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The Welfare of Animals Kept for Fur Production

Report of the

Scientific Committee on Animal Health and Animal Welfare

Adopted on 12-13 December 2001

Contents

1. TERMS OF REFERENCE

The EU Commission has asked the Scientific Committee on Animal Health and Animal Welfare to prepare a report on the welfare of animals kept for fur production.

2. BACKGROUND

The welfare of animals kept for fur production, like other subjects considered by the committee, raises ethical issues. It is not within the aim of the present report to recommend whether or not continued fur farming is ethically acceptable. The present report therefore contains only a scientific assessment of the welfare of animals kept for fur production, and scientifically based recommendations on how their welfare can be improved.

At present there is no European Union legislation on the subject of keeping and breeding animals for fur production, although some Member States have relevant legislation. A Recommendation on the Welfare of Animals kept for fur production was, however, adopted by the Standing Committee of the European Convention for the Protection of Animals kept for Farming Purposes on 22 June 1999.

This report is restricted to the following species;

- *Mustela vison* (mink)
- *Mustela putorius* (polecat/ferret)
- *Vulpes vulpes* (red fox)
- *Alopex lagopus* (arctic fox)
- *Nyctereutes procyonoides* (raccoon dog)
- *Myocastor coypus* (coypu)
- *Chinchilla laniger* (chinchilla)

The report is organized in eight main sections. It begins with a general definition of welfare and the way it can be assessed (Chapter 3). In the second section (Chapters 4 and 5), the general biology of the species under consideration is presented. In the third section (Chapter 6), the issue of domestication is considered so as to understand what is the exact domestication status of the different animal species that are kept for fur production. In the next section (Chapters 7 and 8), the range of farming conditions and the handling and killing procedures to which animals kept for fur production are submitted in the European Union are described. This section is followed by a section on the welfare problems encountered by animals kept for fur production. Since mink have been the most intensively studied, this section begins with the welfare of mink (Chapter 9) followed by the welfare of foxes (Chapter 10) and other fur animal species (Chapters 11-14). Means of improving the human-animal relationship are discussed in the following section (Chapter 15). The report ends with a list of future research, conclusions and recommendations (Chapters 16, 17 and 18).

3. WELFARE – DEFINITIONS AND MEASUREMENTS

3.1. The concept of animal welfare

According to the European Union Treaty of Amsterdam, farm animals that are kept for commercial purposes are considered as living and sentient, in the sense that they are able to experience pleasure and suffering. In order to safeguard welfare and avoid suffering, animals must be kept under conditions that respect their needs including those to show certain behaviours.

The welfare of an animal depends upon its biological features and the housing and management conditions to which it is subjected. The biological features of present day animals are the outcome of the process of evolution that has resulted in animals that are adapted to their natural environment or "niche". Thus the behavioural characteristics displayed by animals are essential to their survival and reproduction in their natural environment. Some elements of this adaptation process are common to all animal species, such as orientation, foraging and feeding, whereas others are specific to a particular niche, such as life in extreme cold or in semi-aquatic conditions. Because niches have many features in common, especially in terms of temporal and spatial features, adaptive behaviour is usually sufficiently flexible to allow an animal to adapt to different environmental conditions from the ones in which it has evolved, providing they bear sufficient similarities to the original niche. Domestication makes use of this flexibility.

The welfare of an animal will become poorer if it cannot successfully adapt to the conditions in which it is kept. This can occur in several ways. At the behavioural level, an animal can be prevented from developing some elements of its species specific behavioural activities because of the lack of trigger, restricted space, or the lack of the appropriate outlet for these activities (Dawkins 1980, 1990). These last two results in the thwarting of needs to show certain behaviours and will often induce suffering, the extent of which depends on the importance of the behavioural activity in the repertoire of the species to which the animal belongs (Dawkins 1980, 1990). Also the effects of genetic selection have to be considered. At the physiological level, excessive constraints upon the animal's adaptive abilities trigger a non-specific neuroendocrine response that is usually referred to as the stress response. This is particularly the case in unpredictable and uncontrollable situations in which temporal and instrumental contingencies are difficult to establish (Hennessy and Levine 1979; Dantzer and Mormède 1983). In all these cases, adaptation failure usually results in a number of altered body functions of which the visible manifestations can be used to assess welfare. Whether this is accompanied with altered emotional states and feelings depends on the emotional and cognitive abilities of the organism under consideration (Dantzer, 2002).

In line with these very general principles, welfare has been defined as the state of an animal as regards its attempt to cope with its environment (Broom, 1993). Welfare therefore varies from good to bad, or more precisely from ease of coping to difficult coping or some failure to cope. Pleasurable mental states will often accompany good welfare; unpleasant states are generally associated with coping failure. For many, it is these mental states which are the essence of animal welfare (e.g., Dawkins, 1980, 1990; Duncan and Petherick, 1991; Mason and Mendl, 1993). Trying to assess animal welfare then may mean, especially, making inferences about mental states.

3.2. The assessment of animal welfare

Environmental conditions that significantly depart from an animal's niche can be the source of welfare problems, the extent of which depends on their prevalence, duration and intensity and on the animal's ability to adjust to them. The reality of such welfare problems can be assessed in the subjected animals by a combination of measures taking into account their physical health, biological functions and behaviour. In general, minimum premature mortality, low morbidity, little or no risk of body injury, the ability to express valued species specific activities including social interactions, grooming, exploration and play, and the lack of abnormal behaviour and of physiological signs of stress, including alterations in immunity, indicate that there are no major animal welfare problems.

3.3. The assessment of welfare in animals kept for fur production

When assessing the welfare of animals kept for fur production, the following points need to be considered in detail:

3.3.1. Mortality and morbidity

Death on farms can be caused by disease, injury or physiological system failure, which shows that the welfare has been poor. Animals can also be culled for the same reasons, and in such cases, culling should be treated as a similar sign of poor welfare. In addition, welfare is poorer if the incidence of production related diseases is higher in animals that are under consideration than in similar animals which have not been exposed to the same management, housing or genetic selection. If animals present inherent weakness or abnormality which makes them more likely to succumb to disease or injury, etc, then their welfare is poorer than that of animals which do not have this weakness or abnormality. In a group of animals, the amount of poor welfare caused by a pathological condition is a function of its prevalence and incidence, severity and duration. Health indicators of animal welfare must also be studied with a broad population perspective; an increased use of preventive and therapeutic veterinary medicines in a certain population may indicate that welfare is more at risk amongst those animals than in animals belonging to populations where such medication is not necessary.

3.3.2. Body condition and reproduction

Welfare is poor if body condition is bad. In general, reproduction is given high priority. If given adequate opportunities to breed, individuals fail to conceive, poor welfare is often indicated. However lack of reproduction does not always indicate poor welfare but can be the expression of alternative strategies to maximise inclusive fitness, for example when close relatives are helped to rear offspring, as it is the case in many canid species.

3.3.3. Behaviour

Animals use behaviour as one of the most important means of adapting to their social and physical environment. Behavioural activities are normally triggered by a set of endogenous and exogenous causal factors, and their performance is the source of important regulatory feedback. When there is a mismatch between these different causal factors, e.g., when endogenous factors set up the conditions for engaging in a behavioural activity for which there is no adequate substrate, deviations in behaviour can occur. These alterations in behavioural expression may be important signs of welfare risks. Various behaviours including abnormalities of behaviour can be indicators of poor welfare.

It is important to point out that the ability of animals to engage in at least some behavioural activity is important for their welfare. Not allowing sufficient locomotion for instance can lead to muscular-skeletal problems. In addition, the inability of animals to engage in appropriate behavioural patterns during development may impair their ability to regulate the corresponding behavioural activity later in life.

One important aspect of behaviour is its use to approach or avoid particular stimuli. Many now believe that feelings of pleasure or displeasure have evolved in order to motivate such behavioural responses, especially when a stimulus can only be attained or avoided by means of instrumentally conditioned, flexible responses (Cabanac, 1979; Rolls, 1999). This means that behavioural preference or aversion can potentially give a very good insight into the resources, or the activities, that animals find pleasurable or unpleasant.

In some instances, animals may perform such sustained attempts to approach or avoid stimuli that these attempts may become stereotyped in appearance (e.g., Mason, 1991a). Stereotypies can also emerge when animals persistently attempt to perform species-typical behaviours, but in the absence of substrates that would allow then to be performed normally. Their possible link with frustration is one reason why stereotypies (and other abnormal behaviours) are often used as welfare indicators (Broom and Johnson, 1993; Mason, 1991b).

3.3.4. Physiology

Physiological indicators of stress, including alterations in regulation of adrenal hormones synthesis and release, changes in autonomic balance, and deviations in distribution of immune cell subsets and functions, can all indicate poor welfare. The problem, however, is that most of these responses are not specific to poor welfare. Glucocorticoid levels, for example, can increase in situations which are probably welfare-neutral (e.g., laying an egg) or even pleasurable (e.g., copulation). Therefore to try and maximise the chances of drawing a correct welfare inference, most researchers advocate simultaneously using a range of physiological and behavioural measures.

3.4. Conclusions

Animal welfare can be assessed in an objective and quantitative manner, and indicators of welfare include health, bodily functions, and behaviour. Each set of indicators has to be validated for the species under consideration. For an adequate assessment of welfare, a wide range of indicators must be used, although single indicators can sometimes show that welfare is at risk.

4. GENERAL ASPECTS OF CARNIVORE BIOLOGY

4.1. Introduction

Animals kept for fur production belong to two different zoological orders, the carnivora and rodents that need to be considered separately since their biological characteristics widely differ.

The general biological characteristics of carnivore species used for fur production are summarized in Table 1.

Carnivora evolved from a marten- or genet-like ancestor that appeared 60 – 65 million years ago (Macdonald 1984, 1995). Ancestrally they may be distinguished by their scissor-like carnassial cheek teeth. Today most are still predatory and carnivorous, retaining a simple gut (simple stomach, short tract, negligible caecum), and developing a powerful shearing jaw-closing mechanism via enlargement of the temporalis muscles. They typically have large brains, with cerebral hemispheres that overlap the cerebellum and large olfactory bulbs. This may be because they need good learning abilities in order to associate cues such as footprints with often-distant food rewards. However, despite the preponderance of carnivory, there are also omnivorous and even herbivorous Carnivora, and this diversity of diet is matched by a diversity of food-acquiring techniques, territory sizes and social structures. Carnivora also vary in their relative brain sizes, with strict carnivorous species having the largest.

Predatory Carnivora show many morphological, sensory, and behavioural adaptations for the search, pursuit and killing of prey. Carnivores often continue to hunt, and to play with their prey, even when well-fed, and in captivity, some of this behaviour is sometimes manifest as object play. They are also generally neophilic, both in the wild and in captivity.

In the wild, their territory sizes depend on primarily social structure, and the density of food resources. These territories are defended by means of patrolling and marking, both by scent (faecal, urinary and glandular) sometimes at latrines and by visual stimuli such as scratching trees. Different species vary in how they respond to opportunities to increase their territory sizes. Home range and territory differ in that the home range is the total, non-defended area that an animal may cover, and male home ranges usually far outstrip female ranges, especially in the breeding season when males often range widely. Carnivore sociality depends on a range of factors, the most important of which is the divisibility and distribution of food. This affects the behaviour of facultative social carnivores like the red fox and domestic cat, and means that even naturally solitary species such as the striped hyena and golden jackal can become social if artificially fed large quantities.

Table 1. General biological characteristics of carnivore species used for fur production (population means or ranges of study means)

	Mustelids		**Canids**		
	Mink	**Polecat**	**Red fox**	**Arctic fox**	**Raccoon dog**
Body weight (kg)	F: 0.6 (0.5 – 0.85) M: 1.2 (0.8 – 1.8)	F: 0.8 (0.5 – 0.9) M: 1.25 (0.8 – 1.7)	F: 4.0 – 6.0 M: 4.4 – 7.0	F: 2.9 M: 3.5	Summer: 4.0 – 6.0 Winter: 6.0 – 10.0
Home range territory size (km^2)	(F: 0.5 – 3.0; M: 2.5 – 6.0)	F: 0.3 – 0.83 M: 0.2 – 3.55	F: 0.54 – 8.8 M: 0.63 - 10	20 – 30 km^2 (range 3 – 120)	Average around 10 km^2 Range not known no reported sex differences
Diet	Carnivorous/ piscivorous	Carnivorous	Carnivorous/ omnivorous	Carnivorous/ omnivorous	Omnivorous
Activity cycles	Nocturnal/ crepuscular	Nocturnal	Nocturnal/ crepuscular	Arrhythmic	Nocturnal
Denning habits	Many dens (5 – 24); not dug by mink	Several dens, usually not dug by polecat	1 –2 large dens; can dig own	Single den? Complex with many entrances; can dig own	Single den (?); usually not dug by r. dog; may be shared with fox/badger
Adult social structure	Solitary; polygamous mating system	Solitary; polygamous mating system	Facultative social; mating system often polygynous with bi-or allo parental care	Solitary, but breeding system can be polygynous with bi- or allo parental care	Often pair-/family-living; monogamous with bi-parental care
Litter size	5 (4 – 6)	6 (5 – 10)	5 (2 – 7)	7 (1 – 11)	5 (5 – 7)
Age at weaning (WA)	c. 6 weeks	Starts at 3 weeks	2 – 3 mos.	5 – 9 weeks (poss. starts 3 weeks)	7-9 weeks
Dispersal age (DA)	DA: 3 - 4 months. (Some Females: up to 11 months.)	Indep: 2 – 3 months.	DA: 5 – 7 months (Males before Females)	Independent': 14 – 23 weeks	DA: c 6 months.
Other notable features	Semi-aquatic – territories always alongside water; can swim/dive	Extent of similarity to ferret disputed	Very wide geographical distribution	Lives in open grassland; tundra/arctic	Can display winter torpor

c. *circa*

4.2. Mustelids

Within the Carnivora, Mustelids emerged c. 35 million year ago (Macdonald 1995). They contain relatively few social species, and are almost all predatory. They typically have very well developed carnassial teeth and associated musculature. Many mustelids also exhibit delayed implantation. Within this group, the Mustelines are particularly prone to solitary lifestyles, and also tend to be highly sexually dimorphic. Mustelids have average brain sizes compared to other carnivora. They generally hunt by scent rather than sight and typically have long thin bodies to pursue burrow-living prey such as rodents and lagomorphs.

4.2.1. The American mink (*Mustela vison*)

Feral American mink are well studied, in order to maximise trapping success, and to enable wild life management. This information is summarised by Eagle and Whitmans (1987). European populations, which are descended from escaped farmed mink, are well studied as well. Information on these feral mink has been gathered by Corbet and Harris (1991) and Dunstone (1993). The native European mink, a different species, is rare and little studied. The knowledge on mink in Europe is thus based on escaped farmed mink.

Physical characteristics

Mink have the shape that is characteristic of the mustelids; fairly small with long slender bodies, short legs, a rather long tail and prominent scent glands adjacent to the anus. The skull has a well-developed temporal crest for a large temporalis muscle; also relatively large canines and carnassials. Mink have a short gastro-intestinal tract, passage through the gut taking just a few hours. The diploid chromosome number is 30.

The average weight of 48 adult males in the River Teign (SW England) was 1153 g (ranging from 850 to 1805 g). Another sample of 23 males in Scotland weighed 1121 g (ranging from 840-1500). Females were smaller; 32 females out of the River Teign weighed 619 g (450-810 g) and 13 females in Scotland weighed 676 g (560-805 g). North American feral mink varied even more, but according to several authors the variation between populations is more important than variation within populations. In Idaho males and females weighed a mean of 780 and 525 g respectively. In North Dakota these averages were 1523 and 853 g. All in all, farmed mink in Europe weigh approximately twice as much as feral mink. Males weigh twice as much as females, both on farms and in the wild. Apart from this difference, there is no sexual dimorphy. The mean weights of females and males are 610 g and 1220 g respectively.

The colour of feral mink is uniformly darkish brown throughout the year, in spite of two moults. The dorsal parts are only slightly darker than the ventral ones. The only colour marking is the white chin patch and a number of white spots on the underside. These remain constant throughout life and can be used in identification. On farms, the white markings can easily be eliminated within some generations. The uniform colour strongly contrasts with that of the related polecat; especially so the polecat's remarkable face markings contrast with the mink.

Several colour mutations (white, grey, lighter brown) are observed in the wild. Farmers successfully bred various colour mutations. The variations result from recessive mutations; thus the colours easily disappear in escaped populations. Another possibility why mutations of mink are rare in the wild is that they maybe less fit. The coat is adapted for a semi-aquatic lifestyle; the density of guard hairs is three times that of the ferret, and the hairs are also shorter. When the animal is wet, the guard hairs therefore plaster down smooth over the underwool and protect it from water logging (as in the otter, and unlike the non-aquatic mustelid, the ferret). However, the coat is not well adapted for prolonged submersion (unlike that of more fully aquatic animals); heat starts to be lost from the minks' body after about 5 minutes of submersion, due to the loss of air from the underwool.

Mink have no skeletal adaptation for an aquatic lifestyle (e.g. pelvic changes that would facilitate hind limb movement in swimming). This would conflict with their need to be effective predators on land too. The small but obvious webbing they display between their digits is used during swimming and may be an adaptation to the aquatic part of their life.

Ecology

Geographical distribution

Mink are distributed throughout Canada and the United States except in the extreme north of Canada and arid areas of the south-western United States. Consequently, mink can be found in arctic regions as well as in the subtropical marshes in Florida. However, many local races are described and in general mink become smaller from north to south, and the density of their coat diminishes.

Animals escaping from fur farms have established populations in insular Newfoundland and in Iceland, Scandinavia, Great Britain, Ireland and Russia. Mink failed to establish feral populations in The Netherlands, in spite of the presence of many mink farms for a long period and frequent mink releases by 'animal liberation' groups during the past 15 years, but the exact reasons for this are not known.

Habitat

Both in America and Europe, mink occupy a wide variety of wetland habitats, including streams, rivers, lakes, freshwater and salt water marshes, and coast lines. American states with the highest mink harvests were those with abundant wetlands. Their territories always run along the edges of water-bodies, e.g. along stream banks, or along stretches of marine coast.

Food habits

The best documented aspect of the minks' biology is its food habits. Many studies are scat analyses. Mink are exclusive carnivores, but they are generalists and prey on locally available food sources. They select particularly vulnerable individuals within prey populations. While always predatory carnivores, mink are flexible and their diet varies greatly with habitat and season. Mink can take prey as small as minnows, or as large as pheasants and hares; they have even been seen attacking swans. There is some sexual dimorphism in diet, with males taking more lagomorphs than females, and females taking more fish and crustaceans than males.

In their homeland, mammals are often the most important class of prey. Muskrats, lagomorphs and small rodents are commonly taken. Unusual items such as bats are taken when available. The importance of fish, birds and invertebrates shifts seasonally. Waterfowl, marsh nesting passerines, crayfish and other invertebrates are taken during summer. During all seasons, the importance of birds in their diet is similar to that of invertebrates. Fishes are consumed more than birds or invertebrates, but less than mammals. Mink tend to prey on slow-moving coarse fish more than faster midstream dwellers. In winter, they profit from the fact that fishes move slower then. Salmon are taken during the vulnerable period of spawning. Amphibians and reptiles are seldom taken according to some authors, and frequently according to others. All studies together reflect the minks' ability to exploit a wide variety of prey from aquatic and terrestrial habitats. This ability may reduce competition with more specialised carnivores and may explain their ability to rapidly colonise new habitat.

Feral mink in Britain also are opportunistic predators, taking a wide variety of mammal, bird, fish and invertebrate prey. In the UK, aquatic prey forms approximately 30 to 50% of the diet. Rabbits are the most common prey, like in America. On rivers and lakes, ducks and coots are taken; in coastal habitats gulls are taken. The choice of fish is governed by relative availability. Amphibians, snakes and invertebrates were infrequently eaten.

Foraging behaviour

Although fish are not the most important prey, all authors emphasise that mink live in aquatic habitats, and often occupy linear home ranges/territories along rivers, shorelines and so on. The extent to which mink are adapted to aquatic hunting has been well studied by Dunstone (1993).

Mink dives are often of short duration (5-20s) and constrained by the degree of physiological adaptation. Mink show a few of the physical adaptations of amphibious mammals and are intermediate in swimming ability between polecats and otters.

On land, mink hunt by searching specific areas of their territory, usually a few hundred metres across, often by traversing it in a zigzag manner; they then move to cover another similar area, in a similar manner. They travel nose to ground, olfaction being the most important cue used in hunting, moving the head from side to side. They also investigate crevices, under boulders, and into burrows, a behaviour known as 'poking'. Their adaptations for this terrestrial predation include powerful jaws, which provide great bite strength; the ability to hear the ultrasound emitted by rodents; excellent olfactory abilities; and a very rapid response to movement and other cues from prey (which perhaps explains why mink, like many carnivores, show surplus killing, i.e. the excess killing of prey, far beyond that which can be eaten, when prey are superabundant and unable to escape). Mink catch their terrestrial prey in short bursts of activity, aided by the element of surprise, rather than via long, sustained chases.

A rather similar foraging strategy is seen when mink hunt in water: they tend to catch prey by means of short, rapid dives and brief pursuit-chases, rather than via sustained pursuits. Mink locate vulnerable prey before they enter the water. This prey is usually located from backside vantage points, and then swiftly pursued. Mink have good swimming abilities; they are more buoyant then the terrestrial ferret, and show more efficient surface swimming than this animal, often gliding across the water after each stroke. They sometimes use this method of locomotion to herd fish onto land, where they are caught and eaten before they can return to the water; they are also strong enough swimmers to have reached and devastated the seabird colonies of some Scottish coastal islands. Mink are also accomplished under-water swimmers, and apart from otters, are the only mustelid able to do this. They may pursue fish under-water, or swim along the water bottom, exploring under boulders for crabs and other prey. Mink are good divers, too: they have been observed retrieving crabs from water over 7 m deep, and the efficiency of their dives is enhanced by their tendency to surface by pushing up from the bottom, so as to glide to the top with a minimum of limb movement.

Mink have many adaptations to swimming and diving that are behavioural; for example, they seem to find retrieving objects from water inherently reinforcing, although, as it has been previously said, the mink's coat is not well adapted for prolonged submersion; heat starts to be lost from the minks' body after about 5 minutes of submersion, and mink have no skeletal adaptation for an aquatic lifestyle. However, they do have some other adaptations, including their pelt structures (see above); a vasoconstriction mechanism in their paws which helps reduce heat loss underwater; an ability, absent in solely terrestrial mammals such as pigs and humans, to detect hypoxia (Raj and Mason 1999); the presence of short, stiff whiskers which act like those of the otter, aiding fish capture through their sensitivity to turbulence; and finally, some visual adaptations. Mink eyes appear to be incompletely adapted to underwater hunting, though mink can locate prey by searching under water. Although the visual acuity of mink is less in water than it is in air, their underwater acuity does appear enhanced by a well-developed sphincter iridis muscle, which can make the lens more convex when the cornea is unable to aid focussing (as happens under water). This muscle development is greater in mink than in the ferret (though possibly greater still in the otter). In addition, minks' ability to detect motion, the main visual cue used in hunting, is unimpaired in water compared with that on land.

Home range and territory

Size and pattern of use of home ranges are revealed by radio tracking. Linear ranges are 1-6 km in length, with those occupied by males, generally larger than those of females. Where habitat quality is good (abundant and predictable prey supply) densities are high and movements restricted.

Females have smaller territories than males, and are also less inclined to vacate them (Birks and Linn, 1982). Males occupy 2.5-6 km, females 0.5-3 km of shoreline. An increase occurs during the mating season. In search for females, their activity may cover the territories of ten and more females.

Within their territory, mink often have half a dozen dens, and sometimes more e.g. as many as 24. As well as prey abundance, mink also choose territories which have a high number of potential den sites, such as abandoned burrows etc. Dens are used for sleeping and resting, but also as places where larger prey are taken to be eaten, and as places where surplus food can be cached. Unlike polecats, mink do not dig them themselves, but rather make use of crevices between tree roots, old burrows dug by other species, etc. Dens are mostly within 10 m from water.

Within the home range, mink tend to show a patrolling pattern, with regular visits to the boundaries. These territories are first established by young mink between August and October (i.e. when animals are three to five months old); there is also a subsidiary period of territory establishment for males during and after the breeding season, in March and April. Juveniles may disperse to just a few kilometres from their natal territory, or travel as far as 50 km in search of a territory of their own (Crowley and Wilson 1991). Both walking and bounding are used when patrolling the territories. It is not clear how boundaries are defended; it may well be that the deposition of scats, with their anal scent components, is important. Anal gland secretions certainly seem adapted to allow individual recognition; and scats are usually deposited in visually conspicuous locations, the same sites being repeatedly used as befits them having a ‘signpost’ function.

Social life

Mink social life is poorly developed. They hunt alone, and adults live solitarily. Territorial behaviour is often reported. During the mating season aggression levels between males are high. Fights often result in wounds to the head and neck region but are only rarely fatal. Mating is the other social contact between adults. Mink are promiscuously polygamous, the male mating with several females and vice versa. Mating behaviour is vigorous; the male grasps the female by the neck and drags her about stimulating ovulation. Copulation lasts up to 3 hours. Stable pairs are not formed. Males are not reported to assist with rearing activities. Sustained social interactions only occur between mothers and their kits.

Reproduction

Reliable data on mating success, litter size, kit mortality and so on are scarce to absent, both in America and Europe.

Females litter once a year, in May, after mating in March. Females are induced ovulators. A remarkable characteristic is the delayed implantation. Consequently, the period between mating and parturition varies from a minimum of 42 days up to 70 days (at farms). The function of this delayed implantation is not fully understood. Litter size is 4-6. Mink show some reproductive plasticity in the wild; the number of implanted embryos falls when population densities are high.

Kits are born altricial. Newborn mink weigh 6-10 g, their eyes are closed, hairs are lacking, but they are very well able to scream, and they do. Eyes open after 1-2 weeks, teeth emerge after 2-3 weeks, meat eating after 3-5 weeks and by 7 weeks they are homoeothermic. Although weaning age has been estimated at 5-6 weeks, studies of farmed animals (for whom daily growth can be measured) show that kits switch from being milk-dependent to food-dependent at 6 -7 weeks (Mason, 1994). Kits leave the natal territory at about 12 weeks old (Gerell, 1969,1970, Birks and Linn, 1982), with large males typically dispersing first. Young females may even stay with their mothers until as late as ten or eleven months of age.

Reproductive success in nature is little documented. It has been found to vary from year to year but the causes are unknown. Across America, reproductive success strongly varies from year to year, but information concerning the cause of variation is not sufficient to warrant conclusions.

Other aspects of behaviour

Mink are predominantly nocturnal or crepuscular, but may be seen at any time. In one study, mink spent only 16 % of time outside dens. Another study mentioned 5-20 %. The frequency and timing of activity is governed by availability of prey. Feral/wild mink are usually more nocturnal than farm mink, but also show crepuscular peaks (Gerrell, 1969).

Locomotion: aquatic locomotion is described above; terrestrial locomotion is of two main forms, walking, and a more rapid (2.5m/s) bounding gait. Mink can also climb trees.

Mortality and morbidity

There are few data on this. Wild mink can apparently live up to 11 years, and with a breeding life of 6 to 7 years, but it is unlikely that many reach this figure. For example, in Ireland, a combination of death and territory loss leads to local populations being completely replaced in just two years. However, live feral mink, in Ireland, have been found to be in generally good condition, with few endo- or exo-parasites.
The relative importance of different mortality factors is not well known. In many places human activities such as trapping, traffic and high levels of organ chlorines, mercury compounds and PCB's may be the most important cause of death. Occasional non-human predators in America include canids, felids, larger mustelids, great horned owls and alligators. In England otters, golden eagles and badgers are reported to occasionally kill mink. In more or less undisturbed populations, mortality may be the consequence of the territorial system, which forces non-territorial animals to move to suboptimal places. One common problem in wild mink seems to be broken or worn teeth, which occurred in about 50% animals in one Canadian population. About 20% animals also had wounds, presumable inflicted by conspecific. Weight loss and mortality are highest in the winter and spring.

4.2.2. The Polecat (Mustela putorius)

Most of the information available on polecats can be found in Corbet and Harris (1991), and Nowak (1991).

Physical characteristics

Polecats have the shape that is characteristic of the mustelids; long slender bodies, short legs, a rather long tail and prominent scent glands adjacent to the anus. Especially in the polecat, the smell is pungent.
The diploid chromosome number is 40. The weight of 28 adult British males ranged between 800 and 1710 g; 14 females ranged between 530 and 915 g. Thus, as in mink and many other mustelids the males are considerably heavier than females. Otherwise, sexes are alike.
The coat contains both underfur and guard hairs. Juvenile and summer coats have relatively less underfur than winter coats. The length of underfur being 25 versus 15 mm. Underfur is buff over most body, but greyish over shoulder and forelimbs, rump and hind limbs and on tail.
The coarser guard hairs are pigmented almost to base. The body colour is greyish to brownish. Dorsal parts are lighter than ventral parts, and there is a dark tail tip. From west to east Europe, the body colour becomes darker. The pattern of the head is remarkably contrasting. Greyish white face markings are distinct features. All polecats have white ear margins, a white chin patch extending onto muzzle and white cheek patches. The mask appears in kits about the ninth week. In winter, both adults and juveniles show varying degrees of development of the white frontal band which appears across the forehead to unite the cheek patches. Sometimes the cheek patches join but more often they remain separated by the grizzled area. The winter coat is fully moulted on May-June, when the animal reverts to juvenile pattern of face patches.

Ecology

Distribution

Polecats live all over Europe, except southern Europe, northern Scandinavia, Ireland and some smaller islands. To the east, the Polecat is replaced by the Asiatic or steppe polecat (*Mustella eversmanni*).

Habitat

In Wales polecats live in a variety of habitats such as woodlands, forest plantations, farmland, marsh, river banks and sea dunes, from sea level up to 1000 m higher. Continental polecats go as high as 2000 m. They are often associated with farm buildings on the edge of settlements where shelter and prey are abundant. This habit possibly predisposed them to gain domestication. Dutch polecats also live in all habitats, but they strongly appreciate living in the vicinity of water. They are often found in reed and other vegetation along the water edge. The domestic form, the ferret, will often sit near the water with its eyes under water. Like the Welsh polecats, Dutch polecats often spend the winter near and in farm buildings.

Radio-tracked Polecats appear to be nocturnal; during the day they sleep in their den. Reports of diurnal activity are known as well; presumably, fish catching polecats are active during the day.

The steppe polecat is sometimes supposed to be one of the ferret’s ancestors. However, this species is found in open grassland and semi desert. Thus, this species is not likely to be water oriented.

Food habits

Polecats are capable of localising sounds very accurately. They react quickly to slight noises. The keen sense of smell is used in hunting, recognising territory and finding mates. They may follow scent trails on ground, and pick up windborne scents. Eyesight during the day is not very good; at night it is relatively good, particularly in relation to moving objects. They can distinguish red from blue or green, but they seem to be more sensitive to light intensity than to colour. Their rod to cone ratio is 15.

Polecats are exclusive carnivores. For many centuries they have been considered to be effective vermin killers. Preys are detected by movements and odours. Prey is stalked and then seized using the canine teeth and killed by a neck bite which is instinctive but perfected by practice. Polecats are able to kill animals as large as adult geese and hares, although many of their preys are young.

In times of excess they cache food, especially so amphibians. Large frogs and toads are bitten at the base of their skull so that they are paralysed but not killed, and remain fresh. Whether this is a special technique or a chance effect is disputed.

Prey selection is known from scat analysis. In a study in mid Wales including 20 polecats and 558 scats, the diet comprised: 37% lagomorphs, 32% rodents, 19% birds and 6% amphibians. There was a semi-aquatic component, but fish was lacking. When corrected for handling and digestibility, the proportion of lagomorphs increased to 63 %. In a continental study, the diet comprised fish as well. All studies revealed an opportunistic nature of diet. Although males are twice as large as females, their diets did not seem to differ strongly. Dutch polecats are less specialised than all other mustelids. Their diet seems to be determined by the availability of prey, and again, they are exclusive carnivores.

Like mink, polecats often live near water (see below), their feet are webbed like mink and they are good swimmers, but polecats rarely venture directly into water. The mink swim and catch more fish whereas the polecats take more amphibians.

Home range and territory

The size of the home range depends on the availability of food. The sizes of the territories of 14 Welsh male polecats varied between 18 and 355 ha; those of 7 females varied between 29 and 83 ha. The core area, in which polecats spend 85% of their time, was about ten hectares in both sexes. Unlike mink home ranges, these ranges were not linear. Nightly activity routes cover 3-4 km, with a maximum of 8 km.

Individual polecats use about 5 different underground dens; nursing females use only one den. Polecats do not dig their dens themselves. Rabbit holes are often colonised.

Social life

The social life of polecats is poorly developed. Adults live solitarily. Territorial behaviour is weakly developed when densities are low. Territories are often vacated voluntarily, and far from always refilled. Mating is the only social contact between adults. Polecats are promiscuously polygamous, the male mating with several females and vice versa. Mating is not preceded by any courtship. Mating behaviours is vigorous; the male grasps the female by the neck and drags her about stimulating ovulation. Copulation lasts up to 1 hour. Stable pairs are not formed. Males may stay in the vicinity of breeding dens, but they are not reported to assist with rearing activities. Thus, polecats and mink do not differ greatly in their sex life.

Reproduction

Females litter once a year, on late May/June; thus a month after mink. Usually, the first observed occurrence of young is the appearance of mothers and dependent young. They are altricial. They weight 9-10 g at birth, and are naked with closed eyes. After a week, they are covered with white silky hair. After 3-4 weeks, they develop a brown-greyish woolly coat. By 50 days, they develop their characteristic face markings. Weaning begins at 3 weeks, and independence occurs between 2 and 3 months.

Reliable data on litter size and kit mortality in the wild are scarce. Corbet and Harris (1991) report without any reference to original reports the litter size to be 2-12 (usually 5-10), with seven or fewer surviving to weaning. Other authors report that the usual litter size is 4-6 and the extremes 2-11.

Mortality and morbidity

Domesticated polecats (i.e. ferrets) easily live 8-10 years; maximal age is 13-14 years. However, no feral polecat lives that long, mainly due to human interference. Their ferocity and powerful scent protect polecats from larger natural predators. In a sample of British polecats, 86% were killed by road traffic or trapping, and the remaining 14% by dogs, snares or shooting. Natural disease accounts for the death of an unknown number of polecats. Mortality among newly weaned kits must be high, if it is true that mothers wean up to seven kits. In The Netherlands, traffic incidents are also said to be the most important cause of death, followed by predation.

4.2.3. Comparison of American mink and polecat

Mink and polecats resemble each other in many aspects. This is shown in table 2. These mustelids are similarly sized and shaped animals, with identical sexual dimorphism. Polecats use olfaction slightly more than mink, but mink use vision more. Social behaviour, mating and reproductive behaviour hardly differ. Habitat selection differs somewhat, the mink being more water dependent than the polecat. They show similar activity patterns, preferably being active at night, and sleeping in dens during the day. Both species often den in burrows dug by other mammals. Both species live exclusively by hunting. Both species often hunt near the waterline, the mink swimming and catching more fish, the polecat taking more amphibians. In both species, lagomorphs, mainly rabbits, are the favourite prey. Unlike mink, polecats may live near and in farm buildings during winter.

Some British authors suggest that the successful colonisation of Britain and Ireland by mink indicate that mink exploit a previously unoccupied niche. Since polecat populations had been greatly reduced there the mink may have taken their place. Mink have failed to colonise the Netherlands and several theories have been developed to explain why the water oriented mink does not flourish in this river delta. Polecats have not been killed in the Netherlands which may explain why the species is abundant there.

In summary, although there are some differences between polecats and American mink, the many similarities indicate they can be kept in similar ways in captivity.

Table 2 Comparisons of American mink and polecat

	MINK	**POLECAT**
Size, shape and colour	Typical mustelid, uniform colour	Same size and shape, but remarkable head markings
Sexual dimorphism	Male twice as heavy as female	Similar
Distribution	Nearctic	Palaearctic, Europe only
Swimming frequency	High	Low
Diving adaptations	Dive to 7 m, hypoxia detectors	Probably none
Habitat	Variable	Similar, but in winter in and near farms
Water preference	Always living near water	Often living near water
Home range	Linear along water	Rectangular
Food	Opportunistic, preys on mammals, fish, birds and others	Similar, but less fish and more amphibians
Mating behaviour and reproduction	Promiscuous, violent long mating, one litter of 4-6 raised in den by female alone. Delayed implantation.	Similar but no delayed implantation
Social life	Solitary, defends territory	Similar, but possibly less vigorous defence
Activity pattern	Preferably nocturnal, active for about 4 hours, but opportunistic diurnal activity. Sleeps in one of many dens	Similar in all aspects
Senses	Good olfaction, hearing and vision. Vibrissae for underwater detection.	Olfaction possibly better and vision probably less developed than in mink

4.3. Canids

Within the Carnivora, the Canids emerged some 35 million years ago, the Raccoon dog being one of the oldest extant lineages (7 million years old). Canids are specialised for a cursorily lifestyle, and most are thus poor climbers but good endurance runners; many also have a digitigrade stance. Some, like the red fox, have re-evolved a caecum to assist their omnivory (MacDonald 1995), and all canids have relatively unspecialised teeth (e.g. they still have at least two post-carnassial, grinding molars). Many have evolved facultative or even obligate sociality (MacDonald 1995), and perhaps relatedly, canids have large brain sizes relative to other Carnivora.

4.3.1. The Red Fox (Vulpes vulpes)

Physical characteristics

This species has a diploid chromosome number of 34 together with 6-7 microsomes (Hersteinsson and MacDonald, 1982). The red fox weighs between 2-14 kilograms with males being about 1.2 times heavier than females (Lloyd, 1980). The mean body weight is between 4-6 kg for females and 5 to 7 kg for males. The tail is about 70% of the body length usually with a white tip (Voight, 1988). It has a total length ranging from 87 to 140 cm and a height ranging from 35 to 52 cm over the shoulder (Oestby et al., 1976). Individual variation occurs in coat colour but there are three major phases: the red (45-75% of population), silver (black, white tail tip, 2-17% of population in North America, Voight 1988), and cross (has a distinct “cross” of dark fur across shoulders). Two genes A and B determine the inheritance of the red colour and the combination of dominant and recessive forms produce the three basic colours. In general the red fox has black tipped ears, black cheek patches, and black socks. The inside of the leg is usually white. It moults twice a year during spring and summer, and the winter coat is dense and prime in December in northern latitudes (Voight, 1988). In the red fox, only about 20% of the coat is underfur, whereas 70% of the Arctic fox’s coat consists of fine underfur (wool) (Henry, 1996).

Ecology

The red fox is usually nocturnal or crepuscular, being active when its prey is active. In winter-time, in the mating and nursing periods it will be actively foraging during the day time (Henry, 1996; Takezatu, 1979, Voight, 1988).

Henry (1996) describes the red fox to be “a canid species that has the widest geographical distribution of any carnivore alive today”. Most areas of the northern hemisphere are occupied by the red fox from Alaska and Northern Russia to the Middle East and eastern Africa. The fox was successfully introduced to Australia in 1864 (Lloyd, 1980). Only South America, Iceland and Antarctica are not occupied by the red fox (Henry, 1996). The success of the red fox can be attributed to its opportunistic feeding strategy, living as a scavenger or hunter on a broad diet ranging from small mammals, domestic animals, fish, birds and birds eggs, invertebrates, grass, berries, and fruits to offal and carcasses (Henry, 1996; Hersteinsson and Macdonald, 1982; Lloyd, 1980). Voight (1988) calculated the amount of food required by a fox family during the denning season to be 18.5 kg prey/ km2, but less in other parts of the year. When food is in surplus, the red fox caches the food in small holes, which are disguised with earth, twigs and leaves (Henry, 1996).

The fox's hearing is of paramount importance for distant and close-up detections of prey. It is very sensitive to lower sounds which correspond to the sounds that small mammals make underground under snow or in cover (Henry, 1996). The red fox shows the best performance of hearing at 3500 Hz but the range of correctly located sounds was 900-14000 Hz (Lloyd, 1980). Vision in foxes plays an important role in finding food in daylight but is subordinate to hearing and smell at twilight (Lloyd, 1980). Smell is important for scavenging and for communication with conspecifics.

The red fox is usually described as a solitary carnivore, though recent literature now acknowledges that its social behaviour is complex (Voight, 1988). The red fox has never been observed to hunt in packs, as does the social living wolf. However, the red fox may live in female/male pairs or in a family group during the mating and breeding period, but each member has its own home range, dens and resting sites. A family group will consist of one male only and an additional number of females. When a family group contains several adult vixens, they are generally kin (MacDonald, 1980, Voight, 1988). Only a minority of adult vixens in a group will breed, and non-breeding vixens are socially subordinate to breeding vixens (Hersteinsson and MacDonald, 1982). Those non breeding females might act as helpers (Voight, 1988; Von Schantz, 1981). Non-breeding females that become pregnant have been reported to abort or to desert their cubs (Von Schantz, 1981). Communal denning (two vixens) and nursing has been observed in large family groups (Hersteinsson and MacDonald, 1982; Macdonald, 1980, Voight, 1988).

In superior habitats density has been reported to be 30 foxes /km^2 and in the arctic tundra as low as 0.1 fox/km^2 (Voight, 1988). Density is cyclic, following the density of prey and outbreaks of diseases. Prime habitat for the red fox is a varied country (Henry, 1996), and the more diverse the area is the more the foxes seem to thrive. Types of habitat range from undeveloped woodland to truly urban. The territorial structure is dynamic changing between seasons (Niewold, 1980). In general, the size of a territory depends on climatic conditions, quality and abundance of food, available dens or suitable landscape for digging dens, water supply, suitable sites to rest or seek refuge, and the fox density. Niewold (1980) found male territories to be between 63 and 1000 ha and female territories between 54 and 880 ha, but Voight (1988) describes the range of red fox territories to be between 500 and 3400 ha, and mentions that the smallest territories (10 ha and less) are found in urban areas. Mean territory size is 1.16 km^2 as reviewed by Servin et al. (1991) and 4 km^2 as reviewed by Gittleman (1983). Male territories never overlap each other, but a male territory overlaps one or more female territories (Niewold, 1980).

During spring and summer, activity is centred around the den. Daily travelling distances by adults rarely exceed 10 km. Males travel a mean distance of 9.82 km per 24 h, equally distributed in the night and day, whereas females travel a mean distance of 5.93 km per 24 h with a greater distance travelled at night than in the daytime (Servin et al., 1991). Woollard and Harris (1990) found that red foxes rest 35% of the time, forage actively 55% and move actively around for 10% of the time when observed from 2200 GMT to dawn.

Usually the fox has one or two large dens to give birth and raise cubs in. Additionally it has a number of smaller dens or sites, used for daytime refugee (Takezatu, 1979, Lloyd, 1980). Sometimes the fox digs the den itself, but old ones are used, as well as abandoned rabbit burrows and badger dens (Lloyd, 1980;

Taketazu, 1979). Foxes also can use as dens natural crevices, holes when trees are uprooted, or caves in a rocky habitat. Henry (1986) mentioned that a den should possess some specific features to be preferred by a vixen: key features are sandy soil (easy to dig in, good drainage), nearby water resource, multiple entrances and closeness to forest (for escape, retreat) and with open land as well (for vigilance and resting in the sun). Hewson (1994) reported that 75% of preferred den sites used during daylight were on high ground and commanded a wide field of view. In favourable conditions the fox will return to use the same den every year and increase and expand the number of entrances accordingly (Taketazu, 1979). Dens have from three to nine entrances with a diameter of 25 cm. Tunnels are interconnected with along them small chambers 40-60 cm in diameter where the fox can curl up. Droppings and carcasses of prey are found in both tunnels and chambers (Taketazu, 1979).

Daytime lying-up sites were studied by Woollard and Harris (1990). They found the range for a single fox to be 1 to 10 with a mean of 3.6 or 4.0 for dispersers and non-dispersers. Fifty six percent of the daytime lying-up sites were recorded inside the home range and 44% inside the home range. In a study by White and Harris (1994), 114 to 166 daily locations of lying-up sites were recorded in female and male pairs of red foxes. Six to twenty four of these lying-up sites were used simultaneously by the pair.

The proportion of reproductive adults within a population of foxes varies between 6 to 40 % among years (Macdonald, 1980; Zabel and Taggart, 1989), though Englund (1970) reported the figures to lie between 5 to 88%. In Zabel and Taggart (1989) it was found that 7% of their reproductive groups consisted of a single mother, 33% consisted of two reproductive nursing females and one male, and 60% consisted of a single nursing female paired with a male. They also reported that in 43% of reproductive groups there was a non-lactating female helper.

The reproductive cycle of red foxes is 12 months long, and the onset of heat is influenced by latitude, length of day light and twilight. In the Northern Hemisphere, the onset of heat ranges from January to March. The period of heat starts with a pro-oestrus phase of about 13 days and then a phase of oestrus of 2 to 3 days. Males track females by the odour of urine. Females can be monogamous, allowing only one male to mate them, or promiscuous, mating with several males in succession (Takezatu, 1979; Henry, 1986, Zabel and Taggart, 1989).

The pregnancy lasts for 52-53 days, and 1 to 6 cubs are born between early April and mid May, though a litter size of 9 has been reported. The female fox has 4 pairs of nipples. The red fox does not use any bedding material, but wool from the belly can be found in the nursing chamber (Taketazu, 1979, Lloyd, 1980). The female stays in the den for about 7-10 days following birth, but after the cubs have reached 3 weeks of age, she spends less time in the den (Macdonald, 1980). Newborn fox cubs are altricial. They cannot regulate their own body temperature, and lack locomotor, visual and auditory skills. They weigh at birth between 50 to 150 g, and have a dark-grey brown fur (Lloyd, 1980). Their eyes and ears are fully opened at 11-20 days of age (Belayev et al., 1985; Lloyd, 1980; Taketazu, 1979). Their canine (milk) teeth appear at about 10-12 days of age, and all milk teeth are fully grown at 6-7 weeks of age (Henry, 1986; Lloyd, 1980; Pedersen, 1994). Maternal care involves licking and cleaning ears and eating waste products until the cubs are about 5-week old and weaning progresses (Henry, 1996). Regurgitating food to the cubs starts when the cubs are about 3 weeks old. Vicious fighting between cubs has been observed by field biologist around the age of 5 weeks and this fighting can be fatal for some cubs.

The fighting continues during the next 10 days establishing a strict dominance hierarchy. The hierarchy determines access to food brought by the parents, maximizing the chances for the strongest cub to survive if food resources are low (Henry, 1996). As soon as the hierarchy is established, play becomes the major activity. The cubs start to emerge from the den at 5 to 6 weeks of age and at 8 weeks they will play several meters from the den (Lloyd, 1980). At about 10 weeks of age the natal den is abandoned and the cubs and mother live on the surface seeking cover elsewhere (Lloyd, 1980). Fox cubs are fully weaned at app. 3 months of age, though weaning has been reported to occur at two months. At the age of 4 months the parents ignore them or become hostile towards them, forcing the now juvenile foxes to leave the den and den area (Henry, 1996). Male juveniles seem to disperse first and for longer distances than female juveniles, starting in late August with a peak in October in northern latitudes (Henry, 1986; Lloyd, 1980, Taketazu, 1979, Voight, 1988). The average dispersal age is 225 days, i.e., around 7 months. Dispersal distances up to 302 km from the natal den have been reported and a positive correlation between mean dispersal distance and mean home range size was reported by Voight (1988). According to Woollard and Harris (1990) 67% of males and 32% of females disperse within their first year. 77% male of males and 36% of females had dispersed within their second year and 97% of males and 52% of females had dispersed within 3-8 years after birth (Allen and Sargeant, 1993). According to Taketazu (1979) in his review of an American study, male juvenile foxes were recorded to disperse from 0 to 162 km from their birthplace, where females dispersed only from 0 to 83 km and 82% of females were found within 16 km of their birth place. Allen and Sargeant (1993) found that dispersal distance was unaffected by fox density and concluded that dispersal was a strong innate behaviour in red foxes. An increase in sub-adult fighting injuries at the start of the dispersal period in autumn and a greater level of bite wounds in smaller males were found by White and Harris (1994). They suggested that the extent of affiliate interactions an individual is involved in at an early age may provide it with some predisposition to dispersal. Woollard and Harris (1990) showed that non-dispersers lived significantly longer than dispersers.

The information on neonatal events in wild red or arctic foxes is based to a great extent on indirect evidence. As both fox species give birth to cubs in underground dens, it is practically impossible to get direct evidence of what is happening there at the time cubs are born. As a result, the reproductive performance of these as well as any other wild animal species is given as the number of corpora lutea in ovaries, the number of placental scars, the number of embryos in uteri, or the number of cubs at den. There are always more or less losses between all these stages. Not all fertile females conceive. Not all ova shed attach in the uterus and develop into viable embryos. The number of placental scars, furthermore, is larger than the actual number of cubs born, as not all embryos reach a full term pregnancy. Not all cubs born will survive but some are stillborn and some die soon after delivery. Furthermore, the concept of productivity, as used in ecology, is the number of live born cubs per fertile females in a population. All of these concepts are used as a measure of reproductive performance of wild animals, often without providing sufficient details of the method used. Furthermore, as all these methods are used for different subgroups of individuals, a simple subtraction of one parameter from another is not possible. If placental scars are counted in red foxes captured in one part of the distribution range of the species whereas the number of cubs at den is counted in another region, the results are hardly comparable. For instance in wild red foxes the percentages of barren females vary from 2 to 84 %, prenatal cub mortality from 3 to 61 % and postnatal cub mortality from 16 to 55 %, depending on abundance of food and density of fox population. Even in fertile matings there is a 25.3 % natural mortality rate between ovulation and 6 weeks of age in London foxes. The role of infanticide as a reason for cub losses in wild foxes cannot be reliably analysed, we only know that it occurs.

Table 3. - Breeding success in urban red fox vixens in London (n=192) and Bristol (n=252)

	London	Bristol
Litter size[a]	4.76 ±1.52	4.72 ±1.55
Barren[b], %	15.4	20.3
Neo-natal losses[c], %	17.0	24.4
Productivity[d]	3.22	2.61

[a] Vixens with placental scars or embryos, [b] Vixens with no placental scars, [c] Vixens with placental scars but no signs of lactation, [d] Number of cubs born per number of vixens in a population

The most reliable within population figures come from a study carried out in London and Bristol (Table 3). In this material the litter size is based on the number of placental scars in autopsy specimens. The percentage of barren females is taken as the percentage of females without placental scars. If vixens killed between April 1st to May 15th were not lactating, their mammary glands were underdeveloped and their belly intact, but the animals bore fresh, darkly pigmented placental scars, such cases were taken to indicate that the vixen had undergone a full-term pregnancy but that the entire litter of cubs either had been killed at birth or had been born dead or non-viable. The exact reason for such cub losses cannot be exactly determined, however. Furthermore, cub mortality was 57 and 54 % per annum for males and females, respectively, while the adult mortality averaged 51 and 47 % for males and females, respectively. These figures fit well the figures generated by the population models, indicating that neo-natal losses of entire litters are common in both populations. Based on population structure, Englund (1970) concludes that losses of entire litters are common in red fox populations. But the reasons for such losses remain unknown.

The reproductive performance of farmed foxes is normally expressed as the number of weaned cubs per mated female, whereas litter size for wild foxes is most often based on the number of placental scars in autopsy specimens. Taking into account the proportion of barren foxes and neonatal losses of entire litters, the mean productivity per vixen was 2.61 and 3.22 cubs in Bristol and London red fox populations, respectively. Despite not including postnatal cub mortality these figures are lower than the mean whelping result for farmed silver foxes.

Postnatal mortality

Prenatal loss (ova that did not implant, lost embryos and reabsorbed foetuses) in red foxes is estimated to be 12-36% (Englund, 1970). Cub mortality within the first year can reach 43-50%. Takezatu (1979), based on his own study and some American reports, describes the mortality rate for young foxes to be 84% or higher. Of foxes that have survived their first year, about 55% will die between the 2nd and

3rd year, 57% will die between the 3rd and 4th year, and 40% will die between the 4th and 5th year. The high mortality rate is due to being killed by natural enemies such as bears, wolves, dogs, wildcats, pumas, leopards, wolverines, hawks and eagles (Takezatu, 1979). Also internal and external parasites, rabies and distemper add to the high mortality as well as contact with humans (harvest machines, automobiles, trapping and hunting). Lloyd (1980) reviewed a number of population studies of red foxes where the animals were aged by dental or skeletal examination. The oldest fox was found to be 10 years old, 0.6% of the population was 9-year old, 40-90% (variation between study-sites) was 1-year old, and 0.6-7% more than 5-year old.

4.3.2. The Arctic Fox (*Alopex lagopus*)

Physical characteristics

The arctic fox has a diploid chromosome number of 52. The body weight of arctic foxes ranges between 2.5 and 8 kg with a mean of 3-4 kg (Oestby et al., 1976). The total length is ranging from 78 to 98 cm and the body length without the tail ranges from 50 to 65 cm. The height from paw to shoulder is about 30cm. The arctic fox has short and rounded ears (adaptation to living under arctic conditions) compared to the red fox which has larger and more pointed ears. It has two distinct colour morphs. One is “white” with the pure white winter coat that in summer is brown on the back and white on the belly side. The other colour morph is “blue” which is grey/blue in winter and dark brown in summer. The white colour morph is less common in coastal habitats and most common inland (Hersteinsson, 1989). About 70% of the arctic fox fur fibres consist of fine under-fur. The paws of arctic foxes are covered by dense fur to reduce heat loss (Henry, 1996, Underwood and Moscher, 1982), so that foxes are able to maintain a foot temperature at just above freezing point when standing on snow.

Ecology

The arctic fox lives in coastal and inland arctic and mountainous tundra, in the arctic regions of Eurasia, North America, Greenland and Iceland. It is able to migrate more than 100 km in one season and up to 2300 km in total (Tannerfeldt, 1997). The southern range of the arctic fox is maintained by competition from the red fox (Hersteinsson and Macdonald, 1982).

The arctic fox is mostly nocturnal or crepuscular, but may also be active during the day. Activity varies seasonally, being lowest in the winter, but no relationship between activity, temperature and wind velocity was observed (Frafjord, 1992). It is circumpolar and tundra-living and considered solitary outside the breeding season.
The arctic fox is an opportunistic feeder. It has a diet containing almost everything available, such as berries seaweed, insects, larvae, birds and birds’ eggs, fish, seal placentas, small mammals and carcasses (Tannerfeldt, 1997). However, Hersteinsson and Macdonald (1982) reported the arctic fox’ diet to be somewhat restricted compared with the red fox, mainly consisting of small rodents. They concluded this difference between species to be due to the more restricted prey-base caused by the geographical range of arctic foxes. A large proportion of food caught during the summer is cached around and inside the den (Garrot et al., 1983, 1984). The arctic fox will often follow its own predators, i.e., polar bears, wolves and man, scavenging on

the left over from these (Frafjord, 1992, Underwood and Moscher, 1982). Daily activity cycles are arrhythmic.

The arctic fox is considered to be monogamous, though being capable of a flexible social system with large family groups seen at high population densities (Eberhardt et al., 1983, Frafjord, 1992, Garrot et al., 1984). Young foxes that stay in their parent's home range usually do not breed (Tannerfeldt, 1997). Hersteinnson and Macdonald (1982) found family groups consisting of one male and two females with cubs from only one of the females. The male is the dominant animal. It spends much time with the breeding female, and the non-breeding female is submissive towards both. In the study of Hersteinsson and Macdonald, (1982) the non-breeding females were observed to bring food to and spend time with the cubs, but they dispersed when the cubs were 6 to 8 weeks old. The arctic fox may undertake seasonal migrations, travelling from the breeding den in the autumn to the coast and even on to the sea-ice, and returning in early spring. These foxes usually travel singly or in pairs (Hersteinsson and MacDonald, 1982, Underwood and Moscher, 1982).

Territories are maintained during the breeding season and sometimes year round with size and shape determined by food availability. Mean home range sizes of 20-30 km^2 have been reported but ranges between 3 and 120 km^2 have been found (Frafjord, 1992; Hersteinsson and Macdonald, 1982)

Arctic fox dens may have an estimated average life-span greater than 300 years as reviewed by Eberhardt et al. (1983), and they seem to be used also during winter. Densities between 1/12 km^2 and 1/34 km^2 have been reported (Eberhardt et al., 1983). Dens are found in various habitats on frost free ground, on banks of streams and lakes, in open country, on hills and slopes, and in rock piles and boulders (Eberhardt et al., 1983; Nielsen et al., 1994; Tannerfeldt, 1997). Fine, well-sorted silt and sand are favoured over clay, boulder clay and rock debris (Macpherson, 1969; Nielsen et al., 1994). Some studies have found that burrow entrances are oriented towards the south (Danilov, 1961; Smits et al., 1988) but others have not been able to confirm this (Nielsen et al., 1994, Eberhardt et al., 1983). In a study of dens of the arctic fox on the Disco Island, Greenland, the mean number of entrances was 18 with a range of 1 to 63, but more than 50% of these dens had less than 10 entrances (Nielsen et al., 1994). The diameters of these dens were on average 16 m with a range of 1 to 38 m. Tannerfeldt (1997) reports the range of den diameters to be between 4 to 250 m, and Garrot et al. (1983) report that the den system can cover an area as large as 650 m2. The mean diameter of the fox entrances is around 15-20 cm (Oestby et al., 1976, Smits et al., 1988). Some cubs are reported to abandon the den as early as 6 weeks of age (summer), but early autumn (August and September) is the normal time of dispersal (Underwood and Mosher, 1982). Some years the parents will not disperse from the den and the home range linked to that, whereas the young will always disperse from a few km to more than 1100 km (Underwood and Mosher, 1982).

Arctic fox females are mono-oestrus with an oestrus of 12 to 14 days. Low lemming density between breeding seasons may delay oestrus and increase prenatal mortality, and insufficient food supply could cause abortion or re-absorption of some or all embryos (Underwood and Mosher, 1982). Mating usually occurs on March-May, and the cubs are born after about 52 days of gestation. Litter size varies according to abundance of food but ranges from 1 to 11 with a maximal reported litter size of 25 cubs (Henry, 1996; Tannerfeldt, 1997). The cubs emerge from the den at 3-4 weeks. They start eating solid food at this age and age at weaning varies between 5 to 9 weeks.

Few data exist on intra-uterine mortality or postnatal mortality of small cubs in wild arctic foxes (Frafjord 1992). Most mortality is attributed to a lack of food. Availability of food also regulates the proportion of reproducing females, which is the main factor affecting reproductive performance in natural arctic fox populations.

Mortality

Premature den abandonment, food scarcity and sibling aggression are the leading causes of cub mortality in arctic foxes (Frafjord, 1992, Underwood and Mosher, 1982). However, natural predation by red foxes, wolves, bears, eagles and snowy owls takes its toll as well. Rabies is common in Alaska and responsible for a high mortality there on some years (Underwood and Mosher, 1982). Adult mortality is around 50% per year and the average life span for animals that reach adulthood is 3 years in Scandinavia (Tannerfeldt, 1997). Juvenile mortality rates were monitored in North West Territories and ranged from 93 to 97% (Hiruki and Sterling, 1989), whereas the adult mortality was about 40%. Maximum recorded longevity was 6 years for males and 7 years for females (Hiruki and Sterling, 1989).

4.3.3. The Raccoon Dog (Nyctereutes procyonoides)

Physical Characteristics

The raccoon dog is a single-species genus among the Canidae native to North-Eastern Asia, which was transported to farms in western Russia, feral animals of which are now migrating westwards into North-Central Europe. This species must not be confused with raccoons (*Procyon lotor*), which resemble raccoon dogs only by their facial colour markings. The Raccoon dog (*Nyctereutes procyonoides*) is the most primitive member of the canine family. Its basic colour is a yellow brown fur with black hair tips on the shoulder, back and tail. It has short dark limbs, a heavy body and rounded ears. There is no sexual dimorphism in body size. The body length is between 50 to 80 cm and the tail length is 15 to 25 cm. Raccoon dogs weigh between 4-6 kg in summer and to 6-10 kg in winter (Jackson, 2000).

Ecology

The Raccoon dog originates from East Asia, the eastern part of Russia, Mongolia, China and Japan. From 1927 until 1950, an intensive effort was made to introduce the Raccoon dog to Northwest Russia and Europe due to its fur. Since then, it has settled successfully in most of Europe and Scandinavia. A large Finnish population is due to immigrants from Russia (Kauhala, 1992), and population density is highest in southern Finland with a northern distribution limit between 65^0 and the Arctic Circle (Kauhala, 1992).

The raccoon dog is a true omnivore, eating what is available according to season such as berries, cereal grains, plant material, fruits, vegetables, hares, voles, shrews, carcasses, birds, insects, frogs, lizards, and fish. The annual variation in diet is linked to the abundance of small rodents (Kauhala, 1992).

The raccoon dog is a nocturnal predator and is often classified as a solitary and strictly monogamous animal (Kauhala, 1992). But it is also reported to live in families as reviewed by Korhonen et al. (1991a). The pair will spend much time together during breeding and in autumn, and the male will stay at the den helping to rear the cubs. (Kauhala, 1992). The raccoon dog deposits faeces on a particular site, termed a latrine (Korhonen et al., 1991b).

The raccoon dog preferably lives close to rivers with dense vegetation. The home range of adults averages 9.5 km^2 (Kauhala, 1992). The home ranges of a paired male and female overlapped completely but not with other adult Raccoon dogs. Home ranges of juveniles were larger than those of adults and overlapped with others (Kauhala, 1992). Non-paired adult Raccoon dogs avoid each other. In harsh winters the raccoon dog's activity decreases and it might become dormant (carnivore lethargy) from November to February, living on deposited fat layers (Macdonald, 1995). During dormancy, the body temperature of raccoon dogs drops 10^0C to about 29^0C and their metabolic rate falls by about a half (Macdonald, 1995). Usually raccoon dogs use dens abandoned by other species, such as badgers or foxes. They might even share a large den with these species (Jackson, 2000).

Reproduction

The raccoon dog has a 12-month reproductive cycle, and in Finland the breeding season starts in February. Adult females ovulate 1-2 weeks earlier than females born in the previous year (Kauhala, 1992). The gestation time of the raccoon dog is 59-64 days. Mean litter size is 5-7 cubs but a litter size of 19 has been found. In Kauhala's study (1992) the mean fecundity was 11.5, the mean embryonic litter size 9.6 and the mean birth litter size 8.8. In total, the mean productivity of the population was 6.9 cubs. Cubs are born with an almost black layer of hair and weigh between 60-90 grams. Eyes open after 9 to 10 days, and the first teeth appear when they are 14 to 16 days old. Females that are 3 to 5-year old show the highest productivity compared with older and younger females.

Dispersal occurs in early autumn, and the greatest distance found in recovered juveniles is 61 km from the natal den (Kauhala, 1992). Adults were not dispersing more than 5 km, and 25% of the juveniles were found more than 20 km from the natal den.

Mortality and morbidity

Kauhala (1992) reported the annual mortality rate in her Finnish study-population to be 81%, with figures of 54% for adults and 88% for juveniles. Mortality rate was the lowest in 2-4 year old raccoon dogs and increased in animals 5-year old or older. About 50% of the cubs died in the course of their first summer, with a 77% mortality rate for cubs and juveniles in their first autumn/winter. The raccoon dog had a maximum life span of 7-8 years in her study. Kauhala (1992) states that abundance of small rodents (food), abundance of red foxes (competition, predation), the duration of the snow cover (body condition), diseases (rabies, sarcoptic mange) and the hunting pressure explained the seasonal and annual variations in population density in the raccoon dog. Wolves, stray dogs, lynx, martens foxes and large birds of prey are natural predators. The most common diseases are rabies, diarrhoea, and parasites.

5. GENERAL ASPECTS OF RODENT BIOLOGY

The first rodents appeared 60 – 65 million years ago. They are now the most common species in the mammalian order, with about 3000 extant species (compared with the 236 species of Carnivora). They live in all parts of the world and a variety of ecological niches. Despite, this, they are relatively conservative in morphology – all are herbivores or at least primarily herbivorous; all are small (the largest extant species being the capybara); nearly all of them are terrestrial; and many are burrowers. They also have small brains and cerebral hemispheres (though it should be emphasised that some species, e.g. the rat, show excellent learning and memory). Their success stems from their rapid reproductive rates (females are typically polyoestrous, producing litters throughout the year), and their specialised dentition and associated musculature. Their incisors are reduced to four in number. They are enlarged, continuously growing, and have enamel only on their labial (i.e. outer) surfaces so that differential wear of the enamel and dentine results in a constantly sharp chisel-like edge. Their cheek muscles (the masseters) are enlarged and modified so as to produce enhanced jaw mobility and a powerful gnawing action. Rodents are also characterised by excellent smell (the olfactory bulbs are typically very well developed) and hearing; vision is also well-developed in arboreal and open-grassland species. Rodent herbivory is aided by hindgut fermentation and many species exhibit coprophagia in order to maximise the absorption of nutrients released by this process. The general biological characteristics of rodent species used for fur production are summarized in table 4.

Table 4.: Biological characteristics of rodent species used for fur production

	Coypu	Chinchilla
Average body mass (kg)	F: 5-6 M: 6-7	F: 0.8 M: 0.5
Average home range	F: 2.5ha M: 5.7	
Diet	Herbivorous	Herbivorous
Activity cycles	Nocturnal/crepuscular	Nocturnal
Denning habits	Digs own burrows	Digs own burrows
Adult social structure	Gregarious (2-15 animals) Polygamous mating	Gregarious, monogamous or possibly polyandrous
Average litter size	5-6	2-3
Weaning (weeks)	8	6-8
Sexual maturity (months)	6	8
Mortality and longevity	Unknown, Up to 7 years	Unknown, Up to 10 years
Other features	Semi-aquatic, territories along water, excellent swimmer and diver	Desert living

5.1. The Coypu (Myocastor coypus)

The higher-level classification of the coypu is controversial. Though coypus are related to echimyids and capromyids, several morphological differences argue against uniting myocastorids with either of these taxa in the same family. Therefore, currently the coypu is placed in its own family, Myocastoridae (Woods et al., 1992).

5.1.1. Physical Characteristics

The coypus are large rodents, weighing up to 10 kg (a maximum weight of 17 kg has been reported for the species, Nowak, 1991). Males are generally larger than females, Gosling (1977) reported full grown males to be 15% heavier than females. The length of the head and body is around 520 mm (472 – 575 mm), and the length of the tail is typically about 375 mm (340 – 405 mm) (Gosling, 1977; Nowak, 1991; Woods et al., 1992).

Coypus have a robust body that shows many indications of their aquatic lifestyle. The ears and eyes are small. The webbed hind feet are large and have 5 toes. Four toes are found on the forefeet, which lack webbing. All toes have well-developed claws. The tail is long, scantily furred, and rounded. It is not compressed as in the beaver, *Castor canadensis* (which is larger and has a large horizontally flattened tail) or the muskrat, *Ondatra zibethicus* (which is smaller and has a vertically flattened tail, higher than it is wide) (Whitaker, 1988).

Like many aquatic mammals, coypus have thick, soft underfur. Their colour is dark dorsally and whitish yellow on the underside. The pelage consists of two kinds of hair, soft dense underfur, and long coarse guard hairs that vary from yellowish brown to reddish brown. The underfur is dark grey, and it is denser on the abdomen. The chin is covered by white hairs. Females have four pairs of thoracic mammary glands that are situated well up on the sides of the body.

The cranium of a coypu is massively built, with well-developed ridges (including a sagittal crest) and a deep rostrum. Coypus are hystricomorphous, and their infraorbital foramina lack a distinct groove for the passage of nerves to the rostrum. The zygomatic arches are heavy and broad, but the jugal does not contact the lachrymal. On the ventral surface of the skull, the auditory bulla is small but the paroccipital processes are unusually long. The lower jaws are strongly hystricognathous. The coronoid process is reduced to little more than a knob.

The coypus have the following dental formula: I1/1, C0/0, P1/1, M3/3 = 20 (Lowery, 1974). The molars are hypsodont, flat-crowned, and rooted. The upper molars have two labial and two lingual folds, while the lowers have one labial and three lingual. The incisors are massive and chisel-like, deeply orange-yellow in colour.

5.1.2. Ecology

The coypu is a large semi-aquatic hystricomorph rodent of South American origin. It has been introduced to many countries for fur farming. As a result of escapes and in some countries of deliberate releases, feral coypus are now present in North America, England, Europe, Russia, the Middle East and Africa (Woods et al., 1992). The coypu was feral in England until recently, as a result of fur farm escapes, but has now been eradicated

The home range of coypus is fairly constant in spite of population density. The average home range for female nutria is 2.47 ha, while for males it is 5.68 ha. Generally, coypus remain in one area throughout their lives. (Nowak, 1991; Doncaster and Micol, 1989; Woods et al., 1992).

Coypus may use logs or other floating objects as feeding platforms. They can eat up to 25% of their body weight in plants per day (Gingerich, 1994; Gosling1974). In a manner reminiscent of lagomorphs, the coypus re-ingest their faecal pellets to digest food more completely while at rest (Whitaker, 1988).

Coypus are opportunistic feeders, consuming a variety of plants throughout their natural and introduced ranges (Gosling, 1974). Coprophagy, an important factor in explaining the ability of herbivores or omnivores to subsist on low protein diets, such as grass is connected with protein digestibility.

The coypu is most active at night (Chabreck, 1962). Most of the active period is spent feeding, grooming, and swimming. It commonly makes platforms of vegetation, where it feeds and grooms itself. For shelter the coypu constructs a burrow, which may be a simple tunnel or a complex system containing passages that extend 15 meters or more and chambers that hold crude nests of vegetation. The coypu also makes runways through the grass and wanders within a radius of about 180 meters of its den. The coypu is highly gregarious. Coypus often live in groups of up to 10-15 individuals (Woods et al., 1992) which are composed of related adult females, their offspring, and a large male. Young adult males are occasionally solitary. Males use specialised anal scent glands, which become more developed from October through December, to mark their territories (Gosling and Wright, 1994).

Coypus tend to be crepuscular and nocturnal; the onset and end of activity periods coincide with sunset and sunrise respectively, and activity peaks around midnight (Chabreck 1962, Norris 1967, Evans 1970, Gosling 1979, Coreil 1984).

Gosling (1979) found that the onset of activity at dusk was less variable and independent of temperature, but the predawn pulse was more variable and suppressed by low temperatures. Fewer feral coypus are caught on cold nights and, if near-dawn activity is suppressed by low temperatures, diurnal feeding is increased (Gosling et al. 1980, Gosling 1981). Evans (1970) found that in the presence of abundant food coypus fed only at night and spent the day resting and grooming. However, in marshes and during winter in agricultural areas, they feed at night and periodically during daylight hours.

Coypus often lie up close to water, under a bush or in dense vegetation. Nests have several entrances at water level (20 cm in diameter). The animals feed and defecate throughout the active period and about 80% of the faecal pellets are produced in water. Coypus are excellent swimmers, capable of staying underwater for up to around 10 minutes. They swim using alternate propulsive thrusts of their webbed hind feet and alternate paddling by the fore feet. They also float immobile or with occasional strokes of the hind feet with only the top of the head and sometimes, the dorsal surface of the back exposed. Grooming is most intense and prolonged after swimming. They prefer slow-moving streams, lakes, and brackish or freshwater marshes. They are good diggers, constructing burrows in river banks, nests being made with plant materials, or alternatively nests are made in the burrows of other animals, such as in the lodges of beavers and muskrats.

The coypu is a polyoestrous mammal. Reports of the length of the oestrus cycle are extremely variable: Intervals of 5-28 days are often recorded. They can reach up to 60 days, with healthy females occasionally showing no cycles over several months. This variation suggests that ovulation is coitus induced. Oestrus persists for a day in young females and seldom exceeds two days in multiparous animals. Courtship includes a good deal of chasing, fighting and biting. The gestation period is long, varying from 127 to 139 days. A postpartum oestrus occurs within two days of parturition (Gosling and Skinner, 1984), as, indeed, might be expected from the very high proportion of females that are found to be pregnant in most post mortem samples. The mean postpartum interval is estimated to be 2.1 ± 0.8 weeks. The young are precocial, born fully furred and active. Mean litter size in general varies from three to six, although it may range from 1 to 13. The mean body weight at birth is about 225 g (range 175-332 g, n = 45. The lactation period extends for about 8 weeks in the wild but can be up to 14 weeks in captivity. The youngs are covered by soft and downy hair; the tail hair appears silky until the end of the first month, when it is replaced by coarse hair. Coypus gain weight rapidly during the first five months of life. Sexual maturity is attained when only 6 months old. Dispersal age is not known. The potential longevity of *Myocastor coypus* is 6-7 years though individuals rarely live more than 3 years in the wild (Nowak, 1991).

5.1.3. Mortality and Morbidity

There are only a few data on mortality and morbidity of coypus in the wild. In England a consistent year to year mortality of 74% and 67% in males and females respectively has been reported.

5.2. The Chinchilla (Chinchilla laniger)

5.2.1. Physical characteristics and basic biology

With its large ears, jumping locomotory behaviour and large tail, the chinchilla's physical appearance is something between a rabbit and a squirrel. The body length is 22.5-38 cm and tail length is 7.5-15 cm. The female is the larger sex and weighs up to 800 g, while males seldom weigh over 500 g. The head is broad, the external ears are large (6 cm), and the auditory bullae are enormous. The eyes are also large. The forefeet and legs are small; the hind feet and legs are larger (Heinrich, 1974; Nowak, 1991). As well as continuously growing incisors like all rodents, chinchillas have continuously growing molars.

The pelage is silky with up to 60 hairs growing from each follicle. Hair length is 1.7-1.8 cm. The general coloration of the upper parts is bluish, pearl or brownish grey. Each hair has a black tip. (Heinrich, 1974; Nowak, 1991).

The physiology of chinchillas shows many modifications for desert life, including thermo-regulatory adaptations (e.g. Wang et al. 1983, Cortes et al. 2000a) and specialisations for water conservation (e.g. Chou et al 1993, Cortes et al. 2000b). The life span in the wild is about 10 years; captives can live 15-20 years. (Heinrich 1974; Nowak 1991).

5.2.2. Ecology

In the 16th century, chinchillas were reported to live from high in the mountains down to the coast (Heinrich, 1974). These days, the natural habitat is the relatively barren areas of the Andes mountains in South America, at elevations of 3000-5000 meters (Heinrich 1974; Nowak 1991).

In earlier days, chinchillas probably were numerous as appears from the number of 500.000 skins exported every year of the late 19th century. In 1905, this number was reduced to 216.000 and to 27.000 in 1909. In the 1920s they were nearly exterminated. Nowadays, the number in the wild is estimated to be 10.000

(Heinrich 1974; Nowak 1991). Attempts to introduce captive bred chinchillas into the wild do not seem to be successful, perhaps because thorough research about their lifestyle is not available.

In the context of animals on the verge of extinction which do not live in their preferred habitat but in areas which are inaccessible to man, it follows that their present distribution is certainly not representative of their original habitat. The long-tailed chinchilla (*C. lanigera*) was considered extinct in the wild, but was re-discovered in 1975, and currently a few scattered colonies remain in Chile (Jimenez 1996).

The diet consists of any available vegetation, namely grasses, fruits, leaves, bark, and the fleshy parts of some cacti (www. chinchillas.co.uk, 2000). To eat, they sit erect and hold the feed in their forepaws, like e.g. squirrels. (Heinrich 1974; Nowak 1991).

The large eyes and ears indicate a nocturnal lifestyle; the large hind legs and feet, a jumping locomotory behaviour in areas where walking is not easy; and the dense fur, a life in cold areas (Heinrich 1974; Nowak 1991). This fur must be cleaned with regular sand-bathing to reduce lipid build-up (Barber and Thompson 1990). Chinchillas shelter in crevices and holes among the rocks. Though nocturnal, they have been observed sitting in the sun, before their holes (Heinrich, 1974). They dig their own burrows . Chinchillas are timid by nature and in the wild are subject to predation.

In the past, colonies of 100 and more chinchillas were frequently seen. Thus chinchillas are social. They are often said to be monogamous, others emphasise that this claim is not proven (Nowak, 1991). The fact that males are far smaller than females prohibits polygamy, and supports polyandry. Females are said to be very aggressive towards each other and also towards males.

In the Southern Hemisphere, the breeding season is from May to November. There are usually two litters per year. Litter size is 1-6, usually 2-3. The oestrous cycle averages 38 days and females have a postpartum oestrus. The mean gestation period is 111 days. Lactation lasts 6-8 weeks. Sexual maturity is attained after 8 months by both males and females (Nowak, 1991).

5.2.3. Mortality and Morbidity

Little information is available on mortality and morbidity in the wild.

5.3. Conclusions of Chapters 4 and 5

1. There is a high diversity in the habitat and biological characteristics of the carnivora and rodent species that are used for fur production.
2. The diversity of the living conditions in the wild of these species is likely to contrast with the relative uniformity of farming conditions across species.

6. DOMESTICATION

6.1. The concept of domestication

The history of domestication of some farm animal species is much shorter than others. For example, Nimon and Broom, (1999) state "In contrast to the thousands of years during which cattle or pigs have adapted to farming by humans, mink have been kept in captivity for only 80 or fewer years. Hence mink are not domesticated in the same sense. This renders it highly unlikely that all of their requirements for good welfare in captivity will have been identified". This section discusses what domestication is and its implications for animal welfare.

6.1.1. Definitions of domestication

A large number of definitions of domestication have been proposed, with the main focus on various aspects of the human-animal relationship from different scientific disciplines (e.g., Hale 1969; Isaac 1970; Ducos 1978; Price 1984; Bökönyi 1989; Clutton-Brock 1989). O'Connor (1997) clarifies the concept by reviewing definitions from different disciplines, while Price (1998) discusses the various genetical processes involved in domestication.

Some definitions emphasise the early stages of the domestication process initiated by humans. According to Bökönyi (1989), e.g., *"the essence of domestication is the capture and taming by man of animals of a species with particular behavioural characteristics, their removal from their natural living area and breeding community, and their maintenance under controlled breeding conditions for mutual benefits"*. This definition also represents the view of domestication, particularly the early stages, as a coevolved mutualistic relationship with evolutionary advantages to both animals and humans (Reed, 1959; Bökönyi 1989; Budiansky 1994). Domestication may, independently of how man or animal contributed to the process, be considered a special form of evolution where unconscious selection contributed to the process prior to conscious selection (selective breeding; Zohary et al. 1998). According to Eibl-Eibensfeldt (1994), some aspects of domestication have a positive selective value, allowing the animal to adapt to particular environmental conditions.

The present context is not the appropriate one for purely semantic or philosophical discussions about concepts and their origin. As is the case for the concept of animal welfare, the concept of domestication has only scientific value if it is defined operationally in relation to the use needed for the scientific context. If domestication is to be considered in relation to animal welfare, definitions should be sought which clarify how animal welfare is affected by the process by which captive animals adapt to man and the environment he (or she) provides.

Price and King (1968) state that *"domestication is an evolutionary process involving the genotypic adaptation of animals to the captive environment"*. As suggested by Price (1984, 1998) defined domestication as *"that process by which a population of animals becomes adapted to man and to the captive environment (he provides) by genetic changes occurring over generations and environmentally-*

induced developmental events recurring during each generation". The definition of Price refers to genetic changes in a population of animals, some of whose effects are to alter the potential for responding to the human contact that precedes taming. The definition used in this report is "an evolutionary process by which a population of animals becomes adapted to man and to the captive environment by genetic changes occurring over generations including those predisposing to environmentally-induced developmental events recurring in each generation". The degree of domestication is a trait of a population, even a small population and there may be different populations represented on different farms or even on the same farm, according to individual genetic traits and experience . Welfare is an individual trait, but some information collected in order to assess the welfare of individuals may also be useful in assessing the degree and nature of domestication..

6.1.2. Characteristics of domesticated animals

Hale (1969) discussed fourteen behavioural predispositions that would facilitate the domestication process; e.g. large social groups that are hierarchically organised, promiscuous mating, critical periods for socialisation, precocial young, short flight distance to humans, omnivorous, and non-specific habitat choice. As adaptation forms a continuum and is difficult to measure, it is difficult to determine the extent to which a population (or individual) has become domesticated (Price 1998). The domestication process is complete in a stable environment only when the fitness of the population has reached some maximal steady state (Price 1998). The domestic phenotype refers to the group of phenotypic traits that facilitates the adaptation of captive animals to their environment (Price 1998).

All morphological and behavioural traits occurring in the domestic population that differ from those of the wild ancestor are indicators of a preceding domestication process (Clutton-Brock 1987). Price (1998) gives a general review of behavioural effects of domestication. "Behavioural development in animals undergoing domestication is characterised by changes in the quantitative rather than qualitative nature of responses. The hypothesised loss of certain behaviour patterns can usually be explained by the heightening of response thresholds. Increases in response frequency accompanying domestication can often be explained by atypical rates of exposure to certain forms of perceptual and locomotor stimulation", he concludes.

Although sometimes claimed, it is not clear that behavioural neoteny (or paedomorphosis) has had a significant role in domestication of species other than dogs (Price 1998). Welfare-related domestication effects would ideally include the ability to breed in captivity without problems, a non-aggressive temperament, hierarchical social structure, and generalised dietary preferences (Price 1998), loss of motivation to perform natural behaviour and loss of fear of humans. Low level of fearfulness towards humans is an important characteristic of domesticated animals, although authors frequently refer to this as docility or suppression of flight instinct (e.g. Price 1984; Zohary et al. 1998). During the process of domestication, the brain weight of mammals has been reduced by up to 30 % (Apfelbach 1996). In all species studied, the reduction in the neocortex, the phylogenetically youngest brain area, was even more pronounced. However, the functional consequences of such changes are not known.

Artificial selection for reduced fearfulness of silver foxes towards humans has been extensively studied for 40 years in Novosibirsk, Russia in the context of fundamental research (Belyaev 1979; Belyaev et al. 1985; Trut 1999). This selection resulted in some individuals showing white patches in the fur, a curled tail, shortened legs or tail, or floppy ears (Belyaev, 1979; Trut, 1999). These changes could burst into the population after only few generations of selection. The more domesticated population also showed a number of reproductive and endocrinological effects, e.g. earlier sexual maturity, larger litter size, lower plasma cortisol and progesterone levels, lower sensitivity of the hypothalamus-pituitary-adrenocortical (HPA) axis to emotional stress, higher plasma levels of oestradiol and higher brain levels of serotonin (Trut et al. 1972; Trut 1999). Belyaev (1979) interpreted these observations as evidence of destabilising selection previously occurring in other domesticated species.

6.1.3. Genetic and breeding evidence for domestication

In many cases, changed selection relaxed natural selection can be expected to accompany the transition from field to captive environments, as certain behaviours important for survival in nature (e.g. food search, anti-predator behaviour) lose much of their adaptive significance (Price 1998). Genotypic and phenotypic variabilities of such traits are therefore likely to increase. Domestication, like any evolutionary process, involves the complex interplay of both random and non-random genetic mechanisms (Price 1998). Control of breeding (artificial selection) may still result in a certain inbreeding and genetic drift. Pleiotropic mechanisms may inadvertently cause morphological and behavioural changes. Welfare effects of various aspects of the domestication process are discussed in 6.1.5.

Much potential exists for actively selecting against behaviours that would be important in the wild. The low tendency to flee novelty and predator-like individuals (e.g., humans) that has developed in domesticated ungulates is a good example. Such a process may happen indirectly, on many farms, laboratory breeding colonies, and zoos, through selection against abnormal behaviour or other stress-related problems such as poor reproduction. However, such changes are not by themselves evidence of reduced frustration. For example, abnormal behaviour could be reduced by selection for decreased ability to initiate or sustain activity. Laying hens have been selected for low motivation to nest, and as a result produced birds with low levels of pre-lay pacing (Faure and Mills, 1998). However, this aspect of domestication remains much under-exploited as a welfare tool. On the contrary, results on selective breeding to modify stress responsiveness have been obtained both on rodent models and on poultry models (Pottinger, 2000; Faure and Mills, 1998). In domestic pigs selective breeding has been mainly directed at elimination of a gene associated with high susceptibility to stress (porcine stress syndrome, PSS), the so-called halothane stress gene' (von Lengerken and Pfeiffer, 1991).

The experimental studies on domestication of silver foxes in Russia reveal that pronounced reduction in fear and aggression, and increased docility and tameness, can be achieved after a few generations if given sufficient weight in the breeding goal (Belyaev et al. 1985; Plyusnina et al. 1991). After ten generations of strict selection for tameness in silver foxes (response to being hand-fed, stroked and handled), 18 % were “elite” animals; eager to establish human contact, whimpering to attract attention, and sniffing and licking the experimenters like dogs (Trut 1999). All lower-classified foxes were also tamer than calm farm-bred foxes. The proportions of “elite” animals were 35 % after 20 generations and 70-80 % after 40 generations. Although some animals (a few percent) of the tame selection line of Russian foxes acquired undesirable morphological traits, such as pie baldness, curly hair, curled tail, or floppy ears,, such traits might well be controlled for with a more balanced breeding index. More recently, such selection studies have also been performed on mink in Russia and Denmark (Trapezov 1987; Hansen 1996). When tested at 2.5-3 months of age, mink kits selected for reduced fear of humans had a shorter flight distance towards humans and a lower plasma cortisol concentration (Kharlamova and Gulevitch 1991). A lower cortisol response after human handling was found in Danish mink selected for confidence (Hansen 1996). Similar results have been obtained in silver foxes. A cross-fostering experiment showed that the temperament of mink kits is dependent more on the biological origin than on the foster mother’s behaviour (Malmkvist and Hansen, in preparation). Mink from the confident line needed a smaller dose of anxiolytic drugs (Buspirone) to reduce fear than mink from the fearful line.

6.1.4. Ontogenetic consequences of domestication

During behavioural ontogeny animals may adapt to environmental conditions; the physical environment as well as the social environment comprising both conspecifics and humans. Generally, the higher the level of genetic domestication, the easier and more successful is the ontogenetic adaptation. This adaptation can be gained by imprinting, habituation, and positive conditioning (Hess 1964; Ochieng’-Odero 1994). Experience with variable environmental stimuli and weak stressors with which the animal is able to cope may reduce the stress susceptibility in the adult animal (Dienstbier 1989; Ogawa et al. 1994). Such early experience may also counteract effects of prenatal stress (Weinstock 1997; Braastad 1998) by reversing its neuroendocrine effects, i.e. increasing hippocampal negative feedback of the HPA axis (Ogawa et al. 1994). Important environmental experience in young animals kept for fur production may include exposure to noise and contacts with humans, to counteract stress responses to sudden noise and to unfamiliar visitors.

Olfactory deprivation during ontogeny (particularly 3rd month of life) of ferrets has been shown to affect neural structures of the olfactory system, manifested as a reduction in density of the dendrites (Apfelbach 1996). This was associated with behavioural changes like a reduced ability to associate odours with other stimuli in conditioning studies compared with non-deprived animals. Considering the 32 % reduction in brain size of ferrets as compared to the undomesticated polecat (Apfelbach 1996), this study shows that changes in the brain of domesticated animals may be related both to the genetic changes during the domestication history and to restricted experience during the ontogeny.

Ontogenetic impact of stimuli often depends on the existence of sensitive periods. For example, domestic chicks may be imprinted on the environment, the food, as well as on social companions in a sensitive period early in life (Hess 1964). Reduction of fearfulness towards humans may occur either through imprinting in the period of primary socialization (Scott and Fuller 1965), or through habituation or positive conditioning towards man. These processes are known as taming which is defined as “the elimination of the tendency to flee in the presence of man” (Wood-Gush 1983). Genetic selection for reduced fearfulness may markedly facilitate the ontogenetic taming process (Belyaev et al. 1985; Trut 1999). It is shown that this facilitation is brought about by delaying the onset of fear reactions from 6 to 9 weeks of age, and reducing maturation of aggression, hence lengthening the socialization period (Belyaev et al. 1985; Plyusnina et al. 1991). These effects enhance the animals’ receptivity towards, and extend the sensitive period for, human contact.

6.1.5. Welfare aspects of the domestication process

Some aspects of domestication in a farmed species may be changed rapidly in a way which has some important consequences for welfare.. The main issues are the breeding goals governing the artificial selection, as well as the degree to which ontogenetic adaptation to confinement and human contact is facilitated by the stockpersons. Generally, when domestication is incomplete it is necessary to use early handling procedures for taming animals. In this last case, the resulting mature animal might to a great extent be the same, regardless of genetic domestication level. As such early handling is time consuming, genetic selection for increased tameness should be encouraged. Even with the most effective selection, however, some handling of young animals is necessary. It is, for example, extremely difficult to handle and tame an adult domestic cat, which has previously had no human contact.

Other aspects of the domestication process that improve welfare include selection for physiological changes that reduce aspects of stress sensitivity and intraspecific aggression and motivational changes that reduce behavioural needs. However, the effects on animals welfare of morphological, or physiological changes during domestication have not yet been clarified . The morphological changes, e.g., may be irrelevant for welfare discussions, unless they are so marked that they cause physical distress or affect the performance of normal behaviour. This has been an issue for some selection lines of e.g. beef cattle, broiler parents, and pigs, but may also concern animals farmed for their fur. In animals kept for fur production such effects may be by-products of selection but not the main target. For example certain colour types of mink have an increased incidence of different defects, e.g. “screw-neck” in lines of pastel mink, “bleeder” tendencies, increased susceptibility to bacterial and viral infections such as plasmacytosis in types with a recessive Aleutian gene, and the white “Hedlund” mink which is deaf as adult and whose ability to care for its kits may be reduced (Nes et al. 1988). Green eyed pastels also have excessively light sensitive eyes (Nes et al., 1988). The welfare of such animals should be checked particularly well in some strains and, the whole strain should be avoided if defects are frequent.

Selection for low fear of novel objects/humans may improve welfare but note that selecting for a high motivation to explore or a high motivation to interact socially with humans could actually be counterproductive for welfare in a barren, physically restrictive, environment. For example, silver foxes selected for high approach behaviour to humans also show high levels of frustrated behaviour (e.g. whining etc.) when denied contact (reference needed).

There may be negative effects of selection for high productivity. According to resource allocation theory (Beilharz et al. 1993), the more resources that are necessary for the animal's adaptation to the production system, the less resources are left to behavioural mechanisms necessary for other demands of coping. Comprehensive environmental alterations and simultaneous intensification of selection for production traits further complicates the animals' ability to adjust to change. The higher the selection intensity and the narrower the production-related breeding goal, the higher is the risk for adverse side effects on the animals' welfare (Bakken et al. 1994). The documented welfare problems found in farm animals, related to physical and mental health, reflect animals that with severe difficulties adjust to the environmental demands (Bakken et al. 1994; Rauw et al. 1998). However, the risk for animals farmed for their fur appears low in comparison with some other intensively farmed animals since the selection process on production has been less intense.

Another aspect of artificial selection in several farmed species is the fact that parents (the breeding stock) and the producing animals (or fattening animals) are kept in different environments. This complicates the genetic adaptation to the production system. Selecting breeding animals in "relaxed" environments contributes poorly to the process of natural (or unconscious) selection for coping mechanisms that, in terms of welfare, is necessary in more intensive systems. However, in species farmed for fur production, breeding and growing animals are usually kept in very similar environments.

6.2. Domestication of animals kept for fur production on farms

6.2.1. Red and silver foxes (*Vulpes vulpes*)

Silver foxes are colour variants of red foxes (*Vulpes vulpes*). It has been suggested that the red fox could have been domesticated by Neolithic people in Switzerland some 3-5000 years ago. This theory was based on remains found in lake dwellings that demonstrated the existence of numerous foxes in close proximity to the community, foxes morphologically distinct from the wild type also being found near the dwellings. In historic time, the first attempts to breed foxes in captivity were conducted in Canada in 1887-1892 (Belyaev 1984; Clutton-Brock 1987), but the first successful attempt was started in 1894. In Europe, the first silver fox farm appeared in Norway in 1914. In the early 1930's there were 11 000 farms in the world producing over 300 000 pelts annually (Belyaev 1984). A few years later, in 1939, 348 000 pelts were exported from Norway alone. As the first silver fox farming in Europe was based on animals imported from Canada, the domestication history of silver foxes can be regarded as being about 110 years old.

As for all animals kept for fur production, silver foxes are commonly selected on the basis of fur quality, body size, and litter size (at birth and weaning), giving little attention to the human-animal relationship. Captive breeding and the first stages of domestication have been accompanied by increased litter size and body weight (see table 8). The frequent reproduction problems encountered may also be expected to bring about a certain unconscious selection on the animals coping best with the breeding system and the physical and social environment, animals hence being less stress sensitive and fearful. The first farm-breeding of silver foxes occurred in wire pens on the ground but parasites, hygiene problems and a desire to keep more animals in a given space led farmers to construct wire-mesh cages (Forester and Forester 1973). Silver foxes have been bred in cages for about 60 years,. As poor reproduction in some individuals is shown to be due to their low social status when dominant neighbours are present (Bakken 1993b), fulfilling the reproductive potential is not possible without separating these animals visually and spatially (Bakken 1993a). The use of neck-tongs and snout-clips to avoid scratches and injuries from bites when handling the foxes may have retarded the conscious selection providing genetic progress related to tameness.

There are no scientific studies exploring whether the genetical bases of needs of silver foxes to show certain behaviours are altered during their domestication history.

Because the genetic predisposition of fear of humans has undergone limited changes and early handling of cubs has been given low priority, silver foxes are usually not adapted to an extent that ensure that their welfare is at a sufficiently high level in the present production system (reference needed). The unconscious selection during 110 years must have provided a certain level of domestication that is difficult to estimate. Further progress related to reproductive ability, low aggressiveness towards conspecifics, and low fearfulness towards humans should be easy to achieve based on the available scientific evidence. Selection for reduced fearfulness towards humans is now being carried out in private farms in Norway, Finland and Denmark (Nikula et al. 2000; Nordrum et al. 2000).

6.2.2. Blue foxes (Alopex lagopus)

Blue foxes are colour variants of the arctic fox (*Alopex lagopus*). Blue foxes were first kept in captivity in 1885 on small islands outside Alaska where they bred freely. Some of these were exported to Norway and Sweden in the late 1920's and kept in wire cages from the beginning, i.e. more than 70 years. The relatively large and high-fertile Alaskan blue foxes were crossed with a light-coloured, but less fertile variant wild-caught on Greenland and other North-Atlantic islands from 1925. After 10-15 years of selective breeding in Norway, the litter size increased from 1-3 cubs to 7-8 cubs.

The farm-bred blue fox is claimed to be adapted to life in captivity (Belyaev 1984) but is less domesticated than the silver fox. Captive breeding has been accompanied by increased litter size and body weight (see table 10.5). Blue foxes have not been subjected to long-term selection experiments on tameness, but selection for reduced fear of humans was recently begun in the Nordic countries (Hansen 1996; Kenttämies 1998; Nordrum et al.2000).

6.2.3. Mink (Mustela vison)

Feral mink are brown, but several colour mutations were discovered and described. About ten of these mutations have been proven economical viable. Since mutant genes can be combined in many ways, far more colour types are possible.

Jörgensen (1985) and Nes et al. (1988) list 115 colour types. Nowadays, approximately 80% of mink are darkish brown or black. The remaining mink are pastel or light brown, white or greyish. Black mink tell a different story. Black colouration in mink is not caused by a single mutation, but is inherited polygenetically. Black and brown mink are known to differ slightly in many aspects, the black ones being weaker. Black mink are smaller, less fertile, more aggressive and restless, more susceptible to diseases and so on. Possibly, the differences have nothing to do with being black. In the past, the pure black colour was produced with a lot of inbreeding. Since then, many black strains have improved characteristics.

As in several other farmed species, the brain size of farmed mink is smaller than in wild mink, independent of body size, age, or sex (Kruska 1996; Kruska and Schreiber 1999). In addition, the relative sizes of the heart and spleen are smaller in farmed than in wild mink (Kruska and Schreiber 1999). These authors explained the effects as adaptation to the ecological demands of domestication.

According to people working with mink (e.g. Shackelford, 1984), the behaviour of farmed mink in close proximity to humans has changed markedly during the last decades. While they in the 1940's inevitably escaped into their nest box when approached, they now more frequently take no notice or show curiosity. Yet, heavy gloves are still required when handling the animals, as they bite strongly. The possibility that mink can be selected for tameness during a few generations was suggested in the late sixties. Tests for fearfulness in Danish mink farms from 1988 to 1999 showed that the proportion of confident animals had increased from 45 to 62 %, while the proportion of fearful animals had decreased from 48 to 23 %, indicating that farmers had paid increased attention to reducing fearfulness among their animals (Malmkvist and Hansen, in preparation). Selection of farmed mink has led to most animals having increased litter size and decreased postnatal mortality.

6.2.4. Ferrets (Mustela putorius furo)

Ferrets (*Mustela putorius furo*) are generally thought to be domesticated polecats (*Mustela putorius, M. eversmanni*), but their exact ancestry is obscure (Davison et al. 1999). Their domestication history is by far the most extensive among farmed fur-bearers and, as in dogs and cats, has resulted in changes that have been defined as a new species. The domestication of the polecat was related to their aid in hunting rabbits and rats and is mentioned as early as AD 20 (Owen 1984; Clutton-Brock 1987). A domestication history of more than 2500 years is suggested (Apfelbach 1996). About 600 AD, Isodorus described rabbit hunting in Spain with help of a ferret like animal, named "furo" (Moorman-Roest and Lumeij, 1987). In later ages reports become more and more reliable, and there is no doubt that rabbits were hunted by use of ferret like animals. The species may have been changed over the years. In the 15th century, Leonardo da Vinci produced a painting known as "The lady with the stoat". The animal cannot be anything else than a ferret. But, although Leonardo da Vinci was a skilled painter, the animal strongly differs from the present ferret.

At the same time its domestication history is the least known of the fur species. How the history exactly may be, in the 19th century ferrets were frequently used for rabbit hunting. Between 1882 and 1884 thousands were shipped over to New Zealand to fight a rabbit plague. Although these animals are referred to as ferrets, it is unlikely that all of them were domesticated and some polecats were included as well. The species destroyed not only rabbits, but many more species. Escaped ferrets and the descendant feral populations became a pest themselves. They had to be hunted and the hunters sold the pelts to the fur trade. This apparent success induced fur farming. Crossings between polecats and ferrets became known as "fitch" (Corbet and Harris, 1991). In the 1970s fitch farming was introduced in Finland and Scotland and spread over Europe. Ferrets are found in a range of colours and are also used as laboratory animals. The ferret is described as exhibiting considerable tameness, and has been reported as being capable of attachment to humans (e.g. Field and Field, 1987). Many ferrets are kept as pets. Ferrets can produce two litters a year compared with the polecat which generally produces only one.

6.2.5. Raccoon dogs (Nyctereutes procyonoides)

The scientific and practical literature on raccoon dogs (*Nyctereutes procyonoides*), has been reviewed by Valtonen (1984) and in the doctoral thesis of Korhonen (1987). The first farming trials with raccoon dogs were performed in the USSR in 1928 (Valtonen 1984), but were later discontinued due to low profit. Similar poor success was experienced in Sweden and Germany in the 1930’s. In Europe outside Russia, raccoon dogs are mainly farm-bred in Finland since 1971-72, based on wild-caught Russian animals (Valtonen 1984). Farming routines were based on trial and error, as little information was obtained from the USSR (Korhonen 1987). No selection for tameness has been carried out and the domestication history is less than 30 years. No studies on ontogenetic taming have been carried out. Nevertheless, raccoon dogs are described as cautious, but easy to handle and feed in captivity (Valtonen 1984). During the past 25 years, the breeding of raccoon dogs has been accompanied by increased litter sizes and reduced mortality.

6.2.6. Coypu (Myocastor coypus)

Coypu (*Myocastor coypus*), its fur being known as nutria, is a large South-American rodent. Farming of coypus was stimulated by high prices for species almost becoming extinct in several areas due to overexploitation (Gosling and Skinner 1984). Coypus have been kept in a number of European countries. In Europe, the first coypu fur farms were established in 1882 in France (Maurice 1931) and in around 1929 in England. Eventually, in the UK, there were about fifty farms, most of which were in the southern and south eastern counties where plentiful natural water supplies were available (Laurie, 1946). After a brief heyday the farms were all discontinued at the start of the war in 1939. Some animals were probably released at this time but in any case numerous escapes had already occurred and by the early 1940's there were small feral populations in Norfolk and Buckinghamshire. The species became a pest but was eradicated in England by a cage-trapping programme. In some other countries, trapping of wild or feral populations continues and is the primary source of pelts. Farm populations of coypus are small and of marginal economic interest.

The colour genetics of coypu is extremely complex, giving rise to much inbreeding. This may lead to low fecundity and reduced grooming behaviour (Gosling and Skinner 1984).
Present-day reproduction of the coypu is described in sections 7.3.5-7.3.6. Reproductive success at an earlier stage of the domestication history is unknown. Due to lack of studies, the domestication level of the coypu must be regarded as uncertain.

6.2.7. Chinchilla (Chinchilla spp.)

Chinchilla breeding is the youngest branch in fur breeding and began only after the near extinction of wild chinchillas. In 1920 Champan started attempts to trap some of the last chinchillas in order to start a chinchilla farm. After three years, in 1923 his co-worker had trapped 17 long tailed chinchillas (*Chinchilla laniger*). Eleven of them arrived alive in the United States, and these eleven animals may be the ancestors of all farmed chinchillas in the U.S.A. In 1934, 16 specimens of the short tailed chinchilla (*C. chinchilla*) were exported to Norway. Breeding this species was not successful (Heinrich, 1974; Nes et al., 1988) and these animals are not believed to have left any gene in the present breeding stock.
Up to now, chinchilla breeders have failed to produce pelts which equal the quality of those of wild chinchillas, and they failed to produce animals that are more fertile than their wild ancestors. Whether the inevitable inbreeding inhibited a proper development of the breeding stock is an unanswered question.
Farmed chinchillas belong to two closely related South-American rodent species (*Chinchilla laniger*, long-tailed and perhaps *Chinchilla brevicaudata*, short-tailed). Domestication of chinchillas began in 1855 in Chile (Grau 1984). In Europe, The Chinchilla Fur Breeders Association was founded in 1960. Breeding is mainly done on *C. laniger*, but in 1970 some *C. brevicaudata* was crossed with *C. latrans* to increase body size (Grau 1984). In 1984, Grau stated that the chinchilla had undergone 60 years of selection and development. Scientific work related to domestication level and its relation to animal welfare in chinchillas is not available. However, chinchillas are widely kept as pets, and it is questionable whether genetic selection for tameness is important as ontogenic changes may be sufficient. The chinchilla is also used as a laboratory animal.

6.3. Conclusions

1. Domestication has been defined as an evolutionary process by which a population of animals becomes adapted to man and to the captive environment by genetic changes occurring over generations including those predisposing to environmentally-induced developmental events recurring in each generation.
2. From a welfare point of view, the crucial aim is a well-adapted individual, regardless of the extent to which this is due to genetic or ontogenetic events.
3. Important characteristics of domesticated animals include a capacity to live under constraints imposed by humans without problems such as reduced reproductive success or substantial fearfulness towards humans.
4. Low fearfulness can be achieved by genetic selection, early handling and by rewarded contacts with humans.
5. All animal species kept for fur production have been submitted to some degree of domestication, but have different domestication histories.

6. The ferret is the most domesticated species of animals kept for fur production. In other species, there has been only a limited amount of selection for tameness and adaptability to captive environments.
7. Selection has not eliminated the motivation of animals kept on fur farms to perform some behaviours nor favoured altered responses to social stimuli. However, there may be some potential for such selection.
8. Selection for reduced fearfulness towards humans is successful and results in positive welfare effects in the species studied: silver fox and mink.
9. Generally, in comparison with other farm animals, species farmed for their fur have been subjected to relatively little active selection except with respect to fur characteristics.
10. Specific welfare problems related to intense genetic selection, e.g., for altered fur colour or for increasing body weight, can be encountered and, therefore, the possible welfare consequences of such selection need to be strictly monitored.
11. Scientific evidence of behavioural and welfare effects of domestication of species kept for fur production is still incomplete.

7. RANGE OF FARMING CONDITIONS IN EUROPE

Many countries already adhere to the recommendations of the Council of Europe on Housing and Management of Fur Animal Species (1991, 1998). There is a tendency, at least in the Scandinavian countries and in Italy from 2001, to make these recommendations mandatory through legislative procedures. Some countries have gone even further and banned fur farming, for example United Kingdom and The Netherlands.

7.1. FOXES

The majority of foxes in Europe (95%) are produced in Finland and in Norway (Table 5). Therefore, this section is based mainly on the data from those countries. Local veterinary services performed inspections of the 101 Finnish farms during the winter 1999-2000 (Nyberg 2000). Comparable inspections were carried out in Norway by order of Norwegian Fur Breeders Association (Westersjö 2000).

Table 5. Production of fox skins during the year 2000, number of farms and calculated average of breeding fox females per farm (Production/4.5 cubs/Number of farms) for some European countries.

Country	Total skin Production 2000	No. of Farms per country 2000	Average no of breeding females per farm
Belgium	600	1	133
Denmark	45,000	111	90
Estonia	55,100	8	1,530
Finland	2,000,000	1,600	278
France	0	0	0
Greece	7,500	4	417
Germany	360	1	80
The Netherlands	20,000	6	740
Iceland	18,000	?	?
Italy	0	0	0
Ireland	1,200	1	267
Norway	375,000	900	93
Poland	220,000	190	257
Spain	0	0	0
Sweden	10,000	15	148
United Kingdom	0	0	0

Data are taken from EFBA, Annual Report, June 2000. For the calculation 4.5 kits are used as an average since silver foxes wean on average 3 cubs and blue foxes 6 cubs. This means 9 cubs/2=4.5 when it is assumed that the stock is half silver foxes and half blue foxes.

7.1.1. Housing and Environment

Farmed blue foxes and silver foxes are usually housed in closed or open-sided sheds holding from two to eight (commonly two) rows of cages. The cages are made of strong wire mesh and raised 60-100 cm above the ground. The cages have 0.6-1.2 m^2 floor area and are 60-75 cm tall (Bakken et al. 1994, Commission of the European Communities 1990, Nyberg 2000, Westersjö 2000).

Breeding animals are kept one animal per cage with the exception of mating, when the female animal for short periods is moved to the cage of a male. Weaning is usually carried out by removing the mother from the cage. In many Scandinavian farms the separation of fox litters takes place gradually after weaning. Often in connection with the weaning the litter is halved or 3-6 cubs are left together in a cage. In late summer or early autumn, in the case of blue foxes the group is further dispersed leaving 2-3 animals per cage (Länsi-Suomen Lääninhallitus 2000, Westersjö 2000). Silver fox juveniles are housed pair wise until September and then singly from September and until pelting.

This number is considered as optimal by the farmers for the growth of cubs. In contrast to breeding animals, young foxes are scarcely kept in solitude. Yet an aggressive cub can be placed alone in a cage to prevent injury of the siblings. Breeding males can be kept for 5-6 years.

The breeding females were previously provided with a nest box for two to three months in the breeding season in the spring and the cages were without any furnishing for the remainder of the year (Bakken et al. 1994). Nowadays, according to the recommendation by Council of Europe, each weaned fox should have access to an elevated resting platform or nest box on the top of which it can rest and inspect its surroundings (European Convention 1991). This is under implementation in the European Union. Nest boxes are placed either on the floor or on the top of the cage.

The provision of suitable material for gnawing has been recommended for foxes (Council of Europe Recommendation 1991). An increasing number of farms are adopting this measure in the European Union (Nyberg 2000, Westersjö 2000).

7.1.2. Feed

The most common feed used for farmed foxes is wet feed manufactured by a special feed kitchen. Some farms use dry pellets as either additional or main feed source. Wet feed is placed either on the top of the cages or on feed plates at the front of the cage. Dry feed is put into hoppers fixed to the cage.

The requirements for feed composition for foxes are extensively studied (Einarsson and Skrede 1989). The composition of the feed varies at different times of the year (Table 6). The quality and the composition of the feed is regularly controlled. Feed is mainly composed of fish and fish offal, slaughter house offal and cereal with mineral and vitamin ingredients. Thus the fur industry consumes a large amount of animal by- products, the use of which is not allowed in the feed of ruminants.

Adult animals are fed once per day and cubs twice or three times per day, either by hand or with a motorised feeder on larger farms. The amount of feed given varies between the farms. In most cases foxes daily allowance is very close to *ad libitum* feeding. This leads easily to excessive fattening in blue foxes (Ahola et al. 1996). Silver foxes spend an average 20 min in 24 hours for eating while blue foxes spend an average 11 min (Korhonen and Niemelä 1994a). Legislation in Scandinavian countries prohibits starvation days, e.g., Sundays.

Table 6. Recommendations for energy and energy distribution in the fox feed.

Feeding period **Describe annual cycle**	**1** **(1/12 – 15/5)**	**2** **(15/5 – 15/7)**	**3** **(15/7 – 15/9)**	**4** **(15/9 – 1/12)**
Metabolizable energy (ME) **Kcal/kg**	1200 *1000-1300*	1350 *1200-1500*	1750 *1500-1800*	1850 *1600-2000*
[*]**Energy distribution** **Protein**	40-50 *42-52*	38-45 *40-50*	30-40 *32-38*	25-35 *28-34*
Fat	32-40 *30-40*	37-45 *38-45*	42-50 *45-60*	45-55 *45-60*
Carbohydrate	15-20 *12-20*	15-20 *12-20*	18-25 *12-20*	16-25 *12-20*

[*] % of metabolizable energy from digestible protein, fat and carbohydrate.
Upper numbers are Finnish recommendations. Lower numbers are Norwegian recommendations.

7.1.3. Water

Watering may be by means of nipple or bowl drinkers, fed through a pipeline or bowls, filled automatically or by hand. Various devices are used to prevent freezing, such as an electric resistance running through the water pipeline. Some breeders fill the water bowls by hand in frosty weather.

At present, 16% of Finnish fox farms have a year round automatic watering system, 62% plastic bowl drinkers, 5% metal bowl drinkers and 17% have both plastic and metal bowl drinkers (Nyberg 2000). All farms in Denmark have automatic watering systems.

7.1.4. Mating

Mating time is February-March for silver foxes and March-April for blue foxes. The gestation period is 52-54 days in both fox species. Cubs are weaned at 6-8 weeks of age.

About one half of fox vixens in Scandinavia are mated, the other half artificially inseminated. Two insemination methods are in use, the intra vaginal and the intra uterine, the latter being most common. The detection of oestrus in foxes requires repeated handling and is confirmed by the use of heat detector, a device for measuring the electrical conductivity of the vagina. Heat detection and confirmation is stressful as it involves the most handling that the animal receives (reference needed). Vixens can be handled up to 20 times in a six week period, with the heat detector used on around five occasions. The main advantages of the insemination for fox keeping are the following:

- The desired hereditary characteristics can be effectively spread,
- Fewer males are necessary in the farm,
- The pregnancy rate (about 90 %) and litter size are as good as in mated vixens.

In most countries the veterinarians have on grounds of their education the right to inseminate domestic animals. In most fox producing countries (Denmark, Finland, Norway) the inseminations are mostly carried out by officially approved insemination technicians.

7.1.5. Norwegian survey of the housing and management of foxes

More detailed information is available concerning housing and management of foxes in Norway because Norwegian fur farmers are visited annually by quality assurance groups of Norwegian Fur Breeders' Association (NFBA) who record statistics on housing conditions and management procedures in relation to animal welfare and the environment. Excerpts from the report of the national average conditions for 1999 are presented here, based on 690 of a total of about 900 Norwegian fox farms (Westersjø, 2000a).

On average, fur farms had 50 breeding vixens of silver fox and 78 of blue fox. Good cleanliness was observed in 43 % of the farms. An escape-safe outer fence of the fur farm was found on 44 % of the farms, while 56 % of the houses were escape-safe and 46 % kept all birds out of the houses. Good cleanliness was found on 53 % of the feed plates, on 68 % of the water cups, on 78 % of the feeding machines, and in 75 % of feed tanks.

Prophylactic treatment of ear mites was done on 59 % of the fox farms during the last year and on 23% 1-2 years ago. Prophylactic treatment of endoparasites was done on 48% of the fox farms during the last year and on 23 % 1-2 years ago. Measures for combating rats and mice were taken on 52% of the farms, while 40% used insecticides. Upon discovering diseases or wounds, 12% of the farmers regularly contacted a veterinarian, 28% regularly euthanised the animal and 52 % used a combination of these. Visually observable health problems were found on 0.8% of the foxes; deformities on 0.4%, inflammation of the eyes on 0.2%, ear mites on 0.05%, diarrhoea in 0.02%, and tooth problems in 0.03 %.

When selecting breeding animals, high weighting was given by 92% of the farmers to body size, by 90% of the farmers to pelt quality, by 88% of the farmers to fertility, and by 81% of the farmers to behaviour. Among all silver foxes observed, 0.83% showed panic reactions or considerable unrest, as judged by the inspectors. This was observed on only 0.01% of the blue foxes. On 47% of the silver-fox farms all animals were calm, on 46% only some animals were disturbed, and on 7% many animals were disturbed. On 90% of the blue-fox farms all animals were calm, while on 9% some animals were disturbed.

On 11 of the fox farms all animals had access to activity objects, while on 37% some animals had this. Shelves or whole-year nest boxes were available for all foxes on 1.2% of the farms and for some foxes on 9.1%. On 26% of the farms all cages were in agreement with the new welfare regulations (single cages, effective by 2009: 75 x 100 x 75 cm, W x D x H), while on 40% more than half of the cages complied with them. Too small width was the most common single problem (35%). On 69% of the farms, the wire netting was in very good repair. Neck-tongs with plastic cover around the tongs was available on 56% of the farms. On 97% of the farms, the neck-tongs were large enough for the largest males.

Only 5% of the farms had watering systems which were protected against freezing, but another 65% had this in some of the houses. In houses with water cups, water was supplied 2-3 times a day during spring/summer in 69% of them, during autumn in 60%, and during winter in 13%. In 94% of the farms the foxes were in good condition (not too fat, not too thin). The oestrus detector was used for all vixens on

77% of the farms, for only difficult vixens on 5%, but was never used on 18% of the farms. On average, the oestrus detector was used 5.0 times per vixen. Killing was done with an approved electric apparatus on 85% of the farms.

7.2. Raccoon Dogs

Raccoon dogs (*Nyctereutes procyonoides*) were first farmed in the USSR in the late 1920's (Schmidt 1931, 1937) and then in Finland in the beginning of 1970's. In Europe, less than 100,000 animals are produced each year (in the year 2000; 60000 skins from Finland and 3000 from Poland, Annual Report, 1st July 1999-June 2000, EFBA).

Housing conditions and management, including feeding are generally the same as those for foxes (Korhonen 1987). Raccoon dogs are generally produced on farms that raise foxes.

Mating time is February-March and the gestation period is 60-62 days for the raccoon dogs. Cubs are weaned at 6-8 weeks. The intra uterine method of insemination has recently been shown to be successful also in raccoon dogs (Heikkilä et al., 2000). It may become more common in the next few years.

In nature, the raccoon dog is known to spend the coldest part of the winter in superficial hibernational sleep under sub arctic regions (Viro and Mikkola 1981, Kauhala 1992). Some farms follow this rule in the farming conditions by fattening the animals and then depriving them of food, triggering the onset of hibernation.

7.3. Mink

7.3.1. History

The first mink farms were founded in the 1860s, in Upstate New York in the homeland of the mink. At the beginning of the 20th century farming of mink had grown to be a serious business. The first count in 1942 showed 2836 operating farms. The breeding of various colour mutations boomed from about 1934 until the 1950s (Smith, 1981). Farming of American mink was introduced into Europe early in the 1930s (Jørgensen, 1985). Until the end of the Second World War, the production in Europe grew slowly. After the war, farming of mink spread over Europe. International counts are available from 1953; then the world production was 4.2 million kits (Jørgensen, 1985). The production grew rapidly up to 34 million in 1989. Nowadays the world production seems to stabilize around 25 million kits. In the year 2000, 73% of these were born in Europe (EFBA, 2000). For statistics of the world production in the years 1998-2000 see table 6. Denmark produced 75% of the mink in Scandinavian countries in 1998-2000.

Table 6. The world production of mink skins is shown in millions for each country and the percentage of the world production (%) of each country is indicated. Countries marked with a * belong to the EU. Some countries in the field "Others" may also belong to the EU as indicated with a star in a bracket (*).

Year	**1998**		**1999**		**2000**	
Country	Million	%	Million	%	Million	%
Denmark*	11.9	41.4	10.5	40.9	11.0	41.2
Finland*	2.1	7.3	2.0	7.8	1.9	7.1
Iceland	0.175	0.6	0.175	0.7	0.17	0.6
Norway	0.3	1.0	0.27	1.1	0.3	1.1
Sweden*	1.3	4.5	1.25	4.9	1.2	4.5
The Netherlands*	2.7	9.4	2.7	10.5	2.9	10.9
U.S.A.	2.9	10.1	2.8	10.9	2.8	10.5
Canada	0.95	3.3	0.9	3.5	0.9	3.4
China	0.7	2.4	0.6	2.3	0.7	2.6
SNG/Baltic	4.0	13.9	3.0	11.7	3.0	11.2
Others (*)	1.7	5.9	1.475	5.7	1.8	6.7
World production	28.725	100	25.67	100	26.67	100

The average farm size on 2500 Danish mink farms (1998) was 923 breeding females (Møller, 1999). In the year 2000, there were 2200 mink farms in Denmark with an average of 951 breeding females on each farm (EFBA, 2000) (Table 7.). In Norway, the figures (1999) were an average of 328 females calculated from a total of 144 farms (Westersjø, 2000a). In the Netherlands, the average farm size was approximately 3,000 breeding females calculated from a total of 200 farms (Risager and Jensen, 2000a). One Dutch mink farmer owned as much as 60,000 breeding females distributed on 7 different farms where 30 people (11 managers included) are employed to take care of them (Risager and Jensen, 2000b).

Table 7. Number of farms and calculated number of breeding females (Production/5.3 kits/Number of farms) for European countries.

Country	**No. of Farms**	**Average breeding females per farm**
Belgium	26	1125
Denmark	2200	951
Estonia	1	2145
Finland	600	629
France	22	1372
Greece	7	1752
Germany	32	2130
The Netherlands	208	2750
Italy	35	1240
Ireland	5	5283
Norway	170	355
Poland	18	4822
Spain	50	1132
Sweden	187	1210
United Kingdom	13	1740
European countries	3568	1025

Many farms produce at least two colour types, often black and brown. On an individual farm the various types are always housed and managed in the same manner. No discrimination between colour types is made, except where information about differences between the types is available and relevant.

7.3.2. Housing and Environment

General

All over Europe and the rest of the world, mink are managed and housed in very similar ways. Adults are solitarily housed from pelting time until females give birth in May. Matings are arranged in March and males are pelted soon afterwards. Young are born in May and weaned at 6-8 weeks of age. There is a growing tendency to postpone weaning until 8 weeks of age in the Scandinavian countries as recommended from the EC in 1999 and implemented National legislation. Kits are normally kept in the litter after weaning until 11-12 weeks of age and then further divided into male-female pairs. Another practice exists in the Netherlands where kits are split into groups of 3 after weaning. From weaning until November, adult females live either alone or occasionally with one or two sons. In November most of the animals are pelted and the remaining breeding animals are then singly housed again.

Shelter

Most European mink cages are placed under long roofs on piles without sidewalls, in two rows of cages. A path about 1-1.5m wide between the rows enables the farmers access to their animals. The length of these shelters is usually about 50m in Scandinavia but some sheds (especially in the Netherlands) can be 100m long.
In the Netherlands, the use of closed buildings is increasing. In these, the cages are placed in three to ten rows. The sidewalls may be permanently open or closed. Curtains and other devices can be used to open or close the building. The roof is always closed, but windows in the roof are mostly present. In the Netherlands, mink are also kept in glasshouses because these are relatively cheap and apparently as good as other closed building (Hof, 1996). In Scandinavia two row sheds are common and a mixture of shed types is rarely seen. However in the Netherlands, several farms have two-row shelters as well as more or less closed buildings. In such cases, the open two-row shelters are often used for breeding, whereas the others are used for raising kits. Farmers reason that light promotes reproduction and that darkness promotes pelt development. The number of buildings with more than two rows of cages is increasing slowly.

Cages

All farmed mink live in wire mesh cages with a nest box. Most farmers use the same cage for: single housing of females and the much larger males, littering and nursing until an age of 6-8 weeks and housing of growing kits in pairs from 12 weeks until pelting.
The bottom of the cage is always made out of wire mesh because other materials can cause hygienic problems (de Jonge and Leipoldt, 1994b). In the breeding

period (from a few weeks prior to partition until the kits are six weeks old) a plastic covered ‘kit’ wire mesh (1 x 0.5 inch mesh size) is placed in the cage, covering the bottom. Usually newspaper and straw are placed between this and the cage’s normal wire mesh bottom. This protects the kits from draughts and gives them an almost solid floor for the first six to eight weeks of their lives. On Scandinavian mink farms the sidewalls are often transparent, consisting of a double layer of wire mesh, with a gap in-between. In the Netherlands, the sidewalls are often made out of non transparent materials. Since these materials are cheaper than wire mesh (Gilbert and Bailey, 1969a; de Jonge, 1986, 1989), their use is likely to increase.

In Scandinavian countries, most standard cages have as dimensions 45 cm (H) x 30 cm (W) x 90 cm (D) (Weiss at al., 2000, Westersjo, 2000). In Finland some cages, labelled standard cages, are used. They measure 38 x 30 x 71 cm (Mononen, 2000). Some cages with a reduced width of 20 cm also exist, though are only used for keeping single females and are prohibited in Denmark from 2010 and Norway from 2005 respectively .

In the Netherlands, the recommended cage size is 45 x 30 x 85 cm. However, many cages are smaller, the width often reduced to 25 or even 20 (de Jonge, 1990a,b,c). Many Dutch mink are also raised in old fox cages of 100 x 60 x 60 cm (de Jonge et al., 1994a,b).

Every standard cage has a nest box mounted outside the cage in Scandinavian countries. Nest boxes are required for breeding, and outside the breeding season are also used for sleeping and refuge. In the Netherlands many farmers use cheaper constructions which are placed in the cage and are used only for rearing the kits. Nest boxes are often made out of wood, but other materials are used as well though no data is available. The nest box is usually as wide as the cage with of depth of between 15 and 30 cm. Dutch farmers are persuaded to use a minimal size of 20 x 25 x 18 cm and no differentiation is made between breeding and sleeping boxes.

In Italy the minimum size dimensions for mink, without the nest, is 2550 sq cm and the minimum height of the cage is 45 cm. From 2008 the animals have to be housed in pens with environmental enrichment, including water.

The Netherlands

Group size in classic mink breeding: It is often advised to house not more than two animals in a standard cage, but in practice groups of three are (de Jonge, 1989a,b,c). Usually, a group of two consists of a male and a female, either two young or a mother and a son. Groups of three often consist of three females, but other compositions are seen as well. The effects of the various sex combinations upon growth and pelt quality have been surveyed by de Jonge (1989a,b,c). Groups of more than three animals in a standard cage were observed in the 1980’s but the present frequency is unknown.

Recent developments in group housing: A change of mink housing towards group housing has developed since 1994 (de Jonge and van Iwaarden, 1995; de Jonge 1996a-c, 1997c, de Jonge and Stufken, 1997a-d, 1998a). Group housing is studied in Denmark as well. It was already known that mink kits easily grow up in groups of 3 to 5 in standard cages. In the 1980s Hansen already kept large groups of kits. However, on farms, group size was limited by the size of the standard cages which seldom exceeded 30 x 85 x 45 cm and not by the biology of the mink. Hence, de Jonge and van Iwaarden (1995) increased cage sizes in a cheap way by connecting existing adjacent cages by holes in the sidewalls. Breeding females were allowed/forced to raise all kits from birth until pelting time in November.

About 15 % of Dutch mink are now raised in this way, and this number is expected to increase.

Connecting the standard cages is only a first step in the development of a fundamentally new way of mink breeding. The mother and young stay with each other for at least 30 weeks instead of 6 - 8 weeks. Knowing that this is possible, various types of group cages may be developed in which mothers may live throughout their life with and without kits. One cage consists of two layers instead two connected standard cages next to each other are connected with a large group-cage (85 x 60 cm) on top (de Jonge, 1996b; de Jonge and Stufken, 1997b). The total space allowance (floor surface) of these two layers is one square meter. The cage may contain ten mink. In The Netherlands, this cage and this way of mink breeding seems to supersede the classical way of mink breeding. Variations on this concept are applied as well. The principle of stacking connected cages above each other is spreading rapidly. In the Netherlands, a common way of mink housing is a group of five mink in two cages above each other. About 30 % of mink kits are raised in these so-called climbing-cages.

Enrichment

It is easy to enrich cages with platforms, play balls or cylinders. It is well established that mink use such objects though the use decreases with time (a.o. Kuby, 1982; Nieuwenhuis and de Jonge, 1989; Jeppesen and Falkenberg, 1990a,b; Hansen, 1990; de Jonge, 1990a-c, 1997a, 1997b; de Jonge and Leipoldt, 1994c).

Dutch farmers are strongly encouraged to enrich mink-cages; nowadays, about 25 % of the Dutch mink have either a wire-mesh platform or a plastic cylinder. In Norway 88% of mink are provided with activity objects (Westerjo, 2000a-b). Data on the frequency of enrichment in other countries are not available. Large group cages, as described above, are always enriched in various ways.

In Scandinavian countries, all mink have access to straw at all times. In the Netherlands, all mink get straw or another type of litter for at least part of their life. Straw is always and everywhere provided prior to parturition; mostly this is soft barley straw because this straw insulates very well but rye straw is most frequently used in Denmark. Straw is packed densely around the nest box and another dense layer of straw serves as a roof to the box, giving shelter from draughts and making the box dark and secluded. Most pregnant mink (at least 90 %) make a nest bowl out of the straw. If pregnant mink do not do so themselves, many farmers assist them by constructing a kind of nest bowl. During the parturition period the whole box is covered with straw. During nursing, low temperatures stimulate the farmers to add straw and high temperatures stimulate them (and the mink) to remove it. In autumn, when pelting time approaches, farmers in the Netherlands provide absorbing types of litter such as wood-wool to clean the pelts but Danish farmers continue to use straw in the belief that this improves the quality of the pelt.

In between nursing and pelting time, many mink do not get straw, especially when they live in groups of four and more. In winter time, mink cannot survive in the cold Scandinavian countries without straw, and in the Netherlands most mink get straw, especially when temperatures are low.

The main variation between farms occurs between weaning and pelting. Straw provision has a number of disadvantages: (1) it influences neither growth nor pelt quality (e.g. de Jonge and Leipoldt, 1994b); (2) it costs time and money; (3) it increases the amount of waste. Hence, straw provision on summertime is not likely to become common practice in the Netherlands. However, Dutch mink farmers are strongly encouraged to give straw throughout the year. Since mink easily survive moderate winters without straw, legislation is required to stimulate all farmers to provide straw in winter.

7.3.3. Feed

Feed composition

The needs for protein, fat and carbohydrates during the annual cycle have been extensively studied, and research continues. Over the years, the recommended levels for proteins have tended to decrease and those for fat increase. Mink and fox requirements do not differ substantially, except that foxes need slightly more carbohydrates than do mink (see Biology). In most countries with mink, foxes and other fur bearing species like ferrets and raccoon dogs, the different species receive exactly the same feed. In countries where foxes form the minority, foxes get "mink feed" and in Norway and Finland, where mink form the minority, mink can get "Fox feed".

The feed is a mixture of slaughter house offal or fish offal. Specialised feed kitchens manufacture most feed. In Denmark about 20 feed kitchens produce and deliver the mink feed (Moller, 1999). Mink feed is a mixture of by-products from the food industry (most frequently in Denmark) and of slaughter house offal or fish offal (most frequently in the Netherlands) and some cereals, vitamins and minerals. The type of raw material used is determined by the availability, legislation (especially in relation to transmissible diseases and carcase recycling, see recommendations of the report adopted on 24-25 June 1999 by the Scientific Steering Committee on The risks of non conventional transmissible agents, conventional infectious agents or other hazards such as toxic substances entering the human food or animal feed chains via raw material from fallen stock and dead animals- including also ruminants, pigs, poultry, fish, wild/exotic/zoo animals, fur animals, cats, laboratory animals and fish- or via condemned materials) and cost in the various countries. More fish is used in the Northern countries, and chicken in the Netherlands. The composition varies with the season. It includes more proteins in winter and more fat in summer.

Additives

Minerals and vitamins are always added. Since the requirements are not always exactly known, mink probably receive more than their minimal requirements. Preventive use of antibiotics is forbidden by legislation in the Scandinavian countries (CFC, 2000), though not in the Netherlands. In that country, antibiotics are added by the feed manufacturers during the pregnancy and parturition periods. Dutch farmers believe that this addition protects mink against infections. However, Jörgensen (1985) concludes that the effect of preventive supplements of antibiotics generally varies considerably and that the achievable benefits are modest and uncertain. In the Netherlands, many farmers add antibiotics to the feed when the temperatures are high, in order to slow down the process of tainting. In the Netherlands this is reportedly common on Saturdays, because (Dutch) feed

kitchens do not deliver fresh feed on Sundays. However, there is no data available on the frequency of use of antibiotics where this is permitted by law.
The addition of hormones is prohibited in the Scandinavian countries and is restricted to melatonin in the Netherlands. Use of melatonin can considerably speed up growth of the winter pelts, such that mink may be pelted 4 - 6 weeks earlier. The application of melatonin is neither recommended nor forbidden in the Netherlands, and the number of treated mink is unknown. There are obvious economic benefits from the use of melatonin, but the welfare implications are poorly understood.

Feed restriction

Kits are fed approximately *ad libitum* (ad lib), and females which live together with their growing kits are fed ad lib as well. In winter, females live alone and in the beginning of the winter they are relatively heavy, due to the *ad lib* feeding in the previous period.
As a consequence of the heavy breeding stock, farmers may restrict their feed in order to achieve a weight reduction, making the breeding animals fit for mating and parturition. Restriction of feed would sometimes start in November and last until February when the mink is again fed ad lib. Some farmers will not restrict the feed until February, and then only for two weeks, after which they again feed ad lib. This procedure is referred to as flushing (Moller, 1999). Data on the frequency and extent of restricted feeding in mink farming is not available, but restricted feeding is now discouraged in most countries.

7.3.4. Water

Farmed mink have free access to water in most countries. Generally, a pipeline with running water is connected to the rows of cages and bowl drinkers or nipples give the mink ad libitum access to the water (73% of Norwegian fox and mink farms). Devices to prevent freezing, such as an electric resistance running through the pipeline, are available and are used on 80% of Danish farms (Weiss et al., 2000). Water bowls without pipelines are used on 27% of all fur farms in Norway but the data do not distinguish between species (Westersjo, 2000a-b). Too high water temperatures may be prevented by management measures such as a continuous water flow through the system.
Swimming water is not provided on commercial farms although some mink on research farms swim daily when given the opportunity (Mason et al., 2001; de Jonge and Leipoldt, 1994c; Hansen, 1997). Some Dutch farmers who house mink in closed buildings or glasshouses use sprinkling systems, especially when temperature is high. In such cases the mink approach the jets of water (de Jonge, pers.obs.). The extent of use of sprinkling systems in the EU is unknown.

7.3.5. Mating

Females are usually captured by hand or trap, and moved to a male's cage. The male is highly territorial and would spend much time investigating the female's cage if he is moved to her (Weiss et al., 2000). Many pairs are formed in one shed at the same time and are supervised by the farmer. If mating has not taken place within about 30 minutes or if serious fighting occurs, the female is removed and tried with another male, most often the following day. An accepting female will stay with the male for up to 90 minutes. Thereafter the female is removed to her own cage. Because of the minks' reproductive system with induced ovulation and delayed implantation, females are mated twice (1st. 8th and 9th day), and occasionally three times in a mating season (Lagerkvist, 1992). Males mate five to ten different females. On occasions in the Netherlands rejecting females may be given hormone or sedative treatment but this practice is forbidden in the Scandinavian countries (Weiss et al., 2000; Westerjo, 2000). In the selection programme in most countries females which are aggressive to males are removed from the farm.

A new mating procedure is being seen in The Netherlands, as a result from the increasing size of the farms, the increasing costs of labour and the introduction of connected cages. Six neighbouring cages with six females are connected with each other by holes in the walls between the cages. In March, a male is placed into this complex of six cages with the group of six females. Some weeks, later the male is removed, killed and pelted; the fertilised females are separated again. Some thousands of Dutch mink are now mated in this way.

7.3.6. Regulation of climate and light

Most mink experience the natural light cycle and climate. In semi-open mink houses, the differences between indoor and outdoor climatic conditions are marginal. In glasshouses, the differences between outdoor and indoor can be significant, but exact figures are lacking. Van Voorst et al. (1989) investigated the climatic conditions in Dutch closed mink-houses. They assessed a wide temperature variation within the house, dependant on the degree of ventilation and the presence of isolation. They gave advice like good ventilation systems and adequate insulation of the roof, but a follow-up study was not carried out.

Artificial increase of the light intensity in late winter and early spring is often expected to promote willingness to mate. But in practice artificial addition of light in spring is uncommon. In completely closed buildings, the life cycle of mink may be disrupted completely by manipulation of the length of the days. Hof and de Jonge (1989) reported the birth of mink shortly before Christmas at the Dutch Research Centre. However, no farmer imitated the procedure.

Artificial reduction of the light intensity in the growing period may improve quality of the pelts (Ill'inskii et al., 1989). Many mink farmers think that mink in the relatively dark middle of large closed mink houses produce better pelts than mink along the edges near the windows. De Jonge (1990a-c) artificially reduced light intensity and assessed a slightly better pelt quality.

Artificial shortening of the days in summer and autumn speeds up considerably pelt maturation (de Jonge and van Beek, 1989a,b). In Norway, in 1974-1976, 6 to 8 weeks were gained with a 6-18 light cycle from 1 July onwards. In Russia in 1954 Hronopulo gained about 4 weeks with a 5-19 cycle from 1 August onwards. In The Netherlands, in 1989 de Jonge (1990a-c) gained 6 weeks with an 8-16 light-dark cycle from July onwards. This manipulation is neither recommended, nor forbidden, but in spite of the obvious economic profits, light regulation is rarely seen in practice.

In general, light manipulation may strongly improve the economics of mink farms. However, the frequent use of open sheds or shelters prevents application of the various possibilities. The replacement of open two-row shed by more complex housing arrangements opens the way for a change in the near future.

7.4. The Ferret

The largest annual production was 400,000 in 1950. Nowadays the annual production is minor. The number of pets is probably far larger. Nowak (1991) estimates a number of 1 million of pet ferrets in the United States alone. In Europe, specialised fitch-farmers always have been rare. Nowadays, most fitch pelts are produced by mink farmers, to obtain an additional income. They supply both the pet trade and the fur trade, though the former is more lucrative. In practice, during spring ferret farms sell their animals as pets. In autumn, the surplus is killed, and the skin is sold as fur. In the year 2000, 1700 ferret/fitch skins were produced in Europe (200 skins from Norway and 1500 skins from Poland). Only 79 breeding ferret females were registered in 2001 in Denmark

7.4.1. Housing and Environment

Because most fur producing ferrets are bred and raised by mink-farmers, ferrets are kept in mink cages. The range of housing conditions cannot differ much from those of mink. Management is different, because ferrets and mink differ in some aspects:

1. Ferrets may produce two litters a year
2. Intraspecific aggression in ferrets is less than in mink, so that groups of adult ferrets are more often seen than groups of adult mink.
3. Ferrets are easy to handle, without gloves

Further, because young ferrets are easy to sell as a pet early in the year, it is economically interesting to disrupt the connection between season and life cycle. With a continuous 16-8 light-dark cycle, ferrets may produce kits throughout the year (Moorman-Roest and Lumeij, 1987). In this way, ferrets differ strongly from mink. But, ferrets may be sold in spring, provided that they are aged at least six weeks. Thereafter they leave an empty cage for a next group of ferrets, or for growing mink. Mink have to stay until their pelts are ready/mature, 6-7 months after birth, occupying the cage for a long time. Thus, in ferret breeding, birth regulation by light manipulation makes sense, from an economic point of view. Hence, knowledge about the light-reproduction relationship leads to applications in ferret farming but not in mink farming. In practice, light manipulation is just the artificial lengthening of the day with lamps in winter.

The low level of intraspecific aggression enables the farmers, to keep large numbers of ferrets in one cage, the only risk being that farmers lose control over matings. Another factor that increases the probability that farmers maintain large groups is that ferrets are smaller than mink.

Litters are kept all together in standard cages for mink (about 85 x 30 x 45 cm with a nest box) during a relatively long period. Since litters are large, groups are large as well. However, most kits are sold early in their life to dealers who may house them in groups of 40-50 animals in large cages.

A normal procedure is to put three adult females in a mink cage after weaning until the next mating. Mating can be arranged by putting a male into the cage with three females, and leaving them together for some days. Thereafter, females are solitarily housed until weaning the subsequent litter.

7.4.2. Feed

Ferrets easily accept mink feed, and mink feed contains all of the ferrets requirements. Hence, ferrets get mink feed. The weight, and thus the food intake, strongly varies with the season.

7.5. Coypu

7.4.1. Housing and environment

Most coypus are usually housed in a fenced area (2 x 6-8m) containing a group of four shelters (1 m^2) with bathing facilities (running water). Provision of bathing water is believed to be essential for thermoregulation. Because coypu defecate in water, the water should be running in order to keep it clean. The floor of the cages and park area are usually cemented. Adult animals may weight 5-7 kg. Coypus are bred in groups of 5-8 females with a resident male, or he is introduced two months after the pups are weaned. Females may have 8-10 kits that are slaughtered at 7-8 months of age when their weight is 4-5 kg.

7.4.2. Feed

The most common feed used for farmed coypus is dry complete rabbit pellets with the addition of vitamins and minerals. Coypus are fed according to regular standards, mostly twice a day (250 g daily for each adult coypu). In some countries, the feeding is primarily based on farm produced feed, namely grains and vegetables (carrots, potatoes) or silage from green plants.

7.4.3. Breeding

Female coypus mature on average at about five months of age and then breed continuously. There is however considerable variation in the success of pregnancies between seasons and years which will be described below. The gestation period is about 132 days and 1-13 young are conceived with an average of almost 6. Some embryos are resorbed at various stages of pregnancy and the mean litter size at birth is close to five. In addition to partial litter resorption some litters are entirely resorbed and some females may abort. There is, however, variation in the extent of this loss between females of different ages: those over 6 months of age at conception typically lose 60% of their litters whereas those under 6 months of age lose about 80%. Most females conceive again within a few weeks after parturition so that variation in conception frequency is probably not an important determinant of reproductive success under different environmental conditions: the great majority of adult females are pregnant at any time of the year.

Variation in embryo number also contributes to seasonal and yearly differences in reproductive success. In the period from August 1962 to August 1964, with winters of average severity, mean litter size declined during the winter to a minimum of 5.0 for conceptions in April and then rose to a maximum of 6.8 for those in July. This seasonal variation did not occur from 1970 to 1972. Instead litter size remained

quite constant with an average of 6.4, that is, at around the summer value of earlier studies.
Juveniles suckle until about six or seven weeks of age and during this period the massive fat reserves of the females are rapidly depleted. The youngs start to eat adult food a few days after birth and by two or three weeks of age are eating quite large amounts.

7.6. Chinchilla

Nowadays, chinchilla breeding is only a minor part of the fur industry but has been growing rapidly in recent years in some countries. Most farms produce chinchillas both for their fur and for the pet trade. Some colour mutations are bred, but knowledge on possible behavioural differences is so poor, that we do not discern the various colour types.

In Denmark the number of breeding females jumped from 5,807 in year 2000 to 14,329 breeding females in year 2001. These are distributed on 137 farms with an average of 105 breeding females on each farm. The total number of chinchilla-skins sold at the Copenhagen Fur Centre 1999/2000 was 31,471 skins (14% Danish skins and 86% skins from other countries).

7.6.1. Housing and Environment

Chinchillas are normally held in polygamous group cages allowing each male to have admittance to a group of female cages. Breeding females are housed individually and are aggressive to each other. The oestrous cycle lasts 28-35 days and the first matings occur when the animals are 6 to 7 months old. The gestation period is on average 111 days. Young are normally weaned at an age of two months.
Breeding females are kept individually in wire-mesh pens where the floor may be partly covered by a wooden shelf. Sizes are 40-60 cm wide, 35-50 cm deep and 35-40 cm high. Males are housed in corridors which may be connected with 5-10 female cages. After weaning at an age of 6-8 weeks, growing kits are housed in much smaller cages. In Germany, the advised minimal measures of pens for breeding females are 50 x 60 x 40 cm. For raising kits, 40 x 40 x 40 cm cage is advised. Usually, cages are stacked in 3-5 layers above each other. Their pens are connected with a male’s pen by means of a lockable opening. The males have access to 4-10 female pens. Males often do not have an own pen, and use feeding and water facilities of the females. Females cannot pass the openings because they wear high plastic collars when the openings are not locked. Since females are heavier than males, most females’ are able to keep the males’ away when they choose so. The openings between females and males pens are closed during gestation and nursing.
Nest boxes are often not provided. Kits are born on the wire bottom of the cage, or on a covered surface. After birth, they are licked dry and hide in the dense fur of their mothers. Shelves and other possible enrichments are far from always present. Some straw or other litter is mostly provided. Most cages have a sand-bath, but, access can be restricted to limit soiling. Droppings are collected in removable pans under the pens.

Although chinchillas are nocturnal, they are inspected and cared for in daytime. Pelleted feed is given daily.
Chinchilla are housed in barns with a constant temperature of around 18°C.

7.7. Conclusions

1. The most commonly farmed species is the mink followed by the blue fox and the silver fox. The other species are farmed relatively infrequently.
2. All animals kept for fur production, with the exception of coypus which are kept in pens, are housed mostly in cages throughout their life.
3. The quality and the composition of the feed is sometimes controlled Feed is mainly composed of fish and fish offal, poultry, poultry offal, slaughter house offal and cereal with mineral and vitamin ingredients. Recycling of carcasses which increases the risk of disease transmission can occur. Overall the fur industry consumes a large amount of animal by-products.
4. For fox and mink both open and closed buildings are used. Coypus are always housed outdoors and chinchillas indoors.
5. For a given species, housing and management conditions can vary both within a country and between countries. Within a given species, all fur colour types are housed in the same way. The different canid species are housed similarly. There is a trend toward uniformity of housing conditions due to increased regulation pressure.
6. In some cases, cages have been enriched, mainly in response to regulatory pressure. Mink and ferrets are provided with a nest box throughout the year. Foxes are kept in cages equipped with a platform and with a nest box in the breeding period. Chinchillas may or may not have a nest box. Coypus are always provided with water to bathe in.

8. RESTRAINT, HANDLING, TRANSPORTATION AND KILLING OF ANIMALS KEPT FOR FUR PRODUCTION

8.1. Restraint

Restraint devices are commonly used in practice in order to limit injuries to stockpersons. Recommendations from the Council of Europe limit their use, but this is rarely achieved on the farm.

8.1.1. Restraint devices, Foxes

Farmed foxes are moved from their cage for measuring estrus, mating, fur grading and possible medical treatments. The most frequent method of handling is to take them with tongs around the neck and then grab them by the tail. Outside the cage the foxes are held in such a way that their abdomen is resting on the leg of the farmer (Bakken et al. 1994).

Fig. 8.1. A standard neck tongs. See text for details. Photo by Knut Langeland and Norwegian Furbreeders Association brought in PELSDYR – Norske 4H (Kleiven, 1986).

The neck tongs

The most frequently used restraint device in fox farming is the neck-tong (Fig. 8.1). The neck-tong is made of steel, is 50 cm long and has a handle in one end where the farmer can open and close the rounded tong at the other end. The rounded tongs have a typical diameter 7.5 cm for females and 8.5 cm for males. It is used when the farmer need to handle sub-adult and adult animals during transport to another cage, at heat evaluations and artificial inseminations, at vaccinations, at live fur gradings, at health checks, at some medical treatments and when killing the fox. Breeding animals are exposed to the neck-tong approximately 15-20 times a year, with the most intensive use of the neck-tong being when evaluation of heat-status occurs (Bakken et al., 1994, Olsrød and Røhme, 1991). The neck-tong is mainly used by the farmer to avoid being injured but also to reduce handling time of individual foxes.

Breeding fox females and males are handled an average of 20 and 10 times respectively per year (Olsrød and Røhme 1991). Handling includes catching and transport of animals often using neck tongs. In traditional farms young animals (6-8 months) are handled an average of five when transported to new cages during weaning, during treatment or vaccination and during examination of fur quality.
Handling using neck tongs causes dental injuries in some individuals because of biting the tongs (Bakken et al. 1998). Most of dental injuries due to bites can be avoided by covering the mouth of the tong and the lock mechanism with rubber. The number of bites on the other hand can be decreased by making foxes more confident either by genetic selection for more docile foxes or by handling foxes without neck tongs.

Live animal exhibitions

Live animal exhibitions are arranged to select best foxes for breeding. Participation in these exhibitions requires in some cases long transport in transport-boxes by truck, especially in Norway. However, a few summer exhibitions take place e.g. in Finland, where the foxes are shown to the public in their normal farm environment.

Snout-clip and live exhibitions

This restraint device is solely used during live exhibitions of foxes. The snout-clip can be seen in fig. 8.2. The fox usually bites the handle and the tong-like device is then closed around the snout almost immobilising the fox’s jaws (2 cm movement possible) and the clip is held tight by a spring. The fox’s tongue should be beneath the handle to avoid suffocating.

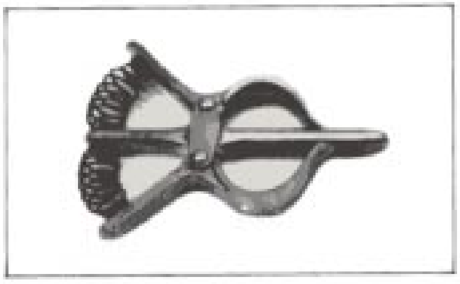

Fig. 8.2. A snout clip used for immobilising jaws of foxes during live exhibitions. See text for details. Photo by Knut Langeland and Norwegian Fur Breeders Association brought in PELSDYR – Norske 4H (Kleiven, 1986).

The fox, now unable to bite, is carried by hand and placed at a table where one person sits at the fox’s head and another person sits at the fox’s tail. The fox is immobilised in that position across the table next to other foxes and persons under strong light. The judges walk back and forth behind the fox, grading the fur visually and by stroking the back of the fox to get an impression of the different fur parameters. The fox will be immobilised this way not more than 15 min. Live exhibitions are carried out in Norway, Finland and Denmark in late autumn (prior to pelting) and only one exhibition is held for each region in each country. The number of live exhibitions in each country is therefore dependent on the size of the country and the number of exhibited foxes is dependent on the total number of breeding animals in each country. The exhibitions are arranged to evaluate the top quality breeding animals from each farm, to compare these between farms and establish the selection criteria for producing top quality fur for the next season.

Transport box

Transport boxes are not used on a regular basis and in fact few foxes will ever experience this in the EU. The minimum sizes of the transport boxes used in Norway are 63 cm in length, 45 cm in width and 53 cm in height for adult animals, whereas cubs can be transported in boxes measuring 45x45x50 cm (Kulbotten and Fougner, 2000). The animals must be provided with water every 8 hours and food plus water every 14 hours of transportation (Kulbotten and Fougner, 2000). The transport box is used when live animals are sold and need to be transported to their new farmer or when farmers are participating in the yearly live exhibition.

8.1.2. Mink restraint devices

Traps

When a large number of mink have to be moved, vaccinated or blood-tested a trap is usually used to capture and immobilise the mink during handling. The mink is lured into its nest box and the trap is inserted and placed at the nest box opening. Then the mink by itself or by being disturbed in the nest box runs into the trap and the trap is closed and removed from the cage. At release the front of the trap is inserted into the cage and the trap door opened. The mink then runs into the cage. Female traps (typically 44 x 12 x 9.5cm) are smaller than male traps (typically 55 x 14 x 12cm). For fur grading and live exhibitions a special trap is used where the floor can be pushed upwards completely immobilising the mink.

Body tongs

When a mink has to be caught some farmers will use a body tong instead of a trap. The body tong has a pair of flattened tongs at one end and a handle at the other end. It is made of metal. The farmer grips the mink just behind the front legs and pulls the mink toward him. Usually the farmer will then takes and hold the mink by hand (with gloves) during handling, since the tong does not immobilise the mink enough to be handled (vaccinated, blood-tested)

8.1.3. Mink transport

Mink are rarely transported, as farms usually breed from within their own stock, and the animals are killed on site. However, it may occur when farmers move stock between farms, to decrease in-breeding, add new colour-types, or replace euthanased Aleutian disease-positive stock. It also occurs when farmers take animals to live mink exhibitions, a practice that also involves restraint, exposure to human crowds, and enforced proximity to unknown conspecifics, all of which are highly likely to cause stress.

Mink are usually transported when pregnant, one week or so prior to parturition (e.g. Sundqvist et al. 1989), over the winter, or at 8 – 10 weeks of age, just after weaning. They are loaded into rows of small transportation cages; these physically restrict the animals, and may or may not allow visual contact between the closely packed neighbours, depending on the design (see 'Handling' section). In the Netherlands, where journeys are generally no more than a few hours, no food or water is provided. There seem to have been no welfare studies of the effects of transporting mink, presumably because it is a relatively rare occurrence. However, the data on the potentially ulcerogenic effect of this sort of confinement, suggest that this is an urgent research issue.

According to Kulbotten and Fougner the minimum allowed measures of mink (and ferret) transport cages are 55x18x18cm (LxWxH). As for foxes, only few mink will ever experience being transported in these cages, that is when breeding animals are sold or when the yearly live exhibition of male mink is taken place. The mink has to be provided with fresh water every 8 hours and food plus water every 14 hours (Kulbotten and Fougner, 2000).

8.1.4. Chinchilla restraint devices

No information on restraint devices in chinchilla farming was found. However these animals can be readily handled with bare hands.

Transport cages for individual animals are used, commonly measuring 80x25x25cm

8.1.5. Ferret restraint devices

Restraint devices in ferret farming are similar to the ones used at mink farms. At least the measures of transport cages are similar (Kulbotten and Fougner, 2000).

8.1.6. Raccoon-dogs restraint devices

The most common restraint devices in raccoon-dog farming are similar to the ones in fox farming (tongs and snout clips).

8.1.7. Coypus restraint devices

No information on restraint devices to be used in coypus is available. When they need to be transported, coypus are put in transport cages that measure 80 x 30 x 30 cm. They can be provided with carrots, apples and water.

8.2. Killing of animals kept for fur production

Killing of mink kept for fur production is always carried out on site. It can be done via several ways, depending on the species under consideration. Possible regulations have been discussed at the Council of Europe, and precise regulatory measures have already been adopted in a number of countries.

8.2.1. Killing of mink

All killing methods involve moving progressively along a shed, removing selected animals from their cages. As with weaning etc., this usually causes both handled and non-handled mink to vocalize, and at least in nervous strains is probably a source of short-term stress to both the euthanised mink and their unpelted shed-mates. Where a gaseous euthanasing method is used, the chamber/cart itself may also be a source of disturbance. However, such effects have not been quantified, and are thought to be brief.

When mink are killed by gas in a killing box, 30 - 50 mink may be placed in there, depending on box-size. Unless unconsciousness is instantaneous, it is likely that this also causes stress. There is clearly no time for these animals to actually fight, as this would be apparent in pelt damage. However, animals may pile up and be killed in part by suffocation (Raj, pers. comm.). Thus the use of a gas apparatus in which each mink is individually placed in a tube is thought to be more acceptable, though no data on the relative merits of the different techniques are available.

Lambooy (1984) observed that CO_2 causes much ‘excitation’. It also induces escapes responses and gasping in cats and pigs (Raj and Gregory, 1995, 1996). Furthermore, although 100% CO_2 induces unconsciousness rapidly, lower concentrations are far less effective; 70%, for example, fails to kill in less than 15 minutes (Hansen et al. 1991). Long killing times would cause stress, especially in animals grouped together in a box. The European Council Directive (93/199/EC) therefore stipulates that animals must be put into the chamber only when the gas is at the maximum concentration possible from a supply of 100% CO_2. Because of animal welfare concerns, Dutch law forbids any use of CO_2. For humans, CO_2 is highly acrid to inhale and therefore very aversive. Behavioural tests on mink showed they too find it highly aversive (Cooper et al. 1998). When mink were trained to enter a chamber to investigate a novel object, they would do so rapidly when the chamber contained air, but would not do so at all when the chamber contained 80% CO_2. They also rapidly recoiled, and coughed and sneezed, upon inhaling the gas. Furthermore, a report of an EC Working Party on laboratory animals does not recommend its use for any carnivore (with the exception of neonates) because of the behavioural distress it causes. Nitrogen can be used to cause death from anoxia (Hansen et al., 1991) but this use is rare.

In the past, exhaust gases from tractors or feeding machines were also commonly used. This has been prohibited due to the heat of the exhaust gases and presence of pollutants; filtered exhaust gases also induce unconsciousness slower than pure CO, and it is preceded by excitation and convulsions. Lambooy (1984) observed that CO causes a rapid death without excitation; Dutch mink are therefore always killed by use of CO. In Denmark, CO is also recommended (and the most common method); its use also occurs in Finland (Suomen säädöskokoelma 1999), as well as outside Europe, e.g. Canada. For many species, this is thought to be an effective and humane means of killing. However, in mink, this gas sometimes can be slow to take effect: the time taken to induce unconsciousness is 64 s for CO (>=7%) and 76 s for 100% N_2, as opposed to 19 s for 100% CO_2 and 26 s for 70% (Hansen et al. 1991). However, these figures are still controversial. Furthermore, Raj and Mason (1999) have shown that mink can detect anoxia (here induced experimentally by means of argon), and that they find it aversive. Minks' responses to anoxia induced by argon differed from those to CO_2; they would enter an anoxic chamber containing a novel object, i.e. they appeared to find it initially undetectable, or at least not inherently aversive. However, they would then leave the chamber, panting, after a very short time – on average 15 s, instead of after their usual 3 min investigation. This is similar to their voluntary dive times in water, which are typically under 30 s (Dunstone, 1993) as mink are not well-adapted for prolonged underwater apnea. The mink would then repeatedly return to the enclosure containing argon, but would always leave it after a few seconds. Thus mink could detect argon-induced hypoxia, and would act to rectify it given the chance to leave the chamber. Mink thus differ from pigs, poultry and humans, who do not find anoxia detectable or aversive (Raj and Gregory 1995, Raj 1996), Minks' surprising ability to detect the lack of oxygen is probably because as semi-aquatic animals, they detect hypoxia as a means of terminating dives (Raj and Mason 1999).

The injection of chloral hydrate, or other chemicals (e.g. sodium pentabarbitone), has been claimed to be the most humane method of killing (e.g. Jørgensen, 1985). However, death by chloral hydrate may be preceded by gasping, muscle spasms and vocalisation, and in other species has been shown not to be acceptable as it lacks analgesic effects and causes irritation of the peritoneum. The intra-peritoneal injection of sodium pentabarbitone is thus preferable, and also relatively easy for a less skilled person to perform, although it takes several minutes to kill. Intra-peritoneal administration is indeed commonly used by vets when euthanasing small animals. Death by injection also has the welfare benefit that each animal is returned to its home cage to die. However, in commercial settings, when many mink would have to be killed rapidly, and by farm workers rather than vets, welfare issues may be raised here; the compound can also cause peritoneal irritation unless suitably diluted. Furthermore, pentabarbitone is a restricted drug in most countries, making this method impracticable.

Other methods, e.g. electrical stunning, have been little used in mink, although a stunning device has been used successfully. An 'Euthatos' electric stunner, followed by neck dislocation, is sometimes used. 'Snap traps' which crush the back of the skull and neck are also potentially quick and effective, and do not damage pelts, although they may not be practical in the farm-situation. Captive bolt techniques may also be useful (cf. Raj and O'Callaghan, in press, on a method recently developed for poultry). All these approaches are potentially humane, because they can induce the immediate lack of consciousness, and given the problems with all gaseous techniques, their development is urgently needed.

8.2.2. Killing of foxes and raccoon dogs

Blue foxes are slaughtered for pelting mainly in November and silver foxes and raccoon dogs mainly in December. The majority of the animals are slaughtered by electrocution. Foxes and raccoon-dogs are commonly electrocuted by an apparatus with two electrodes, one being inserted in the rectum while the other is applied to the mouth. It is believed to induce unconsciousness immediately if the apparatus is used properly, i.e. keeping the current at a correct intensity (0.3 amp, 110 V for 3-4 seconds). When using this method the farmer would induce the current for 30-60 seconds then take a break of 15 seconds and induce the current again for 30-60 seconds. The initial current should ensure cardiac arrest and loss of brain function. The last induced current is just an extra precaution. The current used is also lethal to humans and instructions should be followed strictly (Dansk Pelsdyravl, 1986). In the UK, the use of electrocution to kill foxes is not permitted and when foxes were bred there (no farmed foxes in UK today) they were killed by lethal injection of a barbiturate. According to Finnish legislation, foxes may be electrocuted by using 0.3 amperes during at least 3 seconds and raccoon dogs by using 0.3 amperes during at least 15 seconds.

8.2.3. Killing of Chinchilla

The injection of 5 ml of a 40% chloral hydrate solution in the abdominal cavity of the chinchillas is one of the killing methods (Kvorning, 2000, pers. comm.). Another is breaking the neck of the chinchilla. The following description is taken from Christensen (1989): “The animal is held by its tail with the head down and facing away from you. You then place two fingers on the forehead and the thumb underneath the chin. You hold the chinchilla firm this way, and if you are calm the animal is calm. Then you press your hand downwards while you press your thumb upwards until you feel a “crack” and the animal is dead.” Electrocution is also used, though no description has been found, but breeders are recommended to follow the manual of the apparatus used for electrocution (Christensen, 1989). Gaseous inhalation does not function in chinchilla since they can loose their hair if the pelt becomes wet or humid.

Death by chloral hydrate may be preceded by gasping, muscle spasms and vocalisations. Furthermore a working party on the killing of laboratory rodents has concluded that chloral hydrate is not suitable, as it lacks analgesic effects and causes irritation of the peritoneum.

8.2.4. Killing of Coypus

The majority of coypus are stunned and killed by electrocution in rabbit slaughterhouses after having been transported there in individual cages.

8.3. Conclusions

1. Chinchillas, coypus and ferrets are usually handled with bare hands, mink with gloves or in traps for some procedures, adult foxes often with tongs. Traps and transport cages are used where necessary, e.g., for blood sampling, moving between cages. In the case of mink and foxes, restraint devices are used to increase the efficiency of handling procedures and to protect stock persons from injuries. Immobilisation causes welfare problems especially when prolonged.
2. During annual exhibitions, foxes are prevented from biting handlers and each other by the application of snout clips.

3. All animals kept for fur production are killed on site except coypus. Killing procedures differ both between and within species. Methods have been developed empirically. The canids and coypus are most commonly electrocuted, mustelids gassed, and chinchillas lethally injected.
4. Use of chloral hydrate for killing causes irritation at the site of injection and lacks analgesic properties.
5. Certain killing methods, especially carbon dioxide and chloral hydrate can impair mink welfare. Carbon monoxide is commonly used and even recommended. However, its effects on welfare have not been fully assessed.
6. With the exception of coypus, transport of animals kept for fur production is rare. When this occurs transport is usually by land in small transport cages. Water and food are provided if transport duration exceeds eight hours.

9. THE WELFARE OF MINK

9.1. Mink welfare indicators: attributes, assumptions, and measurement issues

Since more data are available on the welfare of mink than on that of other fur animal species (Nimon and Broom, 1999), discussion of the indicators that can be used to assess welfare and what they reveal in animals housed for fur production is first done for mink and then for other fur animal species (Nota bene: In this and the following chapter, the mink colour types ‘Dark’, ‘Scanblack’, ‘Black’ and ‘Standard Black’ are used interchangeably for black mink, while brown mink are referred to as ‘Brown’, ‘Standard’, ‘Wildtype’ or ‘Standard Brown’).

9.1.1. Mortality and morbidity

As stated in Chapter 3, if aspects of husbandry increase mortality or morbidity, then we assume that this indicates poorer welfare. Mink mortality and morbidity are indeed affected by husbandry (Dietz et al. 2000), as well as by genetic factors resulting from the selection for certain coat colours; how these factors act will be discussed in more detail in 9.2.

The incidence and causes of mink morbidity may be assessed via cases submitted to diagnostic laboratories, but more reliable is the clinical screening of live animals. Both types of data have successfully been used in epidemiological studies assessing the risk factors for neonatal mortality, sticky/greasy kit syndrome, gastrointestinal disorders and other conditions. Many mink health indicators can also be assessed *post-mortem*, which allows pre-clinical conditions, and conditions hard to spot *in vivo*, to be detected. These include digestive tract haemorrhage, spleen hypertrophy, dental decay, bladder and kidney stones, eye infections, paw injuries, fatty infiltration of the liver and gastric ulcers. These *post-mortem* indicators are sometimes so mild in form that they reveal no real welfare issues, or so rare that they provide little information and are statistically useless for comparing different husbandry practices. However, other studies suggest that *post mortems* can be extremely revealing; for example, very high levels of tooth decay were reported on one farm (present in c. 80% of their subjects), kidney abnormalities (present in over 25% Sapphires studied) and other conditions.

The actual relationships between clinical or pre-clinical conditions and other signs of poor welfare such as raised corticosteroid levels, self-administration of analgesics etc have not yet been investigated in mink. *Post-mortem* data from apparently healthy mink may also help us to understand why individual farms differ so much in their productivity, and in the correlates and attributes of other stress and welfare measures.

Pathologies are not the only relevant issue here. The incidence of bite wounds is also assumed to indicate poor welfare, especially skin punctures or scarring. This is because they are assumed to involve pain, although the degree to which this is so in mink has not been investigated, and the experience of pain may vary between species and across contexts. Bite wounds in mink may also reflect poor welfare by indicating social stress. For example, bites are accompanied by raised plasma cortisol levels in studies of group-housed females. Pain or social stress may also be why mink kits with bite wounds appear to grow more slowly than those without – although of course it may be that small body sizes cause animals to be bitten, rather than the other way around. Allowing the self-administration of analgesics and experimentally investigating minks' social preferences could help explore this issue in the future. However, even without such detailed information, it seems valid to use wounds and scars as a sign of poor welfare in mink.

9.1.2. Other aspects of physical health

a) Body condition and changes in body weight

Body weight *per se* is probably of little welfare significance in mink; they are bred for large size, and are now far heavier than their wild counterparts. There are also genetic strain differences, with e.g. Blacks being lighter than Browns. Mink from large litters also tend to be smaller in adulthood which is an effect again unlikely to reflect welfare problems.

However, changes in body weight and condition are likely to be important. For example, these are generally affected by chronic activation of the hypothalamic-pituitary adrenal (HPA) axis in many species, and stressors can also reduce feeding rates and enhance catabolism. In mink themselves, exogenous cortisol is known to reduce kit growth rates, while dosing feed with tranquillizer ('Mecibar') from before birth until the age of eight to nine weeks resulted in kits having larger body weights at pelting. Kit growth rates have therefore often been used to assess welfare, and some relationships with other stress measures revealed. For example, small female mink kits have been shown to be more fearful than larger animals in 'stick tests'. Stressors such as repeated immobilisation have also been shown to suppress minks' feeding behaviour. Changes in body weight can also correlate with other signs of poor condition or welfare in adults. For example, in one of two groups studied, females that failed to give birth were also more prone to be marked as very underweight by the farmers. High levels of weight loss during the winter also correlate with high levels of stereotypy, and *in extremis,* may even indicate effective starvation. Low body reserves can also cause, as well as reveal poor welfare: small females may be more prone to severe weight loss when nursing, and low body weights increase the risk of over-winter mortality.

However, caution needs to be applied when using weight changes to assess mink welfare. They can be affected by many factors not necessarily related to stress, such as activity levels, feed levels, reproductive state, ambient temperature, and in the case of nursing females, the size of their litters. Thus for example, mink lose c. 10% of their bodyweight over-winter even if fed *ad libitum*. When comparing experimental groups, these factors therefore need to be standardised before data collection, or controlled for statistically during analyses.

b) Pelt quality

In a range of species, coat condition is often affected by chronic stress, via the metabolic effects of glucocorticoids and the suppressing effect chronic stress often has on grooming. Minks' pelt qualities may also reflect the level of allo-grooming received which in other species is known to cause plasma endorphins to rise and heart rates to fall.

In mink, pelt condition - or at least aspects of it (e.g. ’clarity’) - is also important commercially, which explains its common use in husbandry and welfare studies. Husbandry is certainly important here: kits matched for litter can develop quite different coat qualities if raised on different farms. Consistent with a link with poor welfare, poor pelt condition was related to greater fearfulness in female kits (but not male), and is low in kits reared without a nest-box, a treatment that causes many other signs of poor welfare. Disturbances in pelt development have also been suggested to precipitate the fur-chewing that sometimes appears just before pelting-time.

However, mink pelt condition can also be affected by many factors not closely related to welfare. For example, genetic factors are important (e.g. coat quality declines in mink selected for large body sizes), as are aspects of nutrition. Perhaps unsurprisingly then, fur clarity and density do not correlate with any other welfare measure. Thus, except in extreme cases indicative of pre-clinical or clinical conditions, or cases of pelt biting, considered below, mink pelt condition is probably best considered a production measure rather than a sensitive welfare measure.

The timing of pelt priming may also be affected by welfare, although this has not yet been used in any applied study. This is because adrenal activity can inhibit the autumn moult (pelt priming is accelerated by adrenalectomy, although the mechanisms are not fully understood), and priming is also affected by prolactin which is another stress-sensitive hormone.

9.1.3. Physiological welfare indicators in mink

a) Cortisol levels and adrenal responsiveness

Blood levels of glucocorticoids increase in response to a number of challenging events, especially those requiring catabolism or the modulation of immune responses. The main glucocorticoid released by the mink adrenal is cortisol. Plasma cortisol is the usual focus of study, but as it can rise within minutes of a stressor such as blood-sampling, it should be noted that mink cortisol can also be non-invasively sampled. For example, excreted cortisol in the urine can be assayed with human plasma RIA kits; this technique is ideal for detecting responses to medium-term stressors (e.g. manipulations lasting 24 h), and possibly too for detecting acute responses. However, correction for urinary concentration by means of creatinine levels, the standard technique, is only possible in mink if individuals do not differ too greatly in their dietary protein intake. Mink cortisol levels can also be inferred from glucocorticoid metabolites in the faeces, which appear to peak three days after exposure to a stressor. Note that salivary sampling is unlikely to be useful for mink, in contrast, as small carnivores produce too little saliva for reliable steroid assays.

Mink cortisol outputs increase in response to a number of events assumed to involve poor welfare, including restraint in a trap or carrying cage for one hour; being moved to a new cage; blood sampling; and having their access to food blocked for 24h. Good studies control for this acute response, when trying to use cortisol to assess the impact of a longer-term treatment condition. Such studies have shown, for example, that mink selected for confident responses to humans also show a decreased cortisol response to handling. In the longer-term, cortisol levels are found in group-housed males to be higher in the subordinate animals than in the dominant ones, and also elevated in kits denied a nest-box during the growing period. These last animals also show an enhanced adrenal reactivity to ACTH.

However, as in other species, mink plasma glucocorticoid levels increase in apparently non-aversive situations too. For example, in female kits (though not male), the levels of play with balls correlated with plasma cortisol levels, a response that may simply reflect their higher levels of activity. Similarly, and again like other species, mink plasma cortisol also shows a circadian rhythm; for example, its levels are lower in the morning than afternoon. Mink cortisol levels also fail to rise in response to some events that are presumed to be aversive, e.g. solitary housing, and repeated catching and trapping, again apparent contradictions that typify much work using this measure.

Thus although mink cortisol levels do seem to rise reliably in response to acute aversive events, they also show some non-specificity, which means that they generally need to be supplemented with other measures of welfare, or with data about possible confounding variables (e.g. season and reproductive state, and activity levels). Their use for assessing more chronic treatments, e.g. housing type, is more difficult still as how mink and especially their HPA systems adapt or respond to longer-term challenges is still incompletely understood.

This last issue particularly highlights how much remains to be understood about the mink HPA system. Its prolonged or repeated activation (e.g. by repeated immobilisation) seems to have a range of effects: baseline levels of plasma cortisol may increase, decrease, or be unchanged, as may adrenal responsiveness to subsequent stressors (although season and reproductive state were, unfortunately, confounded in this last experiment). Thus minks' cortisol responses to repeated immobilisation have been described as 'indistinct and unstable', and therefore claimed to be an unreliable method of assessing chronic stress, deespite the fact that one author has stated that 'habituation and/or change of sensitivity in this axis has been proved, but complete understanding of this phenomenon has not yet been attained'. Research might advance here by incorporating a wider range of variables than is currently used, e.g. ACTH levels and responses to dexamethasone suppression tests.

There are many other research questions too. For example, females show greater corticosteroid responses to stressors than males, although this is no longer the case when the increase is expressed in relation to baseline levels, along with greater fear of humans and more receipt of pelt-biting, yet whether such differences reflect physiological or psychological differences has not been investigated. Likewise, glucocorticoid levels and responsiveness are affected by strain: homozygous Hedlund Whites and Aleutians show more marked cortisol responses to acute stressors than heterozygous animals. As with sex differences, whether this reflects differences in welfare is unknown. Finally, there may be within-sex, within-strain individual differences in HPA responsiveness whose biological basis needs further investigation. It has been proposed that mink HPA responsiveness may dichotomise into two styles of individual responding, sometimes termed 'active' and 'passive' coping strategies that are, respectively, prone to either SAS (sympathetic adrenergic) or HPA responding. Investigating the existence of such alternative strategies in mink would greatly help in the interpretation of cortisol as a welfare measure, for example by indicating whether simultaneous SAS measures should always be taken to supplement HPA measures.

b) Adrenal weights and related measures

In many species, adrenal hypertrophy results from the prolonged or repeated activation of the HPA axis and is neurally mediated. However, this has not yet been experimentally validated for mink, and data on mink adrenal weights are largely from applied studies. As a result the data are, unsurprisingly, confusing. On the one hand, females with nursing sickness, a disease characterised by emaciation and high levels of catabolism, have enlarged adrenals, as do water-restricted animals. In some studies, females also have relatively larger adrenals than males, a finding that makes sense in the light of their generally greater adrenal responses. However, other studies in contrast find that males have relatively larger adrenals than females. Furthermore, adrenal weights may increase in large cages, despite no effect on baseline cortisol or adrenal responsiveness. Conversely, they may show no change, despite baseline change in cortisol and adrenal responsiveness, as in the case of kits deprived of a nest box. Adrenal weights and basal cortisol levels were also found not to co-vary.

Given these contradictions, mink adrenal weight cannot currently be used as a valid indicator of long-term stress. However, some future research and methodological issues may help resolve the apparent contradictions. The first is to standardise how adrenal weight are corrected for body size; this is important issue as large animals tend to have larger adrenals, but expressing adrenal weights simply as a proportion of body weight tends to exaggerate the adrenal size of small or underweight animals (one solution to this dilemma is to use multivariate statistics in which adrenal weight and body weight are covariates). The second research issue is to supplement simple weight data with histological data, e.g. medulla: cortex ratios and measures of cortex cell hypertrophy. The third is to acquire a more complete understanding of adrenal responses to long-term or repeated challenges, as discussed above in section a).

c) Catecholamines

Adrenaline and noradrenaline are classically released in situations of ‘fight or flight’. However, they have been little used in mink research, despite their potential for testing the ‘alternative strategies’ idea outlined in section a). In only one study, urinary catecholamines in mink subjected to different ambient temperatures and different degrees of water restriction were measured. There were no effects, and the conclusion was that the temperature regimes were not stressful, or that catecholamines are not good indicators of this sort of long-term homeostatic challenge. However, catecholamines remain useful possible measures for future mink work.

d) Heart rate

Heart rate changes and heart rate variability are potential measures of the balance between sympathetic and parasympathetic systems. Mink have high basal heart rates (c. 260 bpm), possibly as their basal metabolic rates are also relatively high.

Changes of heart rate in response to acute events have been studied using implanted radio telemetry devices. The heart rates of three mink were observed to increase with activity, and went up rapidly from 200 to 300 bpm in response to ‘uncommon and unexpected events’ (e.g. a tap on the cage). Beyond this, however, heart rate changes and heart rate variability have not been utilised in mink research despite the suggestions discussed above that mink with low HPA responses are using SAS responses instead. Future mink heart rate work should also control for individual differences as activity, e.g. stereotypy levels, as exercise physiology (e.g. changes in stroke volume) will also affect heart rate reactivity.

e) Eosinophils and other leucocytes

The relative and absolute levels of eosinophils and other leucocytes are much-used in poultry welfare work. However, this approach has been little adopted for mammals, except for mink and foxes (see also section 10)

After acute stress (e.g. one hour immobilisation in a carrying cage), male mink respond with reduced levels of circulating eosinophils, as expressed in terms of the number per cubic millimetre of blood or as a proportion of total leucocytes). If the immobilisation stressor is repeated daily, this can switch to eosinopaenia; a response accompanied by reduced home cage activity and decreased tendencies to explore that has been attributed to adrenal exhaustion. Aggression in female kits (though not male) also correlates with eosinophil levels, and eosinophil levels are higher in subordinate mink. Increased numbers of eosinophils have thus been used as an indicator of chronic stress.

However, some studies, in contrast, use *lowered* eosinophil levels as a sign of chronic stress. This is because in studies of repeated immobilisation, this time on female mink, eosinophil numbers steadily fell. In addition, long-term deprivation of a nest-box caused kit eosinophil numbers to decline. This interpretation also helps to explain why relatively high eosinophil levels predict reproductive success in females, and relatively low levels, the failure to mate or loss of kits.

To add still further to this confusing picture, some treatments that cause long-term changes in baseline cortisol levels, e.g. the group-housing of females, have no effect on eosinophils. Likewise, weaning kits into groups or isolation has no effect on eosinophil numbers, even if the treatment occurs at six weeks of age, and even though isolating young mink is known to have a number of deleterious acute and chronic effects (see below). Baseline values also show no sex differences. A similar set of contradictory results has also accumulated for heterophil: leucocyte ratios in mink. They are increased by stressors in poultry, and likewise, increase in mink denied a nest box, or repeatedly immobilised. However, they do not always respond to such treatments: some repeated immobilisation protocols did not cause such effects, and group-housing has no effects on the heterophil: leucocyte ratios of females. Furthermore, ambient light intensity (as determined by season and housing conditions) can also affect eosinophil levels.

On the basis of such findings, it is tempting to conclude that such haematological indices should not currently be used in the assessment of mink welfare. It is certainly clear that neither eosinophil increases nor decreases are well validated signs of poor welfare in the mink. However, before discounting all studies that use such a measure, we should carefully assess what they *do* tell us. First, the acute decline in eosinophil levels in response to a single aversive event is a robust and well understood phenomenon, and a direct result of cortisol release. Indeed in other species studied, the two are so tightly coupled that diurnal changes in cortisol levels are tracked by diurnal changes in eosinophil number, and eosinophil levels fall within minutes of blood-sampling. Thus eosinophil counts can potentially be used as an alternative to hormone assays for measuring minks' cortisol responses to acute events, with all the provisos that apply to plasma cortisol analyses (controlling for time of day, season, length of time taken to take the sample, etc; see section a). Second, long-term changes in eosinophil levels (or indeed other haematological indices) do tell us that a housing system has affected the animals' physiology. We may be unsure as to the interpretation, but we can at least conclude that housing systems causing different eosinophil levels are far from identical as far as the animal is concerned.

Future research may help us to understand more about how eosinophil levels change in response to long-term challenge. Such research is clearly dependent on a better understanding of how mink HPA axes respond to such circumstances, but other issues are important too, as cortisol and eosinophil levels can also change independently of one another. Parasite loads might be one such influential factor. Comparing mink populations that differ in their baseline eosinophil titres might be one useful approach to this problem.

f) Immunological function

Stress is well known to affect immune function, although the effects of stress are complex, and may enhance as well as reduce it. The mechanisms of stress-induced alteration in immune function ideally need to be looked at in terms of the balance between different types of T helper cells, but such work has not yet been done on mink.

Techniques for studying humoral antibody response and natural killer cell activity in mink have been developed. Levels of plasma immunoglobulins were not found to differ between strains. However, strain differences in susceptibilities to bacterial infection are well-characterised, for example being well known to be high in Aleutians; this is discussed further in Section 9.2. Whether such traits have anything to do with strain differences in stress responsiveness seems unclear.

Welfare researchers have tended to use rather simple assays of the immune function, such as infection rates. Other applied researchers have used changes in different cell populations, e.g. increases in the total leucocyte count. However, other *in vivo* and *in vitro* techniques of assessing immune function have not been utilised. Such gaps in our knowledge are important to fill, as disease susceptibility has obvious implications for mink welfare. Furthermore, such knowledge may help to interpret some other welfare measures. For example, if stress-induced immunosuppression were to increase parasite loads, this would increase eosinophil levels, a factor that some might interpret as indicating good welfare (see e, above).

g) Body temperature

Changes in core body temperature are often observed in response to events that are affectively important, including acute stressors, and anecdotally, body temperatures in mink have long been known to increase during handling. For example, farmers have been recommended not to handle mink in very hot weather to reduce the risk of heat stress. However, this measure has been little used in mink welfare assessment, despite its use in fox research, and the fact that mink's high rates of heat production and loss should facilitate a rapid stress-induced hyperthermia (SIH) response. There are a few exceptions. When stress-induced hyperthermia was studied in mink selected for confident and timid behaviour, confident mink showed a decrease in SIH with repeated capture, suggesting habituation, while mink from the fearful line showed the opposite, suggesting sensitisation. Whether such response is due to fever or hyperthermia is not known and requires measurement of. skin vasomotor changes. It is important in such studies to control for ambient temperatures, as when these are above 15°C the rectal temperatures of mink were found to increase.

h) Gastric ulceration

Gastric ulceration has long been linked with stress. True ulcers involve the loss of epithelium and the exposure of the underlying lamina propria. Unless they are very severe, with substantial epithelial loss, they can only be correctly diagnosed after the histopathological examination of fixed tissue.

However, gastric ulcers in mink, as assessed by eye, have been described by various authors. Gastric ulcers are found in the pyloric part of the stomach, and some are just the size of ‘millet seeds’. The ulcers can be of two sorts: a small punctuate pit, less than 1mm across, with nearly defined edges; a polygonal, roughened erosion of the mucosa, c. 2mm x 4mm in size. Lesions ranging from pinpoint erosions to intermediate and larger ones (though all scored ‘3’ or less on an existing 6-point scale for assessing rat ulceration) have also been reported. Mink gastric ulcers seem to appear within a day of exposure to an acute stressor.

Stomach ulceration is not necessarily related to adrenal size, nor to any other welfare-related measure, such as timidity or abnormal behaviour. Furthermore, several apparent stressors (e.g. some forms of immobilisation) do not appear to be ulcerigenic in mink. This may be because ulceration is generally multi-causal in origin, with factors such as gut flora, diet, and diet changes also affecting its incidence. For these reasons, population levels of gastric ulceration cannot be inferred from the *post-mortems* of mink found dead, due to the acute stressors and food intake changes likely to precede death. One issue that might help interpretation here is the location of ulcers: the exact site within the stomach can help distinguish stress-induced ulcers from others. However, sadly this was not done in any of the research studies above. Overall, as a clinical or pre-clinical symptom, it is probably correct to use gastric ulcers as signs of poor welfare in mink; however, without further data or research, stress should not be inferred as the causal factor.

i) Prolactin

Raised prolactin levels have been linked with stress in a variety of species, and also implicated in stress-induced infertility although this effect is unlikely in mink (as being annual breeders, they do not require lactation-induced anoestrous.

Plasma prolactin has not been investigated from a stress perspective in mink. However, circumstantial evidence suggests it may well be important. A decrease in prolactin precedes pelt priming in the autumn. Although this fall is not *essential* for moulting, exogenous prolactin will inhibit the winter moult. This suggests that individual differences in prolactin levels (and also HPA activity, as suggested in ‘Pelt condition’ above) could underlie the great differences in pelt priming time shown by animals on identical photoperiods. In support of this idea, late pelt maturation is anecdotally linked with poor physical condition. Furthermore, Dark mink, which are less placid and more ‘nervous’ than Pastels, tend to show later pelt priming in the autumn, a trait which is especially marked in some selection lines. Darks can also show shorter embryonic diapauses, another aspect of mink biology controlled by rising prolactin. Thus the combination of delayed pelt priming and shortened pregnancies could well indicate stress-induced hyper-prolactinaemia. However, such issues remain to be investigated, and prolactin itself has not yet been used in any applied study of mink welfare.

9.1.4. Reproductive welfare indicators

Stress is well known to have detrimental effects on reproduction. In general, the negative influences of stress on reproduction are mediated by the negative effect of HPA axis hormones on the hypothalamus-pituitary-gonadal axis and the detrimental effect of energy deficit on pulsatility of the hypothalamic LHRH generator. Some of these effects may also be mediated by prolactin and by opioids.

a) Male fertility

Male fertility is affected by very abnormal socialisation periods as kits, and also by pre-natal stress such as the mother being transported while pregnant. It may also be affected by current stress, as there is an inverse relationship between prolactin levels (see above) and 'testis activity'. The very severe slimming down of fat males over the winter can also reduce fertility in the spring. However, other effects of stress and welfare have not investigated, and several other factors can affect male fertility, including excessive body fat and genetic conditions (Dark males have long had low fertility, due to autoimmune testicular reactions). Thus male performance is generally unlikely to be a useful or specific indicator of mink welfare.

b) Willingness to mate

Loss of libido is a symptom of stress in humans, and similar observations have been made in a range of other species. Minks’ willingness to mate may thus be related to welfare. Females that refuse to mate are certainly usually normal in terms of reproductive physiology, suggesting that other explanations need to be sought. In support of a role for stress, excessive or rough handling generally reduces minks’ willingness to mate, and willingness to mate can often be reinstated by treatment with a sedative. Sedatives can also ‘cure’ generally hard-to-mate females. Females that mate rapidly also tend to have larger litter sizes at birth. Furthermore, mink selected for confident, exploratory behaviour mate more readily (i.e. two days earlier) than control animals - though they do so with a longer latency. Ease of mating has also generally increased over the decades, as mink have become tamer, and selection against intra-specific aggression has occurred. Relatedly, females bred for aggressiveness towards humans are less likely to come into oestrous than those breed for docility. Body condition may perhaps be another key variable here; extrapolating from studies of mink in the wild, the timing of oestrous and receptivity may well be affected by feeding levels and body condition.

However, ease of mating seems unrelated to stereotypy levels, and overall, the full reasons why some individual females, and some colour types, are less willing to mate have not yet been clarified. It is, however, affected by female age and the stage of reproductive season, and also by body weight. Deaf Hedlund whites are also more ‘difficult to breed, although details are not given. Thus willingness to mate is likely to be reduced by stress, but several other factors also need to be controlled for when using this to infer mink welfare.

c) Female failure to produce kits

Infertility is commonly used as a welfare indicator. In mink, high stress can indeed lead to implantation failure. For example, abortion rates are higher in females exposed to the chronic stress of daily immobilisation and injection, while females that show aggression to humans also show high rates of infertility. Dark females have unusually high rates, e.g. levels of infertility of >10%, compared with brown colour types’ level of <7%. Body condition can also be important; in one study, female that failed to give birth were more likely to be classified as 'extra thin' by the farmers, and in Sapphires and Scanblacks, though not Standard Browns, the degree of over-winter food restriction also affected the frequency of barrens. Disease, particularly plasmacytosis, can also increase the number of females with failed pregnancies.

However, as ever, there are exceptions to this picture. For example, females bred for timidity are no more likely to be barren than exploratory or control females, while infertility does become more likely with age. Barrenness is also affected by strain effects whose relationship with welfare are unclear, e.g. Sapphires have unusually high rates. It also increases if there is too little fat in the diet. Thus overall, the reasons why rates of barrenness vary between farms are still far from understood. However, if studies control for age, strain and also mating regime, then manipulations that affect rates of fertility might well affect welfare.

d) Pregnancy length

In mink, pregnancy proper is preceded by a facultative diapause of variable length. The blastocysts may not implant for up to 49 days after mating, or even for as long as 12 weeks. Lengthening day lengths trigger this implantation, but there is still considerable variation in pregnancy length between females mated on the same day, and the reasons for this are not fully understood.

Unlike some other mustelids (e.g. badgers), poor body condition or reduced energy intake does not seem to affect minks’ implantation. However, implantation is mediated by rising levels of prolaction, a hormone that also increases in other species in response to stress (see 'Prolactin' above). Implantation is also, in contrast, likely to be *delayed* by another hormone related to stress, ACTH, which inhibits LH.

Individual minks’ HPA and prolactin responses to stress could therefore explain some paradoxical results. On the one hand, mink subjected to repeated restraint stress or handling have longer implantation delays, while mink selected for confident behaviour have shortened delays, despite mating earlier in the spring. However, on the other hand, placid Pastel females have consistently longer implantation delays than the more nervous, restless Darks, and likewise, longer implantation delays are also seen in multiparous Wildtype females with relatively small adrenals. These potential links between minks' stress and reproductive physiologies remain unexplored.

e) Litter size

Litter size is affected by stress and body condition in several species. Litter sizes at birth and three weeks of age are often recorded in mink welfare/husbandry studies, as asides from being potentially affected by stress; it is clearly an important production issue.

Stress, poor handling and transportation, especially in the weeks immediately after mating, might reduce the number of ova that females release and enhance the pre-natal loss of embryos. Mink exposed to lots of overhead aeroplane noise also have more prenatal losses. Russian studies have also found litter size to increase with selection for tameness, while some Danish studies have also shown that it decreases with selection for fearful behaviour, and litter sizes are also reduced in aggressive mink. The effects of stress may be quite delayed. For example, females transported while pregnant gave birth to litters no different in size from control animals that year, but showed reduced litter sizes the next year.

However, not all have found that litter size co-varies with timidity, and litter size does not always immediately reflect exposure to stressors (see transportation example, above), presumably because late in the pregnancy, it is relatively hard to modulate litter size. This might explain why litter size is not increased through use of the tranquillizer 'Mecibar'. Furthermore, litter size is affected by a variety of factors not closely related to welfare, such as nutrients, female age, and mating date. Litter sizes are also affected by female weight, being greatest in females of average size. Genotype is also important. For example, homozygous recessives often have smaller litters than heterozygotes. Litter size can also be selected for. Pearls and Wildtype-Black crosses tend to have large litters, followed by Pastels and Wildtypes, then Standard Blacks and Sapphires. A further complication is that even when all these factors are controlled for, the link between litter size and welfare is not simple, as large litters can actually cause poor welfare, e.g. by increasing breeding females' risk of nursing sickness, and possibly even kits' later levels of stereotypy.

f) Litter mortality

Stress has been found to reduce parental care, including the provision of milk in a range of species. Offspring mortality and failure to thrive may thus be a welfare indicator in mink. In support of this idea, mortality can increase in mink litters whose mothers are exposed to daily immobilisation perhaps because of decreased milk output. Kit loss is also greater in females that lose more than 300g over-winter, or who are exposed to severe over-winter food restriction. Infanticide seems to be rare, although detailed video observations of interactions within the nest-box have not been conducted, in contrast to research on foxes. At the Research Center for Mink of the Dutch Research Institute for Animal Husbandry, up to c. 0.5 % kits are inferred to be killed by their mothers: females were observed biting the tails or limbs of their offspring, prior to the kits' disappearance. Although the relationship between welfare and infanticide in unknown in mink, some attribute it to females being disturbed in the first few days after birth.

However, welfare interpretations of litter mortality need to take several other factors into account. It is affected by litter size, kit mortality being highest in very small or very large litters, by female diet, and, as ever, by genetic issues. For example, in one experiment, unselected control mink lost fewer kits (11.3%) than more inbred lines selected for timid or confident behaviour (av. c. 20%). On farms, strains differ in their typical litter mortality rates too. For example, kit losses are higher in Sapphires than in Standards.

9.1.5. Behavioural welfare indicators in mink

Preference and avoidance

As discussed in Ch. 3, we assume that animals approach and work for resources that improve their welfare, and seek to avoid resources that do the opposite. This does seem to be the case in mink. For example, they will push weights greater than their own bodyweights to reach food, and will also learn arbitrary instrumental responses, performing these to a high fixed ratio. If separated from food by a barrier, they will also scratch at this barrier persistently. Furthermore, food-deprived mink become increasingly willing to scale a wire mesh wall 1.22m high to reach food. Mink also actively avoid certain stimuli that humans perceive as aversive to humans, e.g. atmospheres containing 80 – 100% CO_2. As further, species-specific evidence that such approach/avoidance responses are accompanied by affect, minks' tendencies to avoid humans are often accompanied by hissing and anal gland scent release, and their tendencies to retreat in a 'stick test', where a stick or pen is held in an animals' cage for a brief, fixed period, correlate with their cortisol responses to handling or to human approach, and also their acute changes in body temperature with repeated capture. Furthermore, these avoidance reactions can be ameliorated with anxiolytic serotoninergic drugs.

Such tests are thus highly relevant to farm mink welfare, as they reveal aversion for humans or novel stimuli in general. As females are more timid than males, and Darks more timid than Pastels, this therefore suggests strain and sex differences in on-farm welfare. Minks' tendencies to approach such stimuli have changed over the years, with increasing domestication. Today's farmed mink is no longer flighty, but typically curious. There are also population differences independent of strain, founder effects presumably contributing to differences between farms. As fear of humans and novelty has a strong genetic component, it can be selected for, a process which affects responsiveness to serotonin agonists.

Thus preference tests do seem a valid way of ascertaining the resources that provide mink with high welfare. They could also be used to answer novel questions, e.g. the strength of preference for analgesics could be used to assess the severity of pre-clinical or clinical conditions (see above). Techniques that quantify the strengths of motivations (e.g. by imposing costs on access to resources) are likely to be more valid than simple preference tests or time-budget studies - and indeed in mink, motivation as measured in demand tests is unrelated to the amount of time spent interacting with enrichments when they are free. However, preference and demand experiments do not address one important issue: the extent to which minks' measured motivations to interact with additional resources are merely enhanced by stimuli from those resources. If 'out of sight' is also 'out of mind', mink will not suffer when test resources are not available, even if keen to work for them when they are. Comparisons of mink housed with or without such resources are thus essential complements to motivational studies.

Behavioural signs of good or poor welfare

Overall, tendencies to approach or avoid novel and potentially threatening stimuli, the personality trait of fear can also reflect animals' baseline stress states. For example, being immobilised for one hour daily reduces minks' general tendencies to explore novel objects, while mink on farms where they are weighed regularly are more fearful in temperament tests. Responses in 'stick tests' also predict individual minks' responses to novel objects, to human handling, and to intruder tests, although they seem to have fairly little relationship with behaviour in an elevated plus maze. In one of two populations studied, fearful adult females were found to have relatively large adrenals. Tests of general 'emotionality' (e.g. reduced activity in the Open Field, validated aspects of behaviour in elevated plus maze tests, novel object tests, etc) seem to have great potential as a welfare indicator.

Along with avoidance behaviour, mink may show other acute signs of alarm, fear or distress. These include pilo-erection, defecation and urination, the release of odiferous anal sac secretions, and hissing or piercing, scream-like vocalisations. Although described as defensive, warning vocalisations, an aggressive response to threat most common in males, it should be noted that during social confrontations, they are usually emitted by the submissive animal, and thus probably reflect a degree of fear. Consistent with this, vocalisation rates and tendencies to retreat in a stick test correlate in kits. Kits also squeak repetitively when cold, or separated from their mothers, a behaviour sometimes termed 'croaking'. Croaking is also heard in mothers separated from their kits. Squeaks by adults are usually associated with pain or fear. In general, vocalisations have been little used in mink welfare research, and the detailed spectral analysis of the calls made in different situations has never been conducted. Frustrated animals such as females whose young kits are removed, also show high levels of running in and out of the nest-box, and nodding up and down against the cage wall, both possibly the intention movements of search.

Being inactive or spending long periods in the nest-box has also been linked with chronic stress in mink. For example, being immobilised for one hour daily results in low activity in the home cage. Faecal glucocorticoid metabolite levels also reach the greatest maxima in weaned kits that are quiet, and do not vocalise when moved to a new cage. Mink selected for fear of humans/ novel objects also showed more freezing behaviour in an elevated plus-maze. General activity is also thought to decrease after fur grading, which involves much handling and physical restraint. However, tendencies to reduce activity when moved to a new cage were unrelated to fear responses in a stick test. This may be because reducing activity is a particular individual response strategy, rather than a sign of the magnitude of the stress: thus individuals prone to decrease their activity when exposed to stressors could be 'passive responders', akin to those observed in other species, and there are certainly genetic differences in minks' activity levels, both within and between strains.

Feeding behaviour also declines during and following a period of repeated immobilisation. Chronic stress is known to affect grooming in other species (see 'Pelt quality'), and thus this may decline in stressed mink too. Handling adult females for more than a minute also seems to reduce their latency to contact a distressed kit, in a standardised ‘kit retrieval’ test, suggesting that disturbance also suppresses some aspects of maternal care.

Apparent signs of calmness and relaxation in mink include relaxed postures (e.g. lying belly-up in the cage), and play. Playing mink, like mating mink, perform a species-typical gentle ‘chuckling’ and vocalisation. This is sometimes termed ‘cooing’, and is performed by both adult females with kits, as well as by the juvenile young when playing. The typical postures and facial expressions of play in mink (e.g. the open-mouthed play face) have been characterised. Play in a range of species is linked with low anxiety. In mink, play is enhanced by being housed in a semi-natural environment as opposed to a cage, and possibly also by group-housing, but decreased, in the short term, on being weaned and moved to a new cage. Female kits (though not male) with the highest levels of play are also the most exploratory and least timid.

Abnormal behaviours I: Stereotypies

Farmed mink may perform locomotor stereotypies which typically involve pacing along the cage wall, vertical rearing in a cage corner, repetitive circling or nodding of the head/front half of the body, and/or repeatedly entering and leaving nest-box. Several studies have suggested that different forms have different causal factors. Of the various forms of mink stereotypy, pacing (often called 'pendling' in Danish studies) is the most common. Stereotypies in more complex environments tend to become more complex themselves, for example, incorporating any added water-bath, cage compartments, cylinders or platforms.

The causal factors of stereotypies, and their relationships with welfare, are complex. Mink stereotypies result from an interaction between genotype, rearing history, environmental complexity, and arousal or general activity, as illustrated below:

Genetic effects: Breeds of mink differ in stereotypy levels, for example, Pastels are more stereotypic than Pearls. Furthermore, within breeds, there are inherited differences in stereotypy, both within and between farms. Selection over just a few generations can therefore reduce stereotypy dramatically, and cross-fostering experiments have shown that this is indeed due to genetic effects. How these effects are mediated has not been investigated, however, although stereotypic mink have been found to have higher dopamine levels in the frontal cortex than control animals, and lower levels than animals bred for inactivity.

Rearing history: Weaning age tends to have delayed, long-term effects on stereotypy. The effects of early weaning would be consistent with dopaminergic changes in socially deprived infant primates and rats isolated post-weaning. The type of housing when a kit (e.g. single versus social) transiently affects adult stereotypy levels in winter. Low feeding levels when young also result in high levels of stereotypy in adulthood, an effect that can be manifest over a year later. Again, however, how any of these developmental effects are mediated in mink is unknown.

Behavioural opportunities: Mink stereotypies are not seen in the wild, nor in much enriched enclosures in zoos. Likewise, mink housed in enriched cages, with many objects to interact with, also generally show greatly reduced stereotypy. Some also find similar results for mink in large cages.

Stressful events: Stereotypies peak in speed, frequency and prevalence just before feeding time, and are enhanced by hunger. Stereotypies are also seen in females when caged with a male for mating; in animals making aggressive advances towards a neighbour; and in nursing females whose young are shut in the nest box. Although they are not expressed immediately in mink shut away from swimming-water, which is a potent positive reinforcer, they also come to be performed at higher levels in nine month old kits who had been housed with water-baths until seven months of age and then deprived.

General activity levels/arousal: Stereotypies negatively correlate with levels of inactivity, and may also positively correlate with normal activity. Reduced general activity may explain why very small cages can sometime reduce mink stereotypies, as can repeated immobilisation stress, while in contrast, the presence of 'play-balls' increases stereotypies in female kits.

Thus mink stereotypies result from interplay of genetic predispositions, experiences when juvenile, complexity of current housing, and exposure to environmental events that cause increased activity. We do not yet know if selecting against stereotypy improves welfare (indeed, it may even decrease it, as reviewed below). We do not know if the early experiences that enhance stereotypy development are aversive (although the relationship between weaning age, stereotypy and urinary cortisol output is currently under investigation). We also do not know if the early experiences that enhance stereotypy development have lasting effects on brain functioning. Some circumstantial evidence does link mink stereotypies with CNS dysfunction: high-stereotypy females have deficits in maternal behaviour, e.g. making poor quality nests; and some stereotypies are highly perseverative, or involve self-harm (for example, kits may transiently continue to stereotype for some seconds after the arrival of food, and adults may – albeit rarely - perform stereotypies that involve repeatedly crashing down from the cage-top onto their backs). However, even if mink stereotypies do involve CNS dysfunction, such changes may not affect the stress levels of the animals. We know that some environmental enrichments reduce stereotypies, but not all of them (e.g. swimming-water), yet we do not understand why. Finally, it is clear that some of the events that cause stereotypy are aversive, while others are not. Small wonder, then, that the links between mink stereotypy and other welfare measures are confusing, as we review below.

Stereotypies in kits have been associated with relatively large adrenal glands, although this effect arose from stereotypy being associated with low body weight. In kits and primiparous females, stereotypies are also sometimes linked with poorer pelt quality, low body weight, and infertility. High stereotypy lines are also more vulnerable to over-winter mortality.

However, stereotypy bears no no relationship, or at least no *clear* relationship with 'tail-biting'. In one study, stereotypy was associated with a greater incidence of tail-biting in primiparous females, but the opposite was true for multiparous females, and also for one group of male kits. Stereotypy also bears no relation with willingness to mate. In paired kits, stereotypy was also found to be unrelated to baseline plasma cortisol or eosinophil levels, though it should be noted that the regressions reported here did not block for sex or experimental treatment.

Furthermore, stereotypy has actually been linked with lower levels of fear of humans/novel objects, and lower rates of nursing sickness, in multiparous females. Stereotypy has also been positively correlated with litter size, and linked with lower kit mortality over an unusually hot summer. Lower basal plasma cortisol levels were found in high stereotypers, and kits from stereotypic parents showed the lowest faecal cortisol responses to re-caging. So, stereotyped behaviour can be associated with lower level of plasma cortisol, lower frequency of ulcers, better reproduction and faster physiological responses to acute stress. Selecting against stereotypy does not automatically yield signs of improved welfare: it does not reduce tail-biting nor increase minks' reproductive success, and indeed it seems to be linked with slight increases in pelt-biting, and slight decreases in pelt-quality (though the latter may be a side-effect of increased body-weight).

Thus mink stereotypies sometimes seem related to other indicators of poor welfare and sometimes not. We do not yet fully know why, although the likely reason is that the causes of mink stereotypy include factors both related and unrelated to poor welfare. Fundamental studies suggest we might advance by trying to partition out the effects of raised activity levels and tendencies to perseverate, neither of which are necessarily related to stress. We also need to control for general, beneficial effects of physical exercise (as stereotyping mink can run up to 40 kilometres a day). Studies even suggest that the correlates of mink stereotypy are affected by climate (it can be deleterious in cold conditions, beneficial in warm; see Section 9.2); by subject age; and by the form of the stereotypy (some forms correlate with reproductive success, others do not). How and why such effects are seen are, again, not understood.

While more research is clearly needed on the complex aetiology of mink stereotypy, for practical purposes, we will assume below (9.2) that treatments that replace stereotypies with normal active behaviours are likely to cause good welfare, and that where stereotypy is caused by deprivation, the higher the stereotypy, the worse the welfare. However, we will also assume that treatments which reduce both stereotypy and normal active behaviours (e.g. genetic selection, very small cages) do not necessarily improve welfare, and indeed may well be counterproductive.

Abnormal behaviours II: Self chewing

Some mink on mink farms have been observed to have substantially shortened tails resulting from chewing and, more rarely, to have chewed limbs. Except where a tail or limb becomes trapped, such chewing is very unlikely to be carried out by other individuals. The mink has been mutilating itself and the behaviours sometimes follows the chewing of tail hair. The incidence of such severe self-mutilation is difficult to ascertain as seriously affected individuals are likely to be removed. However, it is possible that a significant proportion of tail-biters or pelt biters eventually progress to major tissue damage and infection.

Psychogenic alopecia, sometimes resulting from excessive self-grooming, has been linked with stress in a range of species. Mink with patches of shortened or absent fur, especially on the tail, exist on every farm. Careful observation has shown this to be caused by animals sucking or biting themselves. The fur on the lower hind part of the back, and/or the tail, may be clipped short, and the tail may even be bald, apparently sucked clean of fur. Sometimes bald tails, or those with closely clipped fur, are even bitten until bleeding (see reference to more severe mutilation later), though possibly because they slip through the cage partitions to be attacked by neighbouring mink (van Iwaarden, unpublished observations). Females that tail-bite after their first mating season, tend to do so again in subsequent years, although some animals do not start doing this behaviour until two or three years old. The behaviour tends to get more severe with age; the average length of the bare tail tip increasing from 3 cm in 1 year olds to 6cm in 4 year olds. As with stereotypy, this behaviour seems absent in the wild. Also as with stereotypy, this behaviour seems to have multiple causal factors. We thus do not yet know why its prevalence differs so greatly between farms, and between countries, not why some animals only develop it late in life.

Some fur-chewing may have a dietary explanation. It could be a form of pica, the eating of inedible substances shown by animals lacking in specific nutrients. Some claim it is not affected by nutrition, and *ad libitum* feedings levels do not reduce it, nor does restricted feeding increase it. However, it has been anecdotally linked with under-feeding and poor nutrition, and in one study no pelt-chewing was observed in well-provisioned kits, only those experimentally fed at low intensities. Feeds with protein, vitamin or mineral deficiencies, e.g. low in biotin, have been particularly linked with fur chewing. When poor nutrition is the cause of pelt-chewing, we should assume this also causes poor welfare. However, this issue seems far from resolved.

'Boredom' has been posited as a contributory factor, in part because the behaviour seems to increase whenever mink are singly-housed. However, there seems to be few systematic data on these behaviours' prevalence in more enriched environments. In one study, the provision of 'toys' did seem to reduce fur-chewing. However, in another, play-balls did not reduce tail-biting, although these enrichments were not added until 6 months of age, which is somewhat after the behaviour first develops (see 9.2). Mink housed in enriched cages never displayed tail-biting. However, in another study, kits raised with access to swimming-water showed no less tail-biting than controls, but if re-housed to standard cages at seven months of age, their tail-biting at nine months was significantly higher than if they had always lived without water. More research is clearly needed here on how environmental enrichments affect tail-biting. Such experiments might also investigate whether providing manipulable, chewable food particularly helps reduce pelt-biting (see 9.2).

Tail-biting is also affected by weaning age, as is discussed below in 9.2. Such findings might suggest that the behaviour derives from re-directed suckling (cf. wool-sucking in cats and belly-nosing in piglets), although developmental studies indicate the behaviour may derive instead from play. Thus as with stereotypy, how such developmental effects are mediated is unclear, as is the significance of such effects for welfare.

Finally, the causes of mink tail-biting include a genetic component. There are strain differences in pelt-biting ('Demis' - Pastel-Pearl crosses - are more prone than Standards, for example), and within strains, selection against tail-biting is effective, as is selection against all forms of pelt-chewing, including allo-chewing (see below). However, as with stereotypies, the effect of such selection on welfare is unknown. In terms of their relationship with other welfare indicators, tail-biting and tail-sucking are anecdotally associated with nervous or restless temperaments. In one of two groups of kits studied, female kits that tail-bit were smaller then other animals, and that in two populations, adult female mink with bitten tails had relatively enlarged adrenal glands; in one of these latter groups of adults, tail-biters were also lighter, with less stored kidney fat. A slight but positive correlation was observed between tail-biting and stereotypy, but contradidctory results have also been obtained. We may also infer poor welfare when tail-biting results in physical injury, (whether self-inflicted or inflicted by neighbours; cases of fur-bitten and bleeding mink have contributed to at least one anti-cruelty lawsuit in the UK).

However, there was no relationship between tail-biting and 'stick test' assessments of temperament. Tail-biting may even positively correlate with litter size although this relationship is not always found. The acute stress of live grading just before pelting can also reduce tail-biting, possibly by reducing all activity. Anecdotally, several severe pelt-biters have been observed within a set of animals provided with swimming-water.

Thus the relationship between pelt-biting and poor welfare is nearly as complex as that for stereotypy, with the provision that unlike stereotypy, there are fewer signs of positive correlates. Future studies could advance by standardising the techniques they use (e.g. live assessment versus assessment at pelting may give different results), by assessing tail-biters with a wider range of welfare measures, and by experimentally producing tail-biting by different means (e.g. manipulating nutrition, weaning age, etc.) to see if the correlates of tail-biting depend on its primary causal factors.

In practice, here we will assume that treatments which reduce tail-biting by encouraging normal behaviours (e.g. playing), or by improving nutrition, also improve welfare. The welfare benefits of other approaches (e.g. selection), however, we will treat as rather less certain.

Abnormal behaviours III: Allo-directed oral behaviours

The allo-sucking of tail-tips occurs in group-housed kits post-weaning up to the age of approximately 14 weeks; the welfare significance of this behaviour is unknown, although it may well represent a substitute for suckling.

In older animals, occasionally large portions of the front part of the back and/or neck will be clipped of top hair, sometimes leaving only the head and back of the neck untouched. In contrast to tail-biting, this tends to be due to mink chewing each others' fur, as it is almost absent in single-housed animals. In pair-housed or grouped kits, females tend to be bitten, and males to be allo-biters. Severe fur-chewing, which we can infer probably included allo-body-chewing, occurred in kits that were restrictively fed from September until pelting. In one study, pelt-biting males showed more aggression, although it has been argued that allo-chewing and aggression are quite distinct, finding no relationship between it and the number of bite-marks through the skin. Pelt-biting males were also reported to be less curious, and to have higher levels of eosinophils than the recipients of the behaviour. This was taken as evidence of chronic stress in the allo-biters, although it should be pointed out that by inspection, their data seem to identify little difference between pelt-biters and the rest of the population as a whole, suggesting that 'recipients' were not a good control to use (see also 9.2). Indeed the 'recipients' seemed to have lower esosinophil levels than both biters and the rest of the population, suggesting that it is their welfare that was the most affected. Overall, therefore, this form of abnormal behaviour, and its welfare significance, is even less well understood than stereotypy and tail-chewing.

The chewing of plastic drinker dishes has also been observed on at least two farms. It appears to be infrequent, but also quite prevalent across individuals. Nest-box-biting and wire mesh licking have also been observed, though, again, infrequently, the latter authors classifying it as a stereotypy. Again, the welfare significance of such behaviour is unknown.

9.1.6. Conclusions:

1. The responses of mink to stressors and environmental manipulations are reasonably well understood but there is much fundamental work still to be done. A wide range of behavioural and physiological indices have been investigated, and furthermore, mink studies can readily involve *post-mortem* measures, as on-site slaughter facilitates autopsy.
2. Body weight, hypothalamo-pituitary-adrenal activity, heart rate, eosinophil levels, gastric ulceration, willingness to mate, infertility, litter mortality, playing, vocalisations, staying within the nest box, showing fear of humans, stereotypy and pelt biting, can all be affected by stress and have been found to be important welfare indicators in many studies.
3. Past experience and genotype interact to affect these responses. Factors unrelated to welfare can also confound them. Thus all welfare measures must be interpreted carefully in the light of factors which may affect them.
4. Potential welfare indicators which have not proved very useful for mink include litter size, kit growth rates, body weight, pelt condition, and heterophil: leucocyte ratios.
5. All these measures, and also mortality and morbidity (including bite wounds), vary between mink farms, sometimes because of known differences in husbandry, but sometimes for reasons which are unclear.

9.2. The welfare of farmed mink

The welfare of farmed mink has been reviewed before, for example by Nimon and Broom (1999), who considered all welfare indicators but emphasised issues of behavioural deprivation, and by the Utrecht Animal Welfare Centre (AWC 1999), who compared mink farming to other intensive farming systems.

9.2.1. Gestation and prenatal stress

Some potential pre-natal stressors do exist, including acute events such as overhead planes, transportation, and the chronic proximity of neighbouring animals.

The effects of transporting pregnant females on their foetuses' HPA function have not been investigated; however, one study has looked at its effects on males' later reproductive performance. In this study it was found that males born from transported pregnant females showed reduced testicular development and sperm production, and often failed to mate. Such effects were not seen in males that had been born from transported pregnant females two years previously, or in the sons of these animals, showing that they were not due to genotype differences between imported and control animals, and also that they could be reversed with time. The authors also suggest that the daughters of female transported while pregnant also had reduced litter sizes, although this point is not clear and is not developed.

In another study, emale mink subjected to daily immobility stress from five weeks before mating until three weeks before parturition (excluding the last trimester) produced a normal litter size at birth, but lost more pups during the lactation period than control animals (Jeppesen and Heller 1986). No effect was found on behavioural responsiveness of the offspring in stress situations. Thus pre-natal stress remains a fairly unexplored area, and potentially an important one.

9.2.2. The first three weeks

The first few weeks of a farmed minks' life are the most dangerous. At the Research Centre for Mink of the Dutch Research Institute for Animal Husbandry (Beek and de Jonge, 1988; de Jonge and van Beek, 1989a,b; de Jonge, 1994a,b; de Jonge and Leipoldt, 1994d; de Jonge and van Iwaarden, 1996; de Jonge and Wassink, 2000a,b), 13 to 30 percent of the kits die in the first three days, with an average of 20%. As overall kit mortality to weaning age varies between 20 and 35%, the first few days represent the peak period of vulnerability: about 80 percent of kit mortality occurs during this period (e.g. de Jonge and Leipoldt 1994e*).* In other studies kit mortality was found to vary between 17 and 29%; Dietz et al. (2000) also report that 20% neonates die before three days of age. Data collected by farmers and others, in contrast, often suggest rather lower mortality rates, e.g. 5 – 10% (Jörgensen 1985, De Jonge et al. 1986). This is likely to stem these workers' poor abilities to assess the true litter size at birth, although it could be that lower rates occur on working farms than they do in experimental research populations. Note that in contrast to some opinion (e.g. Rice 1967), counting true neonates to assess mortality accurately does not itself prejudice kit survival.

Although the true rates are high, it must be remembered that mink are highly altricial at birth, naked, blind, completely dependent on the mother, and with only very small stores of fat and liver glycogen (Jonasen 1987). They do not even have full temperature regulation mechanism until 29 days of age. An estimated 20 % newborn mink therefore die before the age of three days, another 5 % die before the end of the nursing period (de Jonge and Leipoldt 1994a-e). The mortality rate of the first 11 days has been estimated at 15 – 16%. Daily mortality rates fall from 3 –4 % for kits aged one to three days, to less than 0.1% after 21 days. It should also be noted that kit mortality rates on farms seem similar to those in more extensive conditions i.e. zoos. Here, juvenile mortality between birth and 30 days averages 22.8%. Kit mortality is also thought to be high in the wild, with estimates ranging between 22% and 35% (Dunstone 1993). Despite this, it is clear that husbandry can affect the mortality, and hence the welfare, of young kits.

Genetic factors are one such issue; kit mortality decreases with selection for litter size, and increases with selection for body size, despite the fact that within a population, kits' survival rates decrease with decreasing birth weight (Beek and de Jonge 1988). Strain differences are also important, with e.g. Black Crystal, Shadow and Arctic kits being less viable, and homozygosis for Shadow and Crystal actually being fatal (e.g. Nes et al. 1988). Sapphires also have high kit mortality, e.g. in one study, 22% cf. the 15% of Standards.

Disease is also a potential problem for infant mink, e.g. diarrhoea, 'greasy kit' syndrome (a form of acute enteritis characterised by dehydration, reduced growth, and a covering of a greasy yellow-brown exudate), and teat or mammary gland infections in the mothers. Plasmacytosis (Aleutian Disease) can also kill newborns. Spotting these diseases requires careful and regular inspection of the breeding stock, and good management and intervention may prevent many of these problems; for example, washing ’greasy kits’ can be effective, as can the judicious use of antibiotics. The effect on infant mortality of the number of mink per stockman is still an unexplored issue, but a relevant one as farms increase in size.

Cage design can also affect kit mortality. A drop-in nest box bottom that reduces the nest box volume and keeps kits together has a significant beneficial effect, as kit chilling is one of the causes of early mortality. Kit mortality is also higher, and growth rates lower, if families are denied a nest-box, although this would never happen in practice on a commercial farm. Some young may also be lost by falling out of the natal cage, to die on the ground from starvation and dehydration. Farmers usually reduce this by placing a false bottom of fine-mesh wire on each cage floor, over a layer of newspaper and straw. This may also have a vertical edge several centimeters high, the presence of which has been shown to halve kit mortality on Dutch farms (de Jonge 2000). Separating litters with empty cages can reduce the incidence of greasy kits (Overgaard 2000), although how such effects are mediated is unknown. Shed design may also affect kit mortality; excessively warm days (over 25° C as measured in the middle of the standard 2-row shed) may cause mortality in about 20% of the kits (e.g. de Jonge and Stufken, 1999), dehydration being one of the causes. The effects of the better ventilation of sheds, installation of misting systems, and changes in the roofing's design, material or colour, seem to be untested, despite being advocated for regions with hot summers.

Factors affecting the health, behaviour and welfare of the mothers are also important. (e.g. Jörgensen 1985). For instance, providing mothers with high levels of feed is essential for good maternal care and low infant mortality. Restricted feeding over winter and especially during pregnancy increases the incidence of ‘greasy kit disorder’, compared with females nearly *ad libitum* over that time (Møller and Hansen 2000). Females that lose over 300 g over-winter tend to have more kit losses (Tauson, 1992), although not everyone finds an impact of over-winter restricted feeding on kit mortality (Beek and de Jonge, 1988; de Jonge and van Beek, 1989a,b; de Jonge, 1994a,b; de Jonge and Leipoldt, 1994d; de Jonge and van Iwaarden, 1996). Food quality before and after parturition is also an important issue because both hygiene and nutrition affect milk quality. Tauson (1992) reviews that issue as including the bacterial content of the food, the proportion of fish oils or rancid fats (which can increase kit mortality by a third), and the nature of the offal used in the food (offal containing thyroid or uterine tissue can also increase kit mortality, possibly by decreasing female milk yield). Finally, maternal nursing sickness may also cause kit mortality (for details on how husbandry and diet can affect this condition, see below).

Maternal behaviour can also affect kit growth, morbidity and mortality. For example, some of the high infant mortality seen when temperatures rise has been attributed to the females’ reluctance to enter the nest box and huddle with kits (increases in body temperature are certainly known to encourage rat mothers to terminate suckling bouts. In recent work from Denmark, mink mothers’ responses in kit retrieval tests have been shown to accurately predict offspring mortality. The latency to approach and pick up a five days old kit out in the cage was related to kit loss during the first three weeks. Mothers with kits losses of 20% or more are significantly slower to react. Disturbance of the mother may play a role here, as females that were handled for more than a minute also showed longer latencies to retrieve pups. Kit retrieval is thought to be important as kits stranded out in the cage may become cold or dehydrated.

There are many risk factors that lead to poor maternal care and increased kit mortality. Those include congenital deafness, stereotypy, poor nest, overheating, and infanticide. Homozygous Hedlund White mink have problems with maternal care as they are completely deaf. In practice, this is often avoided by using heterozygote females (i.e. Standard females carrying the Hedlund gene) (Nes et al. 1988). Maternal stereotypy is also known to cause reduced offspring growth rates, (Mason et al. 1995) - a risk factor for kit mortality - perhaps because they are prone to making poorer quality nests. Such poor nests are known to be a risk factor for low kit growth and kit straying, although not predictive of infant mortality itself. However, active mothers may also protect their young from over-heating; lines of females selected for high or low activity did not differ in their litter sizes until a year in which the nursing period coincided with a heat wave; inactive mothers that spent a lot of time in the nest-box then had significantly higher kit mortality (de Jonge and Leipoldt 1994b). At the Dutch research farm, up to an estimated 0.5 % kits are killed through infanticide, or so it is inferred; the ‘savaging’ of kits has also occasionally been reported (AWC 1999). However, the causal factors of this rare behaviour are unknown. Finally, primiparous females given swimming water also have raised kit mortality (Skovgaard et al. 1997b), possibly because they are inexperienced at maternal care, and because females given water to interact with can occasionally make their nests wet and dirty (Moller 1991a).

9.2.3. From three weeks of age until weaning (c. 7 – 9 weeks)

Housing issues

Kit mortality rates fall after 21 days and generally become low (e.g. Jörgensen 1985), although kits can still be vulnerable to the diseases mentioned above. Botulism can also potentially cause severe mortality in kits aged 3 - 5 weeks, being a special problem for kits as this young as they cannot be vaccinated. However, this problem has decreased greatly in importance in recent years, as few farms make their own food, and commercial kitchens are very careful with hygiene.

High levels of play are often seen during this period, especially from five and a half to six weeks onwards (e.g. Gilbert and Bailey 1969a, Jonasen 1987). If housed in several inter-connected cages (see ‘family-/group-housing’, below), kits barely leave the natal cage until eight weeks of age, suggesting that space is not an issue until then. However, after eight weeks of age, the additional compartments do get used, and indeed more hide-and-seek play and running is seen in large naturalistic enclosures, as is swimming, from the age of eight weeks on (Jonasen 1987). One potential welfare issue here is the build up of faeces prior to the removal of the cages’ false bottoms. Most farmers clean these regularly, e.g. weekly, but if this is not done, this may possibly cause social stress, as mink use faeces for territorial defence in the wild (Dunstone 1993).

The transition to solid food

Kits start ingesting solid food at about four weeks of age (e.g. Jonasen 1987, Møller 1991b). Placing food on the nest-box lid, rather than on the cage top, accelerates their intake of solid food (Møller 1996). It also reduces inter-kit aggression: fighting occurred in 1% observations when kits were fed on the cage-top, but only 0.2% if fed on the nest box lid, and deaths from fighting/cannibalism occurred in 2.1% of the former group, none at all in the latter (Møller 1996). Female kit growth rates are also affected by feeding levels at this time, as if they are prone to lose out in competition with their brothers when food is not *ad libitum*.

The nature of the mink food itself also raises further, unexplored and lifelong welfare questions. First, it is a soft paste, very unlike the whole-carcass-based diet of the wild (e.g. Dunstone 1993), yet whether the lack of chewing it requires then affects digestive processes, motivations to chew, levels of fur-, mesh- or drinker-chewing, or the incidence of dental disease, has not yet been investigated. Second, on some farms (in Finland in particular), fox food may be fed to mink, even though mink are less able than foxes to digest high levels of fat or carbohydrate, and some potentially useful preservatives are not well metabolized by mink. The effects of these possibly sub-optimal diets on mink welfare still need to be investigated.

Kits start to drink from nipple drinkers at about six weeks. Water-drinking can be accelerated by one week by providing ‘drip watering systems’ which provide a modified drinking nipple that drips continuously (Møller and Hansen 1993). Minks’ need for water increases with temperature, and in warm summers, drip watering systems can increase kits’ rate of weight gain (Møller 1991a), as can the provision of water-sprinklers. Whether such practices also increase kit (and adult female) welfare has been little investigated. Intra-litter aggression does not appear to be reduced by providing a water-tray. However, detailed studies of drinking do show that mink drink about every two hours, night and day, thus suggesting that these animals should always have *ad libitum* water (Møller and Hansen 1993); and at ambient temperatures above 35°C, the restrictions of water can result in cortisol increases.

9.2.4. Weaning

The process of weaning

Various forms of weaning exist. Kits may be weaned via the removal of the mother, with the litter then left intact for a period; or they may be removed themselves, usually in pairs, from the natal cage.

The welfare effects of weaning by removing the mother from the cage do not seem to have been studied. The effects of re-caging young have, however. Kits may be carried manually, or transported in small carrying cages, which causes an acute cortisol response (a doubling of plasma cortisol within two hours, an effect not seen if the kits are fed tranquilliser). It may also cause a reduction in the proportion of leucocytes consisting of eosinophils. This process is usually also accompanied by vocalisation, urination and defecation on behalf of the kits. All kits, whether weaned at 7 - 8 weeks or c. 12 weeks, ‘croak’ in the first days after weaning, and even paired mink kits aged 8.5 - 13.5 weeks will persistently vocalise when experimentally exposed to novel experimental situations without their mothers, and scratch at the barrier separating them from her. Being placed in the new cage also elicits the young animals’ first incidence of brief stereotypy-like head-twirls, performed at the back end of the cage as far as possible from the human disturbance. After placement here, play may then be reduced for one or two days (Houbak and Jeppesen 1987). Feed borne infection are also said to be more common around weaning.

The age of weaning

Weaning age varies between 6.5 and 8 weeks of age. Such weaning ages contrast with dispersal ages in nature. In the wild, kits are not observed outside the den alone before 6 - 7 weeks, and the mother does not start to reject her kits until c. ten weeks (Dunstone 1993). Young thus tend not leave the natal territory until at least 11 - 12 weeks (Gerrell 1970), although there is some variation in this: some put this figure as low as eight-nine weeks, others as late as sixteen. Indeed in semi-natural enclosures, kits did not disperse until 13–14 weeks, (Jonasen 1987), and in the wild, young females may even stay with their mothers until the late autumn (Mitchell 1961), or even the next spring (Gerell 1970). Socialisation during this period seems functionally important for later sexual behaviour, especially in males. Males weaned at nine weeks mate more successfully than those weaned younger, partly because they do not become scared if the female resists perhaps because of fear, while females weaned at seven weeks or younger are unusually easy to mate resists (Gilbert and Bailey 1969a).

Unsurprisingly, then weaning age seems to be a welfare issue. For example, kits weaned at 6 weeks vocalise twice as much as those weaned at eight to ten weeks, even if weaned in a litter (Houbak and Jeppesen 1987). Kits weaned at 6 weeks also spend more time in the nest box than those weaned at 8 or 10 weeks, and showed this response for the entire experimental period (Houbak and Jeppesen 1987). Weaning age also has long-term effects on the later development of abnormal behaviour in pair-housed kits. Tail-biting prevalence at 6-7 months is reliably affected by prior weaning age. For example, 25.8% of six month old mink had bitten tails if they were weaned at 7 weeks, but only 9.8% if weaned at 11 weeks; in addition, only the early-weaned animals had completely bald tails at ten months (Mason 1994). Effects of weaning age on fur-chewing are also reported. The chewing of plastic drinker dishes in adulthood is also greater in seven-week-weaned than eleven-week-weaned mink. Early-weaned animals also tend to display higher levels of stereotypy in adulthood. Females weaned at seven weeks spent 30.7% of the pre-feeding period in stereotypy when nine months of age, compared with the 23.9% for females that had been weaned at eleven weeks (Jeppesen et al. 2000). This effect does, however, fade with time or treatments such as mating, and is abolished by group-housing with the rest of the litter (Jeppesen et al. 2000), which may explain why some studies do not always find such an effect.

Despite these signs that late weaning is better for welfare, some caution is needed. It has been suggested that early weaning (e.g. 6 weeks) would facilitate socialisation to humans, if accompanied by a suitable handling protocol. The numbers of eosinophils were higher (which they interpreted as indicating higher stress) in nine week old kits left with their mothers, compared with same age kits weaned at six or weight weeks. Late-weaning in which whole litters are left together in a standard cage until 10-11 weeks can also cause outbreaks of aggression, which in one study increased mortality in group-housed kits kept together in standard-sized cages. This may be a particular problem in larger litters, as these tend to have more aggression.

The welfare of kits between weaning, and the final splitting into pairs

There is some evidence than being weaned into a group can be less stressful than being weaned into a pair. For example, being weaned in a group until pelting-time protects kits from the stereotypy-inducing effects of early weaning. Kits weaned into group-housing also ‘croak’ far less then kits weaned into isolation (Houbak and Jeppsen 1987), although how this compares with being weaned into pairs was not studied.

However, as mentioned above, whole families left together in standard mink cages until 11 weeks of age may start fighting (Mason 1994), and the same can be true of whole litters without their mothers. Thus aggression is a potential problem within these groups, and weeks 8–12 are highlighted by some as the period most likely to be accompanied by fighting, especially in large families’ cages. Fighting may be particularly intense between same-sex littermates. Thus kits between weaning and being split into pairs a month or so later need careful monitoring and management. Food must be *ad libitum*; and litters must be split down prematurely whenever aggression seems a problem.

9.2.5. Between final splitting of litter (2-3 months.) and pelting age (6 months)

General issues

The post weaning kit mortality rate was 2.1% in one study, and 5% in another study. Mink kits are particularly susceptible to gastro-intestinal disorders in the months immediately following weaning; for example, field studies revealed that in 17% of farms, gastro-intestinal disorders were present in over 10% of weaned kits. Kits are, as a rule, vaccinated against virus enteritis. However, the prevalence of gastro-intestinal disorders differs significantly between farms, suggesting that husbandry issues are crucial here. Six-seven month old kits were also examined post-mortem and autopsied by Møller (2000). He found no paw injuries (despite kits' active life on wire mesh floors), and no bladder or kidney stones. On some farms, a low degree of 'fatty liver' was found. Dental tartar was generally mild, although it could be very prevalent, incidence varying across farms from negligible to c. 50% of kits. Gastric ulceration was not reported. The group of de Jonge also found no ulcers in over 260 pelted kits. Mason (1992), however, found eight cases of gastric ulceration in 65 pelted kits, i.e. a prevalence of 12.3%. Thus this, too, seems to vary across farms, for reasons as yet unknown.

High summer temperatures, over 30^{o} C, may cause juveniles problems, via heat exhaustion. For example, heat stress caused the death of 12 000 Polish mink kits over just a few hours, on one hot July afternoon (Kleyn van Willigen 2000). The provision of alternative water supplies is a possible, but unexplored, solution; suggestions of spraying or misting the animals with water, painting shed roofs white, creating shade so that mink cannot lie in the sun, and replacing cheap polyethylene sidewalls with wire mesh ones have also been made. However, the effectiveness of such measures is unknown.

During this period, kits grow to their adult sizes. Final body weights at 6 - 7 months are predicted by weaning weight in male kits, but not so in females, as if other factors intervene for the latter (Mason 1992). Kit growth rates are also affected by their levels of stereotypy during this period (e.g. Mason 1992), and their feeding levels (Tauson 1992). This could be one of the reasons why kits matched for litter grow at different rates when placed on different farms, although this, and other possibly important factor such as the behaviour and attitudes of the stockmen (cf. e.g. Hemsworth and Coleman, 1998) have not been investigated for mink. Feeding levels at this time also have slight but significant effects on the stereotypy levels they later display in adulthood (de Jonge and Leipoldt 1994a), though the norm for growing kits in commercial farms is *ad lib.* feeding.

Juvenile farmed mink are less exploratory compared with adults (e.g. MacLennan and Bailey 1969). Timid responses to novel objects generally decline with age, e.g. being less common in 13 week old than 10 week old animals (Mason 1992), and decreasing from the age of 3 months on (Hansen 1996). Younger kits also show the greatest behavioural response (e.g. hiding in the nest box) to being moved to a new cage (Mason 1992). Female kits are also more timid than males, for example in novel object tests (Hansen et al. 1994, cited by Hansen 1996). Some experimental studies also suggest that kit fear responses are greater to unknown than to familiar humans (Hansen 1996), although in contrast, Møller and Hansen (2000) say that the results of 'stick tests' on kits are not affected by the familiarity of the human tester. Although juvenile fear responses are not great and probably do not represent a major welfare problem, they can be reduced by selective breeding (e.g. Hansen 1996), and by some environmental enrichments (see below).

There have been no studies on whether having to walk on wire mesh floors impairs kits' play or the development of other behaviours. Møller (2000a) reported that 6-month old kits have no discernible foot problems *post mortem.* Also, as will be discussed in more details below, there have been as yet no studies of how motivated kits are to use environmental enrichments, or to be housed in particular types of social group.

Welfare of kits in standard cages

a/ General

Pair-housing – almost always one male and one female - is the most common housing system for juveniles. This has both pros and cons, as discussed below. Before comparing the normal pair-housing system with variants on this theme, we will first briefly describe how abnormal behaviour first emerges in pair-housed kits.

During this phase of development, stereotypies and fur-chewing first appear. Tail-biting increases from weaning onwards, rising more rapidly from the winter moult in October. Its prevalence differs greatly across farms, e.g. as few as 10% of kits or more than 50% (Møller 2000), may have bitten tails by pelting time. The basis of such difference between farms appears largely unknown. The first stereotypy-like behaviour is manifest as transient paces or head-twirls, starting at about 4 months of age, and incorporated in the general running about the cage (e.g. Mason 1992, 1993; de Jonge et al. 1986). These movements become sequenced into stereotypic patterns by 6-7 months (Mason 1993), although they remain very flexible, cage-mates being capable of highly responsive movement-synchronization (Mason 1993). De Jonge et al. (1986) suggest that stereotypies either develop at this stage, or never appear at all, and in one study at least, each minks' particular stereotypy was indeed very stable beyond six months of age (Mason 1993). Female kits develop higher levels than male (e.g. Jeppesen and Falkenberg 1990a,b, Mason 1992, 1993), for reasons as yet unknown. Possible reasons include the differential impact of standard weaning ages (in the wild, female would often leave their mother later than would males; see above), and frustration stemming from food-competition with their male cage mate. This last hypothesis is discussed in more detail below. Stereotypy levels are, however, generally low at this time, e g. de Jonge (1992); for example, Pastel kits spent roughly 5% of the observation time in the behaviour, peaking in the early morning (4 – 9am), and 1 – 2 hours post-feeding. These low levels of stereotypy are probably because growing kits are fed more or less *ad lib.,* at least until September; it may also be low because of the social nature of the housing (see below for more details).

b/ Social aspects of housing kits in standard cages

Possible social welfare issues during this time include aggression and competition between kits, in which females are particularly likely to come off badly (MacLennan and Bailey 1969, Mason 1992). Thus females have higher eosinophil levels than males, but not if they are singly housed (Jeppesen and Heller 1986), and pair-housed females are more likely than either pair-housed males or solitary females to have bite marks at pelting (Møller 2000; see also auction house reports, e.g. records of the Research Center for Mink of the Dutch Research Institute for Animal Husbandry).

Several factors might cause or exacerbate these negative interactions. The first is competition between the young male and female for food. This is especially evident early in the growth period, when females tend not to eat fully until males have finished. Thus if the food is deprived for 24 hours, female kits become more food-motivated than male kits (MacLennan and Bailey 1969), as if they have lower energy reserves. Furthermore, in female kits, but not males, poor growth in this period is a predictor of later stereotypy levels, suggesting that the causal factors of overall growth rates differ between the sexes (Mason 1992). Such competition is anecdotally more aggressive if food is limited.

The second social problem is male motivations to fur-chew. Females are particularly likely to be fur-chewed (see e.g. Jeppesen and Falkenberg 1990a,b, Møller 1991b), and fur-chewed mink have lower eosinophil levels than other animals. The third social potential problem (and probably a related one) is sexual play between pair-housed kits, which increases dramatically from September onwards, and in which females' neck fur is bitten. Whether this is a real problem, or actually a sign of good welfare, is unknown, but the fact that neck bites can correlate with body and tail bites (Møller 2000a) suggests the former. Fourth and finally, some aggression may result from the maturing kits' motivations to disperse. Aggressive behaviour towards novel objects (e.g. in 'stick tests') emerges and increases in pair-housed kits at 5 - 6 months (Hansen 1996), as does territorial behaviour such as marking the cage. Social aggression may thus be a particular problem in this last month or two of pair-housing.

Additional issues possibly arise from being housed with an unfamiliar non-sibling, as it can happen at weaning. For example, sibling pairs tend to resemble each other in the form of their stereotypies (although not resembling their parents), while non-sibling cage-mates do not (Mason 1992), suggesting that greater behavioural synchronisation occurs between related cage-mates.

Several studies have compared pair-housing with other social groupings in the standard farm cage. Most indicate that pair housing kits is better (or at very least, no worse), than housing kits singly (e.g. Møller 1991b). For example, there were no significant difference in bite-marks or tail-biting between single-housed versus pair-housed juveniles, nor in adrenal weights, nor heterophil:lymphocyte ratios. Eosinophil levels also do not differ between isolated kits and those weaned with sibs. Being pair-housed also has no apparent effects on sex differences in timidity: females are more timid irrespective of whether they housed singly or with males. In terms of body weight, single-housed kits may be smaller, larger or no different from pair-housed kits. The reasons for such contradictions between papers have not been investigated, but they are likely to be due to interactive effects of ambient temperatures, feeding levels, or activity levels.

However, several studies indicate that pair-housing is preferable. For a start, kits weaned into single-housing show far more ‘croaking’ in the first few days than do kits weaned with companions (Houbak and Jeppesen 1987). In the longer term, pair-housed mink have better pelt quality than single-housed mink. Eosinophil levels were found to be lower in pair-housed animals than single-housed, and these animals also had a non-significant trend towards lower adrenal weights. Møller (1991b) observed that pair-housed kits eat more than single-housed animals. Normal, pair-housed kits also show much less fear of humans than single-housed, early-weaned kits, though obviously weaning age and social housing conditions are confounded in this experiment. They also show significantly lower levels of stereotypy. Relatedly, kits may start nibbling and sucking of their own tails and limbs when housed singly (Houbak and Jeppesen 1987); and kits isolated at 6 weeks develop more tail-biting, and also back-biting, than group-housed sibs, after the autumn moult. Single-housed females also tend to be harder to mate, later in life. The benefits of social housing are also suggested by the kits’ social behaviour. Pair-housed kits tend to sleep and rest together, and also to perform social grooming. They also play together about 7% of the day (Mason 1992). All cage-mates' activities tend to correlate to a very high degree, as if they do much of it together.

Putting three (or even four) animals into a typical farm cage of 2,850 cm^2 instead of 2 as recommended by the Council of Europe is common practice on some farms, especially in the Netherlands. Although de Jonge (1999) reports that it results in pelts that realised slightly better prices, especially for males, most studies support Møller (1991b)’s proposal that ‘more than two kits together [is] more often likely to cause trouble’. Indeed de Jonge et al. (1986) reviewed several studies to show that male-female pairs never fared worse, and sometimes fared better, than other groupings, with groups generally having more pelt-damage than pairs. Housing three males per cage also caused reduced growth rates, compared with pairs or singletons, in one US study. Housing a male with two females in a standard cage also lead to higher levels of bite marks, especially to the female (Møller 2000a), while housing two males and a female together led to the greatest pelt damage, a male-female pair, the least, of all two/three-kit combinations tested in another survey (Jorgensen 1985). The relatively high levels of bite-marks on Dutch pelts anecdotally reported by Canadian fur breeders may therefore be related to the frequency of this practice in the Netherlands. Housing three kits per cage also increases their likelihood of developing stereotypy over pair-housed kits. Group-housing in enlarged, modified cages is discussed more below.

c/ Physical aspects of housing kits in standard cages

Experimentally increasing the available space for pair-housed kits without any cage enrichment has rather small effects on welfare indicators in mink. Relatively small variations in cage size do not affect the weight gain of single-housed kits, unless the cages are extremely small (15 cm W x 15 cm H x 45 cm L). It also has no effect on corticosteroid levels. Similarly, no differences in cortisol levels nor eosinophil levels were found between Pastel pairs experimentally housed in small (0.10 m^2, standard (0.27 $m^{2)}$ or large (1.05 $m^{2)}$ cages. Similar small, standard and large cages in another study also caused no difference in growth, even though kits in small cages ate significantly less (Hansen et al. 1994). This result may be because stereotypy was, paradoxically, highest in the large cages. Perhaps relatedly, adrenal weights were found to be higher, and eosinophils lower, in large cages. However, the effect of cage size may well depend on what sizes are being compared, and whether the smaller options actually decrease activity.

The following studies have investigated the resources available in young minks' environments. Pairs of Pastel kits given nest-boxes (as is standard on farms), plus a raised shelf and/or wire cylinder, displayed less stereotypy than pairs of kits without these additions (Hansen et al. 1994). In the former group, the nest-box was used 61% of the time, the shelf was used for about 15% of active behaviour, and the shelf was used more than the cylinder. The lack of a nest box also increases kits' plasma cortisol, increases HPA responsiveness to ACTH challenge, and decreases eosinophil number, and reduces pelt quality. Kits have been observed to play with straw, a possible enrichment provided in Scandinavia though not always in the Netherlands. Kits given a bath of water will perform 'boisterous social play' in it, and also retrieve objects from it without reinforcement. Kits given a tray of water also used it, and showed anticipatory increases in activity, like those seen before feeding, when the water was renewed; however, the resource had no effect on stereotypy or eosinophil levels, and indeed caused the kits to grow more slowly. Even a larger bath will not decrease stereotypy or tail-biting levels compared with control kits, although removing this resource after 6-7 months of age does has deleterious effects on these behaviours. Finally, Jeppesen and Falkenberg (1990a,b) experimentally studied the use of play-balls supplied at the age of 6 months. At this late stage, these objects had no overall effect on pelt-biting, cortisol levels, or eosinophil levels. They increased activity levels, and in females, also increased stereotypy. However, the kits interacted with these balls for the full four weeks of the study (though use did decline over the period), and the balls caused a decrease in time in the nest-box, and an increase in curiosity, manifest as looking at human observers. Thus enrichments and toys seem to have potential to improve the welfare of juveniles, obviously more so than minor cage size changes. However, it is clear that many potential enrichments (e.g. ones involving food or water; see e.g. AWC 1999, Mason et al. 2001) have not been tried, and that there is still a great need for preference studies and other investigations of the relative merits of different enrichments.

Welfare of family-housed kits in modified cages

An alternative housing system (the family system) involves leaving mink in complete family groups instead of weaning them into pairs, and housing them in several inter-connected cages so that their stocking density remains approximately the same as for pair-housed animals. This now occurs for some 20% of Dutch mink kits. The welfare pros and cons of this system are described below.

The potential benefits of this system are numerous. This system does not involve weaning, and so removes weaning stress; the kits receive much social stimulation from a choice of companions. Each animal has more space to move around in and all kits do seem to use all the compartments, when housed in such a system (de Jonge, unpublished data). They have a slightly more complex environment i.e. involving small connecting openings that need to be climbed through. Finally, the animals have a choice of several nest-sites to use, just as they would in the wild. Such potential benefits may account for the following.

Levels of play in this system can be higher in this system than in standard cages. However, such a difference is not always found. Investigative behaviour, locomotion and play-fighting are also more variable in the family-housing system, as is sleeping in that it now occurs in several different nest boxes. Social grooming levels can also be higher in groups, as can levels of self-grooming. Furthermore, like paired kits, group-housed siblings tend to lie and sleep together, even though in this system they have a choice of several nest-boxes and so could easily rest separately. Indeed, given a choice between a standard nest-box and small ones that will each fit just a single mink, they will choose the former so that they can sleep in groups – though groups of unrelated kits huddle together less than do littermates. This 'huddling' behaviour differs greatly between families, but the basis and possible welfare significance of such differences are as yet unknown.

Family-housed kits can also show reduced tail-biting, e.g. 2.6% family-housed kits compared with 15% controls. Other studies found no differences in stereotypy, partly as stereotypy levels were low at this time whatever the housing system used. However, group-housing kits (without their mother) does reduce stereotypy, and also protects kits from the enhancing effects that early weaning would otherwise have on the later development of the behaviour. Family-housed kits are also less fearful of humans than pair-housed. Mononen et al. (2000) also found that family-housed males had relatively smaller adrenals (corrected for body weight). Group-housed kits (i.e. without the mother) have lower mortality than ten-week weaned pairs in standard cages. Surprisingly, given that females are less competitive than males (see above), family- and pair-housed females' bodyweights did not differ in the studies of de Jonge and Mononen et al. (2000); and indeed both found that family-housed females produced longer skins (though this conclusion was not replicated by others). De Jonge and van Iwaarden (1995) also found that family-housed kits of both sexes had better pelt quality at auction (though again, this was not replicated by other authors including Mononen et al. 2000). Overall, such findings suggest that family-housing could potentially improve welfare over at least some forms of pair-housing.

However, not all studies find such positive bodyweight and pelt effects, and indeed many find signs of aggression and fighting. Negative effects on the mother will be dealt with later; evidence of inter-kit aggression, and other possible welfare problems with family-housing, is reviewed below.

Possible problems commence when the kits are young. Family-housing can potentially lead to hygiene problems when the kits are young, as when given a choice of many nest boxes, they may defecate in some (de Jonge 1996). Family-housed females have been observed moving their young kits between the cages (de Jonge 1996), and if left in the cage before they are able to crawl back to the nest box themselves, some of these kits may die. Furthermore, there was also a trend for fewer kits per litter to survive until eight weeks in these systems. De Jonge (1996) found no differences in mortality between pair- and family-housed kits, but de Jonge (unpublished data) later reported slightly higher mortality in the latter system, being 1% compared with the 0.5% of pair-housed animals. However, others reports that 9.5% of family-housed kits in stacked cages died or were separated from the group due to injuries sustained through fighting, compared with no pair-housed kits (though it should be noted that this is a remarkable high figure compared with the Dutch studies and also the 1% mortality reported by Mononen, 2000).

Even where fighting does not have such disastrous consequences, it can lead to health, productivity and welfare problems. Many workers have observed higher levels of aggression in family-housing. Some observe this to peak when the kits are 8–12 weeks of age; others observe it in September, along with stereotypies and marking behaviour as if it is related to increased territorial motivations. Such territorial motivations can make intra-sex aggression particularly intense. Thus bite marks and scars on pelts are generally higher in family-systems than in family-housing (de Jonge 1996, 1999, 2000; Mononen et al. 2000). For example, early data from Holland found an incidence of bitten pelts of c. 18%, causing de Jonge (1996) to express some concerns about this system. Even recent data from the Dutch national farm show that c. 2.5% family-housed females have bite-marks, compared with only 0.5% paired females.

Furthermore, family-housed males weighed typically 50–100 g less than pair-housed males in the studies of de Jonge (de Jonge and Stufken 1997, de Jonge 1999, 2000). Other authors including Mononen et al. (2000) also found that family-housed male kits grew less. Unlike pair-housed females, family-housed females had higher plasma cortisol levels than single-housed females. Such levels are known to be highest in kits of low social rank. Thus several studies indicate increased aggression and food competition in family- or group-housed kits, although not all do. Possible reasons for the contradictions between studies may include differences in mink temperaments, stocking densities, the numbers of nest-boxes provided, feeding levels, and the control groups used for comparison (e.g. the weaning age of the standard-housed kits). Such reasons also suggest some possible solutions to the problems associated with family-housing.

A first potential solution is to reduce stocking density. De Jonge (1996) found that stocking density was the best predictor of bite mark frequency. De Jonge (1996) housed families in three inter-connected cages, regardless of litter size, in one year, and the subsequent year, housed them in modified cages according to litter size, such that stocking density was two or three kits per cage. In the first year, the number of low grade pelts paradoxically decreased with group size (and thus stocking density) but in the second year, families with a stocking density of three kits per cage yielded 21.3% damaged pelts, compared with 14.4% of kits housed at two kits/cage. One technique of reducing all group sizes is to house kits with their littermates, but to remove the mother. The welfare pros and cons of such an approach have not yet been investigated.

A second possible solution is to select animals that thrive in groups. On the Research Centre for Mink of the Dutch Research Institute for Animal Husbandry, new breeders from 1994 onwards are chosen only from groups with no wounds or pelt-bites; as a result the proportion of family-housed females with wounds or scars has steadily declined from 18.2% in 1993, to just 2.1–2.5% in 1999-2000. Their pelt quality has also steadily increased, and is now the same as their pair-housed neighbours (auction records for 2000, compiled by G. de Jonge). Indeed, by 1999, these family-housed animals had become bigger, with fewer pelt defects than those pair-housed kits from other European countries (de Jonge, unpublished data) and far better than their pair-housed predecessors from 1985. Furthermore, only 0.5 to 1% of the groups have to be separated because of fighting.

A third possible solution is to monitor groups closely, and remove aggressive animals (though how to house them raises problems of its own).

A fourth possible solution is to consider environmental resources such as the level of feeding and how the food is placed (multiple cages allow multiple feeding sites), the number of nest-boxes (as will be discussed in more detail in section 9.2.5.4. below on ‘stack housing’), and the provision of shelves and wire cylinders which might allow kits to escape or remove themselves from each other. Cages with cylinders or platforms are certainly visited more often by family-housed kits than those without (de Jonge 1999), and the more so, the more enrichments there are in that compartment. However, these enrichments’ overall effects on welfare have not been investigated.

The relative advantages of family-housing are not always clear. On the one hand, tail-biting, play, female growth rates, and adrenal weight suggest that family-housing is beneficial; on the other hand, male growth rates, and all round levels of aggression and biting, suggest that it can be detrimental. Experimentally investigating young minks’ social preferences might be one way of resolving this paradox. Additionally, welfare assessments of family-housed mink also need to consider the *variance* in welfare measures, as well as their mean values, as the differences between the welfare of subordinate and dominant animals could well be increased by group-housing (although de Jonge – unpublished data – reports that where severe bites occur, it is rare to find them on just one kits in a group). It would also be revealing to see if family-housing reduces kits’ motivation to have physical playthings and other enrichments; if social stimulation seems a substitute for physical enrichments, then the welfare of group-housed animals in barren cages is probably improved over pair-housed animals. If family-housing passes these tests, then the factors that affect aggression need to be investigated, so that fighting can be reliably prevented, and/or pair-housing, in which social problems are fewer, needs to be improved (e.g. with environmental enrichments).

Stack housing

In some systems, at least in the Netherlands, cages may be stacked in two tiers, the top and lower cages being inter-connected to form a stacked cage. Such stacks may consist of two cages, or four (two lower cages and two upper), depending on the group size to be housed. Mink seem to use both upper and lower cages fully, though for rather different behaviours. Most stereotypy are performed in the lower cage and most normal behaviour (resting, grooming etc) in the upper one (de Jonge 2000). The upper cage may be shorter in height than standard cages, e.g. 30cm vs. 45cm, but growing kits appear to prefer the lower cages (de Jonge 2000). Stacked cages seem to cause no more stereotypy and tail-biting (de Jonge 2000). However, others found a significant higher occurrence of tail biting in groups of 5 littermates in stacked cages (50%, 46% severe, 4% minor) compared to pairs in standard cages (29%; 12% severe, 17% severe). Mink in connected cages showed an intermediate value with 42% of the animals having damages to the tail (22% severe). In addition, 9.5% of stack-housed groups of kits received severe injuries, some fatal, compared with 4% of row-housed families of kits and none in the pair-housed kits.

Other than that, the effects of stack-housing on welfare have been little investigated, but they are potentially more problematic than row-housing groups of kits, as they have only one feeding site for 5 animals and one nest box for 5 animals, i.e., half the number of feeding sites and nest-boxes. This may be the reason why stack-housed groups of kits use nest-boxes less than standard pair-housed kits, and therefore why stack-housed groups of kits use a platform more than standard pair-housed kits. These issues are still being investigated. De Buisonjee et al. (2001) showed that four mink housed in two stacked cages with only one nest box developed more pelt bites and wounds than did mink in pairs. Mink actually stayed longer in the lower than in the upper pen, probably because this is where the nest box is, together with food and water. Due to the high number of damaged pelts, the stack-housing system is not recommended in the Netherlands. Its future depends on further work aiming at improving it, e.g., by varying the number or nest-boxes and adding enrichment.

The welfare of kits housed alone with their mothers

In traditional systems, when the litter is weaned, one male kit is often left with his mother until pelting. On the Research Centre for Mink of the Dutch Research Institute for Animal Husbandry, males left with their mothers until six months develop less tail-biting than those pair-housed at seven weeks (de Jonge 1988, 1989, 1991), e.g. de Jonge (1991a,b) reports 11.5% males with their mothers as having a bare tail-tip, compared with 23.3% males housed with a sister. However, no other data relevant to welfare assessment have been recorded. In practice, therefore, we simply do not know whether there is any difference between the welfare of male kits left with their mothers and that of those housed with their sisters. However, the effect this practice might have on the mothers is discussed below.

9.2.6. The single-housing of adults, Nov. - May

Most young adults are pelted at c. 30 weeks, creating sufficient space on the farm for each surviving animal to be given its own cage. Adults are therefore housed on their own after pelting time. As with weaning, this involves catching and moving procedures which are acutely stressful. Catching and putting adult mink in traps leads to an acute cortisol response, as well as an acute stress-induced hyperthermia (Korhonen et al. 2000). Studies on gastric ulceration in adult mink showed that immobilising adult mink for one hour often had just minimal effects. However, in one group, they also found that just one immobilisation of five hours caused five out of ten mink to develop gastric ulcers, and in another, that immobilisation in a crush for one-hour post-feeding led to an approximate tripling of ulcer-frequency.
In this section, we deal with the factors affecting adult morbidity and mortality, the factors affecting their stereotypy levels and other possible welfare indicators, the practice of restrictive feeding, and finally, we discuss potential enrichments that might be added to adult minks' cages.

Adult mortality and morbidity

Adult mink mortality rates are on average 2 - 5 % per year (e.g. Jörgensen 1985, NFE reports 1985 - 2000). Factors affecting mortality rate include strain, feeding regime, and very hot or very cold periods of weather. Some strain differences in mortality are quite marked. For example, Albinos have lower 'vitality' than Wildtype mink (Nes et al. 1988), as do Sapphires; while Standards have 37% mortality between birth and five years of age, that of Sapphires is 80%. Note that genotype affects other aspects of functioning, as well as morbidity/mortality (e.g. the eyes of Green-eyed Pastels – which are no longer farmed – were excessively sensitive to light, while Hedlund White are deaf [Nes et al. 1988]).

Of the husbandry factors affecting mortality, the over-winter feeding regime is particularly important (discussed in more details below), as are other nutritional issues (Dietz et al. 2000), the supply of water and electrolytes to nursing females (discussed in more detail in 'The nursing period'), and proper veterinary care of the animals (e.g. inoculation etc).

Several diseases affect adults throughout the year. Plasmacytosis or Aleutian disease (AD) is by far the most problematic, and mink of the Aleutian type (and their crosses) are particularly vulnerable to that disease (e.g. Nes et al. 1988), while Demis and Pastels are most resistant, followed by Browns and then Darks. Animals suffering from the disease succumb very slowly. Clinical victims become thin, lose coat condition, and usually die, although most infected animals show no clinical signs of illness before being killed. AD easily spreads over the farm, and is impossible to combat with vaccination. The only reliable method of controlling this invariably fatal disease is therefore to test for the presence of serum antibodies, and then isolate or euthanase infected animals; farmers with too many infected animals even may kill the whole herd, and buy new mink from farms free of the disease. In Denmark and the Netherlands, farmers are therefore encouraged to screen their animals annually. In the Netherlands, about 16.5% of farms are deemed AD-free (A.D. Commissie, 2000) as are about 30% farms in Finland (Suomen Turkiseläinten Kasvattajain Liitory 2000). However, in the Netherlands at least, annual screening is not compulsory, and about half of all farmers do not even attempt to gain an AD-free status. In Denmark, in contrast, screening for AD and culling infected animals are compulsory and now only 10% farms have the disease (compared with 65% in 1986).

Pseudomonas, virus enteritis, distemper and botulism are also dangerous diseases for mink, but effective vaccines are available against them. The veterinary services in the Netherlands, Norway, Denmark, Finland and many countries outside Europe therefore advise vaccination. In the Netherlands, Denmark and Finland, insurance companies will not provide cover if animals are not properly vaccinated against botulism (e.g. Kleyn van Willigen, 2000), or if raw offal is used in the food (a practice that has therefore ceased in e.g. Denmark). Note that vaccination must always be carried out humanely, i.e. the mink properly caught and restrained, and needles changed frequently. Streptococcal and staphylococcal infections can also cause nasal and bronchial infections, plus infections of the uterus, mastitis, and sub mucosal inflammations etc. (Smeds, pers. comm.). Staphylococcal infections are more frequent in mutations with Chediak-Higashi-like syndrome (i.e. Aleutians and their crosses) than in Darks and Pastels. Some suggest good hygiene measures will usually prevent these diseases (e.g. Jorgensen 1985), but other aspects of management may be more important. It will be interesting to see if ever-increasing farm sizes, and automatic slurry systems where faeces are not readily inspected, will increase mink mortality.

Post-mortem studies of mink are rare, and the results vary greatly between studies. For example, in two groups of adult females killed for pelting, Mason (1992) found gastric lesions in respectively 3/34, i.e. 8.8%, and 6/29, i.e. 20.7%, animals. On another site, gastric ulceration was observed to affect 2/35 subjects, i.e. c. 6% of animals autopsied - a proportion that increased to 14% when more animals were studied, though this level was still no different from that apparent in wild-caught animals. However, in yet another population, post-mortems of about 240 adult females found no such ulceration rate. The same was true in a recent comprehensive survey of over 3000 Danish mink (Moller 2000). Thus as with kits, there are clearly enormous population and site differences in this measure, and for reasons which are as yet unknown. Very high levels of tooth decay (present in c. 80% of the subjects), kidney abnormalities (present in over 25% Sapphires studied) and other conditions were also observed. Whether tooth decay is a consequence of the soft food that is eaten by mink or associated with AD disease remains to be asserted.

Behavioural and physiological welfare indicators in adult mink

Correcting for body weight, the adrenal glands of farmed and wild adult mink do not differ in size. However, this observation has not been replicated to assess the extent to which different farms vary. Furthermore, the effect of single-housing on changes in such physiological stress indicators does not seem to have been investigated, and not have other stress indices been compared across wild and farmed animals.

Fearfulness of humans is low in adult mink. For example, in a stick test, c. 60% of breeding females in August were characterised as exploratory, only 15% as fearful (Moller 2000). Exploration is also increased over previous juvenile levels (e.g. MacLennan and Bailey 1969). Thus although some adults respond to humans by retreating, most are curious and exploratory. As discussed in Section 9.1, this can be enhanced by selection (although whether such enhanced explorativeness increases the need for environmental enrichments – which could be counterproductive for welfare - has not been investigated). Timidity can also be altered by the handling regime of the farm. For example, repeated weighing seems to cause greater timidity.

Levels of tail-biting increase in single-housed adults especially over the winter. In one study, only adults had tails that were completely bald (Mason 1994) suggesting that severity as well as prevalence increases with age. In one Danish study, its prevalence rose to as high as 80%, though it fell from June-July onwards after the moult. Other assessments of winter tail-biting show that as with kits, its prevalence in adults varies greatly between farms (e.g. between 19% and 66%) and between years (e.g. from 10% to 22% at the Research Center for Mink of the Dutch Research Institute for Animal Husbandry; de Jonge et al. 1986). It also seems to vary greatly between countries (e.g. AWC 1999), being almost never seen in Norway, for example. Unlike stereotypy, it does not seem to be reliably affected by feeding levels (e.g. de Jonge 1991a,b).

Stereotypy levels also increase once mink are single-housed (Mason 1993, Jeppesen et al. 2000). They seem to develop fully by 10 months of age. For example, in one study, adult stereotypy frequencies were double those of kits (Mason 1993). However, the degree to which adults stereotype varies greatly from study to study. Some animals perform no stereotypies, other perform them for over four-five hours a day (de Jonge et al. 1986; Mason 1993). Thus during the seven hours before feeding, mink in some populations spend on average 49% of their time in the behaviour (Mason 1992, 1993), while pre-feeding stereotypy levels of between 4% and 32% on five different Dutch farms. The prevalence of adult females with the behaviour also varies, averaging 98.3% on one site studied (Mason 1993), 61.6% on another (de Jonge et al. 1986; Mason 1993), but under 10% on yet another (although these apparent differences are probably exaggerated by differences in data collection methods). A range of 31–85% has also been reported for farms within the Netherlands (AWC 1999), even using standardised methods of data collection. As in kits, adult females show consistently higher levels of stereotypy than males - between a third and three times as much, depending on the population (e.g. de Jonge 1992; Mason 1993).

There are three reasons for this variation between sites. Strains differ in adult stereotypy levels, e.g. Pastels are more stereotypic than Pearls. Furthermore, there are genetic differences in stereotypy within breeds, both within and between farms, (Jeppesen et al. 1990a,b; de Jonge 1992; de Jonge and Leipoldt 1994a,b). Selection over just a few generations can therefore reduce stereotypy dramatically (e.g. de Jonge and Leipoldt 1994a, AWC 1999). The effects this may or may not have on welfare were discussed in 9.1.

The second reason is that farms differ in how they will have treated the kits. Weaning age, and whether or not early-weaning is followed by group-housing, all affect stereotypy in adulthood, at least to 9 months of age, as does whether the animals were previously housed singly, in pairs, or in triplets. Feeding levels when juvenile can also have long term effects on adult stereotypy (e.g. de Jonge 1992, de Jonge and Leipoldt 1994a).

Finally, current feed levels play a key role in stereotypy. The single-housing of adults does not cause increased stereotypy if the mink are fed *ad lib.* (e.g. de Jonge and Leipoldt 1994). Furthermore, the greater the degree of food-restriction, the greater this increase in stereotypy tends to be; thus Bildsøe et al. (1991) found that a 30% reduction in food doubled general activity and tripled stereotypy levels, while de Jonge and Leipoldt (1994b) found that restricted-fed females developed two to two and a half times as much stereotypy as *ad lib.* fed animals, the effect being greatest in active selection lines. Feeding levels also affect the proportion of animals that stereotype, the prevalence of the behaviour. Note that the impact of *ad lib.* feeding may be somewhat exaggerated by studies that do not collect data 24h/day, as Hansen et al. (1994) showed that *ad lib.* feeding shifts the peak of stereotypy from immediately pre-feeding to the period 4-9am, which is not observed in most studies. However, there is no doubt that increasing feed levels does decrease both pre- and post-feeding levels of that behaviour. Thus the common over-winter peak in stereotypy seen on farms is primarily a result of restrictive feeding, a practice aimed at slimming down the animals (e.g. de Jonge et al, 1999) stereotypy occurrence then falls as animals are ‘flushed’ just prior to mating. The welfare significance of this practice is discussed in more detail below.

Restrictive feeding

It is traditional practice to feed the females over the winter so as they loose weight, and to some extent that is the case for the males. How this is effected, and the extent of weight loss achieved, varies greatly from farm to farm. For example some farmers reduce the amount of food fed from November, others later, using more severe restrictions from January onwards or even just restrictive feeding for one or two weeks in February. Some farms also use weekly starve days, on which the animals are not fed at all (e.g. Mason 1992, 1993).

Whatever the way restrictive feeding is conducted, the aim is always the same - to produce females that yield the maximum number of healthy kits. Food restriction has three potentially beneficial effects on reproduction. First, it prevents breeding animals from being too fat (having been fattened up in the pelting season), a trait known to reduce willingness to mate, ease of parturition (de Jonge and Wassink 2000b), and also potentially reproductive longevity. Second, over-winter slimming increases the impact of flushing, as fat animals are relatively little affected by this practice (Tauson 1992). Third, the final phase of food restriction in February is the basis for flushing, by encouraging the animals to greatly increase their food intake when it is provided *ad lib.* just before mating. Flushing is a highly effective means of increasing reproductive output, increasing the number of growing follicles and ova released, and enhancing their development (Tauson 1992). The problem is that feed restriction is implemented over winter at a time at which the commercial feed kitchens are also reducing the food's calorific content.

Excessive slimming can lead to poorer production. Very severe food restriction, leading to losses of 30% or more of body weight, increases the risk of animals dying during periods where food or drinking water freezes over (Møller and Hansen 2000). Up to 3% of females may die when the temperature drops quickly. Females that weigh 700 g or under are very vulnerable (de Jonge, unpublished observations). As stereotypic animals lose the most weight over-winter (e.g. de Jonge and Wassink 2000a,b), they are particularly vulnerable to over-winter mortality (de Jonge and Leipoldt 1994b). Homozygous Aleutians are claimed not be underfed, as if there are colour type-related differences in vulnerability, too. Severe food restriction also increases the incidence in barrenness in Scanblack mink, though not Browns (Møller 2000b). Weight losses of over 300 g over-winter also cause decreased litter sizes (Tauson 1992). Finally, severe food restriction increases females' chance of having 'greasy kits' (Olesen and Clausen 1990); for example, it can double the incidence of this disease (Møller and Hansen 2000, Moller 2000). If males as well as females are restrictively fed, then this too can be counterproductive if too severe: the excessive slimming of males leads to low fertility (e.g. Tason 1992).

As well as being counterproductive for productivity, severe food restriction results in poorer welfare, even in those animals which do not become ill or die. Restrictive feeding can cause very considerable weight-loss (e.g. de Jonge 1995), especially in yearlings, and some can lose as much as 35% of their body weight. This is in part because even *ad lib.* fed mink tend to lose weight over the winter, this varying greatly from 0% to 29% bodyweight with an average at 10%. Hunger is thus likely to be severe in these animals, as their feeding motivations increase when environmental temperatures fall (MacLennan and Bailey 1969), in line with their increasing metabolic rates. The role of hunger in stereotypy was discussed in section 9.1, as well as section 9.2.6.2. above; sharp falls in temperature and restrictive feeding are also both known to cause an adrenocortical response, while feeding mink to satiety, in contrast, increases serotonin metabolism in the amygdala and hypothalamus, a change highly likely to be associated with pleasurable feelings. Restrictive feeding also makes animals more aggressive in stick tests (de Jonge, unpublished observations). Furthermore, if females are fed less than neighboring males, frustration may arguably add to their problems; 5/10 mink not fed for 24 h while their neighbours were, developed gastric ulceration, although a replicate study using larger sample sizes did not find such a result. Thus restrictive feeding is very likely to cause poor welfare.

How then should animals' weights be managed over the winter? Regimes that reduce the females' body weight by just 10% over the winter, increasing it again a week before the mating season, yield the same litter sizes as harsher regimes that cause weight losses of 25% (Møller 2000b). This can be achieved by giving the animals 20% less food from the second half of February until 5 days prior to mating; restricting their food for the previous two months can be irrelevant (especially if females were not excessively fat the previous autumn). Thus in a survey of Dutch farms, no negative effect of over-winter *ad lib.* feeding on litter sizes was observed. A feeding level of 80% of the energy requirement is recomended solely for this two-three week period in February. Females with over 30% of their body weight as fat in November do, in contrast, benefit from longer-term, over-winter slimming. In line with this, de Jonge and Wassink (2000) also found that body weight had no detrimental effect on litter size, unless females were over 1300 g. Thus successful flushing regimes need not involve any great changes in weight, unless animals are excessively fat.

In general, food restriction is now discouraged in most countries (see 'Farming' chapter). De Jonge and Wassink (2000) on the basis of their Dutch studies recommend *ad lib.* feeding. Møller (1999) recommends that females are slimmed after the pelting season 8, but aiming for weight loss of 15 – 20% (more being allowed from the heavier animals), and never over 25%. He recommends that this occurs in two stages – a weight loss of c. 10% between November and February (which will occur naturally in many animals, even if *ad lib.* fed), followed by a weight loss of 10% over a two-three week period in February just prior to flushing.

Møller also presents careful recommendations as to how best to do these aims in practice. These include: gradually slimming the females from November, rather than suddenly restricting them in February; not slimming males at all; feeding animals more in frosty weather, and doing so in the cage, or pressing the food though the wire mesh, so that it is easier for the animals to reach; feeding or pressing the food down several times a day if temperatures are below –10^{o}C, so that it less likely to freeze before the mink have had sufficient; protecting the animals from cold, with windscreens and/or straw in the cages; under slimming rather than over-slimming animals, as the former is easier is rectify (as well as being better for welfare); and flushing females earlier in cold weather, or if females are underweight. Perhaps most importantly of all, he recommends that farmers regularly weigh their animals, to monitor how their feeding regime is working. This is vital as attempting to modulate minks' bodyweights solely via predetermined food reductions is unlikely to be successful (e.g. Tauson 1992, Møller 2000b): winter weight loss is affected by many other factors, including individual animals' baseline activity levels, and their tendencies to become more active when hungry or cold; the animals' condition in the autumn, and local ambient temperatures, including wind speed, the frequency with which food and water freeze, and the frequency that temperatures fall below –10^{o}C; and also the proportion of yearlings in the population. Individual level monitoring of animals is also vital as very fat females may need an over-winter food restriction to aid weight loss, but other animals will not. Thus farmers need to weigh a sample of their animals at the beginning and end of January, and to adjust feeding levels accordingly, as well as keeping a careful eye out for individuals within their population which are becoming too thin or remaining excessively fat. (Overall, 'heten is weten' – weighing is knowing; however, note that excessive weighing may make animals more fearful, so this practice needs to be done gently and with care, perhaps sampling different animals each time).

Physical aspects of adult housing

Much Danish work has been conducted on the welfare importance of an enclosed nest-box to adult mink. As Hansen summarises, ’all the behavioural and physiological parameters indicated reduced welfare’ in animals denied a nest-box, perhaps unsurprisingly given that adult farmed mink spend 70 - 75% of their time in them. For example, mink not provided with a nest-box have lowered eosinophil levels and raised cortisol. Mink shut out from a nest box perform between two and five times as much scratching at the intervening barrier as they do if shut out from swimming water or an empty compartment. However, such investigations are happily redundant as, nest-boxes are ubiquitous on European farms.

Space needs of adult mink have been much less fully analysed. Single females in Scandinavia may still be kept in cages a mere 20cm wide, although this is being phased out, first in Norway, then Denmark (CFC 2000, Westersjø 2000; see ‘Farming’ chapter). These 0.10 m^2 cages cause more stereotypy than experimental 1.06 m^2 cages. Mink kept in three inter-connected standard mink cages were found to develop more stereotypy, and to be more active, than mink kept in three inter-connected fox cages. If physical restriction causes stress here, such effects may become more important as farmed animals continue to increase in size. However, note that Jonasen (1987, cited by Nimon and Broom 1999) found no such effects of cage size, and de Jonge (1999) also found that females in standard or experimental, double-size, two-level cages did not differ in stereotypy, or in tail-biting.

In terms of potential enrichments, bedding and related substrates can reduce mink stereotypies (Nieuwenhuis and de Jonge 1989); however this effect was more or less absent if straw alone was provided (Nieuwenhuis and de Jonge 1989). Also, the effects of such substrates on other welfare indicators have not been investigated, though some report that a nest box with straw has positive effects on pelt quality (AWC 1999). Farmed mink will voluntarily use a high shelf to rest on if experimentally provided within the cage; however, the effects of this on welfare measures have not been investigated. In laboratory studies, caged mink also spontaneously wheel-run, and even work for this activity.

Adult mink will also swim, given the opportunity, even if not raised with water when young (Cooper and Mason 2000, Mason et al. 2001). They will spend up to 25% of the pre-feeding period at the water’s edge, although relatively little time actually in the water – e.g. 1.2% (de Jonge 1996) or 1.4% (Skovgaard et al. 1997a). Their use of water depends on their motivational state; when wishing to feed, they will use a quicker 'dry' route to food in preference to one that leads through water. Water-bath-use can also increase with ambient temperature. However, when this occurs, it only seems to do so in very large experimental cages, not in standard ones, for reasons as yet unknown.

Mason and colleagues (Cooper and Mason, 2000; Mason et al. 2001) assessed the extent to which various potential enrichments, including swimming-water, act as primary reinforcers. They housed adult farm-raised mink long-term in closed economy set-ups where they could access resources if they pushed weighted doors. In addition to swimming-water, these resources were chewable toys, a platform reached by a 2 m high tunnel, an empty cage, visual access to a conspecific, novel objects (changed daily), and a tunnel. Door-weights ranged from 0g to beyond average body-weight (c. 2000 g). The mink proved highly motivated to perform several 'natural' activities. Behavioural measures of preference also predicted the minks' urinary corticosteroid outputs in response to deprivation. Mink were most motivated to access swimming-water, and when deprived of this for 24 h, showed a urinary cortisol increase as great as if food-deprived for 24 h (Mason et al. 2001); their stereotypy increased too. Some care needs to be taken in extrapolating these results directly to the farm situation, however, as providing several resources simultaneously may reduce the apparent importance of the least preferred resources. Toys, for example, may have been little preferred by the experimental mink simply because they were of little value when compared with swimming; however, they might be valued by mink in a standard barren cage. However, as they stand, these results do suggest that swimming-water would be a highly effective environmental enrichment for mink, and future work may develop more practical water-based enrichments that are as rewarding as a whole bath.

The issue of whether mink suffer without such enrichments is still being investigated. In one study, bathing water increased pelt quality, but decreased pelt size, and swimming-water has also been shown to have negligible effects on stereotypy and tail-biting levels. Bearing in mind the difficulties of assessing long-term stress in mink (see Section 9.1), future work on this topic should probably investigate pyloric gastric ulceration, immunocompetence, and HPA functioning (especially aspects that might underlie habituation, and those related to depression in humans such as responses in dexamethasone suppression tests). It would also be interesting to assess the extent to which the importance of swimming-water depends on climate, and whether providing it on farms in hotter regions would help reduce the heat stress and related mortality that can sometimes occur there.

Social aspects of housing

If unfamiliar animals are put together, severe fighting can occur (e.g. Rice 1967). The effect of experimentally housing adult mink socially has been studied in the 1960's, and more recently by Hansen (1990). Surprisingly, keeping littermates together into adulthood did not result in high levels of fighting (Hansen 1990), although it could lead to greater pelt damage. However, Hansen (1990) found that adult females in groups had higher cortisol levels than single-housed animals, and a greater rate of pre-natal kit loss. This issue is particularly important for non pregnant females, which may be housed three to four per cage over the summer and autumn.

The question of whether adult mink are stressed by the close proximity of neighbours is important, given their naturally solitary lifestyle. However, MacLennan and Bailey (1969) found that visual contact between mink acted to decrease the aggression shown when animals were placed together, while Gilbert and Bailey (1967, 1970 1969b) found that visually isolated females had delayed gonadal and follicular development, and that in extreme cases, such females would not come into oestrous. The visual isolation of males also seems to make them more exploratory (MacLennan and Bailey 1969), as if increasing their motivation for stimulation. Cooper and Mason also found that single-housed adult mink would work for a limited form of social contact (the visual/olfactory inspection of caged neighbours), although it was unknown whether this represented true preference or a form of territorial monitoring. It is also worth noting here that solid cage partitions could also have other negative effects, reducing cage ventilation, and thus increasing the impact of hot days. Overall, these results suggest that adult mink welfare is probably improved rather than reduced by the presence of neighbours. However, the group housing of adults, especially unacquainted barren females, is not advised.

9.2.7. Mating and pregnancy

In the week or so prior to mating, the females are flushed, i.e. fed *ad libitum* food. As well as sating the animals, this has the advantage of making them quiet and easy to handle for mating. Other practices pre-mating can include the artificial exposure to 24 h of light a day; the welfare effects of this are not known. Shadow females are prone to uterine deformities, and often do not become pregnant. The methods that are used for testing for this condition can cause poor welfare.

During the breeding season itself, the close proximity of females may cause males frustration; it certainly causes them to perform raised levels of stereotypy directed towards such females (see 9.1). Indeed in the wild, oestrous females can be used a baits to trap males. However, for the females, stress may be caused by being transported to the males and placed in a strange cage (in the wild, the males would come to the female; Dunstone 1993), by having no mate choice (again, in contrast to the situation in the wild; Dunstone 1993), as well as by being paired with a conspecific from which they cannot escape. This may be why they often perform stereotypies when paired for mating (e.g. Mason 1992, 1993). Mating may be more difficult and less successful if males and females are housed in separate groups away from each other, possibly because olfactory stimuli are important in follicular development.

Females may also have their neck fur chewed at this time, or be fought with. A very small proportion of females may even be injured or killed by males during the mating season, although this is very rare and should never happen on a well-managed farm where mating is supervised. It has been suggested that the nest box be closed off while the mink are paired, if they would be too hard to monitor in there. However, females may sometimes be left for a whole night in a male's cage, unsupervised. Although animals that do not fight within the first hour tend not to do so later, this too is a potential welfare issue. Welfare problems may also arise from the way that rejected females are treated. A female who is reluctant to mate will eventually do so if brought to many males over just a few hours. In the Netherlands, though not in Scandinavia, reluctant females may occasionally be treated with sedatives. Artificial insemination is not used on mink farms, although some suggest it as a likely future development. The welfare pros and cons of such a development are unknown.

Hansen (1990) suggests that being moved immediately after mating can cause the prenatal loss of blastocysts. Stressors such as handling can cause pre-natal loss of foetuses (as discussed 9.1). Papers several decades old suggested that the exposure to neighbours also reduced pregnant females' reproductive performance, increased aggression and weight loss, and possibly increased the number of stillborn kits (Gilbert and Bailey (1967,1969b), in a 'nervous' Dark strain only, decreasing litter size (Gilbert and Bailey 1970). However, Møller (1991) found that visual isolation had no effect on the litter size at two weeks, and that separating females with an empty cage had no effect at all. De Jonge et al. (1986) and Overgaard (2000), reviewing a number of studies, came to similar conclusions.

Farmers may restrict females' food in the second half of gestation, to reduce whelping problems. However, this exacerbates the effects of winter feed restriction, further increasing the probability that the litter will develop 'greasy kit' syndrome. This may be because restrictive feeding in gestation reduces the female's lactational capacity, and the kits' weight gain.

Parturition is generally unproblematic, although as mentioned above, heavy females take longer to give birth.

9.2.8. The nursing period

Females' stereotypy levels, and indeed general activity levels, decrease after the birth of their litters (e.g. Bildsøe et al. 1990b). On mink farms, the average litter size at weaning is about five kits per female, although litter sizes at birth can occasionally reach as high as 15 (Nes et al. 1988).

Even healthy females' body weights fall by c. 15-20% over the lactation period, the amount being affected by litter size (Møller and Hansen 1993), and strain and feeding regime. Female body weights fall most rapidly when the kits are five to six weeks old, just before weaning (Hansen 1997); systems that accelerate the rate at which kits start drinking, e.g. 'drip watering systems' can help reduce this female weight loss, especially when temperatures are high. Although such weight changes are not abnormal for nursing mammals, the costs of suckling can be considerable for farmed mink. Female mortality levels generally rise over the nursing period (e.g. Jörgensen 1985).

One potential cause of high mortality at this time is 'nursing sickness'; this made up around half of all of diseases during the lactation period in one Canadian study (Schneider and Hunter 1993a), and affected 14.4% females in another, with a mortality rate of 7.8%. However, farms differ greatly in its incidence, e.g. in Ontario, it varies from 0.2% to 10.1% of females (Schneider and Hunter 1993a) the variation being associated with the type of water supply, the size of the farm, and the source of the feed (Schneider et al. 1992, cited by Nimon and Broom 1999). Furthermore, levels have been greatly reduced in recent years by a better understanding of minks' dietary requirements. For example, it has not been diagnosed at all over the last 6 – 7 years by the Danish Veterinary Laboratory, and none was reported in a recent cross-farm survey of 9700 Danish breeders (Dietz et al. 2000).

When it does occur, nursing sickness can kill or debilitate lactating females, especially those whose litters grow well, and are larger then average. It is characterised by severe emaciation, dehydration and salt depletion (e.g. Schneider and Hunter 1993b); for example, females typically lose 31% body weight. Females succumb to energy depletion as they convert their own body fat and muscular tissue into milk (Schneider and Hunter 1993b), with ensuing water and electrolyte depletion then making the disease worse, especially when summer temperatures are high, as this decreases food intake, as well as increasing water requirements. Diet has a major effect on nursing sickness. Too little dietary fat or carbohydrate, and too much protein, is a risk factor, but the major issue is salt: extra dietary sodium can reduce nursing sickness by one third, though if dietary salt is provided, water must be *ad libitum* and/or dietary water high. This practice has reduced nursing sickness to such an extent that recent studies of greasy kit syndrome and its relation to female body reserves have simply not investigated whether pre-natal feeding level also affects nursing sickness. However, many farmers also cross foster kits soon after birth, from large litters to smaller ones.

Females may also get mastitis at this time; although its prevalence is unreported, it is presumably more common in strains generally prone to bacterial infections, such as Aleutians (see 9.1). Females may also have their nipples damaged by kits wanting to suckle, although this is rare in standard housing conditions.

The effect of severe prior restrictive feeding on welfare during the reproductive period is unknown. However, pregnant and lactating females need optimum body reserves from which to draw from, as they need lots of energy during this time, and they are also reduce their voluntary food intake when pregnant and lactating. The fact that greasy kit syndrome is most common in females that have been restrictively fed suggests that their lack of energy reserves impairs milk quality, or some other aspect of maternal care. It would be interesting to see whether such females are suffering from stress themselves, as well as having more vulnerable litters.

Separating nursing Black female neighbors with an empty cage led to significantly a reduced incidence of greasy kit syndrome, and reduced overall kit loss so that litter sizes were greater at weaning. The adult females also appeared calmer in their behaviour (Overgaard 2000). Similar results were not reported by Møller (1991b), and it may be that such effects apply only to nervous strains.

However, the effect of cage size, or of environmental enrichments, on females in the nursing period has been little investigated. One exception is a study of wire cylinders and shelves, discussed below. Another exception is the housing of nursing females with access to swimming water. Females housed long term with swimming water show no changes in the pelt quality of their kits (de Jonge 1996), nor in their own reproductive success or stereotypy levels (de Jonge 1996; Skovgaard et al. 1997b) - although note that this time of year is when they use the water-bath least. However, Skovgaard et al. (1997b) found that kit loss pre-weaning was higher in females given swimming water, in one of the two years studied, possibly due to an interaction between the water-bath and maternal experience as this result was only found in females that were primiparous. This may be because nest boxes became wet or dirty. However, none of these studies use any other measures of welfare. If they have several nest boxes to choose between, nursing females may move their litters between them, particularly when disturbed (e.g. de Jonge 1996), but the welfare pros and cons of such behaviour have not been studied. More research is therefore clearly needed on the pros and cons of providing a water-bath - or other types of enrichment - at this stage of the minks’ life cycle.

One factor that perhaps reduces the importance of environmental enrichments is the amount of time females spend with their kits. Given a choice of several nest boxes, they always spend the most time in the one containing their litter (de Jonge 1999). In stacking cages, adult female also spend most of their time in the cage containing the nest box with their litter (de Jonge 2000). The 'chuckling' vocalisations heard on farms at this time also suggest it to be a period of social perhaps pleasurable interaction for females.

Conversely, being separated from their kits during this period therefore causes the females stress; for example, a 30 minute immobilisation, repeated daily, cause a far greater cortisol response and eosinophil fall than the same treatment applied during pregnancy, although note that such separations would rarely if ever occur as part of normal farm routine. The age of kits at weaning can therefore be important for maternal welfare. Most females also show a prolonged stress reaction to having their kits removed at six weeks; they persistently run in and out of the empty nest-box, and females whose kits were weaned at six weeks showed more weight loss than females whose kits were left with her. In addition, mother whose kits were weaned at six weeks showed only a very gradual decline in eosinophil levels, compared with the fall seen within three days when kits were weaned at eight or ten weeks (although the absence of proper control animals make these data rather hard to interpret). Weaning kits at age six-seven weeks (age inferred from weaning date presented in paper) also leads to an acute cortisol response in the mothers (a tripling of plasma levels even 2 hours after weaning), that can be reduced by feeding the animals with a tranquillizer. Weaning kits at eight weeks is also probably not ideal for the mothers (as well as for the kits themselves). Compared with females whose kits are weaned at ten weeks, mothers of kits are weaned at six or eight weeks show stereotypy-like up-and-down and nodding movements, possibly the intention movements of search, and they ‘croak’ far more in the two to three days after weaning. Thus the premature removal of kits, as may happen if mothers are ill (e.g. Thompson 2000), is likely to cause high stress, but so too is any weaning of kits before eight weeks of age.

However, as the kits become bigger and more mobile, so the costs to the mother increase. Eosinophil levels are significantly higher in adult females with housed with ten week old kits than those with eight or six week old. Nursing females provided with a shelf, suspended wire cylinder, or other opportunity to withdraw therefore do use it as a means of avoiding their kits (e.g. Jacobsson and Karlsson 1993), especially when the kits are 5 - 7 weeks old. Nursing females with access to shelves may lose less weight than those without, while those with cylinders show less stereotypy (reviewed Hansen 1998), although not all find such an effect. The use of these enrichments then declines as kits aged 7 weeks plus become able to climb (Hansen 1990). However, the increased ability to escape from kits may explain why mothers kept with their litters in three interconnecting cages show less stereotypy than if family-housed in standard cages.

9.2.9. Weaning of the litter/weaning of all kits except a son/family-housing systems: kit weaning age and beyond

As kits can be a source of stress to the mother, this may be why female cortisol levels fall about one week after the weaning of 6 –7 week old kits, though such effects could also be a by-product of lactation ceasing. When ten week old kits are weaned, mothers show few behavioural signs of disturbance and their eosinophil levels fall within a day. This may not be surprising, given that in the wild, females may start aggressively rejecting their young when they are about 10 weeks old (Dunstone 1993). However, adult female weight loss is also no higher if her kits are left with her until ten weeks of age, compared with earlier weaning protocols. Leaving kits with their mother until 11 – 12 weeks also does not result in bitten nipples, in contrast to leaving them with her until 16 weeks of age and through to pelting age.

Note that the stress experienced by the mother depends on where the kits are placed, as well as their age at weaning. Adult females show stress if eight-week-weaned kits are housed in neighboring cages to them, having significantly higher eosinophil levels than females whose litters were housed on another part of the farm. Furthermore, if separated from their kits by a barrier, they will scratch at this barrier energetically; this occurs even if the kits are c.13 weeks old.

In the longer term, female stereotypy levels also increase after their kits are removed, as does the prevalence of tail-biting, which rises from less then 30% to over 50%. In practice, many farmers leave a male kit with each female. However, if males are left with their mothers until six months, such mothers are then more likely to develop tail-biting (de Jonge et al. 1986). They also continue to suckle these sons until pelting, continue to defend their sons until 7 months of age (de Jonge, pers. observations), and tend to sleep with them (de Jonge 1996). This suggests that late-weaning could bring with it its own welfare pros and cons, as can also be seen in the family-housing system.

Pastel and Pearl mothers in family cages, i.e. with unweaned kits in several inter-connected cages (see above), show elevated plasma cortisol (especially the Pastel females), more frequent cases of teat damage (seen in 89% of females, and again, more so in the Pastels), more frequent pelt bites, and more bites through the skin over more areas of the body. Levels of self-grooming are also reduced. However, family-housed females also show lower stereotypy levels during the nursing period (observations from birth to 6 week-old kits), more curiosity and ‘defensive aggression’ towards human observers, and greater body weights then standard-housed females. De Jonge and van Iwaarden (1995) also found that group-housing did not cause fighting, that the mothers stayed healthy and did not lose weight (e.g. de Jonge 1999, 2000a), and that in 1998 and 1999, they showed negligible pelt-bites compared with than solitary-housed females. De Jonge (1996) also found that mothers housed with whole litters did not differ in weight from those housed with a single son, that they did not differ in reproductive output the following year, and that both groups of adult female showed negligible stereotypy. Mononen et al. (2000) found that that mothers housed with whole litters did not even differ in weight from those housed singly.

9.2.10. Non pregnant females

Rates of non pregnant, or ‘barren’, females are generally low, e.g. c. 5% in double-mated females on an experimental farm (Lagerqvist 1992), and c. 8% on Danish commercial farms (Møller 1999). However, these females potentially have particularly poor welfare, as they will end up being housed alone for at least 12 months. Given that females are less active when they have kits, but more prone to behaviours like tail-biting when they do not, and that the visual isolation of males seems to make them more exploratory; MacLennan and Bailey 1969), it seems very likely that single-housed barren females will be particularly deprived by the inability to perform natural behaviours. However, their response to potential environmental enrichments has not been investigated. A further, even more serious, welfare issue was also raised above: that some barren females may have teeth removed so that they can be group-housed. This practice is an example of a mutilation which involves damage to sensitive tissue with associated pain and distress to the animals.

9.2.11. Risks for older ages: special issues for older females

Ninety to one hundred percent of adult males are killed by ten months of age, but adult females live at least 18 months, and some may live for 3-4 years. For these older females, there may be special welfare issues that stem from their longer period in captivity. This is probably especially true of strains like Sapphires, whose morbidity and mortality are significantly greater than that of Standards.

On the one hand, older females tend to show less fear of humans than primiparous females (Mason 1992), and they also show no increases in adrenal weight or frequencies of stereotypies with age (Mason 1993). There was no gastric ulcers, even in c. 25 four and five year old females.

However, de Jonge (1991) suggests that the frequency of tail-biting may increase with age, and also demonstrates that the severity of the behaviour does increase: the average length of a bald tail tip is just 3 cm for one-year old females, but 6 cm for four-year olds (de Jonge 1991). Those mink that bite their own tail tend to become pelt-biters with age. Animals who bite their tails might also become more serious self-mutilators. Stereotypies also become more frequent with age (Mason 1992, 1993). Other possibly negative changes with age include the decline in reproductive output that happens from three years onwards, especially marked in Sapphires, and in animals that have been kept on a ‘high nutritional plane’ all their lives. However, probably more important are veterinary issues. Carotid body tumours, uroliths and urethral cysts are all more common in older females; carcinoma of the anal sac glands and progressive retinal degeneration may also be particular issues for older mink. Older females are also more likely to suffer from nursing sickness. Finally, dental health is another real area of concern. Although six month old kits only have harmless dental tartar, adult females can present a high prevalence of broken or decayed teeth. This was unaffected by strain or by lifetime nutritional status, but it was dramatically affected by age, rising from 64% in 2-year olds to 84% in 3 to 4-year olds and 93% in 5-year olds. This is higher than that seen in wild adults (c. 20%; Dunstone 1993).

9.2.12. Conclusions

1 The mortality of mink kits during the nursing period has been reported to be up to 30% with a mean of about 20%. After weaning, mortality rates are lower, and in adults they usually range from 2-5% per annum although in some strains they can be higher. Lactation is a period of high risk especially because of nursing disease.

2 Although mink on farms are subject to a range of disease conditions, in general these can be managed so that morbidity from serious infectious disease is low. Non-fatal conditions which affect welfare, for example gastric ulcers, kidney abnormalities and tooth decay, are sometimes widespread.

3 Contaminated food which may include toxins such as botulin is sometimes given to mink. So, in some member states, vaccination against botulism is recommended. Contaminated food may have other significant effects on mink welfare.

4 In experimental conditions, farm mink show strong preferences for the opportunity to swim. An adequate fur-farming system for provision of swimming water has yet to be designed.

5 Stereotypies, largely locomotor in nature, are widespread on mink farms. For example in a large scale study stereotypies were shown to occur in 31 to 85% of females, while other studies have reported higher as well as lower figures. There are many reports of individuals spending over a quarter of day time in these abnormal behaviours. Stereotypies result from interplay of genetic predisposition, experiences when juvenile, complexity of current housing, and exposure to environmental events that cause increased arousal.

6 Mink in farm cages may show sucking or biting of their tail fur, or biting of other parts of their pelt. These behaviours are widespread in farmed mink. Such problems become more severe with increasing age. Self mutilation of tail or limb tissue occurs but its prevalence is unknown.

7 Weaning before nine weeks leads to a variety of welfare problems.

8 Mink farms normally have good ventilation, and natural day-light cycles.

9 The typical mink cage with a nest box and wire mesh floor impairs mink welfare because it does not provide for important needs. Particular problems are limited locomotor and stimulatory possibilities, lack of opportunity to climb, go into tunnels or swim, and inability to avoid social contact. Efforts to improve the environment have been fairly limited but have included group housing in interconnected cages and provision of objects. None of these systems has yet been adopted commercially.

10 Restricted feeding of overweight female mink is often used in practice. However, it can cause welfare problems especially if the loss in body weight is too severe.

11 Some strains of mink show a high prevalence of genetic disorders resulting in deafness, blindness or other sensory impairment, or higher susceptibility to disease.

12 Less common welfare problems arising from management practices are not providing *ad libitum* water, inadequate vaccination programmes, detoothing, housing without sufficient shelter from the sun and lack of protection from freezing temperatures.

13 Welfare problems arising from the social environment include intraspecific aggression caused by inappropriate mixing or overcrowding, and harassment of females due to unsupervised mating. Single housing of young kits is also detrimental. The effects of group housing arenot yet fully understood.

10. THE WELFARE OF FOXES

10.1. Welfare Indicators in Foxes

Welfare research in farm foxes is just in its beginnings, and the methods used have generally been derived from the knowledge of other farm animals, including mink. However, it is not known to which extent a method that is a valid measure of welfare in, say, dairy cows, is as such applicable to fox. It is therefore important to keep in mind that more work is still needed to develop valid methods for assessing welfare in foxes.

10.1.1. Physiological welfare indicators in farmed foxes

Plasma cortisol

Studies of plasma cortisol levels related to stress and welfare in farmed foxes took their beginning in the early 1990s. Jeppesen and Pedersen (1991) found a clear increase in plasma cortisol 2-3 min after onset of a capture procedure, which stressed that if it is to be used as a solid indicator of stress, blood should be sampled within 2 minutes from the initial disturbance of the animal. In 1996, Moe and Bakken evaluated blood sampling as a technique to evaluate stress in farmed silver foxes and concluded that if capture and blood sampling were done within 3 minutes, baseline levels could be obtained. But in farmed foxes the mere presence of people in the shed disturbs most animals and therefore it is very difficult to obtain baseline levels on a large number of animals. This is one of the reasons why a number of studies, which included blood sampling for analysis of baseline levels of plasma cortisol, rejected this parameter with the argument that the levels obtained did not reflect true baseline levels (Bertelsen, 1996).

Despite all these problems, it has also been found that plasma cortisol increases after both acute and long term stressors both in silver foxes (Jeppesen and Pedersen 1991; Rekilä et al. 1997, 1998) and blue foxes (Rekilä et al. 1997, 1998), and can thus be used as a measurement of stress/welfare in farmed foxes in conjunction with other parameters. Jeppesen and Pedersen (1991) found that foxes housed continuously with a whole-year shelter for two years showed a lower baseline level of plasma cortisol than traditionally housed foxes in barren cages. In a further analysis, they found that the baseline levels of cortisol were negatively correlated with the use of the shelters (Jeppesen and Pedersen, 1992). Moe and Bakken found that repeated blood sampling of silver foxes during one year increased baseline levels of cortisol more in the experimental group than in the control group which had experienced no previous blood samplings.

An ACTH challenge test has been used to study social stress in acute or repeatedly stressed foxes. Examination of the dose-response relationship between ACTH injected and cortisol secretion in 4 x 6 animals revealed that a dose of 10 mg/kg was enough to give a maximal cortisol secretion. The maximum response was between 30 to 60 minutes after the ACTH injection, and recovery was reached within 120 minutes. These findings are important for further use of the ACTH challenge test as a physiological welfare indicator in farmed foxes. Repeatedly stressed animals showed a higher cortisol response to an ACTH challenge 20 and

45 minutes after the injection, whereas no significant differences were found at time 0 and 120 minutes post injection between the 2 groups. These endocrine variations correlate with behavioural data, indicating that repeatedly stressed foxes show habituation to being repeatedly captured and therefore are better able to “cope” than the foxes only captured once. However, Rekilä et al. (1998) evaluated the time course of the ACTH response in blue and silver foxes by injecting 0.3 ml ACTH and taking blood samples 20 min and 2, 4, 8, 12, 24 hours. In their study the serum cortisol level was the highest approximately 2 hours after ACTH administration. The exact dose of ACTH per kg animal was not revealed. It has been claimed that blood sampling with or without an ACTH challenge has reduced validity as a method of revealing stress in farmed foxes, due to its invasive nature. Moe and Bakken concluded in the same direction when they found that blood sampling in both the short and long term had a great impact on hormone concentrations (testosterone, cortisol) and leucocyte levels in silver foxes. Therefore alternative methods should be developed that are less invasive when measuring physiological stress in farmed foxes.

Urine cortisol:creatinine ratio

To avoid problems related to blood sampling, cortisol levels can be measured in urine providing correction for urine dilution are made, based on creatinine levels. Significant positive correlations between baseline blood cortisol and urinary cortisol:creatinine ratio in both blue foxes and silver foxes have been found, indicating that both measures reflect adrenal function, and that despite its limitations, a single blood cortisol sample may, if taken quickly from an undisturbed animal, indicate the baseline concentration (Rekilä et al. 1998).

Eosinophils and other Leucocytes

Eosinophils decrease in the blood as a response to an acute stressor. This is due to an initial activation of the HPA-axis which induces a migration of eosinophile leucocytes to the spleen, lymph nodes and thymus. A few studies have used changes in eosinophils to assess stress in foxes. Jeppesen and Pedersen (1991) studied the effect of different housing environments on the number of eosinophiles and lymphocytes in silver foxes. They found that the lack of a nest box increased blood cortisol level and eosinophils (E) and lowered numbers of lymphocytes (L). Several physiological measures were evaluated for the measurement of a potential stress reaction to ether treatment and transport in silver foxes. Eosinophils decreased in response to an acute stressor whereas the H/L ratio increased. The H/L ratio was proposed to be a more valid parameter for measuring physiological stress, since it was more consistent. Similar findings were reported in another study, i. e. lymphocyte, eosinophil, total leucocytes, and total granulocyte counts decreased as a response to acute stress in silver foxes. Other studies failed to find changes in the number of eosinophils. For example early handling did not affect the numbers of eosinophils in the blood in silver foxes (Pedersen and Jeppesen, 1990).

Stress-Induced Hyperthermia

Studies of laboratory rodents have demonstrated that various imposed stressors such as handling, restraint or the anticipation of an unpleasant event results in an increased body temperature. This is termed stress-induced hyperthermia (SIH). Only recently has this measure been evaluated as a tool to measure stress responses in farmed foxes. Both rectal temperatures obtained manually and body core temperatures obtained through implanted transmitters have been used. SIH (rectal temperature) was observed in silver foxes restrained for 30 minutes. Olsrød and Røhme (1991) found a higher increase in rectal temperatures in foxes handled with neck tongs than in foxes taken by hand. In blue foxes, rectal temperature was increased 30 min after the prior temperature measurement (Rekilä 1999). Korhonen et al 2000 found that male blue foxes in large cages showed a higher SIH (rectal) than those housed in small cages. However, they also found that the rectal temperature was significantly affected by capture time and males from larger cages showed a significantly longer capture time, making a conclusion difficult.

Body core temperature (measured by implanted transmitter) of silver foxes increases within 5 minutes in response to human presence and various social situations with conspecifics (Bakken et al. 1999). In blue foxes, a similar increase of body core temperature was found about 30 min after start of the exposure to similar situations.

Heart rate

Heart rate may be used as an indicator of acute stress because it increases rapidly in response to an inhibition of the parasympathetic branch of the autonomic nervous system and the activation of the sympathico-adrenal medullary system. Heart rates in farmed foxes have been measured manually or by telemetry. Olsrød and Røhme (1991) found that the manually evaluated heart rate in silver foxes was higher when they were caught with neck tongs than when they were caught by hand. They found the opposite in blue foxes making them conclude that blue foxes were less sensitive to this particular stressor. High heart rate was found to be related to increased body temperature and increased activity in blue foxes. Heart rate shows both inter-individual and stressor dependent variations when measured by telemetry in blue foxes. Heart rate has a limited value as a measure of stress since invalid heart rate measures from background noise, muscular activity and dysfunction of the implanted transmitters are difficult to control. Heart rate as an indicator of stress should therefore be used with caution because it changes also in situations without any additional stimuli.

Adrenal weight

Silver foxes have heavier adrenals than blue foxes indicating that such parameter should not be used for a comparison of stress in different species (Rekilä et al., 1998). The value of adrenal weight as a stress indicator is questionable, because it does not necessarily correlate with the activity of the HPA axis (Pedersen 1994, Braastad et al. 1998, Rekilä et al. 1998). Similar results have been observed in rats. As most organ weights are related to the body weight of the animal, the adrenal weights should be used as relative to body size. Confident and non-confident silver foxes did not differ in adrenal weights, and neither did confident and non-confident blue foxes, but urinary cortisol:creatinine ratios were lower in confident than in non-confident foxes of both species making the authors conclude that in the short term (animals 8 months old when autopsied) the urinary cortisol:creatinine ratio was a better indicator of stress in farmed foxes (Rekila et al., 1998). Pedersen

(1994) found that handled silver foxes had significantly smaller adrenals (corrected for brain and body size) compared with non-handled foxes, and with the other results it was concluded that post weaning handling adapted the foxes to captivity making them less stressed on long term. Mononen et al. (2000) examined various behavioural and physiological indicators of stress in 48 silver foxes exposed to a feeding test once a month for 6 months. They found no significant correlations between behaviour. Adrenal cortex function and adrenal mass were significantly correlated with body size only. They concluded that the feeding test only measured motivation to eat and not fear.

Other physiological measures

Housing conditions and rate of exercise affect the bone structure and strength of husbandry animals. Welfare is poorer if the bones are weakened by the lack of exercise. The welfare is especially poor if the bones break during normal activity (Korhonen et al. 2000). Only recently has this measure been introduced to the field of fox welfare and Korhonen et al (2000) found that the breaking strength of the tibia increased with increasing cage size. This result was interpreted to indicate that the small cage restricted normal activity, weakening the bones, and the larger cages with access to earth allowed more activity, including jumping, strengthening the bones.

Body and organ weights have been examined by Korhonen et al (2000). They found that male juvenile blue foxes housed in four different cage systems from July to November did not significantly differed in their weights of the body, spleen, brain, heart, thymus, and liver.

The occurrence of gastric ulcerations in handled and non handled silver foxes was examined by Pedersen (1994). She found 6 of 55 animals with signs of gastric ulcerations, but these animals were divided equally among the experimental and control groups.

In general, organ changes appear to be more an indicator of a pathological state of poor welfare, that is, they are only detectable if the health of an animal is really poor.

10.1.2. Behavioural welfare indicators in foxes

Fearfulness, aggressiveness and curiosity

A wide range of behavioural tests has been used to measure fearfulness, aggressiveness and curiosity (or exploration) in farmed foxes, with tests that aim at measuring one of these behavioural characters but also tests that measure all of them (Rekilä 1999).

Exposure to novelty is a widely used measure of fear. It usually results in inhibition of activity, unless accompanied by escape attempts, signs of autonomic activation (e.g., defecation), and decreased motivation to eat.

Fear refers to two different components, the trait of fear which is a personality trait, and the state of fear which is expressed as the animal’s reaction to a sudden change in its environment (Hendrie et al. 1996). Fear as a welfare problem is more closely associated with the trait of fear. This is because an animal living in a constant farm environment may seldom be exposed to a sudden fear-evoking change in its environment, and even if it is the case, this has only a short- term welfare-reducing effect. However, all tests of fear measure the state of fear more than the trait of fear (Rekilä 1999). As a result of this there are no reliable methods for measure the trait of fear in a standardised way.

The titbit test (Dale and Bakken 1992, Rekilä et al. 1997) and the feeding test (Rekilä 1999) seem to be valid tests for the state of fear in blue and silver foxes. Both tests are based on the assumption that a fearful fox refrains from eating in presence of human.

Farmed silver foxes have been claimed to exhibit “extreme fear” of humans, evident from trembling, defecating, withdrawing to the back of the cage, and attempting to bite the handlers. Similarly, Bakken et al (1994) referred to foxes in the vicinity of humans as being in a state of continuous fear. These responses were found by Moe and Bakken (1998) to be comparable to human fear responses and associated with stress-induced hyperthermia.

Fear may be associated with stress and means that welfare is poor, especially if it is prolonged (Broom and Johnson 1993). Fearful behaviour in the feeding test was found to be associated with elevated blood cortisol in silver foxes (Rekilä et al. 1977, 1999) and with elevated urinary cortisol:creatinine ratio in both blue foxes and silver foxes (Rekilä et al. 1999).

Although aggressive and explorative behaviour are measured in several studies their importance for the welfare of foxes is unclear. In farmed foxes the behavioural tests measuring fearfulness, aggressiveness and curiosity have been used to discriminate between animals from different housing histories, different genotypes, or phenotypes or to study effects of human-animal relationship (see review in Rekilä 1999). Behavioural expressions of fear in these tests take the form of active flight or avoidance, lack of approach towards food or passive postures like freezing and immobility. Offensive or defensive aggression has been observed as well as threats or attack reactions towards a passive human or during capture. Curiosity has been measured by approach towards a human, titbit or a novel object.

Competition capacity

The competition capacity test (Bakken 1992, 1993a,b, 1995) is used to measure competition capacity of foxes in a paired contest situation. In this test, two hungry individuals are placed in the same cage, novel to both of them, and they are offered one portion of feed. The individual that monopolises the offered feed is considered to have a higher competition capacity than its cage mate. An adjusted dominance rank test measures competition capacity within litter (Bakken 1992, 1993b).

Activity

Both the intensity and rhythm of the daily activity might serve as a useful indicator of the general physiological state of the fox. For example, extremely low activity during the active period may be a sign of apathy, whereas extremely high activity may be a sign of nervousness. Furthermore, problems in coping with the housing environment may lead to asynchrony in the circadian rhythm. There is an obvious need to study the usefulness of the amplitude and the regularity of the circadian rhythm in welfare research.

Circadian activity has been used as an indicator of welfare of foxes. In a study on behaviour in breeding boxes with or without an entrance tunnel, vixens with

newborn cubs rested at the same level at different times of day and night, while vixens in traditional boxes spent more time watching outside events during working hours and rested less (Braastad 1996). The latter group also had a lower reproductive success. The author concluded that welfare was improved by the tunnel box. Apart from this, circadian activity has not been related to welfare of foxes (Mononen et al. 1995, 1996b, Korhonen and Niemelä 1997, 1998).
Exposure to a new environment can also be used to measure general activity. In blue foxes, the active individuals in their familiar environment were also active in the novel situation (Rekilä et al. 1996).

Stereotypies

Stereotypies have not received as much attention in fox welfare research as in mink. The occurrence and prevalence of stereotypic behaviour have been examined in both fox species. Locomotor and manipulative stereotypies can occur but at low levels. Since foxes may show stereotypies when humans are not present but cease when humans are present, failure to observe stereotypies does not mean that they do not occur.

10.1.3. Mortality and morbidity

The mortality of adult foxes is assumed to be very low due to a generally healthy stock and efficient vaccine programmes, but few statistical records are available. Outbreaks of disease occur only occasionally and stay local. A large scale survey of the mortality on fox farms in Finland was carried out in 1985 and 1986. The total mortality per from April to October for breeding animals was 3.2 % in 1985 and 4.0% in 1986. On both years total juvenile mortality was 3% from June to October. The mortality among pups is at its highest during their first week of life (Sauna-aho, 1985, 1986).

The most important diseases that afflict foxes are described in Henriksen (1996) and in ’Mink Production’, edited by Jørgensen (1985).

Viral diseases

Distemper is caused by a paramyxovirus and is widely distributed in the wild fauna. It mainly attacks the mucosa. Vaccination has reduced the importance of this disease. This disease reappeared in Finnish dogs in 1990 after a 16-year absence (Ek-Kommonen et al., 1997), and vaccination of canids is therefore recommended (Rikula et al., 2001). Fox encephalitis is caused by an adenovirus and causes sudden death, mostly in juvenile foxes, and usually with no clinical symptoms. Efficient vaccines are available. The disease has not been diagnosed in Finland since 1987. Parvoviruses cause embryonic and foetal death in arctic and possibly also in silver fox females if these are initially infected during the early stage of pregnancy (Veijalainen 1987). Aujeszky’s disease (pseudorabies or mad itch) is caused by the porcine herpes virus. Strong itch is a common symptom in fox. Foxes are infected by the use of contaminated slaughterhouse offal in feed (Kangas 1982). It is rarely seen and has never been recorded in animals kept for fur production in Finland.

Bacterial diseases

Infection with *Pseudomonas aeruginosa* can give clinical symptoms of metritis in blue fox females after the animals have been mated or inseminated, usually if a heat detector has been used (Smeds, 1993). There are been few clinical outbreaks, from 1996 to 1999 two outbreaks have been diagnosed on blue fox farms in Finland. Salmonellosis, especially *Salmonella dublin*, can cause abortion in fox females and mortality among young foxes, when they are infected by feed containing cattle and poultry slaughter offal (Loikala and Smeds, 1991). Streptococcal and staphylococcal infections can cause inflammation of the uterus, the udder, the urinary bladder, the gingiva, subcutis and the respiratory tract etc. Inflammations of the uterus and/or the udder are important causes of postnatal loss of cubs (Kangas 1982).

Parasitic infections

Encephalitozoonosis is caused by an infection with *Encephalitozoon cuniculi* and causes central nervous system disease in young arctic foxes. It usually starts as a sub clinical alimentary infection of the dam (Kangas, 1973). There is no treatment for encephalitozoonosis. Clinical outbreaks are usually limited. Since 1996, three outbreaks have been diagnosed on blue fox farms in Finland. The frequency of toxoplasmosis is considered as low. The parasite causes central nervous system disease.

At the beginning of the fox and blue fox farming, animals were kept in pens on the ground. At that time the hook worm (*Uncinaria stenocephala*) was a very common and serious parasitic disease on farm. Other common worm species are *Trichuris vulpis* and *Toxocara* species. Worms are now rare in farmed foxes as these are raised in cages above the ground (Kangas, 1982).

Sarcoptic and Otodectic mange are caused by external parasites. Sarcoptic mange is painful to the animal and often lethal. Otodectic mange is less harmful.

Hereditary diseases

Spongy degeneration of brain white matter in silver foxes is occasionally found in in Norway. Gingival hyperplasia with a probably recessive genetic background is observed in silver foxes. Entropion has been observed usually in heavy individuals among blue foxes during the winter season. It causes conjunctivitis in the affected eye(s). This disorder, which in some respects seems to be hereditary, has until now not been studied systematically. The farmers had been advised not to use these individuals for breeding. Conformation problems, especially plantigrade instead of digitigrade locomotion, have apparently received little if no attention.

10.2. Farming environment

The welfare problems of farmed foxes are assumed to be due to the farming environment and have been reviewed by Nimon and Broom (2001). The main arguments against keeping foxes in the existing systems have been the size and barrenness of the cage and lack of sufficient domestication due to relatively short life history of being subjected to the husbandry of man (Bakken et al. 1994). These claims include the concept of failure to adapt completely or partially to the housing environment or to the presence of humans. The research on welfare of foxes has been a direct response to these claims (Rekilä 1999, Mononen 1996, Bakken et al. 1994, Pedersen 1993a). This explains why this section organised along the main themes of this research rather than along the different stages of life as it is the case for the mink chapter.

10.2.1. Enrichment of cages

Housing of animals in captivity requires a more or less closed environment. As a result of decades of development, the environment foxes are housed in is a barren wire mesh cage situated in a two-row shed house. From the farmer's point of view, a barren interior is a guarantee of minimal fur damage and the wire mesh bottom is a guarantee of good health (Forester and Forester 1973). On the other hand, a major part of the welfare critique is focused on the inside of the cage environment. Commonly used wire mesh cages are claimed to be too barren to guarantee reasonable welfare for foxes. As a result, the cage interior should be enriched with objects that meet the needs of fox. Enrichment in order to provide for the needs of foxes for locomotion, exercise, and appropriate stimulation might require a different housing system, such as those designed to replace confinement systems for sows and hens, but the studies which have been carried out with farmed foxes have been limited to relatively minor changes.

Behavioural and reproductive consequences of access to wooden blocks (30 x 7 cm) have been evaluated in a Finnish study on blue foxes (Korhonen and Niemelä 1998). The results revealed that foxes frequently made use of the blocks (pushing, carrying, gnawing) with a mean daily number of 77 episodes, and with a mean total time of 16.4 ± 2.9 min/day. However, exploration, fear or passiveness measured in different behavioural tests was not significantly altered by access to wooden blocks. However, there was a non-significant tendency towards improved reproduction in the form of more successfully weaned cubs among vixens with access to wooden blocks. Danish researchers repeated parts of the Finnish study in a private fox farm, but the reproduction results in their study did not parallel those reported in another study. According to the authors, farmers observed individual differences in frequency of use. Sticks were used for play, gnawing, and marking with urine and faeces. More studies on the value of wooden blocks as enrichment of cages for foxes are needed before final conclusions can be drawn.

10.2.2. Cage size

In foxes three studies have focused on behavioural and physiological effects of *additional* space. In study 1 the wire mesh cage (80 cm long x 105 cm wide x 70 cm high) was prolonged in two bouts with $^{1)}$40 cm and $^{2)}$additional 120 cm. The authors reported a substantial individual variation in activity between individual foxes, but did not find significant differences between different sized cages in any of the three experiments.

In the second study, four groups of 30 blue foxes were housed in (1) traditional sized cages (80 cm long x 105 cm wide x 70 cm high) CL80, (2) 40 cm prolonged cages CL120, (3) 120 cm prolonged cages CL240, and (4) 120 cm prolonged cages

with access to a ground floor cage (traditional size) CL240E. The physiological measurements demonstrated that foxes housed in the largest cages had the highest breaking-strength of tibia and that rectal temperature following capture was highest in CL240 and CL240E foxes and lowest in CL80 foxes. Cortisol:creatinine ratios did not reveal significant differences among the groups. Behavioural measures showed that open-field activity increased with increasing cage-size, and that capture time and fearfulness in the feeding test was highest in CL240±E foxes.
In study 3, behavioural responses and distance towards an observer, behaviour during capture for blood sampling and plasma cortisol level were measured in relation to four different cage sizes (1, 2, 4 and 8 room cages) in 12 blue and 12 silver foxes. The foxes were previously tested and classified into “most aggressive” and “most confident” prior to the study. No significant differences between cage sizes in plasma cortisol were found in either blue or silver foxes, although the authors concluded that the cortisol levels did not represent true levels due to the capture procedure. In silver foxes the authors reported a significant change in the flight response towards humans in 4- and 8-room cages compared to smaller cages during the study. In 1-and 2 room cages a greater proportion of foxes responded aggressively toward a human observer than in larger cages. Duration of capture prior to blood sampling was longer in 8-room cages than in 1-and 2-room cages. In blue foxes no change in behavioural response towards humans was observed in relation to cage size, although aggressive acts were almost absent in the 4-and 8-room cages. Duration of capture prior to blood sampling was not affected by cage size in blue foxes.

10.2.3. Nest boxes and platforms

The Council of Europe Recommendations (1991) stated that farm foxes have a need for a hiding place and for a resting area with a solid floor, and that nest boxes and platforms meet these needs. Due to this recommendation, research has concentrated during the last decade on the potential benefits of adding nest boxes and platforms in the cages of foxes.

Nest boxes

Traditionally, farmed foxes are given access to nest boxes (breeding nest boxes) only during the reproductive season. Since boxes are meant for giving birth and nursing the cubs, they are provided for breeding vixens only. After the breeding season the boxes are removed to avoid problems with staining and wearing of the fur and damage to the box caused by gnawing and scratching. Some farmers assume that foxes cope well without boxes. Since, the boxes may potentially serve as a place for withdrawing in challenging situations or for undisturbed rest, several studies have been made to report effects of providing silver and blue foxes with a whole-year nest box. Where a nest box is used principally as a hiding place, it may be very important to the fox for the period when the fox needs to hide but not used at other times. Hence the use at times of disturbance by humans or threat by other foxes is a relevant measure, as well as total use. Box design is a significant variable affecting box use and importance for foxes. Boxes may be more important for the more fearful or subordinate foxes.

10.2.4. Nest boxes for silver foxes

Nest boxes outside the breeding season

Although the duration of a given behaviour does not necessarily reflect its importance for welfare, it has been observed that juvenile silver foxes of both sexes spend only a few percent of their daily time in the autumn in a box situated in the cage (Mononen et al. 1995). The median percentage of time decreased from nine in August to zero in November. There were two types of nest boxes differing in interior shape (square versus round), but no difference in use between the types was documented. The cleaning frequency (weekly versus no cleaning) did not affect the use of the boxes either. In another study, the extent of the use of the box by juvenile foxes of both sexes was more stable from August (median 1.7 %), through October (1.0 %) to December (1.0 %) (Mononen et al. 1996). In that study, the use of the boxes was recorded also in the presence of man, and foxes were recorded to be in the boxes in only 63 times out of total 6,780 daytime observations in 20 animals. Mononen et al. (1996a) investigated in August-September the choice between a barren cage and a cage with nest box in juvenile silver foxes. On average silver foxes spent 86 % of the observed time in the nest box cage, and 18 % of their daily time in the box. The foxes spent slightly more time in the nest box cage after one-day deprivation. The box was used more in the evening and at night than during the work day.

Using direct observation, Pedersen and Jeppesen (1993) recorded daytime use of shelters by silver fox breeding vixens all year around for more than one year, excluding the breeding season (from the heat to the weaning the cubs). The foxes had a double cage system in which one cage was empty and the other equipped with three nest boxes and a platform. The mean percentage of the total use of the three boxes never exceeded 15 % of the observations, and was typically less than 10 %. A box situated on the top of the cage (top box) was preferred to a box without a roof in the cage (open box), and a box mounted on the side of the cage (side box) was used little. This study included also a disturbance test. In the non-disturbance situation, only 4-7 % of silver foxes used any shelters, and only a few more were observed in the top box during the test situation when they were frightened. The percentage of silver foxes observed in the empty cage was 76 % when the disturber approached from the side of the furnished cage and 48 % when the disturber approached from the side of the empty cage.

In a double cage system with identical nest boxes in the cages but at different levels, adult silver foxes spent about 80 % of the night in the boxes in January, while the boxes were not used in the daytime (Jeppesen and Pedersen 1990). The boxes mounted high in the cage were preferred.

In a different study carried out in January, silver foxes had a nest box mounted on the top of the cage. During the first and third week the box had solid walls, whereas the solid front wall of the box was replaced with a wire mesh wall during the second and fourth week of the experiment. Animals rested 65-70 % of their total daily time. Silver foxes spent 38, 3, 6 and 21 % (mean) of their total resting time in the nest box during the weeks 1-4, respectively.

Jeppesen et al. (2000) recorded the choice between boxes differing in height, light conditions, number of compartments, and with or without platforms. The results illustrated a preference for an elevated multi-room nest box in addition to a preference for boxes supplied with a platform.

The extent of the use of the nest boxes in silver foxes may vary with seasons but it is not increased by cold weather (Pedersen and Jeppesen 1993, Mononen et al. 1995). Interindividual variation in the use of the nest boxes is substantial (Pedersen and Jeppesen 1993, Rekilä *et al.* 1995, Mononen et al. 1996b)..

Breeding nest boxes

The mother is the source of heat, nutrition and care for the cubs, and breeding box that *stimulates* the mother to spend more time with her litter should be chosen *a priori*. In their first days of life fox cubs have insufficient heat production and are totally dependent on the warmth from their mother (Harri et al. 1991). One can reduce the heat loss by insulating the box. The main avenue of heat loss from the box is the floor, and styrofoam under the wooden floor gives the same insulation effect as straw bedding in the box (Harri et al. 1989). The heat loss is also reduced by the cubs huddling together (Harri et al. 1991). However, the effects of these means are marginal compared to the effect of the mother.

Braastad (1996) recorded the per parturient behaviour (one day before to three days after parturition) in silver fox vixens housed with two types of breeding boxes, a traditional simple breeding box and a box with a narrow entrance tunnel (18 x 20 cm). Vixens with a tunnel entrance spent more time inside the box and spent more time grooming the cubs. During working hours, vixens without a tunnel entrance were more active inside and outside the box than at other times of the day, while the activity of vixens with a tunnel entrance was unaffected by time of day. The cub mortality during the first week in vixens without tunnel was 2.3 cubs compared to 0.5 in vixens with a tunnel entrance. Infanticide was more pronounced in the traditional non-tunnel boxes (in 15 of 22 litters) than in tunnel boxes (in 3 of 16 litters), particularly in inexperienced, primiparous vixens. The author concluded that access to a breeding box with an entrance tunnel improves the welfare of both female and offspring in silver foxes.

In a larger study on nine private farms, reproduction in 834 silver fox vixens housed with four types of breeding boxes was recorded for two subsequent years (Braastad 1994). Access to tunnel boxes increased delivery rate and reduced cub-mortality during the first three weeks postpartum. On average, the tunnel boxes increased litter size at three weeks by about 0.5 cubs per litter. The improved reproduction in tunnel boxes was however found only on farms with a previously poor or moderate reproduction. This illustrates the important fact that a supposed enrichment may not necessarily improve the reproduction. This would depend on what is the limiting factor of the reproduction on a particular farm.

10.2.5. Nest boxes for blue foxes

Nest boxes outside the breeding season

In a study of Mononen et al. (1996) investigating the choice between a barren cage and a cage with nest box in juvenile blue foxes in September, the foxes spent 66 % of the time in the nest box cage, and 12 % in the box. Deprivation for one day did not increase the use of the nest box cage. In the study of Korhonen *et al.* (1991), few blue foxes used boxes or burrows in 24-242 m^2 ground floor pens in the winter. In another study from August to January, blue foxes in a 224 m^2 ground floor pen visited only occasionally the interiors of the five wooden boxes in the pen. The whole group of eight animals spent totally 5 min or less per day in the boxes. Sixteen blue foxes in ground floor pens ranging from 187 to 242 m^2 did not visit the boxes at all during 12-hour daytime observations in October and January (Korhonen et Niemela, 1994). Blue foxes in 88-136 m^2 ground floor pens preferred to rest in the open even during heavy rain in September although there were boxes available in the pen.

Harri et al. (1998) studied the effect of access to top nest boxes compared to access to resting platforms in blue fox cubs (2-6 months old). A highly significant individual difference in use of the boxes was documented, where eight of the 20 individuals accounted for 95 % of the total use.

In blue fox breeding vixens, that were given access to different shelters (side box, floor box, top box and platform) for more than one year, the top boxes were used in 3-29 % of the observations, the percentage being over 15 for the most of the time (Pedersen and Jeppesen 1993). The use of the open and side boxes ranged from 1 to 3 % of observations. The foxes lived in a double cage system in which one cage was empty and the other equipped with the boxes and the platform. When frightened, 44-52 % of the blue foxes were observed in the top box. This was almost twice as much as in the non-disturbance situation. The number of blue foxes observed in the open and side boxes during the disturbance test was only slightly but significantly higher than in the non-disturbance situation. The percentage of blue foxes observed in the empty cage was 35 % when the disturber approached from the side of the furnished cage and 23 % when the disturber approached from the side of the empty cage.

In a nest-box choice experiment Jeppesen et al. (2000) demonstrated that blue fox vixens preferred a nest box elevated on the wall inside the cage to a floor-levelled nest box, a 3-room nest box to a 2-room nest box with a platform entrance, and a dark nest box to a light nest box. In another study, blue foxes were found to prefer a nest box mounted high in the cage to those mounted lower down, but there were also structural differences other than the height between the boxes.

In a similar experiment as in silver foxes, blue foxes had a nest box mounted on the top of the cage, and during the first and third week the box had solid walls, whereas the solid front wall of the box was replaced with a wire mesh wall during the second and fourth week of the experiment (Rekilä *et al.* 1995). Animals rested 65-70 % of their total daily time. Blue foxes spent 8, 12, 13 and 11% of their total resting time (mean) in the nest box during the weeks 1-4, respectively.

The extent of the use of the nest boxes in blue foxes may vary with seasons but it is not increased by cold weather (Pedersen and Jeppesen 1993). Inter-individual variation in the use of the nest boxes is substantial (Pedersen and Jeppesen 1993, Rekilä et al. 1995).

Breeding nest boxes

In two applied experiments, blue foxes given a breeding box with an entrance tunnel had a higher number of weaned cubs per breeding female than blue foxes in traditional breeding boxes (Moss and Östberg 1985). Mononen et al. (1996) found no difference between vixens housed with a top box (situated on the roof of the cage) in number of weaned cubs or cub loss compared to vixens housed with a floor box. However, a higher percentage of barren vixens was recorded in the juvenile vixens housed with floor boxes than in juvenile vixens housed with traditional floor boxes.

In another study comparing top boxes versus traditional floor boxes (Harri et al. 1997), no difference in cub mortality or body weight was found. The results demonstrated individual differences in use of the boxes. Cubs were found to emerge from the top breeding box earlier than cubs housed in floor breeding boxes. Different behavioural tests revealed more fearful animals in the nest box group compared to foxes housed without boxes.

Concealment screens

A concealment screen is an opaque wall in the cage mounted in a way that a fox can conceal itself behind the screen. While resting, both juvenile silver and blue foxes tended to rest as far from the screen as possible. When man was approaching, many foxes withdrew behind the screen.

Platforms for silver foxes

Experiments on the use of platforms consist of inserting a wood or wire-floored platform in an 80-100 cm high cage. The problem is that this does not necessarily permit the fox to sit in a high place, as is the case with the much used platforms routinely given to foxes in zoo housing. Despite this problem, platforms may still be of some benefit.

Age

Adults

Foxes that are provided with platforms at the age of one year or more, rarely use the platforms (Korhonen and Niemelä 1995). The platforms are used mostly by animals that have experiences of the platforms from less than four months of age continuously onwards (Mononen et al. 1995, Mononen et al. 1996b).

Juveniles

Silver foxes may spend up to 80 % of their daily time on resting platforms (Korhonen and Niemelä 1994a, Mononen et al. 1995, Mononen et al. 1998) while some individuals do not use them at all (Mononen 1996). Average use of platforms varies between 4% and 82% (Mononen et al. 1998a, Korhonen and Niemelä 1996b). The platforms are used mainly for resting, but they are visited also during active periods (Korhonen and Niemelä 1995, 1996a Mononen et al. 1995, 1996a 1996b). Consequently, quite naturally, the use of the platforms is at its peak in the late evening and early hours, *i.e.* during the main resting phase of the day (Korhonen and Niemelä 1996a; Mononen et al. 1996b). The platforms are used more in the summer and their use decreases towards winter (Korhonen and Niemelä 1994a, Mononen et al. 1995, Mononen et al. 1996b). Silver foxes used the platforms more during the working week (8 %) than during the weekend (2 % of daily time), when the only human activity on the farm was feeding once a day, but only if the platforms had an open view to the direction from which humans usually entered the shed.

Sex

Adult silver fox females spend much more time on the platforms than males in the winter (20-35 *vs.* 0-2 %) but not in the summer (both sexes about 55 % of daily time) (Korhonen and Niemelä 1996a).

Juvenile silver fox females have be seen to use the platforms more (Korhonen and Niemelä 1995, 1996a), less (Mononen et al. 1996b) and equal amount than the males.

Size/design/material

Juvenile silver foxes in cages with U-bottomed platforms spent 65 % of daily time on the platforms in September and 20 % of daily time in November (Korhonen and Niemelä 1995). In the study by Mononen et al. (1996b), respective figures for a flat-bottomed platform were 70 and 40 % of daily time. No clear-cut preferences have been observed in adult silver foxes between concrete and wire mesh floor (Jeppesen and Pedersen 1990) or between wood and wire mesh floor. Similarly in juvenile silver foxes in the autumn was not observed differences in the preferences for wire mesh and wooden platforms (Mononen 1996).

The use of resting platforms without walls in silver foxes decreased from 73 % in September to 27 % in November if the view from the cage floor was open (Mononen et al. 1996b). The respective decrease was from 70 to 46 % of daily time if the view from the cage floor was obstructed.

Platforms for blue foxes

Age

Adults

Foxes that are provided with platforms at the age of one year or more, rarely use the platforms. The platforms are used most by animals that have experiences of the platforms from less than four months of age continuously onwards (Korhonen and Niemelä 1993, Korhonen et al. 1995).

Juveniles

Blue foxes may spend up to 70 % of their daily time on resting platforms. There is also individuals that do not use platforms. The platforms are used mainly for resting, but the platforms are visited also during active periods (Korhonen and Niemelä 1993, Mononen et al. 1996a). The use of the platforms is at its peak in the late evening and early hours, *i.e.* during the main resting phase of the day (Korhonen and Niemela 1996). The platforms are used more during summer and the use decreases towards winter (Korhonen and Niemelä 1994a, 1994b, 1996b, Korhonen et al 1995). In the study of Harri et al. (1991) blue foxes used the platforms more during the working day if there was some extra human activity (*e.g.* blood sampling) on the farm compared with routine farm days (11 *vs.* 5 % of time).

Sex

In the adult blue foxes the difference between the sexes is not as clear as in silver foxes and not at all detectable in the winter, since foxes of both sexes rarely use the platforms (Korhonen and Niemela 1996).

Juvenile blue fox females have been seen to use the platforms more (Korhonen and Niemelä 1993, 1996; Korhonen et al. 1995) or the equal amount (Harri et al. 1991) than the males.

Size/design/material

Wooden platforms with a slightly depressed bottom (U- or V-shape) are used more frequently than wooden platforms with a flat bottom in blue foxes (Korhonen and Niemelä 1993, 1994a). Blue foxes have been observed to use wire mesh platforms the same extent (Korhonen and Niemelä 1995) or more than wooden platforms (20-50 % *vs.* 10-25 % of day time observations, respectively) (Korhonen and Niemela 1996).

Blue foxes used platforms with open walls more than solid ones: 10 *vs.* 1 % (Harri et al. 1991) or 40-76 vs. 1-13% of daily time. The use of walled platforms decreased from 30 % in September to 2 % in November, whereas the respective decrease in the open platforms was from 40 to 30 % of daily time (Korhonen and Niemelä 1996b).

Function of platforms and nest boxes

Originally, wooden resting platforms and nest boxes were introduced for foxes to offer a shelter against cold and draughts (Harri et al. 1991). Many fur farmers provided fox cages with winter nest boxes or other shelters. The aim was to improve the reproductive performance of foxes in an attempt to reduce the incidence of urinary tract infections at breeding time. However, the idea was abandoned, since no beneficial effects on reproduction were observed.

Both arctic foxes and red foxes are well adapted to cold weather conditions and in the wild they seek shelter only if the weather is extremely cold or rainy. Farmed blue foxes and silver foxes use resting platforms less during winter and more during summer (*e.g.* Korhonen and Niemelä 1996a, 1996). Farmed foxes do not seem to need either nest boxes or platforms as shelter against bad weather (Mononen 1996).

Nest boxes

On fur farms, the foxes may have a need to hide from human, members of their own species, and members of other fox species. Bakken (1992, 1993a, 1993b) showed that the vixens' reproductive performance is affected by the social relations between silver fox vixens in neighbouring cages. This result indicates that especially the low competition capacity vixens might have benefited from the possibility of not seeing or being seen by other animals. Thus, hiding places might satisfy their need for hiding away from dominant neighbours.

Farmed foxes may have a need to have a better hiding place for giving birth and nursing the cubs. It has been shown that both blue foxes and silver foxes wean more cubs if their breeding box has a tunnel (Moss and Östberg 1985, Braastad 1994).

Provision of hiding places for foxes may be good for them, not only during daily life but to help them to cope in acutely disturbing situations by offering the chance to avoid unpleasant stimuli. This may be of great importance in particular in a cage where other escape responses are not possible. On the other hand, they may strengthen fear of human (Mononen 1996, Pedersen, 1991).

Platforms

Foxes may have preferences for high places (Mononen 1996). Both blue and silver foxes spend a substantial proportion of their resting time on the resting platforms mounted high in the cage or on nest box roofs, at least in the summer and autumn (*e.g.* Korhonen and Niemelä 1994a, 1996a, Mononen et al. 1995, Korhonen and Niemelä, 1996, Mononen et al. 1996a, Mononen et al. 1996b). Furthermore, nest boxes mounted high in the cage are also more preferred than those mounted lower down (*e.g.* Pedersen and Jeppesen 1993, Jeppesen et al., 2000). In a choice situation between cages at two different levels, both blue foxes and silver foxes prefer cages that are on a higher level (Korhonen and Niemelä 1994, Harri et al. 1995).

The preference for higher places is probably connected with a preference for those places with good view (Mononen 1996). The view from the higher cage is better than from lower cage. Both silver and blue foxes have a tendency to avoid those parts of the cage where the view is partially obstructed (Mononen et al. 1996a, 1996b). Furthermore, silver foxes use the platforms more if the view from the cage floor is obstructed (Mononen 1996, Mononen et al. 1996b) and both species prefer platforms without solid walls, *i.e.* with unobstructed view (Mononen *et al.* 1993, Korhonen and Niemelä 1996b). All this may imply that the platforms serve as observation places or resting places with an unobstructed view.

10.3. Welfare effects of platforms and nest boxes

10.3.1. Silver foxes

Fear and aggression

Silver foxes housed in double fox cages (2.0 m x 1.2 m x 0.8 m) with three different nest boxes and a resting platform were faster to proceed in an open field than animals housed in traditional cages. Additionally, fewer animals from the enriched environment were fearful towards humans while more showed defensive aggression towards people (Jeppesen and Pedersen 1991). Correspondingly, fewer silver foxes having been housed for about two months in cages with platforms were fearful towards human in comparison with those housed in barren cages (Korhonen and Niemelä 1996b). This result however, was observed only in the human test, but not in other four fear tests.

In contrast, a study by Harri et al. (1995) failed to show any effect of the nest box or platform on the behaviour of silver foxes except for the prolonged capture time in foxes with a top box. The capture time test, however, rather demonstrated the ergonomic configuration of the housing constructions from the human point of view so is not a valid behavioural test.

The behaviour of silver foxes was only marginally affected by the recommended enrichments of the cage interior (Harri et al. 1995, Korhonen and Niemelä 1996b, Rekilä et al. 1998). Furnishing cages with nest boxes or platforms increased the activity of silver foxes in the open field in the studies of Jeppesen and Pedersen (1991) but not in other studies (Harri et al. 1995, Rekilä et al. 1998). One possible explanation for this difference may be the much longer time the foxes had spent in enriched cages in the study of Jeppesen and Pedersen (1991) compared with other studies (Harri et al. 1995, Korhonen and Niemelä 1996b, Rekilä et al. 1998; i.e. 2 years vs. 2 months). In addition, in the study of Jeppesen and Pedersen (1991) the cages were enriched with three different nest boxes and a resting platform, while cages in the study of Rekilä et al. (1998) were provided either with a nest box or a platform and in the study of Korhonen and Niemelä (1996b) with a platform only. Furthermore, cages were twice as large in the study of Jeppesen and Pedersen (1991).

The inclusion of platforms increased the activity of silver foxes in their home cages during the working day, compared with animals living in standard wire mesh cages or cages provided with nest boxes (Rekilä et al. 1998). This result confirms the different role of nest boxes and platforms for foxes as found by Mononen (1996). Nest boxes function as both a hiding and a resting place for foxes, whereas platforms act as an observation place, and observation is an active behaviour with a high arousal level.

Stress

Silver foxes housed in double fox cages (2.0 m x 1.2 m x 0.8 m) with three different nest boxes and a resting platform had a low base level of cortisol (Jeppesen and Pedersen 1991). In addition to the difference in open field activity, silver foxes which had lived for two years in a double cage (2.4 m^2) with three nest boxes and a resting platform had a lower baseline level of cortisol in plasma, and a lower number of eosinophiles and a higher number of lymphocytes than control animals which had lived in barren 2.4 m^2 cages (Jeppesen and Pedersen 1991). The silver foxes that used the shelters most frequently as the observer quietly walked by their cages had the lowest baseline levels of cortisol (Jeppesen and Pedersen 1992).

In an experimental set up, female silver foxes were allowed to live in three different conditions: barren 1.2 m^2 cages (Group 1), 2.4 m^2 cages with two platforms and a nest box (Group 2) and 4.8 m^2 pens with several shelters (Group 3). There were no differences in the levels of cortisol between the silver foxes in the various groups after foxes had lived for three months in the experimental cages. After living for one year under these conditions, the baseline level of cortisol was lower in Group 2 than in Groups 1 and 3, and the cortisol response to acute stress was lower in Group 1 than in Groups 2 and 3.

Reproduction

There was a tendency for improved reproduction in silver fox vixens with shelters in their cages. In a study by Korhonen and Niemelä (1996c) there were no differences in the reproductive performance of silver foxes with platforms from the previous summer onwards and a control group.

The reproductive performance of silver foxes with a year-round nest box on the top of the cage and two platforms (Group 2) was reported to be better in one year and worse in the next year compared to a control group without whole-year-round shelters (Group 1) or a group with a large solid-floored pen with several whole-year-round shelters (Group 3). In the first year, the difference was only in the litter size at birth but not in the litter size at weaning. In the second year, the difference was only in the litter size at weaning.

10.3.2. Blue foxes

Fear

Blue foxes were found to be more fearful and passive towards humans in the unfurnished cages than in cages furnished with nest boxes or resting platforms when tested using the human test (Harri et al. 1995). In another study, however, the human test and the feeding test did not reveal any difference between blue foxes housed in unfurnished cages and cages furnished either with platforms or nest boxes (Rekilä et al. 1996). On the other hand, animals housed with a platform or nest box were more active compared to foxes housed in barren cages. In the study of Harri et al. (1998), both sexes of blue fox juveniles were housed during their growing season either in cages furnished with wire mesh platforms with or without top nest boxes. There were more fearful individuals in the nest box group than in the platform group, probably because of less visual contact with humans during their growth. Fearfulness was evaluated with the feeding test and the disturbance test. Correspondingly, in the study of Jeppesen and Pedersen (1990), more individuals became fearful and stressed with shelters, compared with animals living without shelters.

Several studies have shown that cubs from vixens housed with open top boxes during breeding were less fearful towards humans than cubs bred in closed top boxes (Pedersen, 1992). In a study by Bertelsen (1996), the author concluded that use of open platforms promoted the cubs' habituation towards humans measured as less fear responses towards a human handler in adult foxes compared to cubs housed in closed nest boxes. The opportunity to use shelters seems to increase the foxes' fear towards human. This is probably a result of decreased human contact due to hiding inside the boxes. Human contact has been shown to be important in reducing the foxes' fear of humans (Pedersen and Jeppesen 1990, Pedersen 1992).

Stress

Baseline level of cortisol in plasma, eosinophiles, and lymphocytes in blue foxes which had lived for two years in a double cage (2.4 m^2) with three nest boxes and a resting platform did not differ from those of control animals which had lived in barren 2.4 m^2 cages (Jeppesen and Pedersen 1990).

Reproduction

There was a tendency for improved reproduction in blue fox vixens with shelters in their cages. A breeding nest box or a platform provided in mid-January to blue foxes had no beneficial effects on the reproductive performance calculated as cubs per breeding female. In a study by Korhonen and Niemelä (1995) there was no difference in the reproductive performance of blue foxes with platforms from the previous summer onwards and a control group.

10.4. Cage floor material

The effect of the cage floor materials for foxes has been studied by means of different kinds of preference tests (Korhonen and Niemelä 1997). When given the choice between wire mesh bottom, dry wooden bottom, dry sand and wet/icy sand bottom in four otherwise identical cages, silver foxes preferred dry wood the most and wet/icy sand the least. Blue foxes just avoided wet/icy floor.

The results from several different studies show that foxes' preference, measured as time spent in various activities on wire-mesh or solid floor, are dependent on the species, individual differences, age, earlier floor-type experience, cleanliness of floor, level of floor, season and weather conditions, wet or dry solid floor, type of behavioural activity, and neighbouring fox. Type of wire-mesh did not affect distribution of time spent in active behaviour on three different wire-mesh floors.

There are no studies demonstrating how foxes move on wire-mesh and therefore a clear conclusion on how wire-mesh affects foxes behaviour and welfare cannot be drawn. However, the results do *not* show that full-grown foxes avoid moving on wire-mesh when given the opportunity to move on solid floor. The finding that certain active behaviours more often are performed on solid floor (Korhonen and Niemelä 1997, 1998) may indicate possible restrictive properties of moving on wire-mesh. Blue foxes are found to spend more time on wire-mesh, and this may be due to the fact that they are trying to avoid the dirty, solid floor rather than choosing the wire-floor. Korhonen and Niemelä (1997, 1998) reported that juvenile blue foxes spent more time on wire-mesh than in a ground pen. However, in the study access to the pen went through a 1.5 m long slanting wire-mesh tunnel that could affect the juveniles' motivation to move inside the tunnel.

10.4.1. Digging behaviour

The possibility to dig is closely related to floor material. In the study by Korhonen et al. (2000), 30 blue fox males were housed in four groups; (1) traditional sized cages (80 cm long x 105 cm wide x 70 cm high) CL80, (2) 40 cm prolonged cages CL120, (3) 120 cm prolonged cages CL240, and (4) 120 cm prolonged cages with access to a ground floor cage (traditional size) CL240E. Only CL240E foxes dig an average time being 11 min/ 24 h. Blue foxes having only wire mesh floor did not dig.

Korhonen et al. also explored the digging activity of blue foxes throughout the year in pens. Six juvenile male blue foxes housed in same earthen enclosure from August to next June (6 m wide x 10 m long x 2 m high) dig an average 7 min/ fox/ day. The next part of the study consisted of 10 earthen enclosures (3 m wide x 5 m long x 2 m high) each containing two juvenile male blue foxes. These foxes spent daily an average 17 min per fox for digging from July to December. Digging sites were concentrated below and close to nest boxes and pen walls. Maximally about 20% of the total enclosure area was affected. The total surface area of digging sites did not increase from late summer onwards because foxes tended to simultaneously cover part of the old sites when digging new ones. Digging activity decreased during autumn, almost totally ceased during winter, and resumed again in May. Korhonen et al. (2000) found five reasons for digging: (1) to make a hole or a resting site, (2) to locate an escape route, (3) to hide food, faeces or sticks, (4) in response to a novel object (new nest box, replacement of nest box) and (4) displacement without any clear goal.

Damming-up theory states that when an individual has not had the opportunity to perform a specific behaviour for an extended period of time, the drive to perform that behaviour becomes more intense, i.e. dams-up. Korhonen et al. (1999) tested the predictions of this theory in 24 blue foxes. Foxes spent the first two weeks in small cage (80 cm long x 105 cm wide x 70 cm high). Thereafter, cage length was enlarged to the 120 cm. A rebound effect for digging was not found. After 10 months of exposure to the earthen floor foxes were transferred for 12 days into wire-mesh cages with no possibility to the ground. Thereafter, foxes were transferred back into the earthen enclosure to measure the rebound of digging following deprivation. A rebound effect for digging was not found.

10.5. Group housing of farmed foxes

The social structure of wild red and arctic foxes is described in sections 4.2.1 and 4.2.2. Numerous studies demonstrate large variations in territoriality, sociality, and mating system, both between and within populations (reviewed by Cavallini 1996). The motivation to socialise varies according to the social and reproductive status of the individual and the ability to survive and reproduce on its own. An aspect of equal importance is the possibility to withdraw from conspecifics. Traditional farming procedures restrict the animals’ opportunity to choose whether to socialise or withdraw. Grouping of animals as a means to improve welfare is only relevant if individuals experience the presence of conspecifics as positive or superior to being housed solitary. At present no research is completed that provides a thorough understanding of social preferences in farmed foxes. However, several studies, reported below, focus on the behavioural and physiological effects of group housing compared to solitary housing, without giving the animals options. This method does not consider the biological basis of sociality and the composition of groups is often poorly motivated. Even though naturally occurring groups of wild foxes are composed of family members, it is unknown to what extent familiarity (or genetic relatedness) *per se* is a crucial motivational factor affecting the formation and function of groups. Although helpers in the wild often are young from a previous litter, for theoretical reasons one should not expect any cub to choose to stay with the family. The motivation to stay instead of leaving the natal den should correlate negatively with the individual's resource holding power (RHP; Pusey and Packer 1997) and the ability to defend resources necessary for its own reproduction. Low-RHP offspring should be more predominantly motivated to stay in a functional group and delay their own reproduction should be predicted to show low competition and aggression compared to high-RHP offspring and parents. Research investigating such social behaviour and its consequences for the management of farmed foxes is about to start in Norway.

Under farming conditions both fox species are found to establish social groups (*silver and blue fox*: Ahola et al. 2000b; *silver fox*: Pyykönen et al. 1997, Pedersen 1997a, Ahola et al. 2000b; *blue fox*: Kullberg 1990, Korhonen and Alasuutari 1992a,b, 1995, Dørum 1997, Korhonen et al. 1997, Pedersen 1997b, Ahola et al. 2000a). The studies may be divided into two main categories related to housing procedure; (i) group housing in standard wire-mesh cages ((GS-housed) Ahola et al. 1996, 2000a; Pedersen 1997; Dørum 1997), and (ii) group-housing in large earthen (or semi-natural) enclosures ((GE-housed) Pedersen 1997a, Ahola et al. 2000b, Pyykönen et al. 1997, Korhonen et al. 1997, 1998, Korhonen and Alasuutari 1992a, 1992b).

10.5.1. Reproduction and group housing

Pedersen (1997a) GE-housed different colour mutations of the red fox in 11 groups (1 adult male and 2 adult females) and found during a three-year period that several vixens did not reproduce and loss of cubs was severe. In a study by Pyykönen et al. (1997), three silver fox vixens GE-housed in two different enclosures weaned 10 out of 14 born cubs, a cub-loss of 28 %. Thirty-one percent of GE-housed blue fox vixens did not show oestrus or abort their litters, whereas only 24 % of the vixens in the study weaned cubs successfully (Korhonen et al. 1997, 1998). In a study by Pedersen (1997b) a higher proportion of blue fox vixens housed in pairs delivered cubs compared with the number of solitary housed vixens, although litter size at weaning did not differ between groups. According to the findings of Ahola et al. (1996) there were no significant differences in either species in the number of barren females, litter size and cub loss between GE and singly housed foxes. In traditional farming, cub loss average 25 % in silver foxes and 20-30 % in blue foxes (Farstad 1998). With group housing, reproduction therefore seems to be either unaffected or reduced.

10.5.2. The HPA axis and group housing

Ahola et al. (2000b) found heavier adrenals and a higher cortisol response after ACTH administration in GE-cubs compared to singly housed silver fox cubs. In blue foxes, Ahola et al. (2000a) found a significantly lower cortisol response after ACTH-administration in cubs GS-housed as a family group with their mother compared to singly-housed controls. Dørum (1997) found no significant differences in cortisol level between GS-housed and singly housed blue foxes. A stress response therefore can occur depending on how the group is formed.

10.5.3. Physical condition, body weight and group housing

Compared with singly housed cubs, GE-cubs had a significantly higher mass of the heart and the lower leg muscle, a higher SDH activity (mitochondrial metabolic enzyme), and an increased tibia strength, indicating an exercise effect of GE-housing which may promote the physical condition of the foxes (Ahola et al. 2000b). At pelting body weight was higher in singly-housed than in pair-housed (GS) blue fox vixens (Pedersen 1997, 1998). A tendency for increased body weight among quadruple-housed (GS) as compared to solitary blue foxes was found by Dørum (1997). This was confirmed by another study (Bakken, unpublished). Ahola et al. (1996) found that both blue- and silver fox cubs in a row cage system (GS) were heavier than singly housed cubs. In the same study, singly housed blue foxes weighed more at pelting time than GE-housed foxes. No consistent effect of group housing on body weight is revealed.

10.5.4. Fear towards humans and group housing

There was no difference in fear towards humans (tit-bit test) and towards a novel object (ball) between pair-housed (GS) and singly housed blue fox vixens (Pedersen 1997, 1998). In a silver fox study, GE-cubs was more difficult to capture and reacted more fearfully to handling by humans measured as stress-induced hyperthermia (SIH) than singly housed silver fox cubs (Ahola et al. 2000b). In a study on GS-housed blue foxes, fear towards humans, measured as the distance to a human observer (intruder), declined in both GS- and singly housed foxes during the period (Ahola et al. 2000a). Also in GE-housed blue foxes fear towards humans, measured by a feeding test, decreased during the test period (no control group, Korhonen et al. 1997). The varying results may be attributed to the different methods applied to measure fear. The SIH-method involves a negative association through capture by human beings, the relative neutral presence of a human observer in the disturbance-test may have a habituating effect, while food is a reinforcing agent related to human presence in the feeding test.

10.5.5. Aggression and group housing

In GE-housed silver foxes aggressions between group members increased during the breeding season (Pyykönen et al. 1997). Dørum (1997) could not conclude whether aggression between foxes varied during the period, although there was a decrease during the period in wrestling, which could indicate both fight and play. In the same study of GS-housed blue foxes overt fights during feeding time was not documented, although agonistic postures and wrestling was recorded during a 3 min period prior to feeding. Occurrences of aggression and fights during feeding, particularly throughout the breeding season, were recorded in two GE-studies in blue foxes (Korhonen and Alasuutari 1992a,b). Another study revealed that the number of agonistic interactions between GE-housed blue foxes varied from 12±6 per 24 hours in submissive females to 69±49 in dominant males (Korhonen et al. 1997, 1998).

With regard to damage of the fur, Dørum (1997) found no significant differences between singly and group housed foxes, although damage of the *skin* was significantly higher among group-housed foxes. Korhonen et al. (1997, 1998) reported inferior fur quality of foxes group housed in ground floor enclosures, although the result seems to refer to soiling and not to bite wounds or scars in the skin.

10.5.6. Activity and group housing

The activity level was higher in GS-housed blue foxes than in solitary foxes in the study by Dørum (1997), although this was not the case in silver foxes housed in ground floor enclosures (Pyykönen et al. 1997). GS-housed blue fox cubs were recorded to be together with one or more companion in 70 % of the observed time (Dørum 1997), although during the autumn period foxes spent increasing time by themselves. In the same study social grooming was recorded only once.

10.5.7. Stereotypies and group housing

In blue foxes a lower level of stereotypic behaviour was found in group-housed compared with solitary housed foxes (Dørum 1997). The stereotypies observed were mainly directed towards the wire-netting.

10.5.8. Composition of groups

Dørum (1997) recorded behaviour of GS-housed blue fox cubs housed in groups of four littermates or with four unrelated cubs during a three-month period from August to November. There was no significant difference in interaction level or synchrony of activity between sibling or non-sibling groups. No significant difference in base level of cortisol was detected between sibling and non-sibling groups in the same study. During a three-minute period prior to feeding, siblings were found to display open-mouth signals more often than non-siblings. In the non-sibling group wrestling was more frequent during the pre-feeding period than in the sibling group (Dørum 1997). No difference was found in damage of fur or skin between sibling and non-sibling groups. Keeping littermates together might be slightly preferred, but no major problems of housing unrelated cubs together were detected.

10.6. Reproductive Problems

Knowledge of reproductive performance of foxes is scarce both in natural conditions and in farms. Both fox species give birth to cubs in underground dens and therefore it is practically impossible to get direct evidence of what is happening there at the time cubs are born.

Table 8. Reproductive performance of silver and blue foxes in semi natural environments

Group composition	Pen, m^2	Observed litters Expected litters	%	Ref
Silver foxes				
1 M+2 F	29	6/22	28	1
1 M+1-4F	1000	7/27	32	2
1M+1F	54-120	5/12	42	7
Blue foxes				
1 M+1 F	450-900	4/8	50	4
1-3M+1-4F	88,126	4/18	22	5

1=Pedersen 1997, 2=Macdonald1980, 3=Kullberg and Angerbjörn 1992,4=Malm 1995, 5=Korhonen and Alasuutari 1994, 6=Korhonen et al.1997, 7= Pyykönen et al. unpublished

Some causes of reproductive failure in farmed blue and silver foxes can be regarded as “normal”, such as stillbirth, death of a weak cub and congenital anomalies. On the other hand, some causes of cub losses are classified as “abnormal”, such as infanticide, abandonment of offspring as a result of stress. However the usefulness of this popular distinction is limited.

A survey of all fox farms in Germany showed that 45% of silver foxes and 40% of blue foxes failed to breed. In Scandinavian countries, the proportions of non-mated and barren vixens were 0-13.4 % and 10.3-20 %, respectively, in 1981-82. In 1995-99, 18.3 % were barren in Denmark and 11.9 % in Norway.

The litter size of silver foxes has slowly increased during the last century. Average litter sizes at birth are quite uncertain, as farmers usually avoid disturbing vixens during the first 2-3 weeks postpartum. While on average 2.69 cubs were weaned per mated vixen in Denmark in 1941, during 1995-99 this figure averaged 3.25 in Denmark and 3.28 in Norway (Dansk Pelsdyravlerforening 1980; Den Norske Pelsdyrkontroll 1999). In 1941, 8.5 % of the vixens were non-mated and 12 % of the mated ones were barren (Dansk Pelsdyravlerforening 1980). During 1995-99, 15.3 % of Danish and 11.8 % of Norwegian silver foxes were barren (Den Norske Pelsdyrkontroll 1999). During 1995-99 cub mortality was 16.8 % in Norway (Den Norske Pelsdyrkontroll 1999). Although these figures may vary according to a number of reasons (incl. stockman’s skill and selection intensity), the increase in the proportion of successfully reproducing vixens seems to be negligible. This might reflect natural features of the reproductive system in red foxes. Average body weight is 6.4 kg in females and 7.6 kg in males, whereas in wild red foxes females weigh 4-6 kg and males 5-7 kg (Einarsson and Skrede 1989; Lloyd 1980).

Because of the large litter sizes with small kits in blue foxes, and pronounced kit mortality, records of litter size at birth may be highly inaccurate. While it was reported to be 7-8 cubs around 1940, Danish estimates in 1981-82 were 6.0-7.8 cubs per litter. Litter size at weaning per mated vixen was on average 4.7-5.5 in 1981-82 and during 1995-99 5.5 in Denmark and 5.8 in Norway (Den Norske Pelsdyrkontroll 1999). During 1995-99 cub mortality was 22 % in Norway (Den Norske Pelsdyrkontroll 1999).

Analysis of the reproductive performance was carried out on 10794 silver fox and 3238 blue fox and 10471 silver x blue cross fox vixens in Finland. As these data was based on material collected from farmers, a detailed analysis on causes of cub losses could not be performed. Of silver fox vixens 16.2 and 13.5 % of primiparous and multiparous vixens, respectively, lost their cubs. The corresponding figures for blue fox vixens were 11.4 and 8.8 %, respectively. An analysis of cub losses for 392 primiparous and 744 multiparous blue fox vixens was carried out by checking the nest boxes three times a day. This analysis revealed that 15.7 and 10.3 % of cubs born to primiparous and multiparous vixens, respectively, were lost before weaning. These figures are very similar to those based on a larger number of animals. A detailed analysis, the parities combined, revealed further that some cub losses occurred in about half of the litters (46.9 %), 5.9 % of cubs were stillborn and postnatal cub mortality amounted to 11.4 %. The first study mentioned above is important because the material includes also 437 and 120 silver and blue fox vixens, respectively, that had been barren and 98 and 74 silver and blue fox vixens, respectively, that had given birth to but lost all their cubs in the previous year. Of barren vixens in the first year, 30.0 and 30.8 % of silver and blue fox vixens, respectively, were barren in the next year as well. In comparison, of successful reproducers in the first year 24 and 18.4 % of silver and blue fox vixens, respectively, were barren in the next year. Of silver fox and blue fox females that had lost all their cubs in the previous year 17.3 and 21.6 %, respectively repeated this in the next year. Compared to vixens that had kept their litters in the previous year, 11.7 and 16.1 % respectively, these figures are higher, but not substantially. From these figures the following conclusions can be drawn: 1) as only 1 % of silver fox vixens (2.3 % in blue foxes) were those that had lost heir cubs in the previous year, the farmers believe that cub loss (infanticide?) is a repeatable trait and for that reason they automatically cull those animals that display that trait. 2) As a result, to get enough material to study the repeatability of the trait under practical farm conditions a huge number of animals would be needed. 3) Repeatability of reproductive failure is not necessarily as obvious as is believed.

Killing and injury of cubs by their mother have been reported as a common problem on fox farms (Nimon and Broom, 2001). This statement is based on the results of two studies. In one of these studies, silver fox vixens were video recorded in their nest boxes before and after whelping. Of the 39 whelping recorded infanticide occurred in the case of 17 (44%) whelping. However, the data set of this study do not represent the true farm situation. Because the objective of this study was to describe the phenomenon infanticide, the sample was deliberately selected. For example, five of the 16 multiparous vixens were selected initially for the study because they had a history of previous infanticide. Normally those vixens are not accepted for breeding.

In Canada an attempt was carried out to identify causes for cub mortality in silver foxes in an attempt to find those management procedures which might contribute to cub losses. In 1986, a total of 72 cub carcasses were received from private farms for autopsy. Of the 58 cubs which were not decomposed, diagnosis was dystocia. or difficult birth in 21 (37 %), starvation in 12 (22 %), no diagnosis in seven (12 %), and congenital kidney defects in two (3 %). In 1987, of 61 pups dystocia was the death cause in a total of 73 pups received, but 12 were unfit for the analysis. Diagnosis made on the remaining 61 pups were dystocia in 36 (59 %), injury in 14 (23 %), no diagnosis in three (5 %), abortion in two (3 %), infection in two (3 %). Out of 109 pups which died, 14 died because of injuries. They were one to three days old and originated from one and the same farm. Necropsy revealed subcutaneous haemorrhage over the ribs, broken ribs, and many ruptured livers. A review of the farm revealed that a disturbance had occurred the previous day. These injuries were different from those resulting from infanticide and, furthermore, infanticide usually is not necessarily associated with a disturbance. However, since the cubs were supplied by farmers who might not have sent all dead cubs and since some cubs subject to infanticide could have been eaten, the data are not reliable as an indication of the incidence of infanticide.

An analysis based on farmer’s record on a large number of blue foxes in Finland revealed that on the average 26.1% of blue fox vixens are barren and 12.3 % of cubs are lost before weaning. A careful record of reproduction of 2,413 blue fox vixen in Carelia revealed that on the average 84.8 % vixens give birth to cubs, some cub losses occur in about half of the litters (46.9 %) and highest losses occur immediately postpartum decreasing exponentially with time. Of the cubs born, 5.9 % were stillborn and 11.4 % died before weaning. Only in a very few cases (1.3 %) was the whole litter lost. Abnormal birth and abortion of a part of a litter contributed most to prenatal reproductive failure of the vixen. Infanticide played a minimal role (0.3%) as a cause of postnatal cub mortality, and death of a vixen was extremely rare.

These results were confirmed by Pyykönen et al. (1998): a careful video-recording of 17 blue fox vixens did not reveal a single case of infanticide. Some cubs died because of weakness and were later eaten by the vixen but cub killing as the primary cause of death was not recorded.

Table 9. Reproductive failure in farmed blue and silver foxes

		Cub losses, %					
N	Barren %	Total	Infanticide	Stillborn	Total	Farm	Ref
Blue foxes							
2413	15.2	17.3	0.3	5.9		Exp	1
3238	26.1	12.3				Private	2
59	14.0	9.3				Exp	3
All Germany					40	Private	6
Silver foxes							
10 794	28.6	15.1				Private	2
535[a]	23.3	20.7-22.0				Private	4
200[b]	6.0-14.8	7.6-8.9				Private	4
39		43.5[c]	37-16[c]	1.4-2.3		Exp	5
All Germany					45	Private	6

[a] Standard nest boxes

[b] Nest boxes with tunnel entrance

[c] Infanticide occurred in 17 out of 39 litters: percentage of dead cubs dying from infanticide by primiparous and multiparous vixen

1=Ilukha et al. 1997, 2=Smeds and Ojala 1991, 3=Korhonen and Niemelä 1995, 4= Braastad 1994, 5= Bakken 1993, 6=Haferbeck, 1983.

10.7. Social stress and infanticide among singly-caged silver fox vixens

10.7.1. Infanticidal behaviour

The marked problems with reproduction and cub survival in several farms motivated the first behavioural studies on farmed silver foxes in Norway (Braastad 1993). The studies of Braastad and Bakken on maternal behaviour in farmed silver foxes were partly based on behavioural ecology theories on maternal investment and helper strategies in social mammals in high-density populations. The periparturient behaviour was recorded inside the breeding box by a specially designed camera box with an infrared light mounted on top of the breeding box (Braastad 1993). In this study, 75 % of the cub-loss prior to weaning was attributed to infanticidal behaviour, although it is important to notice that some of the vixens were chosen for the study because they had earlier been infanticidal. Infanticide usually occurred during the first postparturient day in primiparous vixens, but often also later until six days of age in multiparous vixens. The vixens usually ate all dead cubs whatever the cause of death. This could happen already after a couple of hours, or at least during the first 24 hours. Finding a half-eaten, dead cub is therefore no proof that the mother killed it (Braastad 1987, 1993). Infanticide is qn important welfare problem for the cubs because of their likely high sensitivity to pain. A clear relation between infanticide and tail-biting of the cubs was described. Infanticide frequently started with tail-biting, and some vixens only bit tails in some years and killed offspring in other years (Braastad 1993). Tail-biters should therefore always be removed from the breeding stock.

Given that shortage of food is the main reason for reproductive failure in nature while poor farm environment contributes to cub losses on farms, a semi natural environment with unlimited food supply and more freedom than in farm environment should bring about an optimal reproductive performance in foxes. However, in all those studies in which reproductive performance has been evaluated for foxes housed in large outdoor, soil-bottomed pens their reproductive success has been inferior to farm situation or to nature (see Table 8). Despite the small number of studies, the results show that extensive housing per se does not guarantee optimal reproductive conditions. Several reasons can account for that, for example easier female rejection of males when more space is available. Clearly if the objective is to improve reproductive performance of farmed foxes, more specified and systematic approaches are needed.

10.7.2. Competition capacity

Experiments with foxes have shown that they influence each other when kept in conventional single cages with wire walls as a separation. The nature of this influence has been studied in relation to their *competition capacity*, which is estimated by food competition tests at 5-7 months of age in a neutral cage where vixens compete for access to a food item twice with one unfamiliar vixen (Bakken 1992, 1993a). This is repeated three times with different randomly chosen vixens, and the overall success rate, from 0 (no wins) to 3 (won all), is termed the competition capacity. This measure is considered to reflect individual characteristics to a greater extent than the term *social status*, which is heavily dependent on who are the neighbours.

Silver-fox cubs of either sex showing the higher activity in an open-field test at 30 days of age (more lines crossed and more squares entered) had a higher competition capacity when tested at seven months of age (Bakken 1992). The active and highly competitive female cubs showed a higher reproductive success in their first reproductive season (Bakken 1992, 1993a). Females exhibiting infanticide were virtually always of low competition capacity (Bakken 1992). While multiparous vixens in general reproduce better than inexperienced mothers, competition capacity was found to be a better predictor of reproductive success than age (Bakken 1993a).

10.7.3. Social strategy and neighbour relations

Neighbour relations turn out to be important for the reproductive performance. Vixens were tested for competition capacity and grouped into three different categories: high competition capacity (HCC: CC>2), medium competition capacity (MCC:1<CC≤2) and low competition capacity (LCC: CC≤1; Bakken 1993b). The vixens were placed under different neighbouring conditions from October to the end of their reproductive season in June/July the subsequent year; HCC with LCC neighbours (at both sides), HCC with HCC neighbours, MCC with MCC neighbours, LCC with HCC neighbours, LCC with MCC neighbours, and LCC with LCC neighbours.

The HCC vixens both gave birth to and weaned unharmed significantly more cubs than the LCC vixens, but the differences between the groups was greater in regard to number of cubs weaned than to number of cubs born (Bakken 1993b). The HCC vixens both gave birth to more and weaned more cubs unharmed when having LCC vixens as neighbours than with HCC neighbouring vixens. HCC vixens with LCC neighbours showed the highest reproduction among all subgroups. Infanticide among HCC vixens was only found in some that had HCC neighbours. The LCC vixens did not wean any cub unharmed with neighbouring vixens of higher competition capacity than themselves as neighbours, but they weaned some with other LCC vixens as neighbours. Among the HCC vixens that successfully weaned cubs, the HCC vixens with LCC neighbours had a male-biased sex ratio (72.7 % males) and their female cubs were 11 g (1.4 %) heavier at thirty days of age than their brothers (Bakken 1995). By contrast, the HCC vixens with HCC neighbours had a female-biased sex ratio (30.8 % males) and their female cubs were 79 g (8.3 %) lighter than their brothers. Thus, it appears that if highly competitive females during gestation had neighbours with high competition capacity, they produced a female-biased litter in which the females had relatively low body weight. If the highly competitive females had neighbours of low competition capacity, they produced a male-biased litter with females of high body weight. The author concluded that, in the first situation, with potentially high competition, the females might be suggested to produce low-quality helpers for their later litters. A case of a helper strategy was indicated by a farm vixen of low competition capacity that first killed her own offspring and subsequently reared successfully one of the offspring of a neighbouring dominant (HCC) vixen (Bakken 1993a). In the second situation, reproduction of grand-offspring seemed to be favoured by strong, dispersing female offspring that may be expected to acquire a high resource holding power (RHP, cfr. introduction to 10.y).

Infanticide is described in nature. It occurs in many species including primates, but at a low incidence (Hrdy 1979). Among several proposed mechanisms for natural populations, the observations on farmed silver foxes are in line with predictions from the parental manipulation hypothesis, which states that the females, by terminating maternal investment in situations where the probability of successfully raising cubs is small, can increase their lifetime reproductive success and/or inclusive fitness (Hrdy 1979, Hausfater and Hrdy 1984, Bakken 1994).

10.8. Effects of prenatal stress in foxes.

10.8.1. Prenatal stress and its general effects and mechanisms

Prenatal stress may be defined roughly as stress experienced by the pregnant mother which affects the development of the offspring (Braastad 1998). Cognitive and emotional aspects of the stressor operate on the mother directly, not on the offspring. Most reports are based on studies in the last third of pregnancy, but effects of stress in earlier periods and even around mating are reported. Studies, mainly from small rodents and primates, have reported a female-biased sex-ratio at birth, and unfavourable effects on locomotion, play, exploratory behaviour, fearfulness, learning ability, social behaviour, aggression, sexual behaviour, and maternal behaviour, and on their reproductive success in the first, and sometimes also in the second, generation (Braastad 1998). In normal situations without challenge behavioural effects of prenatal stress are frequently not seen. Individual variation in the susceptibility to prenatal stress may exist. In some studies, females are reported to be more susceptible than males. Behavioural inhibition and anxiety when exposed to novelty are typical results that may underlie the effects of prenatal stress on learning and various behavioural responses. Prenatal stress may be associated with reduced birth weight, and reduced weights of adrenals and gonads (Braastad 1998).

The effects of prenatal stress may be mediated by stress-induced excess of glucocorticoids in the pregnant mother which pass from maternal to foetal circulation and influence the development of the foetal brain, as shown in rats and sheep (Zarrow et al. 1970; Wood and Rudolph 1984). Increased responsiveness to stress in the hypothalamus-pituitary-adrenocortical (HPA) axis after prenatal stress is frequently reported in adult offspring of rats, resulting in increased plasma levels of adrenocorticotropic hormone (ACTH) and corticosteroids (e.g. Takahashi and Kalin 1991; Henry et al. 1994). In a review article it is concluded that prenatally stressed animals show impaired coping in stressful situations, and that this is associated with deregulation of the HPA axis characterized by decreased feedback inhibition of corticotrophin-releasing hormone (CRH) and prolonged elevation of plasma corticosteroids (Weinstock 1997). This reduced negative feedback is due to down regulation of glucocorticoid receptor gene expression in hippocampus and frontal cortex (Meaney et al. 1996) with decrease in type I hippocampal corticosteroid receptors (Barbazanges et al. 1996). These effects are quite opposite to those found in animals which are exposed to postnatal handling with maternal deprivation (e.g. Ogawa et al. 1994) or increased maternal care (Liu et al. 1997). This also suggests that early handling can alleviate some of the negative effects of prenatal stress. There is increasing evidence for a role of excessive β-endorphin in the prenatal stress effects (Weinstock 1997). Since behavioural and neuroendocrine effects of prenatal stress in rodents are quite similar to those found in depressed humans, and since increased fearfulness and frustration is implicated (Checkley 1996; Weinstock 1997), it may be predicted that farm animals subjected to prenatal stress will show reduced ability to cope with a difficult environment and increased propensity for developing behavioural disturbances and reduced welfare (Braastad 1998). Farm animals may potentially experience several types of premating and prenatal stressors. Animals may be exposed to handling by humans in connection with mating or insemination and during gestation, inadequate and frustrative housing conditions, social stress related to dominant neighbours, crowding, or transport or being moved to another pen or cubicle with disruption of social contact and exposure to novel stimuli. These situations may not always cause stress, but may do so in some individuals (Braastad 1998).

10.8.2. Research on prenatal stress in animals kept for fur production

In farmed silver foxes (*Vulpes vulpes*) there is clear evidence that the animals may be fearful or stressed by the presence of humans (Braastad 1988; Pedersen and Jeppesen et al. 1990; Bakken et al. 1999), or by handling by humans (Olsrød et al. 1992; Moe and Bakken 1997a,b, 1998). In a study that aimed at reducing this human stress in pregnant foxes that earlier had proved to be successful reproducers, the subjects were given titbits (a dog biscuit) twice a week during gestation (Bakken 1998). These foxes produced a male-biased sex ratio. Their female offspring were heavier than control females and crossed more lines in an open-field at 30 days of age. Such high-quality daughters would not be expected to become helpers. One interpretation of this result could be that the titbit-giving reduced social stress in the mothers during gestation by signalling a human helper function, thereby reducing the need for producing helping offspring.

In 1996 experiments were started to investigate the behavioural and hormonal developments in blue foxes (*Alopex lagopus*) subjected to prenatal stress. The stress treatment consisted of taking the pregnant vixen out of its cage with neck-tongs, holding it for one minute and putting it back, once daily during the last third of the gestation (15 days). Plasma concentrations of ACTH, corticosteroids, and sex steroids and *in vitro* production of corticosteroids in adrenals (with and without added ACTH as stimulant) and sex steroids in gonads (with and without added gonadotropins, hCG) were studied in pregnant females and their foetuses two days prior to expected birth, and in offspring at 10 days of age (Braastad et al. 1998; Osadchuk et al. 2001a,b). Behaviour in novel situations were studied at 35 days of age (Braastad et al. 1998).

10.8.3. Physiological effects of prenatal stress on pregnant blue-fox vixens and their foetuses

In pregnant vixens, daily prenatal handling in the last third of gestation increased plasma concentrations of cortisol and ACTH as well as *in vitro* cortisol production in the adrenals (Osadchuk et al. 2001a). Handling did not cause any changes in adrenal weight, plasma progesterone or oestradiol concentrations or in basal steroid production by the ovaries. The oestradiol response of the ovaries to hCG tended to be lower in handled females than in controls. In addition, handling decreased the ovarian weight to 79% of the control. The body weight and litter size of viable foetuses were lower after the handling treatment (Control: W=59.1±0.9 g, N=12.2±1.9 vs. Handling: W=50.6±1.2 g, N=8.3±1.4). Ten of 11 dead foetuses were from the handling group. It was concluded that consistent handling of pregnant blue foxes resulted in a profound stress response, as indicated by the activation of the HPA axis. Furthermore, the results suggest that this handling had a detrimental effect on ovarian function and foetal survival.

Foetuses of prenatally handled vixens had significantly lower body and adrenal weights than controls. Increased plasma cortisol and progesterone concentrations were found in both sexes, while decreased ACTH levels were found in female foetuses, of the handled group. The plasma cortisol level of male foetuses correlated highly with levels in their mothers in the handled group ($r = 0.71$), but not in the control group. Basal adrenal *in vitro* productions of cortisol were similar in test and control groups. Prenatal handling prevented the normal cortisol response to ACTH in female foetuses. In the handled foetuses, the adrenal content and *in vitro* production of progesterone, particularly in females, were decreased and not correlated with a higher plasma progesterone level. The results indicate that glucocorticoids at an increased level in the stressed vixen may cross the placenta to the foetal side and induce a deregulation of the pituitary-adrenal axis in the foetus. The findings also demonstrated sex differences in the response of the foetal HPA axis to maternal stress in late pregnancy: in general the effect of stress was more marked in females, as also described for rodents. Overall, the results confirm that daily prenatal handling in the last trimester of pregnancy stresses blue fox vixens and affects the development of stress mechanisms in their foetuses.

10.8.4. Physiological effects on neonatal fox offspring

At 10 days of age, the adrenals of prenatally stressed blue-fox cubs (PS) weighed only 60% of those in the control group (C), while body weight was equal in PS and C cubs (Braastad et al. 1998). The serum level of progesterone and the *in vitro* adrenal production of progesterone were higher in PS than C cubs. In PS females the *in vitro* adrenal production of cortisol was higher than in C females. In general, the effects on progesterone paralleled the effects on cortisol. These results indicate that prenatal stress may enhance the postnatal adrenocortical function. In the same study, prenatal handling stress resulted in a significant reduction of morphometric and hormonal measures of the reproductive system in neonatal blue foxes, with more drastic effects in female cubs (Osadchuk et al. 2001b). The maternal stress reduced the *in vitro* ovarian production of oestradiol and testosterone, the ano-genital distance and ovarian weight. Prenatal handling stress had no marked effects on the neonatal development of the male reproductive system in the blue foxes. In conclusion, the findings suggest that prenatal handling stress impaired the neonatal reproductive development of the female offspring, but had no marked effects on males. This may reflect sex differences in sensitivity of the developing hypothalamo-pituitary-gonadal (HPG) axis to glucocorticoids. In general, activity in the HPA axis may inhibit activity in the HPG axis (Rivier and Rivest 1991), accounting for the generally known negative effect of stress on reproduction.

10.8.5. Behavioural effects on fox cubs

At 35 days of age, three behavioural tests were performed in succession on prenatally stressed and control blue-fox cubs (Braastad et al. 1998). In a Human test, the cub was held up by hand in a standardized way for 20 s. It was recorded whether and how persistently the cub tried to escape. In an Open-field test, with 5x5 squares, the number of different squares entered and the total number of line crossings were recorded during three minutes. This was followed by a Box test, where the cub placed in a small box was allowed 30 s to re-enter the open field. In the Human test, fewer prenatally stressed cubs than control cubs calmed down during the 20 s (Fisher’s exact test, two-tailed, P=0.034). The activity in this test consisted of escape attempts, biting, and aggressive signals. During the Open-field test, prenatally stressed cubs on average showed a higher number of line-crossings than did control animals (t=2.02, P=0.047). They also entered a larger fraction of the 25 squares (t=2.03, P=0.047). No difference was found in the fraction of central to peripheral squares used by the groups. In the Box test, a larger fraction of prenatally stressed cubs than of control cubs re-entered the open field from the box (χ^2 =5.71, P=0.017). Cubs that entered the open field previously showed a higher activity in the open field than non-entering cubs (no. of crossed lines: 92.8±12.7 vs. 49.4±5.3, t=3.17, P=0.004; no. of squares entered: 22.1±0.9 vs. 16.4±0.8, t=4.67, P=0.0001). No sex differences were observed in the behaviour tests. These results indicate a higher behavioural reactivity in novel situations in prenatally stressed cubs.

10.9. Stereotypies

The occurrence of stereotypies has been detailed in blue and silver fox by means of both direct observation and video-recording. Four main categories of possible stereotypies were observed: (1) locomotor stereotypies alone (repeated pacing, including pacing and jumping along a cage wall or around in the cage with or without a twirl of the head); (2) locomotor stereotypies with neighbour (repeated pacing and jumping along a cage wall with a neighbouring fox); (3) manipulative stereotypies (including scratching, digging, licking and biting the cage), and (4) tail-chase (repeated chasing and biting of own tail). These behaviours were observed in blue foxes: 2.7, 0.6, 21.6 and 0.8 minutes/24 h and in silver foxes: 4.5, 2.9, 18.5 and 2.2 minutes/24 h.

Korhonen et al. (2000) measured locomotor and oral streotypies for juvenile blue foxes housed in 80 cm, 120 cm and 240 cm long wire floor cages and 240 cm long earthen floor cages. Cages in all groups were 105 cm wide and 70 cm high. Blue foxes in all groups performed stereotyped behaviour an average 14 min/24 h corresponding to 4 % of total active time. The occurrence of stereotypies for blue foxes was 17.0, 0.5 and 3.0 minutes/24 h and for silver foxes 3.6, 1.4, 1.3 and 0 minutes/24 h.

Categories 2 and 3 do not necessarily fulfil all the criteria of a true stereotype since they may have an obvious function. At the time the research was carried out foxes are replacing their teeth, and this may partially explain the large category of manipulative stereotypies. The foxes may have a need to gnaw on something. Locomotor streotypies with neighbour in turn, may be contact seeking behaviour.

10.10. Body mass of blue foxes

Over the years there has been a tendency towards increased body size in blue foxes. The increased body mass might impact on bones and joints of the legs and cause locomotion disturbances. These foxes tend to have a plantigrade locomotion and some of them may suffer from disturbances in the calcification of the long bones. Hereditary and dietary factors may be involved. The research on osteochondrosis is insufficient, but some parallels can be drawn with the problem of fast growing pups of big dog breeds.

Wild arctic foxes live in areas with an unpredictable food supply. They have a tendency to lay down fat during the autumn. Farmers have taken advantage of this biological character of the blue foxes in their breeding program. Body mass of farmed blue foxes (*Alopex lagopus*) has substantially increased due to the intensive selection during the last decades. At pelting, blue foxes were reported to weigh about 6 and 7 kg in 1955 and 1970, respectively while in 1996, body mass of the foxes amounted already to 11 kg.

As shown, the body mass of blue foxes has increased during the last decades. Attempts to achieve as long a skin as possible by effective selection and strong feeding leads easily to excessive fattening (Ahola et al. 1996).

Feeding make up the major of the cost of the production of a skin while skin length is the most important factor affecting the price of the skin. Both feed intake and skin length increase with increasing body mass.

The impact of steadily increasing body mass on the welfare, including health, of blue foxes has begun to be investigated in Finland. The economic value of this phenomenon will also be evaluated.

10.11. CONCLUSIONS

1. Measures for the assessment of animal welfare, including physiological, reproduction and behavioural measures, which have been used for a variety of animal species have only recently been used for farmed foxes, and some of them are in need of validation.

2. Behavioural responses of foxes in various test situations can be measured, using a range of standardised tests to characterise each animal’s degree of fear, aggression, confidence, passivity, etc. Again, adequate validation is needed.
3. Abnormal behaviours such as exaggerated fear response, infanticide, stereotypies and pelt biting are described in farmed foxes but not well quantified.
4. Annual mortality rates for juveniles and adult foxes on fox farms are about 5%. A variety of diseases occurs in foxes but diseases are generally controlled. Data on overall morbidity levels are not readily available but, on average, are not likely to be high.
5. Foxes are kept under natural light and climatic conditions.
6. The typical fox cage does not provide for important eeds of foxes. In particular, it imposes monotony of the physical environment, restricts physical exercise and species-specific behaviour such as digging. In relation to the lack of physical exercise, limb bones are significantly weaker than those of foxes kept in large cages where more exercise occurs. However, limb breakages are not often reported.
7. Several aspects of husbandry can impair fox welfare. Most common welfare problems are fearfulness, and reproductive problems related to the social environment.
8. Less common problems are locomotor problems in heavy blue foxes, and entropion in blue foxes.
9. Possible welfare issues that have not been investigated include weaning age, isolation of aggressive pups, restrictive feeding, dental problems and nail length.
10. Fearfulness of humans is a common feature of foxes on commercial farms. Genetic selection has been used experimentally to produce much less fearful foxes and experience of gentle human handling can substantially reduce fear. However, the less fearful genetic strains are not being used commercially, and farmers are not necessarily devoting the substantial amount of time which is needed for handling of all their foxes. As a consequence, fear of humans is a major and very widespread welfare problem on fox farms.
11. Failure to produce and rear litter of cubs has been reported to occur in up to 45 percent of silver foxes and 40 percent of blue foxes in German farms. On farms in Nordic countries, the figures are 18-44 percent in silver foxes and 23-38 percent in blue foxes. However, significant failure to produce and rear litters occurs in wild foxes. Infanticide is an important welfare problems since cubs are likely to be highly sensitive to pain. Therefore, the extent to which failure to conceive, abortion, and failure to rear cubs can be solved is not clear. Reproductive success on farms can be slightly improved by changes in the physical and social environment such as handling, tunnel entrances and status in relation to neighbours.
12. Prenatal stress influences physiology and reproduction of the mother and physiology and behaviour of the offspring in blue foxes. The implications of these effects for welfare have not been assessed.
13. The welfare consequences of group housing are not well understood due to the lack of basic knowledge on the social biology of foxes and on family dynamics in general. Some group composition can lead to stress and aggression. In farm conditions in which group housing has been tried, problems occur. It is not yet

known whether the welfare is better among group-housed than among singly housed foxes.

14. The type of nest box during the breeding season appears to be important for silver and blue foxes, which reproduce better in boxes with an entrance tunnel. The position of the nest box in the cage is important for both species, which show a preference for an elevated breeding box.
15. Both fox species use nest boxes outside the breeding season, but there is substantial inter-individual variation in the use. These so-called nest boxes may function as hiding places but are not used as shelter against cold weather. Elevated boxes are preferred in both species. Use of nest boxes may increase fear of humans in juveniles of both species and in adult blue foxes.
16. Both fox species use platforms, but there is substantial interindividual variation in their use. Platforms are less used in cold weather in farmed blue and silver foxes and they have no effect on reproductive performance. Wooden surfaces are not preferred to wire mesh surfaces as a resting place in farmed blue and silver foxes. Both fox species prefer an unobstructed view from their cage. Resting platforms without walls do function as observation places.

11. THE WELFARE OF CHINCHILLAS

Little information is available both on the methods that allow assessing welfare of chinchillas and the possible environmental factors that impact on the welfare of animals of this species in farming conditions.

11.1. Behavioural disturbances

Kersten (1996) observed 11 animals during 24 hours, at three different Dutch chinchilla farms. Two of these animals performed obvious stereotyped behaviour, in the form of pacing. They spent 1-2 hours in this pacing, which was up to 21 % of their active behaviour. During global observations of other animals, stereotyped behaviour was seen as well, mostly during darkness. Three other animals showed a routine, i.e. an endless repetition of various patterns resulting in moving around through the pen, which can be interpreted as stereotypy very well. De Jonge included repetitive behaviour, like described by Kersten, into the category of stereotyped behaviour, during his studies on mink.

Pelt-biting is observed with a high frequency and between 10 to 30 % of the stock suffer from this either induced by themselves or by other chinchillas. Kersten (1996) reported that, from farm to farm, 3 to 7 % of the pelts were damaged. Haferbeck (1982) reported that 10 % of American pelts were damaged, due to pelt-biting, and he suggested that disturbances and the absence of raw feed such as coarse straw, promotes pelt-biting. Other possible causes include heredity, malnutrition, deficiency of certain amino-acids or lipids, boredom, and environmental stressors such as noise and to high density. Pelt-biters have a 40 to 60% higher feed consumption on a daily basis and a higher oxygen need and thyroxin-excretion.

Wounds do occur, but most of them presumably result from fighting and not from self damaging behaviour. Kersten (1996) counted wounds at three Dutch farms and assessed that 1 to 3 % of the animals had severe wounds like wounded or lacking ears, lacking eyes and shortened tails.

Several individuals on Dutch farms wasted so much feed that feed wasting may considered to be a new category of abnormal behaviour (Schuurman, 1996).

Organ alterations, such as ulcers and enlarged adrenals, are not reported, but were presumably never been investigated.

11.2. Reproduction

Chinchillas may get as old as 20 years of age. Hence, the natural reproduction rate is low, as compared with most other rodents. The presumed reproduction rate of wild chinchillas is three litters of 1-6 pups per year. If so, the reproduction on farms is suboptimal. Worldwide, the annual production is reported to be on average 2.2 pups per female.

Kersten (1996) analysed data of some Dutch farms. Females may produce three litters per year, but Dutch chinchillas produce only about 1.5 litters per year. Litter size is mostly 1-3, whereas litters of 6 are known. So, one may expects an average production of more than 4 pups per year, an average of 2 were assessed.

The reproduction rate is depressed by rather high pup mortality. The mortality rates at Danish farms, in 1983-1987, from birth until 6 months thereafter were: 24 %, 23 %, 26 %, 25 % and 23 %. From birth until weaning these rates were (1983-1986): 21, 21, 23, and 23 % (DPZ, 1985, 1986, 1988, 1989). One must bear in mind that chinchillas are born well developed after a long gestation period (on average 111 days); they are fully furred, their eyes are open and they are able to locomote immediately after birth. The birth weight is about 40 g. Adults weigh 500 (males) to 800 g (females); thus the birth weight is 5-8 % of the adult's weight. A far better survival rate must be possible with these figures. The birth weight of mink kits is 0.3 % of the adult's weight after a gestation period of only 42 days. Still, the survival rate in farmed mink is better than in chinchillas.

The presumed monogamous nature of chinchillas may entail that not every male and female form a good pair. Anyway, only 26 % of the copulations are reported to be successful. Kits are vulnerable after weaning, when they have to learn to eat pelleted food. A problem may be that chinchillas are often hindered from consuming the placenta, because it may drop through the wire mesh bottom; in many mammal species, the placenta contains vital nutrients.

If it was easy to solve the reproductive problems, the solution would have been available. Bickel (1983) thinks that the feed of pellet and hay is insufficient. He argues that chinchillas will benefit from more green vegetables and fruits.

11.3. Morbidity and mortality in Chinchillas

There are only a few publications on the occurrence of diseases in farmed chinchillas. The following descriptions are taken from a Danish report (Sanotra, 1985) and from a Danish Breeder's manual by Christensen (1989). In Christensen (1989) some statistics on the mortality of young is presented. Overall a mortality of 24% of live born young was observed in the years 1983-1987. In another study the mortality of young was defined to be caused by pneumonia in 47% of the cases, starvation in 16% of the cases and listeriosis in 1% of the cases. The other 26% mortality was caused by various infections.

Gastrointestinal disease is the most common occurring cause of death in chinchillas. Constipation in the large intestine or the caecum is often found when performing an autopsy of a chinchilla. Diarrhoea is another common disease often caused by the bacteria *Pseudomonas aeruginosa,* which is widely spread in hay, straw and earth. The chinchilla will be immune to infections of this bacteria unless their immune system is weakened by malnutrition or decayed feed. Diarrhoea can also be caused by a parasite, *Giardia intestinalis*, which multiply in the intestines. Both young and adults can suffer from gastro-enteritis. It is followed by a high mortality with few symptoms. Stress, bad hygiene, deficiency of vitamins, decayed feed, dirty water or water cups as well as pollution by chemicals in the feed can cause gastro-enteritis. Symptoms are reduced appetite reduced general well-being, going into total apathy and sudden death.

Bloat is an accumulation of gas in the stomach caused by sudden changes of the composition of the feed and/or lack of Bacillus acidophilus in the intestines. It is more common amongst juveniles and symptoms are restlessness, swollen stomach and the animal lies in the cage with outstretched legs, obviously in pain.

Listeriosis is a common infectious disease caused by the bacteria, *Listeria monocytogenes*. It attacks the nervous system resulting in cramps, blindness and prolapse of the rectum. If pregnant females are affected they either abort or give birth to weak young which die early in life. Symptoms are apathy and reduced appetite and the animal will crouch and make whining noises caused by pain.

Haemorrhagic septicaemia is caused by *Pasteurella*-bacteria and is very infectious. Signs include pneumonia, coughing, and diarrhoea and the animals become apathetic. The disease is provoked by sudden changes in the environment, high density and stress.

Ringworm is caused by the fungus *Trichophyton mentagrophytes* and is very infectious. Symptoms are hairless spots and dandruff sometimes with skin-infection. It is caused by bad ventilation, malnutrition, stress and generally bad hygiene.

“Slobbers” is the termed used for chinchillas which suffer from an abnormal development of their teeth and these animals cannot eat properly or handle their feed in a proper way. This abnormal state is caused by malnutrition and deficiency of A, B and D-vitamins and calcium.

Mastitis is an infection of the mammary glands (by *streptococcus*, *staphylococcus* or *E. coli* bacteria) and causes a reduction or end of milk production in some cases the mother will kill the young). It is often caused by young biting the nipples.

Metritis is an acute infection of the uterus in connection with parturition. A non-delivered placenta or an unborn foetus may be the cause, but also bad hygiene or damages during the parturition.

Both in nature and on farms, chinchillas can become rather old. In the wild the lifespan is probably about 10 years, but captives have lived over 20 years, and some have bred at 15 years of age (Nowak, 1991). The high mortality during the first half-year (approximately 25%) suggests a reduced vitality. We do not have reliable information about survival rates after 6 months.

11.4. Anxious or aggressive behaviour

Chinchillas are not regarded as anxious animals and are generally easy to handle. Schuurman (1996) systematically hand tested 150 individuals at three Dutch chinchilla farms. Four reactions to the intrusion of the hand in the cage were defined:

1. Curious: approaching followed by sniffing and other exploratory behaviour was shown by 47 % of the animals.
2. Indifferent: approaching neither fleeing, except following the hand with the eyes was shown by 23 % of the animals.
3. Anxious: excited jumping and other movements without approaching interpreted as an anxious reaction were shown by 20% of the animals.
4. Aggressive: vocalising or urinating into the direction of the hand, sometimes combined with stamping, interpreted as an aggressive reaction, was shown by 11 % of the animals.

Thus, about one out of three animals were either anxious or aggressive, and not more than half of them were as curious, as can be expected from tame and healthy pets. The reactions depended on age and other variables. The reaction of 24 females with pups did not differ significantly from 96 females without pups. The 16 males did not differ significantly from 14 equally aged females without pups. Older females tended to be less anxious or aggressive than younger ones. The percentages of anxious or aggressive animals at the three farms were: 16 %, 28 % and 48 % respectively.

According to Schuurman (1996), anxiety inducing factors may be:

1. The way in which the animals are handled by the farmers,
2. The selection pressure.
3. Sending chinchillas to exhibitions.

Exhibitions are frequently organized, and chinchillas have not only to be transported to and from, they are also expected to stay there for a long day in extremely small cages, under too much light in an unknown environment. This must be stressful, especially so because chinchillas are nocturnal.

Schuurman advised that there should be selection against anxiety and aggression and to improve the interaction between men and animals.

11.5. Normal behaviour

Kersten (1996) described the results of 24-hour observations of 11 different animals at three Dutch farms. Generally spoken, the animals proved to be nocturnal and behaved quite normal. The total resting and activity time strongly varied between individuals. Resting time varied between 36 and 74 % of the time. The time spent to normal behaviours such as grooming and eating seemed to be quite normal.

11.6. Use of enrichment

11.6.1. Shelves

Shelves have been used frequently. Their use was measured by Kersten (1996). Two out of the 11 animals which were observed during 24 hours had shelves both on the bottom and high in the pen. One animal spent 54 % of its time on the bottom shelf and 17 % on the top shelf; another animal scored 1 % and 88 % respectively. Two other animals had only a wire mesh "shelf" high in the cage. It was used for 19 % of the observation time.

11.6.2. Gnawing-stones

Gnawing-stones were not often used (Kersten, 1996). This does not mean unwillingness to gnaw; more likely the gnawing-stones were not appropriate.

11.6.3. Sand bath

Sand baths were frequently used. Four out of Kersten’s animals were allowed to use a sand bath during 4 out of the 24 hours. All of them spent nearly all the possible time in the sand bath. Bickel (1983) and Schweigart (1995) argue that a sand bath is required and the Swiss Bundesamt fur veterinärwesen (1987) recommends offering the opportunity to sand bath twice a week for 5-10 minutes.

Jumping is a normal locomotor behaviour of wild chinchillas. Caged chinchillas do not have enough space to jump. This causes problems when frightened animals jump and perhaps at other times.

11.7. Conclusions

1. The welfare of chinchillas has received very little attention. Possible issues include: lack of environmental enrichment in relation to nest boxes; restricted access to sand baths, height of cages; and large plastic collars worn by females.
2. Welfare problems mainly manifest themselves by stereotyped activities, fearfulness, reproductive disorders, and pup mortality.
3. Although there are certainly ways of reducing these problems by environmental variations, no information is available upon their efficacy.
4. Since chinchillas jump when they are disturbed and during locomotion, the low height of most cages could result in injury because animals hit the roof.

12. WELFARE OF RACCOON DOGS

Raccoon dogs are housed in a similar manner to foxes. This has apparently given good economical results in practice, since there has been no study aiming at improving productivity. This explains why scientific data of welfare of raccoon dogs are very scarce. However, there are a few data available.

12.1. Group size and cage enrichment

In a study by Korhonen and Harri (1988) raccoon dogs were kept as four animals per cage (240 x 105 x 60 cm, L x W x H). Compared with traditionally housed animals those animals were no different in the adrenal, liver, heart or thyroid gland masses or in fur quality. Kidney and spleen were heavier in the group housed animals than in the traditionally housed animals. In this study the tameness of raccoon dogs was evaluated by subjective scaling based on animal's reaction towards the visitor; 1= very tame, 2= tame, 3= normal, 4= defensive, 5= very defensive. The average value for animals housed in enlarged cages was 3.0 and for control animals 3.2. Thus animals in both cage sizes were classified as normal. The problem with this classification, however, is that the authors did not describe the behaviour of the animals in each class.

Raccoon dogs have also been kept in groups in large enclosures (Korhonen et al. 1991a,b), but these studies did not report welfare data. Recently, Kasanen et al. (2000) compared family housing in an enriched environment to traditional pair housing. Enriched cage systems included four cages (one cage: 115 x 105 x 70 cm, L x W x H) connected to each other via openings. A platform and a plastic tube were put in each cage. The final body weight, body length, gastronomies muscle mass and serum cortisol after ACTH administration in cubs housed in this system did not differ from those control brother-sister pairs housed in a cage without enrichment. The adrenals of the family group were heavier and the intestines longer than those of paired cubs. The heart was heavier in pair-housed animals. There were no differences between the housing systems in the severity of bite scars. If the size of the adrenals can be used as an index of stress, this means that the family housed animals were more stressed than the animals in the control group. This might be due to increased social tension in the family group. However this was not reflected in the ACTH response test. Furthermore, the lack of difference in bite scars between the groups may indicate that the animals bite each other also when housed in pairs. The poorer fur quality in the family group might also be due to biting, or simply to mechanical wearing as a result of more complex social and physical environment. In addition, the family group cubs grew as well or even better than the control cubs and produced longer skins, an indication that possible social stress did not impair growth. Since welfare indicators contradict each other, no firm conclusions concerning welfare can be drawn.

12.2. Reproduction

Reproductive success of raccoon dogs during the last 25 years has increased as a result of decreased proportion of barren females and females that lose cubs. This can be seen as an indication of adaptation on housing environment and human.

12.3. Mortality and morbidity

Mortality of adult raccoon dogs is very low due to a generally healthy stock and an efficient vaccine program, but few statistical records on the subject are available. Raccoon dogs are susceptible to viral distemper. Parvovirus can cause morbidity and mortality among raccoon dog pups if they are infected at an age of 2 to 12 weeks (Veijalainen 1987). Isolated cases of streptococcal and staphylococcal infection can occur. Raccoon dogs are susceptible to sarcoptic mange.

12.4. Conclusions

1. In general raccoon dogs are treated like foxes but how this affects their welfare is not known.
2. Possible welfare problems include wire floors, barren environments, weaning age, disease conditions, foot problems, lack of mate choice and monogamy.

13. THE WELFARE OF COYPU

13.1. Behavioural disorders

No information is available on behavioural disorders in farmed animals of this species.

13.2. Mortality and morbidity

In a retrospective survey of causes of death of 1,026 coypus (Table 10) between 1984 and 1993 in Argentina (Martino and Stanchi, 1994), infectious diseases accounted for 61 % of the mortality. Because of the random sampling procedures, the results can be considered representative of the entire population of captive coypu. Outbreaks involving several simultaneous deaths were attributed to pneumonia caused by *Streptococcus zooepidemicus* (36%), a disease that has a seasonal incidence. Other common naturally occurring infections included enteritis caused by *Salmonella typhimurium* (7%), yersiniosis by *Yersinia pseudotuberculosis* (5%) and septicaemia by various bacteria (5%). Among the main non-infective entities diagnosed, trauma accounted for 18% of the deaths, starvation for 4% and meteorism for 5%. Death from pesticide intoxication was suspected in 18 cases. Almost half of the deaths (49.2%) occurred among immature animals (from four weeks to ten months of age).

Table 10. Causes of death of farmed coypus by age and sex

Infectious Diseases	**MALES**				**FEMALES**					
	K	**I**	**MA**	**A**	**K**	**I**	**MA**	**A**	**Total**	**%**
Pneumonia	12	142	1	6	33	165	24	3	386	**35.9**
Salmonellosis	19	5	1	1	11	27	7	3	74	**6.9**
Other Intest. Inf.	8	0	2	1	9	11	0	0	31	**2.9**
Septicemia	10	11	0	0	6	24	0	1	52	**4.8**
Yersiniosis	2	3	0	3	3	17	25	0	53	**4.9**
Urinary Inf.	0	1	0	2	0	4	3	1	11	**1.0**
Other	2	0	3	2	10	2	16	12	47	**4.4**
Non Infectious Diseases										
Starvation	1	6	4	0	28	0	6	1	46	**4.3**
Tail Frost	0	1	2	2	6	4	7	0	22	**2.0**
Intoxications	0	7	0	2	4	2	0	3	18	**1.7**
Trauma	33	9	1	21	47	62	15	8	196	**18.2**
Bloat	0	2	8	0	0	12	26	3	51	**4.7**
Other	1	0	5	3	3	0	7	4	23	**2.1**
NSL*	11	1	6	2	32	12	2	0	66	**6.1**
Total	**99**	**188**	**33**	**45**	**192**	**342**	**138**	**39**	**1076**	**100**

* NSL: No Significant Lesions
K : kits , up to 1 month, **I** : immature, 1-10 months ; **MA** : middle-aged, 10-18 months ; **A** : aged, more than 18 months. Source: Martino and Stanchi., 1994

These data are informative about the primary causes of death and their relation with age, sex and geographical location. The major cause of these diseases was related to poor sanitary conditions of the pens. The principal source of infection was water infected with excrements of diseased individuals, particularly during warm weather. Better food and cleaner pen facilities would reduce the spread of infection. However access to water appears necessary for thermoregulatory purposes.

The skin of coypus can be infected by the smooth beggar tick (*Bidens laevis*). As a result of this condition, chronic dermatitis, the value of the pelt is significantly reduced. The most commonly infected area is the thorax region, the least is the neck. Animals show loss of appetite and appear “depressed”. Smooth beggar ticks can be controlled by spraying with 2, 4-D amine.

13.3. Conclusions

1. There are not enough data to assess the welfare of coypu in the farming environment.
2. Coypus are aquatic for most of their life and running water is normally provided on farms. Health problems can arise if the water becomes dirty.
3. Welfare problems may be caused by large group size, lack of environmental enrichment, fear of people, and too early weaning.

14. THE WELFARE OF FERRETS

14.1. Abnormal behaviour

Systematic observations on ferrets at mink/ferret farms, in cages which are never left, are not known. Pet ferrets are known to be curious and investigating animals. They often are extremely excited when they are allowed to leave their cage. Stereotyped behaviour in ferrets has not been investigated.

Ferrets are fully tame, thus not anxious and not aggressive towards human. Though they have been bred as pets the need for human contact, when they are kept in commercial conditions, has not been investigated.

14.2. Reproductive problems

Ferrets are known to be fertile animals. Two litters per year, up to 17 kits per litter, are reported to be normal, one in spring and one in autumn. However, in autumn some females do not come into heat. Reliable records about their fertility at farms are not [yet] known. A Dutch farmer claimed an average litter size of 9.5 kits with about 3 % during the first three weeks.

The mating procedure does not cause welfare problems. Males and several females in heat can easily stay all together for several days.

During 1983-86, 9.4 % of female ferrets in Denmark were barren, while litter size weaned per mated female was on average 7.65 (Jørgensen 1985).

14.3. Mortality and morbidity

Ferret farmers are secretive about problems during heat waves, but temperatures in mink sheds often rise above 32°C. The problem is that ferrets cannot cope with high temperatures. They do not have well developed sweat glands and their fur is well developed. When the temperature is more than 32°C, the ventilation is poor and the air is humid, they cannot maintain their body temperature, and they may die. The signs preceding death are immobility, open mouth and gasping. is Submersion in water is an appropriate therapy (Moorman and Lumeij, 1987).

Moorman and Lumeij (1987) reviewed ferret deaths on the basis of veterinary experience with pet ferrets. The list of reported reasons for death is long, but quantitative data are given neither for pets nor for ferrets on fur farms. Vaccination against botulism and distemper is to be recommended.

14.4. Conclusions

1. Because of their long history of domestication, ferrets are less likely to be disturbed by human contact than other animal species kept for fur production.
2. Possible welfare problems are broadly similar to those of mink. In particular barren cages which do not meet the needs of ferrets are a problem.

15. IMPROVING THE HUMAN-ANIMAL RELATIONSHIP: MINK AND FOXES

15.1. General introduction

Selection for docility or against fearfulness is a successful method to reduce the number of fearful animals on fox and mink farms. In the chapter on domestication (section 6.1) it was stated that "domestication is achieved through genetic changes occurring over generations as well as environmentally-induced developmental events reoccurring during each generation in individuals". This chapter will deal with some of the environmentally induced events that occur at the level of individuals. It will be documented that implementing a more intense human-animal contact of a neutral or positive nature can maintain docility in adult animals and make cubs more docile, preparing them for a life in captivity. The following review stresses the importance of forming a positive human-animal relationship in both adults and cubs, reducing fearfulness and thus improving the welfare of the animals. The end of the chapter will examine the quality of stockmanship. This is a neglected area in research on animals kept for fur farms. This factor might be responsible for at least part of the important variation that is observed between farms within a same country and between countries.

15.2. Selection for reduced fear of humans in silver and blue foxes

One of the major welfare problems in certain fur-animal species (foxes, chinchillas) is considered to be fear of humans. The large potential of selecting animals for reduced fearfulness is described in section 4.1.3. A possible change in the boundaries of the sensitive period of primary socialisation, as reported by Belyaev et al. (1985) to be effected by such selection, would increase the potential to improve the relationship between humans and foxes during ontogeny.

Since the mid 1990's, selection work in the Nordic countries with this aim has been performed on foxes on private and experimental farms and since 1988 on mink on a Danish experimental farm. Similar selection work has yet to be done in the other species.

Effects of selection for reduced fearfulness on reproduction have been variable, with increased reproduction performance being observed in Denmark in 1995-1996, but not in 1997-1998, and reduced reproduction observed in Norway 1995-1999. If not controlled for, there is a chance that this kind of selection could increase the frequency of animals with low social status leading to reduced reproduction, depending on the reason for the low fearfulness.

In 1995, several selection experiments in both fox species for increased tameness were established in the Nordic countries (Kenttämies 1998, 1999; Hansen 1996; Nordrum et al. 2000). The aims of the selection experiments were to document whether temperament is subject to heritable variation in farmed foxes, the degree of heritability, and finally whether increased tameness or reduced fear of humans affects fertility and reproductive parameters.

15.2.1. Behaviour tests

In order to select for increased tameness or for reduced fear, relevant tests must be chosen that can detect the least fearful individuals of the population. A number of different tests have been developed for this purpose; the flight-distance test, the pencil test, the stick test, the titbit test, the feeding test, and recently the empathic test. Evaluation and validation of some of these tests have been done (Rekilä et al. 1996, 1997; Rekilä 1999). The foxes' behaviour during a feeding test, in which it is recorded whether feed placed by hand on the cage roof is taken within 30 seconds with a human in front of the cage, was found to be a significant reflection of fear towards humans (Rekilä et al. 1997). A method rather similar to the feeding test, although not validated, is the titbit test (Bakken 1998), in which it is recorded how many of five subsequent days the fox take a titbit (dog biscuit) given through the wire netting within 20 seconds. To evaluate the temperament of foxes in the Norwegian and Danish part of the selection project, the titbit test was applied whereas in Finland the feeding test was chosen. In Norway, also the position of the fox in the cage when the test person was in front of it was recorded. In all studies, the number of foxes that ate the food or titbit increased with repeated tests.

15.2.2. Selection criteria

The breeding progress of a heritable trait depends on the initial population variance of the trait, the relative magnitude given to the trait compared to other traits in the breeding goal, the selection intensity, and whether the trait is considered in both breeding males and females. In the Nordic selection experiments, slightly different criteria were applied. In all countries, two breeding lines were established, one selection line in which tameness was given 50-100 % weight and one control line in which variable weights were given to traditional fertility and production traits (litter size, fur quality, body size). The temperament of both breeding males and females were considered, with the exception of the Danish silver fox study which considered only the vixens. Breeding animals of the preceding years and their offspring were included in the first selected generation, apart from the Finnish study on blue foxes where only cubs (F_1) of P_1 (original population selected for tameness) were chosen for further breeding (Kenttämies 1998).

In Finland two different studies were conducted; (i) on private farms (n=29) in order to examine genetic variation in temperament and to study genetic and phenotypic association between temperament and fertility and pelt quality traits, and (ii) on one experimental farm in order to examine the selective responses in temperament and production parameters (Kenttämies 1998). In Norway, selection work was performed on both fox species on 14 private farms (Nordrum et al. 2000). The confidence score was given 50 % weight in the breeding goal (fertility: 25 %; pelt quality 25 %). In Denmark, four farms participated in the selection experiments on silver foxes and four farms on blue foxes. In the first generation, silver foxes taking the titbit within 15 seconds in 8 of 10 tests were chosen for the selected line. In later generations, production criteria were also considered to some extent. The tests on blue foxes were performed slightly different, by giving the titbit into the open cage door and expecting an active approach in later tests to be classified as confident.

15.2.3. Selection effects on behaviour

The studies confirm the existence of genetic variation in confidence in farmed blue and silver foxes. In the Norwegian experiment, the heritability of confidence was estimated to 0.20 in silver foxes and 0.10 in blue foxes (Nordrum et al. 2000). In the Finnish studies, the heritability of confidence was estimated to 0.21 for blue foxes (but 0.32 for blue fox cubs) and 0.18 for silver foxes on the private farms (Nikula et al. 2000) and to 0.30 in blue foxes of the experimental farm (Kenttämies 1998). Estimated heritabilities are as yet not reported from the Danish experiments.

In the Finnish study in 1995, 27 % of cubs in the selection line came to eat during the first time of testing, whereas this figure increased to 68 % in 1998. In the control line this figure was 32 % and 43 %, respectively. In the Norwegian selection work, the relative differences in titbit score between control and selected lines in silver fox were 0.46 in 1997 and 0.03 in 1998. In blue foxes, the relative differences in titbit score between the control and selected lines were 0.43 in 1997 and 0.51 in 1998 (Nordrum et al. 2000).

15.2.4. Selection effects on reproduction

The Danish experiment (1996-1998) on blue foxes demonstrated that vixens selected for tameness delivered and weaned more cubs compared to non-selected ones. In primiparous vixens, litter sizes were 6.5 at birth and 4.5 at weaning in the selected line, and 5.5 and 3.6, respectively, in the control line. Multiparous vixens in the selected line gave birth to 9.1 cubs and weaned 7.4 cubs, whereas in the control line they gave birth to 8.0 and weaned 6.2 cubs. In the Danish silver fox experiment (1995-1998), significantly more cubs were weaned in the selection line in 1995 and 1996, but not in 1997 and 1998. In 1996, control vixens delivered 4.8 cubs and weaned 4.0 cubs, whereas selected vixens delivered 5.2 cubs and weaned 4.4 cubs.

In the Finnish experimental-farm study on blue foxes, where confidence was given 100% weight in the selected line, reproductive performance during 1995-1998 tended to be higher in the selected line compared to the control line. In 1998, litter size at 2 weeks was 6.8 in the selected line and 6.4 in the control line. In the private-farm study, correlations between temperament and reproduction approached zero (Nikula et al. 2000).

In the Norwegian study, where confidence was given 50 % weight in the selected line, foxes produced fewer cubs than in the control line (Nordrum et al. 2000). This was expressed as a negative correlation between titbit score and litter size at 3 weeks of age; -0.13 in silver foxes and -0.26 in blue foxes. Although small negative correlations were found between confidence and production traits, it was concluded that, subjected to long-term selection with modern selection methods, genetic progress seems obtainable both for confidence and production traits (Nordrum et al. 2000).

15.2.5. Outcome of the selection work so far

The breeding experiments show that genetic reduction in fear of humans is obtainable also on private farms, confirming the experimental evidence provided by Belyaev et al. (1985). Positive effects on reproduction are found only sometimes. If receiving a titbit is particularly important for vixens with low social status, indicating the human serving a helper function (Bakken 1998), it might be necessary to examine if selection based on the titbit test sometimes could increase the frequency of animals with low social status in the population. This could explain the negative effect on reproduction found in the Norwegian study.

15.3. Selection of mink for reduced fear of humans

A selection work based on the behaviour of mink towards humans, which is still in progress, started at Danish Institute of Agricultural Sciences in 1988. The selection is based on two tests, the stick test and from 1995, the Trapezov hand test. In the stick test, while being excluded from the nest box, a tongue spatula is inserted through the wire net and the minks' spontaneous reaction during 30 seconds is recorded either as (i) curious, sniffing persistently at the stick, (ii) fearful, the mink escapes, (iii) aggressive, or (iv) unspecified. In the hand test, the gloved hand is slowly moved into the cage. Starting on a 0 score, the behaviour is successively recorded on a scale from +6 (can be completely handled without biting) to –5 (the mink attacks through the cage net) according to increasing demands made by the hand. This test is similar to the test used on selection of Russian mink (Trapezov 1987). A cross-fostering experiment showed that the behaviour in the stick test was more dependent on the biological origin than the foster mother's behaviour. An elevated plus-maze test failed to separate between mink being confident and fearful towards humans.

In the selection experiment, mink were selected divergently for increased confidence or increased fear of humans, in addition to a control line. Selection was based on tests repeated monthly during July to November. After six generations, selection for fearful behaviour caused the normal habituation to humans to disappear, with 90 % of the mink responding consistently with fear to human contact (Hansen 1996). A less distinct effect was found in the confident (or explorative) line. A lower cortisol response after human handling was found in mink selected for confidence, although the capacity of the adrenals to secrete cortisol was unaffected. After eight years of selection it was possible to mate mink of the confident selection line on average two days earlier than mink of the other lines, indicating an effect earlier reported to be much stronger for selected Russian silver foxes (Belyaev 1979). Mink from the confident line needed a smaller dose of anxiolytic drugs (Buspirone, a serotonin agonist) to reduce fear than mink from the fearful line. Measurable differences in stress-induced hyperthermia (SIH) were found between mink selected for confidence and fear in a small study (Korhonen et al. 2000). Repeated capture led to an increase in SIH among mink of the fearful line, but a decrease for the confident line, suggesting sensitization and habituation effects, respectively.

In summary, divergently selecting mink for fearful and confident behaviour resulted in divergent effects. The weaker effect in the line selected for confidence towards humans might reflect a generally high level of explorative behaviour in Danish mink by the start of the experiments (Hansen 1996). This is also supported by the views that mink are much tamer than earlier in the selection history (e.g. Shackelford 1984).

15.4. Handling of foxes

In foxes, experimental work typically consist of taking the animal out of its cage, holding it for some time, and putting it back into its cage. In general, early handling is most effective a few weeks around the period of separation of offspring from their mothers (Boivin and Braastad 1996; Hemsworth and Coleman 1998), regardless of the age at such separation (Boivin and Braastad 1996). This is also documented for silver foxes in extensive studies (Pedersen 1993a). Early handling is most effectively performed during 6-9 weeks of age, but silver foxes are also sensitive to such experience both earlier and later (3-12 weeks; Pedersen 1992). Generally, effects were reduced general fearfulness, reduced stress-sensitivity, and improved reproduction (Pedersen 1992, 1993a). Early handling may be done forcibly or gently, i.e. petting the animal while carefully avoiding avoidance reactions in the animal (Pedersen 1993b). While gentled foxes showed a marked reduction in fear towards humans and a weaker reduction of the response to novel stimuli, forcibly handled foxes showed a weaker reduction in fear towards humans and more explorative behaviour towards novel stimuli (Pedersen 1993b). Gentling might represent part of a socialisation process, while forcible handling might result in habituation and/or a general “toughening up” (Dienstbier 1989).

An alternative way of reducing fear in foxes is by regularly giving titbits such as dog biscuits by hand (Bakken 1998). This is also effective for adult silver and blue foxes previously not subjected to early handling, producing typical habituation effects of reduced acceptance latency and more frequent positioning by the front of the cage (Dale and Bakken 1992; Bakken 1998).

A side effect of improving the human-animal relationship sufficiently might be that the animal develops positive expectations about the presence of the stockpersons. Further research might reveal the optimal handling scheme in terms of amount of handling of various age groups to gain an optimal level of positive expectations about the presence of, or contact with, the stockperson in relation to a certain level of genetic predisposition.

15.4.1. Handling of Silver foxes (Vulpes vulpes)

Traditional management routines in most countries ensure that fox cubs are fully exposed to their captive environment from the age of 4 weeks. But some juvenile and adult foxes still show fear and avoidance reactions towards humans, indicating that the occasional exposure to humans during everyday management routines is insufficient to cause an effective socialisation, habituation, or positive conditioning to humans.

Pedersen (1991) aimed at examining whether the behaviour of foxes was affected by different early experience with the farm environment. A total of 104 silver fox cubs and 218 blue fox cubs were used in the experiment, and experimental cubs had a solid door of their nest box removed at their age of 2 weeks. Behavioural tests at the age of

12-16 and 23-28 weeks revealed that constant exposure to the captive environment had reducing effects on foxes' later fear responses towards an unknown human being. Foxes rose with the possibility to avoid stimuli, by hiding or staying in their closed nest box, showed high fear levels when confronted with an unknown human being. During occasionally, but repeated, exposure to the captive environment (including humans) foxes habituated to some degree to neutral stimuli, and thus showed less avoidance when later confronted with them. Foxes, which had the possibility to escape and hide in their nest box during rearing, prevented themselves from habituating to external stimuli in the farm. So the standard routines normally performed at most fox farms probably ease the habituation of foxes to the captive environment to some extent, at least when compared to foxes raised with a possibility to hide in their nest box.

A few authors including Pedersen and Jeppesen (1990) studied the short and long-term effects of early handling on silver foxes' behaviour, physiology and stress-responses. Handling procedures were intended to be of a positive nature and were applied between ½ to 5 minutes once or twice a day for 3½ to 6 weeks between the cubs age of 2 to 9 weeks of age. The behavioural responses towards humans were positively affected until the cubs' age at 7 months but these positive effects had vanished within a year. Pedersen and Jeppesen (1990) examined only short term effects but found positive effects on the foxes behavioural responses towards humans until the cubs age of 18 weeks. In one study some physiological effects were found, i.e. a higher body weight at 7 weeks of age in handled foxes compared to non-handled foxes. Pedersen and Jeppesen (1990) found also evidence of stress-physiological differences between handled and non-handled cubs indicating a state of chronic stress in the non-handled animals. These positive results initiated a line of studies where 1) the "optimal" age in which early experience with humans would make significant reductions of fear responses in farmed foxes and 2) the "optimal" handling procedure, which would cause reduced fear on a long term basis in the foxes were looked for. The study of an "optimal age interval" was made by Pedersen (1992). A total of 344 silver fox cubs were distributed in 8 treatment groups, exposed to gentling at different age intervals. No effects on later behaviour were found in foxes gentled between birth and 3 weeks of age. Gentling for 6 weeks prior to weaning (prolonged handling), for 3 weeks during the weaning period (6-9 weeks of age) or 3 weeks after weaning (9-12) all showed an optimal effect on later reductions of fear responses in farmed foxes. The results indicated that fox cubs were not able to react to handling from birth to 3 weeks of age, most likely due to their not yet fully developed sensor and locomotor systems. It seems reasonable that an attachment to a mother, a mother substitute or conspecifics cannot be formed unless the sensory system is capable of obtaining information, and this information can be stored and recalled. Some form of socialisation to humans could be an explanation for the observed reduced fearfulness in the groups gentled after their third week of age. If it is so, the sensitive period of socialisation in the present study seemed to resemble the one of selected tame foxes in the study of Belyaev et al. (1985). The different age interval of foxes when handled, meaning different stages in development, might have caused differences in the underlying mechanism producing the effects, though. Finally it should be mentioned that the time-gap between termination of gentling and start of testing differed between different age groups. If gentling affected the behaviour of foxes treated from 0 to 3 weeks of age, it was on a short-term basis and vanished before the onset of testing.

During the studies of Pedersen and Jeppesen (1990), and Pedersen (1992), it was noted that the fox cubs showed marked avoidance behaviour during gentling.

Crouching or flight was the major reactions of foxes, but offensive or defensive threats or attacks were observed, too. This indicated that foxes did not perceive gentling as pleasant, positive, or even neutral, though a positive experience for the fox was the intention in all studies. Thus an effort was made in Pedersen (1993b) to make the early experience with humans “really positive” in its nature compared to a supposed “negative” procedure. The "positive" element was allowance of control together with a reward (positive reinforcement). The fox was allowed to control the relative distance between itself and relatively passive handler. If the fox approached the human hand it was rewarded with pieces of raw liver, but the handler made only few, slow and gentle movements towards the fox. In contrast to this "positive with control and reward" experience, the “negative” treatment was forced with lack of control. The fox was gently caught and transported by hand (grip in the tail and a hand under the belly), to a small cage where it was restrained for 2 minutes. Thereafter the fox was re-captured and transported by hand again to its’ home cage. This "negative" handling procedure resembled the most often used handling procedure in laboratory rodents, and a frequently used procedure when handling other farm animals (esp. rabbits, chickens). It does not resemble the unpleasant or aversive handling procedures used in pig and sheep studies, which often include punishment or severe physical restraint. The foxes' responses towards these two handling procedures were markedly different. The "positive" experience caused an increase in number of curious and calm foxes during the 21 days of post-weaning handling, whereas the "negative" (forced) experience caused persistent and high levels of fear responses in the same period. When tested later for behavioural responses towards humans and novel stimuli, “positively” handled animals showed marked reductions of fear responses towards humans, whereas ”negatively” handled animals surprisingly showed some reductions of fear towards humans and a marked reduction of fear responses towards novel objects (Pedersen, 1993b). It seemed that the "positive" experience with humans specifically reduced the later fear responses towards humans, presumably through positive conditioning (caused by reward) or through socialization to humans caused by the frequent and positive contact with humans. The supposed “negative” experience with humans caused more general reductions of fear responses. The persistent high levels of fear during forced handling out-ruled habituation, but the effects was rather caused by the acute but short-term exposure to stress, modulating the pituitary-adrenocortical system, and thus causing a better adaptation to cope with later challenges from the environment.

For the keeping of foxes as farm animals it is equally important that a positive human-animal relationship is formed, and that the animals are able to cope with the different and sometimes aversive routine management practices on the farm (for example being moved, being heat evaluated which both include restraint by neck tongs). On short term a handling procedure with some forced elements might be more beneficial to achieve these goals, compared to the obvious weaker effect of gentle handling.

Previous studies of early experience in foxes concerned only juvenile animals that had not yet reached sexual maturity, and the effects were thus only observed on a relatively short-term basis. Since the hypothesis about the underlying mechanism of (forced) handling was that a modulation of the pituitary-adrenocortical system occurred, affecting the later behaviour towards novelty and stressful situations, these effects would most likely be permanent. The foxes from Pedersen (1993b) were kept as adults and used to examine long-term effects of the different handling procedures (Pedersen, 1994). In addition to behavioural observations, various physiological and production-related parameters were observed. The negative, forced handling procedure showed to produce persistent reductions of fear responses towards humans and novelty, since effects lasted until the last testing at 18 months of age. In addition, the forcibly handled animals showed a higher reproductive performance, compared to both “positively” handled and non-handled animals. On physiological level non-handled controls showed hypertrophy of the adrenals as adults, both compared to forcibly handled and positively handled animals. Production-related parameters were not affected by the different early treatments. The positive effects of the un-forced gentle handling (positive reinforcement) on behaviour observed prior to sexual maturity seemed to be overshadowed by the supposed aversive effects of different routine management practices imposed on the sexual mature animal (negative reinforcement). This has also been observed in sheep and pigs, i.e. gentle handling produced some short-term positive effects on behaviour, a long-term positive effect on stress sensitivity, but no positive effect on reproductive performance. Thus the overall conclusion was that early forced (but gentle) handling was superior in producing long-term positive effects on behaviour, reproduction and stress-sensitivity in farmed foxes.

In the above studies of Pedersen and Pedersen and Jeppesen, litter mates had been subjected to the same treatments, which meant that different genetical backgrounds between treatments could have affected the results. Since Pedersen (1994) surprisingly revealed positive and long-term effects of forced handling it was examined again (Pedersen 1993b) if forced handling was a reliable means to produce generally less fearful foxes and if it could enhance reproductive performance when differences in genetical background were eliminated. A higher number of individuals and only females were used. In addition, siblings were distributed to different treatments. It was also examined if effects of forced handling could be modulated by extra (normal management + 1 minute exposure to human close to the cage 3 times a day) or minimal (normal management) experience with humans post-handling, and at the same time, it was examined if the behaviour of non-handled foxes could be modulated by the extra or minimal experience with humans. Handling was performed from the foxes' age of 8 to 11 weeks (as in Pedersen, 1994) and the extra/minimal experience with humans commenced at 16 weeks and lasted to 34 weeks of age.

Extra or minimal experience with humans failed to influence any of the behavioural and physiological measures, both within treatments, between treatments, and as a main effect. This result indicates a possible existence of a sensitive period for socialization to humans prior to the age of 16 weeks in farmed silver foxes. The forced handling again reduced the general fearfulness of foxes, as reflected in behavioural responses to different "in cage" tests, capture procedures and open-field exposure. No differences in pre-stress levels of plasma cortisol were revealed between treatments. Since the pre-stress levels were of a relatively high range, they were concluded not to reflect true base-levels, based on evidence of a lower range of base-levels of plasma cortisol in foxes in earlier studies. However, handled vixens showed lower post-stress levels of plasma cortisol, which could indicate a lower adrenocortical reactivity to stress, as also found in rats. But since repeated blood samples were not drawn, we do not know if the adrenocortical response was increasing, at a peak or decreasing, which make a firm conclusion difficult. Reproductive performance was not significantly affected by treatment or contact, which then failed to confirm earlier findings (Pedersen, 1994). The conclusion of the study was that forced post-weaning handling was an effective means to reduce the general fearfulness and stress-sensitivity of farmed silver foxes, indicative of a better adaptation to the captive environment in these animals. Early experience seemed crucial for the later reductions of fear responses towards humans in silver foxes.

15.4.2. Handling of blue foxes (Alopex lagopus)

Blue fox handling studies have been conducted recently and published by Bertelsen (1996) and others. Bertelsen (1996) studied the effects of early handling and access or no access to a whole-year box on blue foxes later behavioural and physiological responses to humans and novel stimuli. The handling procedure was a mixture of a gentle and a forced procedure and was conducted for 3 minutes a day for 3 weeks when the cubs were 7 to 9 weeks old. The main groups of handling and control were split into a whole-year box -and a platform- group at 10 weeks of age. Behavioural tests during the juvenile phase of the cubs revealed significant reductions of fear towards humans and novelty in handled foxes. In addition, it was found that access to a whole-year box in the juvenile phase to some extent overshadowed the positive effects of handling on the fear responses towards humans in handled foxes and made non-handled foxes even more fearful compared to platform-kept handled and non-handled foxes, respectively. Physiological parameters such as body-weight and growth and plasma cortisol levels pre- and post-exposure to novelty were neither affected by handling nor housing. These results indicated that as much as we want to improve the physical environment of farmed foxes by provisioning of whole-year boxes this seems to be premature due to the general fear level of farmed foxes and will only delay or even hinder an adaptation to the captive environment. Other authors examined long term effects of the above combined handling and housing experiment. Behaviour just prior to and during heat was examined as well as behaviour during pregnancy. Reproductive success was registered and the maternal qualities of the vixens were evaluated during the suckling period. The results showed that early handling of blue foxes caused long-term reductions of fear responses towards humans, and reproductive success was significantly increased compared to non-handled blue foxes. Housing effects were non significant and in-consistent, which made the author conclude that early handling was more important for positive effects on the foxes later behaviour and reproduction than different housing conditions.

15.5. Quality of stockmanship (management)

A substantial amount of literature also reveals that the mere attitude of the caretaker or people often in contact with the animals affect the fear level of the animals and has a great effect on performance. Since the late 1980ies Hemsworth and co-workers have intensively examined relationships between behaviour and attitudes of the stockperson and fear levels and productivity of the farm. For example, if the caretaker believed that a pig was difficult to move, he tended to use more aversive handling. The efficiency of milking was reduced and the residual milk was doubled when cows were milked in the presence of a person who had treated the cows aversively. Hemsworth successfully introduced a training programme for stockpersons which modulated their later behaviour towards their animals in a positive direction (Hemsworth and Coleman, 1998).

It is most likely that these findings are applicable to fur farming as well, but no studies have so far concerned the attitude and behaviour of the farmer in relation to the productivity, temperament and welfare status, of animals at his farm. However, one important finding has been that silver foxes are able to anticipate whether the approaching human has pleasant intensions or unpleasant intensions, by means of their clothing colours. The silver foxes were given tit bits once daily for 5 days by a person in blue clothes and captured by neck tong once a day by a person in white clothing. After the initial training, data on body core temperature, received from implanted radio transmitters showed that the mere sight of the white clothing caused a higher increase in the body core temperature than the sight of the blue clothing and when exposed to the white "person" more foxes stayed in the back of the cage, than when exposed to a "blue" person. The authors also found that the greatest stress response was found when the animals expected a pleasant treatment but received an unpleasant one. These findings are very important, since welfare in foxes seem to be improved if the handlers are trained to clearly indicate their intentions, for example by consistently wearing different jackets or colours, showing the foxes if they should expect to be caught or treated. In a another study, Bakken (1994) studied the effect of giving adult multiparous pregnant silver foxes a tit bit twice a week and compared several aspects of reproduction and cub characteristics to a group of multiparous pregnant silver foxes which received the same amount of human contact but no tit bit. His results showed that reduced fear of humans obtained in the tit bit group affected the females' parental investment with a bias towards more male cubs. In addition the female cubs' growth and behavioural ontogeny were positively affected in the tit bit group implying an improvement of their later maternal qualities.

15.6. Conclusion

1. Genetic selection against fearfulness is effective in mink and foxes.
2. Genetic selection against fearfulness affects reproductive function. The direction of these effects may depend on what exactly is selected for, but this has not been systematically investigated.
3. Early neutral or positive experience with humans decreases fearfulness in foxes on both a short and long-term basis. This has positive welfare effects in the form of reduced stress sensitivity and improved reproductive success.
4. The effect of early experience is dependent on the intensity of the interaction with humans and the time at which it takes place. The optimum period is 3 to 16 weeks of age in foxes.
5. To maintain docility in adult foxes, frequent positive reward is necessary.
6. Some individuals respond with aggression towards their handler. These animals are normally not used for breeding.
7. Early neutral or positive experience with humans does not necessarily induce tameness in foxes and mink. This could be achieved by positive conditioning and selection.
8. The relationship between man and foxes improves when the farmer clearly and consistently indicate his intentions.

9. The nature of the human-animal relationship and thus the farmer’s attitude and behaviour towards his animals is a very important aspect of fur farming, but only limited research on this subject has been carried out.

16. FUTURE RESEARCH

- There is still a need for a complete picture of how clinical illness, pre-clinical symptoms, HPA responsiveness, haematological indices, and abnormal behaviours inter-relate. The hypothesis that HPA and SAS responses are alternative strategies should be validated. There is also a need for an understanding of the aetiology of tail-biting, allo-biting and stereotypy; the attributes of the mink HPA system, especially after prolonged exposure to stress; the factors affecting various white cell ratios; the causal factors of gastric ulceration; and factors affecting willingness to mate, rates of fertility, and offspring mortality. There is a need to develop and validate some additional potential welfare indices in mink, in particular: heart rate and heart rate variability; catecholamine assays; immune functioning; changes in core body temperature; plasma prolactin; assessment of ACTH levels; probes of HPA function such as ACTH challenge and dexamethasone suppression tests; preclinical changes; and the self-selection of analgesic or anxiolytic agents.

- Research work needs to cover more strains. Nearly all fundamental mink studies have focussed on just three: Wild Type/Standard Brown, Dark/Black/Scanblack, and Pastel. While these studies are relevant to commercial animals for now, this specificity is important, as strains do differ in their responses to husbandry.

- Data need to be collected from more farms. To date, most studies have been replicated on just a few sites (e.g. five for most behavioural data - a well-run research farm in the Netherlands, and three similar in Denmark, plus a commercial farm in the UK). When results from one site fail to be replicated at another (as seems to be a frequent occurrence) this small sample size makes it currently impossible to tell whether this is due to differences in experimental protocol, strain, farm management practices, local climatic conditions, or other factors like stockman behaviour. Mink farms potentially yield great scope for helping us understand how a range of factors affect stress responses.

- A wider range of simultaneous measures, including under-utilised non-invasive techniques such as urinary and faecal cortisol; and post-mortem signs of clinical or pre-clinical illness, need to be used in applied research.

- It is necessary to acquire more information on how husbandry factors interact with strain, latitude, and other aspects of farm management; and to identify why there are such enormous farm differences in gastric ulceration, dental tartar, abnormal behaviour etc.

- More information is needed on the effects of wire mesh floors on possible foot or gait problems, and the development of play and other behaviours in kits; on dental and behavioural problems that might stem from the soft food; on the effects of various levels of restrictive feeding on hunger, gastric ulceration, HPA activity, etc., and how it interacts with activity levels, local temperatures, etc. to affect mortality; on how to avoid the heat stress that may be caused by sudden or extremely hot days, and the interactions between this and the activity levels of the mink; on the welfare costs to mother and kit of weaning at 6, 7, 8, 9, 10, or 11 weeks of age in both standard cages and modified cages; sex differences in this; and comparison of weaning methods (e.g. removing mother with son from natal cage, group-housing kits until September); on the factors that determine the success or failure of family-housing, and the role of the mother in this system; on how pre- and post-weaning experience affects lifelong stress responsiveness; on the welfare implications of selecting against stereotypy, and against the various forms of pelt-biting; on the effect of physical enrichments, including swimming water, on a range of welfare indicators, and the factors affecting their importance to mink; on the possibility of selecting against undesirable behaviours; on the welfare issues involved in transportation, and in live mink exhibitions; on the relative merits of killing with CO or by injection; and on the possible development of other slaughter methods (e.g. electrocution).

- Scientific evidence of behavioural and welfare effects of domestication of fur animal species is not yet complete. Further research is warranted. Should red and arctic foxes be housed in sight of each other? The potential problem to arctic foxes should be examined experimentally. Further research is needed on prenatal stress in silver foxes and mink. Further research is needed on welfare at live animals' exhibitions.

17. CONCLUSIONS

Welfare – definitions and measurements

1. Animal welfare can be assessed in an objective and quantitative manner, and indicators of welfare include health, bodily functions, and behaviour. Each set of indicators has to be validated for the species under consideration. For an adequate assessment of welfare, a wide range of indicators must be used, although single indicators can show that welfare is at risk.

General aspects of carnivore and rodent biology

2. There is a high diversity in the habitat and biological characteristics of the carnivore and rodent species that are used for fur production.
3. The diversity of the living conditions in the wild of these species is likely to contrast with the relative uniformity of farming conditions across species.

Domestication

4. Domestication has been defined as an evolutionary process by which a population of animals becomes adapted to man and to the captive environment by genetic changes occurring over generations including those predisposing to environmentally-induced developmental events recurring in each generation.
5. From a welfare point of view, the crucial aim is a well-adapted individual, regardless of the extent to which this is due to genetic or ontogenetic events.
6. Important characteristics of domesticated animals include a capacity to live under constraints imposed by humans without problems such as reduced reproductive success or substantial fearfulness towards humans.
7. Low fearfulness can be achieved by genetic selection, early handling and by rewarded contacts with humans.
8. All animal species kept for fur production have been submitted to some degree of domestication, but have different domestication histories.
9. The ferret is the most domesticated species of animals kept for fur production. In other species, there has been only a limited amount of selection for tameness and adaptability to captive environments.
10. Selection has not eliminated the motivation of animals kept on fur farms to perform some behaviours nor favoured altered responses to social stimuli. However, there may be some potential for such selection.
11. Selection for reduced fearfulness towards humans is successful and results in positive welfare effects in the species studied: silver fox and mink.
12. Generally, in comparison with other farm animals, species farmed for their fur have been subjected to relatively little active selection except with respect to fur characteristics.
13. Specific welfare problems related to intense genetic selection, e.g., for altered fur colour or for increasing body weight, can be encountered and, therefore, the possible welfare consequences of such selection need to be strictly monitored.
14. Scientific evidence of behavioural and welfare effects of domestication of species kept for fur production is still incomplete.

Range of farming conditions in Europe

15. The most commonly farmed species is the mink followed by the blue fox and the silver fox. The other species are farmed relatively infrequently.
16. All animals kept for fur production, with the exception of coypus which are kept in pens, are housed mostly in cages throughout their life.
17. The quality and the composition of the feed is sometimes controlled Feed is mainly composed of fish and fish offal, poultry offal, slaughter house offal and cereal with mineral and vitamin ingredients. Recycling of carcasses which increases the risk of disease transmission can occur. Overall the fur industry consumes a large amount of animal by-products.
18. For fox and mink both open and closed buildings are used. Coypus are always housed outdoors and chinchillas indoors.
19. For a given species, housing and management conditions can vary both within a country and between countries. Within a given species, all fur colour types are housed in the same way. The different canid species are housed similarly. There is a trend toward uniformity of housing conditions due to increased regulation pressure.
20. In some cases, cages have been enriched, mainly in response to regulatory pressure. Mink and ferrets are provided with a nest box throughout the year. Foxes are kept in cages equipped with a platform and with a nest box in the breeding period. Chinchillas may or may not have a nest box. Coypus are always provided with water to bathe in.

Restraint, handling, transportation and killing

21. Chinchillas, coypus and ferrets are usually handled with bare hands, mink with gloves or in traps for some procedures, adult foxes often with tongs. Traps and transport cages are used where necessary, e.g., blood sampling, moving between cages. In the case of mink and foxes, restraint devices are used to increase the efficiency of handling procedures and to protect stock persons from injuries. Immobilisation causes welfare problems especially when prolonged.
22. During annual exhibitions, foxes are prevented from biting handlers and each other by the application of snout clips.
23. All animals kept for fur production are killed on site except coypus. Killing procedures differ both between and within species. Methods have been developed empirically. The canids and coypus are most commonly electrocuted, mustelae gassed, and chinchillas lethally injected.
24. Use of chloral hydrate for killing causes irritation at the site of injection and lacks analgesic properties.
25. Certain killing methods, especially carbon dioxide and chloral hydrate can impair mink welfare. Carbon monoxide is commonly used and even recommended. However, its effects on welfare have not been fully assessed.
26. With the exception of coypus most animals kept for fur production are rarely transported. When this occurs transport is usually by land in small transport cages. Water and food are provided if transport duration exceeds eight hours.

The welfare of mink

27. The responses of mink to stressors and environmental manipulations are reasonably well understood but there is much fundamental work still to be done. A wide range of behavioural and physiological indices have been investigated, and furthermore, mink studies can readily involve *post-mortem* measures, as on-site slaughter facilitates autopsy.
28. Body weight, hypothalamo-pituitary-adrenal activity, heart rate, eosinophil levels, gastric ulceration, willingness to mate, infertility, litter mortality, playing, vocalisations, staying within the nest box, showing fear of humans, stereotypy and pelt biting, can all be affected by stress and have been found to be important welfare indicators in many studies.
29. The mortality of mink kits during the nursing period has been reported to be up to 30% with a mean of about 20%. After weaning, mortality rates are lower, and in adults they usually range from 2-5% per annum although in some strains they can be higher. Lactation is a period of high risk especially because of nursing disease.
30. Although mink on farms are subject to a range of disease conditions, in general these can be managed so that morbidity from serious infectious disease is low. Non-fatal conditions which affect welfare, for example gastric ulcers, kidney abnormalities and tooth decay, are sometimes widespread.
31. Contaminated food which may include toxins such as botulin is sometimes given to mink. So, in some member states, vaccination against botulism is recommended. Contaminated food may have other significant effects on mink welfare.
32. In experimental conditions, farm mink show strong preferences for the opportunity to swim. An adequate fur-farming system for provision of swimming water has to be designed.
33. Stereotypies, largely locomotor in nature, are widespread on mink farms. For example in a large scale study stereotypies were shown to occur in 31 to 85% of females, while other studies have reported higher as well as lower figures. There are many reports of individuals spending over a quarter of day time in these abnormal behaviours. Stereotypies result from interplay of genetic predisposition, experiences when juvenile, complexity of current housing, and exposure to environmental events that cause increased arousal.
34. Mink in farm cages may show sucking or biting of their tail fur, or biting of other parts of their pelt. These behaviours are widespread in farmed mink. Such problems become more severe with increasing age. Self mutilation of tail or limb tissue occurs but its prevalence is unknown.
35. Weaning before nine weeks leads to a variety of welfare problems.
36. Mink farms normally have good ventilation, and natural day-light cycles.
37. The typical mink cage with a nest box and wire mesh floor impairs mink welfare because it does not provide for important needs. Particular problems are limited locomotor and stimulatory possibilities, lack of opportunity to climb, go into tunnels or swim, and inability to avoid social contact. Efforts to improve the environment have been fairly limited but have included group housing in interconnected cages and provision of objects. None of these systems has yet been adopted commercially.
38. Restricted feeding of overweight female mink is often used in practice. However, it can cause welfare problems especially if the loss in body weight is too severe.
39. Some strains of mink show a high prevalence of genetic disorders resulting in deafness, blindness or other sensory impairment, or higher susceptibility to disease.

40. Less common welfare problems arising from management practices are not providing *ad libitum* water, inadequate vaccination programmes, detoothing, housing without sufficient shelter from the sun and the lack of protection from freezing temperatures.
41. Welfare problems arising from the social environment include intraspecific aggression caused by inappropriate mixing or overcrowding, and harassment of females due to unsupervised mating. Single housing of young kits is also detrimental. The effects of group housing arenot yet fully understood.

The welfare of foxes

42. Measures for the assessment of animal welfare, including physiological, reproduction and behavioural measures, which have been used for a variety of animal species have only recently been used for farmed foxes, and some of them are in need of validation.
43. Behavioural responses of foxes in various test situations can be measured, using a range of standardised tests to characterise each animal's degree of fear, aggression, confidence, passivity, etc. Again, adequate validation is needed.
44. Abnormal behaviours such as exaggerated fear response, infanticide, stereotypies and pelt biting are described in farmed foxes but not well quantified.
45. Annual mortality rates for juveniles and adult foxes on fox farms are about 5%. A variety of diseases occurs in foxes but is generally well controlled. Data on overall morbidity levels are not readily available but, on average, are not likely to be high.
46. Foxes are kept under natural light and climatic conditions.
47. The typical fox cage does not provide for important eeds of foxes. In particular, it imposes monotony of the physical environment, restricts physical exercise and species-specific behaviour such as digging. In relation to the lack of physical exercise, limb bones are significantly weaker than those of foxes kept in large cages where more exercise occurs. However, limb breakages are not often reported.
48. Several aspects of husbandry can impair fox welfare. Most common welfare problems are fearfulness, and reproductive problems related to the social environment.
49. Less common problems are locomotor problems in heavy blue foxes, and entropion in blue foxes.
50. Possible welfare issues that have not been investigated include weaning age, isolation of aggressive pups, restrictive feeding, dental problems and nail length.
51. Fearfulness of humans is a common feature of foxes on commercial farms. Genetic selection has been used experimentally to produce much less fearful foxes and experience of gentle human handling can substantially reduce fear. However, the less fearful genetic strains are not being used commercially, and farmers are not necessarily devoting the substantial amount of time which is needed for handling of all their foxes. As a consequence, fear of humans is a major and very widespread welfare problem on fox farms.
52. Failure to produce and rear litter of cubs has been reported to occur in up to 45 percent of silver foxes and 40 percent of blue foxes in German farms. On farms in Nordic countries, the figures are 18-44 percent in silver foxes and 23-38 percent in blue foxes. However, significant failure to produce and rear litters occurs in wild foxes. Infanticide is an important welfare problems since cubs are likely to be highly sensitive to pain. Therefore, the extent to which failure to conceive, abortion, and failure to rear cubs can be solved are not clear. Reproductive success on farms can

be slightly improved by changes in the physical and social environment such as handling, tunnel entrances and status in relation to neighbours.

53. Prenatal stress influences physiology and reproduction of the mother and physiology and behaviour of the offspring in blue foxes. The implications of these effects for welfare have not been assessed.
54. The welfare consequences of group housing are not well understood due to the lack of basic knowledge on the social biology of foxes and on family dynamics in general. Some group composition can lead to stress and aggression. In farm conditions in which group housing has been tried, problems occur. It is not yet known whether the welfare is better among group-housed than among singly housed foxes.
55. The type of nest box during the breeding season appears to be important for silver and blue foxes, which reproduce better in boxes with an entrance tunnel. The position of the nest box in the cage is important for both species, which show a preference for an elevated breeding box.
56. Both fox species use nest boxes outside the breeding season, but there is substantial inter-individual variation in the use. These so-called nest boxes may function as hiding places but are not used as shelter against cold weather. Elevated boxes are preferred in both species. Use of nest boxes may increase fear of humans in juveniles of both species and in adult blue foxes.
57. Both fox species use platforms, but there is substantial interindividual variation in their use. Platforms are less used in cold weather in farmed blue and silver foxes and they have no effect on reproductive performance. Wooden surfaces are not preferred to wire mesh surfaces as a resting place in farmed blue and silver foxes. Both fox species prefer an unobstructed view from their cage. Resting platforms without walls do function as observation places.

<u>The welfare of chinchillas</u>

58. The welfare of chinchillas has received very little attention. Possible issues include: lack of environmental enrichment in relation to nest boxes; restricted access to sand baths; height of cages; and large plastic collars worn by females.
59. Welfare problems mainly manifest themselves by stereotyped activities, fearfulness, reproductive disorders, and pup mortality.
60. Although there are certainly ways of reducing these problems by environmental variations, no information is available upon their efficacy.
61. Since chinchillas jump when they are disturbed and during locomotion, the low height of most cages could result in injury because animals hit the roof.

<u>The welfare of raccoon dogs</u>

62. In general raccoon dogs are treated like foxes but how this affects their welfare is not known.
63. Possible welfare problems in raccoon dogs include wire floors, barren environments, weaning age, disease conditions, foot problems, lack of mate choice and monogamy.

<u>The welfare of coypu</u>

64. There are not enough data to assess the welfare of coypu in the farming environment.

65. Coypus are aquatic for most of their life and running water is normally provided on farms. Health problems can arise if the water becomes dirty.
66. Welfare problems of coypus may be caused by large group size, lack of environmental enrichment, fear of people, and too early weaning.

The welfare of ferrets

67. Because of their long history of domestication, ferrets are less likely to be disturbed by human contact than other animal species kept for fur production.
68. Possible welfare problems of ferrets are broadly similar to those of mink. In particular barren cages which do not meet the needs of ferrets are a problem.

Improving the human-animal relationship: mink and foxes

69. Genetic selection against fearfulness is effective in mink and foxes.
70. Genetic selection against fearfulness affects reproductive function. The direction of these effects may depend on what exactly is selected for, but this has not been systematically investigated.
71. Early neutral or positive experience with humans decreases fearfulness in foxes on both a short and long-term basis. This has positive welfare effects in the form of reduced stress sensitivity and improved reproductive success.
72. The effect of early experience is dependent on the intensity of the interaction with humans and the time at which it takes place. The optimum period is 3 to 16 weeks of age in foxes.
73. To maintain docility in adult foxes, frequent positive reward is necessary.
74. Some individuals respond with aggression towards their handler. These animals are normally not used for breeding.
75. Early neutral or positive experience with humans does not necessarily induce tameness in foxes and mink. This could be achieved by positive conditioning and selection.
76. The relationship between man and foxes improves when the farmer clearly and consistently indicate his intentions.
77. The nature of the human-animal relationship and thus the farmer’s attitude and behaviour towards his animals is a very important aspect of fur farming, but only limited research on this subject has been carried out.

18. RECOMMENDATIONS

. The welfare of animals kept for fur production, like other subjects considered by the committee, raises ethical issues. It is not within the aim of the present report to recommend whether or not continued fur farming is ethically acceptable. The present report therefore contains only a scientific assessment of the welfare of animals kept for fur production, and scientifically based recommendations on how their welfare can be improved

General

1. Farmers and other persons responsible for the animals should be authorised to keep animals for fur production only if properly trained in all relevant aspects of their biology, welfare, and management. They should keep adequate monitoring systems recording all interventions and cases of mortality and morbidity. Farms should be inspected at least once a year by the competent authority.

2. Animals should be inspected daily. Animals with signs of poor health, conformation problems or injury, and who are likely to suffer should be treated adequately and promptly. If this is not possible, they should be killed immediately and in a humane manner. Appropriate vaccination should be conducted according to good veterinary practices.

3. Animals born in the wild should not be brought into farming conditions.

4. Since current husbandry systems cause serious problems for all species of animals reared for fur, efforts should be made for all species to design housing systems which fullfill the needs of the animals.

5. In general, all animals should be housed in clean cages or other housing systems with appropriate shelter and provided with sufficient and appropriate food and *ad libitum* water. Accommodation dimensions should not impose any restriction on basic movements. Accommodations for animals should be enriched according to species specific requirements.

6. Means of avoiding intraspecific aggression should be available, especially at time of mating, e.g., partitions, supervision and separation if necessary.

7. The composition of food for animals on fur farms should be carefully controlled so as to prevent the presence of toxins such as botulinin or the spread of pathogenic agents such as those which can cause transmissible spongiform encephalopathies. In respect of this last problem, the information and recommendations contained in the Report of 24-25 June 1999 adopted by the Scientific Steering Committee on “The risks of non conventional transmissible agents, conventional infectious agents or other hazards such as toxic substances entering the human food or animal feed chains via raw material from fallen stock and dead animals- including also ruminants, pigs, poultry, fish, wild/exotic/zoo animals, fur animals, cats, laboratory animals and fish- or via condemned materials” should be considered.

8. Appropriate measures should be taken to prevent heat and cold stress.

9. Restraint devices should be used as little as possible. Staff carrying out the handling procedure should be properly trained for the task. The equipment used should be designed and maintained in a way that reduces the risk of stress or injury to the animal.

10. Display of live animals from fur farms at commercial exhibitions should be avoided.

11. Killing of animals kept for fur production should be carried out only with humane methods. In particular chloral hydrate should not be used. Animals should be handled gently prior to killing. Research on killing methods for animals reared for their fur should be encouraged

12. Weaning age should be selected so that poor welfare does not result for offspring or mother. Social housing conditions should receive special attention in accordance with species-specific social requirements.

13. Breeding programmes and handling practices should aim at the reduction of fearfulness and aggressiveness.

14. Strains with health problems, disabilities or other welfare problems should not be used in fur production.

15. Mutilations of animals kept for fur production, e.g. detoothing, should be avoided.

Species-specific: Mink and foxes

16. The cages and management methods used for mink should be greatly improved because they result in: a mortality of mink kits of 20 percent; some significant morbidity problems; stereotypies often for long periods; fur biting or more serious self mutilation to the point of tail or limb loss. Changes in accommodation are needed in order to provide: sufficient environmental complexity and opportunities for investigation and exercise. Examples of normal mink behaviour which cannot be carried out in typical farm housing are running, climbing, and swimming.

17. The cages and management methods used for foxes should be greatly improved because they result in: excessive fear of humans which is not at present solved by either genetic modification or early contact with humans; limb bone weakness associated with lack of exercise: high rates of failure to conceive and failure to rear young; maternal infanticide; and other abnormalities of behaviour which are not adequately quantified. Changes in accommodation are needed in order to provide sufficient environmental complexity, sufficient separation from fear-inducing conspecifics and humans, and opportunities for investigation and exercise. Examples of normal fox behaviour which cannot be carried out in typical farm housing are running and digging.

18. In mink, colour mutation associated with poor health or any other aspect of poor welfare should be excluded from breeding programmes.

19. To decrease fearfulness and promote tameness, foxes should be given frequent, positive human contact, particularly during the juvenile period. Mink may also benefit from appropriate human contact.

20. The use of neck tongs and snout clips in foxes should be avoided as much as possible. Bare metal tongs should not be used.

21. Mink should not be kept in a carrying cage or in a trap for more than one hour.

22. Cages should be equipped with a nest box at all the times for adult silver foxes. Blue foxes should have access to an open nest box or platform except during the breeding season when a closed box should be provided. The use of entrance sections, e.g., tunnels, should be encouraged. Mink should have permanent access to a nest box.

23. All animals should have access to objects that stimulate normal behaviours, such as play and exploration, e.g., for mink, wire platforms or cylinders, straw and/or water containers, and for foxes objects to gnaw.

24. Restrictive feeding should not be allowed except for female mink in winter time whose weight is excessive. This practice should then be used with care with regard to individual animal condition.

25. The use of flexible cage systems allowing animals to move away from their neighbours should be encouraged. There should be adequate separation between neighbouring breeding silver foxes.

26. Mink should not be weaned before nine weeks of age. The use of larger cages allowing safe late weaning, e.g., at 12 weeks, should be encouraged. Female mink housed with kits older than 16 weeks of age should have means of escaping from them (e.g., platforms or cylinders). Recently weaned mink kits and fox cubs should not be housed next to their mothers.

27. When using group housing for mink, care must be taken to ensure that adequate feeding space, drinking space and nest boxes are provided. Supervision must be enhanced in order to detect any animals bullied by others.

28. Until a new design of housing system for mink can be developed, after 16 weeks of age no more than two animals should be housed in a standard cage (90 x 30 x 45 cm) and 2.5 animals per cage in multiple cages

29. Mink aged less than six months should not be housed singly except for veterinary reasons.

30. Killing mink with CO_2 should be avoided, and humane methods developed.

Other species

31. In the absence of specific evidence to the contrary, ferrets should be treated similarly to mink.

32. Welfare problems are apparent in chinchillas. These should be investigated with a view to their reduction. In particular, access to a sand bath is desirable for chinchillas, as well as cages high enough for the animals to jump normally without hitting the roof.

33. Until there is sufficient information on the welfare of raccoon dogs, keeping of this species on fur farms should be discouraged.

19. EXECUTIVE SUMMARY

The Scientific Committee on Animal Health and Animal Welfare has prepared a report on the welfare of animals kept for fur farming in response to a request from the EU Commission. The report deals with the welfare of mink, polecats (ferrets), foxes, raccoon dogs, coypus and chinchillas. Since the most numerous species used for fur production are mink and foxes, information about the welfare of these species dominates the report. This document is a short summary of the main conclusions and recommendations of the report.

The welfare of animals kept for fur production, like other subjects considered by the committee raises ethical issues. It is not within the aim of the present report to recommend whether or not continued fur farming is ethically acceptable. The report therefore contains only a scientific assessment of the welfare of animals kept for fur production, and scientifically based recommendations on how their welfare can be improved.

The report examines the extent to which the species used for fur production can be regarded as domesticated. It is concluded that these species, in comparison with other farm animals, have been subjected to relatively little active selection, except with respect to fur characteristics. There has thus been only a limited amount of selection for tameness and adaptability to captive environments.

With respect to the welfare of mink, the report concludes that there is an average kit mortality of about 20%, and a yearly adult mortality of 2-5%. There is usually a low level of morbidity due to infectious disease, but gastric ulcers, kidney abnormalities and tooth decay can sometimes be common. Stereotypies, largely locomotor in nature, are widespread on mink farms. In the largest study conducted, the number of affected animals varied between 31 and 85% of the females on different farms . Stereotypies have a complex causation, where one important aspect is the housing environment. Furthermore, mink in farm cages may show sucking or biting of their tail fur, and biting of other parts of their pelt. Self mutilation of tail or limb tissue occurs, but its prevalence is unknown. In experimental conditions, farm mink show strong preferences for the opportunity to swim. The report concludes that the typical mink cage impairs mink welfare because it does not provide for important needs.

With respect to the welfare of foxes, the report concludes that there is an annual mortality rate for juvenile and adult foxes on fox farms of about 5%. Failure to produce and rear litters of cubs has been reported to occur in 18-45 % of farmed foxes. However, significant failure to produce and rear litters also occurs in wild foxes, and hence the extent to which this problem can be solved is not clear. Abnormal behaviours such as exaggerated fear responses, infanticide, stereotypies and pelt-biting are described in farmed foxes but not well quantified. The report concludes that the typical fox cage does not provide for important needs of foxes.

The report also presents information and conclusions on other aspects of the management of animals kept for fur production and on methods of killing them humanely.

Concerning the other species, the report concludes that few scientific studies have been conducted, so a thorough assessment of their welfare is difficult. However, welfare problems are apparent in farmed chinchillas.

It is concluded that genetic selection to reduce fearfulness is effective in mink and foxes. Early neutral or positive experience with humans also decreases fearfulness in foxes. In practical farming, however, such selection and modifications of early experience have not been widely used.

The report presents a list of areas where future research is desirable.

The SCAHAW recommends that farmers and other persons responsible for the animals should be properly trained in all aspects of the biology, welfare and management of the species. Breeding programmes and handling practices should aim at the reduction of fearfulness and aggressiveness. Since current husbandry systems cause serious problems for all species of animals reared for fur, efforts should be made for all species to design housing systems which fulfil the needs of the animals. The SCAHAW further recommends that cages and management methods used for mink and foxes should be greatly improved in order to provide sufficient environmental complexity. All animals should have access to objects that stimulate normal behaviours, such as play and exploration.

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