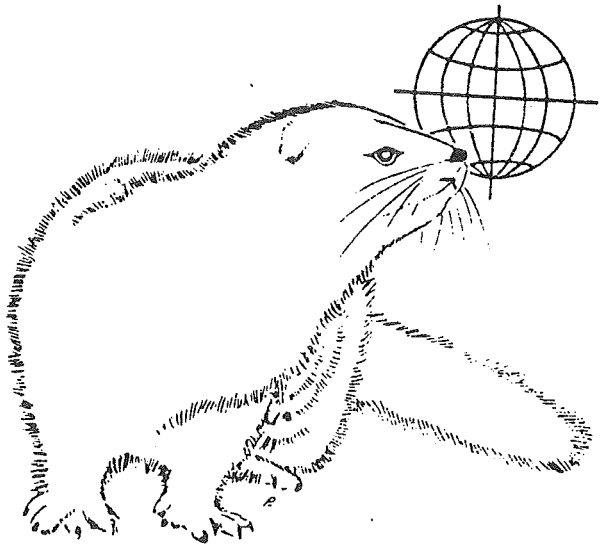

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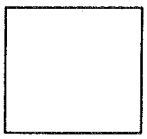

IFASA / SCIENTIFIUR
P.O.Box 13
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Denmark

From:

Vth INTERNATIONAL SCIENTIFIC CONGRESS IN FUR ANIMAL PRODUCTION

OSLO PLAZA HOTEL,
AUGUST 13th - 16th 1992

Notes

SCIENTIFUR

Vol. 16, No. 2

May 1992

Organized by IFASA

From the editorial side we are glad to inform you that we have only one problem - a luxury problem - we receive more information than we can bring without delay.

Mainly the number of contributions of original reports is increasing. This is a good thing if they are really original. But from time to time we have seen that some of the reports received have been published in the original language in other journals. This should be avoided, and only the author can be responsible for that, so please - bear that in mind.

Our next point is the length of the reports. Many of them are much longer than necesssary to give full scientific information. Normally a scientific report should be of a maximum of 6 printed pages equal to about 12-14 typed pages. On going through the articles, we find that the main reason for the excessive length of the reports is the use of too many tables.

To ensure that SCIENTIFUR will have space enough to bring all relevant scientific information we ask our contributors to bear this in mind, too.

From January 1993 the authors will be invoiced DKK 1,200.- per printed page exceeding 6 pages per report. Excepted are Review articles which are accepted in any reasonable length and which are very much in demand by the majority of SCIENTIFUR's readers.

Please remember that very often a good figure can be better documentation than several tables. Remember also that the very few readers who need the basic material from the experiment in question, are in a position to contact the author and ask for it.

MODERN SCIENTIFIC REPORTS ARE NOT INCLUDING THE TOTAL BASIC MATERIAL - ONLY THE MATERIAL GIVING DOCUMENTATION FOR THE PRIMARY RESULTS.

Many of the contributors for the Vth International Scientific Congress in Oslo have learned that.

Speaking of the Vth INTERNATIONAL SCIENTIFIC CONGRESS IN FUR ANIMAL PRODUCTION in OSLO, NORWAY August 13-16, 1992 - the secretariate has informed us that more than 100 reports and posters have been received and that about 200 participants are expected.

It is really nice to see that the start of all this at the 1st international congress in HELSINKI in 1976 initiated by The Fur Animal Division of Scandinavian Association of Agricultural Scientists (NJF), was the seed that gave rise to the very important IFASA tree which will hopefully at the OSLO Congress be planted so effectively in the fur animal scientific garden that it will grow and become even more important in the future for all parties concerned.

Furthermore, it is worth remembering that the offical confirmation of the articles of IFASA and the election of the board will take place in Oslo, August 13, where the first council meeting is advertized.

WHAT IS THE COUNCIL OF IFASA:

The council consists of representatives from each country according to the following schedule:

Number of individual memberships	Number of representatives in the council
1 - 5	1
6 - 20	2
More than 20	3

The councillors will be elected in the different countries in which there are individual members.

The initial board of IFASA, the names of which can be seen on the inside of the cover of SCIENTIFUR, has chosen the following individual IFASA members as IFASA representatives in each country. These representatives, who will receive direct information and material from the president at the latest 45 days prior to a council meeting, are responsible for information and election of the council members in the respective countries.

The list is as follows:

IFASA representatives in different countries

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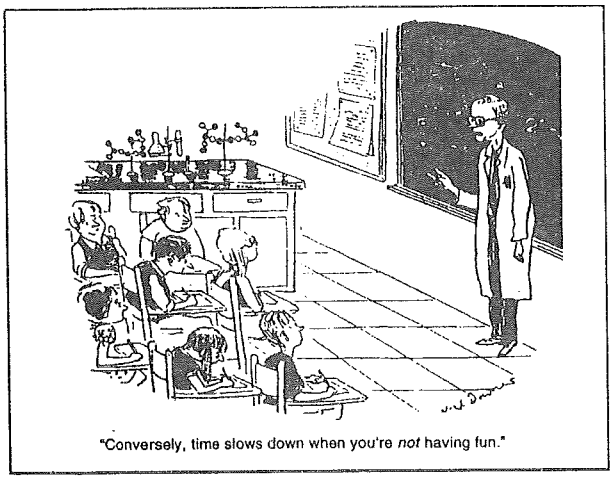
USSR:	Dr. Alexander V. Taranin Inst. of Cytology and Genetics Siberian Dept. of the USSR Academy of Sciences 63 0090 Novosibirsk Russia
and	Amatolij Kaldaeva, Mr. Fur Farming and Rabbit Breed Science Research Institute Gurianova 11 - 48 109 548 Moscov, Russia



"Conversely, time slows down when you're *not* having fun."

Members of IFASA and those who want to become members can contact their representatives or the secretary of IFASA. Address, phone and fax number as for SCIENTIFUR. See inside cover.

Possible questions regarding the Vth International Congress in Oslo should be directed to the congress secretariate:

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N_0509 Oslo, Norway
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My best wishes to all of you until we meet in Oslo in August this year.

Have a good summer,
Your editor

Gunnar Jørgensen

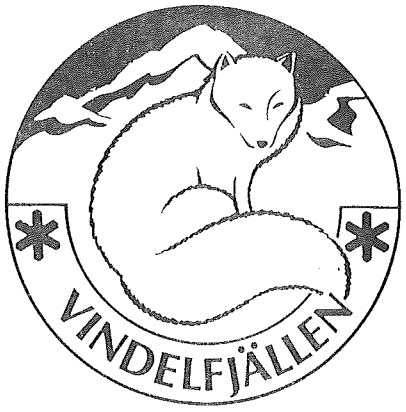
SCIENTIFUR INDEX

In the latest issue of SCIENTIFUR (Vol. 16, No. 1) we informed that the SCIENTIFUR INDEX II covering the last 5 volumes is under preparation and that we will produce an electronic version covering all 15 volumes. Ordering card was enclosed that issue.

Preparation of the index takes far more time than expected so we can today realize that we will come close to the congress in August before it is finished.

For those who prefer the electronic version we can inform that as advertized it will be delivered in a "packed" form on a 3 1/2" diskette (1.4 MB). But when "unpacked" the necessary space on the harddisk is 6 MB. This is worth to have in mind when ordering.

The printed version is free of charge but the electronic version will be charged by DKK 800,-. Please use the received order card if you want to receive the Index. It will do it easier for us to estimate the number we have to produce.



ARCTIC FOX BIOLOGY

ABSTRACTS FROM THE FIRST INTERNATIONAL ARCTIC FOX MEETING, SWEDEN, SEPTEMBER 1991

The first International Arctic Fox Meeting took place at Ammarnäs in Swedish Lapland from 30 August - 1 September 1991, and was followed by a field trip to an Arctic fox study area in the Vindelfjällen Nature Reserve. The meeting was organized by Anders Angerbjörn of Stockholm University and Páll Hersteinsson of The Wildlife Management Unit in Iceland.

The arctic fox (*Alopex lagopus*) was the subject of intensive studies in the 1920's and 1930's in the Soviet Union at the time when fur prices were at an all-time maximum. Besides analyses of harvest figures, very little work has been done since then on the ecology of this species until the late 1970's and 1980's. Considerable work on various aspects of the biology of farmed arctic foxes, however, has been going on in recent decades.

For a number of years, the organizers have been of the opinion that scientists from different areas and fields doing research on the arctic fox should meet on a regular basis to exchange information and ideas.

There were 20 participants from 7 countries at the meeting giving a total of 18 oral presentations and 3 posters. Three workshops took place during the meeting. In addition, two introductory talks were given on the first night and one 30-min video film on arctic foxes in Iceland was shown.

Following are the abstracts from the meeting and short resumés of the workshops and field trip.

Editors: Anders Angerbjörn and Páll Hersteinsson. Only abstracts received. For further information contact the editors or the single author.

The effects of winter food on reproduction in the arctic fox: a field experiment.

Anders Angerbjörn.

The population of arctic foxes in Fennoscandia is very small and has been so for around 60 years in spite of total protection for over half a century. The reasons why the arctic fox population has not increased to its former size are unknown. The population numbers fluctuate highly in relation to vole numbers. There is also very high interannual variation in reproduction among arctic foxes.

To determine the effect of winter food availability on reproductive success, we carried out a feeding experiment. The study area is situated above the treeline from an altitude of 700 m to mountains of 1600 m in Swedish Lapland. We added food (reindeer and moose carcasses) to dens during the winter months, January - April 1985 - 1988. To determine the effect of this extra food on reproduction, we made inventories at both food manipulated dens and control dens. These inventories of dens took place during July so we could not only check if dens were occupied, but also whether a litter was born and assess the number of cubs appearing outside the den.

The proportion of occupied dens in the experimental group was significantly higher than in the control group. The number of cubs at weaning in

the food manipulated dens was also higher than in control dens in each year. However, no effect on litter size was found.

From these results we conclude that the larger number of cubs produced in dens with extra winter food shows that reproduction under present dietary poor conditions was limited by available food. Many canid species show this close relation between reproduction and food availability, with pregnancy rates and litter sizes declining with the abundance of the main food.

References: Angerbjörn, A., ArvidSon, B., Norén,E., Strömgren, L. 1991. The effect of winter food on reproduction in the arctic fox, *Alopex lagopus*: a field experiment. J. Anim. Ecol. 60: 705-714.

Social behaviour of arctic foxes in relation to food distribution.

Anders Angerbjörn, Lena Almqvist, Cecilia Kullberg, Weronica Linkowski, Helena Rygme, Magnus Tannerfeldt.

The arctic fox (*Alopex lagopus*) is described as a solitary animal with very opportunistic feeding habits. When large carcasses are available, many foxes can be gathered around, and interact heavily. In such situations, the outcome of the conflict is likely to be related to the individuals' dominance order.

We studied arctic foxes in an enclosure of 4 + 4 ha south of Stockholm. The two parts of the enclosure contained 6 + 6 individually marked foxes. We made all observation from a 7 m high tower. The linear rank order found in each group was based on number of avoiding behaviours in interactions with other foxes. The rank order was related to both age and sex, with old males and females being dominant over younger animals. Furthermore, males always dominated females of the same age.

In a feeding experiment, we alternated food distribution from patchy (all food on one location), to be dispersed over the whole area. The number of food items a fox found in a dispersed distribution, was related to its rank order, and so was activity. The two dominating females in each enclosure showed the highest activity together with 2nd-ranking males, and they also found more food than did both dominant males and low-ranking individuals. When food was distributed patchily, we found an overall higher level of aggression, with 2nd-ranking males at the highest levels. On the other hand, when food was dispersed, there were more movements with larger activity ranges especially for old males.

An overview of the arctic fox population in coastal tundra of western Alaska.

R. Michael Anthony.

Studies of arctic foxes (*Alopex lagopus*) in coastal tundra of the Yukon-Kuskokwim Delta of western Alaska from 1985 through 1990 have provied insight into their biology. The study area, which is encompassed by a 642,000 km^2 national wildlife refuge, has several small Yupik Eskimo villages but is roadless and relatively undisturbed by man. Due to declining fur prices in recent years, annual harvest of arctic foxes for subsistence use and sport is generally limited to areas near the villages. Radio telemetry, observation of foraging foxes, den surveys, analyses of harvested foxes, and trapping of small mammals provided the main sources of information about territoriality, movements, foraging behaviour, productivity, and age structure.

The wet tundra of this portion of Alaska's Bearing Sea coast is nesting grounds for millions of migratory birds. The birds, their eggs, and their young provide an abundant source of food from May through August that foxes use for immediate energy needs, and also cache to supplement their diet of small mammals and carrion after the birds leave. Arctic foxes observed from tower blinds cached 1.50±0.35 eggs/hour in an area with 30-50 nests/km^2 and 3.50 eggs/hour in a brant (*Branta bernicla nigricans*) colony with 100-1600 nests/km^2. These foraging rates extrapolated to an entire nesting season yield estimates of several hundred to more than two thousand eggs cached per individual fox. Marine mammal carrion, primarily walrus (*Odobenus rosmarus*) carcasses that are commonly beached, also are a valuable food. In 1986 24 foxes were captured during 1 month within a 13 km^2 area in which the remains of 2 walruses were found. Twenty-one of the foxes had yellow-stained fur indicating use of marine mammal carrion. In 1987 16 foxes were captured within 48 km^2 of the same coastline. Three walruses that were not present in 1986 were found

and 12 foxes had stained fur.

The relatively abundant food supply apparently permits many foxes to remain in the vicinity of their summer home ranges throughout the year. Of 54 arctic foxes that were radio-collared in spring and summer, 30 were successfully relocated for at least 10 months after marking, which generally included the denning season of one year to the breeding season of the next. There was no difference (P=0.38) between mean distances from capture location to relocation sites for 19 males (x=5.6±2.2 km) and 11 females (x=2.9±0.7 km). Intensive radio tracking of 18 of these foxes indicated that all were captured within the boundaries of the summer home ranges, which ranged from 9.9 km^2 for females to 19.6 km^2 for males. Therefore, these data suggest that most foxes that remained in wet tundra habitat during winter did not move far from their summer ranges.

Although food resources appear to be adequate to allow overwinter survival of established foxes, they do not enhance fox productivity. Only 22 of 88 (25.0%) uteri from fox specimens collected from December to March 1987-89 had placental scars (x=8.32±0.84 scars). Furthermore, only 21 of 87 (24.1%) specimens collected in April and May 1985-90 were gravid (x=11.46±1.10 fetuses). There was no difference (P=0.57) in the ages of breeders (2.15±0.50 years) and non-breeders (2.44±0.28 years).

Den availability does not appear to be a limiting factor to fox productivity in this region. At an inland location that is arguably the most productive waterfowl area in North America, intensive searches yielded 38 dens within a 37 km^2 area (about 1 den/km^2). Another area (about 107 km^2) with moderate waterfowl nest densities, and much less upland breeding foxes had 6.9±2.1 burrows per 10.7 km^2. Dens occupied by breeding foxes had 6.9±2.1 burrows compared to 2.8±0.9 burrows for unoccupied dens.

Despite the relatively low reproductive rate observed in the 1980's, observations of foxes and nest predation increased greatly from the 1960-70's. Hypotheses explaining this apparent increase in foxes include decreased harvest due to declining fur prices and higher survival rates due to increased marine mammal carrion resulting from increased hunting by a larger, more mobile native population. Based on fur buyers' records, harvest by residents of the region have decreased. A summary of the age structure of 418 arctic foxes trapped from 1986 through 1990 indicated relatively high survival with 10.72% of the population at least 3 years old.

An automatic location system for wildlife telemetry.

Dennis Becker, Anders Angerbjörn.

A conventional telemetry system confers many limitations. It assumes an experienced user, and is very time consuming. Despite the fact that the radio transmits constantly, you can only get information when actively receiving signals. This gives small sample sizes with only a few locations per day. Furthermore, it can be difficult, risky, and sometimes even impossible, to get data under severe conditions, in bad weather, in darkness, or in a difficult terrain. To have a more or less continuous recording of a group of animals is extremely costly and demands very high labour intensity. A common pattern is, instead, to take bearings intensively over a short period of time. But dispersing individuals can be lost when there is no telemetry. Furthermore, often only one person has to take all bearings, with possibilities of animal movements between the bearings, with a lower accuracy as a result.

The principle for a conventional system is to use multiple element antennas with a high directivity, which normally gives longer ranges. A direction finder based on the Doppler principle works differently. Four dipole antennas are vertically polarized, and show an electronic pseudo-rotation. The Doppler principle makes it possible to generate a direction to the transmitter in only fractions of seconds due to this pseudo-rotation.

The transmitters used in this system are of the same type as of a conventional system with one exception; the length of the pulse needs to be about 200 ms long. However, one pulse is enough to get a bearing.

Each automatic location unit contains an antenna, a radio receiver, a Doppler direction finder, a PC-computer, a 3.5" floppy drive, and a telephone and/or radio modem. The whole system can be controlled via the radio or telephone modem, from a distant computer, or from one of the receiving units. The calculations of coordinates are done either at one of the receiving units, or at a

distant computer.

All calculated bearings are marked with channel, date, and time by the controlling software. The operator can choose to observe them directly, to store them in strings in ASCII-format on 20 bytes, to print them, to sort them, or to export them via the modem. With a disk capacity of 720 kb, this gives about 30.000 strings with telemetry data on each disk.

With an automatic location system there should be no inexperienced operators, and the measurements should be without subjective errors. Despite the fact that the system needs no operator, all signals are continually received, all day long the whole year round, as long as the batteries in the transmitter have power enough to transmit. Since the sampling is continuous, we can see when an individual is migrating, and even under what circumstances. We can separate mortality from emigration, and from "dead" transmitters. There are also good opportunities to analyze different time budget situations.

References: Angerbjörn, A. & Becker, D. an automatic location system for wildlife telemetry. In press in: Priede I.G. & Swift S.M. (Eds) 1992. *Wildlife Telemetry*. Ellis Horwood, Chichester.

Environmental and ecological constraints on the development of oral vaccination programs for the control of rabies in arctic fox population.

Erich H. Follmann.

The arctic fox (*Alopex lagopus*) is considered to be the principal vector of rabies in arctic regions, although other species such as the red fox (*Vulpes vulpes*) and the raccoon dog (*Nyctereutes procyonoides*) support rabies epizootics in more restricted areas. Due to the arctic fox's association with rabies throughout much of its range, oral vaccination campaigns are being considered to reduce the danger of epizootics in areas of human habitation. Oral vaccination campaigns involving red foxes have proven effective in Europe and Canada and a similar approach is being considered for the arctic fox. Aspects of the environment in which the arctic fox lives and differences in their ecology, however, preclude direct application of all methodology developed for the red fox. Environmental factors include the presence of annual and multiannual ice in northern seas, seasonal movements of oceanic ice, and the potential for the occurrence of freezing temperatures throughout the year. Aspects of the arctic fox's ecology include the breakdown of territorial boundaries following pup rearing, widespread movements during winter, and movements onto the pack ice of the Arctic Ocean following establishment of the shorefast ice. These factors pose significant challenges to developing a strategy for an effective and economical rabies vaccination program. Recent studies with captive animals have shown that oral rabies vaccines are effective in vaccinating arctic foxes, but only a small trial in eastern Canada has been attempted in the field. Large-scale programs will probably not occur in the near future.

Adult arctic foxes in the denning area; numbers and behaviour.

Karl Frafjord.

Behaviour of arctic foxes, *Alopex lagopus*, in the denning area was studied in two mountain regions in southern Scandinavia, and in one region of the western coast of Svalbard. More than two adult foxes were recorded in 6 of the 9 den-years in Scandinavia. One den probably contained two litters of pups and two pairs of adults, while two more dens may have contained two litters. In one den with no pups three adults were observed. Several adults probably visited dens only briefly, and more than two adults were rarely observed at the same time. Some spatial separation of adults was also found. In one denning area in Svalbard most likely three adult males were observed and one adult female, in addition to several more adults passing through the area. Another denning area was visited by a minimum of 5 adult foxes during spring and summer, in addition to the resident pair. Since parenthood of pups was unknown, and since the role of "surplus" adults was not clear, they could not be assigned a "helper" role.

Surplus adults in the denning area may have resulted from a relaxed territorial defence, rather than from a need for more adults to bring food to pups. Interactions between adults were rarely observed, and were mainly restricted to the transfer of food from male to female. Adults were mostly inactive when observed in denning areas, and were resting 60-90% of the time. Male activity varied significantly with time of day, but female

activity did not. Foxes were inactive 79.6 and 75.2 % of day- and nighttime hours respectively, but the difference was not significant.

Seasonal variations in energetics of Svalbard foxes (*Alopex lagopus*).

Øyvind Haga, James B. Mercer.

The Svalbard arctic fox population differs from other populations in that there are no small rodents available as a food item to them. In other fox populations these constitute an important part of their food intake. The size of these populations are known to vary with accessibility of these rodents. In summer and autumn the diet of Svalbard foxes consists mostly of seabirds and at this time, when food availability is high, the animals are known to hamster excess food. In the winter, when food availability is much more unstable, they have to rely on carcasses of reindeer and ptarmigan. However, mortality in Svalbard reindeer is usually low in the winter until April, so this source of food is somewhat unreliable. In addition to the problem of food availability, low ambient temperatures and lack of light combine to give unfavourable energetic conditions for Svalbard arctic foxes in the winter. The question arises as to whether these animals have developed any special adaptations, particularly with regards to energetics, to cope with these harsh conditions.

We are carrying out a research program designed to examine seasonal variation in several aspects of energetics in captive arctic foxes from Svalbard. Since the Norwegian mainland is a rabies free area, our animals were kept under strict quarantine conditions for a period of 6 months after arriving on the mainland. (Rabies in arctic foxes have been frequently diagnosed in polar areas during the last century. In Svalbard the last outbreak came in 1981 when 12 arctic foxes were found to carry the virus). Measurements of food intake, body weight, resting metabolic rate (RMR), RQ, activity and heart rate during periods of temporary food restriction are planned in order to see whether there are any seasonal variations in the animal's ability to cope with this sort of situation.

Metabolic rate will be measured by open circuit indirect calorimetry. All parameters necessary for calculating RMR will be collected by a computerized data acquisition system. Heart rate, body temperature and activity will be measured continuously throughout the year with a computerized telemetric system.

Pair bonds and territory fidelity among arctic foxes.

Páll Hersteinsson.

In a study of the behavioural ecology of arctic foxes in Iceland (*Hersteinsson, 1984*) it was not noted that two out of three mated pairs studied in 1978 stayed on their home ranges through the following winter and produced litters in 1979. In the case of the third pair the male disappeared during the winter and a new male mated with the vixen of that range in 1979.

In all three ranges a second female was present during the cub-rearing season and in two of the ranges in 1979, including the range where a new male had taken over. In spite of apparent courting of that male and the younger female in his range, no evidence was ever found of two litters being produced within any of the ranges in either year. It is concluded that one vixen in each case was non-breeding.

At least two non-breeding vixens were found to "help" at the den while one never did so. Insufficient information was available on two non-breeding vixens.

Age determination of breeding pairs killed at breeding dens in Iceland reveals a positive correlation between the ages of mated pairs. This may indicate long-term pair bonds, in agreement with the observations mentioned above.

If pair bonds last while both members of the pair survive, the mean age of mates of foxes should change in predictable way with age for each sex if the rate of mortality and mean age of "eligible" foxes are known. A model which explores this hypothesis will be introduced.

References: Hersteinsson, P. 1984. Behavioural ecology of the arctic fox in Iceland. D. Phil. thesis, Oxford.

Population fluctuation in the Icelandic arctic fox.

Páll Hersteinsson.

In many parts of its geographical range the arctic fox exhibits marked population cycles lasting 3-5 years in response to cycles in small rodents (*Macpherson, 1969; Finerty, 1980*). The only wild rodent in Iceland, *Apodemus sylvaticus*, is of minor importance in the diet of the arctic fox there (*Hersteinsson, 1984*) and the arctic fox population there does not go through short term population fluctuations.

Records of fox skin exports, however, show that the arctic fox went through considerable long term population fluctuations in the latter half of the 19th century and early 20th century. Indeed such fluctuations are still going on, with the latest population peak taking place in the 1950's followed by a population minimum in the early 1970's. At the present time, the population is increasing in size.

The causes of the long term population fluctuations are not known, but it is possible that epizootics of distemper, known to have almost wiped out the dogs in large parts of Iceland occasionally, may play a part. In addition, the use of poison, particularly strychnin, may have been of importance in the past.

Superimposed on the long term fluctuations are fluctuations of approximately 10-years duration due to population cycles in ptarmigans *Lagopus mutus* (*Gudmundsson, 1960*) of the same duration. Although the numerical effects on foxes of ptarmigan cycles has only been detected in north-eastern Iceland during the last few decades, this effect may have been more widespread geographically in earlier times.

References: Finerty, J.P. 1980. The population ecology of cycles in small mammals. Yale University Press, New Haven, U.S.A.
Gudmundsson, F. 1960. Some reflections on ptarmigan cycles in Iceland. Proc. XIIth Orn. Congr., Helsinki, pp 259-265.
Macpherson, A.H. 1969. The dynamics of Canadian arctic fox populations. Can. Wildl. Service Rep. Ser., 8, 1-49.

Colour morphs of arctic foxes in Iceland.

Páll Hersteinsson.

In his historical book on the arctic fox in Iceland, Gunnlaugsson (1955) states that the species occurs in a wide variety of colour morphs. He describes them as white, grey, blue, brown, yellow and black.

It is clear that the non-white morphs mentioned are all varieties of the so-called blue fox which does indeed occur in a wide range of hues in Iceland. The grey, blue and brown colours all appear to be controlled by a number of loci which results in a wide spectrum of colours. Only the yellow (now termed "cinnamon") and black have been hypothesized to be controlled by single genes (*Adalsteinsson et al., 1987*).

The white morph is greyish brown dorsally and light grey ventrally during summer and virtually white during winter. A majority of white foxes, however, have a low but variable amount of dark guard hairs during winter. Similarly many foxes of the dark morph have a white patch on the chest, which may vary in size from just a few hairs to a large cross. In such cases white toes and a small white blaze on the chin are the rule. Furthermore, white bands just below the tip of guard hairs vary in frequency between foes, thus affecting colour.

At present about one-third of the arctic foxes in Iceland are of the white morph. There is considerable geographical variation in the frequency of the colour morphs, with less than 10% white in parts of the northwest and over 60% white in the east.

The dark (blue) morph appears to be associated with coastal habitats where a large proportion of the diet comes from bird cliffs and sea-shores while the white morph is associated with inland habitat where the camouflage value of a white coat is of importance during winter.

Export records from the late 19th century and early 20th century suggest that the frequency distribution of the colour morphs was roughly similar to what it is today, with the exception of

the northwestern fjords where the white morph was far more common in earlier times. It is suggested that this may be caused by one or both of two factors, firstly a colder climate in the late 19th century, and secondly a higher dependence there on ptarmigan (*Lagopus mutus*) in earlier times than is the case nowadays.

References: Adalsteinsson, S., P. Hersteinsson & E. Gunnarsson. 1987. Fox colors in relation to colors in mice and sheep. J. Heredity 78: 235-237. Gunnlaugsson, T. 1955. A refaslódum. The Agricultural Society of Iceland, 383 pp.

Arctic fox in the Kilpisjärvi region, NW Finnish Lapland, in 1985-91.

Asko Kaikusalo.

The distribution of the arctic fox in Finland covers only the northernmost part of the country, the mountain (fell) region. In addition, in the 1980's we have one observation of successful breeding on an isolated treeless fell (Naltiotunturi) in the middle of eastern Lapland. The most abundant population with a continuous range inhabits the most northwestern part of the Finnish Lapland, the only part of Finland that reaches Scandinavian mountain range.

Arctic foxes have been monitored there with a varying intensity since 1964. In 1985-91 there were 42 dens (some of them close to the border on the Norwegian side); more than half of them have been checked every summer in 1985-91. During the same period the supply of food resources has been determined with snap-trapping of small mammals and estimating the abundance of reindeer carcasses. During this period, the year-to-year variation in the total number of arctic foxes in Finland has been estimated to range between 10-80 individuals.

The food of arctic foxes has been analyzed by identifying all the prey remains found at dens and by analyzing scats collected at dens in all seasons. In addition, supplemental feeding has been attempted in the vicinity of some dens.

The number of arctic foxes in Kilpisjärvi region has varied from 10 to 60. The reproductive success depends primarily on food supply, which consists of microtine rodents (*Lemmus lemmus, Clethrionomys rufucanus, Microtus oeconumus* and *M. agrestis*) and reindeer carcasses. In the absence of big predators, as is the situation in the Kilpisjärvi region, the supply of carcasses depends on whether winter grazing and calving of reindeer takes place in the vicinity of fox dens, and how unfavourable weather and other conditions are during calving. In the summer, arctic foxes feed considerably also on birds of the alpine zone and in the winter on fish, mainly burbots, which fishermen abandon on the ice.

Litter size estimates have been based on the number of young seen at the dens. There is an alarming trend in the litter size: in 1964-74 the mean was 6.6 (range 3-12, n=10) whereas in 1985-91 the mean was only 2.4 (range 1-5, n=28). This difference was not related to any observable trend in microtine fluctuations or abundance of reindeer carcasses.

In 1989-91 some supplemental feeding has been attempted. From February to May whole or cut reindeer carcasses and frozen fish have been transported with snow mobile to the vicinity of five dens situated close to each other. Censuses in late May have shown that with the help of the supplemental food single foxes or pairs have stayed at the den site in spite of poor supply of natural food. Breeding success has not, however, improved, obviously because the supplemental feeding has been finished in early June due to transportation problems. On the other hand, 1 or 2 red fox litters have been raised yearly in these dens at the same time. We hope this is an accident even though records on breeding red foxes in the alpine zone in this region are extremely rare.

Acknowledgements: The World Wildlife Fund (WWF) in Finland has supported this project in 1985-1991.

Arctic fox project - Greenland: Parasitology and morphology of the arctic fox in Greenland.

Christian M. Kapel, Thomas Bjørneboe Berg.

The project's aim is to investigate the parasitology and morphology of arctic foxes, *Alopex lagopus*, from various parts of Greenland in relation to feeding biology and fauna composition of the different habitats.

The 5 study areas were selected with respect to logistic accessibility, the degree of geographical

isolation of the fox populations, diversity of potential food items and diversity of potential parasitological vectors (transmitters).

Study areas: 1) Upernaviarssuk, Southern West Greenland: Absence of small rodents and moskoxen. Commercial sheep and reindeer farming area. Year round ice free coastal region, but with drift ice in summer. Foxes from the east coast may follow the drift ice.
2) Godthaab/Nuuk, Central West Greenland: Absence of small rodents and muskoxen. Reindeer area (wild and farmed). Inland areas and year round ice free coastal areas.
3) Kangerlussuaq/Sdr. Stroemfjord, Central West Greenland: Absence of small rodents. Reindeer and muskoxen area. Inland area.
4) Thule, North West Greenland: Absence of small rodents and ruminants Coastal area, sea ice (Oct-Jun). The area may be influenced by immigrating Canadian arctic foxes.
5) Kronprins Christians Land, North East Greenland: Absence of reindeer. Lemming and muskoxen area. Inland areas and coastal areas with access to a polynia (Year round ice free sea zone). The population is well isolated from other populations in Greenland.

Parasitology: No publications exist on the general parasitology of arctic fox in Greenland, and only limited information exists on helminths and trichin infections. The parasitology of collected foxes will be examined for all potential endoparasites. Of special interest is the epidemiology of gastro-intestinal helminths and trichinas.
Pathology: The material will be tested for rabies only.
Feeding biology: The feeding biology of the collected foxes will be estimated using analysis of stomach contents. The results obtained here will be of interest in relation to both parasitology and morphology.
Morphology: 1000 fox craniums from all parts of Greenland (present in the museum of Zoology, Copenhagen) will be examined by metrical and non-metrical measuremetns. Integrated with results from foxes colleced in the present study new knowledge maybe revealed on the morphology of arctic foxes in relation to feeding biology, colour morphs, sexes and geographic isolation of distinct populations of foxes.

Social behaviour and cooperative breeding in arctic foxes, in a semi-natural environment.

Cecilia Kullberg, Anders Angerbjörn.

All species of canids that have been studied in detail show cooperative breeding at least occasionally. The helper-at-the-den system, when extra adults serve as helpers by feeding and guarding the cubs of an alpha pair, have been observed a few times among wild arctic foxes, but have not been studied in any detail.

During a 3-month study of arctic foxes in two enclosures of each 4 ha, we measured the social behaviour during the reproduction season, and analysed changes by a factor analyses. The behaviour could be categorized in four different factors: 1) territory defence, 2) food related, 3) friendly interactions, 4) aggressions. Older foxes dominated younger ones and males dominated females of the same age. The subordinate females were probably suppressed from breeding by the high aggression levels and territory defence of the dominant females in each enclosure.

A litter with one surviving cub was born in one enclosure. The father of the cub increased his territory defence (urine marking and barking) and began feeding the alpha female when the litter was born. However, about 10 days after the birth, the alpha female died. The cub was adopted by his one year old sister, who also increased her territory defence. Also, the father and a one year old brother helped in feeding the cub. The dominant female in the other enclosure came into heat only after the death of the alpha female in the other enclosures (her mother), probably due to a behavioural inhibition by the alpha female as long as she was present. Striking differences in social behaviour between the enclosures illustrates how dependent the social organization in a group of arctic foxes can be on reproductive status and composition of foxes in the group.

Fishing arctic foxes on a rocky island in West Greenland.

Sussie Møller Nielsen.

The study took place on a small rocky island off

the coast of West Greenland in 1990. A breeding pair of arctic foxes was repeatedly observed catching live fish in small rock pools. It was found that a major part of their diet consisted of live-caught fish and that hunting for live fish only took place at low tide, while most resting and sleeping took place at high tide.

Use of various types of whole year nest boxes in farmed blue fox (*Alopex lagopus*).

Vivi Pedersen.

The use of 3 different whole-year nest boxes and a shelf was examined among 50 blue fox vixens from November 1987 to February 1989. All vixens had simultaneous free access to a top box, a side box, an open box and a shelf. The vixens were manually scanned for choice of stay each 10th minute in 5 * 2 hours observations in twenty-two 14-day periods.

The use of each nest box and the shelf differed significantly during the 22 periods ($p<0.0001$, GLM). After a short period of getting accustomed to the shelters the vixens preferred to use the top box and used the shelf a little less.

During a disturbance test performed twice in 1989 most blue foxes fled into the top box when disturbed and some into the side box.

It was revealed that the use of the top box and the shelf was for both short and longer lasting stays, whereas the use of the sidebox and open box was mainly for shorter stays. Short versus long lasting stays were supposed to reflect exploration/territorial patrol and resting/hiding, respectively.

Most blue foxes used the open box for defaecation but a decrease in number of animals defaecating ($p<0.0001$, chi-square) and a decrease in amount of faeces ($p<0.0011$, Kruskal-Wallis test) in the open box were found during the study. very little defaecation was observed in the side box and top box.

The conclusion of the study was that farmed blue foxes used whole-year shelters when provided to them and defaecation took place mainly outside the nest boxes, except for the open box. It was also concluded that when they had a choice between 3 different types of nest boxes they preferred to use a top box which had a tunnel and a solid floor.

Fat deposition and seasonal variation in body composition of arctic foxes in Svalbard.

Pål Prestrud, Kjell Nilssen.

We studed the seasonal variation in body composition of arctic foxes (*Alopex lagopus*) to determine the adaptive significance of fat deposition in this species. Homogenates of 75 minced fox carcasses were analyzed. On a large sample of trapped animals the thickness of subcutaneous fat was measured and the amount of fat was indexed subjectively. Fat was deposited both subcutaneously and viscerally in September-October, and it reached a maximum of about 20% of the skinned carcass weight in November. In no year did the amount of fat deposited decline between November and March. The fat deposits were depleted from March through May, reaching about 6% of the carcass weight by the summer. Fifteen percent of the trapped foxes did not have any subcutaneous or visceral fat deposits in winter. The amount of fat deposited varied among years but did not change with age and was independent of sex. Females that reproduced the previous spring were less fat in winter than other foxes. Fat depositon in arctic foxes is probably an adaptive response to a combination of food shortage in severe winters or in brief periods during normal winters, increased energy requirements during the reproductive season, and thermoregulation during low termperatures.

Growth, size and sexual dimorphism in arctic foxes (*Alopex lagopus*) in Svalbard.

Pål Prestrud, Kjell Nilssen.

Weight gain and lower leg length increase of arctic foxes captured in Svalbard, Norway, from age 25 days to maturity were described using the Gompertz growth model. The asympotic values of calf length were 14.3 cm in females and 15.2 cm in males. The asymptotic values of body weight were 3102 g in females and 3583 g in males. Males grew larger than females mainly by growing for a longer time. Growth ceased when foxes

were 6-7 months of age. Absolute growth rates were approximately 50% greater than were predicted from the established regresssion between growth rate and body weight in carnivores. The difference in body weight, body length, tail length and calf length among juvenile, yearling and adult foxes caught in December-March were not significant. From measurements on a sample of trapped foxes, males were significantly larger than females in body weight (19%), body length (4%), calf length (6%) and tail length (4%). From the weight of 13 fully-furred fetuses, the neonatal weight of arctic foxes was estimated to be 45-60 g.

Temporal and spatial variation in the proportion of the blue colour phase in arctic foxes in Svalbard.

Pål Prestrud.

The proportion of the blue colour phase in trapped arctic foxes (*Alopex lagopus*) in Svalbard from 1901 to 1989 was examined by collecting data from trappers accounts and diaries, by interviewing trappers and direct observation of live foxes during a field study. The proportion of blue foxes declined from more than 30% at the beginning of this century to less than 4% in the 1980s. Most of the decline took place before 1941. The reason for the change in frequency of occurrence of the different colour phases is unclear. The overall proportion of blue foxes did not vary between 4 different areas in Svalbard, although there were differences in the proportion caught by different trappers in the same year (5%-60%).

The proportion of the blue colour phase in arctic fox populations varies throughout the Arctic, though the reason remains unclear.

The effect of summer feeding on juvenile arctic fox survival - a field experiment.

Magnus Tannerfeldt, Anders Angerbjörn.

The arctic fox (*Alopex lagopus*) population in Sweden is small and its numbers fluctuate widely with food availability, i.e. rodent populations. This fluctuation is mediated through differences in recruitment rates between years. The recruitment consists of three factors: number of litters, number of cubs per litter and cub survival rate. The number of litters and their size have been shown to depend on food availability during the winter and spring.

To examine cub survival during the summer and how it relates to food availability, we conducted a feeding experiment in northern Sweden during a year of low rodent density, involving six occupied and six unoccupied arctic fox dens.

Feeding lowered cub mortality rate, which revealed that food availability during the period of parental care has a decisive effect on cub survival.

Also, a body condition index measured early in the summer can be used to indicate the chances for cub survival until the autumn, provided that most deaths are caused by starvation.

Arctic fox cubs that had access only to natural food had negative rates of growth more often than fed cubs did. Although there was no difference in overall growth rate, cubs with a steady food supply grew in accordance with the curve given by a quadratic equation, whereas those with low food availability had a large variation and did not fit any of the examined growth curves in a sensible way. These findings indicate that arctic fox cubs minimize the risk of starvation rather than maximizing the growth.

Workshop I: Aspects of population dynamics and demography.

Participants discussed the great differences in demography between populations, in particular the greater variance between years in areas with fluctuating food resources.

The following factors were identified as varying temporally within populations: 1) proportion breeding by age group, 2) cub survival.

Factors identified as varying between populations: 1) Fertility, 2) Litter size, 3) Variance of cub survival, 4) Variance of adult survival.

The importance of genetic and environmental components affecting these differences are still unsolved.

Workshop II: Experimental work in the wild and in captivity.

The need for experimental work on arctic foxes in captivity on aspects of reproductive biology and energetics was emphasized by the participants.

The major obstacle to such work was identified as the difficulty involved in breeding wild-caught arctic foxes in captivity.

While farmed blue foxes are readily available it is clear that artificial selection in the past may have affected the variables of interest.

Some of the reproductive variables may be amenable for study by experiments in the wild, particularly those associated with food resources.

Workshop III: Ecology and the epidemiology of arctic rabies.

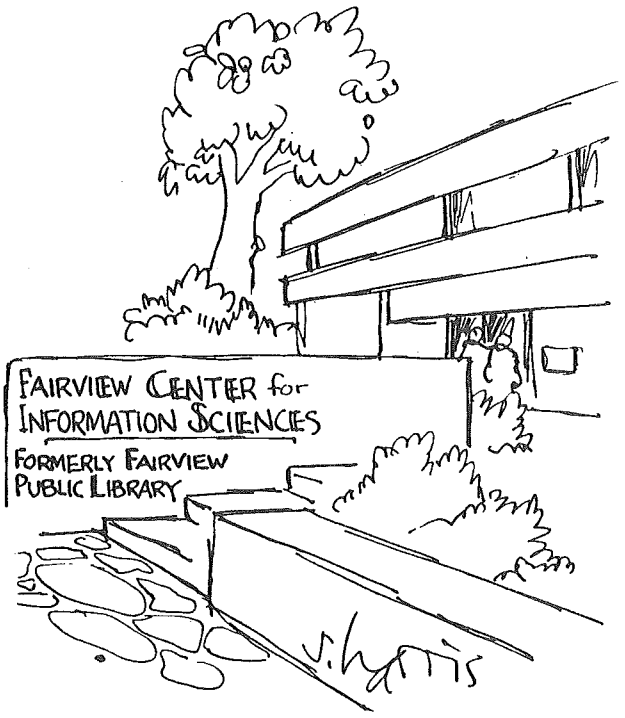
The draft recommendations of the WHO meeting on arctic rabies in Uppsala in 1990 with regard to research on the ecology of host species and epidemiology of arctic rabies were presented by Páll Hersteinsson and Erich Follmann.

It was the general view of the participants that the recommendations as drafted would be useful as guidelines.

When conducting studies on the arctic fox, whether in captivity or in the wild, information of importance in the event of a rabies outbreak should be collected whenever possible. The need for studies on the importance of nutritional status and other factors, such as parasite load, which may affect arctic foxes' susceptibility to rabies, was emphasized.

The participants agreed that studies on the movements of arctic foxes, particularly dispersal movements of juveniles and migrations/emigrations of adults and juveniles on sea-ice, must be emphasized in order to gain further understanding of rabies epidemiology.

Participants also agreed that those present at this meeting should stay in contact and discuss both data and theories on arctic fox ecology and rabies epidemiology at future meetings. The Second International Arctic Fox Meeting should take place in 1994. In order to facilitate the attendance of Soviet scientists, who could not be present at this meeting, Alaska was suggested as a likely venue. Dr. Erich Follmann undertook the coordination of such a meeting.



Original Report

Content of some mineral elements in hair of cross foxes during ontogenesis

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Summary

Fur samples of cross foxes (red fox x silver fox) of both sexes were analysed by means of disperse - roentgenfluorescent spectrometry from three topological parts of the body (middle part of back, dorsal part of middle of tail, terminal part of tail) during ontogenesis. On the basis of statistic evaluation of observed concentrations of K, Ca, Mn, Fe, Cu, Zn, Br, Rb, Sr and Pb, an uneven distribution of these elements was noticed in dependence on age, sex and sampling locality. Higher concentrations of the majority of the observed elements were found in fur of males compared with females. The highest content in males and females was on the tail.

Introduction

Observation of abiogenic substances concentration in the fur of animals seems to be a perspective method of research which is made for optimalization of their mineral nutrition.

It was assumed that this method can be significant mainly in furbearing animals, where the mineral composition of fur can also influence the fur quality. Samkov, Ju. (1972) and Saba et al. (1982) were of this opinion. They determined the concentration of P, K, Ca, Mn, Fe, Zn, and Cu in the fur of silver foxes, and Saba et al (1982) found that white hairs contain more Ca, Mg, and P than the coloured fur. Berestov, et al. (1984) observed the concentration of Zn, Fe, Mg, Ca and Cu in the fur of polar foxes and standard black mink during ontogenesis and they found that the content of mineral elements in fur changed in dependence on age of animals and stage of fur maturation and that the content of observed elements differs also in dependence on the locality from which the fur was sampled. In polar foxes they found the highest concentrations of Zn, Cu, Fe, and Ca in the fur tail. Mertin, et al. (1990, 1991) dealt with the content of mineral substances in the fur of silver foxes and cross foxes in individual periods of their ontogenetic development and found that the concentration of mineral substances changes during ontogenesis also in foxes of Vulpes genus. Significant are also differences in deposition of mineral elements in individual localitites of the body and between the sexes.

Material and method

The experiment took place in the Department of Fur Animals Breeding of the Research Institute of Animal Production in Nitra, CSFR. There were used 90 males and 90 females of cross foxes (red fox x silver fox) in the trial. Fur samples were taken during ontogenesis at the ages of 30, 60, 90, 120 and 200 days. In 30, 60 and 90 day old animals the fur was taken from the back. To study the topographic differences in concentration of mineral elements, the samples were taken from the middle part of back, the dorsal part of the middle of the tail and the terminal part of the tail at the ages of 120 and 200 days. Fur samples were cut from the animals (approximately 2 g). Each age category was represented by 5 males and 5 females. The mineral elements K, Ca, Mn, Fe, Cu, Zn, Rb, Sr, Br and Pb were determined by means of disperse - roentgenfluorescent spectrometry in fur samples (*Tumanov, J. & Stepanok, V. 1986*). The obtained concentration values of the observed elements were elaborated to basic variance-statistical characteristics (M ± SD). Significance of differences of arithmetical means were tested by a t-test. Animals were kept in iron cages with grates in two-row sheds and they were clinically healthy during the experiment. The nutritional value of feed rations is given in table 1.

Table 1. Contents of digestible nutritive substances in feeding doses (g 418 $KJ^{-1}ME$).

	Month							
Index	IV	V	VI	VII	VIII	IX	X	XI
Digestible protein (g)	10.7	10.3	10.3	8.6	8.6	9.1	9.2	9.3
Digestible fats (g)	3.5	3.8	3.8	4.2	4.2	3.7	3.6	3.9
Digest. sacharides (g)	5.8	5.5	5.5	5.4	5.4	6.2	6.5	6.1
$ME.plece^{-1}.day^{-1}(KJ)$	2092	2510	2510	3096	3096	2594	2176	1966

Results and discussion

Basic statistical traits of the concentrations of the observed elements during ontogenesis in the fur of cross foxes are given in tables 2 - 10. In all categories, in the observed topological regions of the body and in both sexes, there is quantitative representation of the studied mineral elements. It is obvious from the results of our analyses that the content of observed mineral elements in the fur of young cross foxes (table 2, 3, 4) changes in most cases in dependence on their age. This fact manifested itself markedly with manganese. We observed the highest concentration in males at the age of 60 days, and the lowest content in females at the age of 30 days. Zinc content had a rising tendency in dependence on age during the growth of the observed young. More marked differences were found in females.

A similar tendency of concentration increase with regard to the age of the animals was observed also with iron. It concerns mainly the first phase of growth of juvenile hairs up to the age of 60 days, whereas a moderate decrease of its content is observed in the further phase. Observations of copper content showed that its increase in connection with age manifested itself only in the group of males. The content of the observed element varied in juvenile hairs of females and a falling tendency was noticed. Similar tendencies can be stated also with bromine content and it is documented mainly with results obtained in females.

Concentration of potassium, calcium, rubidium, strontium and lead in juvenile hairs of cross foxes is relatively stable and there were not observed significant differences in their content in dependence on sex and age.

From our results follows that the concentration of most of the observed mineral elements in juvenile

hairs increases in dependece on the age of animals. We came to similar results in our previous work (*Mertin et al., 1991*) which dealt with concentration of elements in juvenile hairs of silver foxes. The increases of mineral element contents is less marked in cross foxes than in silver foxes.

Table 2. The concentration of elements in juvenile hair of cross foxes.

Element	Group of males M ± SD			Group of females M ± SD		
(mg.kg^{-1})	n = 5 Age 30 days	n = 5 Age 60 days	n = 5 Age 90 days	n = 5 Age 30 days	n = 5 Age 60 days	n = 5 Age 90 days
K (%)	0.301 ± 0.024	0.300 ± 0.030	0.319 ± 0.054	0.329 ± 0.015	0.252 ± 0.022	0.337 ± 0.001
Ca(%)	0.078 ± 0.006	0.076 ± 0.005	0.068 ± 0.007	0.006 ± 0.007	0.071 ± 0.005	0.074 ± 0.005
Mn	43.76 ± 4.64	67.04 ± 3.40	47.14 ± 7.70	30.24 ± 6.36	45.82 ± 5.52	45.92 ± 3.63
Fe	182.6 ± 12.1	586.0 ± 33.3	578.0 ± 27.5	238.8 ± 4.6	1164.0 ± 123.3	380.0 ± 39.6
Cu	5.96 ± 0.78	6.41 ± 0.90	8.04 ± 1.16	10.76 ± 0.85	9.76 ± 1.42	3.23 ± 0.29
Zn	184.6 ± 19.7	449.2 ± 42.1	449.0 ± 9.1	182.8 ± 2.6	543.6 ± 47.3	538.8 ± 15.3
Br	31.38 ± 1.48	34.00 ± 0.49	31.60 ± 0.97	35.76 ± 0.59	28.00 ± 1.66	27.40 ± 1.18
Rb	2.93 ± 0.35	3.72 ± 0.61	3.52 ± 0.59	3.28 ± 0.31	3.50 ± 0.28	2.36 ± 0.21
Sr	1.77 ± 0.33	3.25 ± 0.41	1.97 ± 0.21	1.60 ± 0.09	2.55 ± 0.19	2.29 ± 0.05
Pb	2.47 ± 0.23	2.68 ± 0.11	3.49 ± 0.56	2.46 ± 0.03	3.08 ± 0.49	3.00 ± 0.36

Table 3. Evidence of differences of arithmetical averages of the concentration of investigated elements in juvenile hair between males and females according to age.

Element	Age (days)		
	30	60	90
K	0.028	0.048	-0.018
Ca	0.012	0.005	-0.006
Mn	13.520 +	21.220 +	1.220
Fe	-56.200 ++	-578.000 ++	198.000 ++
Cu	-4.800 ++	-3.350 +	4.810 ++
Zn	1.800	-94.400	-89.800 ++
Br	-4.380 +	6.000 ++	4.200 +
Rb	-0.350	0.022	1.160
Sr	0.170	0.700	-0.320
Pb	0.010	-0.400	0.490

+ $P \leq 0.05$
++ $P \leq 0.01$

Table 4. Evidence of differences of arithmetical averages of the concentration of investigated elements in juvenile hair according to age.

Element	Group of males			Group of females		
	1 : 2	1 : 3	2 : 3	1 : 2	1 : 3	2 : 3
K	0.001	-0.018	-0.019	0.077 ++	-0.008	-0.085 ++
Ca	0.002	0.010	0.008	-0.005	-0.008	-0.003
Mn	-23.280 ++	-3.380	19.900 +	-15.580	-15.680	-0.100
Fe	-403.400 ++	-395.400 ++	8.000	-925.200 ++	-141.200 ++	784.000 ++
Cu	-0.450	-2.080	-1.630	1.000	7.530 ++	6.530 ++
Zn	-264.600 ++	-264.400 ++	0.200	-360.800 ++	-356.000 ++	4.800
Br	-2.620	-0.220	2.400	7.760 ++	8.360 ++	0.600
Rb	-0.790	-0.590	0.200	-0.220	0.920 +	1.140 +
Sr	-1.480 +	-0.200	1.280 +	-0.950 ++	-0690 ++	0.260
Pb	-0.210	-1.020	-0810	-0.620	-0.540	0.080

1 - age 30 days; 2 - age 60 days; 3 - age 90 days

In male crosses there was a significantly higher content of manganese, bromine and strontium ($p \leq 0.01$) at the age of 60 days, of zinc, ($p \leq 0.01$), and iron, copper and rubidium ($p \leq 0.05$) at the age of 90 days compared with silver foxes. On the contrary, in the fur of silver fox males, there was significantly more lead ($p \leq 0.01$) at the age of 60 days and rubidium ($p \leq 0.05$) at the age of 30 days. Furthermore, the authors determined higher values of most of the observed elements in the fur of female crosses, namely potassium, copper and zinc ($p \leq 0.01$) at the age of 30 days, iron and copper ($p \leq 0.01$) at the age of 60 days and potassium, zinc ($p \leq 0.01$), and calcium ($p \leq 0.05$) at the age of 90 days compared with females of silver foxes.

Changes in the concentration of the observed mineral elements in juvenile hairs of foxes is probably related to the changes in nutrition. In the fur of young which pass from milk nutrition to nutrition with standard feed mixtures, we observed changes in concentration mainly of those elements the content of which differs in solid food and maternal milk. Determined differences in the concentration of the observed mineral elements in the fur of males and females are probably in relation to the varying intensity of the individual generations of fur in both sexes and specific differences in their metabolism.

The results of the concentrations of the observed elements in summer fur of crosses in the moulting period at the age of 120 days are given in tables 5, 6 and 7. We noticed significant differences in arithmetical means of the content of the observed mineral elements between the sexes in most cases in the fur of males within one locality. On the level of significance $p \leq 0.01$, in the back for Mn, Fe, Br, Sr, in the middle of the tail for Fe, Br, and on the level of significance $p \leq 0.05$ for Pb, and on the terminal part of the tail for Mn, Rb, and Pb. An uneven distribution of mineral elements in the individual localities of the body was noticed in the fur of males and females. The highest content of observed elements was in males in the terminal part of the tail. We noticed highly significant differences for Ca, Fe, Zn, Cu, Rb, Pb ($p \leq 0.01$) and for K ($p \leq 0.05$). The content of Sr was approximately on the same level and Mn was significantly higher on the back ($p \leq 0.01$). Results determined from the observed topological sites in females show a more even distribution of mineral elements compared with males and is in line with the results of Mertin et al. (1991) gained in silver foxes, although compared with silver foxes there occur greater differences in the concentration of Ca and Zn. The highest concentrations of the observed elements in fur of cross foxes were in the terminal part of the tail: Fe, Cu, Zn, Rb ($p \leq 0.01$) and Ca, Br ($p \leq 0.05$).

Table 5. The concentration of elements in the hair of cross foxes in the moulting season (age 120 days).

Element	Group of males (n = 5= M ± SD			Group of females (n = 5) M ± SD		
($mg.kg^{-1}$)	MPB	MT	TPT	MPB	MT	TPT
K (%)	0.150 ± 0.015	0.205 ± 0.019	0.273 ± 0.034	0.181 ± 0.002	0.185 ± 0.031	0.225 ± 0.043
Ca (%)	0.068 ± 0.007	0.062 ± 0.003	0.253 ± 0.169	0.063 ± 0006	0.052 ± 0.003	0.074 ± 0.005
Mn	67.04 ± 2.93	40.88 ± 1.98	52.06 ± 7.87	34.88 ± 4.28	39.18 ± 1.27	44.20 ± 4.59
Fe	220.4 ± 14.5	566.0 ± 28.0	690.0 ± 107.7	130.8 ± 8.7	312.8 ± 34.6	471.0 ± 44.7
Cu	4.09 ± 0.36	7.05 ± 0.26	11.60 ± 0.59	6.59 ± 0.90	9.07 ± 1.23	10.23 ± 1.11
Zn	207.8 ± 3.2	218.2 ± 15.9	296.6 ± 21.8	205.4 ± 10.5	230.0 ± 31.0	468.8 ± 69.5
Br	25.10 ± 0.67	29.06 ± 0.34	26.40 ± 0.46	20.46 ± 0.86	19.10 ± 1.12	25.18 ± 1.45
Rb	2.00 ± 0.22	2.71 ± 0.38	4.21 ± 0.12	2.08 ± 0.05	2.87 ± 0.38	3.36 ± 0.21
Sr	2.42 ± 0.13	2.26 ± 0.11	2.36 ± 0.90	1.31 ± 0.12	2.10 ± 0.15	1.88 ± 0.23
Pb	2.47 ± 0.16	3.85 ± 0.17	7.19 ± 0.54	2.52 ± 0.24	2.93 ± 0.33	2.39 ± 0.15

MPB - the middle part of the back; MT - the middle of the tail; TPT - the terminal part of the tail

Table 6. Evidence of differences of arithmetical averages of the concentration of the investigated elements in hair in the moulting season between males and females from three localities of the body.

Element	Locality		
	MPB	MT	TPT
K	-0.35	0.020	0.048
Ca	0.005	0.010	0.179
Mn	32.160 ++	1.700	7.860 ++
Fe	89.600 ++	253.200 ++	217.000
Cu	-2.500 ++	-2.020	1.370
Zn	2.400	-11.800	-172.200 ++
Br	4.640 ++	9.960 ++	1.220
Rb	-0.080	-0.160	0.850 ++
Sr	1.110 ++	0.160	0.480
Pb	-0.050	0.920 +	4.800 ++

+ : $P \leq 0.05$; ++ : $P \leq 0.01$

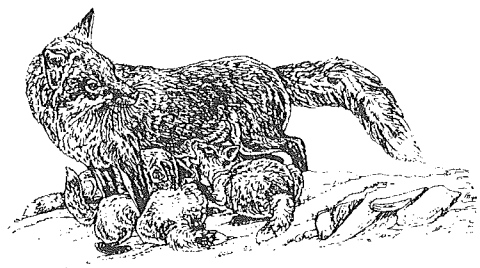

Table 7. Evidence of differences of arithmetical averages of the concentration of the investigated elements in hair in the moulting season from three localities of the body.

Element	Group of males			Group of females		
	1 : 2	1 : 3	2 : 3	1 : 2	1 : 3	2 : 3
K	-0.055	-0.123 +	-0.068	-0.004	-0.044	-0.040
Ca	0.006	-0.185	-0.191 ++	0.011	-0.011	-0.022 +
Mn	26.160 ++	14.980	-11.180	-4.300	-0.320	-5.020
Fe	-345.600 ++	-469.600 ++	-124.000	-182.000 ++	-340.200 ++	-158.200 +
Cu	-2.960 ++	-7.510 ++	-4.550 ++	-2.480	-3.640 +	-1.160
Zn	-10.400	-88.800 ++	-78.400 +	-24.600	-263.400 ++	-238.800 +
Br	-3.960 ++	-1.300	2.660 ++	1.360	-4.720 +	-6.080 +
Rb	-0.710	-2.210 ++	-1.500 ++	-0.790	-1.280 ++	0.490
Sr	0.160	0.060	-0.100	-0.790 ++	-0.570	0.220
Pb	-1.380 ++	-4.720 ++	-3.340 ++	-0.410	0.130	0.540

+ : $P \leq 0.05$; ++ : $P \leq 0.01$; 1 : MPB; 2 : MT; 3 : TPT

In the period of fur maturity (tables 8, 9, 10) was found a significantly higher content of K, Ca, Mn and Pb in females. The concentration of Cu and Zn was approximately on the same level and the content of bromine was significantly lower in females. When the observed elements in the fur of males and females were evaluated in various sites of sampling an uneven distribution of these elements was determined. The highest concentrations of the observed elements were in the fur of males on the tail. We also noticed similar results in females. The highest concentrations were manifested in most cases on the tail.

Significant differences in the content of K, Fe, Zn, Br, Pb were in the terminal and of Cu and Sr in the dorsal part of the middle of tail. Most of the significant differences between the terminal part of the tail and further observed localities in both sexes confirms the presupposition that there exists a relationship between fur colour and concentration of elements (*Samkov, Ju., 1972*) although this fact is mentioned in the quoted work in relation to Ca, Mg and P. The high concentrations of mineral elements in the fur of the tail is confirmed by Berestov, V. et al. (1984) in the fur of polar foxes and mink, and Saba, L. et al. (1984) in the fur of silver foxes. In connection with the significantly increased level of the observed mineral element contents, it is necessary to assume that they are important during the growth and formation of winter fur with due impact on its qualitative properties.

Table 8. The concentration of elements in the hair of cross foxes in the fur ripeness period (age 200 days).

Element ($mg.kg^{-1}$)	Group of males (n = 5) M ± SD			Group of females (n = 5) M ± SD		
	MPB	MT	TPT	MPB	MT	TPT
K (%)	0.150 ± 0.014	0.158 ± 0.111	0.173 ± 0.003	0.234 ± 0.027	0.200 ± 0.034	0.318 ± 0.018
Ca (%)	0.059 ± 0.003	0.054 ± 0.002	0.078 ± 0.005	0.084 ± 0.002	0.083 ± 0.011	0.063 ± 0.003
Mn	31.08 ± 3.80	39.30 ± 0.70	40.70 ± 2.71	64.14 ± 3.97	68.02 ± 7.06	43.72 ± 2.87
Fe	85.9 ± 12.1	255.4 ± 46.7	608.2 ± 30.9	134.5 ± 11.9	241.6 ± 35.3	379.8 ± 43.9
Cu	5.05 ± 0.75	8.16 ± 0.77	8.59 ± 0.77	5.30 ± 0.32	7.59 ± 0.79	6.42 ± 0.69
Zn	156.8 ± 6.1	210.4 ± 3.8	267.8 ± 36.5	168.6 ± 9.3	221.0 ± 32.9	363.4 ± 62.1
Br	21.88 ± 0.82	24.00 ± 0.45	22.96 ± 1.32	18.48 ± 0.83	22.40 ± 1.01	29.38 ± 2.46
Rb	2.03 ± 0.08	2.16 ± 0.20	2.91 ± 0.25	2.48 ± 0.12	1.92 ± 0.17	3.94 ± 0.25
Sr	2.41 ± 0.09	3.13 ± 0.49	1.88 ± 0.20	2.28 ± 0.05	2.70 ± 016	2.47 ± 0.08
Pb	2.21 ± 0.07	2.62 ± 0.13	2.40 ± 0.14	2.35 ± 0.23	3.85 ± 0.18	3.80 ± 0.22

MPB - the middle part of the back; MT - the middle of the tail; TPT - the terminal part of the tail.

Table 9. Evidence of differences of arithmetical averages of the concentration of the investigated elements in the hair in the fur ripeness period between males and females from three localitites of the body.

Element	Locality		
	MPB	MT	TPT
K	-0.084 +	-0.042	-0.145 ++
Ca	-0.025 ++	-0.029	0.015
Mn	-33.060 ++	-28.720 ++	-3.020
Fe	-48.600 +	-13.800	228.400 ++
Cu	-0.250	0.570	2.170
Zn	-11.800	-10.600	-95.600
Br	3.400 +	1.600	-6.420
Rb	-0.450 ++	0.240	-1.030 +
Sr	0.130	0.430	-0.590
Pb	-0.140	-1.230 ++	-1.400 ++

+ : $P \leq 0.05$; ++ : $P \leq 0.01$

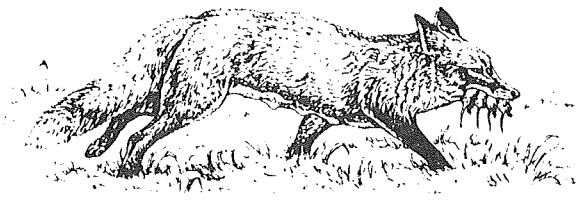

Table 10. Evidence of differences of arithmetical averages of the concentration of investigated elements in the hair in the fur ripeness period from three localities of the body.

Element	Group of males			Group of females		
	1 : 2	1 : 3	2 : 3	1 : 2	1 : 3	2 : 3
K	-0.008	-0.023	-0.015	0.034	-0.084 +	-0.118 +
Ca	0.005	-0.019 +	-0.024 ++	0.001	0.021 ++	0.020
Mn	-8.220	-9.620	-1.400	-3.880	20.420 ++	24.300 +
Fe	-169.500 ++	-522.300 ++	-352.800 ++	-107.100 +	-245.300 ++	-138.200 +
Cu	-3.110 +	-3.540 +	-0.430	-2.290 +	-1.120	1.170
Zn	-53.600 ++	-111.000 +	-57.400	-52.400	-194.800 +	-142.400
Br	-2.120	-1.080	1.040	-3.920 +	-10.900 ++	-6.980 +
Rb	-0.130	-0.880 ++	-0.750 +	0.560 +	-1.460 ++	-2.020 ++
Sr	-0.720	0.530 +	1.250 +	-0.420 +	-0.190	0.230
Pb	-0.410 +	-0.190	0.220	-1.500 ++	-1.450 ++	0.050

+ : $P \leq 0.05$; ++ : $P \leq 0.01$; 1 : MPB; 2 : MT; 3 : TPT

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Original Report

Influence of the curing time of nutria muscles on over-reaction degree of muscle pigments and some of their functional properties

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Summary

The influence of the curing time of the forepart and hindquarter nutria muscles on over-reaction degree of muscle pigments and cooking losses and heat contraction were studied. There were not found differences in chemical analysis, total haeme pigment content, pH and heat contraction between forepart and hindquarter muscles. The over-reaction degree of muscle pigments in forepart muscles was higher (by 3%) and its maximum occured earlier (about 12 h) in comparison with hindquarter muscles. Taking into consideration the over-reaction degree of muscle pigments, cooking losses and heat contraction of cured nutria muscles, the optimum curing time for nutria forepart is 2.5 days and for hindquarter muscles 3 days.

Introduction

Nutria meat in Argentina, Brazil, Chile and Uruguay is commonly consumed and treated as a delicacy. In Poland we can observe prejudice against consumption of this meat, probably caused by the animal appearance. On the other hand, about 3.8 thousand tons of valuable nutria carcasses obtained during the year (ref. 10) are an important source of proteins.

The slaughter yield of nutria meat of about 55 % (ref. 11) is similar to beef and rabbits. The nutria muscles contain high-quality proteins, provide the complete range of essential amino acids and contain a relatively high level of unsaturated essential fatty acids (the rate of essential unsaturated fatty acids to saturated fatty acids is about 0.367) (refs. 4, 8). Moreover, they can be treated as a rich source of minerals and vitamins, especially of niacin, thiamin and riboflavin (ref. 8). Nutria muscles are characterised by good functional properties i.e. gelling (ref. 5) and emulsifying ability (ref. 6). Lesiow et al. (ref. 7) compared, after 48 h storage, the influence of the curing time on the changes of some functional properties of nutria meatcured by a dry method and beefcured without or with the participation of enzymatic preparation. They found that emulsifying capacity, cooking losses and heat contraction for nutria meat and beef cured with the enzymatic preparation were similar and more preferable than corresponding functional properties for beef cured without the enzymatic preparation.

There is lack of information available in the literature concerning the influence of the curing time on over-reaction degree of muscle pigments and a little on functional properties of nutria muscles.

The objective of this work was to examine the

influence of the curing time on over-reaction degree of muscle pigments, cooking losses and heat contraction of nutria muscles.

Material and methods

Investigations were made on forepart and hindquarter muscles isolated from nutria slaughtered at 7 months of age. The nutria meat pieces of 2 x 2 x 5 cm were removed 24 h after slaughter, without fat and connective tissue and were cured by a dry method. The curing mixture consisted of 99.4% NaCl and 0.6% sodium nitrate, which was added in an amount of 2.3 kg/100 kg meat (ref. 13). The curing was carried out at 2-4°C till 96 h.

The protein content was calculated by multiplying the nitrogen content determined by the Kjeldahl method, by 6.25. The fat content was determined by the Soxhlet method and the water content by the drying method at 105°C.

pH was measured with a digital pH-meter by direct coupled electrode insertion into ground meat.

Cooking losses and heat contraction were determined by the method described by Duda (ref. 2) and expressed in %. It was done in the following way: 20 g ground meat balls were immersed in cylinders with 200 cm^3 of water and the volume of dislodged water was measured. After weighing, the samples were heated for 20 min. in a water bath at 100°C, followed by cooling in running water for 5 min. and draining for 10 min. After weighing to assess cooking losses, the samples were once more immersed in cylinders to assess heat contraction.

Total haeme pigment content in meat and nitroso pigment content in cured meat was determined by the Hornsey metod (ref. 3) in modification by Mroczek et al. (ref. 9) in the following way: a 5 g minced meat sample was mixed in a dark glass bottle to a smooth paste with 5 cm^3 of the solvent (acetone to chloride acid 40:3). The remainder of the solvent in the volume 16.5 cm^3 was then added with intermittent mixing for 3 min. The samples were kept in dark for 30 min., and then filtered. The intensities of the colors of the resulting solutions were measured in a 1 cm cell at a wavelength of 512 nm and 640 nm with the spectrofotometer "Specol". The control sample was prepared by completing 21.5 cm^3 of acid acetone solvent with distilled water to the volume of 25 cm^3.

Total haeme pigment content (Z_s) in ppm of hematin was counted on the base of the formula: $Z_s = A_{640}x680$. In the estimation of total pigments the ratio A_{512}/A_{640} should not be greater than 2.0 if oxidation of the nitroso-haeme to hematin is complete.

Nitroso pigment content was measured by the same procedure. However, in place of the acid acetone solvent, the water acetone solvent (acetone to water 40:3) was added. Moreover, the control sample was prepared by completing 21.5 cm^3 of water acetone solvent with distilled water to volume 25 cm^3 and then the absorption was measured at a wavelength of 540 nm.

Nitroso pigment content (Z_n) in ppm hematin was counted on the basis of the formula: $Z_n = A_{540}x290$.

Total haeme pigment contents (Z_s) and nitroso pigment content (Z_n) were expressed in mg/g muscle tissue by multiplying the Z_s and Z_n values by 0.026 (ref. 1).

The over-reaction degree of muscle pigments was counted on the basis of the formula: $P = Z_n/Z_s x100\%$.

Three parallel determinations were made within each of the three series of study. Data were analysed statistically using methods of correlation and regression. The t-Student test was used to estimate the significant differences between average values ($P = 0.05$) (ref. 12).

Results and discussion

Characteristics of the testing material

The testing material was characterised by determination of:

1. The percentage of forepart and hindquarter muscles (together with dorsal), fat and bones in eviscerated nutria carcasses (table 1).

2. Total haeme pigment, protein, fat and water content in forepart and hindquarter muscles (table 2).

3. pH, cooking losses and heat contraction of forepart and hindquarter muscles (table 4).

Percentage of hindquarter muscles in nutria carcasses was slightly lower (3.4%) compared to muscles of the forepart (table 1).

Table 1. Percentage of forepart and hindquarter muscles, fat and bones in eviscerated nutria carcasses.

	Average weight of carcasses g	Muscles forepart	Muscles hindquarters	Total meat	Fat	Bones	Losses
$\bar{x}$	1832.6	24.1	20.8	44.9	8.6	45.2	1.4
SD	102.7	3.1	5.1	5.9	4.5	9.0	0.4

$\bar{x}$ - mean values of 18 carcasses, SD - standard deviation

Similar results were obtained by Niedzwiadek et al. (ref. 11). However, the authors compared the content of muscles in nutria carcasses excluding the dorsal muscles. Percentage of fat in nutria carcasses (about 8.6%) was consistent with that observed by Niedzwiadek et al. (ref. 11). The lower percentage of total meat (about 44.9%) in comparison with data (63.2 to 70 %) presented by Niedzwiadek et al. (ref. 11) may be attributed to different feeding conditions and age of animals. There were not found significant differences in the chemical analysis and total haeme pigment content of nutria muscles excised from the forepart and hindquarters, respectively (table 2). Niedzwiadek et al. (ref. 11) pointed out the lack of differences in content of protein and water, value of pH, water-binding capacity, content of myoglobin and haeme pigments between samples from nutria of different sex and age. The authors (ref. 11) only found an influence of animal age on the fat content in muscles, which increased from 9.1 to 107 % in 6 month old to 12.1 to 12.8 % in 18 month old nutria. On the other hand, the chemical analysis of nutria muscles according to Niedzwiadek et al. (ref. 11) i.e. protein content (about 19.9-20.7%), fat (9.1-10.7%) and water (65.7-69.9%) differs from data presented in table 2.

Table 2. Total haeme pigments, protein, fat and water of forepart and hindquarter nutria muscles.

Muscles	Protein (%)	Fat (%)	Water (%)	Total haeme pigments content (mg/g tissue)
Forepart	22.54	1.99	74.44	4.08
SD	0.18	0.25	1.41	1.93
Hindquarters	22.56	2.49	75.17	3.97
SD	0.14	0.24	0.26	1.43

$\bar{x}$ - mean values of 18 carcasses, SD - standard deviation

Over-reaction degree of muscle pigments

On the basis of the data presented in table 3 concerning the influence of curing time on the nitroso pigment content, and the values of total haeme pigment content (table 2), the over-reaction degree of muscle pigments was counted.

It was found that the over-reaction degree of muscle pigments in hindquarter muscles had lower values in comparison with forepart muscles during all the examination periods (fig. 1). The time to obtain the maximal over-reaction degree of muscle pigments in the forepart and hindquarter muscles was 63 h and 40 min. and 75 h and 30 min., respectively. From a practical point of view it means that, considering the over-reaction degree of muscle pigments, the hindquarter muscles should be cured for 3 days and forepart muscles for 2.5 days.

Table 3. Influence of curing time on nitroso pigment content in mg/g muscle tissue.

Muscle	curing time (hours)			
	24	48	72	69
Forepart	2.01	2.21	2.32	2.08
SD	0.14	0.09	0.09	0.13
Hindquarters	1.79	1.99	2.14	2.05
SD	0.13	0.17	0.10	0.07

$\bar{x}$ - mean value of 9 determinations SD - standard deviation

Table 4. Influence of curing time on cooking losses, heat contraction and pH of forepart and hindquarter nutria muscles.

Time (h)	pH				Cooking losses (%)				Heat contraction (%)			
	Forepart		Hindquarters		Forepart		Hindquarters		Forepart		Hindquarters	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
0	6.14	0.009	610	0.022	20.02	1.09	21.75	1.41	19.80	1.06	20.53	1.49
24	6.10	0.019	6.08	0.053	9.13	0.51	8.78	0.97	8.76	0.78	7.91	1.12
48	6.12	0.005	6.06	0.017	0.33	0.42	7.87	0.80	10.41	0.26	8.41	0.89
72	6.13	0.014	6.08	0.005	7.23	0.98	8.08	1.31	8.17	0.80	9.27	1.07
96	612	0.029	6.07	0.008	6.79	1.13	8.31	1.33	8.18	0.99	7.80	1.10

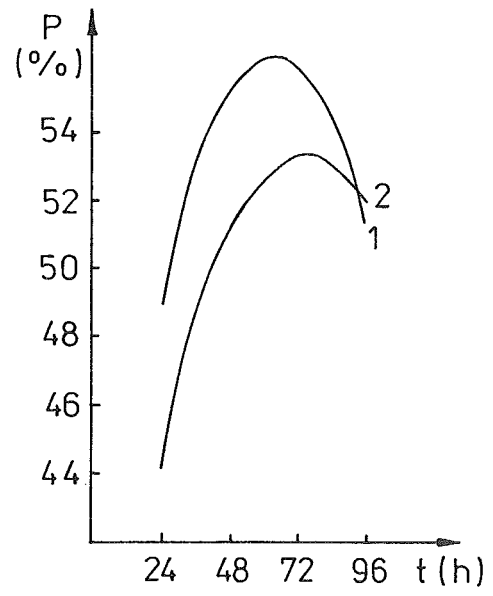

Figure 1. Influence of curing time of fore-part (1) and hindquarter (2) nutria muscles on changes in the over-reaction degree of muscle pigments (P):
1 $P = -4.61 \times 10^{-3}t^2 + 0.59t + 37.65$ $r = 0.97$
2 $P = -3.14 \times 10^{-3}t^2 + 0.47t + 35.36$ $r = 0.98$

Cooking losses and heat contraction

In comparison of uncured hindquarter and forepart nutria muscles, it was found that cooking losses of hindquarter muscles are higher than the forepart, but heat contraction of both kinds of meat do not differ significantly (table 4).There were not found significant differences between pH values of uncured and cured meat during 96 h. On the other hand, both cooking losses and heat contraction of uncured forepart and hindquarter muscles are over two times higher in comparison with cured meat. The observed decrease of both parameters was the highest within 24 h curing time.

Cooking losses of hindquarter muscles decreased during curing till 48 h and then observed changes were not significant. In the case of the forepart muscles, the lowest cooking losses were found for cured meat at 96 h. The result does not differ significantly from the one obtained after 72 h of curing.

The hindquarter muscles cured for 96 h were characterised by the lowest heat contraction and this value and values obtained after 24 and 48 h

for cured meat were insignificant. On the other hand, forepart muscles cured for 72 h were characterised by the lowest heat contraction and did not differ significantly from the results obtained after 48 and 96 h of curing.

On the basis of obtained results of cooking losses and heat contraction one can point out that the curing time at which is obtained the highest over-reaction degree of muscle pigments is also optimum for obtaining the lowest heat contraction and the lowest weight change of the meat.

Significant correlation coefficients between heat contraction and cooking losses for nutria forepart ($r = 0.99$) and hindquarter muscles ($r = 0.99$) were found.

Correlations were also found between corresponding parameters of nutria forepart and hindquarter muscles, i.e. over-reaction degree of muscle pigments ($r = 081$), cooking losses ($r = 0.99$) and heat contraction ($r = 0.98$) (r_k-critical correlation = 0.73, for $n-1 = 4$, at $P = 0.1$)

Conclusions

1. The percentage of hindquarter muscles in nutria carcasses was lower by 3.37% in comparison with forepart muscles and the total meat in nutria carcasses was about 44.9%.

2. There were not found differences in chemical analysis, total haeme pigment content, pH and heat contraction between forepart and hindquarter nutria muscles.

3. The over-reaction degree of muscle pigments in forepart muscles is higher (by 3%) and its maximum occurs earlier (about 12 h) in comparison with hindquarter muscles.

4. Taking into consideration the over-reaction degree of muscle pigments, cooking losses and heat contraction of cured nutria muscles, the optimum curing time for nutria forepart is 2.5 days and for hindquarter muscles 3 days.

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Original Report

Endocrine gonadal function in silver fox under domestication

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Summary

The selection of silver foxes for domesticated behaviour produces changes in the ovarian and testicular endocrine functions. It was established that in the anoestrus period the plasma level of progesterone in domesticated females was significantly lower than in undomesticated ones. Before the mating season the selected females had a plasma oestradiol level significantly higher than non-selected foxes. Differences were also found in the content of the sex hormones between female silver foxes of two types of defensive behaviour at the period of oestrus and in pregnancy. The cessation of testicular endocrine function at the end of the breeding season occurred more rapidly in domesticated males than in the control males.

Introduction

The hereditary reorganization of behaviour is one of the key mechanisms of the domestication of animals (*Belyaev et al., 1985*). This concept was experimentally proved in the studies on silver fox selection for domesticated behaviour (*Belyaev, 1979*). The aim of silver fox selection is to analyze the mechanisms of the evolutionary changes occurring during domestication. There is no doubt that domestication being carried out on the basis of selection for defensive behaviour with respect to man involves some deep changes of physiological functions connected with behaviour through the nervous and neuroendocrine regulatory mechanisms. Up to date it has been cleared up in detail for the sexual function and the pituitary-adrenal complex (*Naumenko & Belyaev, 1980; Belyaev & Trut, 1983; Osadschuk & Trut, 1989*). The article presents some results of research of many years on hormonal activity of gonads in silver foxes after twenty years of selection for domesticated behaviour.

Materials and methods

The work was carried out on sexually mature female and male silver foxes (*Vulpes fulves Desm.*) 2-3 years of age, bred on the experimental animal farm of the Institute of Cytology and Genetics, Siberian Branch of the Academy of Sciences of Russia. The animals chosen for this study were from a population selected for domestication and tame behaviour (here called "tame" or domesticated) and from a commercial population showing clearly aggressive behaviour towards humans (comparatively wild or undomesticated). The state of the gonad's endocrine function was assessed by measuring sex steroids (testosterone, oestradiol and progesterone) in the peripheral

blood plasma and by production of these hormones by the gonads in vitro.

A peripheral blood sample was taken from *v. saphena* in the same females once or twice a month during anoestrus, three times during prooestrus and once during oestrus. The onset of prooestrus was determined by vaginal smears and the external appearance of the genitalia and that of oestrus - also by vaginal smears and the readiness of females to mate. During pregnancy the interval between taking blood samples was 5-10 days. In silver fox males blood was collected once a month but during the breeding season (January - February) the samples were taken after the males were given access to females in oestrus, whether the mating took place or not.

The determination of sex hormone production by the gonads in vitro was carried out in November in females, in mid-December (beginning of activation of the reproduction system) both in males and females and in mid-March (end of the breeding season) only in males. The study of the ovarial hormonal production was performed at prooestrus and oestrus. The glands were incubated in Kreba-Ringer bicarbonate buffer with a glucose content of 200 mg %, in an atmosphere of 95% oxygen, 5% carbon dioxide, at 3°C. Steroid hormones in plasma and in gland incubates were radioimmunoassayed using commercial kits produced by the firm "Cea-Ire-Sorin" (France). Results were analyzed using Student's t-test.

Results

Females

Figure 1 shows the concentration of oestradiol and progesterone in the blood plasma of female silver foxes in anoestrus. During this period, changes in plasma oestradiol are similar in tame and in undomesticated animals. The lowest concentration occurs in spring and summer. In domesticated and undomesticated females a significant increase in blood plasma oestradiol concentration is found in autumn. After that, its level declines and begins to increase again by the onset of the breeding season. For almost the complete anoestrus period the oestradil concentration in tame and undomesticated females does not change significantly. However, in January, the oestradiol concentration in domesticated animal significantly ($p < 0.05$) exceeds that in the undomesticated ones. It should be noted that the oestradiol concentration in January was measured in females showing no signs of oestrus activity. The progesterone concentration throughout anoestrus fluctuates insignificantly, but increases to the beginning of the breeding season ($p < 0.05$) in both sets of animals. During almost the whole anoestrus the blood concentration of progesterone in tame females is significantly lower than in undomesticated ones (fig. 1).

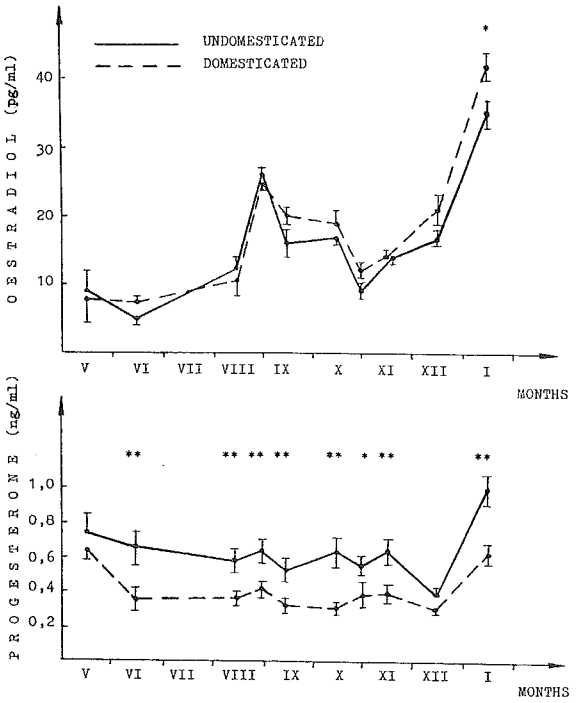

Figure 1. Oestradiol and progesterone concentrations in the blood plasma of silver fox females during anoestrous. The significance of differences between domesticated and undomesticated animals is marked by an asterisk in all pictures. * - $p < 0.05$ ** - $p < 0.01$.

While the reproductive tract of female silver foxes is functioning actively, characteristic changes are observed in blood sex hormone concentrations (fig. 2). In both groups, the oestradiol concentration rises during prooestrus to reach maximum concentration before it ends (significantly different from values of the earlier and the later prooestrus, $p < 0.05$). During oestrus, the oestradiol level decreases in association with ovulation. In prooestrus, the concentration of oestradiol does not differ significantly between the two groups of animals, but in oestrus in tame animals it is significantly lower than in undomesticated foxes (fig. 2). The progesterone level in prooestrus also rises significantly in both groups. In

oestrus it significantly rises on average 4-6 times (fig. 2) owing to the development of the corpora lutea which secrete progesterone. While at the start of prooestrus the progesterone concentration in tame females is significantly ($p < 0.05$) lower than in the undomesticated, by the end of prooestrus the difference is no longer significant, and in oestrus the progesterone level in tame animals is significantly higher than in domesticated ones ($p < 0.01$).

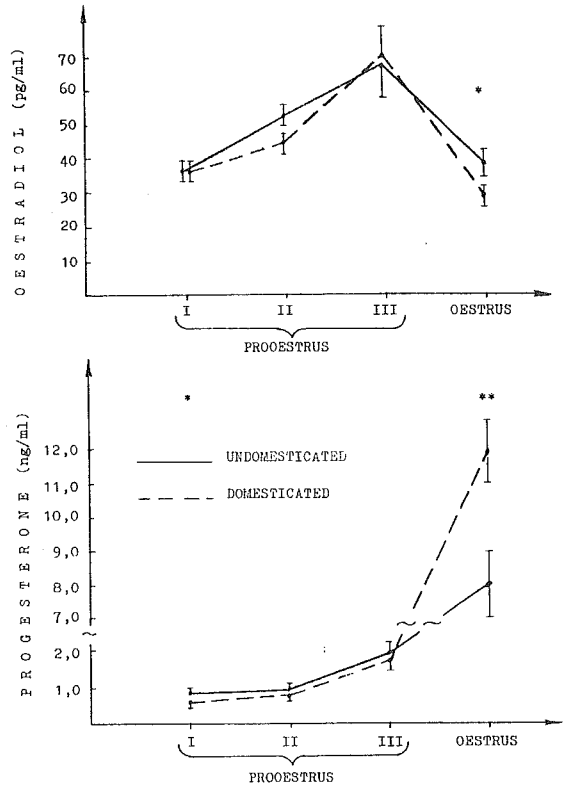

Figure 2. Oestradiol and progesterone concentrations in the blood plasma of silver fox females during prooestrus and oestrus.

The production of oestradiol and progesterone was studied twice during anoestrus - in November and December (fig. 3). In November, there was no significant difference between the two groups in ovarial production of the hormones. In the tame females there is a significant increase in ovarial progesterone and oestradiol production from November to December ($p < 0.05$). In the undomesticated animals these variables remain unchanged from November to December (fig. 3). In December, ovarial oestradiol and progesterone production in vitro are significantly greater for tame than for undomesticated foxes. In both groups, ovarial production of oestradiol is significantly greater in prooestrus than in anoestrus ($p < 0.01$), and the increase in progesterone production is much more considerable (150-200 times). From prooestrus to oestrus the ovarial production of oestradiol decreases ($p < 0.05$). Ovulation and the transformation of follicular to luteinizing cells and the formation of the corporea lutea at the place of the ovulated follicles leads to an increase of ovarial progesterone production at oestrus (fig. 3). At this stage of the cycle significant differences in production of both hormones are found between the two groups: the production of oestradiol is significantly lower, and that of progesterone significantly higher in tame than in undomesticated foxes (fig. 3).

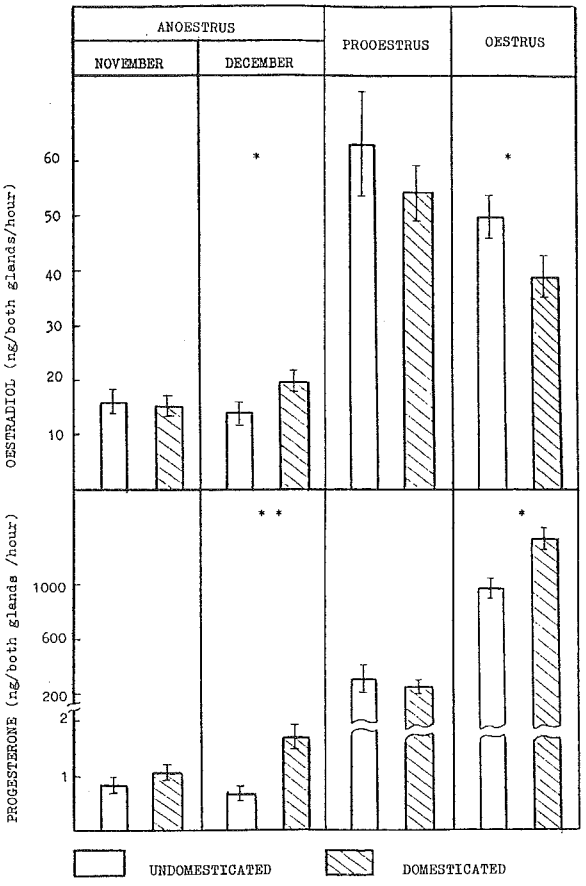

Figure 3. Oestradiol and progesterone production in vitro by silver fox female ovaries.

Changes in blood progesterone concentration during pregnancy are identical in the two groups. It significantly increases, reaching a maximum value at the 5-10th day of pregnancy after which

it gradually and steadily declines until the end of pregnancy (fig. 4). The concentration of oestradiol in blood is comparatively stable throughout pregnancy (fig. 4). In the preimplantation period and the last week of pregnancy the concentration of sex hormones in tame animals is significantly higher than in relatively wild animals.

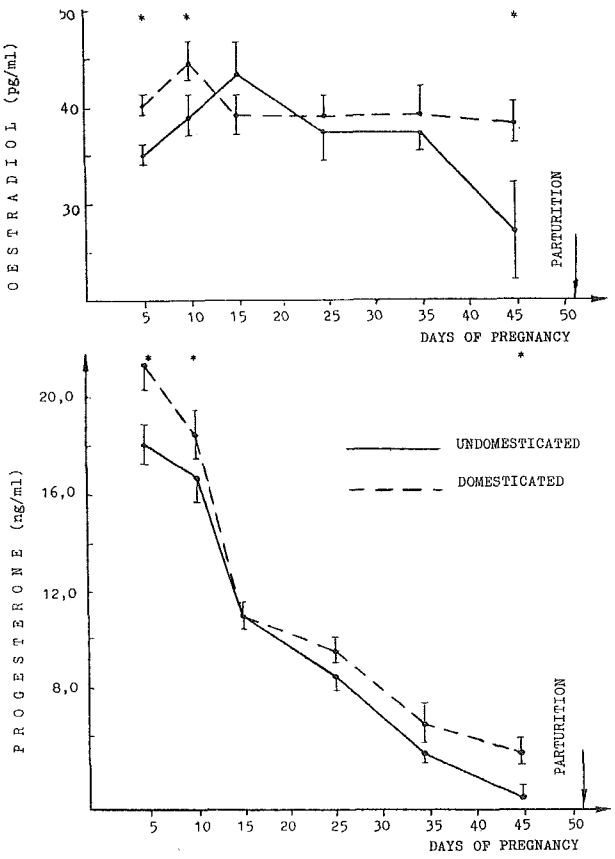

Figure 4. Oestradiol and progesterone concentrations in the blood plasma of silver fox females during pregnancy.

Males

As seen in figure 5 both groups of silver fox males show a characteristic seasonal variation in peripheral blood testosterone levels. The maximum concentration occurs in January-February while low values occur in June-October. The data indicate that fluctuations in testosterone level correspond to the male sexual activity.

Except for spring, no significant differences in testosterone concentration have been found between the two groups of animals which display genetically determined differences in behaviour. The testosterone level is significantly lower in domesticated than in relatively wild animals in only March and April.

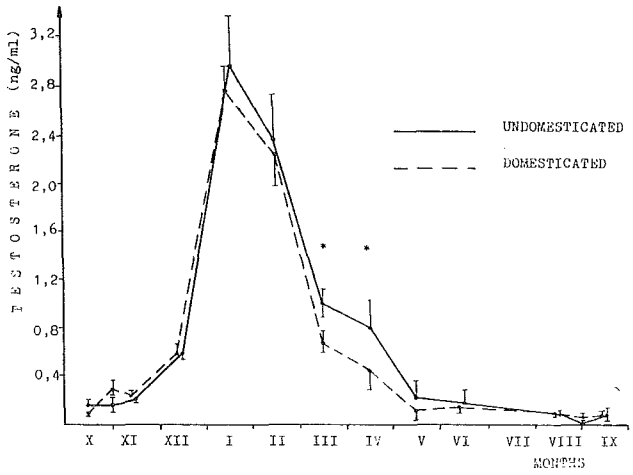

Figure 5. Testosterone concentrations in the blood plasma of silver fox males during the annual reproduction cycle.

To help explain observed differences in testosterone concentration, the production of this hormone by testicles in vitro was measured. In the period preceding the mating season (December) the testosterone production by the testicles was practically identical in the two groups (fig. 6). In March when the mating season is coming to an end, the two groups differ in testicular secretion of testosterone, the latter being significantly lower in domesticated animals. Thus, there is a close correspondence between the peripheral blood concentrations and testicular production, since in both cases the alues for domesticated animals are lower than for relatively wild ones.

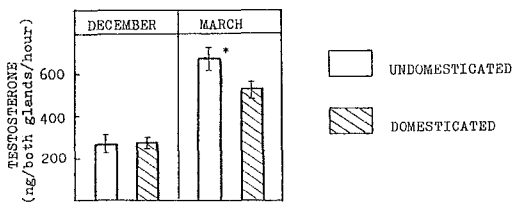

Figure 6. Testosterone production in vitro by silver fox male testicles.

Discussion

The prolonged period of sexual quiescence in the silver fox is characterised by an almost complete atrophy of the gonads and the reproductive tract and a very low concentration of plasma oestradiol and progesterone in females and of testosterone in males in comparison with the breeding season when endocrine function of gonads rises to the highest activity. At the end of prooestrus the oestradiol level reaches its maximum value and the progesterone level comes to its maximum on the 5-10th day of pregnancy. Maximum testosterone concentration in blood plasma also coincides with the mating season.

Similar dynamics of sex hormone levels in the blood in the reproductive cycle of red and blue fox were reported by Mondain-Monval et al. (1977), Moller et al. (1980), Sirotkina et al. (1990).

It has already been noted that by being lower through most of anoestrus, the progesterone level of tame foxes is significantly different from undomesticated ones. An obvious explanation might be that this difference is due to increased secretion of this hormone by the ovaries. However, in vitro progesterone production of ovaries during anoestrus (November, fig. 3) is not significantly different in the two groups which does not support the suggested explanation. On the other hand, the ovaries are not the only source of progesterone. The adrenal glands secrete progesterone into the blood stream in silver fox and its production by the adrenals is comparable with that in the ovaries through all stages of the oestrus cycle (*Osadchuk, 1989*). Accordingly, it is possible that the low anoestrus progesterone concentration in the blood of tame foxes, compared to undomesticated ones, is due to a decreased secretion of progesterone by the adrenals. During activation of the reproductive system in December, ovarial oestradiol and progesterone production in vitro, unlike in November, are significantly greater in tame than in undomesticated animals (fig. 3). In January, a significant difference in blood oestradiol levels appears between the two groups (fig. 1). We may suppose that such differences are due to the growth and, correspondingly, the hormone secretion by the follicles in tame being earlier than in undomesticated animals. This supposition agrees with earlier work (*Braude & Trut, 1970*) which showed that in domesticated silver foxes the number of growing follicles and the weight of the ovaries in December are higher than in undomesticated animals, which supports the earlier activation of the reproductive system in tame animals in the period just prior to the mating season. The above data suggest that the behavioural domestication of silver fox correlates with the changes in their hormonal system.

In oestrus was also shown the difference between females of two behavioural types. In particular, the blood progesterone level and its production in vitro by the gonads are significantly higher in the tame animals while the level and production of oestradiol are significantly lower (fig. 2, 3). One possible explanation of the observed difference in hormonal gonadal function between the two groups is that in the tame foxes more egg-cells ovulate and a larger number of corporea lutea are formed. It is possible that a higher level of ovulation in the tame animals results in a greater secretion of progesterone by the corporea lutea.

At the preimplantation stage of pregnancy the oestradiol and progesterone concentration in tame animals is significantly higher than in undomesticated ones (fig. 4). The reason may also be connected with the increased number of corporea lutea in tame ones.

The selection of silver foxes for domesticative behaviour leads to changes in the endocrine function of testicles. At the end of the breeding season the testosterone - producing function of the testicles as well as the level of testosterone in the peripheral blood of tame males are lower than in undomesticated ones (fig. 5, 6). In other words, the domesticated males are characterized by an earlier extinction of the endocrine function of the testicles in the reproductive season.

Thus, the present paper indicates that the domestication of silver fox developed at the basis of genetically determined polymorphism of the defensive behaviour has changed not only the selected character proper, i.e. behaviour, but as a correlated response, has considerably changed the hormonal function of the gonads. What are the actual mechanisms involved in the realization of correlated responses? By now, few facts have been accumulated to imagine this process. It has been shown that in domestication of silver fox, considerable changes occur not only in the endocrine system, but also in the nervous links of the neuroendocrine regulation of the sexual system, in particular, in the state of the neurochemical brain mechanisms, including serotonine (*Naumen-*

ko & Belyaev, 1980). Brain regions of domesticated and undomesticated silver foxes differ sharply in the content of serotonine and enzymes of serotonine biosynthesis (*Kulikov et al., 1987*). Higher levels of brain serotonine in the tame animals, on the one hand, may inhibit aggression and, on the other hand, change the secretion of hypophysial gonadotrophins regulating the hormonal function of gonads.

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"Of course I'm sure it's hereditary. My father treated your father for the same thing."

Original Report

Review of

Protein and amino acid requirements for mink

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Introduction

Investigations of the protein requirement in mink is probably the specific area offered the most scientific attention during the period where mink have been produced as farm animals.

This review covers some basic investigations for the determination of the requirements of protein and amino acids but, additionally, a certain number of investigations concerning the influence of protein levels on production and reproduction will be reevaluated on the basis of the estimated content of digestible amino acids.

Conclusively, the estimated demand for amino acids during early growth on late growth/fur growth will be given on the basis of experiments for evaluation of the protein and amino acid requirements and determined digestibility coefficients of each single amino acid in the feedstuffs used.

Deposition of protein and amino acids in mink during the growth period

Analyses for the content of amino acids in the shaved body of mink and the hair show clearly that the deposition of amino acids in mink differs from most other domestic animal species by a higher deposition of cystine. The analyses also give the explanation for this since the hair contains an extremely high amount of cystine.

From table 1 it can be seen that the differences in amino acid composition between mink and pigs are very small except for the content of cystine. Investigations by Smith (1980) have shown that the amino acid composition in muscles from different species vary only a little. The differences in total deposition between species are thus primarily connected to differences in the amount of protein deposited in hide, hair, claws, hooves and horns.

Investigations have shown that mink hair contains only 7-12% of the total deposited amount of protein, but approximately 60% of the deposited amount of cystine. This by itself indicates a high requirement for cystine, but it is further stressed by the fact that the analyses do not include the amount moulted with the summer coat. Investigations of the amino acid composition in hair, body, and hide have been carried out by Jørgensen & Eggum (1971), Chavez (1980) and Glem-Hansen & Enggaard Hansen (1981). In table 2 is shown the deposited amount of nitrogen and amino acids in hair and the shaved bodies of a male and female kit on 24th August when the summer coat is fully developed.

The deposition of protein and amino acids in mink throughout the growth period was investigated in slaughter experiments where the mink were killed at different stages and analysed for nitrogen and amino acid (Glem-Hansen & Enggaard Hansen 1981). The deposition of all the amino acids except for cystine follow the same curve liniarity as for nitrogen. Figure 1 shows how the deposition of cystine deviated from the other amino acids represented by the nitrogen deposition. As mentioned previously, the curve

liniarity for cystine deposition would have deviated even more from the nitrogen curve if the cystine deposited in the hair of the summer coat had been included. The curve liniarity shows a minor irregularity for nitrogen for the stage representing the moulting of the summer coat but, much more important, a marked increase in deposition of cystine during the period from moulting to the time for a fully developed winter coat at ultimo November.

Table 1. Amino acid composition of mink and pigs at different stages of development given in grams per 16 g of N.

	Mink		Pigs[3]		
	24 days[1] old	Mature[2]	10 kg	25 kg	100 kg
Threonine	3.71	4.18	3.44	3.35	3.53
Valine	4.39	4.85	4.11	4.05	4.85
Isoleucine	3.03	3.29	3.17	3.24	3.90
Leucine	6.70	7.05	6.74	6.59	7.14
Tyrosine	2.89	2.16	2.19	2.07	1.87
Phenylalanine	3.45	3.50	3.18	3.43	3.68
Lysine	5.69	6.88	5.98	6.09	6.93
Histidine	1.87	2.28	2.16	2.30	2.81
Methionine	1.65	3.20	1.57	1.74	2.01
Cystine	1.95	2.29	0.84	0.72	0.99
Tryptophan	1.00	0.97	1.20	1.27	1.19
Aspartic acid	7.34	7.64	7.49	7.41	7.95
Serine	3.84	4.93	3.64	3.52	3.09
Glutamic acid	12.66	13.38	12.71	12.92	14.00
Glycine	8.38	6.88	8.16	9.40	9.33
Alanine	5.54	5.49	5.94	6.25	6.51
Arginine	6.43	5.78	5.43	5.77	6.13

Sources: 1) Glem-Hansen (1976); 2) Jørgensen & Eggum (1971); 3) Buraczewski (1973)

This indicates a rather high requirement for cystine or methionine which within certain limits, can replace cystine as a source for cystine deposition in the period from 20 weeks of age to pelting time.

Determination of amino acid requirement in mink

Experiments for the determination of the amino acid requirement in mink are sparse and have concentrated on the sulphur-containing amino

acid methionine and cystine and, in some cases, lysine and arginine. Leoschke & Elvehjem (1959) found that methionine and arginine were the first limiting amino acids for mink fed a casein diet. It should be considered that the level of arginine in a casein diet is much lower than in a traditional Scandinavian diet based primarily on fish products.

Table 2. The content of N and amino acids in grams per animal in the hair and the hairless body, respectively, from a male and female kit on August 24th.

	Male		Female	
	Hair	Hairless body	Hair	Hairless body
Nitrogen	5.2	43.5	3.8	29.0
Alanine	1.0	18.0	0.7	11.4
Arginine	2.3	17.6	1.6	11.3
Aspartic acid	1.7	22.0	1.1	14.6
Cystine	4.5	2.8	3.3	1.9
Glutamic acid	3.9	37.0	2.7	24.1
Glycine	2.0	28.3	1.4	16.6
Histidine	0.4	6.1	0.3	4.2
Isoleucine	0.7	8.3	0.4	5.7
Leucine	1.8	18.5	1.2	12.6
Lysine	1.0	16.8	0.7	11.3
Methionine	0.3	5.1	0.2	3.4
Phenylalanine	0.8	9.8	0.5	6.6
Proline	2.2	18.1	1.6	11.3
Serine	2.9	11.1	2.1	7.3
Threonine	1.7	10.2	1.3	6.9
Tyrosine	1.5	7.5	1.0	5.2
Valine	1.4	11.5	0.9	7.7

Source: Glem-Hansen & Enggaard Hansen (1981)

Figure 1. Nitrogen (——) and cystine (- - -) deposition in dark males throughout the growth season

Danish experiments have shown that the sulphur-containing amino acids are the first limiting factor for hair growth in mink fed a diet with a traditional amino acid composition (Glem-Hansen 1980 & 82). The experiments showed that the following contents of sulphur-containing amino acids fulfilled the requirement for maximum protein retention when the digestible protein content equalled 20-25% of the metabolizable energy in the diet.

PERIOD	Gram Methionine + Cystine
10 to 19 weeks of age	2.6 - 2.7/16 g N
20 to 24 weeks of age	3.7 - 4.1/16 g N
26 to 30 weeks of age	3.0 - 3.1/16 g N

The influence of sulphur-containing amino acids on pelt characteristics, body weight and body length is shown in table 3.

Table 3. The effect of increasing content of sulphur-containing amino acids on pelt characteristics, final body weight, and body length. The protein level in the basic diet was 28 to 29% of ME from digestible protein.

	Sulphur-containing amino acids of the protein*		
	3.47	5.60	7.70
g Sulphur-containing amino acids during the growth period	85	136	188
Final body weight, g	1995±136	2073±188	2001±190
Body length, cm	46.6±1.54	46.7±1.35	46.1±1.36
Pelt length, cm	71.4±2.14	72.6±2.63	70.9±2.91
Pelt quality, points	5.5±1.88	6.5±1.43	6.6±1.90
Quality of the guard hairs, points	2.6±1.05	3.4±1.04	3.4±1.18
Cover of guard hairs, points	3.3±1.12	3.3±1.16	3.6±1.19
Pelt colour, points	7.1±2.25	7.7±1.18	7.1±1.39

*** The supply of sulphur-containing amino acids was given as DL-methionine. Later experiments have shown that D-methionine cannot be utilized by mink which means that the utilizable amounts of methionine + cystine in the last two experimental groups is reduced from 5.6 to 4.5 and from 7.7 to 5.6 respectively.**

These experiments indicate that a diet with a protein content equal to 28-29% of ME from digestible protein and a content of 3.5% of the protein from sulphur-containing amino acids does not fully meet the minks' requirement for maximum pelt quality. An amount of 4.5% of the pro-

tein from sulphur-containing amino acids apparently meets the requirement.

Finnish reports concerning supplementation with DL-methionine and L-lysine to diets containing protein equal to 20-25% of ME from digestible protein concluded that a supply of methionine and lysine did not have any effect on pelt quality. Even though the differences were not statistically significant, there was a tendency to improved pelt quality when the basal diet was supplied with methionine, while a supplement of lysine did not affect the pelt quality. The results are shown in table 4 and described in two reports by Berg et al. (1986) and Työppönen et al. (1987).

Table 4. The influence of methionine and lysine supply on pelt characteristics in pastel mink males.

Protein in percentage of ME[1)]	25/20	25/20	25/20
Methionine supply g/Mcal[1)]	0	0.5/1.0	0.5/1.0
Lysine supply g/Mcal[1)]	0	0	1.5/2.7
Number of skins	48	43	40
Pelt length, cm	71.9±4.0**	72.4±4.3**	72.0±5.1*
Pelt quality, points[2)]	7.7±1.4**	7.8±1.4**	7.9±1.4**
Cover of guard hairs, points	5.8±2.1***	6.9±1.7**	6.7±2.3**
Pelt density, points	5.0±2.5***	5.6±2.4***	5.2±2.7***

1) **The two levels of protein shown were used in the periods 8 to 20 weeks of age and 21 to 31 weeks of age, respectively**
2) **Points for pelt characteristics: 10 = best, 0 = weakest**
3) *** P< 0,05; ** P< 0,01; *** P< 0,001**

Previous research by Jørgensen & Glem-Hansen (1970) showed an obvious improvement of the pelt quality when DL-methionine was added to a diet containing 25/19 percent of the ME from digestible protein during the period 1st July to 31st August and 1st September to pelting, respectively. The results are shown in table 5.

Table 5. The effect of different protein and methionine content on pelt characteristics in dark mink (30 males and 30 females per group)

Percent. of ME from dig.	44/33		25/19		25/19	
DL-methionine	-		-		+	
Sex	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
Pelt length, cm	64.8	55.4	59.8	53.1	61.2	52.8
Pelt quality, points	5.9	6.0	4.2	4.1	5.3	5.6
Underfur density	5.8	5.8	4.0	4.0	5.1	5.3

It can be seen from the table that a reduction of protein in the diet from 44/33 to 25/19 deteriorated the pelt length as well as the pelt quality and the underfur density. A supply of methionine

improved all pelt characteristics to nearly the same level as the high protein group.

The content of sulphur-containing amino acids per 16 g nitrogen was 3.7 g in the basal diet and the supplemented diet contained 4.6 g per 16 g nitrogen. Thus, the results agree very well with later experiments.

Results from an investigation by Jørgensen & Glem-Hansen (1979), where DL-methionine was added to diets differing in protein content, is shown in table 6.

Table 6. The effect of protein content and supply of methionine to the diet on pelt characteristics in dark males (15 males and 15 females per group).

Percent. of ME from dig. prot.	63		44		25	
Supply of DL-methionine	-	+	-	+	-	+
Pelt length, cm	64.5	64.1	64.8	64.7	59.8	61.2
Pelt quality, points	5.5	5.7	5.9	5.4	4.2	5.3
Underfur density, points	5.6	5.1	5.8	5.5	4.0	5.1

The experiment showed a positive effect on pelt length as well as pelt quality when the diet containing 25 percent of the ME from digestible protein was supplemented with methionine even though the characteristics did not reach the same level as the 44 percent protein level.

Investigations of the effect of supplementation of methionine, threonine, lysine and isoleucine to diets containing protein equal to 30, 35 and 40 percent of ME from digestible protein during the growth period did not show any influence on weight gain, pelt length or other pelt characteristics. On this basis, it was concluded that 30 percent of ME from digestible protein in a diet of traditional Danish composition meets the requirement (Lund 1983).

In a later series of experiments, where the protein level was reduced to 25 percent of ME from digestible protein, it was shown that even that level of protein meets the requirements since there was no effect of supplementation with methionine. The results are shown in table 7. Unfortunately, the diets were not analyzed for amino acid content.

Table 7. The effect of different protein contents and supplementation of DL-methionine to the diet during the growth period on pelt characteristics in dark males.

Percent. of ME from dig. protein	35		30		25	
Supply of methionine	-	+	-	+	-	+
Number of skins	60	60	60	60	60	60
Pelt length, cm	73.4	75.2	74.6	74.8	74.7	74.5
Pelt quality, points	12.9	12.8	12.1	12.4	13.0	12.9

Methionine as replacement for cystine in the diet

Nitrogen balance experiments have been carried out to investigate the possibilities of replacing the expensive cystine with methionine. Supplementation with L-methionine, D-methionine and L-cystine were compared to sulphur-containing amino acids given from natural sources (Glem-Hansen, 1982). The results are summarized in table 8.

Table 8. The effect of sulphur-containing amino acids originating from natural feedstuffs, L-cystine, D-methionine, or L-methionine on N-retention in pastel mink males (3 weeks balance period).

		Synthetic amino acids		
	Natural feedstuffs	L-methionine	D-methionine	L-cystine
Intake sulphur amino acids, g	19.3	18.9	17.7	19.3
N-retention, g	4.9±1.7	5.7±1.7	3.0±1.3	5.5±1.0

The experimental diets for supply of amino acids contained 2/3 of the amount of protein in the control diet (natural feedstuffs). It means that 2/3 of the amino acid in question was given from natural feedstuffs and 1/3 as a synthetic amino acid. It can be concluded from the table, that D-methionine cannot be utilized by mink, which should be taken into consideration in the evaluation of result from experiments investigating the requirement of sulphur-containing amino acids on the basis of diets supplemented with DL-methionine. This has been considered in the conclusions in the present report.

The table also shows, that within the levels used in this experiment, L-methionine can be utilized just as effectively as L-cystine by the mink.

Based on amino acid experiments, it can be concluded that the sulphur-containing amino acids are the first limiting factor for utilization of protein for mink kits fed a traditional Scandinavian diet during the period from ultimo August to primo December.

During the period of intensive growth, the results have been ambiguous since some experiments have shown a positive response on the weight gain to a supply of methionine while others have responded positively to a supply of lysine. However, it is obvious that the requirement for sulphur-containing amino acids is less pronounced during the early growth period than during the period where the winter coat is developed.

The majority of investigations have shown that the requirement for sulphur-containing amino acids are met if the content of methionine plus cystine equals 3% of the protein during intensive growth from 10 to 20 weeks of age with a protein content equal to 25 to 30 percent of ME from digestible protein. During the period from 20 weeks of age until pelting in December the requirement for sulphur-containing amino acids is larger if we want to minimize the amount of protein, namely 3.5 - 4.0% of the protein with a protein content of 30 percent of ME from digestible protein.

The available research reports indicate that a diet which meets the requirements of sulphur-containing amino acids, without any supply of synthetic amino acids, automatically fulfills the requirements for other amino acids if a traditional Scandinavian diet is used.

The requirement for protein during the growth period

Usually we talk about a requirement for protein, even though we know that it is a wrong expression, which summarizes the requirement for a number of essential amino acids needed for the synthesis of body protein by the organism. However, the practical value of experiments for determination of the protein requirement is obvious as long as the basis for the experiments are diets which do not differ too much from the composition used in practice. This very important limitation should be kept in mind when results from experiments are transferred to practical use.

Due to the fact that availability and market prices have caused considerable changes in diet composition over the years, this chapter will be concentrated on recent investigations. The already mentioned investigation by Lund (1983) included groups of dark and pastel mink kits which were fed protein levels of 30, 35 and 40 percent of ME from digestible protein during the period from 1st July to pelting in late November. The key results are shown in table 9.

Table 9. The effect of different dietary protein contents during the growth period on pelt characteristics in dark and pastel males.

Percent. ME from dig. protein	40		35		30	
Colour type	Dark	Pastel	Dark	Pastel	Dark	Pastel
Number of skins	40	50	20	25	20	25
Pelt length, cm	75.6	76.2	75.6	77.6	75.2	76.3
Pelt quality, points	5.9	6.4	6.4	6.4	6.4	5.9
Colour/clarity, points	6.2	7.9	6.5	7.8	6.3	8.0

It can be seen that none of the pelt characteristics were influenced to any important extent, which means that the lowest level of protein fulfilled the requirement just as well as higher amounts. From table 7 i was concluded that even a level of 25 percent of ME from digestible protein did not affect the pelt characteristics negatively. Experiments carried out in Norway during the early seventies referred by Skrede (1975), investigated levels of dietary protein from 26 to 42 percent of ME from digestible protein. The results are shown in table 10 and 11.

Table 10. The effect of dietary protein content during the growth period on pelt characteristics in dark males.

Percent. ME from dig. protein	41-42	34-35	29-30	26
Number of skins	55	56	56	29
Pelt length, cm	67.5	67.1	67.1	67.1
Pelt quality, points	2.6	2.7	2.5	2.1
Colour, points	4.0	4.0	3.9	4.0

Table 11. The effect of dietary protein content during the growth period on pelt characteristics in dark males.

Percent ME from dig. protein	53-55	41-42	28-29
Number of skins	25	25	25
Pelt length, cm	68.9	69.5	69.4
Pelt quality, points	2.9	2.9	2.7
Colour, points	3.1	3.0	3.2

The conclusions drawn from the experiments were that diets with 3/4 of the protein originating from fish offal meet the requirement when the protein content equals 30 percent of ME from digestible protein or maybe even less.

Experiments carried out in Finland during the early eighties agreed reasonably well with the Danish and Norwegian results showing that 30 percent of ME from digestible protein meets the requirement for weight gain as well as for development of the pelt. The results are shown in table 12 and 13 (Berg et al. 1983 & 1985).

Table 12. The effect of dietary protein content during the growth period on pelt characteristics in males.

Percent. ME from dig. protein*	41/39*	34/36*	34/31*
Number of skins	56	56	58
Pelt length. cm	68.2	68.3	67.0
Pelt quality (relative)	100	99	100
Pelt density (relative)	100	96	98
Cover of guard hair (relative)	100	101	106
General impression (relative)	100	101	102

* **The levels of protein refer to the periods July to August/September to pelting in table 12 as well as table 13.**

Table 13. The effect of dietary protein content during the growth period on pelt characteristics in dark males.

Percent. ME from dig. protein*	40/36	36/31	31/27	27/23
Number of skins	45	30	29	31
Pelt length	70.4	71.4	71.4	70.6
Pelt quality, points	8.7	8.8	8.6	8.4
Pelt colour, points	8.2	8.2	8.1	8.3

It can be seen that these investigations confirm the earlier mentioned requirements. Even though, the difference between the two protein levels 40/36 and 27/23 is small, it was statistically significant.

Hillemann & Lyngs (1989) found in disagreement to the above mentioned investigations a marked deterioration in pelt quality in pastel males when the dietary protein content was reduced from 39 to 25-26 percent of ME from digestible protein. A similar decrease was not found in dark males on the same diets. The results are shown in table 14.

Table 14. The effect of different dietary protein content and different fat/carbohydrate relationships during the growth period in dark- and pastel males.

Percent. ME from dig. protein	39		26		25		25	
Percent. ME from dig. fat	42		58		55		49	
Percent. ME from dig. carbohydrate	19		16		20		26	
Colour type	ST	PA	ST	PA	ST	PA	ST	PA
Number of skins	65	61	58	57	55	61	62	59
Pelt length, cm	74.2	73.5	73.9	74.1	74.0	75.6*	73.4	74.0
Pelt quality, points	9.5	8.5	8.9	7.0*	8.3*	6.1*	9.2	6.6*
Colour/clarity, points	10.1	10.3	8.6*	9.9	9.1*	10.1	9.0*	9.8

* **The differences were statistically significant at the 95 percent level.**

A series of experiments with different protein levels at certain stages during the growth period can give information on when we have the highest requirement (Lund & Hansen 1987). The experimental period was divided into three subperiods, namely 1st July to 15th August, 16th August to 30th September, and 1st October to pelting time (ultimo November). The results are shown in table 15 and 16.

From table 15 it can be seen that a protein content of 30% of ME from digestible protein apparently meets the requirement in the period 1st July to 15th August.

Table 15. The effect of different dietary protein contents during the below-mentioned subperiods on pelt characteristics in dark and pastel males.

Percent. ME from dig. protein*	30/30/30*		45/30/30*	
Colour type	ST	PA	ST	PA
Number of skins	38	40	39	40
Pelt length, cm	74.9	75.6	74.2	76.4
Pelt quality, points	6.50	8.70	7.00	8.25
Colour/clarity, points	8.10	7.75	7.82	7.20

* **Percentage ME from dig. protein in the periods 1st July to 15th August/16th August to 30th September/1st October to pelting.**

Table 16. The effect of different dietary protein contents during the below mentioned sub-periods on pelt characteristics in dark and pastel males.

Dark					
Percentage ME from dig. protein*)	30/30 /30*	30/45 /30*	30/45 /45*	45/45 /45*	45/30 /45*
Number of skins	38	39	39	38	40
Pelt length, cm	74.9	74.6	74.1	74.6	75.2
Pelt quality, points	6.50	6.70	7.70	8.00	7.50
Colour, points	8.10	7.50	7.82	7.94	7.75
Pastel					
Number of skins	40	42	39	41	44
Pelt length, cm	75.6	76.5	75.8	75.4	75.8
Pelt quality, points	8.70	9.00	9.45	9.35	8.30
Clarity, points	7.75	7.73	7.46	7.21	7.65

*** Percentage ME from dig protein in the periods 1st July to 15th August/16th August to 30th September/1st October to pelting.**

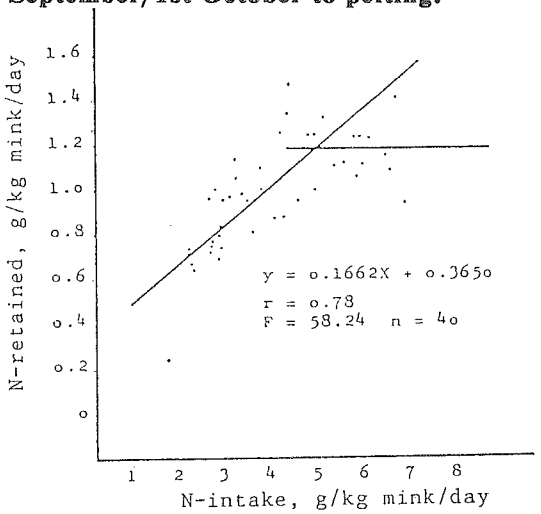

Figure 2. The effect of N intake on N-retention in dark male mink at 10 to 15 weeks of age

Even though the authors conclude that they did not find any statistically significant differences between the experimental groups, it can be seen that there is an obvious tendency to a decrease in pelt quality in the groups fed the low level of protein during the period from middle August until pelting.

The requirement for protein at different stages during the growth period has been investigated by Glem-Hansen (1980). The requirement was determined in N-balance experiments with N-retention as a function of protein intake. The results are shown in figure 2. The requirement is traditionally considered to be the intersection between the two regression lines.

Similar curves were made for the following periods until pelting time. On this basis the protein requirements for maximum N-retention were as shown below.

From 10 to 15 weeks of age =
41 percent of ME from dig. protein

From 16 to 17 weeks of age =
42 percent of ME from dig. protein

From 19 to 21 weeks of age =
32 percent of ME from dig. protein

From 22 to 24 weeks of age =
31 percent of ME from dig. protein

In a follow-up experiment these levels of protein were used with the shown variations throughout the growth period. The experiment included three groups where one followed the "standards" shown above and the other two were fed 25 percent less and 25 percent more protein, respectively. The results of this experiment are shown in table 17.

Table 17. The effect of dietary protein levels during the growth period on pelt characteristics in dark males.

Protein level	25% above "the standard"	"The standard"	25% below "the standard"
Number of skins	49	49	47
Pelt length, cm	72.2	73.0	72.9
Pelt quality, points	6.0	5.1	4.6
Colour, points	4.9	4.8	4.8

It can be seen that the protein content which resulted in maximum N-retention did not fully meet the requirement for maximum development of pelt quality. The group which had the best pelt quality was fed a diet with 32 percent of ME from digestible protein. The other two groups were fed diets with 24 and 20 percent of ME from digestible protein during the period 7th October to 30th November. In the period from 3rd July to 6th October they were fed diets with 41, 32 and 24 percent of ME from digestible protein, respectively.

Norwegian investigations concerning the protein requirement during the growth period based on different protein sources have been published by Skrede (1978). The experiments showed that the protein source influences pelt development, but the use of inferior protein sources can be compensated by a larger amount of protein in the diet. In the first experiment, two different protein sources namely, traditional cod offal without the heads and cod offal with very little meat left on the bones, were used as the main protein source given at two dietary protein levels. The results from the experiment are shown in table 18.

Table 18. The effect of different protein levels from two protein sources in diets during the growth period on pelt characteristics in dark males.

Protein source	Traditional cod offal		Cod offal with little meat		Half and half of each kind of offal	
Percent. ME from dig. protein	40	28	39	28	40	28
Number of skins	21	20	22	21	21	21
Pelt length, cm	69.3	69.3	68.9	68.9	70.4	69.9
Pelt quality, points	3.0	2.9	3.0	2.6	2.8	2.7
Colour, points	3.1	3.3	2.7	3.3	3.2	2.9

The next series of experiments included groups fed diets with a lower protein content and comprised a combination of slaughter house offal and fishmeal, cod offal with little meat left, cod heads, and cod skin as the main sources of protein. The results are shown in table 19.

Table 19. The effect of different dietary protein levels from different protein sources during the growth period on pelt characteristics in dark males.

Protein source	Slaughter-house offal and fish-meal		Cod offal with little meat		Cod heads		Cod skin		
Pct. ME from dig. prot.	27	23	28	24	28	23	33	28	24
Number of skins	18	19	18	13	14	18	8	8	8
Pelt length, cm	65.4	65.7	64.7	63.8	67.1	65.0	64.8	62.0	57.0
Pelt quality, points	2.5	1.9	2.8	2.6	2.3	2.4	2.9	2.4	1.8
Colour, points	2.7	3.1	3.2	2.6	3.2	2.8	3.0	3.8	2.8

In tables 18 and 19 only experimental groups up to the protein level which met the requirement are included. This means that a further increase of the protein content did not influence the pelt quality. From table 19 it can be seen that a reduction of the protein content from 28 to 23-24 percent of ME from digestible protein had a negative influence either on pelt quality or pelt length. Several investigations have shown a negative correlation between pelt quality and pelt length. This means that a reduction in pelt length automatically has a positive influence on the pelt quality. Based on this investigation, it can be concluded that 23-24 percent of ME from digestible protein does not fully meet the requirement for maximum pelt development in mink.

When cod skin was the main protein source the pelt length as well as the pelt quality were improved by an increase of the protein content up to 33 percent of ME from digestible protein. It should be taken into consideration that the figures for this group in the table are based on 8 skins only, but it can also be added that the same tendency was found for female skins.

It can be concluded that the protein requirement during the growth period is normally met by a content of 30 percent of ME from digestible protein when the basis is a traditional Scandinavian feed composition. However, attention should be given to amino acid composition especially during the period of intensive hair growth from about 20 weeks of age to pelting time. During this period the content of sulphur-containing amino acids should be 3.5 to 4.0 percent of the protein (g/16 g N).

The requirement for protein during the reproduction period

Most of the investigations for determination of protein and amino acid requirements are carried out during the growth period. This is understandable since the greatest part of the feed is used during that period.

The breeding or reproduction period covers two separate periods, namely the period from pelting time to mating in March when the requirements are dominated by the need for maintenance and a gestation period from mating time to the time when the females give birth. During this period the requirements are partly needs for maintenance and partly for foetal growth. The lactation period is normally considered a part of the reproduction period. The requirements during this period are dominated by the need for milk production by the females during the first 3-4 weeks after birth of the kits and by the need of easily digestible nutrients for the kits during the remaining period until weaning at 6 to 8 weeks of age.

In the Scandinavian countries it has been considered appropriate to use diets with a high amount of protein during the reproduction period. In Denmark, the protein content has been between 50 and 58 percent of ME from digestible protein while Norwegian, Swedish and Finnish diets usually contain 40 to 50 percent ME from digestible protein. Climatic differences between the countries might indicate a certain difference in the energy requirement during winter which influences the relationship between nutrients.

However, logical considerations concerning the protein requirement for maintenance and the content in the diets do not justify such a high amount of dietary protein during the period prior to whelping.

Experiments have in agreement with this shown that 26-27 percent of ME from digestible protein meet the requirement prior to whelping (Skrede 1978). The result can be seen from table 20.

It can be seen from the table, that mortality was high in all groups. Based on litter size and mortality, there is a tendency to inferior reproduction in the group fed 26-27 percent of ME from digestible protein compared to higher amounts.

Table 20. Reproduction in dark females fed decreasing dietary protein levels of different origin during the breeding and lactation periods.

	Protein source					
	50 % cod offal without heads and entrails and 50% cod offal with heads and entrails			Cod offal without heads and entrails		
Percentage ME from dig. protein	51	39	27	49	38	26
Number of mated females	29	29	30	28	30	30
Number of fertile females	24	27	29	23	27	25
Percent barren females	17	7	3	18	10	14
Litter size at birth	5.1	5.7	6.0	5.9	6.0	4.8
Number of kits alive at birth per litter	4.5	4.9	5.1	5.0	5.4	4.1
Number of kits at 6 weeks of age per litter	3.3	3.3	2.3	3.1	3.7	2.7

The same tendency can be seen from the weight gain of the kits up to 21 and 42 days of age. This can be seen from table 21.

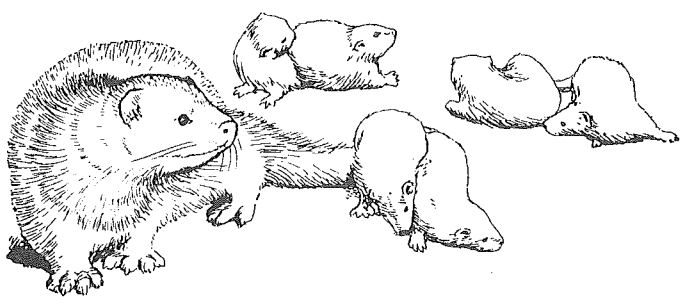

Table 21. The weight gain of kits fed diets with two different protein sources at three protein levels during the lactation period

	Protein source					
	50% cod offal without heads and entrails and 50% cod offal with heads and entrails			Cod offal without heads and entrails		
Percent. ME from dig. protein	51	39	27	49	38	26
Body weight at 21 days of age (average of males and females)	107	112	94	107	110	93
Body weight of males at 42 days of age	334	325	234	288	274	244
Body weight of females at 42 days of age	271	276	226	259	253	219

The results indicate that the protein requirements for lactating females as well as for kits in the very early growth period are met by a diet with 38-39 percent of ME from digestible protein.

Danish experiments from the sixties (Jørgensen & Glem-Hansen 1970) did not show significant differences in litter size between groups fed diets from 65 to 25 percent of ME from digestible protein.

However the mortality from birth to weaning was twice as high in the low protein group compared to groups fed higher protein levels. The results are shown in table 22.

This experiment shows that a protein content of 44 percent ME from digestible protein does not fully meet the requirement for maximum weight gain for the kits.

Table 22. Weight gain in kits from groups fed different protein levels during the lactation period (Dark mink).

Percentage ME from dig. protein	63	44	25
Body weight at 21 days, g	105	97	79
Body weight of 42 days, g	348	306	190

Investigation of the influence of the amount and quality of the protein on the composition of mink milk showed that the biological value (BV) and the protein content did not influence the content of protein, fat, and carbohydrate in the mink milk. The amino acid composition in the milk was not influenced either, but the composition of fatty acids in the milk clearly reflected the fatty acid composition in the diet (Glem-Hansen et al. 1973). The weight gain of the kits as a measure for milk production indicated that the protein content and the protein quality to a considerable extent influenced the amount of milk produced (Glem-Hansen & Jørgensen 1973).

Experiments with different protein contents in the diets during the lactation period, comprising levels from 21 to 54 percent of ME from digestible protein, showed that protein levels below 42 percent of ME from digestible protein did not meet the requirement for maximum weight gain even in the period before they begin to eat solid feed. Thus it can be concluded that the requirement for maximum milk production in females

was not fully met. The weight gains in the kits are shown in figure 3 and 4.

As can be seen from the figures, the weight gain was increasing by increasing levels of protein in the diet. However, it should be added that analyses of one male and one female kit from each of the group 1 to 3 showed no differences in the retained body protein between group 1 and 2. This means that 42 percent ME from digestible protein apparently covers the protein requirement for maximum N-retention. The difference in body weight between group 1 and 2 was equalized during the following growth period. This was also reflected in the pelt length as shown in table 23.

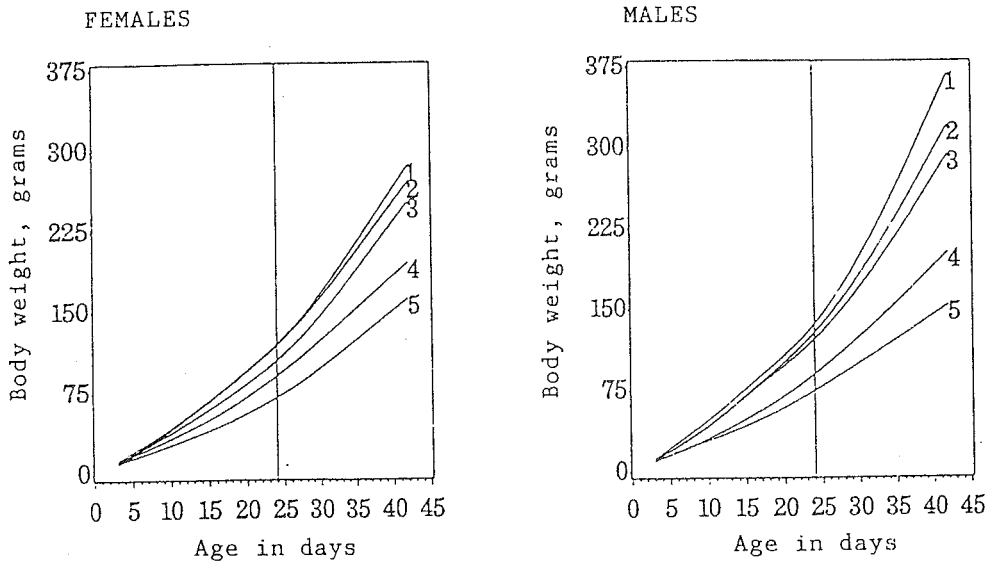

Figure 3 and 4. The body weight development in male and female kits on different dietary protein levels during the lactation period. Group 1 to 5 were fed diets with 54, 42, 34, 26 and 21 percent from digestible protein, respectively

Table 23. Effect of different dietary protein levels during the lactation period on pelt characteristics in dark males fed the same diet from weaning to pelting.

Percent. ME from dig. protein	54	42	34	26	21
Number of skins	12	9	11	16	17
Pelt length, cm	74.2	74.0	68.3	68.3	65.8
Pelt quality, points	6.0	4.7	5.9	5.6	5.9

From weaning to pelting all groups were fed a diet containing 50 percent of ME from digestible protein. Thus, it can be concluded that a lack of protein during the lactation period and the very early growth period causes a reduction in the pelt length.

Recent experiments with different dietary protein contents in the diets showed no differences in weight gain in dark kits fed protein levels from 43 to 57 percent ME from digestible protein. A group of pastels was fed a diet containing 38 percent ME from digestible protein and showed a tendency to lower weight gain, which can be seen from table 24 (Olesen 1990).

Table 24. Weight gain of pastel male kits fed different dietary protein levels during the lactation period.

Percentage ME from dig. protein	57	49	43	38
Body weight at 29 days (ave ♂ ♀), g	149	161	171	168
Body weight at 43 days (♂♂), g	343	353	377	344

Investigations on the effect of a reduction in dietary protein content in relation to common Danish standards in the eighties combined with a supplement of four different amino acids up to the level given in the "standard diet" did not show any statistically significant effect when supplying with the amino acids methionine, lysine or threonine during the lactation period when the basic diet contained 39 percent ME from digestible protein (Lund 1985). However, there was a negative response to a supply of isoleucine as shown in table 25.

Table 25. Effect of supplement of a diet containing 39 percent ME from digestible protein with methionine, lysine, threonine, and isoleucine to pastel and dark mink during the lactation period on weight gain.

Pastel					
Amino acid supplement	**none**	**Methionine**	**Lysine**	**Threonine**	**Isoleucine**
Body weight at 12 days, g	50	52	53	51	44
Body weight at 22 days, g	114	117	127	109	97
Body weight at 42 days, g	351	330	362	347	281
Dark					
Body weight at 12 days, g	54	54	56	56	55
Body weight at 22 days, g	125	120	130	127	120
Body weight at 42 days, g	385	337	376	363	321

Even though the differences were not statistically significant, it should be noticed that there was a tendency to a positive effect on weight gain when supplementing with lysine.

The lactation period and the very early growth period until the kits are 8 to 10 weeks of age is the period where we have shown the highest demand for protein. In one particular experiment it was indicated that lysine might be the first limiting amino acid for kit growth during the lactation period. Most experiments show that the requirement for protein and amino acids will be met by a diet containing 40 to 45 percent of ME from digestible protein.

The investigations indicate that litter size and percentage of barren females will not be affected as long as the protein content equals 30 percent of ME from digestible protein. However the weight gain and the mortality during the lactation period

are affected negatively when the protein content is lower than 40 percent of ME from digestible protein.

The practical experience in Denmark of an improved reproduction by increasing protein levels up to 55 to 60 percent ME from digestible protein seems to an effect of something else than protein.

Estimation of the amino acid requirement during the growth and pelt development period

Based on the previously referred reports for determination of requirements for protein and amino acids during the growth and pelt development period, the requirements are estimated for the most important amino acids. Since the feed intake primarily depends on the dietary content of metabolizable energy, the requirement for amino acids will be related to the content of ME in the diet.

The content of digestible amino acids in a number of experimental diets is calculated on the basis of Nordisk Fodermiddeltabel, which is a table of the contents of digestible amino acids in feedstuffs based on amino acid digestibility experiments with mink (Glem-Hansen et al. 1985). Since it has been shown that the sulphur-containing amino acids, cystine and methionine, are the first limiting factors for maximum pelt development the effect of these amino acids on pelt quality will be examined in the following.

The results in table 26 to 28 show that a content of sulphur-containing amino acids of less than 0.25 to 0.30 grams per 100 Kcal ME cause inferior pelt quality.

Table 26. The effect of content of sulphur-containing amino acids (cystine + methionine) in the diets during growth and pelt development on pelt quality (Lund & Hansen 1987).

g CY + ME/100 Kcal ME	1st July to 15th Aug.	0.23	0.23	0.23	0.34	0.34
	16th Aug to 30th Sept.	0.25	0.30	0.30	0.34	0.25
	30th Sept. to pelting	0.22	0.22	0.30	0.36	0.36
Pelt quality, points (Dark)		6.50	6.70	7.70	8.00	7.50
Pelt quality, points (Pastel)		8.70	9.00	9.45	9.35	8.30

Table 27. The effect of content of sulphur-containing amino acids (cystine + methionine) in the diets during growth and pelt development on pelt quality (Hillemann & Lyngs 1985).

g CY + ME/100 Kcal ME	0.32	0.20	0.19	0.19
Pelt quality, points (Dark)	9.5	8.9	8.3	9.2
Pelt quality, points (Pastel)	8.5	7.0	6.1	6.6

Table 28. The effect of content of sulphur-containing amino acids (cystine + methionine) in the diets during growth and pelt development on pelt quality (Lund 1988).

g CY + ME/100 Kcal ME	0.39	0.33	0.28
Pelt quality, points (Dark)	12.9	12.1	13.0

Table 28 shows the results from the previously mentioned experiment where they found no difference in pelt quality when the protein content was reduced to 25 percent of ME from digestible protein. The content of sulphur-containing amino acids in the diets explains the probable reason for that since it was relatively high and thus, most probably, met the requirement.

In table 29 to 30 the analysed amounts of sulphur-containing amino acids are related to pelt quality. In table 30 the influence on pelt length is included since it was influenced by the treatment which was not the case in the experiments referred in the other tables.

Table 29. The effect of content of sulphur-containing amino acids (cystine + methionine) in the diets during growth and pelt development on pelt quality (Dark) (Glem-Hansen & Jørgensen 1973).

g CY + ME/100 Kcal	0.37	0.25	0.14
Pelt quality, points ♂♂	5.47	5.93	4.17
Pelt quality, points ♀♀	6.36	6.00	4.14
Pelt density, points ♂♂	5.60	5.79	4.00
Pelt density, points ♀♀	5.73	5.75	4.00

Table 30. The effect of content of sulphur-containing amino acids (cystine + methionine) in the diets during growth and pelt development on pelt quality and pelt length. (Skrede 1978).

g CY and ME/100	0.22	0.20	0.25	0.21	0.24	0.20	0.24	0.21	0.18
Pelt quality, points. (Dark ♂♂)	2.5	1.9	2.8	2.6	2.3	2.4	2.9	2.5	1.8
Pelt length, cm	65.4	65.7	64.7	63.8	67.1	65.0	64.8	62.0	57.0

The amounts of amino acids in tables 26 to 30 are given as the total amounts. Therefore, the digestibility of amino acids should be taken into consideration. On the basis of the experiments referred above it can be concluded that a content of digestible sulphur-containing amino acids of 0.25 to 0.30 grams of cystine + methionine per 100 kcal ME fully meets the requirement for maximum pelt development.

Based on the above-mentioned experiments and the calculated amount of digestible amino acids in the diets it will not be possible to list up the minimum requirements for each single amino acid, but it is possible to estimate the levels for amino acids which most probably will meet the requirements during the growth and pelt development period. In table 31 these amounts are given for the amino acids which are considered as essential.

It will probably by somebody be considered irresponsible to state demands for amino acids on this basis. Therefore, these demands should only be used as a basis for composition of diets for experimental purposes until a better basis in established.

Table 31. Demand for essential amino acid content in diets for mink during the growth and pelt development period.

g amino acid per 100 Kcal ME	Period	
	Weaning to 15th Aug	16th Aug. to pelting
Methionine + Cystine	0.20	0.30
Lysine	0.40	0.40
Tryptophan	0.03	0.03
Threonine	0.27	0.27
Histidine	0.15	0.15
Phenylalanine	0.30	0.30
Tyrosine	0.22	0.22
Leucine	0.50	0.50
Isoleucine	0.30	0.30
Valine	0.35	0.35
Arginine	0.40	0.40

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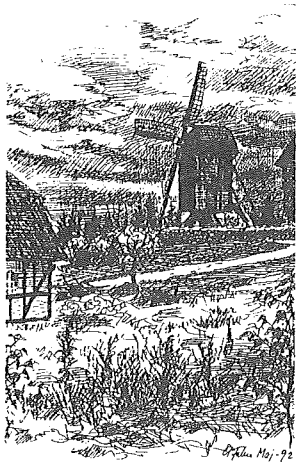

Original Report

Long-term effects of dietary fish fatty acids on the breeding performance of blue foxes

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Abstract

Blue foxes (*Alopex lagopus*) were fed a slaughterhouse offal-based (SH) or a fish mixture-based diet supplemented with fish oil (FM) for one year. The trial lasted from weaning to the following breeding season, until the weaning of the litters. The aim of the study was to clarify the long-term effects of feeding abundant fish fatty acids on the breeding result of blue fox females and early growth of the puppies. Both dietary groups consisted of 20 vixens and 7 males. The number of unmated females in the SH and FM dietary groups was 3 and 4, the number of barren females was 2 and 5, and the number of females which destroyed their litters was 4 and 3, respectively. The litter size at weaning, counted per mated and (whelped females), was 4.71 and (5.33) in the SH group and 3.94 and (5.73) in the FM dietary group. During the suckling period, body weight of the vixens declined significantly more in the SH dietary group than in the FM group. The weight gain of the puppies during the early growth period was better in the FM dietary group. Pup mortality (1-42 days) in the FM dietary group (23.2%) was, however, twice as great as in the SH group (11.1%). This may be due to deleterious effects caused by accumulation of long-chained polyunsaturated fish fatty acids in the tissues and organs. Moreover, two females from the FM group died during the experiment showing lipid accumulation in their internal organs.

Introduction

Fish products are commonly used in the feeding of the farmed fox species, blue fox (*Alopex lagopus*) and silver fox (*Vulpes vulpes*). Fish oil supplementation in the diets, based on slaughterhouse offal, is also employed. Fish is, however, very seldom included in the diets of these carnivorous fur-bearers in their natural habitat. Their nutrition in the wild is mainly based on small mammals and birds (*Dekker, 1983; Fay & Stephenson, 1989; Kaikusalo, 1971; Papageorgiou et al., 1988; Robertson & Whelan, 1987*). As the animals adapt to certain food sources during their evolutional development, different dietary fatty acids may prominently alter the physiology of the animal when accumulated in the tissues (*Nelson & Ackman, 1988*). The polyunsaturated long-chained omega-3 fatty acids, found in fish oil, have been shown to accumulate in the tissues and organs, especially the liver, of blue and silver foxes (*Rouvinen & Kiiskinen, 1989; Rouvinen, 1991*). This is an indication of impaired oxidation of these fatty acids. The previous part of this study also revealed that long-term feeding of blue and silver foxes with fish oil caused unphysiological lipid accumulation and degenerative changes in the liver tissue of the animals (*Rouvinen, 1991*).

Accumulation of polyunsaturated fatty acids in the body increases the requirement for antioxidative agents by being susceptible to peroxidation. Vitamin E, as a natural antioxidant, is known to

protect tissues by inhibiting the formation of free radicals together with a selenium dependent enzyme, glutathione peroxidase, which damages the free radicals formed during lipid peroxidation (*Kormann & Weiser, 1984*). In fur-bearing animals, vitamin E deficiency has shown to cause anaemia and poor growth, depigmentation of hair, yellow fat, muscular degeneration and death (*Ender & Helgebostad, 19875; Havre et al., 1973; Helgebostad, 1971*). Moreover, reproductive failure has been reported in several species, including embryonic degeneration in rats, hens, tur-keys, cows and ewes, sterility in male rats, guinea pigs, hamsters, dogs and cocks, and also reduced egg production and hatchability in hens (*McDonald et al., 1988*).

In this study, the effects of long-term feeding with a fish mixture based, fish oil-supplemented diet on the breeding performance of blue foxes were clarified. Emphasis was on the litter size of the mated and whelped vixens and on the growth and mortality of the offspring during the suckling period.

Materials and methods

The animals used in this study were born in the spring of 1988 and were fed two different diets from their weaning, on July 18th, onwards (*Rouvinen et al., 1991*). The diets were a slaughterhouse offal-based diet (SH) and a fish mixture-based diet supplemented with fish oil (FM). During the following breeding and lactation season, until July 27th, 1989, the animals were fed the same type of diets as they received during their growing-furring period (table 1). There were 20 females and seven males in both dietary groups at the beginning of the breeding season, but only four males from both groups were used in matings.

Table 1. Composition of experimental diets from January 1st to April 27th and from April 28th to July 27th, 1989. SH = slaughterhouse offal, FM = fish mixture diet.

	Diet			
	January - April		May - July	
Ingredient, %	SH	FM	SH	FM
Slaughterhouse offal [a)]	20	-	17	-
Fur animal carcasses	6	-	5	-
Meat meal	8	-	6	-
Fish mixture [b)]	-	57	-	51
Fish meal	-	3	-	2
Soybean meal	3	2	3	2
Cereals [c)]	15	15	12	13
Vitamins [d)]	2	2	2	2
Sugar beet pulp, dried	2	2	2	2
Fish oil	-	4	-	4
Water	44	15	53	24

a) beef offal, Pouttu Oy, Kannus

b) cod 56 %, Baltic herring (spring) 35 % and blue whiting 9 %

c) cooked wheat 50 % and barley 50 %

d) 1 kg mixture contains: vitamin A, 500.000 IU, vitamin D_3, 50.000 IU; vitamin C, 6.000 mg; vitamin E, 4.000 mg; vitamin K, 10 mg; vitamin B_1, 1.500 mg; vitamin B_2, 600 mg; vitamin B_{12}, 1 mg; choline, 2.500 mg; pantothenic acid, 500 mg; nicotinic acid, 1.000 mg; pyridoxin, 400 mg; folic acid, 50 mg; and biotin, 3 mg.

During the experiment, feed consumption of the groups was measured on the basis of the feed delivered minus the feed collected the next morning. Feed spill was ignored. Feed consumption was calculated per breeding animal unit, which in this experiment was as follows: females + 7/20 male + number of kits per female. The animals were fed once a day. Watering was by hand during the winter months and was automatic during spring and summer. Proximate chemical composition of the diets was analyzed from samples collected during February 6-18th and during May 3rd-8th, 1989. The feeds were analyzed for dry matter (DM), ash, Kjeldahl nitrogen, fat and gross energy (GE, bomb calorimeter) according to standard procedures employed by the laboratory of the Institute of Animal Production, Animal Nutrition Section, Jokioinen. Metabolizable energy (ME) of the diets was calculated by using the digestibility coefficients determined in the production experiment during the autumn of 1988 (*Rouvinen et al., 1991*) and the factors 18.8 (protein), 38.9 (fat) and 17.2 (carbohydrates) kJ per gram apparently digestible nutrient (*Tauson, 1988*).

Breeding females were weighed to the nearest 20 g on February 7th, and at mating time, i.e. on the average April 11th for the SH dietary group and April 15th for the FM dietary group. The vixens which gave birth were weighed one week after parturition and six weeks after parturition, at the end of the suckling period. The pups were counted on the day after birth, and were both counted and weighed to the nearest 1 g at 7 days of age, at 21 days of age and at weaning, i.e. 42 days of age.

After the breeding season, empty females and females that died during the experiment were sampled for histopathological study. Samples from liver, heart, kidneys, small intestine and skeletal muscle were stored in buffered formalin and sent to the National Veterinary Institute for examination.

Statistical significances were tested by the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS Institute Inc., 1988).

Results

Chemical composition of the diets (table 2) was kept constant during the breeding and lactation periods. Fat content in the diets varied between 19 and 21 % in DM. In the FM dietary group, the protein content was higher, varying between 34-35 % in DM, than in the SH dietary group (30-31 %). GE and ME contents of the diets did not differ between the experimental groups.

Table 2. Proximate chemical composition of the diets during February 6th to 18th and May 3rd to 8th, 1989. SH = slaughterhouse offal, FM = fish mixture diet, DM = dry matter, GE = gross energy, ME = metabolizable energy.

	Diet			
	February		May	
Analyzed	SH	FM	SH	FM
DM, %	34.1	33.2	31.1	30.4
In DM, %				
Ash	8.9	6.8	8.8	6.4
Protein	30.4	34.4	30.7	34.8
Fat	19.2	18.8	20.9	18.6
Carbohydrates	41.5	40.0	39.6	40.2
GE, MJ/kg DM	22.0	22.3	22.1	22.3
ME, MJ/kg DM [a)]	16.1	16.3	16.5	16.3

a) Digestibility coefficients for protein 77.9, 79.2; fat 88.6, 91.3; and carbohydrates 70.5, 64.8 in SH and FM diets, respectively (*Rouvinen et al., 1991*).

The number of males and females in the experimental groups, the number of barren females and those who destroyed their litters are presented in table 3. All males mated with the barren females produced litters with other females, therefore, sterile males were not the cause of reproductive failure. During the experiment, two females died from the FM dietary group, one in the late suckling period and the other soon after weaning of the litter.

Table 3. Number of breeding animals in the experimental groups during spring 1989 and the number of unmated and barren females and females which destroyed their litters. Diet SH = slaughterhouse offal, FM = fish mixture.

Number of animals	Diet SH	FM
Males	7	7
Females	20	20
unmated	3	4
barren	2	5
whelped	15	11
destroyed litters	4	3

Feed consumption and consumption of metabolizable energy were similar in both experimental groups (fig. 1), except during June and July when the animals in the SH dietary group consumed more. This was due to the higher number of puppies per breeding animal unit in the SH group. In this group, there were 82 puppies at three weeks of age and 80 at weaning, while in the FM dietary group there were only 67 puppies at three weeks of age and 63 at weaning. Furthermore, July feed consumption declined in both dietary groups due to weaning of the litters. After weaning, the pups received the normal fur animal diet produced by the local feed kitchen.

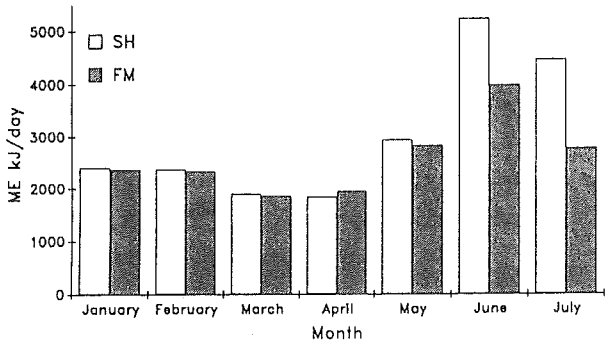

Fig. 1. Daily intake of metabolizable energy per breeding animal unit (c.f. text) in blue foxes from January 1st to July 27th, 1989. Diets SH = slaughterhouse offal, FM = fish mixture.

Body weight of the whelped females (fig. 2) were similar in both dietary groups from February until mating. During lactation, one week after parturition ($p < 0.001$) and at the end of the suckling period ($p < 0.05$) the females receiving the FM diet were heavier than the females in the SH dietary group.

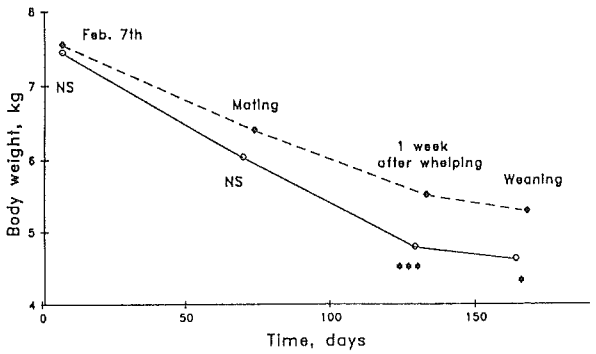

Fig. 2. Body weight of the whelped blue fox vixens from February 7th until weaning in July, 1989. The slaughterhouse offal diet (SH) is marked with --o-- and the fish mixture diet (FM) with --•-- . For statistical significance NS = not significant, * $p < 0.05$, and *** $p < 0.001$.

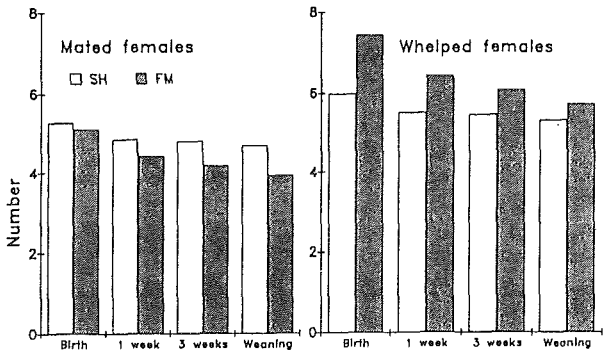

Fig. 3. Litter size per mated and whelped female at birth, one and three weeks after parturition, and at weaning. SH = slaughterhouse offal diet, FM = fish mixture based diet.

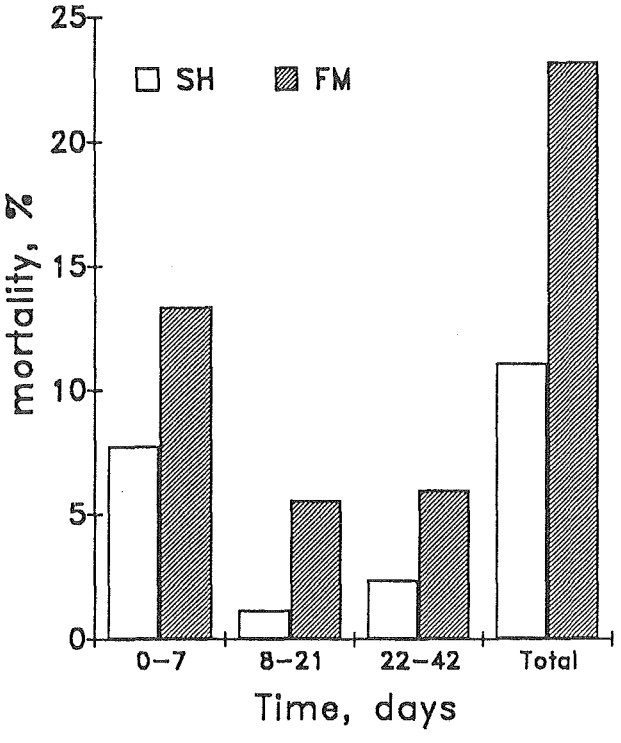

Fig. 4. Pup mortality during the suckling period in blue foxes SH = slaughterhouse offal diet, FM = fish mixture diet.

At birth (24 hours after parturition), the litter size per mated female was slightly better in the SH dietary group (5.29) than in the FM group (5.13) (fig. 3). The difference increased towards weaning, being 4.71 in the SH group and 3.94 in the FM group. The litter size calculated per whelped female was better at parturition in the FM dietary group (7.45) than in the SH group (6.00) (fig. 3). At weaning time, however, there were only 5.73 pups per whelped female in the FM group and 5.33 in the SH group. This was due to the much higher mortality rate in the FM group (fig. 4). In the FM dietary group, 23.2 % of the puppies died between days 1-42. In the SH group the corresponding figure was 11.1 %.

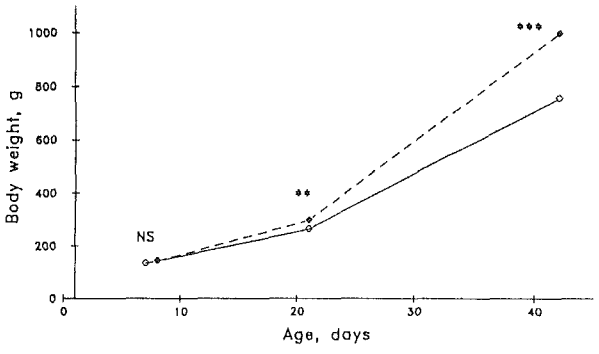

Fig. 5. Body weight gain in blue fox puppies during the suckling period. The slaughterhouse offal diet (SH) is marked with --o-- and the fish mixture diet (FM) with --•--. For statistical significance NS = not significant, ** $p < 0.01$, and *** $p < 0.001$.

Body weight of the blue fox puppies at one week of age did not differ between the dietary groups (fig. 5). At three weeks of age ($p < 0.01$), and at weaning ($p < 0.001$), the pups from the FM dietary group were, however, significantly heavier than those receiving the SH diet.

The results of the histopathological study of the dead and barren females are presented in table 4. Both barren females from the SH dietary group showed degenerative changes in their livers and heart and also chronic enteritis. Moreover, one suffered from nephrosis and the other from chronic myocarditis. In the FM dietary group, four out of the five barren females had chronic nephritis. One of these animals also had muscle degeneration, and fibrous tissue growth in the liver. Both mortality cases from the FM dietary group showed lipid accumulation in their internal organs.

Table 4. Histopathological findings of the barren females and the females which died during the experiment. Findings are graded as follows: + slight, ++ moderate, and +++ severe. Number of findings per group is given in parenthesis. N = number of animals sampled.

Organ/finding	SH	FM
Barren females	N = 2	N = 5
Liver		
reticulo-endothelial proliferation	++/+++ (2)	+++ (1)
degeneration	+/++ (2)	-
fibrous tissue growth	++ (1)	- (1)
Heart		
chronic myocarditis	+ (1)	-
muscle degeneration	+ (2)	-
Kidney		
chronic nephritis	-	+/+++ (4)
nephrosis	+ (1)	-
Intestine		
chronic enteritis	+ (2)	-
Skeletal muscle		
degeneration	-	+ (1)
Dead females	N = 0	N = 2
Liver		
lipid accumulation	-	+ (1)
fibrous tissue growth	-	++ (1)
Heart		
lipid accumulation	-	+ (2)
Kidney		
lipid accumulation	-	+ (1)
Intestine		
chronic enteritis	-	

Discussion

The average breeding result of blue foxes counted three weeks after parturition is 5.8 kits per mated female (*Einarsson & Skrede, 1989*). In this experiment, the corresponding litter size was much smaller, 4.8 in the SH group and 4.2 in the FM group, due to all the females being in their first breeding season. The number of empty females on average is 14.9 % and pup mortality from birth until three weeks of age is 22.4 % (*Einarsson & Skrede, 1989*). For one-year old blue foxes, the amount of barren females is usually higher, about 22.5 %, and pup mortality during the first 50 days

is 35 % (*Einarsson & Skrede, 1989*). In the present study, the percent of barren females was 11.8 % in the SH group and 31.3 % in the FM dietary group. The number of implantation scars in the uterus of the mated females was, however, not examined at the following pelting time. This would have given valuable information about the absorption of the fetuses in the uterus and also about the number of barren females and destroyed litters. In young blue fox females, the prenatal mortality of the fetuses is known to be about 25 %, and in 60 % of the "empty" females approximately 4.5 implantation scars have been observed (*Einarsson, 1982*).

The marine fish fatty acids have been shown to accumulate in blue and silver fox tissues due to the limited oxidation of these long-chained polyunsaturated fatty acids (*Rouvinen, 1991*). In the rat, feeding fish oil or high erucic acid rapeseed oil is known to cause lipid infiltration, cell destruction, local inflammatory reactions and fibrous scar tissue growth in the heart muscle (*Beare-Rogers, 1977; Kinsella, 1987*). In addition to the body fat composition, dietary influences on the composition of the milk in monogastric animals are well documented (*Seerley, 1984*). In milk fat, the fatty acids and triglycerides are derived from blood plasma of the nursing female. During lactation the vixen uses its own body fat reserves in addition to the nutrients in the diet. In a recent study, blue fox vixens fed PUFA (polyunsaturated fatty acids) and control diets showed clear dietary effects in their milk fat composition (*Rusanen & Valtonen, 1991*). The diets fed to the vixens during breeding and lactation were formulated according to the same recipe as the diets described in the present study, PUFA diet being the FM diet and control being the SH diet. The fat of the milk from the PUFA (FM) females contained considerably more eicosenoic (C20:5ω3) acids than the milk from the control (SH) females. Furthermore, the level of cetoleic acid (C20:1ω11) was almost significantly ($p < 0.06$) elevated (*Rusanen & Valtonen, 1991*). In the present study, the pup mortality observed in the FM dietary group (23.2 %) was twice as great as in the SH group (11.1 %). Moreover, the vixens had been fed the fish fat diet during several months before their pregnancy and lactation. Their dietary background, and especially the more prominent accumulation of the fish fatty acids in the body fat reserved over time could have had an even greater impact on the milk fatty acid composition. Therefore, it is reasonable to believe that the higher mortality observed in the FM dietary group is related to the harmful effects of the accumulation of cetoleic and omega-3 fatty acids in the tissues and organs of the animals (*Rouvinen, 1991*).

The pup mortality figures obtained in this study (fig. 4) were, however, very low compared to literature. This is explained by the fact that the pups were counted the first time one day after parturition and thus the mortality during the first day was ignored. For the same reason, our figures for litter size 'at birth' were also very low, being 6.0 in the SH group and 7.5 in the FM group per whelped female, compared to the value 9.0 given by Einarsson & Skrede (1989).

The body weight of the whelped females (fig. 2) in the SH dietary group declined more after parturition and during the suckling period than the females from the FM group, although the amount of metabolizable energy provided by the diets was similar (table 2). The higher protein content of the fish diet may have enabled the females to maintain their body weight better during lactation, although the females in this group had larger litters to take care of (fig. 3).

The growth of the puppies in both dietary groups was poorer than the average weight gain for blue foxes during the suckling period (*Einarsson & Skrede, 1989*). This may be partly due to the late breeding and parturition of the young vixens. It is, however, more likely to be caused by the low percentage of ME from protein in both diets. According to recommendations (*Enggaard Hansen et al., 1990*), ME from protein should be above 35-37 % during breeding and lactation. In this study, ME from protein varied between 27-32 %, and the percentage from carbohydrates was correspondingly higher (27-31 %). The dietary ash content was, however, lower in the present study than in the previous part of this research (*Rouvinen et al., 1991*). Fat and protein digestibilites are known to decrease with high dietary ash contents (*Åhman, 1976; Skrede, 1978; Rouvinen & Kiiskinen, 1991*). Lower ash content may have improved the digestibilities of fat and protein in the present diets, and thus elevated their percentages in ME, compared to the diets employed during the autumn of 1988. Moreover, the digestibility coefficients employed in the ME calculations were determined on approximately five month old animals (*Rouvinen et al., 1991*). In young blue fox puppies, the utilization of beef tallow varies between 73-84 % (*Rouvinen, 1989*). Apparently the

more efficient utililzation of the fish fat diet in the present study resulted in better growth during the suckling period (fig. 5).

It is generally recommended that fur-bearing animals should be supplied with 100 IU of vitamin A per kg body weight daily (*Juokslahti, 1989*). The requirement for vitamin E given in the literature (*Brandt, 1987*) is 6.6 mg/Mcal plus 0.6 mg/g polyunsaturated fatty acids plus a non specified amount depending on the production intensity. In the present experiment, the supplementations used were 80 mg/kg feed for vitamin E and 10000 IU/kg feed for vitamin A (table 1). Both levels were well above the recommended minimum (*Roche, 1987*). Keeping in mind the dietary history of the animals and the long-term accumulation of polyunsaturated fatty acids in the body, it is possible that the vitamin E7 supplementation empolyed was not adequate to meet the increased requirements during gestation and lactation. In addition, one barren female suffered from muscular degeneration (table 4), which is probably the most important manifestation of vitamin E deficiency in domestic animals (*McDonald et al., 1988*). In the present study, the males were apparently not affected by vitamin E deficiency, since all males used in matings produced litters. The barren females, however, may have been pregnant, but absorbed or aborted the fetuses or destroyed their litters after birth. In this study, this was not controlled.

Conclusions

Feeding abundant fish oil to blue foxes during the breeding and suckling periods increased the mortality of the females, the number of barren females, and the mortality of the puppies. It is likely that the reproductive failure and poorer viability of the offspring is caused by long-term accumulation of long-chained polyunsaturated fish fatty acids in the tissues and organs. On the basis of these results it is not recommended to use feed mixtures with fat, which is solely of fish origin or high fish oil supplementations in blue fox diets during their breeding and lactation periods. In this experiment, the number of breeding females per dietary treatment was small, and a further study on this subject is clearly needed. Since the litter size of the blue fox is relatively large, the data regarding the early growth and mortality of the puppies should, however, be sufficient to support the present conclusions.

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"But enough about spiral galaxies, and the hundreds of billions of stars they contain. Let's dance."

Original Report

Mink feeding from pregnancy to pelting with diets containing a high content of hake offal

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Abstract

The effect of feeding mink during pregnancy, lactation and growth with 3 levels of hake was investigated. The diets comprised 87, 73 and 58 % hake; and 0, 14 and 28 % slaughter offal, namely D1, D2 and C or control diet, respectively. Thirty pregnant wild female mink were assigned to each of the experimental diets (D1 and D2) and 10 to C. At lactation, both groups were divided in 6 lots of 10 dams, and animals from D1 were fed either D1, D2 or C, and from D2 continued on D2, or D2 supplemented with 3 % oil or C. The control group continued on diet C. After weaning, offspring from dams fed C continued on the same diet, and weaned kits from each of the 6 feeding treatments were fed either on diets D1, D2 or C. Feed intake, digestibility, number of weaned kits, body weight of dams and kits were measured, and fur characteristics evaluated. Digestibility was higher in the control diet (77.4 vs 70.1). The intake during pregnancy and early lactation was not affected by diet. However, in late lactation and growth, the intake of the experimental diets was 40 to 60 % higher than the control. Body weights of dams and kits at weaning were slightly higher in the control diet; however the differences were of no practical importance. The number of weaned kits was higher in dams fed diet D2 during pregnancy (6.4) than C or D1 (5.0). During growth, neither body weight nor fur characteristics were affected by diet. It was concluded that diets with higher levels of hake than 55-60 % were nutritionally adequate to feed mink, however the feed uptake, with exception of pregnancy and part of lactation, was 40 to 60 % higher.

Introduction

Hake offal is widely used in the South East of Argentina as part of mink diets, because its price is competitive compared to cattle and poultry offal. However, there is some caution required when feeding mink with a high content of hake due to potential risks with some anti-nutrional factors, and also because the feed uptake may increase with the augmentation of fish offal in the diet.

With regard to the nutritional properties of fish, Stout (1960) pointed out that some factors in Pacific hake may interfere with iron metabolism, bringing about anemia and undercoat decolorization. However, Skrede (1978) found no adverse effect when feeding diets with a high amount of cod offal on fur quality and animal growth. Additionally, DiMarco and Maldonado (1990) reported that adult mink were fed with hake offal as the only source of protein with no adverse effect on animal growth and fur characteristics.

In view of all these findings the present study was carried out to evaluate the effect of feeding mink during pregnancy, lactation and growth with 2 levels of hake offal higher than in the conventional diet.

Materials and methods

A feeding trial was carried out on a mink farm, close to Mar del Plata (Province of Buenos Aires, Argentina) from September 1989 to June 1990, to study the effect of feeding mink with a higher content of hake than in conventional diets.

Three diets were used; a control diet (C) and two experimental diets: D1 and D2. The control was formulated with 55 % hake offal, 28 % cattle offal and 14 % carbohydrates, and the two experimental diets were formulated with (%) 87:0 and 73:14 hake and cattle offal, respectively, and 12 % carbohydrates. Additionally, the three diets contained 1 % sunflower oil.

Thirty pregnant wild females, right after mating (20-9-89) were assigned to each of the experimental diets (D1 and D2) and 10 to the reference diets (C). At birth, each group of dams fed the experimental diets (D1 and D2) was subdivided in 6 groups of 10 dams with their kits, and fed as follows. Animals fed D1 during pregnancy were fed during lactation either diets D1 + 3 % oil; or D2 or C. And animals from D2 were fed either diets D2, or D2 + 3 % oil, or C. And animals from C during pregnancy were fed the same diet during lactation. In all cases, the addition of 3 % oil was made by reducing the amount of hake by 3%.

After weaning, kits fed the control diet continued on the same feed, and those from the 6 experimental treatments (D1-D1; D1-D2, D1-C and D2-D2, D2-D2 + oil, D2-C), were fed either diets D1, D2 or C until pelting.

Feed intake was estimated by the difference between the offered and refused meal placed in a tray inside the cage, during 4 days, at the middle of pregnancy, at 15, 30 and 45 days of lactation and 65 days of postweaning growth. Also, at the middle of lactation, diet digestibility was measured.

The number of kits, weight at weaning (28-12-89) of dams and kits, and live weights during growth at 5, 40, 68 and 110 days of weaning were recorded. Furs were individualized at pelting and pooled with the rest of the furs. Undressed, dry skins were visually rated by a fur grader according to a standard based on: length of the pelt, density and coverage of the underfur and guard hairs, luster, silkiness, depth of underfur and general fur quality.

Intake during the 3 suckling periods was studied by regression analysis, using the number of kits as independent variable, and an equation to predict intake according to the days of lactation was established. Other parameters such as weights, number of kits and fur characteristics were compared by analysis of variance.

Results and discussion

Diet composition

The weight of the ingredient from animal sources represented 85 to 87 % of the three diets, although in C, 58 % was fish offal which increased to 73 % in D2 and 87 % in D1. Other components were similar, with exception of cerelose that was present only in C at 2 %. All treatments were fortified with the same mineral and vitamin mixture.

According to theoretical estimations (NRC, 1982), D1 was richer in proteins and poorer in lipids than C. Therefore, during the suckling period, oil was increased from 1 to 4 %, to raise ME from lipids to 48 %, lowering proteins to 44 % of the ME.

Diet D2 was also richer in proteins and poorer in lipids than C, therefore it was used in lactation and growth with two levels of oil, one as during pregnancy and supplemented with 4 % oil to have similar lipid and protein levels to D1.

Table 1. Composition of the diets (1).

Parameter (T)	Diet 1 (D1)	Diet 2 (D2)	Control
Slaughter offal (2)	-	14.0	27.0
Hake offal	87.0	73.0	58.0
Corn gluten	2.0	2.0	2.0
Wheat bran	5.0	5.0	5.0
Flour by-product	5.0	5.0	5.0
Cerelose	-	-	2.0
Sunflower oil	1.0	1.0	1.0
Energy/Prot (3)	12.4	12.0	11.0
% ME as protein	55.7	54.0	49.3
% ME as lipid	34.5	35.8	40.0

(1) In lactation, oil in D1 increased from 1 to 4 % and gluten was replaced, in both diets, by blood meal in equal proportions. D2 was used in lactation as stated in table 1 and supplemented with up to 4 % oil.
(2) 36 % bovine liver, 28 % lung, 36 % rumen and omasum
(3) Values were calculated from NRC (1982)

Digestibility

Dry matter (DM) digestibility of the experimental diets (70 %) was slightly lower than the control diet (79 %), which is in agreement with previous results in adult mink fed high levels of hake (*Di-Marco and Maldonado, 1990*).

Digestibility depression could be related in part to the higher content of bones (ash) in high-fish diets, which can reach up 13 % ash versus 9 % in the conventional diet. Previously, it was observed that digestibility corrected by the faecal excretion of ash was not different among diets. The negative effect of the ash in the diet was also pointed out by Skrede (1978a), who found that each 1 % of dietary ash was able to depress nitrogen digestibility by 0.6 %. Digestibility of the high fish diet might also depend upon the proportion of bones, meat, head and skin present in the fish offal (*Skrede, 1978b).*

Intake during pregnancy

Intake was unaffected by diet composition during pregnancy, where the average daily intake of the three diets was 213 g/head daily or 59.1 g/head of DM.

Table 2. Intake of pregnant mink fed a conventional diet (C) and with high contents of fish by- products (D1 and D2).

Intake	D1	D2	C	Average
Wet feed	216.1	215.1	207.7	212.6
Dry feed	58.8 [a]	58.2 [a]	60.4 [a]	59.1
% DM	27.7	27.1	29.1	27.8

[a] Averages followed by equal letters do not differ statistically ($p < 0.05$).

Intake during lactation

Intake during the suckling period depended upon the stage of lactation, number of kits and type of diet. At the beginning of lactation, the relationship between daily DM intake in g (Y) and the number of kits (X) was described by the function:

$$Y = 43.4 + 4.7\ X \qquad (1)$$

Function 1 shows that the average consumption of feed, during the first 10-15 days of lactation, was 43.4 g for the dam and only 47 g per suckling kit. The expected intake of wet feed with 28 % DM for a dam with 5 kits will then be:

Consumption of wet feed (g/d):
(43.4 + (4.7 x 5)) / 0.28 = 238.9

The intake at the beginning of lactation was only 15 % higher than the average intake measured during pregnancy (table 2), and was not affected by the level of hake on the diet.

At the middle of lactation, when kits were between 30-36 days of age, the intake of the control diet was described by the equation:

$$Y = 51.3 + 12.7\ X \qquad (2)$$

In midlactation the intake of DM per kit increased from 4.7 g to 12.7 g, which represents for a dam with 5 kits 410 g/day of feed, or 100 % more than in pregnancy. Animals fed experimental diets showed intakes over and under the mentioned values, but the average trend was similar to that described by equation 2 (fig. 1a).

At the end of lactation, intake of the control diet for dams with kits aged 42 to 48 days (fig. 1b) was described by the relationship:

$$Y = 47.2 + 38.2\ X \qquad (3)$$

The additional intake of DM per kit increased from 12.7 g to 38.2 g in the last 15 days of lactation. The feed uptake of a dam with 5 kits would then be 851 g/day, which is 311 % higher than in pregnancy, and twice the intake observed 15 days before.

Intake at the end of lactation was on average 53.7 % higher in both experimental diets (D1 and D2) compared to the control (fig. 1b). From mid to end of lactation the consumption of feed increases with the number of kits (fig. 2).

Fig. 1.a

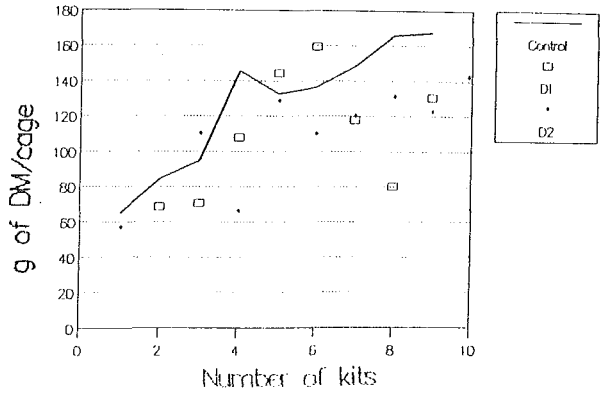

Fig. 1.b

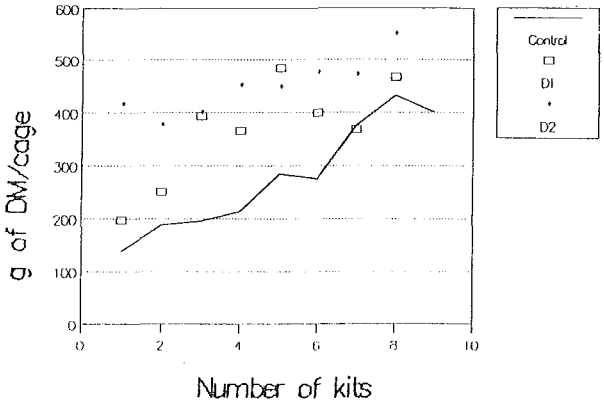

Fig. 1. Consumption of dry matter at 30 (a) and 45 (b) days of lactation as a function of the number of kits, for the control (C) and high fish offal diets (D1 and D2).

From equations 1, 2 and 3, the following relationship was established to predict the feed consumption of dams and kits at any time of lactation (x).

$$Y = (50 + (5 + 0.00006\ X^{3.45})\ n) / 0.28 \qquad (4)$$
(a) _____ (b) _____ (c)

where (a) is the dam intake obtained by rounding the intercepts of equations 1, 2 and 3. (b) is the intake per kit, (n) number of kits, and (c) or 0.28 in this case, is the average feed dry matter (table 2).

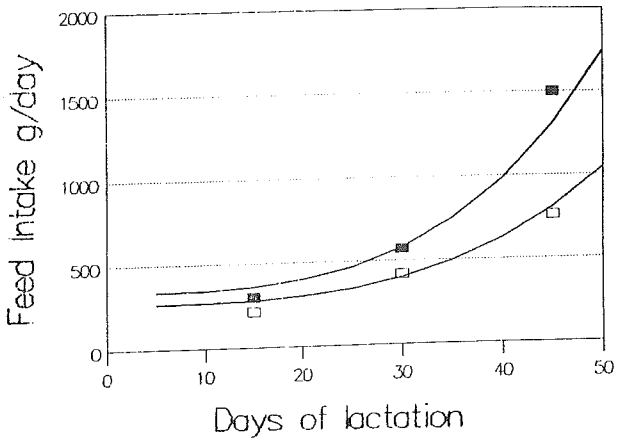

Fig. 2. Predicted and observed feed uptake for a dam with 5 or 9 kits. (Filled square: 9 kits; Empty square: 5 kits).

Differences between intakes of the experimental and control diets, are hard to explain since D2 with and without oil supplementation did not show intake differences, and both diets D2 and D1 in lactation presented 40 % of the ME as similar to the control diet (table 1).

Intake in growing mink

The average intake of a male and a female, of 19 weeks and 2.9 kg of weight, fed the control diet was 707.6 g of feed, or 205 g of DM/cage or 708 g DM/kg of body weight. This is close to the recommendation of 65.7 of DM/kg of body weight for mink of the same age and weight (*Ensminger and Olentine, 1978*). However, it is lower than the previous results of DiMarco and Maldonado (1990) who reported an intake of DM/kg of body weight in 103.7 g in adult mink. The intakes of the experimental diets were between 55 to 65 % higher than in the control diet (table 4).

Table 4. Consumption of feed in growing mink at 65 days postweaning.

Diet	Body weight (kg) Male + Female	Intake/cage g/d	Intake/kg g/d	Diff. %
Control (C)	2.9	707.6 [a]	241.1 [a]	-
D1	3.0	1120.9 [b]	370.9 [b]	54.8
D2	2.9	1165.8 [b]	402.6 [b]	66.2

a, b: Averages followed by equal letters do not differ statistically ($p \leq 0.05$) in the same column.

The greater intake of the experimental diets is in disagreement with previous results (*DiMarco and Maldonade, 1990*) where the intake of an experimental diet similar to D1 was lower than the control. In short, these results pointed out that growing mink consumed 55 to 65% more when fed the experimental diets. This indicates that the feed uptake increases according to the proportion of fish in the diet. This should be taken into account for formulation of minimum cost diets.

It seems important to study the effect of different levels of lipids and/or carbohydrate in high fish offal diets on feed intake.

Number of kits and body weight performance

The effects of the diets upon body weight of dams and kits at weaning, and the number of weaned kits are shown in table 5. In general, dams fed conventional diets were heavier at weaning but body weight of the kits did not show a definitive drift. Kits fed experimental diets seemed less developed during lactation. Nevertheless, dams and kits reached an acceptable body weight at weaning. Differences between treatments were of no practical importance (table 5). For example, kits whose mothers were fed the maximum level of fish offal (D1) during pregnancy and lactation, weighed at weaning 798.9 g (males) and 611.3 g (females) and dams ended at 937.6 g.

Table 5. Number and body weight of mink kits at weaning.

DIETS		PARAMETERS AT WEANING			
Pregnancy	Lactation	Body weights			
		Dams	Kits		Number
			M	F	
D1	D1 + 3 % oil	937.6	798.9	611.3	5.1
D1	D2	855.4	787.9	603.9	4.6
D1	C	972.4	844.4	598.4	5.5
D2	D2	853.2	731.2	559.8	6.5
D2	D2 + 3 % oil	823.6	798.8	567.8	6.1
D2	C	943.2	874.6	630.5	6.5
C	C	1040.2	8575	618.8	5.0

The average of weaned kits from dams fed the maximum of fish offal during pregnancy (5.1) was similar to dams fed constantly with the control diet (5.0), which were below dams fed D2 (6.4). Feeding a combination of diets in lactation after D1 or D2 in pregnancy did not improve animal performance.

During postweaning growth, the increase of body weight was not affected by diet, reaching average weights of 2130 g and 1160 g for males and females, respectively, at 110 days. Body weight changes are depicted in fig. 4, where it can be observed that weights for both sexes were slightly higher (non-statistically different) in the animals fed the experimental diets (D1 and D2).

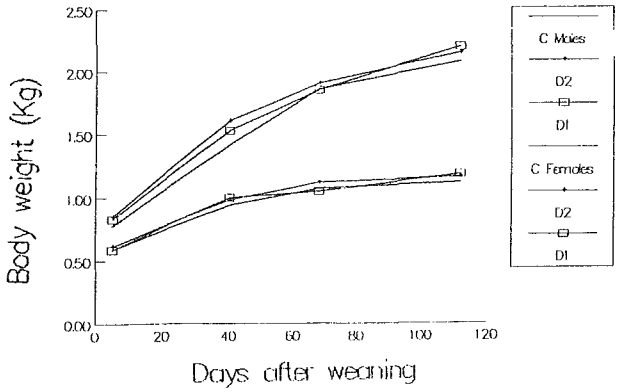

Fig. 3. Evolution of body weights in male and female mink fed two experimental diets (D1, D2) or the conventional diet (C).

Pelt characteristics

The size of the pelts was not affected by the type of diet, as it was expected according to similarities of the animal weights. Between 30 to 40 % of males and 45 to 55 % of the female pelts were graded in the largest categories for each sex (more than 77 cm and between 59.1 to 65.6 cm, respectively).

Fur quality in terms of visual trade characteristics was similar in the 3 diets. Important is to remark that the furs from each treatment of this study were individualized with colored tags and pooled with the furs from the farm, to avoid any bias at grading.

The results of this trial show that diets with higher levels of hake offal were nutritionally adequate to feed mink in all stages, since performance and pelt characteristics were not different from the conventional diet. However, the feed uptake was up to 65 % higher in late lactation and growth. From an economical perspective high fish offal diets can bring about benefits during maintenance of the breeding stock, pregnancy and part of lactation but thereafter, only if the total price of the diet is at least 65 % cheaper than conventional diets with 30 % slaughter offal.

Reformation of these diets with different amounts of carbohydrate and or fat to lower the intake at the level of the conventional diets, seems to be of central importance.

Acknowledgements

I am grateful to Adrian Maldonado for the care, feeding and help during the development of the experiment, to Mr. Carlos A Maldonado for the classification of the furs and to Mrs. Maria L. Cocimano for her help with the translation of this paper.

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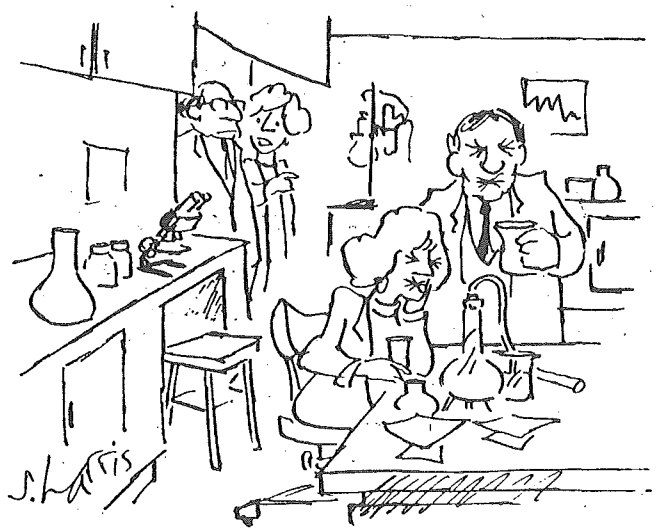

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5

FUR ANIMALS PRODUCTION AND BREEDING

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Animal Production Review

Applied Science Reports, No. 5 - 1991

Fur Animals Production and Breeding

An estimation of usefulness of studies on the karyotype polymorphism in selection of blue foxes. I. Distribution of the polymorphic forms and their relationship with punctual estimation of phenotype, individual index and body weight.

M.Switonski, D. Lechniak, P. Przysiecki, A. Filistowicz, A. Pietrzak, D. Landzwojczak.

It is known that in populations of blue foxes the existing karyotype polymorphism (2n=50 or 49 or 48) is caused by the centric fusion. On the fox farm in Sniaty (RSP Lubnica) cytogenetical studies were undertaken with the main aim to increase the proportion of animals with 48 chromosomes. At the first stage of this project karyotypes of 334 animals were studied. Among them the following frequencies: 46.4%; 42.5% and 11.1% of animals having 50, 49 and 48 chromosomes were observed, respectively.

It was revealed that animals with 48 chromosomes demonstrated higher values of the punctual estimation of phenotype and the individual index. An analysis of body weight was carried out on 66 foxes. It was also found that animals with 48 chromosomes achieved higher body weights. However, it should be mentioned that statistically significant differences were observed for the punctual estimation of phenotype (males) and the individual index (females), only.

3 tables, 14 references. In POLH. Authors' abstract.

An estimation of usefulness of studies on the karyotype polymorphism in selection of blue foxes. II. Relationship with reproductive performance.

M. Switonski, D. Lechniak, P. Przysiecki, A. Filistowicz, A. Pietrzak, D. Landzwojczak.

An analysis of some parameters of reproductive performance of blue foxes showed that animals with 48 chromosomes were better than the other two forms. In the case of females, it concerned a litter size at birth (8.73) and especially at weaning (7.48) - statistically significant differences. The values of these two parameters in females with 49 chromosomes were 8.33 and 6.41, but in females with 50 chromosomes, 7.76 and 6.03, respectively. Also body weight of cups at weaning was the highest in litters of females with 2n=48. However, it was also found that these females killed their pups more frequently than females of the other two karyotype forms.

The reproductive performance of males was analysed from the point of view of their sexual activity only. The following parameters were taken into consideration: number of matings during the reproductive season, date of the first and the last mating and duration of the reproductive activity. All above mentioned parameters were better in males with 48 chromosomes.

The above relationships showed that propagation of animals with 48 chromosomes on blue fox farms is desirable.

2 tables, 13 references. In POLH. Authors' abstract.

Genetic parameters of body weight of polar fox.

A. Filistowicz, P. Przysiecki, P. Los.

Heritability of body weight and genetic, phenotypic and environmental correlation coefficients among body weights measured at 3, 4 and 5 months of age, at pelting time and after slaughtering were estimated.

Heritability estimated from father's component oscillated from 0.012 to 0.290, estimated from parent's component from 0.357 to 0.628, estimated from mother's component from 0.602 to 1.170.

The greatest genetic (0.988) and phenotypic (0.944) correlation were found between body weight of foxes at pelting time and after slaughtering.

The fathers of progeny which grew fast to 3 months of age had lower results of genetic evaluation in comparison to the body weight of progeny at 5 months age during pelting time and after slaughtering.

3 tables, 10 references. IN POLH. Authors' abstract.

The results of work on establishing highly fertile lines of white New Zealand rabbits.

S. Niedzwiadek, P. Bielanski, J. Fijal, M. Rynski.

The experimental material consisted of white New Zealand rabbits. After the analysis of pedigrees, two lines of rabbits N1 and N2 were established, each containing 200 females and 80 males. Five full generations were analysed. Selection for reproduction traits comprised the number of rabbits born and reared in each litter.

Selective breeding allowed high indices of reproductory utility to be obtained. The average number of rabbits per litter in the generation F5 was 7.6 for N1 and 8.2 for N2. The achieved progress manifested itself as the increase in the number of rabbits born by 14.7. The number of rabbits reared per litter amounted to 7.2 and 7.6 which meant an increase by 18% for N1 and 20.6% for N2. The progress per one generation was about 2.5%.

1 table, 10 references. In POLH. Authors' abstract.

The effect of age, sex and breed on the level of AspAT and ALAT activity in rabbit tissue.

H. Stepkowska, J. Rysinska, A. Kolataj, E. Pietrzycka-Wilczewska.

The experiment was conducted on 70 and 140 day old rabbits New Zealand (Nz), Black Tan (Czp), and crossbreeds of NzX (♂ Nz, ♀ Czp) and CzpX (♂ Czp, ♀ Nz).
The concentrations of AspAT and ALAT activity were determined in liver and kidney homogenates.

The changes of the levels of the two analyzed traits were observed to depend on age, sex and breed of rabbits. The greatest changes depended on age. The level of AspAT groups as well as the ALAT activity were lower in the tissues of older rabbits.

Great substantial effects of age on the analyzed traits were confirmed by analysis of variance.

2 tables, 8 references. In POLH. Authors' abstract.

The effect of age, sex and breed on the LDH activity in the rabbits tissues.

W. Wilczewska, H. Stepkowska.

The experiment was conducted on 70 and 140 days-old rabbits New Zealand (Nz), Black Tan (Czp) and crossbreeds of: NzX (♀ Nz, ♂ Czp) and CzpX (♀ Czp, ♂ Nz).

The activity of LDH was determined in liver and kidney homogenates. The changes of the activity of LDH were observed to depend on age, sex and breed of rabbits. The greatest changes depended on age.
The LDH activity was lower in the tissues of older rabbits.

2 tables, 10 references. In POLH. Authors' abstract.

Comparison of the electrophoretic pictures of blood serum proteins in different varieties of common fox.

A. Brodacki, G. Jezewska, Z. Rupec.

The aim of the studies was to determine differences between the electrophoretic pictures of blood serum proteins in five varieties of common colour foxes. With the help of horizontal electrophoresis serum proteins were separated into 30 - 35 striated classified into 19 subregions. In five subregions a variability was observed that has been described in literature. Slight differences were observed in the phenotypic frequencies of serum proteins forms between individual varieties of common colour foxes.

1 table, 1 fig., 13 references. In POLH. Authors' summary.

The estimation of the effect of administered hormonal preparation on heat stimulation and synchronization in arctic fox females.

A. Frindt, M. Brzozowski, M. Bednarz, T. Kaleta.

The aim of the study was to attempt to estimate the effect of the hormonal preparation D-phe^6-Gn-RH (VEB Berlin Chemie) classified in the group of gonadotropin hormones on heat stimulation and synchronization in arctic fox females. The investigations were carried out in 1987-1989. The preparation was administered intramuscularly. The dose was 100 µg per animal. Favourable influence of the administered preparation on heat stimulation and the improvement of reproduction indicators was observed. Particularly, this effect was observed in primiparae and in females in which heat was late. The investigations comprised a relatively small number of animals. Thus, obtained results should be confirmed in further detailed studies.

3 tables, 1 fig., 4 refs. In POLH. Authors' summary.

Repeatability of curve form of electric resistance of vagina mucus of fox dams.

P. Przysiecki, P. Los, A. Filistowicz.

Electric resistance of vagina mucus at succesive days of fox dams estrus was estimated. The curve type of electric resistance (A, B, C and D) of vagina mucus measured 4 days before and 4 days after the day characterized by highest resistance was measured with the use of an electric resistance reading instrument and the number of values (1, 2, 3 and 4) were assigned respectively.
Repeatability and fenotypic correlations between electric resistance and succesive days of estrus were estimated. The greatest repeatability (0, 4) of electric resistance was found at the first day and the day of maximum resistance (0 day).
The curve type of vagina mucus resistance is characterized by relatively significant repeatability (0.38).

2 tables, 4 refs. In POLH. Authors abstract.

Remarks and observations concerning technology of artificial insemination in foxes as a result of a poll.

A. Frindt, M. Brzozowski, R. Trojnar.

The method of fox artificial insemination has been applied in farm practice only in recent years. The first instruction concerning this operation was elaborate. However, not all points were fully clear. Because of this fact the poll was sent to inseminators comprising questions related to the technology of foxes insemination. Their remarks and observations will be used for elaboration of a new, broadened and supplemented version of instruction.

In POLH. Authors' summary.

Characteristics of raccoon dog reproduction under farm conditions.

G. Jezewska, I. Kotual, J. Maciejowski, S. Socha.

The course and reproduction results of raccoon dogs reared in two farms were examined in four successive years. Significant differences were found in the dates of oestrus occurrence in females from a farm in northern Poland (later oestrus) as compared with those from a farm in western Poland. The factors differentiating reproduction results appeared to be environmental conditions (differences between farms) and age of females. Older females produced and reared more offspring than did younger females.

3 tables, 2 figs., 6 refs. In POLH. Authors' abstract.

Slimming of raccoon dogs in the pre-reproduction period.

B. Barabasz, A. Zon, R. Grzyb.

The aim of this study was to estimate the slimming rate of raccoon dogs and to define breeding procedures when preparing these animals for reproduction. The experiment was carried out on

66 raccoon dogs, divided in 3 groups, according to body weight in November: I - males, over 10 kg, females, over 8.5 kg; II - males 8.5-10 kg , females 8-8.5 kg; III - males under 8.5 kg, females under 8 kg. The feed for all animals was identical and contained 0.565 MJ M.E./100 g feed and 15.3 g dig. protein/MJ M.E. Feed consumption and temperature on the farm were controlled. Males in group I reduced body weight by 30.4% and mated 9.2 times on average, their sexual activity period being 26.9 days. Males in groups II and III reduced body weight by 28.6 and 23.6% respectively, and their mating results were poorer. Best results in reproduction were observed in group III females; their body weight was reduced by about 18.4%, in this group were lowest empty females (22.2%), the largest litter size (6.2), and kit mortality in this group was negligible (2.3%). Decidedly poorer results were obtained by females of group I and II, which lost body weight by 22.2 and 23.6%, respectively. The study confirmed a possibility of considerable reduction in feeding raccoon dogs in the period: November-March.

2 tables, 2 figs., 11 refs. In POLH. Authors' abstract.

Description of silver fox females destroying their litters in Batotowka farm in 1981-1988. The influence of age and the repeatability of behaviour.

T. Kaleta, M. Brzozowski.

Using the breeding documentation of the Batorowka farm the age and breeding utilization of 73 silver fox females killing cubs (at least once) were analysed. The control group comprised females in which natural losses of cubs were observed about the country's mean. The majority of experimental females destroyed litters at the age of 4 years, being previously good mothers.

3 tables, 6 refs. In POLH. Authors' abstract.

Studies on the purposefulness of using biologically active substances administered in feed rations for young mink.

N.A. Balakiriev.

The effect of a few biologically active substances used in feed rations on digestibility, growth of mink, antioxidant state of blood activity and skin histological structure of young mink was studied. Experimental animals had higher body weight than control animals. Better mink skins were also obtained from them. The preparations given did not increase feed digestibility. Thus, the author concludes that these substances do not work at the level of nutrient availability but at the cellular level of metabolism.

6 refs. In POLH. Author's abstract.

Digestibility of nutrients and nitrogen retention in polar foxes fed with doses containing shrimp remnants (*Leander adspersus*).

M.O. Lorek, S. Florek, I. Rusiecka.

The experiment was carried out on 12 polar foxes at the age of 4 months divided into three groups. The animals in group I were fed standard feed and were the control. In feed doses in the experimental groups, 50% of the meat in the feed was substituted with fresh shrimp remnants in group II and in group III shrimp meal was used. Nutrient digestibility and nitrogen retention showed a negative effect of the experimental factor - that is that of shrimp remnants.

4 tables, 17 refs. In POLH. Authors' abstract.

The digestibility of nutrients and nitrogen retention in ferret fed diet with slaughter blood and livex.

H. Bieguszewski, T. Pietryga, B. Glowinska.

The digestibility of nutrients and nitrogen retention of 100 young ferrets were tested. To the meal dose of experimental groups (DI-DIV), the following additives were added: DI - frozen slaughter blood, DII - slaughter blood conserved with sodium benzoate and sulphuric acid, DIII - livex, DIV - livex and synthetic methionine. The experimental feeding did not have an unfavourable effect on body weight and nitrogen retention. Decrease of digestibility of organic matter and crude fat was noticed in ferrets fed the diet with livex.

5 tables, 7 refs. In POLH. Authors' abstract.

Studies on the food engineering of poultry offal in the feeding of foxes. Part I. Food engineering of poultry offals.

J. Slawon.

Factors limiting the use of poultry offal in the feed for carnivorous fur animals are biological impurities, short storage life and presence of biologically active substances. The aim of the studies was to work out industrial methods to eliminate these factors. As a result of laboratory and technological tests a method was worked out to process the offals with the help of a destructor which sterilizes and dehydrates the product down to 50.3-52.3 dry matter. The product, having a consistency of sausage pastry, protected with antioxidants, is ready to be fed or stored in a cold store.

1 table, 4 refs. In POLH. Author's abstract.

Studies on the food engineering of poultry offal in the feeding of foxes. Part II. Calculation of feed dose recipes with a high share of processed offals.

J. Slawon.

The usefulness of processed poultry offal in the fee for carnivorous fur animals was examined. Relatively low price and availability made their high share in the feed justified. In two successive breeding seasons, the processed offal was used as a feed component for young foxes and mink. Metabolic energy from the offal in per cent of total feed energy ranged from 37.5-48.7%. Analysis of body weight gains and hair cover quality of the experimental animals showed that feeding with 35% offal, which corresponded to 40% EM made it possible to obtain results similar to those of the control animals.

3 tables, 5 refs. In POLH. Author's abstract.

"Unfortunately this lab is funded only by as much gold as we can make from bismuth."

Studies on the composition and content of complete dry and granulated mixed feeds for foxes.

J. Slawon.

The paper presents 5 year's studies on the content and production technology of complete dry mixed feeds for young polar foxes as a substitute for fresh food to be used permanently or periodically. Studies were performed at the same time on two kinds of mixed feeds, that is, on the complete dry mixed feed and on the complete granulated mixed feed. The dry mixed feed had been soaked in water before feeding and mixed with the traditional food. The share of metabolic energy from the dry mixed feed in the ready-made food constituted 50 and 75%. The granulated feed was given to foxes 2 days a week during the whole period of rearing, and was the main source of food. The components for the feed were of Polish origin, well selected with regards to chemical and microbiological quality. Young polar foxes fed partly with the complete dry mixed feed reached a body weight and hair cover quality equal to those of the control animals. The foxes which were given the complete granulated mixed feed 2 days a week had full value hair cover and their body weight equaled or significantly exceeded that of the control animals.

4 tables, 16 refs. In POLH. Author's summary.

Hematological indices and acid-base balance in ferret, fed a diet with slaughter blood and livex.

B. Glowinska, H. Bieguszewski.

Hematological indices and acid-base balance parameters of 100 young ferrets were tested. To the meal dose of experimental groups (DI-DIV), the following additives were added: DI - frozen slaughter blood, DII - slaughter blood conserved with sodium benzoate and sulphuric acid, DIII - livex, DIV - livex and synthetic methionine. The experimental feeding did not have any unfavour-

able effect on the morphological indices of ferret blood, electrophoretic picture of blood plasma protein and on aminotransferases activity. Addition of conserved blood to the ration had an influence on the gamma globulin of blood plasma. Decrease of blood pH, the level of bicarbonate and sum of base excess was noticed.

3 tables, 6 refs. In POLH. Authors' summary.

Use of fox carcasses as a feed for carnivorous fur animals.

B. Dzierzynska, A. Swulinska, I. Narucka, E. Pospiech.

Experiments were carried out on 84 carcasses of the polar fox strain (*Alopex lagopus*). An emulsion and a carcass pulp were produced from eviscerated carcasses without heads, legs, tails and pelts. The experiments demonstrated that:

- the chemical composition and biological values of fox muscles are as slaughter animals,
- the emulsions were composed of lower amounts of protein than muscle tissues but this did not decrease their usefulness as a feed,
- the post mortem changes in the fox carcasses differ from these processes in porcine and bovine muscles. The increased storage life in a cold store in a freezer room is characteristic for the fox carcasses,
- increased slaughter hygiene increases stability of the carcass pulps and the emulsions.

2 tables, 1 fig., 11 refs. In POLH. Authors' summary.

Effect of feeding on efficacy of nutria producting.

J. Kuzniewicz, F. Paluch, P. Los, Z. Olszowski.

Economical effectiveness of two different feed systems was estimated. Comparison of profitable feeds systems was found that can be used to reduce calculations. Low feeding is connected with greatest expense compared to heavy feeding.

2 tables, 3 refs. In POLH. Authors' summary.

The improvement of rearing indices in polar foxes by means of additional pup feeding.

M. Rynski, S. Niedzwiadek, P. Bielanski, A. Zon.

The introductory research comprising 72 litters proved that additional pup feeding should be started on the twenty-first day after birth. In the second phase 288 litters of polar foxes were examined. They were fed high protein and high energy mixed feed. The experiment proved that giving pups high protein mixed feed resulted in considerable improvement of rearing indices in young foxes. In the first 21 days of life the losses in all groups of pups were uniform and amounted to 7.3–10.4 per cent. In the groups where the pups were additionally fed from the 21st day till weaning loss rate was lower than in the control. The lowest loss rate (3.4 per cent) was observed in the group fed with high protein mixed feed.

2 tables, 7 refs. In POLH. Authors' summary.

The influence of additional feeding on rearing indices in ferret pups.

M. Rynski, S. Niedzwiadek, P. Bielanski, A. Zon.

The introductory phase of research comprised 120 ferret litters. It was establised that the seventeenth day after birth is the optimum time to start additional feeding. In the main phase 375 litters were examined. It was determined that additional feeding of ferret pups with specially devised high protein and high energy mixed feed gave satisfactory results with regard to improvement of rearing indices. Pup losses decreased by 8 per cent food, in comparison with the animals not receiving additional feed. Pups additionally fed with high protein and high energy mixed feed were characterized by considerably higher body weight at weaning in comparison with the controls.

2 tables, 5 refs. In POLH. Authors' summary.

Effect of animal number in cages on body weight of polar foxes.

A. Filistowicz, P. Przysiecki, J. Kuzniewicz, P. Los.

The litters for the experiment were selected by

analogy to number of kits (4, 5, 6, 8), rate of males and females, date of birth and body weight of weaning kits. All animals were kept for 5 weeks after weaning in cages. The dimension of 1 cage was: 200 x 100 x 100 cm. The number of animals in cage (from 4 to 8) in the first month of the weaning didn't influence significantly the daily gain. The rate of males and females and the number of kits in one cage significant influences the movement of growth at the different periods of life.

1 table, 6 refs. In POLH, Authors' summary.

Effects of animal numbers in cages on some behavior forms of pups polar fox.

A. Filistowicz, D. Kiecon, P. Los, P. Przysiecki; M. Switonski.

The litters for the experiment were selected by analogy to the number of kits in litters, number of males and females, date of birth and body weight of weaning kits. All animals were kept in cages. The dimension of 1 cage was: 200 x 100 x 100 cm. Behavior forms of polar fox pups 6 days after weaning were observed. Number of litters and rate of puppies, feeding time, the way of feed intake, frequency of fights, rest time and break in rest time and time of establishment of the hierarchy in the groups were observed.

2 tables, 8 refs. In POLH. Authors' summary.

Effect of black-out cages on some physical traits of underfur hair and cover hair of polar fox.

P. Przysiecki, I. Narucka, A. Cwikla, A. Filistowicz, J. Blasiak, P. Los.

Thickness, length, strength and extension of under fur and cover hair of male and female polar fox were compared. The animals were kept from 1th of August till 30th of September in 1989 and 1990 in black-out pavilions and the control group was kept in non black-out pavilions. Black-out cages have a detrimental effect on mature cover hair development, but not significantly on the strength of underfur hair and thickness, nor length and extension the both ports of polar fox hair. It was found that year was the most important factor which influenced the estimated physical traits of hair (extension of under fur hair, length and strength of cover hair). Sex effected only extension of cover hair. The interaction of year x sex, group x sex, year x group x sex on all of the estimated physical traits was not observed.

1 table, 6 refs. In POLH. Authors' summary.

Determination of hair density in skin of polar Norwegian and Polish foxes and crossbreds.

S. Kubacki, W. Brudnicki, J. Zawislak.

Scraps of skin for histological investigation of skin tissue from Polar foxes were collected from three animal groups (that is Norwegian, Polish and crossbred o Polish x o Norwegian) from two farms (Warlity and Zalesie). Together for each farm during the years (1987-1989) 54 skin scraps were collected (18 pieces for each group). As a result of these investigations it was ascertained that the hair in the skin of Polar fox grows in complexes (hair formation group) with a different number of clusters in a complex (from 1 to 3 or more). Complexes with one cluster exhibit the highest hair formation efficiency. According to the investigated types of fox (Norwegian, Polish and crossbred groups) large differences appear in the structural participation. Most numerously represented in Norwegian fox are the double and threefold cluster formation, but in Polish fox a single cluster formation dominates. In general, hair formation efficiency in a complex is greater in Norwegian fox and the number of secondary hairs (S) on one original hair is formed from 35 (Warlity) to 45 hairs (Zalesie).

1 table, 4 figs., 19 refs. In POLH. Authors' summary.

Selected quality indices of hair cover in ferrets.

M. Piorkowska, S. Niedzwiadek, G. Palimaka-Rapacz.

The examination comprised 72 skins of young ferrets obtained after achieving fur maturity. A laboratory method was applied to evaluate the pelts. It was determined that the hair cover is characterized by high volume and the diameter of underfur hairs is similar to that of mink and considerably higher than in nutria and rabbit. Compared with other species it has been determined, by measuring the guard and under fur hair

length, that ferret pelts should be viewed separately as belonging to the medium hair group. The density of underfur was low and that of guard hair relatively high.

1 table, 1 fig., 13 refs. In POLH. Authors' summary.

Comparison of hair cover colour in Greenland and steel-silver coypus.

R. Cholewa, J. Gedymin.

For more exact and objective evaluation of hair cover colour in Greenland and steel-silver coypus a colorimeter was used to determine 293 hair samples taken from the centre of the posterior half of the right side. The colour was characterized by the tone (λd), saturation (Pe) and photometric brilliance (Y%). A high similarity was found with regard to the colour quality factors, that is tone (λd) and saturation (Pe). Photometric brilliance appeared to depend upon the hair cover colour in both coypu varieties.

1 table, 4 refs. In POLH. Authors' summary.

Establishing optimum number of animals per cage for fur-bred raccoon dogs.

P. Bielanski, A. Zon, S. Niedzwiadek.

The experiment concerned 378 raccoon dogs during the period from weaning till slaughter and was carried out at Chorzelow fur animal farm. After weaning, in the 6-7th week of life, raccoon dogs were divided in three experimental groups and kept in cages; group I - 1 animal per cage, II - 2 and III - 3. The experiment proved that the number of animals per cage had no influence on growth and development of raccoon dogs. Animals from all groups achieved, before slaughtering, uniform, high body weight from 8652 g in group I to 8722 g in group III. Organoleptic evaluation of pelts proved the pelts of raccoon dogs kept individually in cages to be better with regard to size and quality.

4 tables, 12 refs. In POLH. Authors' summary.

Cage-housing of muskrats.

W.L. Shevyrkov, T.Yu. Antipova.

Possibilities of adapting muskrats to cage-housing were examined. Over 50% of the females were transported about 1200 km from the place they were caught and produced offspring in the same year. The authors examined the body weight in larger and smaller groups. The best results were obtained when two animals of opposite sex were kept in one cage. It was noticed that males from early litters (until July 12) and from late litters (middle of July till the end of August) developed equally well and all of them reached sexual maturity in the spring of the following year. Their maturity was determined on the basis of the testosterone level in blood.

4 refs. In POLH. Authors' summary.

An attempt to adapt muskrats to cage housing conditions without a swimming-pool.

R. Cholewa.

To increase our knowledge about cage housing of muskrats (*Ondatra zibethica L.*) without a swimming-pool, studies were carried out on the reproduction, growth and skin quality of muskrats. Typical cages used for foxes and mink were readapted. The studies were conducted for 4 years. The offspring came from 30% of the females, 4.5 offspring per mother, on average. Until 4 weeks of age 3.6 offspring were reared. The type of housing had little effect on the result. However, monogamous breeding gave better results than that of a harem type. The size of the animals was larger than that of those at large, but the skin quality was similar.

3 tables, 8 refs. In POLH. Authors' summary.

Coccidiosis in coypu.

W. Scheuring.

Testing of 1059 slaughter coypus seemingly healthy and 43 sick animals during one year (1984-85), stated that:

1. Infection level with intestinal parasites was 38.9% (hematodosis - 28.5% and coccidiosis - 19.5%).
2. Six species of Coccidiae were discovered - three of them are new for Polish parasitofauna, they are: Eimeria myopotami, E.nutriae and E.fluviatilis.
3. Clinical and sectional forms of coccidiosis in the intestinal epithelium from duodenum to rectum were caused by E. coypi in the given period of time.
4. Seasonal incidence in extensity of coypu coccidiosis (June - September).

3 tables, 3 figs. In POLH. Authors' summary.

The influence of breeding conditions on the occurrence of Eimeira in nutria.

A. Balicka-Laurnas, S. Niedzwiadek, A. Ramisz.

Standard nutria both bred in cages and in enclosures with water pools were examined. The total number of examined faeces samples was 300 in which 168 were from nutria bred without water pools and 132 with. Three species of Eimeria were found (*E.pellucia, E.seideli and E.coypi*). Differences in intensity and extent of contagion with coccidia depending on the system of breeding were found. A greater extent and intensity of contagion was present in nutria bred with water pools. A positive result was present in 91.7 per cent of faeces samples with an average intensity of 3718 oocytes per 1 g of faeces. The respective values for nutria bred without water pools were 88.1 per cent and 732 oocytes per 1 g.

1 table, 13 refs. In POLH. Authors' summary.

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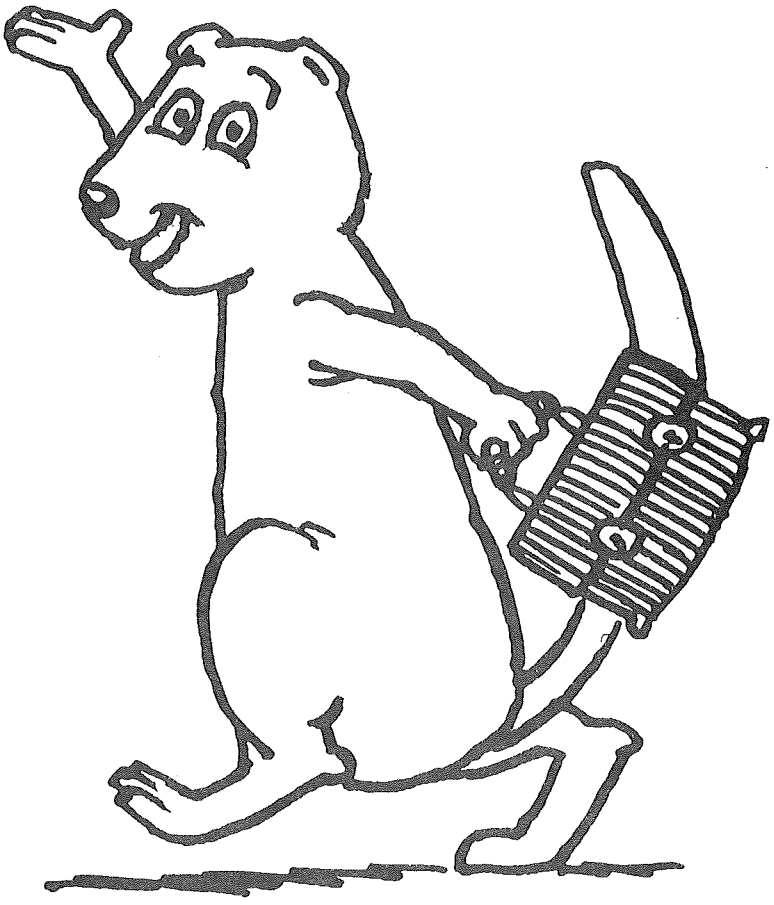

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