contributes to the development of hemorrhagic pneumonia in mink

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Vet Microbiol. 2020 Jan; 240:108542.
Doi: 10.1016/j.vetmic.2019.108542.
Epub 2019 Dec 2.

Regional adaptations and parallel mutations in Feline panleukopenia virus strains from China revealed by nearly-full length genome analysis

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Protoparvoviruses, widespread among cats and wild animals, are responsible for leukopenia. Feline panleukopenia virus (FPLV) in domestic cats is genetically diverse and some strains may differ from those used for vaccination. The presence of FPLV in

two domestic cats from Hebei Province in China was identified by polymerase chain reaction. Samples from these animals were used to isolate FPLV strains in CRFK cells for genome sequencing. Phylogenetic analysis was performed to compare our isolates with available sequences of FPLV, mink parvovirus (MEV) and canine parvovirus (CPV). The isolated strains were closely related to strains of FPLV/MEV isolated in the 1960s. Our analysis also revealed that the evolutionary history of FPLV and MEV is characterized by local adaptations in the Vp2 gene. Thus, it is likely that new FPLV strains are emerging to evade the anti-FPLV immune response.

PLoS One. 2020 Jan 16; 15(1):e0227705.

Doi: 10.1371/journal.pone.0227705.

eCollection 2020.

Ecology and Infection Dynamics of Multi-Host Amdoparvoviral and Protoparvoviral Carnivore Pathogens

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Amdoparvovirus and *Protoparvovirus* are monophyletic viral genera that infect carnivores. We performed surveillance for and sequence analyses of parvoviruses in mustelids in insular British Columbia to investigate parvoviral maintenance and cross-species transmission among wildlife. Overall, 19.1% (49/256) of the tested animals were parvovirus-positive. Aleutian mink disease virus (AMDV) was more prevalent in mink (41.6%, 32/77) than martens

(3.1%, 4/130), feline panleukopenia virus (FPV) was more prevalent in otters (27.3%, 6/22) than mink (5.2%, 4/77) or martens (2.3%, 3/130), and canine parvovirus 2 (CPV-2) was found in one mink, one otter, and zero ermines (N = 27). Viruses were endemic and bottleneck events, founder effects, and genetic drift generated regional lineages. We identified two local closely related AMDV lineages, one CPV-2 lineage, and five FPV lineages. Highly similar viruses were identified in different hosts, demonstrating cross-species transmission. The likelihood for cross-species transmission differed among viruses and some species likely represented dead-end spillover hosts. We suggest that there are principal maintenance hosts (otters for FPV, raccoons for CPV-2/FPV, mink for AMDV) that enable viral persistence and serve as sources for other susceptible species. In this multi-host system, viral and host factors affect viral persistence and distribution, shaping parvoviral ecology and evolution, with implications for insular carnivore conservation.

Pathogens. 2020 Feb 15;9 (2). pii: E124.

Doi: 10.3390/pathogens9020124.

Seroprevalence and B1 gene genotyping of *Toxoplasma gondii* in farmed European mink in the Republic of Tatarstan, Russia

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Parasitol Int. 2020 Jan 28; 76:102067.

Doi: 10.1016/j.parint.2020.102067. Epub ahead of print.

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ANNUAL REPORT 2019

BEHAVIOUR AND WELFARE

Adjusting the body condition without compromising mink welfare in the winter period

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The aim of the project was to evaluate the mink welfare in different strategies for body condition adjustment in the winter period. We also wanted to evaluate if data from electronic weighing devices can be used as a tool in the prevention of hunger and stereotypic behaviour in mink. The study showed that slimming primiparous female mink from early December to body condition 2 in late February is less stressful for the mink compared with the end of January. However, there are welfare challenges with both feeding strategies, and it should be questioned whether it is necessary to adjust the body condition down to 2 to be able to respond to flushing. It was difficult to find any clear picture of changes in the patterns of weights from the electronic weighing devices that could indicate animals with stereotypic behaviour, and further analysis are needed.

Annual Report 2019, 4-9. Copenhagen Research. Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Correct WelFur-Mink assessment of partial weaning of large litters at 42 days

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In WelFur-Mink we assess the effect of partial weaning in the same way as weaning of the full litter which will lead to a score of 18 out of 100 for the measurement "Age and procedures at weaning". If this should be changed, we need a scientific background for a different interpretation of partial weaning of a part of the kits than of full weaning of all kits in the litter. We therefore conducted an experiment comparing the partial weaning procedure of litters of 6 or more kits 42 days pp. as described in the Danish 'Code of practice' to normal weaning of the full litter at 56 days. The first of a two-year experiment showed that

both the dam and the kits reacted shortly to the weaning at 42 days, but also to the weaning of the remaining kits at 56 days. The long-term effects were in favour of partial weaning, in terms of less fearful and more exploratory animals and less fur chewing. In total, this indicates that there will be a scientific background for a different interpretation of partial weaning at 42 days than of weaning of the full litter at 56 days.

Annual Report 2019, 10-15. Copenhagen Research. Agro Food Park 15, DK-8200 Aarhus N, Denmark.

BREEDING AND REPRODUCTION

Correlation between skin length and alternative measures for mink size, and the potential of early selection of breeding animals

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The aim of this project was to explore possibilities for early selection of mink, to optimize welfare and fertility for the breeding animals. With an early selection, we can restrict the feed intake in the fall, and avoid a tough diet over the winter for the breeding animals. We used 1261 white mink born in 2018 at Copenhagen Fur Farm, Denmark, to investigate the heritability (h^2) of different measures of size: circumference, body weight and length during the growth period in the fall and at pelting in November. We also estimated the genetic correlation to skin size. We found heritabilities (h^2) between 0.07 (SE~0.09) and 0.72 (SE~0.12), lowest for circumference (in October), highest for weight (at pelting). We also found high genetic correlations (r_a) between weight and skin size. For females, September weight was just as good an indicator for skin size as weight at pelting ($r_a = 0.91$, SE=0.04). For males, r_a was 0.80 (SE=0.09) for weight at pelting, and 0.65 (SE=0.09) for September weight. In September, we have same information about (mothers) fertility and size of females as we do in November. We can use this information to select females in September. However, we cannot measure quality of the winter fur in September. To compensate for the lack of quality measure in

September, a three-step selection strategy for females can be implemented. First step: Select females based on mothers fertility which is practiced on many farms today. Second step: Select females based on body-weight in September, select a surplus for third round sorting. Third step: Females from second round are finally selected based on pelt quality. Same strategy can be applied to males. The phenotypic observations will be even better used together with pedigree information to create a breeding index and select breeding animals based on this. With restricted feeding of breeding animals from September a tough slimming down will be unnecessary in the winter period, which is expected to result in improved animal welfare and reproduction. The strategy will be challenged by the fact that five times as many females as males is needed for breeding purposes. Males caged with females on a restrictive diet will potential not be able to show their full potential for growth.

Annual Report 2019, 16-21. Copenhagen Research, Agro Park 15, DK-8200 Aarhus N, Denmark.

NUTRITION AND FEEDING

Feeding with a high proportion of vegetable proteins to mink kits in the growing-furring period results in reduced production results

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The purpose of the experiment was to investigate whether a high proportion of vegetable protein sources can be used to mink kits in the growing-furring period. The experiment comprised three groups of 138 brown mink male kits. Five vegetable protein sources, potato protein, corn gluten, soy protein, pea protein and wheat gluten were used. To one group (Lveg) 1% of all vegetable protein sources were used, in another (Mveg) 2% was used, and in the last group (Hveg) 3% of all five vegetable protein sources were used. It amounted a proportion of digestible protein from vegetable protein of 19, 39 and 58% respectively. In order to maintain this proportion of vegetable protein, the percentage of vegetable products was reduced in August as protein was lowered from 32 MEp to 28 MEp.

Feeding with 19, 39 or 58% of digestible protein from vegetable protein during the growing-furring season

(Lveg, Mveg and Hveg), showed reduced growth, lower feed utilization, shorter skins and more kits with kidney problems with increasing vegetable protein content.

Annual Report 2019, 22-29. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Large effect of feed allowance during the growing season for reproduction in white young females in the following reproduction period

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White young females fed with different feeding allowance during the growing season 2018, Ad libitum (Adlib) by appetite, or feed amount reduced by 10% and 20%, respectively (Redu10 and Redu20), compared to Adlib from September, were selected for the 2019 breeding season.

Young white female kits fed restrictively throughout the growing season gave birth and weaned more kits in the following reproduction period than young females fed ad libitum. This show that feeding in the growth period have greater effect, than on skin parameters and health, but also breeding result in the following reproduction period, and this should be included in the feeding and selection of breeding animals in the future.

Annual Report 2019, 30-35. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

The importance of feeding strategy during the winter, mating and gestation periods for reproduction in mink females in the nursing period

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The purpose of the experiment was to investigate different body condition scenarios during the winter season, combined with different models for female feed allowance and weight increase through mating and pregnancy. The trial started after pelting in November 2018 and continued until the kits were 6

weeks old and the mink were fed feed from the central feed kitchen throughout the period.

Early slimming of mink females to January 20 and keeping them slim until February 20 rather than slow slimming to February 20 had no effect on the percentage of barren females and the number of kits at birth and weaning. Early slimming resulted in slightly lower kit weights the day after birth, but the largest kits weights on day 42. Reduced feed allowance and weight gain in March and strong feed allowance and weight gain from mid-April to birth rather than steady feed allowance and weight gain throughout mating and pregnancy, did not affect the percentage of barren females and number of kits at birth and weaning, but resulted in the largest kit weights on day 42. There was no interaction between feeding during the winter period and feeding in March-April.

Annual Report 2019, 36-45. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Reduced feed allocation from mid-September to pelting and its importance for animal growth, size, quality and health

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To the experiment we used 3 groups of approx. 330 white male mink and 330 white female mink. In one group (Adlib), the animals were fed ad libitum from mid-July to pelting, another group (Redu10) was fed ad libitum until September 14, after which the allocation was reduced by 10% compared to Adlib. In the last group (Redu20) animals was fed similarly, but reduced by 20% from 14 September.

The planned reduction in feed allocation from mid-September in Redu10 and Redu20 by 10 or 20% compared to Adlib was not fully achieved. During periods there was a lot of waste in Adlib and Adlib stopped eating on several occasions. The actual reduction in feed allocation was estimated to around 4 and 16%. The male kits in Redu10 were not significantly lighter at pelting than the Adlib animals, but Redu20 kits had a significant weight reduction, significantly lower BMI and significantly shorter skins. For the female kits, the same was seen, except that there was a decrease in skin length already at Red10. The skin quality was only rated in males, the only difference

being a slightly better quality in Redu10 compared to Redu20 and a significantly higher frequency of wet belly in Adlib. For the females, the highest number of tail rubbing were seen in Redu20. These investigations show that it is important in the future to include both the advantages and disadvantages of a more restrictive feeding of mink kits from mid-September to pelting on fur quality, health and tail rubbing.

Annual Report 2019, 46-55. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Feeding seven different poultry by-products to mink kits during the growing-furring period resulted in different feed utilization, growth and fur characteristics

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The purpose of the experiment was to investigate the effect of feeding mink kits with different poultry by-products during the growing and furring period. The experiment comprised 8 groups of 138 brown male kits. Two groups were feed raw poultry by-product either from Øland (Øla) or from Poland (Pol). Four groups were fed heat treated poultry by-product: cat 2 from Gudensberg (Gud), cat 3 from Farmfood (FFk3), defatted poultry from Farmfood (Laff and Haff) and Badenhop mix with hull (Bad). In addition one group was fed poultry meal (Fmel). The levels of the poultry products used are chosen so that the proportion of digestible protein from the poultry by-product selected was approx. 34% of the digestible protein (except for Haff where it accounted for about 43%). The proportion of digestible protein from fish and vegetable products, on the other hand, varied between groups.

The experiment showed differences between the poultry by-products. The two fresh products (Øla and Pol) had the best feed utilization, best kit weights and together with Gudensberg (Gud) the longest skins. In addition they were among the groups that had the best kit survival and few kits with kidney problems.

Annual Report 2019, 56-68. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Vitamin E to female mink in the winter period from December to weaning

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To study the need for vitamin E from Dec. 16 to weaning, 3 groups of 330 brown females were used. The three groups received identical feed except for the vitamin E supplement, which was 0, 60 or 120 mg vitamin E per kg. feed in the UE, KON and DOBE groups.

Results showed no difference in litter size in young females, but kit loss in young females from day 28 to day 42 was greatest in DOBE. In the second year females, DOBE gave most kits compared to UE and KON. UE and KON were not different. The kit weights were not significantly different for the young females, but for the second year females we found the best weight gain in KON over UE (female kits) and DOBE. UE and DOBE were not different. Young females in the KON group had the lowest weight loss from day 28 to day 42, for second year females the difference was not significant. Based on this and previous studies with contradictory results, it is recommended to maintain the current recommendations, but to repeat the testing of vitamin E during the winter period on a large number of females.

Annual Report 2019, 70-75. Kopenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Effect of iron supplementation on iron status and growth of mink kits, when iron is given directly to the kits via injection or indirectly via the feed fed to the females during the gestation and lactation period

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Two experiments were conducted. The purpose of experiment 1 was to investigate the effect of supplementing 70 mg Fe/kg diet from Marts 20 during the gestation period and until day 63 after birth on the kits' liver iron content, hemoglobin and hematocrit level as well as growth. The experiment comprised

24 mated brown first year females fed a diet produced by Holstebro feed kitchen and supplemented with 0 or 70 mg Fe/kg diet in the form of iron sulphate. The kits were fed the same feed as the females until day 63. The purpose of experiment 2 was to investigate the effect of giving kits an injection with iron (10 mg Fe/kit) at day 3 after birth on kits' hemoglobin and hematocrit level as well as growth. The experiment comprised 25 litters (brown first year females) of which half of the kits in each litter (balanced in relation to sex) was given an iron injection and the other half and saline injection. In experiment 1, the iron content of the feed without and with iron sulphate was 382 and 547 mg/kg dry matter, respectively. Addition of iron to the feed fed to the females and kits had no effect on the mink kits' weight and content of iron in the liver day 3, hemoglobin and hematocrit level as well as growth. Experiment 2 showed that iron injected kits had a significantly higher hemoglobin and hematocrit level at day 16 and 38, but not at day 63. Iron injection did not affect the growth of the kits from day 3 to 63. Overall, the two experiments show that the mink kits' iron status is improved to a limited extent by iron injection day 3 after birth, but not by supplementing extra iron to the feed fed to the females during gestation and until day 63, where the kits ingested the same feed as the female. Furthermore, neither supplementation of iron via the feed nor via injection improved the growth of the kits.

Annual Report 2019, 76-81. Kopenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Different methionine levels for mink kits during the growing and furring period

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The purpose was to investigate the effect of feeding different levels of methionine from 16/7 to pelting on growth and skin parameters of mink kits both when the methionine content was constant throughout the whole period or reduced in the last part of the period. Furthermore, it was investigated whether mink kits utilize crystalline L-methionine. 9 groups each of 137-140 brown male kits was fed one basal diet supplemented with crystalline L-methionine to achieve the following levels: 0,12 (no added methionine); 0,13, 0,14, 0,15, 0,16 and 0,18 g digestible met/100

Kcal ME. Based on the results the overall assessment is that a content of 0.12 and up to 0.18 g digestible met/100 Kcal ME results in the same growth from 16/7 to 21/9, whereas 0.12 digestible met/100 Kcal ME from 22/9 to pelting results in lower growth compared with 0.14 and up to 0.18 g digestible met/100 Kcal ME. For the entire experimental period (16/7-1/11), the overall assessment is that the growth will not be negatively affected provided that the methionine level is not reduced to a level below 0.14 g digestible met/100 Kcal ME. An increase from 0.12 and up to 0.18 g digestible met/100 Kcal ME from 16/7 to pelting resulted in a linear increase in skin quality. This indicates higher digestible methionine optima for skin quality compared to growth. Overall, the experiment showed that mink kits utilize crystalline L-methionine and that the current recommendation of 0.16 g digestible/100 Kcal ME fits quite well, but that there may be economic potential in reducing to 0.14 g digestible met/100 Kcal ME as well as using feed ingredients with a low methionine content combined with crystalline L-methionine.

Annual Report 2019, 82-91. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Feed kitchen feed and minks' vitamin needs

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The study investigates the excretion of B vitamins in the urine in September and October and the vitamin A and E status at pelting in male mink fed conventional feed from feed kitchens. Samples were collected at 12 mink farms fed with feed from Holstebro Feed Kitchen, Sole Mink Feed, or Tværmosse Feed Kitchen. The investigation showed that riboflavin, niacin, pantothenic acid, and pyridoxal are excreted in the urine in high amounts and based on results of previous studies it is concluded that the addition of these vitamins to the feed can be omitted without any problems. The average vitamin E status in plasma was above 10 µg/ml for all three feed kitchens. However, 25% of the mink fed feed from Holstebro Feed Kitchen had a vitamin E status below 10 µg/ml plasma. In September, Holstebro Feed Kitchen decided to reduce the addition of vitamin E to 3,9 mg synthetic and 2 mg natural vitamin E per kg feed, the addition of vitamin E was however increased to 6,6 mg synthetic and 6,1 mg natural vitamin E per kg

feed in mid-October. Sole Mink Feed and Tværmosse Feed Kitchen kept on adding 36 mg synthetic and 18 mg natural vitamin E per kg feed. The study showed that the addition of vitamin E may be reduced in mink feed from feed kitchens but this should be done based on the actual feed composition. The study furthermore showed that addition of vitamin A apparently not is necessary with the feed ingredients used and that it is highly recommended to omit addition when the feed contains swine offal with a high content of liver.

Annual Report 2019, 92-99. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Chemical protein modifications in poultry by-products for mink feed – how does quality, processing and storage affect the protein quality?

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Chemical modifications to feed protein can occur during processing (including heat treatment) and storage of the product as well as due to microbial activity. These protein modifications can affect the protein quality of the feed. The aim of the experiment was to investigate the development of chemical protein modifications in poultry byproducts in relation to quality of raw material, processing and storage. In order to identify which chemical modification occur in the feed, key indicators at amino acid level were selected. Analysis of chemical modification caused by oxidation (carboxymethyllysine and carboxyethyllysine), heat-induced modifications (lanthionine and lysinoalanin) and heat- and pressure-induced conversion of natural L-amino acids to D-amino acids were conducted. The experiment showed that protein modification was observed already in the non-processed raw product, which may be caused by microbial activity. Furthermore, the concentration of all chemical modifications increased during boiling and storage. In particular, boiling of feathers contributed to generation of lanthionine, D-serine and D-cysteine. Therefore, it is important to optimize the quality of raw materials and processing of poultry byproducts to mink

feed, so that development of heat-induced modifications in feed is minimized and a high quality is maintained. The current experiment show that there is good opportunity for such an optimization.

Annual Report 2019, 100-107. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Different levels of vitamin E fed to female mink in the winter period January-March

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The purpose of the experiment was to investigate whether it is possible to reduce the vitamin E supplementation to mink during the winter period without negative effects on the mink's performance, and to ensure that vitamin A status was kept at a sufficient level. An experiment was performed with four treatments with 24 females in each group fed 0, 30, 60 or 120 mg/kg feed of synthetic vitamin E. Eight animals from each group were sacrificed on January 18, February 28 or March 30 respectively, and deposition of vitamins A and E in plasma and tissue were analyzed. Analyzes of plasma and tissue showed that mink's measurable short-term deposits (plasma and liver) were generally highest for mink fed 120 mg/kg of feed of vitamin E. Whereas, adipose tissue, brain, and heart was only minimally affected by different vitamin E supplementation. No mink were under supplemented with vitamin E from an analytical point of view, the lowest vitamin E levels were measured on March 30. Vitamin A status was appropriate and unaffected by vitamin E supplementation. Based on an overall assessment of the female vitamin E status, it is recommended to maintain supplementation with 60 mg of synthetic vitamin E during the winter period. Moreover, supplementation of 2000 IE/kg vitamin A in the winter period is appropriate.

Annual Report 2019, 108-114. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Effect of temperature and pH on recovery of protein bound and crystalline methionine in mink feed after 0, 8, and 24 hours, respectively

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The objective of this *in-vitro* experiment was to investigate the amount of methionine that could be recovered after 0, 8 and 24 hours, and whether this finding was influenced by the origin of methionine (protein bound versus L- and DL-methionine), pH of the diet (5, 5.5 and 6.5) and temperature (5°C and 17°C (time 0 only at 5°C)). Two diets with a calculated content of 0.20 g and 0.40 g digestible methionine / MJ ME (0.20met and 0.40met) were used. The three diets in this *in-vitro* experiment contained 1) exclusively protein bound methionine (0.40met), 2) 0.20met supplemented with 0.2% crystalline L-methionine (0.40L-met) and 3) 0.20met supplemented with 0.2% crystalline DL- methionine (0.40DL-met). The results of the present experiment showed that the recovery of methionine was significantly higher (4% and 5%) in the 0.40met diet compared with the diets 0.40L-met and 0.40DL-met (p <0.01 and p <0.0001, respectively). Furthermore, it can be concluded that the recovery of methionine was high (≥ 89%) regardless of the source of methionine used.

Annual Report 2019, 116-119. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

HEALTH

The presence of *Toxoplasma gondii* and *Cryptosporidium* infection in Danish farm mink

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Toxoplasma and *Cryptosporidium* are both zoonotic, protozoan parasites infecting a wide range of animal species including mink and humans. Both parasite-species have been identified in several Danish wild-life species and Danish farmed animals. *Toxoplasma* antibodies have been identified in 3% of Danish farm mink back in 1994, but no studies have been published since. Danish farmed mink have never been examined for *Cryptosporidium* infection, but farmed mink from among other China, Polen and Spain has been tested positive for *Cryptosporidium*. The present study aimed at determining the prevalence of *Cryptosporidium* and *Toxoplasma* infections in farmed mink, and thereby can the infection risk of humans working with the mink be evaluated. Luckily, none of the tested mink were positive for *Toxoplasma* antibodies (0%) and only 2.4% [95% CI: 0,8 – 6,5] were positive for *Cryptosporidium* infection. Hence, the risk of infection with these two potential zoonotic parasites for the personal on mink farms is minimal.

Annual Report 2019, 120-125. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Non-effect of antimicrobial treatment of cystitis in mink kits on a mink farm in July

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In a parallel-group trial the treatment effect of antibiotics on urinary tract disease in mink kits was studied. The study was conducted on one mink farm with high mortality caused by urinary tract disease in July. Treatment consisted of a sulfadiazine/trimethoprim antimicrobial in a dose of 250 g pr. 2000 kg mink once a day in 5 days. The prevalence of urinary tract disease postmortem in mink kits treated with antimicrobial

therapy (8/1920) was not significantly different ($p=0,18$) from the control group (16/1920). In this case, we did not find the treatment effect sufficient to justify flock treatment with sulfadiazine/trimethoprim. Further investigations are relevant to optimize prevention and treatment of urinary tract disease in mink and to avoid unnecessary treatments with antibiotics.

Annual Report 2019, 126-129. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Farmed chinchilla (*Chinchilla lanigera*) infected with *Yersinia enterocolitica*

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Infection with *Yersinia enterocolitica* (*Y. enterocolitica*) has previously been acknowledged as a causal factor of gastrointestinal disease and fatalities in chinchilla. This article presents the results from the master's thesis project "Causes of Mortality in Farm Chinchillas – With a focus on gastrointestinal disorders and *Yersinia enterocolitica* infections" where gross pathological postmortem examinations were performed on 74 Danish chinchillas in order to determine causes of disease and increased mortality. The study concluded that *Y. enterocolitica* was the most frequent bacteria isolated from samples obtained from 54 examined animals. The focus of this report is therefore results concerning *Y. enterocolitica*.

Combining results from the pathological examinations and the bacteriological analysis the study revealed that yersiniosis was significantly associated with post mortem findings of splenomegaly ($p=0,002$) and hepatomegaly (0,003). These post mortem findings may potentially serve as diagnostic indications of yersiniosis, but they should be followed by bacterial analysis for final confirmation of the diagnosis.

Annual Report 2019, 130-134. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Pilot study of possible disease mechanisms in the development of paw callus in framed mink (*Neovison Vison*)

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Previous studies on paw-callus have shown that the skin lesions are heritable, but it is not yet clear which disease mechanisms that lead to some mink developing the paw-callus. This pilot study aimed to investigate differences in possible factors, including whether anatomical abnormalities in the paws or differences in the movement system can lead to the formation of paw-callus. The study included a total of 12 male mink, 6 with paw-callus and 6 without. All mink were recorded from various angles during normal voluntary movements in the cages as well as during feeding to assess leg posture and movement patterns. Paw prints were also taken during regular walking. After euthanasia X-ray and CT recordings, dissections around the callus areas as well as recording of bodyweight and length were performed. Due to the body conditions of the mink, the video material was deemed not useful for assessing leg posture and pressure distribution on the hindlimbs and no differences in paw prints from between mink with callus and mink without callus were found. Dissections and X-rays showed no underlying pathology related to the callus formation but have formed the basis for a more accurate anatomical nomenclature of the location of the callus. Overall, the results of this pilot study have contributed to more knowledge about callus in farm mink and may form the basis for further studies.

Annual Report 2019, 136-139. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

MANAGEMENT

Transfer of mink kits from large litters: Benefits of extending the early lactation period

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The aim is to identify factors of importance for the vitality of mink kits and the welfare of the dams from day 1 to weaning at week 8. The main question relates to the optimal management for transfer of kits from large litters in the first week after birth. It was advantageous for the foster kit from a large litter (9-14 kits) to be transferred to a younger litter with fewer kits. The newly delivering mink mothers displayed the highest accept of an older kit from a large litter, i.e. day 2 was better than day 4 after birth for the recipients. Small recipient litters (1-3 kits) resulted in a higher kit weight and reduced the occurrence of damages on the kits. This was particularly true for female kits, otherwise having a markedly higher risk for damages and wounds at week 7 after birth. The transfer of kits is typically done after the early period (day 0-1) with substantial kit mortality; thus, the foster kits had no marked different chance of survival. However, the foster kits gained a significant higher body weight after transfer from a large litter. Older (second and third year) dams resulted in heavier kits, which confirm the recommendation from 2018, to primarily transfer foster kits to older rather than young (first year) dams.

Annual Report 2019, 140-147. Copenhagen Research, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

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Nielsen, V.H., Møller, S.H., Hansen, B.K. & Berg, P. (2007). Genotype - environment interaction in mink. *Scientifur*, 31 (3), 89.

Shirali, M., Nielsen, V.H., Møller S.H. & Jensen, J. (2015). Longitudinal analysis of residual feed intake and BW in mink using random regression with heterogeneous residual variance. *Animal*, 8 (10), 1597-1604.