

THE WELFARE OF FARMED MINK (*MUSTELA VISON*) IN RELATION TO HOUSING AND MANAGEMENT: A REVIEW

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Abstract

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*Early research on farmed mink was predominantly concerned with increased productivity; however, in recent years there have been an increasing number of studies related to welfare. The biology of feral mink has also become better understood, and such knowledge can aid in the assessment of welfare on farms, or in the interpretation of problems related to captivity. This paper is a comprehensive review of research pertinent to the welfare of farmed American mink, *Mustela vison*, in relation to their housing and management. It indicates how housing conditions might be changed to improve welfare, and where our present knowledge is insufficient. Many significant aspects of mink behaviour in the wild, such as their lack of social contact, their tendency to travel long distances and use several den sites, and regular swimming and diving, are denied them in captivity. Farmed mink also show high levels of stereotypy, suggesting that their welfare is not good. Welfare may be improved by appropriate environmental enrichment and changes in the social environment of farmed mink. In general, studies aimed at improving housing conditions have been limited in scope and outlook.*

Keywords: *animal welfare, housing, management, mink, *Mustela vison*, recommendations, stereotypies*

Introduction

There is debate about whether or not animals should be killed for their fur. The personal decision whether to wear or not to wear a fur garment may be different in a very cold region, where alternatives to fur garments are difficult to find, from that in regions where alternatives are readily available and the fur is a luxury worn to impress others. However, the assessment of the welfare of fur-bearing animals is independent of such considerations. Welfare refers to the state of an animal at a specific time and can be good or poor irrespective of what people think about the morality of such usage of animals. If the individual animal is having difficulty in coping with its environment, or is failing to cope, then its welfare is poor; but if strongly preferred resources and opportunities for behaviour are available, and normal behaviour can be shown, then good welfare is indicated (Broom & Johnson 1993; Broom 1996). A wide range of indicators of welfare can and should be used when welfare is being assessed. The selection and interpretation of welfare indicators should

be based upon knowledge of the biological functioning of such animals, especially the systems used by them to attempt to cope with adversity.

American mink, *Mustela vison*, are bred for their fur on farms in temperate or cold regions of the world. In contrast to the thousands of years during which animals such as cattle or pigs have adapted to farming by humans, mink have been kept in captivity for only 80 or fewer years (Hansen 1996). Hence, mink are not domesticated in the same sense. This renders it highly unlikely that all their requirements for good welfare in captivity will have been identified. Indeed, some mink on every farm show self-mutilation in the form of fur chewing (Joergensen 1985; de Jonge & Carlstead 1987) and many show high levels of stereotypies (de Jonge *et al* 1986): neither of these problems occur in the wild (Mason 1991b; Dunstone 1993), nor have been mentioned in relation to other captive conditions, such as zoos (eg DonCarlos *et al* [1986]) or laboratory studies (eg see Dunstone [1993]).

Mink usually breed successfully on fur farms (Elofsen *et al* 1989; Møller 1992). However, successful breeding alone cannot indicate whether welfare is good, as many animals which are successfully bred under farm conditions are found to have severe welfare problems (Fraser & Broom 1990). It is, therefore, important that research on housing in relation to the welfare of mink on farms is reviewed in order that significant problems are recognized, and their welfare in captivity can be improved.

Early research on farmed mink was predominantly concerned with reproduction and other aspects of biology relevant to improved production and hence economic gain (Shackelford 1950; Enders 1952; Rice 1967). However, in recent years, there have been an increasing number of studies relating to welfare (eg see Braastad [1992]). Furthermore, the behaviour and general biology of feral mink are becoming increasingly well understood. Such knowledge can aid in the assessment of welfare on farms, for example, by indicating the range of normal behaviours, and may be useful in understanding mink behaviour under restricted conditions. Dunstone (1993 p 181) emphasizes the importance of taking 'sound ecological data concerning wild mink' into account when devising guidelines for their keeping in captivity. This review begins with an overview of the biology of mink in the wild and housing conditions on farms.

The biology of feral mink

American mink were first brought to Europe in the late 1920s. Wild and escaped feral mink were found in Sweden in 1928 and in Britain in 1938, and the species is now one of the most common carnivores in the British Isles and Scandinavia (Burton 1979). Adult male mink are approximately 39cm long, and females are 34cm (Burton 1979). Males weigh on average 1.2kg, females are about half that weight (Dunstone 1993).

Breeding and kit development

Both males and females become fertile in their first year. The mating season lasts for about 4 weeks, starting in early March (Dunstone 1993). Gestation varies from 40–75 days, with an average of 50 days (Joergensen 1985); the delayed implantation of the fertilized ova (up to 30 days) is a unique feature of mink biology which interested early scientists (eg Enders [1952]; Rice [1967]). Kits are born from early May onwards and grow rapidly in size: from a birthweight of 5g, they increase to 100g over the first month (Dunstone 1993). However, they do not open their eyes nor begin to hear until approximately 33 days of age (in comparison with 5–7 days in kittens, 7–10 days in rabbits and 14 days in dogs: Foss & Flottorp [1974]). They begin to eat solid food at 4 weeks of age and to drink water at 6 weeks of age (Møller 1991a). Kits are, therefore, nutritionally reliant on their mother until at

least 5 or 6 weeks of age, yet in the wild they remain with their mothers for longer. In a study of a wild population in Scotland, the first occasion on which a kit was observed outside the den alone was at 6–7 weeks of age (Dunstone 1993); in another study, kits were weaned, leaving their natal territory at 11–12 weeks (Gerell 1970). On farms, they may be weaned as early as 5 weeks (Joergensen 1985). This is postulated to be the cause of behavioural maladaptions, as will be discussed below.

Aquatic lifestyle

Wherever mink occur in the wild there will be water close by, in fact most mink activity in North America and Europe occurs in water, or within 100–200 m of it (Dunstone 1993). A radio-tracking study of 19 mink in southern Finland found that both sexes swam distances of 250m almost daily, sometimes twice a day (Niemimaa 1995), and a large proportion of the wild mink's diet is generally derived from aquatic sources (Day & Linn 1972; Poole & Dunstone 1976; Birks & Dunstone 1985; Dunstone & Birks 1987; Niemimaa & Pokki 1990, cited in Niemimaa [1995]; Dunstone 1993). Laboratory studies have found that farm-bred mink can be trained to retrieve objects from a tank with no reinforcement other than from the moving cork or cotton reel itself (Poole & Dunstone 1976). Although mink do not see particularly well underwater (Sinclair *et al* 1974; Dunstone & Sinclair 1978a), they tend to retrieve prey by locating it from the surface, then making brief dives of between 5 and 20 seconds and sometimes longer (Poole & Dunstone 1976; Dunstone & Sinclair 1978b). Despite the fact that mink seem better adapted to locomotion on land than in water, they have partially webbed feet, and their swimming speed is much greater than that of terrestrial mammals and half that of the otter, *Lutra lutra* (Dunstone 1983; 1993). It seems clear that swimming and diving are highly significant aspects of the mink lifestyle.

Other behaviours and activity patterns

Mink have been noted for their agility and flexibility (Rice 1967) and for their ability to climb trees (Burton 1979). Radio-tracking studies of 20 mink (9 male, 11 female) in Britain determined that mink spent 5 per cent to 20 per cent of the 24h period (on average, approximately 3h) actively foraging outside their dens; male mink spent just under 2h travelling, and female mink travelled for around half this time (Dunstone & Birks 1985). Mink travel within a definable home range. Home range lengths of individual radio-tracked feral mink have been found to vary from 0.5–5.94 km (Gerell 1970; Birks & Linn 1982), although Birks and Linn (1982) considered these upper estimates to have been affected by the behaviour of males with unstable social environments (such males travel distances up to 30km [Niemimaa 1995]). They estimated mean home range length to be between 1 and 3km. A recent study of five mink in eastern Tennessee measured mean home range lengths of between 5.6 and 11.1km in autumn and early winter (Stevens *et al* 1997). Mink use a number of dens within these ranges: Gerell (1970) recorded mink using between two and five dens, changing dens on successive nights to a den usually 500m distant (although sometimes as far as 2000m); Stevens *et al* (1997) recorded the use of between 8 and 24 dens per mink, with overnight trips between them of up to 4300m. Dens are not excavated by the mink themselves but tend to derive from rabbit holes or natural crevices, for example around tree roots. Mink favour specific dens rather than apparently similar sites for reasons that are not evident (Dunstone 1993). Travelling and the use of several den sites are, therefore, significant components of feral mink behavioural biology. The fact that physical activity is important to mink has also been suggested by experimental studies showing that caged mink will run on a wheel for no reward (Zielinski 1986).

It is not known for certain that mink actively defend their home ranges as territories, however male territories never overlap (Dunstone 1993). Females may tolerate the intrusion of kits for part of the year, and can on occasion have territories partially overlapping with males, especially during the breeding season (Dunstone & Birks 1983; Dunstone 1993). Severe aggression has been reported among unfamiliar adults forced together by captivity (Rice 1967; Heller & Jeppesen 1986; Dunstone 1993). However, it is possible to keep captive mink which are familiar with one another together (eg those housed together since weaning or reared without weaning; see, *Social conditions of housing*).

Sensory biology

The mink's anal gland is a major source of specialized odour compounds (Brinck *et al* 1978). Mink perform marking by dragging this gland over the ground, or by depositing faeces (Dunstone 1993). Brinck *et al* (1978) suggested that mink may be able to discriminate between individuals, and that such an ability may help in detecting intruders in the home range. Unpublished research (Robinson 1987, cited in Dunstone [1993]) supports minks' use of scent to identify one another, to distinguish between known and unknown individuals, and between males and females. Experimental studies have shown that ferrets, *Mustela furo*, have similar capabilities (Clapperton *et al* 1988). Gerell (1968, cited in Dunstone [1993]) first noted that mink leave scats in prominent positions within their home ranges, where the scent is likely to have carried furthest. Dunstone (1993 p 139) states 'the violent reaction of a mink to the scent of an intruder leaves one in no doubt about the value of a scat'.

Mink are sensitive to lighting conditions, as the processes of fur growth and sexual development are dependent on exposure to an appropriate photoperiod. Melatonin is the photoperiodic signal for the autumnal weight increase and moult (Valtonen *et al* 1995). The shorter day length controls such changes via melatonin excretion. Other experimental studies have demonstrated that short day lengths during autumn stimulate spermatogenesis in October to November, and this effect is enhanced by additional month-long illumination before the short-day period (Klotchkov *et al* 1985). Jallageas *et al* (1994) and Gulevich *et al* (1995) have further demonstrated that artificial photoperiods can cause significant changes in mink gonadal function and activity.

The extent of modification in relation to captivity

There is anecdotal evidence suggesting that mink on farms have become less fearful and tamer in response to contact with humans. Hansen (1996) noted that early reports (eg in the 1940s, see Shackelford [1984]) described mink fleeing into the nest box when people were close by. Hansen (1996) stated that mink now often respond to the presence of a human with curiosity. He suggested that nervous individuals might have been eliminated by natural selection. Hansen's own study (Hansen 1996) involved 3000 farm mink over 6 years in which he selected and bred mink for exploratory, aggressive or fearful behaviour in the presence of a human. He found that it was possible to select for fearful behaviour, but not for exploratory behaviour; in fact those mink selected and bred for exploratory responses showed a significant increase in fearful behaviour. Thus, while this, and earlier work with similar results (eg Hansen [1991b]); Houbak [1990], both cited in Braastad [1992]), suggested that certain behavioural traits may be inherited, no results were achieved which suggested that farmers could selectively breed for less fearful, and potentially better adapted, animals.

Standard farm housing conditions

Details of standard housing conditions on mink farms appear in Joergensen (1985), Mason (1991a), Møller (1991b), and Hansen *et al* (1994). These indicate that mink cages have approximately 0.27m² (90x30 cm) of floor space, and a height of 30–40 cm. A single nest box, with a floor area of 0.06m², is attached to the cage via a circular hole. The cages are made of square, galvanized steel mesh, allowing faeces to fall through, and the nest boxes are generally made of wood, but may have a mesh roof. Drinking water is continuously available via an automatic system: a drinking nipple inside the cage is attached to a hose. The water is protected from freezing via a circulation or heating system. Mink are fed once or twice a day with a nutritious purée that is placed on top of their cages.

Cages are made in six- or eight-cage sections (joined side-by-side) and placed in rows in sheds. Sheds generally contain two or more parallel rows, with a roof above and walls which are either left open or filled in with wire mesh (Mason 1991a) or a screen made of heavy plastic or sacking stretched on wooden frames (Joergensen 1985). Joergensen (1985 p 38) recommends that a hedge be grown around the sheds for ‘cold does not affect mink, but draught is their worst enemy’.

After weaning (usually at approximately 7 weeks of age [Mason 1996]), mink may be housed individually, or placed in male/female sibling pairs in one cage. They stay this way until pelting, at approximately 8 months of age. At this point, some individuals may be selected for breeding purposes and rehoused.

It is clear that the housing conditions of mink on farms differ markedly from those of mink in the wild in terms of the rearing of kits, the proximity of other mink, and the opportunities for swimming and diving, roaming, using different dens, and engaging in physical activity. Undoubtedly, the olfactory environment and lighting conditions on farms also differ greatly from conditions in the wild.

Health and disease on mink farms

Mink have been described as ‘extremely hardy’ (Rice 1967 p 73) and ‘healthy vigorous animals [that] rarely get sick if they have adequate food, water and clean conditions’ (Dunstone 1993 pp 183-4). The incidence of disease appears to be relatively low: Wahlstrom (1987, cited in Harri *et al* [1995]) reported that the summer mortality rate on 16 farms in Sweden averaged 1.3 per cent for adult males, 1.5 per cent for adult females and 2.1 per cent for kits. Joergensen (1985) recommended that good housing conditions include well-spaced sheds and that good hygiene should involve both cleaning and disinfection to prevent manure and dirt from becoming chronic reservoirs for viruses and bacteria. It is further recommended that farmers be vigilant and regularly (eg daily) inspect their mink for any signs of disease.

Disease is always a threat. Rice (1967) considered that there are three diseases which, if introduced, will seriously deplete a colony: botulism, distemper and Aleutian disease. Botulism is said to occur only infrequently, but when it does occur, the powerful toxin produced by the anaerobic bacterium *Clostridium botulinum* can cause widespread mortality throughout a colony. Only a small portion of infected food may kill a mink. Distemper is also very infectious and will easily spread from one infected mink to the majority of the colony during the 8–14 day incubation period. One-time vaccination can protect animals from these diseases for life; however, Joergensen (1985) noted that vaccination is costly, and the act of vaccination may risk spreading disease via infected syringes. He recommended

frequent cleaning under cages, and disinfecting of sheds, while the decision to vaccinate is considered and made on an annual basis.

Aleutian disease can be a major cause of mortality, and there is no treatment for infected animals. Investigations involving over 5500 autopsies in Argentina indicated that Aleutian disease was the most important cause of premature death (Martino *et al* 1991). Airborne transmission may be substantial, although mechanical transmission is probably more to blame (Jackson *et al* 1996a). Jackson *et al* (1996b) reported that transmission may be enhanced by the use of contaminated toenail clippers for blood collection. Farmers can, however, test for the disease and cull infected animals from the stock (Dunstone 1993).

Nursing disease is also reported among adult female farmed mink in Europe (Møller 1991b). A study of the pattern and relative frequency of diseases in adult female mink during the lactation period on 48 farms in southern Ontario found that nursing disease was the most common diagnosis (56%), the mortality rate among this group ranging from 0.2 per cent to 10.1 per cent, with a median of 1.9 per cent (Schneider & Hunter 1993a). Variation between farms was associated with the type of water source, size of the farm and source of feed (Schneider *et al* 1992). It has also been suggested that nursing disease may result from energy depletion due to lactation (Schneider & Hunter 1993b).

While farmed mink may be relatively hardy, there exist no published reports of the incidence, causation and appropriate prevention of disease among farmed mink in Europe.

Harri *et al* (1995) examined the possibility that farmed mink experience a high incidence of stomach ulcers. An incidence of ulcers in 35 per cent to 40 per cent of kits, and in 55 per cent of adults, was reported by Wahlstrom (1987, cited in Harri *et al* [1995]). This result was then cited to demonstrate that approximately half of all farmed mink have ulcers, and to conclude that ulcers were the result of stress and an inability to cope with farm conditions (Kollberg & Bjorkland 1989, cited in Harri *et al* [1995]). Examining singly housed mink under standard conditions, Harri *et al* (1995) found a lower incidence of stomach ulcers (24%). Most of these ulcers rated only one on a five-point scale of severity. However, the study also found that mink subject to aversive treatments (such as frequent, regular immobilization in a restrainer) failed to develop significantly more ulcers than control animals. They concluded that the incidence of stomach lesions was not a useful indicator of poor housing conditions.

The nest box

As discussed above, wild mink use a number of den sites, change dens daily, and prefer particular dens for as yet unidentified reasons. This would suggest that the presence of at least one nest box is essential. Results from Hansen (1988) suggested that male and female mink housed in standard-size cages without nest boxes had poorer fur quality than those with access to nest boxes. This was thought to result from their lying against the wire mesh, and from the inhibition of blood circulation and nourishment of the hair follicles due to additional heat loss. Reduced fur quality can be considered a sign of poor welfare – and an indication that an animal is having difficulty in coping. Results also suggested that the absence of a nest box might lead to an increased metabolic rate and higher adrenal weights. The latter effect may indicate chronic stress, reflecting the adrenal gland's capacity for cortisol secretion (Mason 1992).

Determining the effect(s) of captivity without access to a nest box on physiological parameters in mink has been complicated by results which could support contradictory hypotheses (Hansen & Brandt 1989). However, later investigations (Hansen & Damgaard

1991a) showed that male and female mink in standard cages without nest boxes had a lower level of circulating eosinophil leucocytes than mink with nest boxes – a reaction seen in mink subjected to acute immobilization (Heller & Jeppesen 1985). The effects of the absence of a nest box were comparable with those produced by 30-min immobilization sessions. Furthermore, female mink housed without nest boxes also had higher cortisol levels than those housed with nest boxes. In another experimental study, female mink deprived of nest boxes during the whelping period were found to lose significantly more kits than other experimental groups, and weight gain among their kits was significantly lower (Møller 1990).

Hansen *et al* (1992; 1994) found that female mink in cages without nest boxes showed more stereotypic behaviour than those housed with nest boxes. They considered that this might arise from frustration at the inability to avoid contact with neighbours. These mink also had a greater food intake which did not result in more rapid, or greater, weight increase. Hansen *et al* (1992) stated that the growth rate was higher in mink housed with nest boxes, although it is unclear how this was measured. These results accord with those of Hansen (1988), ie that mink housed without nest boxes had a higher metabolic rate.

The importance of the nest box for the health and welfare of farmed mink has now been amply demonstrated for both male and female animals. No further experimentation should deprive mink of this basic necessity. Rather, any further experiments could examine how the provision of nest boxes might be improved: for example, work by Møller (1990) suggested that a 'drop-in' bottom (ie a false bottom) in the nest box was associated with better kit survival than in standard nest boxes. He supposed that this made it easier for a mink to keep her kits from wandering and, thus, protect them from hypothermia. An obvious further issue for investigation is the preference of mink for more than one nest box (see below).

Drinking water

Møller (1991a) identified three points with regard to the provision of drinking water for mink. i) Water must be available 24h a day, for captive mink drink frequently, day and night. Standard farm conditions meet this recommendation (as above). ii) While water is often circulated so as to prevent it freezing and becoming inaccessible, it may reach high temperatures in summer. iii) The water intake of mink and kits during the female's lactation period is an important issue. Møller's observations showed that kits began to eat food at 4 weeks of age, but did not begin to drink water until 6 weeks of age: therefore, their moisture requirements must be met via food, milk, and licking the mother's saliva. During this period, Møller (1991a) noted that females may experience dehydration, and weight loss (particularly during hot summers), and that 'nursing disease in the female and cannibalism among the kits' (Møller 1991a p 5) occurs. He concluded that the earlier kits begin to drink, the greater the relief for the mother and her kits.

Supplementary watering systems

It was not possible to determine how widespread or serious the problem of potential kit and mother dehydration may be in Europe. However, it is clear that water intake during the lactation period is an important issue that warrants investigation. Møller (1991a) noted that mink will drink from an open water surface but have no natural inclination to drink from the valve in the cage, and that various devices have been used to teach kits how to drink water. He tested the effect of a supplementary watering system – a 'drip' watering system, which is described by Joergensen (1985) as a tube dripping water into drinking cups. Experiments over 2 years, involving two groups of 60 mink families each year, indicated that kits

provided with this supplementary system made significantly fewer unsuccessful attempts to drink than those provided with just the standard nipple system. The behavioural observations conducted in the second year indicated that kits with the drip watering system began to lick water from around 40 days of age. In the first year, there was no difference in weight gain between experimental and control groups; but in the second year, kits in the experimental group were reported to gain weight significantly faster, and females to lose significantly less weight, than those in the control group. Joergensen suggested that the difference in results between these two years might be due to the higher average temperature in the second year (2.1°C higher). The benefits of supplementary watering systems may, therefore, be greatest when the summer is especially hot. Møller (1991a) concluded that it is important to provide supplementary systems for helping kits to drink before they are able to activate nipple systems.

Møller and Hansen (1993) examined minks' use of a spray watering system which, when activated on a timer, produces a jet of water. This is said by the manufacturer to provide a shower for the mother and extra water on her pelt for the kits to lick (thus supplementing their water intake). In experiments involving two groups of almost 100 animals, the spray watering system was switched on for 30–60 s at a time, four times each day. The results showed that while the majority of the females used the spray for at least part of the time it was available, there was no positive effect on the weight of the females. This, they suggested, might have been due to the effect of low temperature, and the possibility that benefits are greatest when temperatures are highest. Kits did, however, gain weight more rapidly. This effect was probably because kits licked water from the cage and floor after spray watering: they did not lick water from the female's pelt. In another experiment (Hansen 1990), the provision of a 2cm-deep water tray in the cages of lactating females did not affect weight change in the mother. However, the lack of positive effect may have arisen because the female was reported to routinely empty the tray of water by getting into it.

The provision of supplementary watering systems would appear to be problematic, given that commercially available products have produced varying results, and that certain claims made by manufacturing companies as to how mink will behave in relation to their equipment are incorrect (eg Møller & Hansen [1993]). The issue of mother and kit dehydration, and how to provide readily available supplementary watering systems, is a continuing problem.

Drinking water temperature

Møller (1991a) also investigated minks' drinking water temperature preferences in experiments which gave the animals a choice between cool (6°C) or warm (40°C) temperatures. His results showed that mink accepted, and sometimes preferred, drinking water at temperatures up to 40°C. He reported that similar results have been found with rats. In fact, he argued, mink may prefer cold or warm water under different circumstances. A preference for warm water may occur when a mink is dehydrated, as cold water is let out of the stomach only slowly, and the stomach is filled quickly. While the feeling of thirst is satiated, the animal is not as well hydrated. Water at body temperature passes through the stomach, allowing a greater volume to be ingested before stomach distention signals a satiation of thirst. On the other hand, cold water may be useful when the temperature is high. According to Møller (1991a), mink may die from heat exhaustion in temperatures of 30°C or more. Rats drinking cold water (eg at 12°C) have been shown to lower their body temperature by up to 1.2°C (Deaux & Engstrom 1973): thus, the opportunity to cool the body may also be useful for mink. However, more experimentation is needed to provide conclusive evidence regarding water temperature preferences in mink, and whether these

proposed benefits of hot and cold water might indeed be applied so as to benefit captive mink.

Stereotypies and enrichment

Stereotypies are repetitive, invariant behaviour patterns with no obvious goal or function (Mason 1991b). Their occurrence is often associated with barren and restrictive conditions, or environments which might be considered suboptimal, and they develop in animals faced with insoluble problems of frustration or conflict (Hinde 1970; Mason 1991b). Once developed, stereotypies can be elicited independently of the original stimulus, becoming part of an animal's behavioural repertoire.

Some authors have argued that stereotypic behaviour may be an adaptive response to an aversive situation (eg, see Hansen *et al* [1992]), and some results suggest that farmed mink showing high levels of stereotypy are, in other respects, coping better with their environment. For example, in one study, it was concluded that highly stereotyping female mink had lower baseline levels of plasma cortisol than those showing low levels of stereotypy (Bildsøe *et al* 1991), although it is not entirely clear that their results supported such a conclusion. Also, signs of poor welfare, such as low body weight, do not necessarily correlate with stereotypy levels in adult mink (Mason 1991a; 1992; 1993), although in kits, the level of stereotypy was found to be negatively correlated with body weight, and positively correlated with the mean size of the adrenal gland ($P < 0.05$ in both cases [Mason 1992]). While it is possible that those individuals performing stereotypies might be better off in some respects than those which do not (since individuals have widely differing ways of reacting to aversive stimuli [Broom & Johnson 1993]), the very existence of stereotypies indicates an inadequate environment in which mink are having to do much to cope. Furthermore, exposure to aversive stimuli, such as restricted feeding and daily immobilization sessions, has been shown to lead to an increase in stereotypies in farmed mink (Bildsøe *et al* 1991), indicating that stereotypies arise from aversive environments even if they are eventually elicited under different circumstances. Performance of stereotypies is also associated with negative consequences, such as slower growth in kits (Mason 1992; Mason *et al* 1995) and increased feed intake without a consequent increase in growth (Hansen *et al* 1992). In contrast, studies of both mink and other farmed or captive animals suggest that stereotypies can be ameliorated by improving the animals' environment, for example, via enrichment (eg increasing the size and complexity of the environment [Fraser 1975; Ödberg 1987; Bryant *et al* 1988; Markowitz *et al* 1995; Cooper *et al* 1996]). Although stereotypies, and aberrant behaviour such as tail biting, appear to have a genetic component (eg Hansen [1993]; de Jonge [1988; 1989], cited in Mason [1994]), it is apparent that learning and environment can affect the occurrence of stereotypies.

Stereotyped behaviour is widespread among farmed mink. In a study of 142 singly housed female mink, de Jonge *et al* (1986) found that 70 per cent of them performed stereotypies to a greater or lesser extent, and 50 per cent did so for greater than 25 per cent of the time they spent awake. In a study of 187 male and female mink, Bildsøe *et al* (1990a) found that stereotypies accounted for an average of 15.8 per cent of active behaviour. Levels of stereotypy vary between individuals, from farm to farm, and from season to season (Bildsøe *et al* 1990b), but are an ever-present feature of farmed mink behaviour. Wild mink, mink in zoos and mink in enriched laboratory conditions do not show these abnormal behaviours (eg Dunstone [1993]; Erlebach [1993]). This is a strong indication that standard farm conditions are inadequate and should be improved for the sake of mink welfare. The following sections

examine improvements to the cage environment, and note how these may be related to stereotypies.

Feeding regimes

It is often reported that stereotypies are at their peak in farmed mink prior to feeding (de Jonge *et al* 1986; Bildsøe *et al* 1990a; Mason 1991a; 1993), and it has been suggested that food deprivation (Bildsøe *et al* 1991) and minks' inability to access food at will are significant factors in producing stereotypies. In fact, Rushen and de Passillé (1992) considered that most stereotypic behaviour reflects inadequacies in feeding regimes, rather than in housing. Hansen *et al* (1994) observed stereotypic activity among farmed mink which were fed *ad libitum*, and thus should have experienced no frustration at the lack of food: in these mink, stereotypy occurred mainly at night and after feeding. However, this study did not involve a control group which might have indicated whether *ad libitum* feeding reduced the incidence of stereotypies. Nor has research examined whether *ad libitum* feeding will prevent the occurrence of stereotypies in mink which have not yet learned to stereotype.

If farmed mink stereotype because of their lack of control over their environment, particularly in relation to feeding, then measures aimed at increasing individual control may improve mink welfare and reduce stereotypies. For example, caged mink have learned to work for food, by running on a wheel and earning pellets at varied work:reward ratios (Zielinski 1988). Shepherdson *et al* (1993) found that providing food to zoo-housed small felids in a way that maximized the functional consequences of foraging behaviour (eg requiring cats to hunt for food) reduced the incidence of stereotypy and increased behavioural diversity. Evidently, such a change in feeding regime would require substantial changes in farm management in relation to the type of food delivered, but further research could explore the potential benefits of permitting caged mink greater control over their feeding regime, after which point the feasibility and practicality of such a change could be assessed.

Stereotypies in farmed mink are, however, unlikely to derive from pre-feeding frustration alone, as post-feeding stereotypic behaviour occurs even in very young mink. Furthermore, Mason (1993) has pointed out that the form and timing of the occurrence of certain stereotypies (eg head twirling) suggests that they are more likely to be derived from attempts to escape the cage, thus suggesting that the physical conditions of the cage are inadequate.

Cage size

Research does not suggest that increases in cage size in the absence of further enrichment improve the welfare of farmed mink. Jonasen (1987, cited in Hansen [1988; 1991a]) conducted experiments using six- and eight-room cage sections (ie six or eight contiguous cages in a 2m section) and found no difference in the frequency of stereotypies associated with the different cage sizes. This result was replicated in a repetition of the same experiment with pairs of kits. Hansen (1988) studied the behaviour of 228 mink kits housed in pairs in bare wire cages with floor areas of 1.05m² (large), 0.27m² (standard) and 0.1m² (small). He found that stereotypies did not occur significantly less often in the largest cage size, only that cage size influenced the type of stereotypy. In addition, he found significantly higher adrenal weights among the mink kept in the larger cages, suggesting that this treatment may have led to higher stress levels. Later work (Hansen *et al* 1992) on 60 male:female pairs in cages of these same sizes found that mink in the larger cages performed significantly more stereotypies, and had a significantly lower level of circulating eosinophil leucocytes, than

those in small or standard cages. The measurement of eosinophil levels is not easy to interpret because a variety of factors affect these levels, although they can indicate stress in some circumstances. This suggests that, within the size range tested, mink given larger floor areas in barren cages had no better (or perhaps poorer) welfare than those in standard cages.

The smallest cage size was also found to inhibit the performance of scent-marking and climbing. Hence, mink showed fewer of their natural behaviours in the small cages, and could be said to experience poorer welfare than those in standard cages.

Environmental enrichment

Markowitz (1982) introduced the concept of environmental enrichment for zoo animals, in which the cage environment was modified to provide appropriate contingencies for the performance of natural behaviours not otherwise observed. For example, gibbons, *Hylobates* spp., were able to earn food by swinging on a series of artificial vines. Enrichment, or the improved biological functioning of captive animals resulting from modifications to their environment, has since become a general concern in animal welfare research (eg Newberry [1995]). A few studies have examined the consequences for farmed mink of enrichment-oriented modification of the standard cage environment.

Additions to the standard cage environment

Hansen (1990) compared the behaviour of female mink in standard cages during whelping with those in cages enriched by the addition of a suspended wire-netting cylinder. Females in the enriched cages showed a significantly lower incidence of stereotypic behaviour, and it was suggested that the cylinder provided a resting place, where the mother could escape her kits temporarily: there was a decrease in the use of the cylinder when the kits were 7–8 weeks old and able to reach their mother there. Later work (Hansen *et al* 1994) attempted to examine the potential enrichment benefits of wire-netting cylinders, in conjunction with increases in cage size, for adult mink without kits. However, the increase in cage size (from small to large, as in Hansen [1988]) involved cages which either had no nest box, or had nest boxes and wire-netting cylinders. Hence, the effects of enrichment were confounded by the effects of the presence or absence of a nest box. Thus, it is not known whether a suspended wire-netting cylinder would reduce stereotypic behaviour in mink other than lactating females housed with kits. Nor is it known whether a larger cage floor area (eg 1.05m²) in conjunction with one or more wire-netting cylinders would produced less stereotypic behaviour than a standard cage enriched with such a device.

Jeppesen and Falkenberg (1990) examined the effect of introducing toys into the standard farm cage environment. Mink kept in male:female pairs were given two, hard, red, 4.5cm (diameter) balls for a period of 1 month. The toys had no effect on physiological measures (eg eosinophil or cortisol levels), on the extent of bite marks recorded on pelts, or on levels of stereotypy, although the method of recording mink behaviour (involving an observer close to the cages) may have reduced the incidence of stereotypic behaviour. Mink spent time manipulating the balls (ranging from 15% of all observations in the first 24h, to close to zero after 27 days), and lasting effects were detected in terms of higher levels of non-stereotypic activity, and greater 'curious(ness)'. Thus, the introduction of balls might be regarded as having caused a limited improvement in welfare, although no overwhelming effect can be inferred from the one-time introduction of a single type of toy. Newberry (1995) has warned that toys intended for environmental enrichment should have relevance to the animals' natural behaviour: while balls would seem appropriate to elicit chasing and pouncing, it

appears that part of the appeal of this toy derived from its novelty value, which reduced substantially over the trial period.

Wider-ranging enrichment

Just as it has been noted that stereotyped behaviour does not occur in the wild, there is evidence to suggest that such behaviour may be absent among mink kept in highly naturalistic enclosures. Erlebach (1993; 1994) compared the behaviour of mink kits individually housed in standard cages with those living with their litter in large enclosures (8x5.5x2.5 m [*lxwxh*]) in which the ground was formed of soil and sand, and the enclosure contained natural vegetation, climbing branches, tunnels, nest boxes, and a concrete waterpool (2x2x0.6 m [*lxwxh*]). The author reported that all cage-housed mink developed running stereotypies, whereas no such behaviour occurred in those housed in the enriched enclosure. The enclosure-housed mink played for 13.8 per cent of all observations, but play among cage-housed mink was significantly lower (1.7%). Enclosure-housed mink were also observed using climbing branches. The effects of enrichment and the social conditions of housing were confounded, but the results suggest a substantial difference between the standard cage environment and a naturalistic enclosure for kit development. In a study of zoo housing of the stoat, *Mustela erminea* – another asocial mustelid – no mention is made of stereotypic behaviours among individuals housed in enclosures containing artificial rocks and vines (DonCarlos *et al* 1986). Given that the goal of this project was to increase visitor enjoyment of the stoat exhibit, one might assume that behaviours of such unpleasant appearance would have been mentioned, had they occurred. Research with bank voles, *Clethrionomys glareolus*, has shown that stereotypies rarely develop among animals kept in large enclosures enriched with items such as intertwined twigs (Ödberg 1987).

Recent, experimental investigations involving preference testing offer the best potential method of defining appropriate housing for captive mink. Cooper and Mason (1997b) studied 8-month-old farm-reared kits in an apparatus consisting of a standard farm cage connected to seven compartments, each containing one of seven resources. The mink visited all the compartments. In order of preference, they spent 52 per cent of their time in the home cage and connecting tunnels; 36 per cent of their time in a hay box (intended to represent an alternative den site); 4 per cent of their time in a bath (standard human-size); 2 per cent of their time, respectively, with a novel object (changed daily), a prey-like toy, a raised platform and a tunnel; and 0.3 per cent of their time in an empty compartment. However, the true importance of these resources to the mink was indicated not by how much time they spent with each, but by how hard they were prepared to work to spend time with each. This was measured by gradually increasing the weights on the access doors to each compartment until mink ceased seeking access to resources. All mink overcame a weight of 1250g in order to visit the novel object and the bath, whereas no mink overcame weights of 750g to visit the empty compartment, 1000g to visit the tunnel, or 1250g to visit the toys or platform. Overall, consumption of resources in terms of both highest 'entry fee' paid, and time spent with the resource, indicated that mink ranked the hay box, bath and novel object as most important, with the toys, tunnel and platform less important, and the empty compartment of minimal importance. This rank ordering of the resources by mink supported earlier experimental results (Cooper & Mason 1996) and another study, in which the hay box, bath and novel objects were three of the four most important resources (Cooper & Mason 1997a, c). The preference for the resources existed even though the mink had been reared in wire cages without novel objects or swimming opportunities. Recently, an experimental investigation allowed farmed mink access to a swimming basin the size of a human bath for a year or more (Skovgaard *et al* 1997). However, these researchers concluded only that the litter size of

these mink was not significantly different from that of controls: such results suggest little about the welfare of mink.

As described earlier, wild, feral mink make use of several dens and their lifestyle is highly involved with water. These results, suggesting that mink will work hard for access to an alternative nest box and a bath large enough for swimming, are, therefore, not surprising. It also appears that mink seek a degree of novelty in their environment: this concurs with the findings of Jeppesen and Falkenberg (1990), indicating that the use of balls for play was highest when the objects were first introduced and thus, had the greatest novelty value.

These studies indicate that captive mink can benefit from environmental enrichment. With regard to the effect of environmental enrichment on the amelioration of stereotypies, it is possible that such an effect would be limited in adult mink, once stereotypies had already developed. Cooper *et al* (1996) found that stereotypy was harder to prevent by environmental enrichment in older bank voles. By transferring voles from barren cages to enriched cages, they were able to show that young voles ceased stereotyping, yet older voles continued to show stereotypic behaviour, supporting Mason (1991b)'s hypothesis that stereotyped behaviour becomes harder to disrupt with time. This may be true of mink also, as several papers have emphasized the importance of rearing conditions in the development of stereotypies in mink (see, *Kit age at weaning*). Similarly, Marriner and Drickamer (1994) concluded that rearing conditions were more important than present environmental conditions with regard to the occurrence of stereotypies in captive primates. The effect of age in relation to mink stereotypies and environmental enrichment is, therefore, unknown at present.

Social conditions of housing

Housing individually or in pairs or groups

After weaning, mink kits may be housed individually or placed in male:female pairs. Given that wild mink live in large territories which generally do not overlap, and that they have been reported to be extremely hostile when brought into close proximity with unfamiliar adults, there has been some debate about the most appropriate social housing conditions for mink. When mink are housed together on farms, however, this generally occurs at or soon after weaning. A number of experiments have compared different social housing conditions for mink.

Heller and Jeppesen (1986) compared individual housing of kits with housing in pairs or triplets. At the age of 8 weeks, 50 male and 50 female mink were transferred to one of four housing conditions (male and female housed singly, male:female pairs, male:male pairs and groups of three females). Blood samples were taken regularly, and all social groups showed higher circulating eosinophil leucocyte levels than individually housed animals until the animals were 6 months old. They also reported that females housed with other mink had higher eosinophil levels than when housed alone. Hansen and Damgaard (1991b) examined the effect of individual housing versus housing in groups of three males and three females in larger cages (floor area 1.05m²) on a number of haematological variables and pelt quality in 168 kits. They found no difference between males under the two conditions, but results again suggested that females kept with other mink may experience more stress than females housed alone: both cortisol concentration and the frequency of bite marks were higher in these mink.

However, the same problems were not found to be associated with housing in pairs. Damgaard and Hansen (1996) compared individual housing with housing in pairs from weaning to pelting in 96 kits equally divided between the two conditions. They found no evidence of problems – as indicated by the heterophil:lymphocyte ratio – to suggest any

difference in welfare between the two groups, for either males or females. The level of total leucocytes was significantly higher in group-housed mink than in singly housed mink, which the authors suggested might indicate a greater immune response in group-housed mink. Mink kept in pairs had better pelt quality and, surprisingly, did not have a significantly higher incidence of chew or bite marks on their skins. Similarly, Møller (1991c) studied mink kits kept singly or in pairs from weaning to pelting. He found no statistical difference in the skin quality between the two groups, despite finding that individually housed kits were lower in weight at pelting and had shorter skin length, a situation which would be expected to result in higher quality skins. The fact that individually housed kits showed lower weight gain than kits housed in pairs may not have been due to housing conditions, given that those kits housed individually weighed less from the outset and initial weight at rehousing was significantly related to weight at pelting. Similar studies (eg Sønderup [1990], cited in Damgaard & Hansen [1996]) have not found this effect of housing on weight. However, these results do suggest that mink housed in pairs have no worse, and possibly better, welfare than those housed individually.

Studies by de Jonge (1996a, b) and de Jonge and van Iwaarden (1995) have led them to conclude that housing mink in groups in bigger cages is an economically sound choice. Contrary to the results of Hansen and Damgaard (1991b) and de Jonge (1996a), they found that pelt quality was not clearly influenced by group-housing, and damage to the pelt corresponded more closely with the mink density per cage, than the size of the group. With regard to welfare, de Jonge and van Iwaarden (1995) raised 37 litters of mink without weaning: instead they remained with their mothers in housing consisting of three connected traditional cages. These animals were reported to grow up without fighting, and their mothers stayed healthy. According to the results, these mink had a normal size and a better pelt quality at auction when compared with mink housed in male:female pairs.

Some anecdotal observations suggest that a familiar partner may provide some degree of environmental enrichment for a farm kit. Hansen *et al* (1994) mentioned that kits housed in pairs preferred to lie together regardless of the cage size or the presence of the nest box. Damgaard and Hansen (1996) remarked that living alone in a barren, static environment increased stereotypies in farmed mink. Jeppesen *et al* (1990, cited in Braastad [1992]) reported that individually housed mink kits kept in single cages developed stereotypies earlier and with a higher frequency than kits kept in pairs. Although Erlebach (1993) made observations relating to a very small sample in this respect, she also reported that running stereotypies appeared earlier in individually housed mink than in those housed in groups of three. She suggested that the presence of playmates might have delayed the development of stereotypies.

There is a discrepancy between the results of Heller and Jeppesen (1986) and those of later studies. This early work involved a relatively small sample size in some comparisons (eg 20 kits only housed in male:female pairs), and it is possible that later studies, with larger sample sizes, are more reliable. Two studies (Heller & Jeppesen 1986; Hansen & Damgaard 1991b) suggested that females housed in groups showed some signs of poorer welfare than individually housed females. However, there is also evidence to suggest that pair- and group-housed mink of both sexes fare no worse, or even better, than mink housed individually. Fur quality may be better in mink housed in pairs, and the presence of another kit from the time of weaning may provide enrichment for mink, although adequate behavioural studies have yet to be conducted.

The effects of visual isolation

The solitary nature of wild mink suggests that visual contact with other mink may also lead to poor welfare on farms. Experiments have generally focused on whether visually isolated females will have higher breeding success.

Gilbert and Bailey (1967) separated 54 farmed mink into two groups, one of which was visually isolated by placing fibreboard partitions between individual cages, and one of which was housed under standard conditions. From early January until mid-March, there was no visual contact between mink in the isolated group. They found that visual isolation seemed to inhibit ovarian development in comparison with the control group, a result that they attributed to a lack of social facilitation. Similarly, Gilbert (cited in Gilbert & Bailey [1969b]) found that mink which were visually isolated in the long term (ie for 4 months) showed inhibited gonadal stimulation and follicle development: in extreme cases the females did not come into oestrus.

However, Gilbert and Bailey (1967) suggested that isolation may have been beneficial after mating, because females did not engage in agonistic encounters with neighbours, and thus may have enjoyed better welfare. Isolates had a slightly lower number of stillborn kits (although no statistical test was employed), and it was suggested that increased litter size might result from visual isolation. Later experiments (Gilbert & Bailey 1969b), using 44 female mink under the same conditions, found that the control females showed greater body weight losses during oestrus and pregnancy (or pseudo-pregnancy) than isolates. However, physiological parameters (eosinophil leucocyte levels) indicated that visually isolated mink may have had poorer welfare during anoestrus. They concluded that visual isolation during anoestrus may be detrimental to farmed mink, whereas isolation during oestrus and pregnancy appeared to be beneficial.

In another study of the breeding success of 102 females of three different mink varieties, Gilbert and Bailey (1970) found little overall difference between isolates and controls, although a significant increase in litter size only resulted from visual isolation of the 'dark' strain. This result was attributed to the particular nervousness of this strain, with the suggestion that isolation reduced stress induced by conspecifics and thus limited *in utero* loss of kits. In larger-scale experiments, Møller (1991b) also found little evidence of an improvement in breeding success achieved via visual isolation, although it is not clear whether visual isolation 'by means of an empty cage' (Møller 1991b p 39) achieved the same degree of isolation as the use of board partitions. In the one experiment reported by Møller (1991c), which involved visual isolation by means of filling the adjacent cage with straw, isolated females gave birth to significantly more kits – although no difference in litter size was apparent 2 weeks later.

Behavioural observations relating to the potential effects of visual isolation on welfare are limited. Møller (1991b) reported that the control mink in his experiment were much more active during all time periods than isolated females, although the type of activity and its significance were not discussed. Vestergaard (1983) reported that visually isolated females differed from controls in showing no aggressive or stereotyped behaviour. De Jonge *et al* (1986) suggested that adjacent animals adjusted their activity patterns so as not to be active simultaneously.

In conclusion, while the visual isolation of females may not lead to better production results, and long-term visual isolation in singly housed mink may have adverse effects, little research examining whether visual isolation may improve welfare, at least for limited

periods, exists. What evidence there is, indicates that isolation may improve welfare in females during oestrus and pregnancy. The effects of visual isolation from unfamiliar animals among mink housed in familiar pairs or groups are unknown.

Kit age at weaning

Mink kits on farms become nutritionally independent of their mothers by 5–6 weeks of age. If this accurately indicates kit development in nature¹, then the question arises as to why kits do not leave their natal territory until they are approximately 12 weeks old. Recent, as yet unpublished, research has attempted to answer this question. Gimpel (1997) examined the role of the mother as a 'secure base' for exploratory behaviour, in a manner similar to studies regarding contact with mothers and exploration in rhesus monkeys, *Macaca mulatta* (eg Harlow & Zimmerman [1959]). Using kits from six litters, she measured their latency to explore, amount of time spent exploring, attempts to return to the rest of the litter, and distress calls, when they were with a littermate or their mother. Between the ages of 8.5 and 13.5 weeks (ie the time between when they would be weaned on a farm, and when they would be weaned in the wild) kits made more attempts to return to the home cage and gave more distress calls when with the littermate; there was also a trend towards decreased latency to explore when the mother was present. These results suggest that, following nutritional weaning, mothers are important to kits as they learn to explore and interact with their environment.

Research results have shown that age at weaning can influence the later development of aberrant behaviours, such as stereotypy and tail biting. Mason (1996) used kits from 53 litters: one from each was weaned at 7 weeks, in accordance with standard farm procedure, while another was weaned at 11 weeks. She compared the development of stereotypies in the two groups, and found that the earlier-weaned group spent significantly more time stereotyping (44% versus 23%), and that their stereotypies also consisted of a greater proportion of completely fixed sequences. Tail biting, which has been shown to occur in approximately 20 per cent of farmed mink in the Netherlands (de Jonge [1989], cited in Mason [1994]), is significantly higher among male mink removed from their mother at 7 weeks of age, than in those left with their mothers for 6 months (de Jonge [1988; 1989], both cited in Mason [1994]). Mason (1994) examined male and female kits removed from their mothers at either 7 or 11 weeks of age, and found that earlier-weaned females showed a significantly greater tendency to tail bite than later-weaned females; the same trend was still evident in both sexes at 10 months. On the basis of kits' immediate reactions to weaning (distress calls, changes in the number of eosinophil leucocytes), Houbak and Jeppesen (as reported in Hansen [1991a]) concluded that kits weaned at 6 weeks of age were more stressed than kits weaned later (the upper age is not given). Together with the findings of Gimpel (1997), these results suggest that the mother continues to influence behavioural development after nutritional independence, and that mink left with their mothers till 11 weeks of age will experience better welfare.

Hansen (1991a) examined kits weaned at 6, 8 and 12 weeks of age, and placed in pairs. He found no difference between the groups in latency to intromission (a measure of willingness to mate) and the number of successful matings. Despite the lack of an individually housed control group, he concluded that the physical contact between the kits placed in pairs in conventional cages was sufficient to secure normal reproductive behaviour,

¹ Jonasen (1987, cited in Hansen [1991a]) found no difference in the ontogenesis of kits raised under farm and semi-natural conditions.

irrespective of weaning age. Using a small sample size ($n = 3$ in each group), Gilbert and Bailey (1969a) concluded that females weaned at 5–8 weeks of age were significantly easier to mate than those weaned at 8–10 weeks, although male breeding performance seemed to depend on a critical period of socialization from 5–8 weeks of age. However, the 1988 studies of Houbak and Jeppesen (cited in Hansen [1991a]), and of de Jonge (1988; 1989), Mason (1994; 1996), and Gimpel (1997) indicate that other aspects of normal behaviour, and the long-term welfare of mink, are at risk from the standard weaning age adhered to on farms.

Heller *et al* (1988) examined mother-kit separation from the mother's perspective, using changes in circulating eosinophil levels as an indicator of welfare. They found that the mother's levels increased with the weaning age of the kits from 6 to 8 to 10 weeks, with levels significantly highest when kits were at 10 weeks of age. However, levels reduced immediately following separation from the kits when they were 8 and 10 weeks of age, whereas the mother showed a prolonged reaction to separation at 6 weeks of age. While it seems likely that later weaning is better for the long-term welfare of kits, the short-term consequences for mothers which have to live with grown kits for longer may be ameliorated by the provision of a resting area which only mothers can access (see, *Additions to the standard cage environment*, with regard to allowing females an escape from their kits). In addition, work by de Jonge and van Iwaarden (1995) found that mothers which remained living with their kits in a greatly increased cage area remained healthy.

Lack of knowledge of the effects of olfactory, auditory, visual stimuli

The biology of feral mink indicates that various olfactory, auditory and visual stimuli may have significant effects on mink, although such effects may be unrecognized by humans. For example, Dunstone (1993) has commented that given the mink's (likely) high dependence on olfactory stimulation in detecting and even recognizing conspecifics, the overwhelming aroma on farms might be a source of chronic irritation. Preliminary studies have suggested that females in cages sprayed with the urine of the male prior to mating show no increase in successful matings (Møller 1991b), but such a study hardly considered the welfare of mink subjected to a concentrated mix of odours. The effects of the auditory environment are also unknown. Photoperiod has been shown to substantially affect mink: but whereas Kavanau *et al* (1973) examined light level preferences in other mustelids, no such work has been done on mink. Newberry (1995) has emphasized the importance of examining the effects of the wider environment on captive animals, ie of all stimuli within their sensory range. Few conclusions can be drawn regarding the extent to which these factors may affect the welfare of farmed mink.

Overall comments regarding research on the housing aspects of farmed mink welfare

This review has examined the available scientific evidence and has endeavoured to evaluate the state of knowledge regarding farmed mink welfare. While it is encouraging that a recent increase in research effort has attempted to examine the welfare of farmed mink, it is extremely important that such research is of adequate quality and is readily available to the wider scientific community. A proportion of the available literature has been published without peer review and does not include sufficient detail to permit thorough analysis of the work undertaken.

Conclusions and animal welfare implications

- i) Feral mink which have escaped from farms have become established in Europe. Extensive studies of such animals indicate that kits do not leave their natal territory until 11 or 12 weeks of age, that climbing, swimming and diving are significant aspects of their lifestyle, that they regularly engage in travelling and foraging over distances of at least 1–3 km, that they make use of a number of different dens and that they probably make extensive use of scent-marking and olfactory cues. All these aspects of their natural behaviour are denied them on mink farms.
- ii) Mink have been kept in captivity for relatively few generations. No research effort has focused on long-term selective breeding of mink for reduced fear in relation to farm conditions; and research which has been conducted has, thus far, indicated only that mink can be bred to be more fearful over a few generations.
- iii) The high level and pervasiveness of stereotypies among farmed mink, and the incidence of fur chewing and even self-mutilation of tail tissue, suggest that farmed mink welfare is not good. Stereotypies are associated with negative consequences such as slower kit growth, and higher levels of feed intake without an increase in growth.
- iv) Research has been sufficient to show that farmed mink have poorer welfare when they are denied access to a nest box. A nest box is clearly essential.
- v) Lactating female mink, and kits in the first 5–6 weeks of life, seem to experience problems with dehydration. The provision of water so as to avoid dehydration is important.
- vi) Merely increasing cage size, without a consequent increase in enrichment, does not appear to improve welfare.
- vii) Some experiments concerning enrichment of the standard cage environment suggest that additions can improve the welfare of mink. Research in this area has not been sufficiently far-reaching.
- viii) Studies aimed at improving housing conditions for mink have, on the whole, been conceived and conducted within the framework of the standard cage environment. This has limited the aspects of mink housing welfare which have been subject to scientific investigation. A small number of recent studies indicate that moving away from a cage-housing system towards an enriched enclosure-type system may benefit captive mink. Mink show very strong preferences for access to water in which they can swim and also strong preferences for an alternative hay box (ie nest box) and for novel objects. They will also use tunnels or branches for climbing, and will manipulate objects if they are available. There has been no research in which knowledge gained from studies of wild mink biology has been used to design and test a complete, improved enclosure for farmed mink.
- ix) Research concerning social interactions between mink suggests that housing in pairs or larger groups of mink may not be detrimental. It may possibly provide enrichment for animals. Socially housed mink must be familiar with one another, having been housed together since weaning.
- x) There is acceptable evidence that kits on mink farms are weaned too early. Such mink may be deprived of an aspect of social development which could lead to them becoming better-adjusted adults. Further large-scale studies should examine whether leaving mink and kits together until the age of 11 or 12 weeks would improve the mink's long-term behaviour on farms.

- xi) Much of the research in this area is not of an adequate scientific standard. Any future efforts should aim to correct this problem.
- xii) As summarized in conclusions ii), iii), v), viii) and x), there is considerable evidence of poor welfare in mink kept in the most widely used cages and under normal management procedures.

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