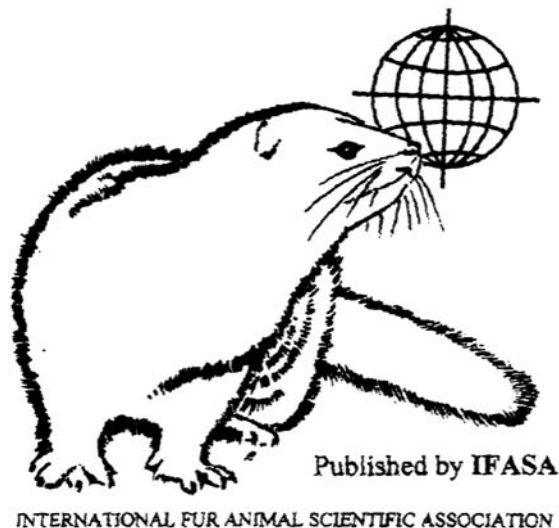


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Group housing may impair fur quality in raccoon dogs

L. Ahola, S. Hänninen, T. Pyykönen, J. Mononen
Institute of Applied Biotechnology, University of Kuopio
POBox 1627, FIN-70211 Kuopio, Finland
leena.ahola@uku.fi

Abstract

In the wild, the raccoon dog (*Nyctereutes procyonoides*) is a rather social species. Therefore, to meet the species-specific needs of this species also on farms, group housing of farmed raccoon dogs could be considered as an alternative, enriched way of housing these animals. Group housing may, though, affect fur quality e.g. due to aggressiveness or play behaviour between the group mates. In the present study, effects of group housing on production-related parameters were established in farmed raccoon dogs. The animals were housed either as litters (three male and three female siblings in a so-called row-cage system) or as conventional male-female sibling-pairs (in a traditional cage) throughout their growing season. The body mass of the animals, the length of the skins and the number of bite scars in the skins did not differ between the litters and the pairs ($p > 0.05$, GLM for repeated measures). Fur quality was worse ($p < 0.05$) in the litters than in the pairs. Despite impaired fur quality in the litters, no difference in the price of the skins was emerged between the litters and the pairs ($p > 0.05$). In conclusion, group housing of farmed raccoon dogs may, due either to altered physical or to social conditions, impair the fur quality of the animals.

Introduction

According to the recommendations concerning fur animals and their welfare (European Convention, 1999), it is important that the animals have e.g. a stimulating environment appropriate to meet the species-specific needs, including for social species an opportunity to show social investigation and behaviour. In the wild, the raccoon dog (*Nyctereutes procyonoides*) is a rather social species: both parents take care of the young and the cubs may stay their first winter with their mother (Kauhala, 1998). Accordingly, group housing of farmed raccoon dogs could be considered as an alternative, enriched way of housing these animals. Housing fur animals in larger groups may, though, affect the fur quality e.g. due to occasional aggressiveness or play behaviour

between the group mates. To clarify the effects of group housing on production-related parameters, farmed raccoon dogs were housed either in groups comprising of three male and three female siblings or in traditional male-female sibling pairs.

Material and methods

The present study was performed during the years 2000 and 2001 at the Research Station of Institute of Applied Biotechnology (University of Kuopio, Finland). Altogether 168 raccoon dog cubs from 28 litters were included in the study during these two years. The raccoon dog cubs were weaned from their mother at the age of approximately eight weeks. Thereafter the litters were divided evenly into two experimental groups that were matched with the cubs' date of birth and litter size. Three male and three female cubs from each litter were transferred into their experimental cages.

One half of the litters (i.e. 36 and 48 cubs in years 2000 and 2001, respectively) was housed throughout their growing season in groups comprising of three male and three female siblings (the sextet group, S). The housing system for the S litters was constructed out of three traditional cages (115 x 105 x 70 cm, L x W x H) that were connected together with openings (30 x 30 cm, W x H) through the walls between the cages (a so-called row-cage system). The other half of the litters was housed as conventional male-female sibling pairs (the pair group, P), i.e. the P litters comprising of three male and three female cubs were divided to live in three separate traditional cages as sibling pairs. Thus, space allocation was 0.6 m² per animal in both groups. The matched pairs of litters in the S and P groups were placed into one outdoor fur shed so that in both cage rows of the shed every other three cages were connected together to form a three-cage system (a row-cage system for one sextet) and every other three cages were kept as such (three traditional cages for three male-female sibling pairs).

The raccoon dog cubs were fed, according to the recommendations given by the Finnish Fur

Breeders' Association, on fresh fur animal feed twice a day until late September, thereafter once a day. The daily feed portion per animal was the same for each group. In the S and P group, the feed was delivered onto three trays of the row-cage system and onto the only feeding tray of the cage, respectively. Straw was available for the animals during the whole experiment to meet the animals' nutritional fibre needs. Water was available *ad libitum* until it froze and thereafter twice a day. The health of the raccoon dog cubs was checked daily. The body mass of the animals was monitored at weaning and at pelting. After pelting, the severity of bite scars was recorded from the leather side of the fleshed skins using a subjective scale from zero (no scars) to seven (plenty of scars). The length of the skins was measured from dry skins from the tip of the nose to the base of the tail. Professional fur graders at the Finnish Fur Sales Ltd (Helsinki, Finland) evaluated the overall quality (density, cover, quality) of the furs using a 10-point scale (1: poorest, 10: best). Also the prices of the skins were obtained from the Finnish Fur Sales Ltd. Because the cubs within each litter cannot be considered as independent from each other, mean values of measured parameters within each litter, separately for male and female cubs, were used in statistical analyses (Martin & Bateson, 1993). Also the matched-pairs, i.e. one litter from both the S group and the P group that were matched with the cubs' date of birth and litter size, were dependent. Therefore, GLM for repeated measures with both

sex and experimental group as within-subject factors was used to analyse the effects of sex and treatment on the measured parameters. Independent-samples T-test was used to analyse differences between the results from years 2000 and 2001.

Results

Within the experimental groups and within sexes (i.e. either male or female cubs in either S or P group), no statistically significant differences emerged in the measured parameters between the two years (2000 and 2001) (for all parameters: $p > 0.05$), except in the price of the skins. Therefore, all the results but the price results from these years were pooled together.

During the two years, four and six raccoon dog cubs from S and P groups, respectively, died (or were euthanised) during the experiments. The causes of deaths (or of euthanising) were apparently not due to the housing systems.

There was no difference between the sexes in the body mass at weaning (Table 1). However, at pelting, the males were significantly heavier than the females. Despite this sex difference in the body mass at pelting, there was no difference between the males and the females in the length of the skins. Bite scar score and fur characters as well as the price of the skins in the year 2000 were equal in the males and the females. In the year 2001, the price of the skins was higher for the males than for the females.

Table 1. Body mass (BM, kg) at weaning and at pelting, length (cm) of skins, scar score (8-point scale: 0 = no scars, 7 = plenty of scars), density, cover and quality of furs (10-point scale, 1 = poorest, 10 = best) and price (euros) of skins in raccoon dog cubs housed in sextets or in male-female sibling pairs. G = group (sextets vs. pairs), S = sex (males vs. females). P: GLM for repeated measures. NS: $p > 0.05$. The data is based on 42 animals in each group (i.e. altogether 168 animals) although statistically the number of subjects is 14 in each group (see Material and methods).

	Males		Females		S	P G	SxG
	Sextets N=14	Pairs N=14	Sextets N=14	Pairs N=14			
BM, weaning	2.5±0.4	2.6±0.4	2.5±0.5	2.6±0.4	NS	NS	NS
BM, pelting	11.1±1.2	11.4±1.4	10.7±1.4	10.8±1.1	0.009	NS	NS
Length of skin	103±3	105±4	103±3	103±3	NS	NS	NS
Scar score	1.5±1.0	1.5±0.9	2.0±1.3	1.7±0.9	NS	NS	NS
Fur characters							
Density	5.7±1.5	7.2±0.7	5.5±1.5	6.9±0.7	NS	0.008	NS
Cover	5.8±0.9	6.3±1.2	5.6±1.2	6.7±0.9	NS	0.034	NS
Quality	6.0±1.9	8.0±0.9	5.9±2.0	7.8±0.8	NS	0.006	NS
Price							
Year 2000	61±8	70±12	60±6	68±9	NS	NS	NS
Year 2001	102±8	113±19	102±14	98±14	0.045	NS	NS

Between the S and P groups, no statistically significant differences were emerged in the body mass of the animals at weaning and at pelting, in the length of the skins, or in the price of the skins (Table 1). The density, cover and quality of furs were significantly lower in the animals housed in sextets than in the animals housed in pairs. Despite impaired fur quality in the sextets, the price of the skins did not differ statistically between the two experimental groups.

Discussion

In the present study, the body mass of the animals and the length of the skins did not differ between the raccoon dog cubs housed in the sextets and in the pairs. This result is in accordance with the earlier results by Korhonen & Harri (1988) who found that group size is the least factor affecting growth performance in farmed raccoon dogs. Thus, it can be concluded that group size does not have any major effects on the growth of raccoon dog cubs.

The number of raccoon dog cubs within the group did not affect the number of bite scars in the skins of the animals. Because the behaviour of the animals was not observed in the present study, it remains unclear whether the bite scars were due to aggressiveness or to play behaviour between the cage mates or were the scars self-inflicted. In the mink, that is considered as a rather solitary species, Hänninen et al. (2002) found that bite scars were more common in cubs housed in litters than in pairs, and concluded that fighting may cause problems in group housed mink. On the other hand, in the silver fox, considered to be a more social species than the mink, the number of bite scars was not affected by group size but more likely by space allocation (Ahola et al., 2002). These results from other farmed fur animals may indicate that bite scars truly reflect the amount of aggression between the animals. Thus, it seems that raccoon dogs, considered as rather social animals, do not fight more in larger groups but are capable of adjusting to variable social environments.

The density, cover and quality of furs were, however, more degraded in the animals that were housed in sextets than in the animals housed in pairs. There may be two reasons for this impairment of fur quality in the S group. First, the raccoon dog cubs housed in sextets were often seen to rest in huddles. This huddling may have abraded the furs of these animals. Second, the animals in the S group were housed in cage systems built up of three traditional cages connected together with rather

small openings through the walls between the adjacent cages, and going through these small openings may have caused mechanical wearing of the fur of these animals.

The price of the skins was 4-13 % (years 2001-2000) higher in the pair-housed raccoon dogs than in the sextet-housed raccoon dogs. Although this difference in the price was not statistically significant, the difference is worthwhile to note because the price of skins is still the main factor that affects fur farmers' willingness to change housing systems and to raise farmed raccoon dogs in merely potentially welfare promoting housing systems.

In conclusion, the present results showed that group housing may, due either to altered physical or to altered social conditions, impair fur quality of farmed raccoon dogs.

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I – 6 RP

Comparison of hall and shed as housing environments for blue foxes

Hannu T. Korhonen¹, Teppo Rekilä¹, Tapani Kivinen² and Lauri Jauhiainen³
MTT Agrifood Research Finland, ¹Animal Production Research, Kannus, ²Agricultural
Engineering Research, Vihti, ³Information Services, Jokioinen, Finland
e-mail: hannu.t.korhonen@mtt.fi

Abstract

The study evaluated differences in housing environments between a brand-new fox hall (16 m wide x 75 m long x 7 m high) and a traditional shed. The experiment was carried out during the growing season on two groups of juvenile blue foxes, one housed in a shed and the other in a hall. Each group comprised 50 males and 50 females kept in male-female pairs. The results showed that the temperature was 2-3 °C higher in the hall than in the shed and that relative humidity was 2-4% lower in hall than in the shed. The NH₃ concentration ranged from 0 to 9.5 ppm in the hall but was less than 1 ppm in the shed. The dust concentration ranged from 1 to 2.9 mg/m³ in the shed and from 0.9 to 3.2 mg/m³ in the hall. Wind speed was from 0.2 to 0.4 m/s in the shed and from 0.09 to 0.26 m/s in the hall. Average light intensity during Oct-Dec was 4.7 lux in the hall and 5.2 lux in the shed. Sense-based impressions revealed that investigators experienced higher levels of smell and dust in the hall than in the shed but less draught. Substantial differences were not found in body weights, welfare-related variables or fur properties between the groups. Hall conditions seem to be suitable for the commercial raising of juvenile blue foxes.

Introduction

Farmed blue foxes (*Alopex lagopus*) have traditionally been housed in wire-mesh floor cages under shed. Experience of many decades shows that it is possible to produce animals of large body size and good fur quality under such conditions (Korhonen et al. 2000, 2001). However, recent stipulations in environmental and animal welfare legislation, in particular, have put pressures on breeders either to improve the present form of shed housing or to seek alternative housing environments. One potential option would be to raise foxes in fully-covered halls. Such conditions are expected to provide more controlled and stabilized environment, thus, possibly enhancing animal welfare and production performance (Pasanen, 1988; Nydahl & Fors, 1989; Nydahl et al.

1989; Aarstrand & Bøe, 1990). Furthermore, the hall is expected to minimise ground water and air pollution, and make manure handling easy (Kivinen & Rekilä, 2002). Unfortunately, little scientific information is available on the suitability of halls as housing environment for large-scale fox production. Therefore, more research on this subject is needed. The purpose of the present study was to fill this gap and to provide measured data on halls and sheds as housing environments for farm-bred blue foxes. Our specific aims were (1) to compare the physical conditions of these two types of housing; and (2) to establish the differences, if any, in production and welfare-related parameters during growing season.

Material and Methods

The study was carried out at the Fur Farming Research Station (of MTT Agrifood Research Finland) in Kannus, Finland, (63.54°N, 23.54°E) during July-December 2003. The experimental animals were juvenile blue foxes born in May. Until weaning, they were housed with their mothers and littermates in conventional shed cages 120 cm long x 105 cm wide x 70 cm high. At weaning (age 8 weeks; on July 30), the foxes were divided into two experimental groups: 1) a shed group, with the animals housed in a traditional wire-netting shed; and 2) a hall group, with the animals housed in a hall. The hall was 16 m wide and 75 m long. The height at the ridge was 7 m. Ventilation was natural, gravity based air flow (Kivinen & Rekilä, 2002). Each group comprised 50 males and 50 females housed in male-female pairs. The cage of both groups were 120 cm long x 105 cm wide x 70 cm high. Each cage contained a wire-mesh platform (105 cm long x 25 cm wide) located at about 23 cm from the ceiling and was equipped with birchwood blocks (7 cm long x 5 cm in diameter). Freshly mixed fox feed was supplied twice a day *ad libitum* from commercial feeding machines. The main ingredients of the feed were slaughterhouse offal, fish, fish offal and cereals, in accordance with standard Finnish recommendations. Fresh water was

available *ad libitum* from automatic watering devices.

Ammonia emissions were determined with Dräger ammonia tubes (accuracy ± 1 ppm) at the cage level. The NH_3 indication was based on the colour reaction of ammonia with bromophenol blue and acid. Ammonia changed the colour of the indicating layer from orange to blue, the length of the discoloration indicating the concentration. The indication was evaluated immediately since the colour tended to change somewhat in the course of time. Temperature and relative humidity were measured automatically with tiny tag detectors placed on the ceiling and at cage levels in both the shed and the hall. The dust concentration was measured with Hagner SI Universal (Sweden) equipment at cage level. Wind speed was measured with a Thermo-Anemometer (GGA-26, Finland) at cage level. Light intensity was measured with a photometer at cage level in the shed and the hall and outside the confinements. Sense-based impressions of temperature comfort, smell, draught and dust were evaluated by 10 persons (5 working on the farm, 5 employed in the office building) during the experiment. The evaluation scale was from 1 to 4, where 1= comfortable, 2=fairly comfortable, 3=moderately comfortable, 4=uncomfortable. Manure was collected once a month by Agromatic machine (Bobcat).

Blood samples were collected for determination of the blood picture at pelting (Korhonen et al. 2001). Final body weights were measured on a Vaakakoskinen AD-4326A balance. Adrenals were carefully dissected, cleaned and weighed at autopsy. Mass, quality, cover and purity of colour were evaluated by the Finnish Fur Breeders' Association on a scale from 1 to 10, where 1=poorest and 10=best (Korhonen et al. 2000).

Blood picture, organ weights and fur properties were evaluated only from males.

Statistical analyses were based on the models accounting for litter as a block effect (Korhonen et al. 2000, 2001).

Results

Outside temperatures were typically only a few degrees lower than those in the hall. In August, the air temperature was almost the same in both the hall and the shed. Thereafter, the average temperature was 2-3 °C higher in the hall than in the shed. The other physical data are summarized in Table 1. Relative humidity was fairly similar in both housing types. No NH_3 concentrations at all were measured

in the shed. In the hall, NH_3 concentrations ranged from 0 to 9.5 ppm, the highest concentrations being measured during the carting of manure. Wind speed was higher in the shed than in the hall. Substantial differences were not found in light intensity during October-November. The dust concentration tended to be slightly higher in the hall than in the shed (Table 1).

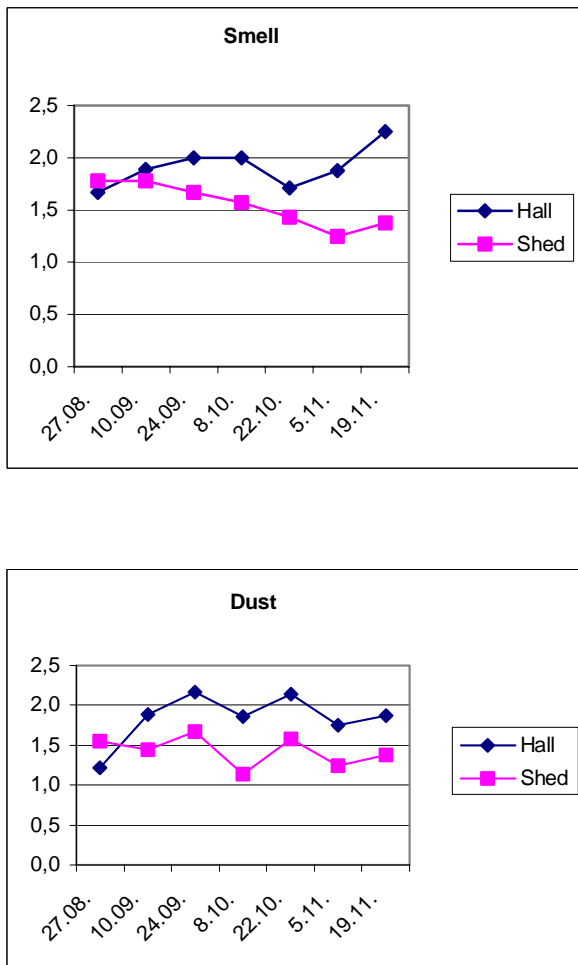
Table 1. Range of physical variables measured under hall and shed conditions. The measurements were made during August-November.

Variable	Hall	Shed
NH_3 (ppm)	0-9.5	0
Dust (mg/m^3)	0.9-3.2	1.0 -2.9
Wind speed (m/s)	0.09-0.26	0.20-0.40
Light intensity (lux)	0-45	0-55
Relative humidity (%)	58-100	57-100

The investigators had a higher sense-based impression of smell and dust in the hall than in the shed (Fig.1). The differences between people working on the farm and in the office building were not significant. The sense-based impression of temperature comfort was fairly similar for both hall and shed. The impression of draught tended to be higher in the shed than in the hall.

Significant differences were not found in final body weights either in males (hall 13.6 kg, shed 13.1 kg, s.e.= 0.33, $P=0.22$) or in females (hall 11.8 kg, shed 11.3 kg, s.e.=0.22, $P=0.08$). Nor were there any significant differences in blood picture (haemoglobin: hall 162 g/l, shed 161 g/l, s.e.=1.70, white blood cells $9.0 \times 10^9 \text{ cells}^{-1}$ vs $8.2 \times 10^9 \text{ cells}^{-1}$, s.e.=0.48, red blood cells $8.5 \times 10^9 \text{ cells}^{-1}$ vs $8.7 \times 10^9 \text{ cells}^{-1}$, s.e.= 0.10, haematocrit 51.6% vs 52.6%, s.e.=0.63) or weight of adrenals (hall 317 mg, shed 331 mg, s.e.=19.0, ns). The differences in fur parameters such as quality, mass or cover were not significant. However, purity of colour was significantly poorer in males kept in the hall than in those raised in the shed (6.25 vs 6.94, s.e.=0.17, $P=0.006$).

Fig. 1. Sense-based impressions of smell and dust during the experiment.



The evaluation scale was from 1 to 4 where 1=comfortable, 2=fairly comfortable, 3=moderately comfortable, 4=uncomfortable.

Discussion

When interpreting the present results, we should keep the following points in mind: (1) at the beginning of our growing experiment, in summer, the hall was brand new, i.e. conditions were pristine and clean, and so, we do not yet know how conditions will change in the long run or seasonally.; (2) The animals kept in the hall were all born in a shed, and were not brought to the hall until after weaning. Thus, we have no data on animals born and bred in a hall; (3) comparison of our results with those of previous hall trials is difficult because of the scarcity of data available and

because experimental halls differ from each other in structure.

Physical measurements did not reveal any great differences in housing conditions between the hall and the shed. Although NH_3 was detected in the hall, the concentrations measured were lower than the maximum permitted 10 ppm (Ministry of Agriculture and Forestry, 2002). The same holds for dust, i.e. the dust concentrations measured were below the maximum permitted 10 mg/m^3 . Sense-based impressions revealed that the investigators experienced higher levels of smell and dust in the hall than in the shed. However, the differences were not striking, and the smell and dust impressions were considered to be within the limit of acceptable sense perception. The NH_3 concentrations reported by Pasanen (1988) ranged from 5 to 10 ppm, i.e. they were very close to those detected here. In another Finnish experiment, Nydahl et al. (1989) measured NH_3 concentrations that were slightly higher than those in our experiment, i.e. from 13 to 25 ppm. They concluded that such concentrations were still well acceptable under hall conditions. In Norway, NH_3 concentrations have been reported to range from 1 to 6 ppm (Bøe & Aarstrand, 1989). Thus, it appears that NH_3 will not be a health problem for either animals or workers in a hall.

Air temperatures inside the hall were measured only during the autumn period. They were either about the same as in the shed or only 2-3 °C higher. These findings agree rather well with measurements made earlier in Norway (Aarstrand & Bøe, 1990) and Finland (Nydahl et al. 1989). The most interesting periods of the year will be mid-winter and mid-summer, when the temperature differences between hall, shed and ambient air can be expected to be at their highest (Pasanen, 1988). We look forward to evaluating these periods in detail. The present results revealed that wind speed was higher in the shed than in the hall. This may affect temperature comfort in the hall owing to the wind-chill effect, i.e. the combination of higher wind speed and lower temperature will increase the effect of cold. In principle, the relative humidity of the air may also affect the impression and/or impact of temperature. Our measurements revealed that relative humidity in the hall was not substantially different from that in the shed.

According to Pasanen (1988), hall conditions are positive in terms of animal welfare. In the present study, welfare-related parameters demonstrated that the health of our experimental foxes was similar in both housing environments. Thus, hall environment

did not increase the welfare of growing blue foxes. On the other hand, neither was hall housing detrimental to foxes which encourages us to continue this project. It is obvious that further studies will be needed in order to clarify long-term effects on wellbeing.

Our results showed that the production of foxes with large body size and good fur quality is just as possible in halls as in sheds. We conclude that there do not seem to be any obstacles to the commercial raising of growing foxes under hall conditions until pelting. Our next experiments will seek to clarify effects of the hall environment on mating and reproduction. Before we have that information, we cannot draw final conclusions as to the suitability of the present type of hall on commercial fox production as a whole.

Acknowledgements

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I – 7 RP

Mink welfare improved by combined implementation of several small initiatives

Leif Lau Jeppesen

Biological Institute, University of Copenhagen

Tagensvej 16, 2200 Copenhagen N, Denmark

lljeppesen@bi.ku.dk

Abstract

Several small initiatives, each separately supposed to improve welfare were implemented at one half of a mink farm population: the experimental group (N = 300 females of the colour type wild including males and kits). The other half of the population served as a control group. The initiatives comprised selection for confident behaviour, an empty cage between mated dams, separation of the litter 1-2 weeks after weaning at 8 weeks of age, and furnishing cages with shelves and occupational objects. The initiatives were implemented in the order mentioned from early spring 2003, and the synergistic effect of the initiatives on stereotypies, temperament and pelt damages was measured in kits and in dams during summer and autumn 2003. The results showed that confident behaviour was increased and that frequency of stereotypies and of damages was reduced in the experimental group. It was concluded that welfare was improved by the combined implementation of the initiatives.

Introduction

Current thinking about welfare improvements for mink seems to be somewhat out of focus. The Council of Europe recommended research on swimming and group housing (European Convention, 1999). However, from a biological point of view, access to swimming water and forced cohabitation with conspecifics during group housing are not the first choices of improvements for a species, which is solitary and mainly terrestrial (Dunstone, 1993).

Accordingly, group living and access to swimming water has been shown to impair welfare or to leave it unaffected (Pedersen and Jeppesen, 2001; Hansen and Jeppesen, 2003, 2001).

As mink is an exploring and active opportunistic hunter in the wild, it can be expected that farm housing, in spite of the developed domestication of the species (Kruska, 1996; Kruska and Schreiber, 1999), fails to meet possible needs for being active and exploring. It is also likely, that biologically based fear of humans and neighbouring animals still

has to be taken into consideration during future welfare promoting initiatives.

Such initiatives should include further genetic adaptation to farm conditions and proper early stimulation of the animals together with possible changes of the farm environment. The purpose of the present welfare research initiative is to concentrate on minor changes of the conventional cage system since totally alternative environments on the short term are likely to impair welfare in the farm mink that has lived in and adapted to cage systems for more than 100 years (Schackelford, 1984). Several minor changes or initiatives have been shown to improve welfare, but this knowledge is mainly obtained in experimental settings and with smaller group sizes. Recently, Vinke et al. (2002) compared the effect of various degrees of minor changes on five different farms, and they showed that the degree of change was reflected in the level of welfare measured at the farms. The present experiment aims at trying out the combined effect of such minor initiatives by comparing control and experimental groups within one farm population at one large farm.

The implemented initiatives are, in short, (1) to select for confident behaviour, (2) to keep lactating dams and litters in every second cage, leaving an empty cage between them, (3) to wean litters at 8 weeks and keep the kits together (without the dam) for another two weeks, and (4) to provision cages with shelves and occupational object.

Materials and Methods

Animals

The study was initiated by buying a new wild mink stock to the host farm, 600 females and 100 males. The animals were tested for temperament with 10 stick tests (Hansen and Møller, 2001) at the delivery farm, and moved to the host farm in the end of February 2003. The half of each of the sexes that scored confident in most tests was allocated the experimental group. The other half was allocated the control group.

Farm

The animals were housed in a shed with 6 rows of conventional wire mesh cages (30x90x45cm) provided with attached wooden nest boxes covered with straw. The 4 central rows made up the study area with a control section placed in the one end of the rows and an experimental section in the other. In the control section cages were without equipment. In the experimental section each cage was furnished with either a shelf or a tunnel made of wire. The shelf measured 15 x 30 cm and was placed in the back of the cage 10 cm below the roof. The tunnel was a 30 cm long square formed tube measuring 10 cm at each side. One of the flats of the tunnel was connected to the roof in the right side of the cage. Thus, the bottom of the tunnel was in the same distance from the roof as the shelf. Throughout this study tunnels and shelves were used to the same extent, and for easiness they are in the following just referred to as "shelf".

Mating and lactation

The animals were kept individually in adjoining cages during mating (in the beginning of March) and in the control group they were still kept in adjoining cages during lactation and until weaning, which took place when the kits were about 7 weeks old. In the experimental group females were placed in every second cage one week before the earliest expected delivery (in the end of April) and kept with this distance to neighbouring females and litters until weaning, which took place at 8 weeks.

The post-weaning period

After weaning the dams were moved to new cages together with a male or a female kit. Each cage held such a pair of animals. In the experimental section cages were equipped with one occupational object (in addition to the shelf), either a plastic tube, a wire cylinder, or a rope of hemp or sisal. However, the ropes gave rise to problems with the pumps of the farm's mucking out equipment, and they were therefore replaced by sawdust fuel briquettes. The tubes and the cylinders measured 11 x 20-25cm (diameter x length); the briquettes measured 6 x 11 x 15 cm.

The control kits were separated in male-female pairs immediately after weaning. The experimental litters were kept together for another 1 – 2 weeks in one or two cages depending on the litter size. After that, they were separated and the kits kept in pair as in

the control group. Experimental pairs were supplied with the same types of occupational objects as the dams from the middle of august

Observations

Qualitative observations were sampled frequently from the onset of the study. Quantitative observations during daytime (09.00-16.00) were performed as follows:

A varying number of lactating dams were scanned 10 times a week while their kits were in their 5th to 7th living week (N = 161, 59 and 198, respectively; almost equally distributed on groups). After weaning, all dams (N = 564) were scanned once a day for 5 days from August 19th to September 15th, and they were tested for temperament once on September 13th. Kit pairs from the control group (N = 512) and from the experimental group (N = 576) were scanned once a day for 5 days between September 1st and September 22nd, and tested for temperament September 12th. During the scanning observations of dams the cages that were adjacent to the feed gangway were observed from the gangway and through the door to the cage. During the scanning observations of kits, the cages that were one row away from the gangway were observed through the back part of the cage.

On the 25th of September, while damages on the summer pelt was still visible, the 512 control pairs and the 576 experimental pairs were examined for damages on ears, neck, back/hips, and tail. Damages were attributed to 3 degrees of severity: insignificant (1), moderate (2), and severe (3). "Severe" implied that larger areas of the pelt were gnawed to the skin. "Insignificant" implied that just single guard hairs were gnawed or damaged.

Behavioural elements

The observed elements are listed in table 1. They are distributed to three categories: positions, behaviours, and social distance. During each scanning observations each of the categories were registered separately, meaning that the three positions amounted to 100 % of the scannings. The same held for the two levels of social distance. Since behaviour could not be observed in the nest, the behavioural categories made up a fraction of the scannings during which the animals were out of nest. For the observations of lactating dams only a limited number of the elements were used (fig. 1); together these made up 100 % of the scannings.

Table 1. Catalogue of behavioural elements distributed to the three categories: position, behaviour and social distance. Elements marked with (d) were registered without regard to category in the first scanning of lactating dams.

Position	
Cage	At least the forepart of the animal visible in the cage, but not on the shelf
Shelf (d)	The animal at the shelf / in the tunnel
Nest (d)	The animal in the nest
Behaviour	
Active (d)	The animal performs other active behaviours than those specified below, e.g. exploration, eating, drinking, defecation, marking, etc.
Object	The animal manipulates the occupational object or passes through
Inactive (d)	The animal is inactive in the cage or at the shelf
Stereotyp (d)	Invariant, five or more times repeated behaviours with no obvious function
In/out (d)	Frequent running in and out of the nest box
Neighbour contact (d)	The dam reacts to the presence or vocalisations of neighbouring dams, mainly by starring at the dam / in the direction of the sound or by starting activity/stereotypy in response to stereotyping neighbours
Play	Social play with cage mate; play fights included when they are performed peacefully, with open mouth display, and without screaming.
Alert	Reaction toward the observer, including flight to the nest-box and starring watching of the observer; to be seen only when observations took place from a distance and through the back part of the cage
Distance	
Alone	The animal has no contact with the cage mate; heads more than 5 cm apart
Together	The animal is in physical or behavioural contact with the cage mate

Temperament

The temperament was measured with a stick test (Hansen and Møller, 2001). The observer inserted a stick through the front door to the cage, waited for 15 seconds, and noted whether the reaction of the animals to the stick/observer was confident (approached the stick curiously, sniffed at it, or manipulated it softly with the teeth), fearful (saw the stick and then actively avoided it), aggressive (attacked the stick violently with claws and teeth), inattentive (stayed in nest) or uncertain (reacted in a way that could not be assigned to one of the before mentioned categories). It is an as yet unsolved problem for the procedure that animals staying in the nest may do so for two reasons: because they are inattentive or because they are fearful. Since inattentive is usually scored at rather low frequencies it is, however, considered to be a minor problem.

Welfare

Based on Broom and Johnson (1993) the following criteria for good welfare were used: Low levels of stereotypy, of damages, of fear and of overt

aggression. Accordingly, high level of confident temperament is also a sign of good welfare.

Statistics

Group comparisons: Data on damages were categorical and tested with a two-tailed Chi-Square test. Data on repeated scannings were treated in different ways according to the frequency of occurrence of the elements. For infrequent elements it was noted for each animal whether the element occurred or not in all of the repeated tests, and this individual result was tested with a two-tailed Chi-square test. For frequently occurring elements the proportion of scannings in which the element occurred was calculated for each individual, and this result was tested with a Mann-Whitney U test, since data were not normally distributed.

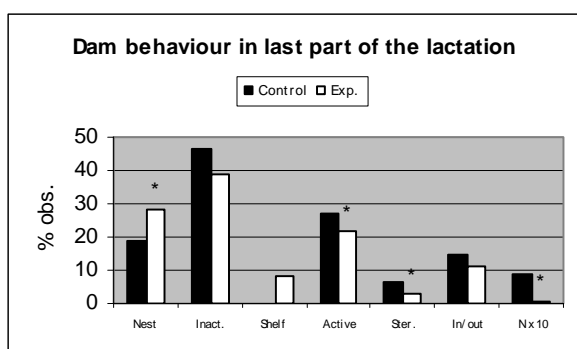
Time development: The development of the behavioural elements during lactation week 5-7 was tested with a Kruskal-Wallis one-way analysis of variance. All tests were performed according to Siegel and Castellan (1988).

Results

During the first weeks of lactation dams and litters spent most of the time in the nest box and all of the behaviours in the cage increased sharply during week 4 to 5 after delivery. During the quantitative observations in the last part of the lactation, weeks 5 – 7, the experimental dams were more in the nest and they were less active in the cage as compared to control dams (fig. 1). They also performed less stereotyped behaviour, less running in and out of the nest box, and showed less neighbouring contact. They spent about 8 % of the observation on the shelf, mainly by lying inactive. Therefore they were inactive outside the nest to the same extent as the control dams.

Some of the behaviours developed significantly during the 3 week period. The use of the shelf decreased over the weeks 5, 6 and 7 from 13.2 to 8.5 and 4.8 % of the observations, respectively ($P < 0.05$). This corresponded well with qualitative observations of the kits' increasing ability to enter the shelf in search of the dam. The frequency of stereotypies increased over the weeks (control dams: 1.5 – 3.8 – 12.2 % of observations, $P < 0.001$; experimental dams: 0.7 – 0.7 – 4.8 % of observations, $P < 0.02$). Based on qualitative observation during the 8th week, stereotypies increased further in the experimental group in that week and several kits were bitten and damaged by the dam.

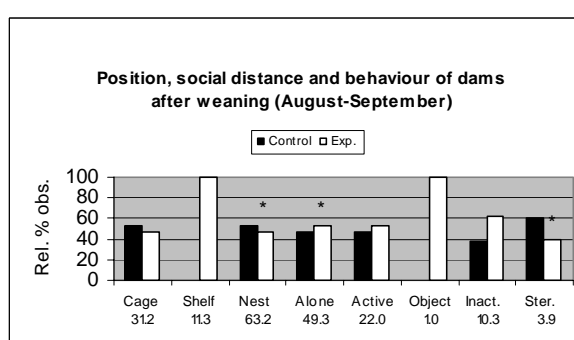
Fig. 1. Average % of observations of selected behavioural elements in the last part of the lactation (weeks 5 to 7 after delivery) in control and experimental dams. * $P < 0.05$; chi-square test / U-test.



After weaning, the experimental dams used the shelf for about 11 % of the observations (fig. 2). For this reason they were observed less frequent in the cage and significantly less frequent in the nest as compared to control dams. They were also

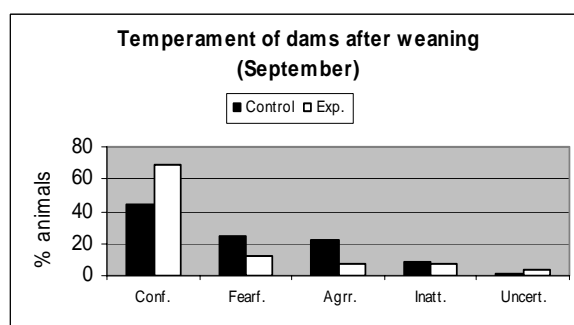
significantly more alone and less stereotyping. They used the occupational object for only 1 % of the time during the quantitative observations. Qualitative observations performed daily during several weeks confirmed this low frequency of use, and gave the impression that plastic tubes and wire cylinders were used more than ropes and briquettes.

Fig. 2. The figures at the bottom show the combined average % of observations in the control and the experimental group, apart from data for shelf and for object that relate to the experimental group only. The columns above show the relative distribution on control and experimental dams. * $P < 0.05$, Chi-square test / U-test.



The temperament of the experimental dams was significantly different from that of the control dams, the experimental dams being more confident and less fearful and aggressive (fig. 3).

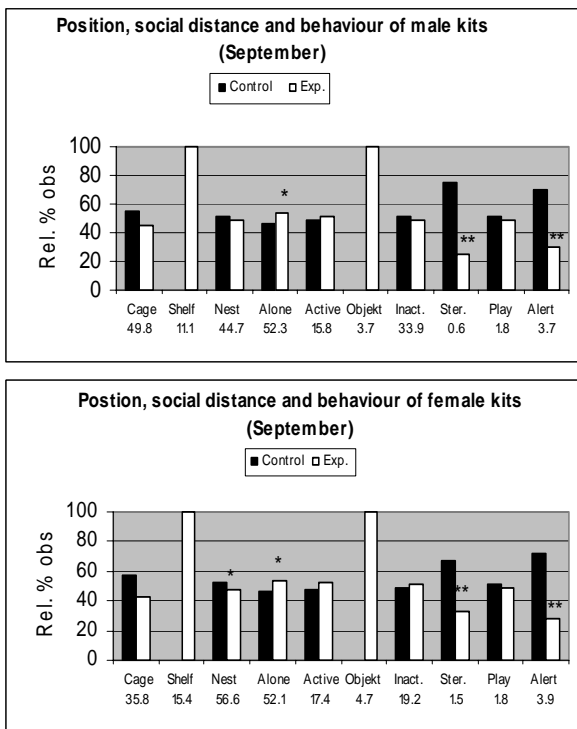
Fig. 3. % control and experimental dams in various temperament categories in September. $P < 0.0001$, Chi-square test.



The male and female experimental kits (fig 4) used the shelf 11.1 and 15.4 % of the observations, respectively. As compared to control kits, they were observed correspondingly less in the cage and in the nest (last result significant for females). Both sexes of experimental kits were significantly more alone.

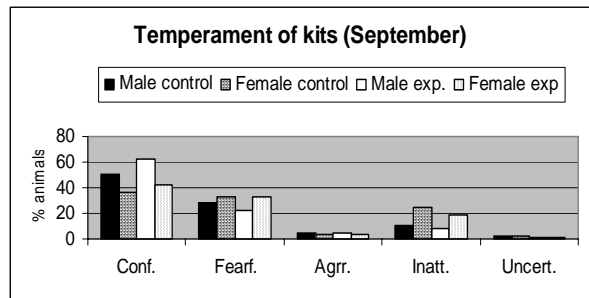
Objects were used 3.7 and 4.7 % of the quantitative observations in male and female kits, respectively. This frequency was much higher during the main activity period in the evening. The plastic tubes and the wire cylinders were used significantly more than the briquettes ($P < 0.001$, $N = 1152$, Chi-square test). All objects were manipulated with claws and mouth. Additionally, passage through the tubes and the cylinders was frequently observed. Frequency of stereotypy and of alert watching the observer was lowest in the experimental group.

Fig. 4. The figures at the bottom of each panel show the combined average % of observations in the control and the experimental group, apart from data for shelf and for object that relate to the experimental group only. The columns above show the relative distribution on control and experimental dams. Top panel: male kits. Bottom panel: female kits. * $P < 0.05$, ** $P < 0.01$, Chi-square test / U-test.



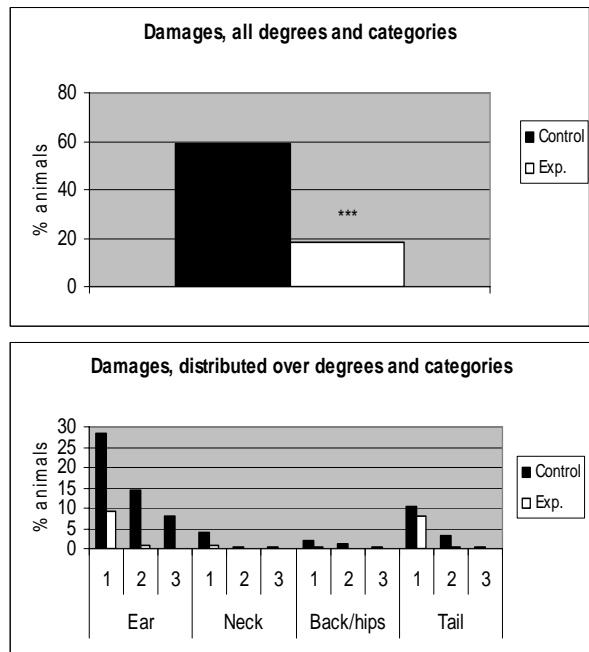
The temperament of control and experimental male kits differed significantly, and the female kits showed the same tendency. Experimental animals were more confident, less fearful, and less in the nest (fig. 5). The differences between the kit groups were smaller than the differences between control and experimental adult females.

Fig. 5. % control and experimental kits in various temperament categories in September. Males: $P < 0.05$, females: $P < 0.1$, Chi-square test.



The number of animals with some degree of damages to the pelt was about 60 % in the control group and about 20 % in the experimental group (fig. 6). Damages to the pelt around the ears and on the tail were most frequent. Some animals had both kinds of damage. Animals with moderate and severe damages amounted to less than 20 % in the control group and less than 1 % in the experimental group.

Fig 6. % of animals with one or more damages (top) and % of damaged animals distributed over degrees and categories (bottom). $P < 0.001$ for both diagrams, Chi-square test.



Discussion

The present study compares two groups of animals that differ in several ways, since several initiatives were implemented in the experimental group. Therefore, differences between groups may be seen as effects of the combined experimental treatment, and cannot be attributed to any single initiative. For instance, the selection for confidence in the experimental dams may be part of the explanation for any of the observed differences. In the following each initiative is discussed separately in relation to previous literature. Welfare improvement expected from the literature and measured in the present study are attributed, with the above reservation, to the initiative under discussion.

The effect of an empty cage between lactating females has been examined before, and so has the effect of various kinds of visual isolation. Recently, Overgaard (2000) showed that reproduction was improved by keeping lactating dams with an empty cage between them. However, this was the case only in primiparous dams of the colour type standard, said to be more stress sensitive than most other colour types. The reproduction of the colour type wild was not influenced by empty cages. Overgaard also noticed that dams located in every second cage were calmer, more in the nest, and not as easily disturbed by neighbouring mink. This was valid for all colour types. Gilbert and Bailey (1967), working mainly with standard mink, found reproduction to be improved by visual isolation of dams from neighbouring dams. Isolation was obtained by placing fibre board partitions between cages. They convincingly explained their result as an effect of reduced social stress (Gilbert and Bailey, 1969). Hoffmeyer and Møller (1986) worked with much larger groups of animals than Gilbert and Bailey and failed to find significant improvements of reproduction as a result of empty or straw filled cages between dams of the colour types standard and pastel. They, too, observed that isolated dams were calmer and less active in the cage.

The results of the present study is in agreement with earlier results, and show further that dams isolated by an empty cage perform less stereotyped behaviour. Together these results show that dams' welfare is improved by placing them in every second cage, although the effect of the improvement is reflected in the reproduction only in stress sensitive individuals or lines.

During week 5, dams were observed to be on the shelf for 13.2 % of the observations, and this was in sharp contrast to much lower frequency of use in the

weeks before. However, as soon as the kits also began to climb to the shelf, dams abandoned this refuge. One likely interpretation is that dams go to the shelf to withdraw from the kits from week 5 onwards, and that they are strained by the kits, when they are deprived this privacy. This might explain the observed increases in stereotypy frequency, as discussed below.

Weaning by removing the dam from the litter took place one week later in the experimental group, and this was supposed to improve welfare in the kits, since it has been shown that individuals that are weaned late show less abnormal behaviour later in life (Mason, 1994; Jeppesen et al., 2000). Whether this is the case also in this study, remains to be examined. However, the pre-weaning welfare seemed to be impaired by the later weaning in the experimental group, both for dams and kits, since several kits were bitten and damaged by the dams, and since frequency of stereotypies in the dams increased sharply in the weeks before weaning. The initiative on later weaning certainly needs further scientific examination. The dams' damaging and stereotyped behaviour may be caused by the restricted area available for the dam and the litter in conventional cages. If this is right, both pre and post weaning welfare should benefit from later weaning in alternative housing systems allowing dam and litter to share e.g. three cages (e.g. Vinke 2002, Pedersen et al., 2004). However, keeping dams and litter together until pelting time impairs welfare (Pedersen and Jeppesen, 2001).

Selection of mink for confident behaviour towards humans with a stick test has been shown to result in mink that experience less fear in many situations, whether it is in relation to humans or other animals or novel situations (Malmkvist and Hansen, 2002). The stick test has been shown to be applicable at the farm level to select for confident animals (Hansen and Møller, 2001). The experimental kits of the present study were as expected less fearful than control kits. It was shown in the stick test and by the lower frequency of alert behaviour in the scanning observations. An overall reduced level of fearfulness is in itself an improvement of welfare, and the demonstrated effect of selecting for confidence confirm that this initiative is an effective means of improving welfare in praxis.

Conventionally, mink are provided with straw on their nests for most of the year. They use it for nest building, and are occupied by pulling it down, carrying it around in the cage, losing it, and pulling in new pieces. Maybe therefore, studies on

alternative occupational objects have not received much attention in mink. Jeppesen and Falkenberg (1990) tested the effect of two plastic balls, and although activity with the balls ceased within one month, general activity and curiosity was still increased after that period in mink kits that lived with plastic balls. Vinke et al. (2002, describing a new Dutch housing system) report on use of plastic tubes as occupational objects. Such tubes were also found to elicit the most lasting activity in pilot examinations previous to the present study, and therefore included in the final testing. In the kits, the wire cylinder and the plastic tube were used to the same extent, about 4 % of the time after about one month's use. This is more than previously observed with other objects, and it might have influenced the behaviour and the welfare of the kits, as observed in the behavioural tests and the damage registration. These objects seem to be important enrichments for kits. In the adult animals they are used less frequent. Both age groups used the shelves in 10-15 % of the observations during the autumn, and they are therefore a much used enrichment of the cage. Although a shelf has room for two or more animals it was mainly occupied by just one individual. This is most likely the main reason that experimental animals were observed to be more alone. Whether mink need to be more alone and therefore benefit from fulfilling such a need is not known. Shelves are part of a new Dutch housing system (Vinke et al., 2002).

The frequency of damages was very high in the present study. The main reason for this may be that there was no selection against this trait, which is genetically based (Nielsen, 1996) and usually selected against at farms. The new breeding animals for the study were bought at farms that kept the least damaged animals for their own use, and the only selection performed during the study was in favour of confident animals. The high damage frequency made it possible to see a marked reducing effect of the experimental conditions on the damages. The reasons for this difference may be any of the implemented initiatives. However, important contributions may come from the shelf and the occupational objects. They were used a lot in the period leading up to the damage registration. The calmer raising conditions in the experimental group could also play a role. The low level of damages in the experimental group underline that welfare is improved by the implemented initiatives.

The behavioural observations indicated that experimental animals showed less stereotyped

behaviour than control animals. They were also less fearful based on results from the stick tests and from the scannings, in which they showed less alert watching at the observer. In conclusion, these results suggest that experimental animals experience better welfare than control animals as a result of the combined implementation of the minor initiatives that were tried out in the present study. The only exception was that experimental dams and kits were more stressed due to later weaning. As mentioned, Vinke et al. (2002) also tried out several small changes and showed that the more changes that were implemented on a farm the lower were the stereotypy frequency. A part of their study was to provide larger free area for the dam and litter by allowing them to roam through several joined standard cage until weaning at 11 weeks. This may be a solution for improving the weaning situation. However, because of the experimental design a causal relationship was not implied in their study. Many of the more extensive initiatives that have been proposed and tried out in the recent years, e.g. introduction of water for swimming and group housing for extended periods (e.g. Hansen and Jeppesen, 2001; Pedersen and Jeppesen, 2001) have failed to show comparable positive effects on welfare or in fact impaired welfare due to the introduction of new problem that the animals are not adapted to cope with. Therefore, the general advice to be taken from the present study is that improving welfare of mink in the short term is best accomplished by smaller improvements of the current management practices and housing conditions for which the mink are adapted. More excessive initiative may well jeopardise the welfare by threatening the adaptive abilities of the species.

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The anticipatory behaviours of mink expecting a positive or negative reward

Steffen W. Hansen¹ & Leif L. Jeppesen²

¹ Department of Animal Health and Welfare, Research Centre Foulum, P.O.Box 50, DK-8830, Tjele. E-mail: Steffenw.hansen@agrsci.dk

² Department of Animal Behaviour, Zoological Institute, University of Copenhagen, Tagensvej 16, DK-2200 Copenhagen N, Denmark

Abstract

The anticipatory behaviours of high and low stereotyping female mink were observed in relation to either a positive (a tit-bit) or a negative reward (capture in a mink trap). The results demonstrated that mink are sensitive to rewards and have the capacity of distinguishing between positive and negative rewards. The anticipatory responses to a positive reward increased several activities out in the cage. The primary anticipatory response to a negative reward was to stay in the nest box or in the entrance of the nest box. However, the anticipatory responses were influenced by the test situation and the feeding time.

Introduction

It has been argued that welfare is the balance between positive and negative experiences or affective states, and that observing behaviours during anticipation of reward in a Pavlovian conditioning paradigm is an easy and useful tool to assess the state of this balancing system (Spruijt et al., 2001). Behaviour during anticipation of an oncoming positive or negative reward may therefore be used as a valuable tool to assess welfare.

Another tool to assess welfare is the occurrence of stereotypies, which is often considered amongst the most important indicators of long-term animal welfare problems (Broom, 1993). Stereotypies are associated with past or present suboptimal aspects of the environment (Mason, 1991), and therefore they have been used as welfare indicators. However, some studies indicate that stereotypies in farm mink should not unconditionally be regarded as indicators of poor welfare (Wiepkema, 1987; Mittelman et al., 1991; Jeppesen et al., 2004).

In the present study, the anticipatory behaviours of high and low stereotyping female mink were studied when they were expecting either a positive reward (a tit-bit) or a negative reward (catching in a mink trap). The purpose of the study was to identify useful behavioural elements during an anticipation

test for the assessment of welfare of farmed mink and to validate the effect of positive and negative rewards on the performance of stereotypies.

Materials and Methods

In this experiment, 48 adult female mink were used. As a criterion for selection of the 48 mink, half of the mink should have performed stereotypies in more than 15 of 54 scans (High-st mink) and the other half should never have been observed performing stereotypies (Low-st mink). The behaviour of the selected 48 female mink was tested (day 0) before the experiment in order to obtain basic knowledge with respect to the behavioural elements 'use of nest box', 'stereotypies', and 'general activity'. All the mink were kept solitary in commercial mink cages with free access to drinking water and a nest box. All of the cages contained solitary mink, however, test mink were situated 2 meters apart. The mink were fed *ad libitum* by a machine at 11 o'clock with feed from a commercial feed kitchen (four out of six mink had feed left over the next day and the left-overs were distributed to the ones without left-overs).

To investigate anticipatory behaviour, a classical Pavlovian conditioning set-up was used, where the unconditioned stimulus (US) was given immediately after the conditioning stimulus (CS) on each trial. This procedure was used for the first 10 days of training. Then another procedure was used for the next 17 days, where the US was not presented until 1 min after the CS had ended. In total, the mink were trained on 27 successive days in the period from 8.30 a.m. to 10 a.m. During the 1 min CS-US interval the anticipatory behaviour of the mink was observed on days 11, 25, 26 and 27.

The CS used in the present studies consisted of either a high or a low tone. The high tone was followed and paired with the US positive reward (a tit-bit) and the low tone was followed and paired with the US negative reward (catching in a mink trap).

Immediately after the CS the mink was offered a tit-bit on a spoon (canned cat food) through the front wire netting of the cage or the cage-door was opened and the mink cached in a mink trap. The trapped mink was taken out of the cage and then the mink was released into the cage again.

Half of the High-st mink and half of the Low-st mink, hereafter called group-PH and group-PL, P indicating the positive reward and H and L indicating a high and low level of stereotypies, respectively, received the positive reward. The other half of the High-st mink and Low-st mink, hereafter called group-NH and group-NL, received the negative reward.

The physical distance between the mink allowed the succeeding mink to hear the CS tone when the preceding mink was trained. Therefore, on days 25, 26 and 27 the behaviour of the succeeding mink was observed during 1 min before the normal testing procedure. This extra test of the succeeding mink was performed simultaneously with the normal testing procedure. These extra tests allowed a comparison between the behaviour during the ongoing test and the behaviour before the test situation, when no person was present in front of the mink, but the mink was aroused by the CS-tone from the previously tested mink.

On the last day of testing (day 27), all the mink were tested five times, two times before feeding (in the period from 8.30 a.m. to 10.30 a.m.) and three times after feeding in the period from noon to 15.00 p.m.

This procedure was chosen to see if the behaviour of the mink was affected by the time of feeding.

Two persons performed all the training of the mink. The person who performed training with the positive reward wore orange clothes and the person who performed training with the negative reward wore grey clothes.

The duration of the behavioural elements of each mink was observed during a 1 min continuous sampling on days 0, 11, 25, 26 and 27. The behavioural elements observed are shown in table 1. The combination of the elements of the full repertoire was used on days 1 and 11. The full repertoire was used on days 25 to 27.

Statistics

Data were processed using the Statistical Analysis Systems Institute (1996) program. Anticipatory behaviour was calculated as the percentage of the total observation time. The mean of the behavioural parameters on days 25 and 26, and in the first test on day 27 was calculated for each individual during and before the test situation, and used in the statistic. In the same way the mean of the behavioural parameters on day 27 was calculated per individual before and after feeding. Because the behavioural data violated the assumptions of parametric statistical tests, distribution-free methods were used. Wilcoxon matched pairs test was used between independent groups, and Wilcoxon signed rank t-test between trials within the groups.

Table 1. Catalogue of behavioural elements.

§ Nest box	The mink is totally withdrawn to the nest box.
§ Nest entrance	The mink is lying in the nest box with the head and the forepart outside the box
Stereotypy	Regularly repeated and morphological identical movements without any obvious function (e.g. Bildsøe et al. 1991)
* Normal locomotion	Normal walking around in the cage
* Scratching	Scratching and biting the cage door,
* Standing	Standing in front of the cage door looking at the observer
* in/out	Running in and out of the nest entrance
Other activities	Drinking, eating, defecating, lying, freezing etc. These made up less than 1% of the observations and are not presented

§ on day 11 combined to: Nest

* On day 11 combined to: General Activity

Results

Behaviour before treatment

Before the start of the treatment on 24 October (day 0) the High-st mink spent less time in the nest box than did the Low-st mink (10.9% vs. 60.2%, $p < 0.001$). There was no significant difference in general activity (High-st mink: 45.5% vs. Low-st Mink: 39.8%). The low level of time spent in the nest box of the High-st mink corresponded to 43.6% stereotypic behaviour out in the cage. The Low-st mink did not perform stereotypic behaviour.

There was no significant difference between the two groups of High-st mink that subsequently received a negative or a positive reward. However, as regards the time spent in the nest box, a difference was found between the two groups of Low-st mink that later received a positive or a negative reward. The Low-st mink that were subsequently given a negative reward (NL) spent more time in the nest box on day 0 (78.0%) and less time out in the cage (22%) ($p < 0.05$) than Low-st mink (43.8% and 56.2%, respectively) that subsequently received a positive reward (PL) ($p < 0.05$).

Effect of 10 days of treatment

After ten days of training, the positive reward given on day 11 had the effect of group-PH and group-PL spending less time in the nest box (8.1% and 19.4%, respectively) than group-NH and group-NL that received a negative reward ($p < 0.001$) (59.2% and 78.3%, respectively). Group-PH performed stereotypic behaviour in 14.4% of the time, whereas group-NH did not perform stereotypic behaviour at all. Group-PL increased the general activity to 80.5% compared to 21.7% in group-NL ($p < 0.001$).

Group-PL spent more time in the nest box (19.5%) than group-PH (8.1%) ($p < 0.05$), but in contrast to PL, group-PH performed stereotypic behaviour. No significant difference in the behaviour of group-NH and group-NL was found.

Compared to the level on day 0, group-NH increased the time spent in the nest box from 9.8% to 55.5% ($p < 0.05$) and reduced the stereotypic activity to 0% ($p < 0.01$). As right from the beginning of the experiment the mink in group-NL spent much time in the nest box, the negative reward did not result in a significant increase.

Compared to the level on day 0, group-PH reduced the time spent performing stereotypic behaviour from 45.3% to 14.7% ($p < 0.05$), and increased the general activity from 42.8 to 77.5% ($p < 0.01$). The mink in group-PL reduced their time spent in the nest box from 43.8% to 19.4% ($p < 0.01$), while they

increased their general activity from 56.2% to 80.6% ($p < 0.01$).

Effect of 25-27 days of treatment

At the test on days 25-27, the previously demonstrated difference in the use of the nest box between mink receiving a positive or negative reward remained significant.

The mink in group-NH ($p < 0.05$) and group-NL ($p < 0.01$) spent more time in the nest box and in the nest entrance ($p < 0.01$) than the mink receiving positive rewards (group-PH and group-PL).

The mink in group-PL spent more time in normal locomotion ($p < 0.01$), they spent more time standing at the cage-door ($p < 0.001$), they scratched the cage-door ($p < 0.05$), and they spent more time moving in/out of the nest box ($p < 0.001$) than the mink in group-NL.

The mink in group-PH performed stereotypic behaviour, but not significantly more than the mink in group-NH. The mink in group-PH as well as in group-PL spent more time moving in/out of the nest box than the mink in group-NH and group-NL ($p < 0.001$). In general, the High-st mink performed more normal locomotion than the Low-st mink ($p < 0.01$).

Effect of observer

No significant effect of the presence of the observer was found on the time spent in the nest box. However, during the test, when the observer was standing in front of the cage, the mink in group-NL spent more time in the nest entrance than when the observer was not present ($p < 0.05$). The mink in group-NH performed less stereotypic behaviour when the observer was present than when the observer was not present ($p < 0.05$), whereas in group-PH the presence of the observer did not imply a significant reduction in stereotypic behaviour. Without the observer, the mink in group-PH as well as in group-NH spent 30% of their time performing stereotypic behaviour. In the presence of the observer, the mink in group-PH spent 13.2% of their time performing stereotypies, and in group-NH the mink only spent 2.4% of their time performing stereotypic behaviour.

In the presence of the observer, the mink in group-PH spent less time performing normal locomotion ($p < 0.001$), spent more time standing ($p < 0.05$), and spent more time moving in/out of the nest box ($p < 0.01$). Scratching the cage-door was only observed during the presence of the observer, and only in mink given a positive reward. However, it

was not possible to demonstrate a significant increase in the time spent performing such activities ($p=0.06$ for low-st mink).

Effect of feeding time

The mink were more active before feeding than after feeding. Although all the groups spent more time in the nest boxes after feeding ($p<0.05$), the difference between the mink given a positive reward and the mink given a negative reward remained significant. The mink in group-PH as well as in group-PL spent more time scratching the cage-door ($p<0.05$) and they spent more time moving in/out of the nest box ($p<0.05$) before feeding than after feeding, however, the mink in group-PH continued to spend more time moving in/ out of the nest box than group-NH ($p<0.05$). The mink in group-PH and group-PL spent more time performing normal locomotion ($p<0.01$) and more time standing ($p<0.01$) than group-NH and group-NL. However, as regards the time spent in the nest entrance, performing stereotypic behaviour, or scratching the cage-door, no differences were found between the mink given a positive reward and the mink given a negative reward. Within each group of treatment no significant differences were found after feeding between High-st mink and Low-st mink. Before feeding, group-PH spent more time performing stereotypies than group-PL ($p<0.05$), and they also spent more time performing normal locomotion ($p<0.05$) and less time in the nest box ($p<0.05$) than did the mink in group-PL.

Discussion

In general, the results demonstrated that mink are sensitive to rewards and have the capacity of distinguishing between positive and negative rewards. The impression was that expectation of a positive reward increased several activities in the cage while expectation of a negative reward increased time in the nest or in the nest entrance. This is in accordance with studies on rats (van den Bos, et al., 2003) and foxes (Moe et al., 2003), and suggests that the methods to access the value of supposed enrichments or the level of experienced welfare (Spruijt et al., 2001) can be developed on the basis of this behavioural response. Stereotypies were seen during the anticipation of both positive and negative rewards, but only in High-st mink. In the present study, the stereotypies during anticipation of a reward decreased on days 11 and 25-27 compared to the level on day 0, and the decrease was more pronounced in group-NH than in

group-PH. However this decrease seems to be related to the presence of the observer in the test situation. When the observer was standing in front of the cage, the fear of the negative reward increased the stay in the nest entrance, and thus decreased the stereotypies in group-NH and the normal locomotion in group-NL. When expecting a positive reward, the mink directed their response towards the observer by standing in front of the cage door, scratching the cage door, or by running in/out of the nest box, and thus they also reduced their stereotypies and normal locomotion, even though the reduction in stereotypies in group-PH was not significant. When the observer was not present and the mink, presumably, were aroused by the CS-tone, the levels of stereotypies in group-NH and group-PH were almost at the same levels as before the treatments, and new stereotypies were not developed in group-NL and group-PL. This shows that the performance of stereotypies was affected in the same way by welfare inducing and welfare reducing influences, and that the levels of stereotypy were mainly related to the presence or absence of the observer, acting as a proper stimulus to direct the normal behaviour. This confirms that stereotypies are not always a valid measure of poor welfare (Mason & Latham, 2004; Jeppesen et al., 2004). In a recent study (Vinke et al., 2004) it was not possible either to find any relationships between anticipatory activity (behavioural transitions) and stereotypies.

The effect of treatments (in nest box, normal locomotion, standing) was not affected by the feeding time. However after feeding, the mink spent more time in the nest box. Within treatment on day 27, no behavioural differences between High-st and Low-st mink could be found after feeding, whereas High-st mink performed more stereotypies and spent more time performing normal locomotion out in the cage before feeding than did Low-st mink. This could indicate that appetitive behaviour caused by feeding motivation is part of the normal and stereotyped activity observed in High-st mink before feeding.

The behavioural changes during anticipation of a positive or negative reward differed in the mink, indicating the potential of developing an anticipatory test for mink. However, the levels of anticipatory responses were influenced by the feeding and the test situation. The tendency of the animals to reduce stereotypies during anticipation of a reward may primarily depend on the observer's capacity to direct normal behaviour.

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Have fur bearers become domesticated (behavioural and brain biochemistry aspects).

O.V. Trapezov, N.N. Voitenko, V.A. Kulikov

Institute Cytology & Genetics, Siberian Department, Academy of Sciences of Russia;

630090, Novosibirsk, RUSSIA. Fax: 7 (3832) 33 12 78; Tel: 7 (3832) 33 05 12;

E-mail: trapezov@bionet.nsc.ru (work), E-mail: trap@philosophy.nsc.ru (home)

Abstract

It is well known that the wild individuals differ in compare with domesticated in degrees of body conformation, coat colour and correlated behaviour. Minks were tested for behaviour by “*hand catch test*”. As a result, two types of minks were distinguished, showing domestic or nondomestic behaviour. As shown the highest number of minks with domestic behaviour occurred among the *Sapphire* colour phase, than *Standard*. Two lines of standard minks were developed through behaviour-targeted selection for 15 years: one showing domestic behaviour, the other nondomestic. In minks showing nondomestic response to human, the level of *serotonin* in the hypothalamus and corpus striatum was reduced. This raised the question, what may be the specific differences in brain biochemistry between the *Standard* and *colour phase minks*? It was found that the activity of MAO A, the enzyme of serotonin catabolism, was significantly higher in the brain of *Sapphire* and *Silver-blue* minks than *Standard*.

Introduction

When we compare the wild individuals with domesticated of the same species, one of the first points which strikes is, that they differ from each other to different degrees in body conformation coat colour and correlated behaviour. This is also true for the American mink that has been captive-bred (under domestication) for more than a century. Its number keeps decreasing in nature, making apparent the growing need in its man-provided welfare. The purpose of the work is to demonstrate that mink has become a domesticate and as such will further benefit from human care.

We proceeded from the development of specific estimates of domestic behaviour in mink, using the “*hand catch test*”.

The results of many years of research conducted at the Institute of Cytology and Genetics (Novosibirsk, Russia) showed that mink behaviour can be

modified from wild to domestic provided that the experimental (starting) population includes individuals that are more docile, tameable, amenable to domestication than others a major evidence for the capacity of wild mink to become domesticates was the inherited reorganization of behaviour through breeding in captivity, or the reorganization of Nondomestic behaviour to Domestic.

Support that domestic behaviour has genetic bases came from the experimental fur farm of this Institute.

Materials and Methods

Testing the Level of Defensive Behavior Towards Man

Minks were tested for behaviour by “*hand catch test*”. As a result, two types of minks were distinguished, showing Domestic or Nondomestic behaviour.

The expression of **Nondomestic behaviour** varied qualitatively enabling to score it. Four scores were assigned to Nondomestic behaviour:

- Score 1. *Fearful response towards human*. When attempts were made to catch the caged mink, it retreated, hid in its wooden kennel, gaping and baring its teeth, cried shrilly or hissed, its posture showed intense emotional stress.
- Score 2. *Attack from the wooden kennel*. When attempts were made to catch the caged mink, it jumped to the entrance of wooden kennel, hid in it to attack the gloved hand, bit it with considerable intensity.
- Score 3. *Active attack outside shelter*. When attempts were made to catch the caged mink, instead of hiding, promptly attacked the hand. Even after the test was over, it kept crying, gnawed in fierce assault the bars of the cage at the sight the approaching gloved hand.
- Score 4. *Attacks enhancing in response to human approach*. Before test onset, i.e. before the breeder opened the cage and stretched out his hand, the caged mink vehemently responded to human presence by about the cage, gnawing its bars.

The expression of **Domestic behaviour** also varied qualitatively allowing to score it. Six scores were assigned to Domestic behaviour:

- *Avoidance of contact* with the gloved hand. This behaviour was assigned score “0”. When attempts were made to catch, it turned aside (slowly or rapidly).
- Score + 1 *Demonstration of exploratory responses*. The caged mink calmly responded to the stretched hand, showed the exploratory response, sniffing the hand with quivering vibrissae.
- Score + 2. *Calm response to contact with hand*. The mink displays exploratory reaction when observer bring the tips of his fingers into physical contact with snout and throat. Score +2 differed from those assigned score +1 in that at shorter distances from the hand, they did not retreat from it, endured the contact, allowing to touch face, chest, paws.
- Score + 3. *Active contact shown by the tested mink*. When human approached the cage, the mink excitedly ran around, awaiting human contact, tried to thrust its face out of the bar to reach the approaching hand, infrequently “cooing”. When the cage was opened, the mink got up, leaning

against the open door, reached out for the gloved hand. Inside the cage, it actively sniffed about the gloved hand, not infrequently leaned on it. When attempts were made to touch any part of its body, the mink dodged and freed itself.

- Score + 4. *The caged mink allowed to touch any part of its body*. It was actively exploratory, played with the hand, but resisted attempts to handle it.
- Score + 5. *The caged mink allowed to handle it*. These were unique among the farm population. They showed extreme domestic behaviour, allowed handling without displaying fear, aggression. Females tolerated examination of her kits, even during lactation in a way making all precautions unnecessary.

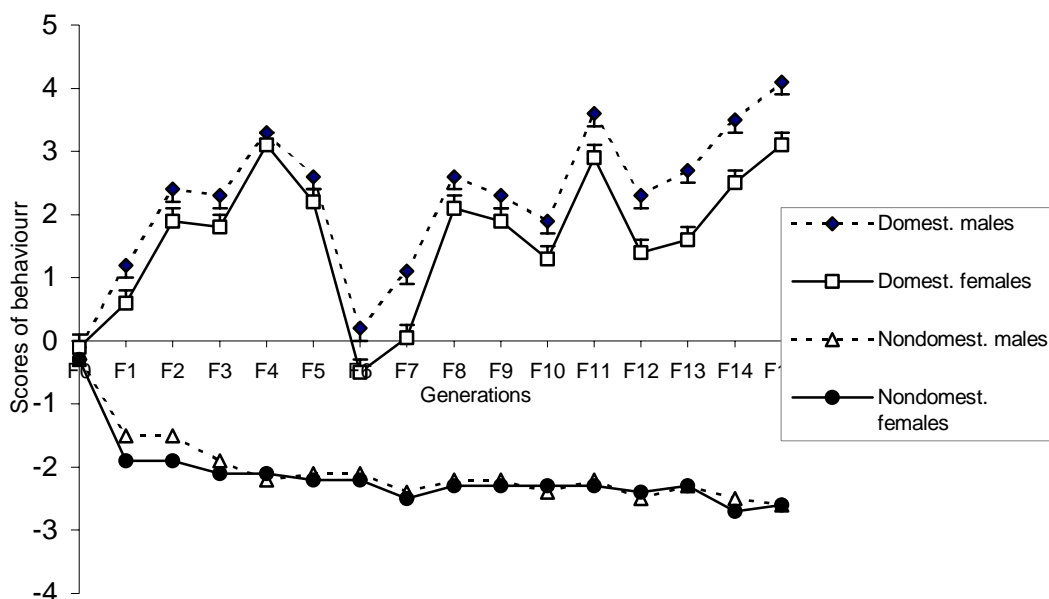
Results and Discussion

As the data in table 1 show docile, tameable, or amenable to domestication minks occur in populations of the standard commercial farms. Most minks of the farm population showed domestic behaviour according to the results of the “hand catch test”.

Table 1. Coat colour and occurrence frequency of American minks showing domestic behaviour in a farm population

				Nondomestic (17.3%)				Domestic (82.7%)					
				-4	-3	-2	-1	0	+1	+2	+3	+4	+5
STANDARD	♂	n	8 700	6	113	426	559	7262	188	88	41	15	2
		%	100	0.07	1.3	4.9	6.4	83.5	2.1	1.0	0.5	0.2	0.02
	♀	n	8 800	14	214	643	844	6 917	91	41	28	5	3
		%	100	0.1	2.4	7.3	9.7	78.6	1.0	0.5	0.3	0.06	0.03
♂+	n	17 500	20	327	1069	1403	14179	279	129	69	20	5	
	%	100	0.1	2.0	6.1	8.0	81.0	1.6	0.7	0.4	0.1	0.03	
SAPPHIRE	♂	n	7 200	7	81	318	413	5782	261	138	120	57	23
		%	100	0.1	1.1	4.4	5.8	80.3	3.6	1.9	1.7	0.8	0.3
	♀	n	7 220	17	248	716	945	5071	123	42	43	8	7
		%	100	0.2	3.4	9.9	13.2	70.2	1.7	0.6	0.6	0.1	0.1
	♂+	n	14 420	24	329	1034	1358	10853	384	180	163	65	30
		%	100	0.2	2.3	7.2	9.4	75.3	2.7	1.2	1.1	0.4	0.2

Fig. 1. Change in the mean score for behaviour in the offspring of minks selected for aggressive and tame behavior for 15 generations.



Are the *colour phase minks* more domestic in terms of behaviour than the *Standard*?

This table 1 also shows that the highest number of minks with domestic behaviour occurred among the *Sapphire* colour phase. Thus, the number of minks scored + 5 was tenfold greater among *Sapphire* than *Standard* minks.

ENHANCEMENT OF DOMESTIC BEHAVIOUR AND OF THE REVERSE NONDOMESTIC BY SELECTION

Two lines of standard minks were developed through behaviour-targeted selection for 15 years: one showing Domestic behaviour, the other Nondomestic.

The founding stoks selected for domestic and nondomestic behaviour was of a farm population, 10,000 individuals in size. The F_0 designed to be selected for nondomestic behaviour showed distinct aggressiveness (-2.4 ± 0.1 scores for males and -2.2 ± 0.1 scores for females); and the F_0 selected for docility toward human was scored $+ 3.6 \pm 0.1$ for males and $+ 2.3 \pm 0.1$ for females. A hundred fifty females and 100 males were taken as the founding generation for selection in either direction. Fig. 1 present the results for 15 selected generations.

Because sexual dimorphism was observed for the selected mink populations, the data for the behavior of males and females are given separately.

The data primarily demonstrate the efficacy of selection for enhanced domestic behaviour and in the reverse direction, for enhanced nondomestic. The mean effect of selection for nondomestic behaviour was manifested in the first two generations (fig. 1), the mean value changed slightly in the subsequent. The course of selection for domestic behaviour was more complicated. The effect was marked up to the fourth generation, the mean value reduced somewhat at the fifth and sharply fell at the sixth so that the initial state almost completely recovered (fig. 1). In the subsequent selected generations, the mean value again rose substantially.

It should be noted that in calculation of the means for the observed response to selection per generation, there were no differences in selection direction, although the effect was strongest for the domesticated males. This was possibly because the selection coefficient for enhanced domestication was smaller in females than males. The mean response to selection for nondomestic behaviour was somewhat smaller and there were no differences between the sexes. However, in the populations selected for nondomestic behaviour, all the offspring was already aggressive in the third generation. Furthermore, aggressiveness smoothly increased in offspring of nondomestic aggressive minks (from -1.5 ± 0.1 in the F_4 to -2.2 ± 0.04 in the F_{15} for males and from -1.9 ± 0.1 in the F_1 to $-$

2.2± 0.02 in the \bar{F}_5 for females). This was not observed in the course of selection for domestic behaviour. However, among minks selected for domestication in all the selected generations, there appeared all the two behavioural types: domestic and nondomestic. As seen in fig. 1 selection effect reduced at generations 5 and 6, there appeared many individuals with the nondomestic aggressive response, more among females. From generation 7, the mean domestication score rose again. In contrast to selection for nondomestic behaviour, sexual dimorphism was retained in behaviour expressivity throughout the 15 selected generations. What is more important: the value of the phenotypic variance of the character in the selected for nondomestic behaviour.

The materials for behavioural modification through selection for domestic and nondomestic behaviour reveal heritable variation in the behaviour of farm-bred mink populations. The presence of this adaptive polymorphism is a prerequisite for successful genetic adaptation of minks to captivity conditions and for their historical domestication.

To provide a basis for polymorphism study, a founding stock of minks showing extreme domestic and nondomestic behaviour had to be set up. These were to be subjected to selection in the opposite directions. Thousands of minks had to be analyzed. It was expected to involve young minks of the year. This was because young growing minks were numerous and diverse. To cover diversity wider, one representative of each litter was analyzed. For this reason, parameters of similarities between the parental pairs were not statistically estimated. Based on these estimates, judgements could be made about the range of genetic diversity. However, standard conditions of cage maintenance at the farm and the same limited contacts with human allowed us to believe that the revealed polymorphism had a

genetic basis. This was confirmed by the effects obtained in the early selected generations.

The observed heritability expressed as the ratio of the shift produced by selection (R) to the selection differentiation (S) yielded a rather rough estimate (table 2). It indicated, however, that 60% of additive diversity contribute to selection for domestication and about 40% to selection for nondomestic behaviour (37% of females and 38% of males) in two generations. The considerable shift obtained in selection of the first two generations for nondomestic behaviour demonstrated that the number of major genes controlling the threshold nondomestic behaviour was small, one or two, and the genes rapidly became fixed at the early steps of selection. This supported the results of the previous genetic analysis of dog behaviour (*Krushinsky, 1938, 1945, 1946*).

As seen in fig. 1, selection for domestication followed a more complicated course. Judgments were made on the observed heritability (table 2). Additive genetic effect was not responsible for the recovery to the almost initial state observed in generations 4-6. This recovery was hard to explain, although dissimilar responses to selection was a feature of many breeding experiments (*Falconer, 1960*). Quite possibly, maternal embryonic effects started to play an important role in the determination of a character. It is generally accepted that various prenatal factors affect many behavioural traits, including emotional reactivity and the fear response (*Trut, Borodin, 1976*). The extent to which the behavioural phenotype is modified by interference in the prenatal period is dependent on many factors, including the offspring and maternal genotype, the stage of embryogenesis, interference time.

Table 2. Estimates of the observed heritability in selection for domestic and nondomestic behaviour.

Generations	$h^2 = R/S$			
	Domestic		Nondomestic	
	♀♀	♂♂	♀♀	♂♂
$F_2 - F_0$	0.37	0.38	0.60	0.61
$F_4 - F_2$	0.30	0.18	0.07	0.18
$F_6 - F_4$	-1.43	-0.70	0.05	0.03
$F_8 - F_6$	0.40	0.39	0.06	0.02
$F_{10} - F_8$	-0.10	-0.15	0.01	0.01
$F_{12} - F_{10}$	0.30	0.22	0.01	0.01
$F_{15} - F_{12}$	0.44	0.42	0.02	0.01

However, it may be thought that these interferences have been established by natural selection and act as mechanisms of phenotypic stabilization of a character. There is evidence indicating that the prenatal effect of the maternal environment are reverse to the maternal additive genetic effects, i.e. the maternal genotype determines the low level of a character, whereas mothers promote the formation of its higher level. Thus, prenatal effects may smoothen genetic differences at the phenotypic level. Very likely, by the fourth generation selected for domestication, certain neurochemical mechanisms regulating development are modified by various agents acting on pregnant. This possibility prompted us to further search for differences in the brain serotonin and catecholamine systems between nondomestic and domestic minks.

Interesting relations between selection direction and variability in behaviour were revealed in the course of selection for domestic and nondomestic behaviour. Phenotypic variability in selection for domestication is several times greater than that in selection for nondomestic (fig. 1). This pattern was observed even in the unselected commercial population: phenotypic variability in the expressivity of domestic behaviour considerably surpassed that of nondomestic behaviour. Variability in the expressivity of domestic behaviour is particularly high among *Sapphires* direcessives, which are produced by a combination of two gray colour variations: *aleutian* (genetic symbol for colour type – *a/a*) and *silver-blue* (genetic symbol for colour type – *p/p*). There is a possibility that selection of *Sapphire* minks for domestication was more efficacious than for *Standard*. The coat colour genes have been called with good reason “*the domestication genes*” (Keeler, 1942, 1947). A plausible explanation for this are that the early steps are common in the synthetic pathways of the neural mediators and the pigment melanin in minks under domestication.

The materials for behavioural modification through selection for domestic and nondomestic behaviour reveal heritable variation in the behaviour of farm-bred mink populations. Thus, the demonstrated behavioural diversity in mink farms has a genetic nature and the degree of its expression can be estimated by the “*hand catch test*”. The presence of this adaptive polymorphism is a prerequisite for successful genetic adaptation of minks to captivity conditions and for their historical domestication.

The affirmative answer was provided by the “*hand catch test*” results.

As shown in Tab. 1, *Sapphire* (genetic symbol for colour type, *a/a p/p*) raised in the usual commercial farms are more domesticated than *Standard* (colour type *+/+*). There was good reason for referring to the coat colour genes as the domestication genes (Keeler, 1942, 1947). Therefore, it follows that the *colour phase* resulting from breeding mink for many generations in captivity is more domesticated, in terms of behaviour, than *Standard*.

This raised the question, what may be the specific differences in brain biochemistry between the *Standard* and *colour phase minks*?

Do changes in brain biochemistry take place in the course of mink domestication?

Genes that influence the extent to which the emotional state is manifest have been identified. These genes program the synthesis of *serotonin* involved in the conveyance of neural impulses in the brain structures and of the *enzyme monoaminoxidase* degrading serotonin. It has been amply demonstrated that *serotonin* is important to the neuroregulation of behaviour (Naumenko & Popova, 1975; Popova et al., 1978).

Interest in serotonin keeps augmenting with reference to the problem of the domestication of fur bearers. This is because serotonin participates as an inhibitory factor in the central regulation of different types of aggression. The higher level of brain serotonin in domestic animals can make them less aggressive. Previously was shown the activity of the key enzyme of serotonin biosynthesis *tryptophan hydroxylase* was substantially lower in the midbrain of highly aggressive foxes than in domestic (Popova et al., 1975). This might have played a role in the domestication of wild fur animals, and the reorganization of their behaviour and many of their morphological-physiological changes might have been the result of the same genetic changes produced by *natural selection in captivity* vectorized for the amenability to domestication (Belyaev, 1969, 1979, 1981).

In fact, the inhibitory properties of serotonin have been demonstrated for different models of aggression (Popova et al., 1978; Malmkvist et al., 2003).

This raised the question, if there exists in the founding population of farm bred minks not subject to selection polymorphism for brain monoamine

acids and, if it does exist, how is it related to animal response to human?

It was found that:

1. The farm bred mink population was heterogeneous with respect to the activity of the brain monoergic systems. This polymorphism was consistent with the one observed for the response to human. Minks with domestic and nondomestic response to human all differed by the measured characteristics of the serotonin and catecholamine brain systems.
2. In minks showing nondomestic response to human, the level of *serotonin* in the hypothalamus and corpus striatum was reduced (Fig. 2) and so was the content of its metabolite 5-hydroxyindolactic acid in the corpus striatum (Fig. 3).

Materials and Methods

Brain monoamines were studied in minks differing by the response to human. There were 30 male American minks (*Standard*, +/+), aged 6 months, of a common farm population that has been, as yet, not selected for behavioural response to human. They were scored as follows: nondomestic - 3.6 ± 0.2 ; domestic 0.0 ± 0.0 ; domestic + 4.1 ± 0.1 . There were 10 minks in each group.

The experiments were performed in November at pelting for commercial purposes. The minks were sacrificed by cervical dislocation, the brain was placed on ice, and the midbrain, hypothalamus and corpus striatum were dissected. The level of noradrenaline, dopamine, serotonin and of its main metabolite 5-hydroxyindolacetic acid (5-HIAA) were determined fluoremetrically (Jacobowitz, Richardson, 1978). The level of dopamine was determined in the corpus striatum; the content of noradrenaline, serotonin, and 5-HIAA was measured in the hypothalamus, midbrain (with the pons area), and corpus striatum.

Results

It was found that serotonin content varies in the brain structures of minks differing by the response to human. In the hypothalamus and corpus striatum, the content was lower in nondomestic minks than domestic (fig. 2, 3). The content of the serotonin metabolite 5-HIAA in the corpus striatum was also lower in nondomestic minks compared to evasion. No difference were found in the content of serotonin and 5-HIAA in the corpus striatum in minks of all three groups.

INFLUENCE OF GENES AFFECTING COAT COLOUR ON SEROTONIN TURNOVER IN THE MINK BRAIN.

There is evidence to suggest that the catabolism of brain neuromediators is also altered in minks carrying genes affecting coat colour (Voitenko & Trapezov, 1999). As the data in table 1 show, genes affecting coat colour act like the domestic behaviour genes. These observations are consistent with Keeler (1947) who justly called the coat colour genes "the domestication genes". This prompted us to compare brain serotonin metabolism in *Sapphire* and *Standard* minks of a farm population not subject to selection targeted at domesticated behaviour.

Fig. 2. The level of serotonin in the brain regions of minks differing by the response to human.

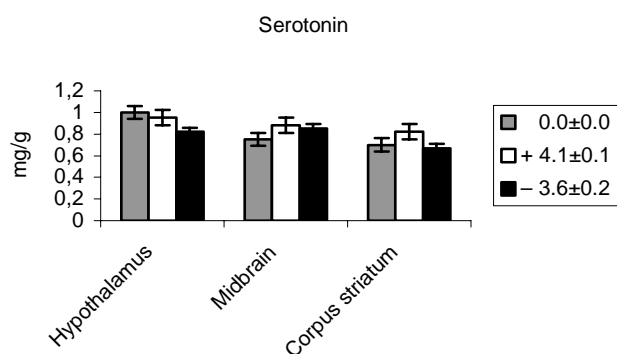
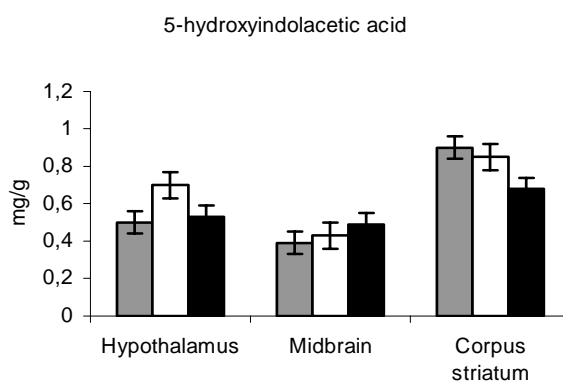


Fig. 3. The level of 5-HIAA (serotonin metabolite) in the brain regions of minks differing by the response to human.



The measurements in the brain areas included: 1) the levels of serotonin and of its major metabolite 5-HIAA; the activities of the metabolic enzymes of serotonin; 2) the key enzyme of serotonin biosynthesis tryptophan hydroxylase, and of the

major catabolic enzyme monoamine oxidase type A (MAO A).

Materials and Methods

Male mink were used in the experiments. Their genotypes were: 1) *Standard* (+/+), 2) *Sapphire*, color phase homozygous for the *aleutian* and *silver-blue* coat colour genes (*a/a p/p*), and 3) *silver-blue*, homozygous for the coat colour gene (*p/p*). The experiments were performed in November at pelting for commercial purposes. The mink were sacrificed by cervical dislocation, the brain was placed on ice, and the midbrain, hypothalamus and corpus striatum were dissected. The levels of serotonin and 5-HIAA were determined fluorometrically (Jacobowitz, Richardson, 1978); the measured values were expressed as $\mu\text{g/g}$ brain issue. The activity of tryptophan hydroxylase was determined fluorometrically (Kulikov, 1992) in the presence of 6, 7-dimethyltetrahydropteridine co-factor; the measured values were expressed as nmoles of 5-hydroxytryptophaan/mg protein/min. The activity of the monoamine oxidases A type was determined by spectrophotometry (Gorkin, 1981) in the presence of serotonin (substrate of MAO A) and benzylamine.

The kinetic parameters K_d and V_{\max} were estimated using the least squares method (Cornish-Bowden, 1979). Student's t-test was applied to treat the other parameters.

Results

This analysis demonstrates that *Sapphire* colour phase considerably affected serotonin metabolism in the brain (Fig. 4).

It was found that the activity of MAO A, the enzyme of serotonin catabolism, was significantly higher in the brain of *Sapphire* and *Silver-blue* minks than *Standard* (Table 3).

An increase in the activity of the enzyme of serotonin biosynthesis was found in the midbrain of *Sapphire* mink (fig. 5). It may be concluded that the changes in the activity of the key enzyme of serotonin biosynthesis tryptophan hydroxylase are caused by the *Silver-blue* colour phase.

Fig. 4. Concentration of serotonin and its metabolite 5-hydroxyindolacetic acid (5-HIAA) in the midbrain of *Standard*, *Sapphire* and *Silver-blue* mink.

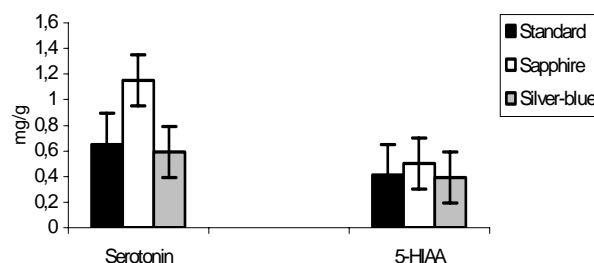


Table 3. MAO A activity in the midbrain and hypothalamus of *Standard*, *Sapphire* and *Silver-blue* mink

Colour phase	Number of animals	The activity of type A MAO A	
		Midbrain	Hypothalamus
<i>Standard</i>	10	2.17± 0.32	3.51± 0.62
<i>Sapphire</i>	10	3.05± 0.23*	2.41± 0.24
<i>Silver-blue</i>	14	4.84± 0.30**	2.59± 0.29

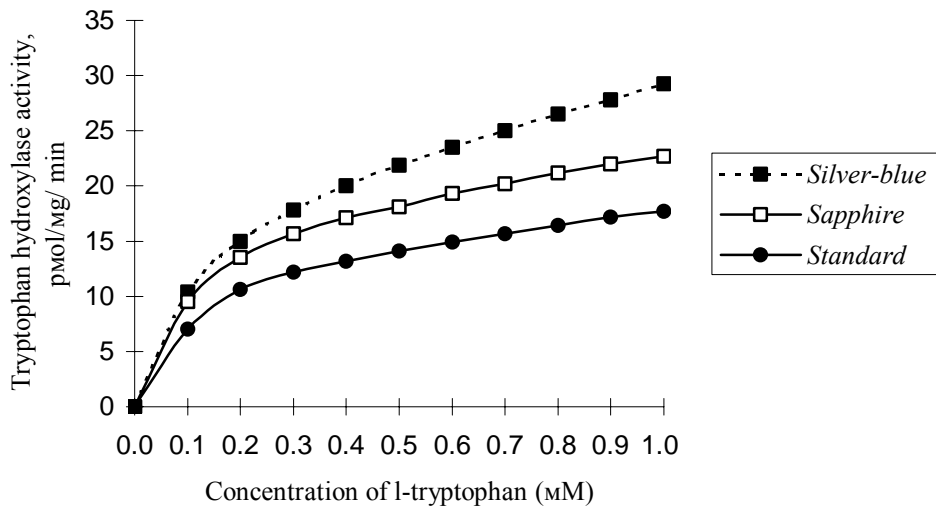
* $p < 0.05$

** $p < 0.01$ in comparison with *Standard* mink (Student's "t" test).

Significant changes in serotonin metabolism were demonstrated in more domesticated *Sapphire* mink. The pleiotropic effect of such colour phase is manifest as changes in the major metabolic enzymes of serotonin, i.e. the key enzyme of serotonin biosynthesis, tryptophan hydroxylase, and the catabolic enzyme MAO A.

Serotonin is a phylogenetically ancient brain neurotransmitter with an extremely wide spectrum of action (Naumenko & Popova, 1975) and for this reason at least some of the physiological features of mutant colour phase mink may be explained by changes in serotonin metabolism. One of these features may be reduced nondomestic behaviour of *Sapphire* mink towards humans.

Fig. 5. The tryptophan hydroxylase activity in the midbrain and hypothalamus of different colour phase mink.



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I – 11 P

Evaluation of comfort of fur-bearing animal keeping by analyzing behaviour

Igor A. Plotnikov, Olga Ye. Yevenko, Oleg Yu. Bespyatykh

Russian Research Institute of Game Management and Fur Farming, Russian Academy of Agricultural Sciences, 79 Engels Street, Kirov, 610000, Russia

e-mail: bio.vniioz@mail.ru

Abstract

Conditions of fur-bearing animal keeping in different cages: generally used and those constructed according to the recommendations of the Council of Europe were studied. The welfare of animal keeping was evaluated by behaviour. The methods of finding, registration and analysis of the elements of fur-bearing animal behaviour were worked out. Animals' behaviour was observed in two ways: visually and with video cameras. The latter way is more universal and makes it possible to observe animals without disturbing them in their covers and in a dark time of a day. The main studies were carried out on red fox. The methods were tested on polar fox, raccoon dog, marmot, nutria, sable, mink, ferret. 170 elements of behaviour were totally observed, 35 of them were used most often. The analysis of behaviour will give an opportunity to evaluate the comfort of keeping conditions, the efficiency of using a new way or element of technology of fur-bearing animal keeping.

Introduction

In 1999 the Standing Committee of the European Convention for the Protection of Animals Kept for Farming Purposes under the Council of Europe adopted "Recommendations Concerning Fur Animals – T-AP (96) 19". Requirements on significant improvement of the conditions of animal keeping given in those recommendations should be fulfilled by the 31st of December 2010. Besides, certain organizations that support the protection of animals stated that conditions of fur-bearing animal breeding were not humane, and drastic measures should be undertaken to improve the welfare of animal keeping.

Some requirements advanced are not scientifically grounded, so it is necessary to study their necessity in details. When animals do not show abnormal behaviour, self-wounding and diseases then it means physical and mental health and may be interpreted as comfort keeping (Niedzwiadek et al., 1998). The indices of comfort keeping can not be objectively defined only by traditionally used biochemical and

morphological studies of animal health. Environmental conditions don't always have a direct effect on physical and morphological features. The change of metabolic and behaviour reactions of an organism is most usual (Schwarz, 1960). Changes in behaviour are the first reaction of an organism to environmental transformation that is easily found. Comparing those reactions we have an opportunity to realize in what direction conditions of animal keeping change – favourable or unfavourable one (Kovalcikova & Kovalcik, 1974).

Material and Methods

The main studies were carried out on red fox. Observations of behaviour of other species of fur-bearing animals (polar fox, raccoon dog, marmot, nutria, sable, mink, ferret) were also made. We worked out the method of finding, registration and analysis of caged fur-bearing animals. That method was universal and suitable for every species of animals but the features specific for them should be taken into account. Behaviour was evaluated in two groups of animals simultaneously. The first group served as a control one and animals of that group were kept under usual conditions. The animals of the second group (an experimental one) was kept under new conditions that were supposed to be more comfortable (microclimate conditions, the size of a group, the area of a cage, a cover, a shelf for rest, toys and so on). The number of cages in every group for observing the behaviour per one investigator made up 4 cages for red fox, polar fox, raccoon dog, marmot, nutria and sable and 6 ones for mink and ferret.

The registration of the elements of behaviour was carried out by the observer and with video cameras with an infrared light that were connected with a monitor and a recording device. 1-2 video cameras set up at some distance from a shed, and with video cameras – peep-holes set up in the roof of a house were used. Video observation was the only way to record animals' behaviour in covers and in a dark time of a day. Cameras were switched on for 1 minute at intervals of 5-15 minutes. The whole

information was entered in the ethological observation record. For every element of behaviour its own number and graphic symbol was given. With computer statistical processing the frequency and duration of showing of different elements of behaviour were evaluated.

All forms and elements of behaviour were subdivided into groups, two of them were the principal ones – a comfort and discomfort behaviour. Such classification and analysis of behaviour as to the comfort level made it possible to give a well-reasoned conclusion on the efficiency of using a new version of caged keeping of fur-bearing animals.

Studying of the influence of microclimate on the behaviour was carried out on red fox. Together with behaviour registration the changes in microclimate indices were registered. They were temperature, relative humidity, air speed, pressure (Plotnikov at al., 2000). Observations were carried out in summer and winter as those seasons of a year were characterized by the highest positive and negative fluctuations of microclimate indices and had the most significant influence on the changes of animal behaviour.

Results and Discussion

170 elements of behaviour were totally revealed, 35 of them were observed most often.

Elements of behaviour associated with taking care of a body were referred to a comfort one. In the majority of animal species the way of maintaining the cleanliness of a body was expressed in different ways of fur licking, scratching, shaking. Such behaviour was observed more often and longer during the period before and after sleep. Different ways of scratching and shaking oneself were observed at feeding, locomotion and rest. Yawning and stretching oneself took place after sleep.

Elements of behaviour similar to comfort were referred to a separate group. They were different poses of local activity (poses at which animals are awake, being on one and the same site and in a sitting, standing or lying position).

Elements of behaviour characterized as discomfort were included in a separate group. They were different showing of nervousness (fear, aggression, pain, depression and so on). Discomfort had a pronounced outward exhibition. If an animal was aggressive, then it had raised ears, fixed look directed forward, disheveled hair on the back and in the neck, a strainedly raised tail. Depression was characterized by the decrease of intensive activity

and appetite. A head, a tail and flabby cheeks and eyes became lackluster. Even a very low level of fear was invariably expressed in the behaviour when a tail was put between legs. That putting of the tail between legs was accompanied with drawing ears backward.

A greater influence on the behaviour of animals was caused by microclimate changes. Investigations carried out on red fox and other representatives of *Canidae* showed that with the rise in temperature of environmental air up to 20 °C a motor activity of animals increased. Animals became more active, different elements of playing behaviour and jumping to a mesh wire cage side were observed. When the rise of temperature continued a typical pose of rest was noted when an animal lay on its side flat on the floor. And its pads were at a distance from a body. Therefore, animals instinctively tried to increase heat emission enlarging their body area. When it was too heat (30 °C and higher), and in particular at the direct sun radiation a mouth cavity was open, a tongue dangled, the breathing became faster. That favoured the cooling of an organism through the increasing of an evaporation rate from mucous membranes.

If the effect of high temperature took place for a long time (usually in mid-summer) the appetite of animals fell, their motions became sluggish and they lay longer. During those periods overheating of organisms might occur, and in more severe cases – even a heat stroke.

All elements of behaviour mentioned may be included in the group of elements disturbing comfort. These forms of behaviour indicate that it is necessary to take urgent measures to improve the technology of keeping of caged fur-bearing animals. Fur-bearing *Carnivora* bred in farms are adapted to low environmental temperatures most of all. This is associated with the fact that their wild ancestors live in northern latitudes.

In a winter period of a year low air temperatures increase the heat emission in animals, so to conserve a steady temperature of a body in an organism metabolism becomes more intensive. Animals are not active during that period, the greater part of the time they lie rolling themselves up into a ball. Their feet are bent at an angle and are put under their body. A head lies on hips, a muzzle rests against the root of a tail. A tail rounds a body on the outside. Such pose decreases a body surface and heat losses and preserves sensitive parts from overcooling. When the air temperature falls as low as – 30 °C and

lower, reflex shiver in animals is observed because of skeletal muscular contraction. Hair cover becomes disheveled. Such behaviour also shows the state of discomfort.

It is known that at the increased air humidity animals endure worse both high and low air temperatures. A high relative humidity of air results in worsening of an appetite and makes it difficult to evaporate moisture through a respiratory tract. At that time animals become inert, motor activity decreases. At high positive temperature the passes in sheds and cages should not be splashed with water. That will cause the increase of relative humidity of air and worsen the state of animals, and therefore that will immediately change their behaviour.

The rise of the air speed always favoured the welfare of animals at high positive temperatures, and it increased discomfort at negative temperatures. The highest depression in caged red foxes was observed in a winter period at low atmospheric pressure under the effect of cyclone when the air temperature was about 0 °C, relative humidity – 100 %, air speed – 5-8 m/s with rushes of wind up to 14 m/s. Beyond doubt such conditions maximally increased a cooling effect of air and resulted in overcooling of young and weakened animals.

Conclusion

Therefore, when analyzing behaviour of animals, revealing and registering elements of comfort and discomfort, it is possible to evaluate in time the

conditions of animal keeping and to suggest measures on microclimate optimization. The analysis of behaviour allows to draw substantiated conclusions on the efficiency of using of a new way or an element of technology of caged fur-bearing animal keeping.

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I – 12 RP

Conflicts arise between minks of different behavioural types

O.V. Trapezov, I.N. Oskina, R.G. Gulevich

Institute Cytology & Genetics, Siberian Department, Academy of Sciences of Russia;

630090, Novosibirsk, RUSSIA. Fax: 7 (3832) 33 12 78; Tel: 7 (3832) 33 05 12;

E-mail: trapezov@bionet.nsc.ru (work), E-mail: trap@philosophy.nsc.ru (priv)

Abstract

Hostility between two minks raised in the same cage (♂+♂ and ♀+♀) can be evaluated in dominance terms: “alpha” (α) and “beta” (β) individuals. This is vividly manifest at pelting time in conditions of Siberia when temperature drops to -30°C , food freezes hard on cage wire nets, and fur animals lose weight. As a result the leader in the pair weights more than the subleader. The important question then is, how sex and behavior may affect conflict between two paired minks. To study the role of typical behavioral patterns involved in conflict between young minks raised pair wise, standard males and females of groups selected during 15 generations for tame and aggressive behavior in response to human were used. The obtained results (intensity of bites, body weight, cortisol and plasma transcortin levels) shows that aggressive animals suffered more from stressing exposures.

Introduction

Several types of aggression can be in juvenile pair-wise housed mink as based on different motivational backgrounds.

1. Aggression engendered by fear characteristic of cornered animals, the aggression is preceded by attempts to flee.
2. Aggression between males, the aggression is exaggerated when two strange males encounter. To study this aggression type, males are conventionally maintained alone, then in pairs. The preceding isolate has usually a decisive influence on the manifestation of the aggressive response. There are data to indicate that conditions of isolation enhance the trend toward fighting possibly related to a decrease in the levels of the brain biogenic amines serotonin and noradrenaline (Welch, 1970). The emergence probability of aggressiveness between males can be reduced by drugs when pharmacological anticholinergic effects (interfering with acetylcholine function) which inhibit isolation produced aggressiveness. However, a meaningful interpretation of data on the

influence of drugs on the aggressiveness type is difficult because it can be suppressed by substances that either elevate or lower the level of acetylcholine, serotonin or noradrenaline in the brain.

3. Aggression due to irritation differs from other aggression types in that it is elicited by a variety of stimuli many of which, in all likelihood, are annoying. The hypothalamic ventromedial nucleus and also sex hormones play an important role in aggression of this type.

Hostility between two animals raised in the same cage can be evaluated in dominance terms: one individual can without penalty or attack reprimand another. In these conditions, a despot is brought into prominence, it is the “alpha” (α) individual having priority for food access. The other “beta” (β) individual, is pushed away. This is vividly manifest at pelting time in conditions of Siberia in the second half of October, when it is already frosty, and by November, when temperature drops to -30°C , food freezes hard on cage wire nets, and fur animals lose weight. Good heat isolation in wood boxes is frequently too costly. As a result, at the time of pelting, the leader in the pair weighs more than the subleader. The important question then is, how sex and the typical behavioural patterns may affect conflict between two paired minks.

Materials and Methods

This study was performed at the experimental fur farm of the Institute of Cytology and Genetics (Novosibirsk). Minks were tested for behaviour by “hand catch test”. As a result, two types of minks were distinguished, showing domestic or nondomestic behaviour. Two lines of standard minks were developed through behaviour-targeted selection for 15 years: one showing domestic behaviour, the other nondomestic (see proceedings of IFASA 2004: *O.V.Trapezov, N.N.Voitenko, V.A.Kulikov*: “Have fur bearers become domesticated (behavioural and brain biochemistry aspects”).

Mink breeding practice demonstrated that it is most profitable to raise young mink in pairs of different cages. To identify the typical behavioural patterns (aggressive and tame) in tolerance to conflict situations, we deliberately used pairs of the same sex. One reason was to exclude, for example, the effect of heavier males on the result of leadership establishment. For this purpose, from weaning to pelting time (November 20th), pairs of the same sex whose weights were the same before grouping were used. The groups were as follows.

1. Pairs homogenous in behavior (aggressive male + aggressive male), (tame male + tame male), (aggressive female + aggressive female), (tame female + tame female).
2. Pairs heterogenous in behavior (aggressive male + tame male), (aggressive female + tame female). Identification (classification) of the tame or aggressive leader was subsequently based on body weight only.

Two-month-old mink males were weaned in June and placed into free cages in pairs simultaneously. The pairs were selected so that the animals were of equal weight; one of them was derived from a mother with the aggressive type of behavior, the other from a tame mother. In the age of seven months the males were tested for behavior and weighed. Further hormonal studies were done on 17 pairs of animals, where the neighbor differed clearly in body mass. Simultaneously, blood samples were taken from the tips of the tails. After slaughter bite marks were counted on the fresh skins. The numbers of animals in the groups are indicated in figure legends.

The levels of total cortisol in blood were tested by the method of competitive protein binding (Murphy, 1967), using mink cortisol-binding protein (transcortin), cortisol (Sigma Chemicals, US), and [1, 2, 6, 7-3H]-cortisol 90 Ci/mmol (Isotope, St.-Petersburgh, Russia).

Intra- and interassay coefficients of variation were less than 5% and 10%, respectively. The percentage and level of free cortisol were detected according to Martin, Cake, Hartmann, Cook (1977). Transcortin was assayed by the radioligand method (Tinnikov, 1993). To assess the precision of this method transcortin was measured in 10 various samples on different days, each time using freshly made up reagents. The mean coefficient of variation was 8%. The dissociation constant K_d , characterizing the binding between transcortin and cortisol, was found by the Scatchard method to be 4.0 nM.

The results are represented as mean values and mean errors. The statistical treatment was done by analysis of variance and the Student test. Because of wide variability of data on the level of free cortisol, the Wilcoxon test was applied for comparison of the mean values.

Results

Based on body weight measurement data, the α - individuals were significantly heavier than the β - individuals in all male or female pairs by the beginning of August. This difference in body weight kept increasing, and maximal discrepancy was reached by pelting time. There were just a few pairs with the same body weight. In pairs heterogeneous with respect to behavior, it was possible to distinguish which behavior type (tame or aggressive) confers body weight advantage. As the data in Tables 1 and 2 show, a weak tendency was observed for males: leaders for body weight proved to be tame and, vice versa, body weight leaders proved to be aggressive among female (33 g versus 29 g). When differences in body weight between the α - and β - individuals were compared, it was found that the β - aggressive males lost most weight. Thus, their weight was 80% of the α - individuals in group I, 70% of those in group IV.

Tame β - individuals, when raised in homogenous and heterogenous pairs, suffered smaller losses: 85% in α of group II and 84% in α of group III. Clearly, the β - aggressives suffer most appreciable body weight losses for males raised in heterogenous pairs. The situation was less dramatic for females. In homogenous for behavior pairs (groups I and II) body weight in both aggressive + tame pairs was 86% of α . In heterogenous pairs, in contrast to males, greatest body weight losses were observed for the β - tame females of group III (82% the β of the α).

At the time of molting, the conflict situation in the pairs became much more dramatic, judging by the frequency of fights leading to increasing number of bites on pelt. The intensity and duration of bites in male pairs was significantly higher than in female pairs.

As a measure of variability in the number of bites, we used variance values which are the values of mean square deviations from the mean value of a character (σ^2) and also the maximum and minimum values for bites.

From the data in Table I it follows that mean bite number per pelt of groups I, II and III is significantly higher than that in the α -males. The highest bite number per pelt was for the β -tame males of group III. In this very group, the smallest number of bites was recorded for the α -aggressive males. As for group IV, it illustrates well the hereditary predisposition of aggressiveness to human in a stressing situation of inadequate food supply. These were extremely aggressive to counterparts, despite significantly smaller body weight. In this group, the β -aggressive males, inferior to the α -tame ones in body weight, (by 423 g lighter) bit them more frequently. How to explain this behavior?

Discussion

Aggressive behavioral patterns are affected by many hormones, the products of endocrine glands (the pituitary, gonads, adrenals). The hormones are addressed at target cells in the brain, modifying the level of the biogenic amines serotonin and adrenaline. The sex hormones determine the potential ability for aggressive behavior and also maintain aggressiveness in the adult. The products of ovary secretion usually attenuate aggressiveness in females, whilst testicular androgens enhance it in males. This may be a reason why fights among males are fiercer than females. The adrenal cortex releases at least 28 different glucocorticoid hormones contributing to the development of aggressiveness. To examine their effects during pelting time, the functional state of the adrenals was studied. It was found the basal glucocorticoid level in the β -aggressive males of group IV significantly increased when they are chronically stressed, whilst, like in the β -tame females of group III, in the same heterogeneous maintenance, the level remained normal. Data were also obtained indicating that, as a result of long food stress, in the β -aggressive males of group IV, the level of a specific plasma protein transcortin significantly decreased. And transcortin is important for retaining adrenal cortex hormones in bound or inactive state, when food conditions are normal.

Consequently, in conditions of strong competition for food among tame males (both the α and β), in contrast to aggressives, body weight does not considerably affect cortisol and transcortin levels. Perhaps, aggressive males, lighter than their partners, suffered more from stressing exposures not only because the concentration of plasma cortisol is maximal, but also because that of plasma transcortin

is minimal. These animals proved to be less stress tolerant to competitive struggle for food compared with tame males.

Numerous hormones, the products of the endocrine glands (the pituitary, gonads, adrenals) serve as chemical signals for relationship among organs. It was found that hormone effect on behavior is dependent on genotype, individual features, time of the year, interaction between individuals, sex, and species-specificity. The sex hormones act also during the neonatal period, determining the potentialities for aggressive behavior and they retain aggressiveness in adulthood. The adrenal cortex secretes at least 28 various steroid hormones influencing metabolism and infection resistance. The hormones are delivered to appropriate target cells in the brain. Their function is manifold. The hormones alter the protein-synthesizing function of DNA and RNA. They can affect behavior, acting on the sensory perceptive mechanisms, on the activity of the nervous system and on the effect or mechanism providing behavioral acts. In the nervous system, hormones exert an influence on morphological structures, on physiological activity and neurotransmitter function. Estrogen, progesterone and testosterone influence brain activity, as evidenced by changes in EEG, evoked brain potentials, and single neuron activity (*Komisaruk, 1971; Pfaff et al., 1973*). Hormones affect the level of monoamines in the brain, which are, in turn, under the influence of their level. Thus, estrogen causes a decrease in noradrenaline concentration in the anterior hypothalamus. It has been suggested that progesterone exerts an inhibitory influence on brain serotonergic activity.

Glucocorticoids are important as transmitters in the behavioral and psychological effects of stress (*Munch et al., 1984*). There are ample data indicating that basal glucocorticoid level elevates in conditions of chronic stress (*Schribner et al., 1991; Katz et al., 1981; Cure et al., 1989; Kant et al., 1987; Neufeld et al., 1994*). Such a prolonged state of high basal glucocorticoid level can produce profound changes in the state of metabolic processes, nervous excitation and animal behavior. The more recent data indicated that chronic stress leads to a decrease in the level of the corticosterone-binding protein, or transcortin (*Neufeld et al., 1994*). Transcortin is a plasma protein keeping adrenal cortex hormones in a bound or inactive state (*Hammond G.L. 1990*). As a consequence, transcortin-bound cortisol cannot gain access to the needed receptors in the target tissues (*Padridge,*

1981). As high as 90-95% of plasma glucocorticoids are transcortin-bound, with the decreased transcortin level producing a measurable increase in unbound or free biologically active cortisol (*Mendel, 1989*). In this way, an increase in the basal glucocorticoid and a decrease in transcortin levels as consequences of chronic stress lead to a considerable rise in free cortisol and to its subsequent strong effect on steroid hormones in the target tissues. It has been shown that transcortin level decreases also in conditions of stressing starvation (*Tinnikov, 1993*).

Hormones have a significant effect on food consumption and body weight (*Wade, 1976*). Sex differences in food consumption body weight are due to both the organizing role of perinatal and activating effects of hormones on adults. The products of ovary secretion decrease, as a rule, body weight, while androgens increase it.

Interaction of the gonad-pituitary axis is manifest also as changes in body weight. Genes do not affect behavior by "magic". The pathways from a gene to a behavioral trait are intricate, through biochemical, morphogenetic, and physiological, milestones. Changes in behavioral patterns result from the combined action of genes and environment. All this ensures the development of a fit organism.

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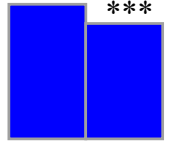
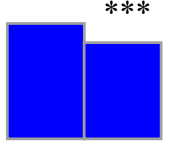
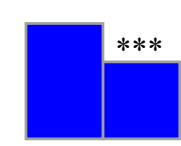
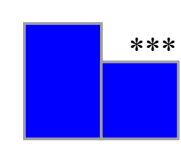
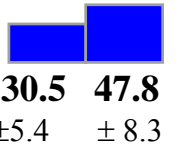
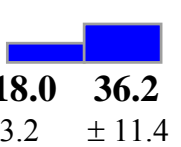
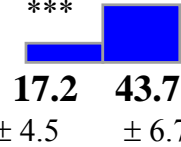
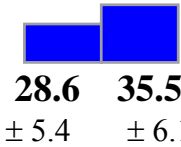
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Table 1. The results growing of young males different form of behaviour in pairs from weaning to pelting time.

M A L E S								
	HOMOGENOUS PAIRS				HETEROGENOUS PAIRS			
	I Aggr + Aggr		II. Tame + Tame		III. Aggr + Tame		IV. Tame + Aggr	
Behaviour leader based on body weight	α	β	α	β	α	β	α	β
Body weight (gr) at pelting (20 Nov.)								
Number of skin examined	47	47	46	46	7	17	21	21
Mean bites number per pelt								
σ^2	2206	3372	1739	5200	888	12110	4625	1575
Lim	3-170	2-296	1-160	6-334	4-120	5-358	7-172	7-203
Free cortisol level (ng/ml)								
Total cortisol level (ng/ml)								
Transcortin level (nM/l)								

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (Student's "t" test)

Table 1. The results growing of young females different form of behaviour in pairs from weaning to pelting time.

F E M A L E S						
	HOMOGENOUS PAIRS		HETEROGENOUS PAIRS			
	I. Aggr + Aggr	II. Tame + Tame	III. Aggr + Tame	IV. Tame + Aggr		
Behaviour leader based on body weight	α	β	α	β	α	β
Body weight (gr) at pelting (20 Nov.)					1164	1008 ***
	± 17.3	± 17.3	± 23.7	± 18.9	1024	907 ***
			± 32.2	± 26.6	1127	925 ***
					1079	918 ***
Mean bites number per pelt					30.5	47.8 ***
	± 5.4	± 8.3	± 3.2	± 11.4	18.0	36.2 ***
			± 4.5	± 6.7	17.2	43.7 ***
					28.6	35.5 ***
σ^2	894	2114	294	3646	788	1475
Lim	3 -170	2 -296	1-160	6-334	4-120	5-358
Number of skin examined	31	31	28	28	33	33
					29	29

*** $p < 0.001$ (Student's "t" test)

I – 13 P

Effect of coat colour mutation in mink on the adrenal cortex function at pelting time in Siberian climate

O.V. Trapezov

Institute Cytology & Genetics, Siberian Department, Academy of Sciences of Russia; 630090, Novosibirsk, RUSSIA. Fax: 7 (3832) 33 12 78; Tel: 7 (3832) 33 05 12. E-mail: trap@philosophy.nsc.ru (priv), E-mail: trapezov@bionet.nsc.ru (work)

Abstract

Study on the stress reactivity of the organism would be helpful on clarifying the mechanism by which coat colour mutations may affect total viability. To our knowledge, no such study has been performed yet with minks. The aim of the current study was to analyze the effects of the “*hedlund*” and “*aleutian*” mutations, which are common in mink commercial populations, on the adrenocortical function at pelting time (early December) when the temperature in SIBERIA was lowed to – 40°C at night. Comparison of the obtained data demonstrates that the homozygotes (genotypes *a/a*; *h/h*; *+/+*) are quite stressing compared to heterozygotes. The level of 11-oxy in the pooled group of coat colour homozygotes was significantly higher than in heterozygotes (*a/+*; *h/+*). This superiority of minks heterozygous for coat color loci manifest their higher stress tolerance.

Introduction

Perennial questions are related to the influence of coat colour mutations on different physiological and biochemical characteristics, such as reproduction (Belyaev & Evsikov, 1967; Belyaev & Zhelezova, 1968), growth and development (Belyaev *et al.*, 1977) thermal homeostasis. The questions have been raised with good reason. In fact, development and larger reproduction of a wider range of coat colour hues and patterns are promising trends in effect of coat colour mutations of the adrenal cortex function under environmental conditions in mink. Study on the stress reactivity of the organism would be helpful on clarifying the mechanism by which coat colour mutations may affect total viability (Belyaev *et al.*, 1977). To our knowledge, no such study has been performed yet with minks. However, from the data in the literature it is known that coat colour genotype in species other than mink may considerably affect the features of emotional behaviour, of the nervous and endocrinological

systems, which are the mayor regulators of stress responses, determining both the threshold and intensity of their reactivity.

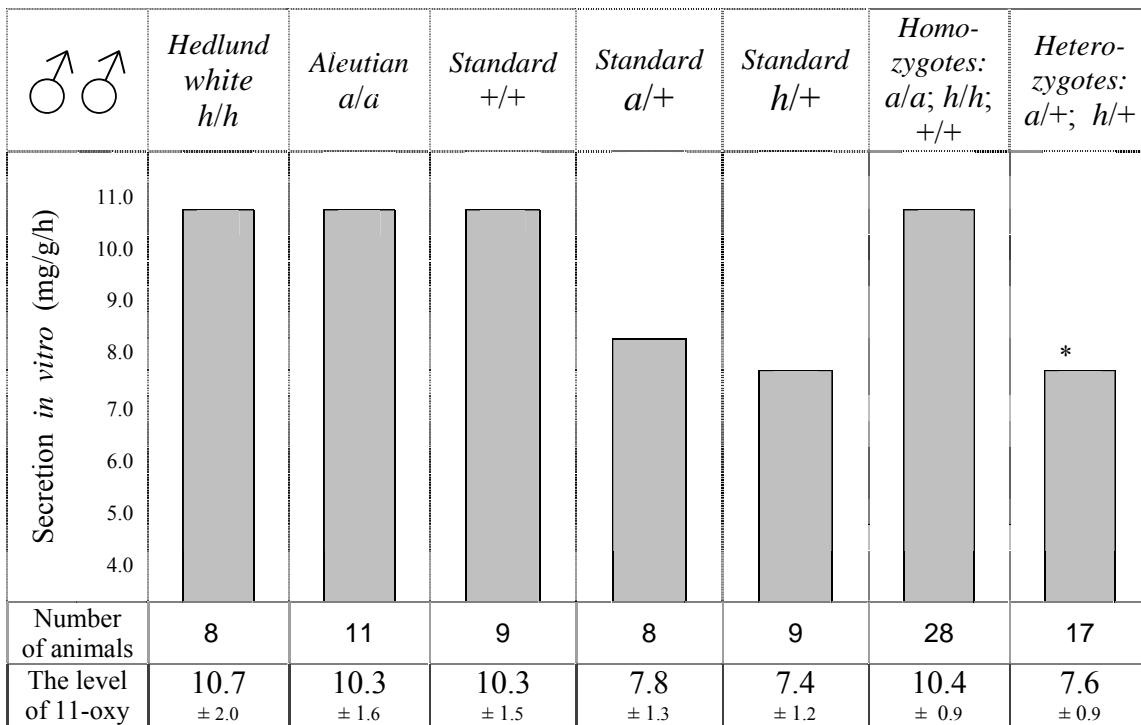
The aim of the current study was to analyze the effects of the “*hedlund*” and “*aleutian*” mutations, which are common in mink commercial populations, on the adrenocortical function at pelting time (early December) in Siberia.

Materials and Methods

The study was carried out with minks bred at the experimental farm of this Institute. Males of 5 genotypes were studied: Standard (*+/+*), homozygotes for the recessive mutation “*hedlund*” (*h/h*) and “*aleutian*” (*a/a*), heterozygotes for these two ones (*h/+*) and (*a/+*). Animals of all groups were maintained in pairs (a mail with female). The experiment was started July, when minks were 3 months old. Animals were fed a standard ration. The pelting period was at 4-7 December when the temperature outside was lowed to – 40°C at night. Minks of the genotypic groups were sacrificed on the same day. Promptly after sacrifice adrenals were removed to study their secretion capacity and incubated *in vitro*. The concentration of 11-hydroxycorticosteroids (11-OCS) in the incubation medium was determined fluorimetrically using spectrofluorimeter “Specol”.

Results and Discussion

There was a clear-cut trend to higher secretion by homozygotes for the coat colour loci (fig. 1). This allowed us to divide minks into 2 groups according to the character homo – (genotypes *a/a*; *h/h*; *+/+*), and heterozygosity (genotypes *a/+*; *h/+*) and to carry out comparisons. It was found that adrenal secretion in minks homozygous for the examined coat colour loci was significantly higher than in heterozygous.

Fig. 1. Effect of coat color mutations on 11-oxy secretion level by adrenals in conditions of *in vitro* incubation.

* – significant

To understand this, it is well to recall that paired cage maintenance of young minks in November-December, when temperature in Siberia drops to -40°C in the night time, was very demanding. This caused mobilization of the adaptive mechanisms, including stress systems. The minks homozygous for the standard ($+/+$) and mutant alleles (a/a ; h/h) were tensed at a higher level than the heterozygotes ($a/+$; $h/+$). That animals are stressed at this time of the year when placed in pairs.

Comparison of the obtained data demonstrates that in the homozygote (genotypes a/a ; h/h ; $+/+$) when winter temperature fall to -40°C are quite stressing compared to heterozygotes. The level of 11-oxy in the pooled group of coat colour homozygotes was significantly higher than in heterozygotes ($a/+$; $h/+$).

Concluding, it is noteworthy that here we are dealing with a manifestation of heterosis due to a broad pleiotropic effect of alleles controlling the biosynthesis and distribution of pigments. It appears likely that a most important genetic-physiological mechanism providing heterosis is involvement of genes for the neuroendocrine and adrenocortical system provoking adaptation to unfavorable factors in the pleiotropic effects.

This superiority of minks heterozygous for coat color loci manifest their higher stress tolerance.

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I – 14 P

Young nutria behaviour in runs of different types

O.Yu. Bespyatykh

*Russian Research Institute of Game Management and Fur Farming,
79 Engels Street, Kirov, 610000, Russia,
e-mail: mink@mink.kirov.ru*

Abstract

The comfort of runs of different types for nutria keeping was estimated with the method of ethological observations. The behaviour of nutria females and males at the age of six months was studied. Animals were visually watched during 24-hour periods. 36 elements of behaviour were totally registered, 13 of them being the main ones. Some runs have a typical wire mesh floor. In other runs metal shelves that occupied 1/3 of a floor area were set up. Young nutria used shelves not only for feeding, but also for different elements of an intensive and local activity, for rest and sleep. As compared with a wire mesh floor, young animals rested on shelves for a longer time, the length of comfort behaviour increased. Thus, shelves in a run raised the comfort of nutria keeping.

Introduction

Behaviour is the most effective mechanism of animals' adaptation to living conditions. Any change in environment resulted in the change of behaviour that is the first and easily recognized response of animals. When studying behaviour response in usual and changed conditions it is possible to make conclusion about the trends (favourable or unfavourable) in which the environmental conditions change (Kovalcikova & Kovalcik, 1974).

When carrying out farm breeding, animals' behaviour may be used to estimate the ecological effect of different zootechnical measures and to improve conditions of animal keeping (Korytin & Zabotskikh, 1983; Kholeva, 1997). The principle of creating comfort conditions of keeping and welfare of animals (absence of disturbances of behaviour and general status of animals) was entered in the Recommendations concerning fur animals – T-AP (96) 19 (1999), adopted by Council of Europe and directed to agricultural animal conservation.

Earlier we designed a shelf (a feeding table) to

decrease the losses of feed for nutria. It was a metal plate with a plane surface and low sides. A shelf decreased the losses of feed for nutria more than three times, increased the growth rate of the young by 9-12 % and its survival by 3-9 % (Bespyatykh & Plotnikov, 2000, 2002).

We studied the effect of a shelf placed in a run on the behaviour of the nutria's young. When analyzing animals' behaviour a comfort level of runs of a different type was estimated.

Materials and Methods

Investigations were carried out at the nutria nursery of the fur-bearing animal farm "Pushnina" (Kirov region). Animals were kept indoors with a regulated microclimate in runs without a house and a pool.

Behaviour of females and males of the nutria's young was studied in typical and improved runs. A typical run was made of a metal wire mesh measuring 0.8x0.6x0.35 m with holes 25x25 mm in diameter. Along a short side of a run there was a feed tray, at an opposite side, in the corner there was a drinking bowl. Water was poured into a bowl from 8 to 17 o'clock. Granulated mixed feed (granules' diameter – 10 mm) was given once a 24-hour period in the morning. An improved run had the same size as a typical one. But in addition to a feed tray a metal shelf was set up. It had a plane surface 0.6x0.22 m in size and sides 3 cm in height. The shelf occupied one third of a floor area of a run.

Nutrias' behaviour was studied through 24-hour visual observations of animals. The elements of behaviour were noted in 15-minute intervals (Scholz et al., 1964; Kovalcikova & Kovalcik, 1974). In a dark period of a day observations were carried out with little electric lighting. In all, 36 elements of behaviour of young animals were noted.

Experimental groups were formed of young nutrias at the age of 6 months. Animals of the first group were kept in a typical wire mesh run (males n=9, females n=12), animals of the second group – in a run with a shelf (males n=9, females n=12).

Results

During ethological observations 36 elements of behaviour were taken into account, 13 of them being the main ones.

In nutria males kept in the runs with shelves as compared with the males in typical runs the ratio of the categories of activity and rest in their behaviour practically did not change. Thus, in typical runs an intensive activity in males was registered during 0.84 hour, a local activity – 14.67 hours, sleep – 7.97 hours in a 24-hour period. In the runs with shelves those indices were 0.80, 14.45, 8.25 hours in a 24-hour period, correspondingly.

But in those categories the duration of the elements of behaviour changed (Table 1). In typical runs males sat on a wire mesh floor by 41.2 %, slept in a sitting position by 15.8 % and drank water by 34.1 % longer as compared with the males in the runs with a shelf. In typical runs males lay on a side by 21.8 %, lay on a belly by 69.1 % ($P<0.05$), slept on a side by 18.9 %, slept on a belly by 66.0 % and ate feed by 15.6 % less than males in the runs with a shelf. Other elements of behaviour of the nutria's young had no significant differences between groups.

To reveal preferences in the young (young animals preferred to be on a shelf not only to feed, but also to

rest) we equated the area of a wire mesh floor in a run to the area of a shelf.

On a wire mesh floor of a typical run we noted an intensive activity in animals during 0.24 hour, a local activity – during 3.29 hours, sleep – during 1.11 hours per a 24-hour period. On a wire mesh floor of a run with a shelf those indices made up 0.28, 4.29, 2.28 hours per a 24-hour period, on a shelf – 0.1, 6.24, 5.45 hours per a 24-hour period, correspondingly.

In that case the elements of behaviour had the following indices (Table 2). On a wire mesh floor of a typical run males moved 1.5 times as many and were in contact with a neighbour 5 times more frequently than males on a shelf. On a wire mesh floor of a typical run animals sat 1.2 times, lay on a belly 6.5 times ($P<0.05$), slept in a sitting position by 1.8 times, slept on a side by 3 times, slept on a belly 9.2 times, pawed their hair cover by 1.4 times and ate feed by 3.6 times ($P<0.01$) as many in comparison with the animals on a shelf. Other elements of behaviour of the nutria, s young did not have any significant differences between groups.

Females of nutria had a similar behaviour in typical runs and in runs with shelves as males.

Table 1 Behaviour elements in nutria males in runs of different type during a 24-hour period, hour

Behaviour elements	Control (n=9)	Experiment (n=9)		
		Totally	On wire net floor	On shelf
Laying on side	1.97±0.24	2.52±0.89	1.99±0.58	0.53±0.41 * ⁰¹
Sleeping on side	2.74±0.50	3.38±1.34	1.01±0.55 * ⁰¹	2.35±1.08
Laying on belly	0.34±0.17	1.10±0.22 * ⁰⁵	0.46±0.05	0.65±0.19
Sleeping on belly	0.17±0.12	0.50±0.29	0.05±0.05	0.46±0.31
Moving	0.53±0.02	0.70±0.38	0.60±0.46	0.10±0.10 * ⁰⁰¹
Climbing on wire mesh	0.31±0.17	0.10±0.10	0.10±0.10	0
Contact with neighbours	0.36±0.24	0.36±0.10	0.34±0.07	0.02±0.02 ⁺⁰⁰¹
Feeding	2.18±0.14	2.52±0.38	0.29±0.05 * ⁰⁰¹	2.23±0.41 ⁺⁰⁰¹
Drinking of water	1.32±0.07	0.87±0.17 * ⁰⁵	0.86±0.17 * ⁰⁵	-
Pawing of hair cover	1.66±0.34	2.16±0.12	1.49±0.17	0.67±0.05 * ^{05, +001}
Sitting	6.41±0.77	4.54±1.18	2.40±0.48 * ⁰⁰¹	2.14±0.74 * ⁰¹
Slipping in sitting position	5.06±1.27	4.37±1.70	1.73±1.01	2.64±0.86
Pulling of wire mesh with teeth	0.43±0.02	0.38±0.02	0.38±0.02	0

*⁰¹ - differences are reliable with control, $P<0.01$

*⁰⁵ - differences are reliable with control, $P<0.01$

*⁰⁰¹ - differences are reliable with control, $P<0.001$

⁺⁰⁰¹ - differences are reliable with wire mesh floor, $P<0.001$

Table 2 Behaviour elements in nutria males on equaled areas of shelf and wire net floor of typical runs during a 24-hour period, hour

Behaviour elements	Control (n=9)	Experiment (n=9)	
		On wire net floor	On a shelf
Laying on side	0.56±0.07	0.80±0.23	0.53±0.41
Sleeping on side	0.78±0.14	0.40±0.22	2.35±1.08
Laying on belly	0.10±0.05	0.18±0.02	0.65±0.19 * ⁰⁵ , + ⁰⁵
Sleeping on belly	0.05±0.03	0.02±0.02	0.46±0.31
Moving	0.15±0.01	0.24±0.18	0.10±0.10
Climbing on wire mesh	0.09±0.05	0.04±0.04	0
Contact with neighbours	0.10±0.07	0.14±0.03	0.02±0.02 ⁺⁰¹
Feeding	0.62±0.04	0.12±0.02 * ⁰⁰¹	2.23±0.41 * ⁰¹ , + ⁰⁰¹
Drinking of water	0.38±0.02	0.34±0.07	-
Pawing of hair cover	0.47±0.10	0.60±0.07	0.67±0.05
Sitting	1.83±0.22	0.96±0.19 * ⁰¹	2.14±0.74
Slipping in sitting position	1.45±0.36	0.69±0.40	2.64±0.86
Pulling of wire mesh with teeth	0.13±0.01	0.15±0.01	0

*⁰¹ - differences are reliable with control, $P < 0.01$

*⁰⁵ - differences are reliable with control, $P < 0.01$

*⁰⁰¹ - differences are reliable with control, $P < 0.001$

+⁰¹ - differences are reliable with wire mesh floor, $P < 0.01$

+⁰⁵ - differences are reliable with wire mesh floor, $P < 0.05$

+⁰⁰¹ - differences are reliable with wire mesh floor, $P < 0.001$

Discussion

After setting up a shelf in a run the elements of behaviour in males, i.e. of rest– periods of laying on a side and a belly, sleeping on a side and a belly became longer. It took place due to the decrease of the duration of sitting, sleeping in a sitting position and drinking water. The increase of the time of feeding was explained by the fact that a shelf favoured the decrease of feed losses (Bespyatykh & Plotnikov, 2000, 2002). In a feed tray more feed remained, and animals ate it more quietly, slowly and without fighting.

The equaling of a wire mesh floor area of a typical run to an area of a shelf showed that on a wire mesh floor of a run the young preferred to move along a run, to climb a wire mesh, to pull it with teeth and to contact with neighbours through it. Thus, on a wire mesh floor of a run animals showed the elements of an intensive activity. On a shelf males of nutria preferred to sit, to lie, to sleep and to paw their hair cover. On a shelf the young showed the elements of a local activity.

The increase of a local activity is characteristic of the level of animals' adaptation to living conditions and of the level of an ecological comfort and

optimum (Korytin & Zabolotskikh, 1983). In our case a local activity of nutria is greater on a shelf than on a wire mesh floor of a run. It proved that animals preferred to be not on a wire mesh floor, but on a shelf and not only for feeding.

Therefore, a shelf corresponds to biological peculiarities of nutria and favours the increase of the level of runs' comfort.

Conclusion

Setting up of a shelf in nutria runs increases the level of comfort conditions of keeping the young. It resulted in changes of animals' behaviour. The duration of a local activity increases, i.e. of the elements of comfort behaviour (lying, pawing their hair cover). The length of an intensive activity decreases.

Comfort conditions of nutria keeping will give an opportunity to obtain from animals the greatest total volume of skin and meat output.

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