STEREOTYPIC BEHAVIOUR AND TAIL BITING IN FARMED MINK (*MUSTELA VISON*) IN A NEW HOUSING SYSTEM

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Abstract *Animal Welfare 2002, 11*: 231-245

Farmed mink are known for showing stereotypies and tail biting, behaviours that are mostly viewed as indicators of reduced welfare. Among the factors that are often described as being relevant for the welfare of mink are food management systems, age at weaning, and type/presence of nest boxes and bedding. In the present study of commercially farmed mink, all of these factors have been integrated in one housing system. The occurrence of stereotypies and tail biting were observed at six Dutch mink farms, which differed from one another with respect to the number of modifications and the time since the introduction of these modifications. On each farm, 60 non-lactating female mink were observed during winter and 50 lactating female mink (with kits) were observed during summer. Mink on the farm with the most modifications spent 4.1% and 0.8% of their time performing stereotypies in winter and in summer, respectively. Mink on the farm with the least modifications spent 32% and 10.9% of their time performing stereotypies in winter and in summer, respectively. The occurrence of stereotypic behaviour in winter gradually increased as feeding time approached. This gradual increase was not observed at the farm with the least modifications. In general, mink spent less time performing stereotypies in summer than in winter. No clear differences were found between the farms for the occurrence of tail biting in relation to the modifications of the new system, although one farm showed a lower percentage (4%) of tail biters during summer. In conclusion, the farms that had introduced more modifications into their husbandry system housed animals showing less stereotypic behaviour. The results of this field study demonstrate an inverse relationship between the number of modifications and the occurrence of stereotypies; because of the experimental design, however, a causal relationship is not implied. Further work is required to investigate the impact of each measure both in isolation and in the integrated system under more carefully standardised conditions.

Keywords: *animal welfare, enrichment, housing, management, mink, stereotypies*

Introduction

Under traditional farm conditions, mink are known for displaying behaviours such as stereotypies and tail biting (eg de Jonge & Carlstead 1987; Bildsøe *et al* 1990a,b; Heller 1991; Mason 1993a, 1994). These behaviours are unknown in feral mink (Dunstone 1993, p 183) and are normally perceived to be indicators of reduced welfare (eg Broom & Johnson

1993). Deviant behaviours can result from lack of environmental variation, restriction of opportunities for specific behavioural activities, or deprivation of specific commodities (eg Mason 1993b; Rushen *et al* 1993; Wemelsfelder 1993a,b) — situations that are well known from the housing conditions encountered in the intensive farming industry (eg pigs and poultry). Zoo animals can also develop deviant behaviours such as stereotypies as a result of the severe limitations of their captive environment (eg Meyer-Holzapfel 1968; Wechsler 1991; Reinhardt & Roberts 1997).

The aim of this applied field study is to assess the effects on stereotypic and tail-biting behaviours of a new housing system for commercially farmed mink. The new housing system integrates the advice of Wiepkema (1994), which was subsequently enforced by the Dutch law. The present study focuses in particular on the effect of the integration of the measures, which may have additional effects on the behaviour of mink. Some aspects of the new system are described unambiguously in the literature as 'positive' for farmed mink's welfare; others are assumed to be positive, but proof is lacking. The modifications for the new housing system are as follows:

Nest box: All cages designed according to the new system include a permanent nest box with straw bedding. There are several indications that nest boxes with straw bedding have a positive effect on mink's welfare: a nest box reduces stereotypies (Hansen *et al* 1994); it increases the survival chances of mink kits (all test groups were given straw daily) (Møller 1990); and straw stimulates manipulation behaviour and results in improved pelt quality (de Jonge & Leipoldt 1994). The importance of the nest box is supported by physiological measures of stress (Hansen & Damgaard 1991), and Cooper and Mason (1996) found that mink were willing to 'work' for visits to the hay box, implying that this bedding is an incentive.

Cage enlargement: A minimum standard cage size of 85 x 30 x 45 cm (l x w x h) is used in the new system. The cage is enlarged in the summer, when each family (female plus kits) lives together until weaning, by connecting several standard cages (depending on the number of offspring). Cage enlargement may be of benefit to mink welfare: mink housed in large 'semi-natural cages', such as those described in the studies of Kuby (1982), Jonasen (1987) and Erlebach (1994), did not show stereotypies. Additionally, Jeppesen *et al* (2000) found that stereotypies were more frequent in a smaller traditional cage (90 x 30 x 45 cm) compared to a larger alternative system (three adjoined traditional cages).

Additional resources: To create a more complex environment, the new housing system includes two items: a cylinder and a platform. The effects of environmental enrichment are described extensively for animals in captivity (eg Rosenzweig & Bennett 1976; Pham *et al* 1999) and enrichment is a well-known method of enhancing the welfare of zoo and laboratory animals (eg Markowitz 1982; Newberry 1995; Baumans 1997; Sambrook & Buchanan-Smith 1997). The effects of such environmental modification on mink are not clear. The introduction of a novel object seems to stimulate mink to explore or to use it for a short time (Jeppesen & Falkenberg 1990; Cooper & Mason 2000), but consumer-demand studies of mink also show that mink place little value on platforms, toys or cylinders (Mason *et al* 2001). Hansen (1990) mentioned that a wire-netting cylinder was possibly used as a refuge by nursing females. The presence of a play ball, cylinder and/or platform did not reduce stress hormone levels, stereotypic behaviour or tail biting (Jeppesen & Falkenberg 1990; de Jonge 1997b).

Late weaning: All kits in the new system are weaned at 11 weeks of age at the earliest. Mason (1994) found a negative correlation between tail biting and the age of weaning: as age of weaning increased, tail biting decreased. The weaning age in the new system is based on

Mason's (1994) study, which suggested that a weaning age of 11 weeks may be effective in reducing tail biting behaviour. In addition, Jeppesen *et al* (2000) mentioned that early weaning (along with individual housing and small cages) may promote the development of stereotypies (although the effects of early weaning seem to decline with age). Weaning at later than 11 weeks may impair the welfare of the mother (Pedersen & Jeppesen 2001).
No food restriction: Mink kept under the new conditions are not food-restricted during winter, in contrast to traditional practices (for example, see de Jonge 1994; Møller 1998). Studies of other animal species have demonstrated that food restriction can seriously influence the induction of stereotypic behaviour (eg Appleby & Lawrence 1987; Terlouw *et al* 1991; Redbo & Nordblad 1997). Stereotypies in farmed mink show a strong relationship with feeding time (eg de Jonge & Carlstead 1987; Bildsøe *et al* 1990a,b, 1991; Heller 1991; Mason 1993a; de Jonge 1994).
Selective breeding: The new system introduces additional selection criteria with the aim of breeding against stereotypic behaviour and tail biting. The introduction of these breeding criteria is mainly based on the possibilities for selection shown in a study by Hansen (1996), who selected different temperaments (explorative, fearful and aggressive) in farmed mink within six generations, and on the experiments on selection against tail biting and 'restless' behaviour by de Jonge (1989, 1993, 1997a). Stereotypies and tail biting were not influenced by the selection criteria used by Hansen (1996).

To study the effects of the new housing system, the mink populations of six Dutch mink farms were studied. As the implementation of the new system was enforced by law, no practising farms could be found at which both a traditional system and a new housing system could be studied simultaneously (which would have allowed each farm to be used as its own control). The farms differed with respect to both the number of modifications and the elapsed time since their implementation. The observations in winter and in summer yield an insight into the consistency of the differences between the farms in different conditions.

We hypothesised that, if the new measures had any effect, we would find fewer stereotypies and less tail biting on farms that had introduced more numerous modifications into their housing system for a longer period. This descriptive study focuses on the effects of the whole set of integrated measures in the two different seasons, and does not aim to give any insight into the impact of each individual measure.

Methods

Farms and housing conditions

In January 1998, six Dutch mink farms were selected on the basis of their having good facilities for making observations and the availability of the required number of female mink with respect to colour and age. At four farms (Farms 1, 3, 5 and 6), the mink were kept outside in standard half-open sheds covered with a roof; on Farm 2, half of the mink population was kept in a closed hall, and on Farm 4, the whole population was kept in a closed hall. Each shed contained a double row of about 300–400 wire-mesh cages. Water was available for 24 h per day. In winter, the animals were fed once per day at a regular time, which varied between farms (see Table 1). In summer, food was available *ad libitum*. At the beginning of March, the mink were allowed to mate. The females gave birth to their kits at the end of April and the beginning of May. Weaning ages differed between farms (Table 1).

The new housing system introduced the following modifications:
1) Permanent availability of straw in a nest box, each standard cage having one nest box;
2) Minimum standard cage size of 85 x 30 x 45 cm (l x w x h). The cage size is increased in summer by connecting together a number of standard cages (plus nest boxes). The number of

connected cages depends on the number of kits in the family (eg female plus 1 kit = 1 cage; female plus 2–5 kits = 2 cages; female plus 6–8 kits = 3 cages);
3) A plastic cylinder (15 cm diameter, 20 cm long) and/or a wire mesh platform (30 x 15 cm) installed at the back of the cage at a height of about 30 cm above the cage floor. Each standard cage contains at least one of these additional resources;
4) Kits weaned at the age of 11 weeks at the earliest;
5) No food restriction;
6) Extra selection criteria for breeding against tail biting and 'restless' behaviour. Individuals with bald tail tips and stereotypies are not selected for further breeding. (The standardisation of the selection criteria in practice is still under development.)

Table 1 The implemented modifications of the new housing system per farm.

Modifications	Farm number					
	1	2	3	4	5	6
Food restriction no longer imposed	+	+	+	–	–	–
*Selection (breeding) criteria**	++	++	+	+	–	–
Straw in nest box	+	+	+	+	+	–
Enrichment†	++	+	+	+	+	–
Housed in family groups (experimented in previous year)	+ (+)	+ (+)	+ (–)	+ (–)	+ (–)	–
Usual age of weaning (weaning age in new system)	9 (11)	9 (11)	8 (11)	8 (11)	8 (11)	7
Feeding time in winter	1300h	1300h	1300h	1400h	1530h	1300h

* + selection against tail biting ++ selection against tail biting and 'restless' behaviour
† + platform or tube ++ platform and tube

Table 1 summarises the modifications made to each farm, and presents both the age of weaning in the new system and the age at which each farm used to wean before the introduction of the new system. Farms 1 and 2 started using the breeding selection criteria and group-housing the families raised under the new system in 1996 (ie two generations at the time of observation). All farms had increased their cage sizes at the time of observations and therefore this measure has not been included in the table.

Subjects

On each farm, 60 and 50 female mink were selected for winter and summer observations, respectively. The selected subjects were never neighbouring animals, so as to allow independent observation clusters as far as possible. Information on the genetic relationships between the subjects was not available. Each sample contained an equal number of young females (one year) and females of two years and older; 66 per cent of the subjects were wild-type and 33 per cent were black.

For the selection of the 50 female mink in summer, two extra selection criteria were used because of the presence of juveniles: first, each female had an almost equal number of kits (mean number of kits = 6.5 ± 2.0 SD); and second, all kits had an almost equal date of birth (around 11 May 1998).

Data collection

The six farms were each visited three times in winter (between 3 February and 4 March 1998; mean temperature in °C [T] = 8.89 ± 3.50) and three times in summer (between 19 June and 31 July 1998; T = 16.28 ± 2.65). Observations were made by two observers: each

observer observed all the animals every day. In winter, the females were observed using focal animal sampling (2 min per sample) and instantaneous sampling (two scans: one before and one after the focal animal sampling procedure). In summer, the adult females were observed using the same focal animal sampling method as that used in winter. In winter, the subjects were observed from neighbouring sheds in order to cause the least disturbance (for a description of the method, see Mason 1993a). In summer, the presence of the kits made it necessary to observe from inside the subjects' shed.

In order to control for the increasing probability of stereotypies with the approach of feeding time, the winter observations were split into three observation periods: 4½–3 h before feeding time (period 3); 3–1½ h before feeding time (period 2); and 1½ h until feeding time (period 1). An observation scheme was used to ensure that each subject was observed during each period.

In summer, female mink were housed together with their kits. The three observation days in summer were planned in such a way that the families could be observed in three different stages:
1) Adult females housed with all their kits (kits aged six weeks) both in the new system and in the traditional system.
2) Traditional system: kits aged eight weeks recently weaned (adult females housed with one or two kits, remaining kits housed without mother in male–female pairs); new system: adult female and kits aged eight weeks living together in connected cages.
3) Traditional system: kits aged 11 weeks weaned for three weeks; new system: adult female and kits of 11 weeks of age still living together in connected cages. (This stage controlled for possible aggression, as the families stayed together until 11 weeks.)

Focal animal sampling in winter and summer was carried out with the use of two hand-held computers (Psion-Workabout, Software The Observer®, version 3.0, Noldus Information Technology, Wageningen, Holland). Data from the instantaneous sampling in winter were collected using pen and paper.

Ethogram

For both focal animal sampling and instantaneous sampling, a set of behaviours was observed. In total, 31 behaviours were scored (eg eating, walking, running, grooming, manipulation of object, staying in nest box). Normally, object manipulation was directed to the standard cylinders, but some individuals obtained extra objects by 'reaching' branches, pieces of paper and straw from outside.

If movements were repetitive, invariant and without an obvious goal or function (see Mason 1991), the sequences were scored as a stereotypy (two repetitions for movements performed over the full length of the cage, and three repetitions for movements performed in one place). In total, 16 different stereotypic behaviour patterns were distinguished, varying in direction, type of body movement and length of movement.

To record social interactions between females and kits, the ethogram in summer contained behaviours such as social grooming, social play and lactation. Agonistic interaction was scored when the interaction of two individuals resulted in flight or fight reactions (fast body movements such as tumbling and jumping, combined with biting and/or scratching with paws, screaming and/or hissing, eventually resulting in physical harm of at least one of the individuals involved). Social interactions were scored if the female was involved either as an actor or as a reactor (interactions between kits were not scored in this study).

Tail biting and body weights

Mink were assessed for bald tail tips once in winter and once in summer. The length of the bald tip was estimated in centimetres, and the mink in question was described as a "biter" or a "non-biter". Pelt-biting individuals were recorded separately. Tail-biting data at Farm 6 could not be collected in summer as the adult subjects were no longer present at the farm. All subjects were weighed once at the end of the last observation day in winter. On Farm 6, the weights of the females were estimated. These data were not used for analysis.

Statistical tests

The behaviours have been clustered for analysis into groups of stereotypies, solitary (not stereotypic) active behaviour, object manipulation, and inactive behaviour or staying in the nest box. In summer, two extra clusters of agonistic and other social behaviours have been included.

Non-parametric test statistics were calculated using the statistical package SPSS for Windows (version 7.5.2). In all tests, significance was considered at the two-tailed minimum $P < 0.05$ value except where otherwise indicated. For calculation of differences between the farms, Kruskal-Wallis tests were used first, followed by *post hoc* tests to assess differences between two groups. Related groups were compared using a Wilcoxon signed-ranks test and Friedman test when directions were not a consideration (for small samples and Wilcoxon signed-ranks test, see Siegel & Castellan 1988 pp 88–91 and Table H, Appendix I, p 332).

Results

Stereotypies in winter and summer

Data on stereotypies were first analysed for influences of some general factors, such as the day of observation, age of the females and colour type. There were no significant differences in the time spent performing stereotypies between the three days of observation either in winter ($\chi^2 = 0.28$, $df = 2$, $P = 0.87$, n = 359) or in summer ($\chi^2 = 5.32$, $df = 2$, $P = 0.07$, n = 248).

In winter, no significant differences were found in the time spent performing stereotypies either between the different colour types ($U = 11106.5$, $P = 0.15$, n = 360) or between the one-year-old females and the two- or three-year-olds ($\chi^2 = 2.79$, $df = 2$, $P = 0.25$, n = 360). No significant differences were found between the age of the females and the occurrence of tail biting and pelt biting ($\chi^2 = 4.12$, $df = 2$, $P = 0.13$, n = 352).

On average, female mink spent 111.0 s (± 139.0 SD) performing stereotypic behaviours in winter out of a total observation time of 720 s per focal animal — this is about 15 per cent of the total observation time. The mean percentage of animals showing stereotypic activities at all six farms during the total observation period in winter was 63.2 per cent (± 18.5 SD).

During summer, the average time spent performing stereotypies was 24.0 s (± 41.1 SD) out of a total observation time of 720 s per focal animal — this is about 3 per cent of the total observation time. The mean percentage of animals showing stereotypic activities at all six farms in summer was 56.2 per cent (± 7.3 SD).

There was a significant decrease on each farm of the time spent performing stereotypies in summer compared to winter ($T+ = 21$, $P = 0.03$, n = 6). In addition, the mean percentages of time spent both in inactive behaviour/remaining in nest box and in performing solitary active behaviours did not differ significantly between winter and summer.

Figure 1 depicts the distribution of the percentages of the time spent performing stereotypies, (solitary) active, and inactive (in nest box) behaviour by the adult females on each farm for winter and for summer. The low percentages for the other behaviours mentioned above (eg object manipulation, agonistic behaviour) are not shown in the figure. An aggressive interaction between female and kit was scored once in summer on the first observation day, when the kit was seven weeks of age.

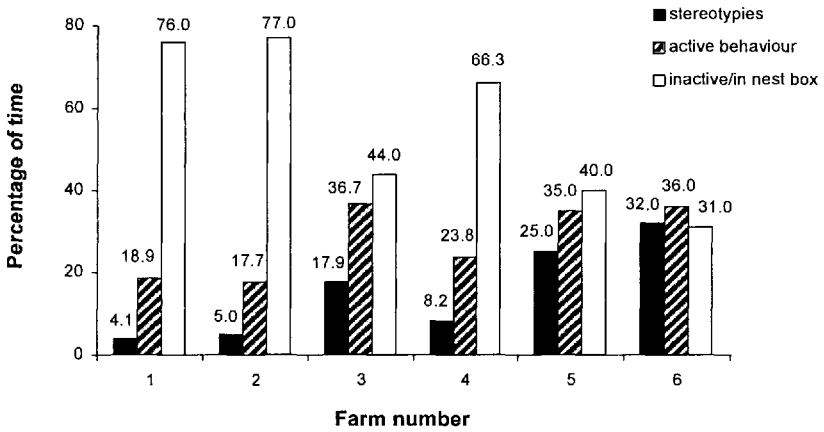

Figure 1a **Percentage of time spent performing stereotypies, non-stereotyped active behaviour and inactive/in nest box behaviour on each farm in winter.**

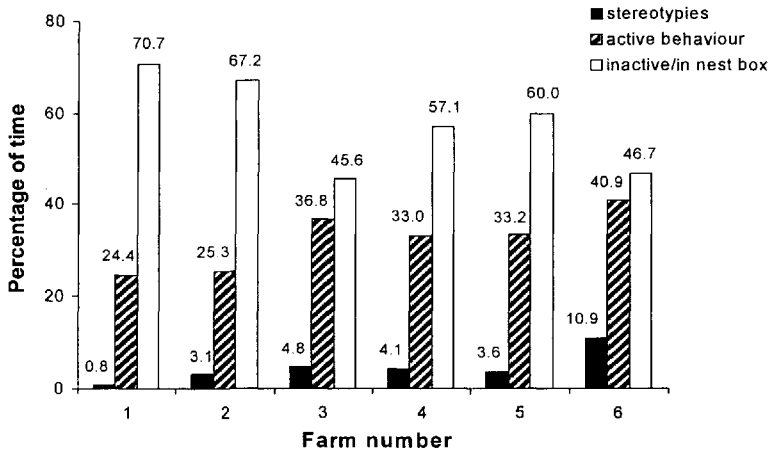

Figure 1b **Percentage of time spent performing stereotypies, non-stereotyped active behaviour and inactive/in nest box behaviour on each farm in summer.**

Significant differences were found between the farms with respect to the duration of stereotypies both in winter ($\chi^2 = 102.12$, $df = 5$, $P < 0.001$, $n = 359$) and in summer ($\chi^2 = 44.39$, $df = 5$, $P < 0.001$, $n = 298$). The time spent performing stereotypies at Farm 6 (winter 32%, summer 10.9%) was significantly higher compared to Farms 1, 2, 3 and 4 in winter ($U > 584.0$, $P < 0.001$) and to all other farms in summer ($U > 408.0$, $P < 0.001$).

Farm 1 showed a relatively low percentage of stereotypies both in winter (4.1%) and in summer (0.8%).

In addition, the duration of non-stereotypic active behaviour ($\chi^2 > 34.46$, $df = 5$, $P < 0.001$) and inactive behaviour or time spent in nest boxes ($\chi^2 > 64.90$, $df = 5$, $P < 0.001$) differed significantly between the farms both in winter and summer. Inactivity or the time spent in nest boxes in winter at the farms that implemented the most modifications (Farms 1 and 2) was significantly higher compared to Farms 3, 5 and 6 ($U > 483.5$, $P < 0.001$).

The occurrence of stereotypies in winter and the relationship with time of feeding

To test for a relationship between stereotypies and time of feeding, the instantaneous sampling data were split into three observation periods: 4½–3 h before feeding time (period 3), 3–1½ h before feeding time (period 2), and 1½ h until feeding time (period 1; see Figure 2 for an overview by farm).

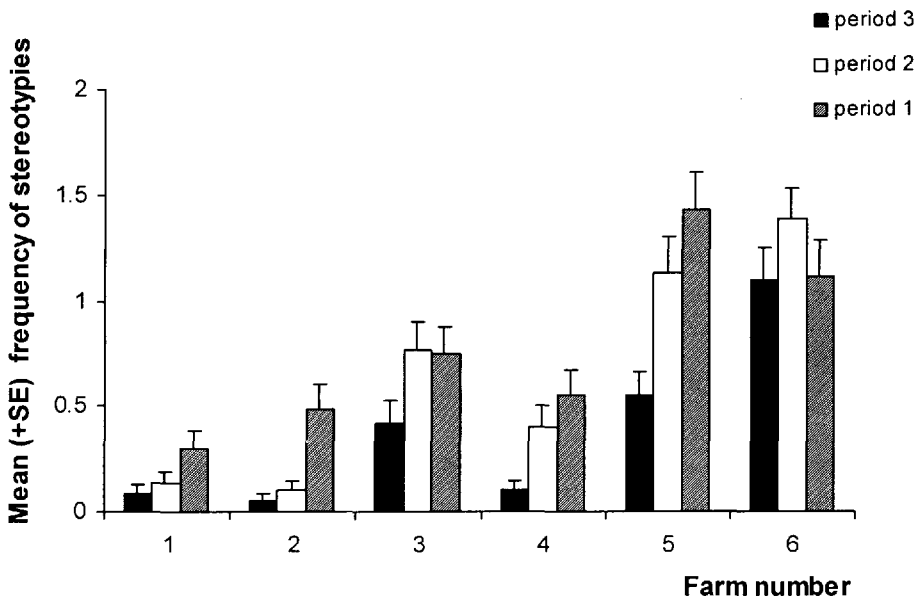

Figure 2 **Mean frequencies of stereotypies on each farm in periods 1, 2 and 3 before feeding time in winter (n = 60 per farm).**

Overall, the frequencies of stereotypies during the three distinct periods before feeding time differed significantly ($\chi^2 = 45.43$, $df = 2$, $P < 0.001$, n = 360), with a gradual increase occurring as feeding time approached. Period 3 differed significantly from both other periods ($|Z| > 5.58$, $P < 0.001$, n = 360). In order to test the differences between the periods for each farm, the frequencies of stereotypies during the three observation periods were compared for each farm separately. We found significant differences for all farms in the frequencies of stereotypies between the three observation periods, gradually increasing as feeding time approached ($\chi^2 > 5.19$, $df = 2$, $P < 0.05$, n = 60), with the exception of Farm 6. On this farm, mink performed stereotypies at equal frequencies during all three observation periods before feeding.

The occurrence of stereotypies in winter and the relationship with body weights

The average female mink body weight was 1086.90 g (± 176.23, n = 359) in winter (see Table 2 for an overview per farm). Overall, no significant relations were found between the age of the females (one year old, two years old, or older) and their body weight, nor between colour type and body weight.

Overall, a significant negative correlation was found between the body weights of female mink and both the duration of stereotypies ($Rs = -0.35$, $P < 0.001$, n = 299) and the duration of non-stereotypic active behaviour ($Rs = -0.23$, $P < 0.001$, n = 299). Furthermore, a significant positive correlation was found between body weight and the time spent in the nest box ($Rs = 0.37$, $P < 0.001$, n = 299). Figure 3 depicts the regression lines of the time spent performing stereotypies in relation to the females' body weights, both by farm and in total. The highest negative correlations were found on the farms with animals with the lowest body weights.

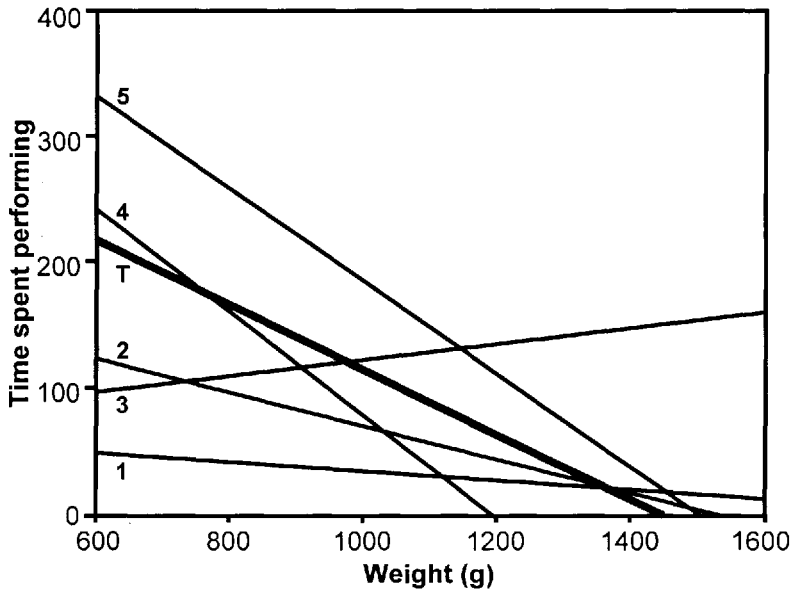

Figure 3 **Regression lines of the time spent performing stereotypies in relation to body weights of mink on each farm (numbered 1 to 5 [Farm 6 estimated data excluded]; *Rs* = –0.13, –0.27, 0.03, –0.67, –0.41, respectively) and total (T; *Rs* = –0.35) in winter.**

The occurrence of tail biting in winter and in summer

Figure 4 shows the percentages for each farm of subjects with a bald tail tip. Table 3 shows the mean estimated length of the females' bald tail tips for each farm in winter and in summer. The kits did not have bald tail tips at the time of observation in summer.

Overall, there was a significant difference between farms in the number of tail-biting individuals in winter ($\chi^2 = 28.88$, $df = 5$, $P < 0.001$, n = 357) and in summer ($\chi^2 = 38.02$, $df = 4$, $P < 0.001$, n = 248). Farm 6 had a significantly higher number of female mink with bald tail tips than all the other farms in winter ($U > 1019.00$, $P < 0.001$) except for Farm 4 ($U = 1436.00$, $P = 0.06$). In addition, Farm 6 had more extreme forms of bald tail tips and pelt biters.

Table 2 **Mean body weights of adult females per farm in winter.**

Farm number	Mean (± SE) body weights (g)
1	1161.3 (± 20.8) (n = 60)
2	1255.8 (± 11.5) (n = 60)
3	1132.2 (± 18.3) (n = 59)
4	1044.5 (± 17.8) (n = 60)
5	1033.3 (± 25.0) (n = 60)
6	No data

Table 3 **Mean lengths of bald tail tips of adult mink on each farm in winter and in summer.**

Farm number	Winter	Summer
	Mean (± SE) bald tail tips (cm)	Mean (± SE) bald tail tips (cm)
1	0.3 (± 0.1) (n = 60)	0.7 (± 0.2) (n = 49)
2	0.6 (± 0.2) (n = 55)	1.3 (± 0.3) (n = 50)
3	0.7 (± 0.3) (n = 59)	0.2 (± 0.1) (n = 50)
4	1.2 (± 0.3) (n = 54)	1.3 (± 0.2) (n = 49)
5	0.6 (± 0.2) (n = 59)	0.7 (± 0.1) (n = 50)
6	3.7 (± 0.8) (n = 55)	No data

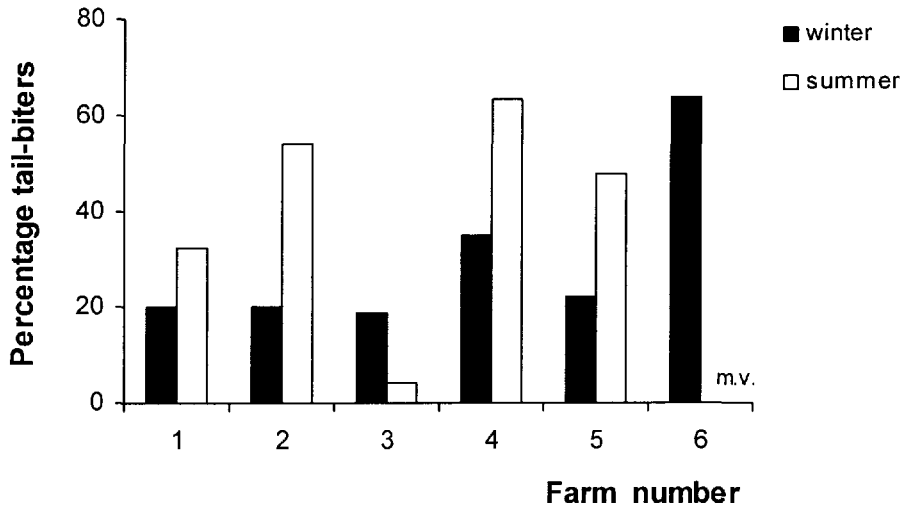

Figure 4 **Percentage of tail-biting animals on each farm in winter and summer.**
$n_{(winter)}$ = 60 per farm. $n_{(summer)}$ = 50 per farm. m.v. = missing value.

In winter, the number of tail-biting individuals was lowest on Farm 3 and significantly different from the number on Farms 4 and 6 ($U > 1019.00$, $P < 0.02$). In summer also, Farm 3 showed a significantly lower percentage of tail-biting individuals (4% of the population) compared to all other farms ($U > 597.00$, $P < 0.001$). Overall, no significant difference was found between winter and summer in the number of tail-biting individuals.

Relationship between the occurrence of tail biting and stereotypies

The time spent by adult females performing stereotypic behaviour on all the farms together in winter was correlated with the lengths of the bald tail tips of the subjects. A significant

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positive correlation was found ($Rs = 0.17$, $P = 0.001$, n = 359), indicating that animals with longer bald tail tips performed more stereotypic behaviour.

Furthermore, we categorised the subjects into three groups: group 1, non-biting individuals (n = 242); group 2, tail biters (n = 73); and group 3, pelt biters (n = 41). The mean time spent performing stereotypies out of the total observation time of 720 s per group was 93.1 s (± 119.9) for group 1, 136.3 s (± 166.7) for group 2, and 178.4 s (± 162.6) for group 3, which was a significant difference ($\chi^2 = 10.08$, $df = 2$, $P < 0.01$, n = 359). Mink in group 3 (pelt biters) showed significantly more stereotypic behaviour than the animals both in group 1 ($U = 3324.50$, $P < 0.001$, n = 359) and in group 2 ($U = 1064.00$, $P = 0.004$, n = 359). No significant differences were seen in the duration of stereotypies between these three groups in summer.

Conclusion and discussion

The main aim of the study was to assess whether the introduction of a new integral housing and management system would decrease stereotypies and tail biting in farmed mink. The study was performed at six commercial mink farms, which differed from each other with respect to the number of modifications that had been made and the time since the implementation of these modifications. The results demonstrate an inverse relationship between the number of modifications and the performance of stereotypies (both in winter and in summer); however, because of the experimental design, a causal relationship is not implied. In general, less stereotypic behaviour can be seen in summer on all farms. This seasonal variation in stereotypies was also demonstrated in studies on Danish farm systems (see Bildsøe *et al* 1990b).

No clear differences were found between the farms for frequency of tail biting in relation to the new system's modifications, although Farm 3 showed low percentages of tail biters both in winter and in summer. In the present study, one incidence of aggression was observed in summer between a mother and kit. Pedersen and Jeppesen (2001) showed that kits older than 11 weeks of age are capable of severely injuring their mother. The present study raises some issues that should be considered carefully and are discussed below.

Experimental control and standardisation

This study should be interpreted as a descriptive study of the Dutch situation in 1998. The results can be used as a base for more goal-directed studies on underlying mechanisms. The implementation of the new system was enforced by law and all farmers had already started the implementation before these observations were carried out. Therefore, this study lacks a proper control for the traditional Dutch system. To compensate at least partly for this absence of data from the traditional system, the results can be carefully compared with earlier studies carried out on Dutch mink farms before the existence of the new system. De Jonge and Carlstead (1987) reported that on five Dutch mink farms, 70 per cent of the adult females performed stereotypic behaviour (half of them for more than one hour per day, mainly during the hours before feeding). Furthermore, they mentioned that the amount of stereotypic behaviour displayed during summer did not differ from that during winter. A later report by de Jonge (personal communication 1998), which included studies of the modifications subsequently used in the new housing system, also mentioned reductions in stereotypies. In the present study, the results of the Dutch farm with the most modifications may be comparable to the situation in these later studies of de Jonge, while the results of the farm with the least modifications are more in line with the results of the earlier study.

One disadvantage of field studies on commercial mink farms is the difficulty of standardisation between and within farms. An example of the last is that in summer the observations had to be carried out in the subjects' shed. Mason (1993a) mentioned that stereotypies are sometimes observed in particular contexts, such as during disturbance by humans. Although observations were not carried out until any human disturbance had subsided, it is quite probable that the observation method in summer did influence the subjects more than that in winter (when observations were made from neighbouring shed, as described by Mason 1993a, p 195). Thus, the levels of stereotypies in summer might have been overestimated.

An example of the difficulty of between-farms standardisation concerns the 'selection criteria' in the new system. The researchers had no influence on the selection and could only record the selection procedures present on each farm. Selection for 'restlessness' turned out to be problematic for the farmers. Some of the farmers seemed, as intended, to have selected against stereotyping animals, whereas others had selected against fearful mink (personal communication and observation of the farmers). These procedures should be investigated more closely in order to achieve better standardisation. The influence of the new selection criteria on the present results is expected to be minimal, however, as the selection was in an experimental phase at the time of observation. The long-term effects of the new selection criteria should be assessed over the next generations.

Another example of the difficulty of between-farm standardisation is the difference in husbandry methods. Both Mason (1993a, p 224) and Møller (1998) mentioned that some aspects of mink farming routines can be important for causing differences between farms. It is probable that differences in the daily routines on the six farms studied here may also account for the differences in stereotypies between the farms. Therefore, systematic recording of the differences in husbandry styles should be incorporated into future studies in order to give a more accurate interpretation of the results.

Stereotypies and tail biting

The results of the study show that stereotypies gradually increase as feeding time approaches. A pre-feeding peak in stereotypies is well known from other studies on mink (eg de Jonge & Carlstead 1987; Bildsøe *et al* 1990a,b, 1991; Mason 1993a) and is also found in other carnivorous species (eg Ödberg 1987, Mason 1993a; Wechsler 1991). The performance of stereotypies just before feeding time may stem from appetitive behaviour, as feral mink usually forage and hunt intensively before feeding (see Dunstone 1993; Mason 1993a; Mason & Mendl 1997). Interestingly, this gradual increase was not observed on Farm 6, where the animals were traditionally food-restricted (personal communication with the farmer). Mason (1993a, p 221) suggested that hunger was an important factor in the high levels of stereotypy on the day that mink were not fed. Continuous feelings of hunger may also explain the non-gradual, high levels of stereotypies shown on Farm 6 in winter in the present study.

This study shows no clear differences between farms for the occurrence of tail biting in relation to the new system's modifications, although on Farm 3 it was demonstrated that a percentage of tail biters as low as four per cent in summer is achievable. The results addressing tail-biting behaviour might be explained by the fact that most of the adult subjects in the present study were weaned before 11 weeks of age themselves (because the new system was implemented in the year of observation). In order to assess the relationship between weaning age and tail biting, inspection of the kits born under the new system one year later would be more relevant and should be carried out in future research.

An integral housing system

The new housing system comprises an integrated set of modifications that are of particular interest in relation to mink's welfare. The results suggest an inverse relationship between the number of modifications and the occurrence of stereotypies. Further work is required to investigate each modification for its impact and relevance for mink's welfare under more standardised conditions. For example, the impact of a platform and a cylinder is still not clear. On the basis of the literature, platforms and cylinders are expected to have a low impact on mink's behaviour (eg Jeppesen & Falkenberg 1990; de Jonge 1997b; Cooper & Mason 2000). However, all of these studies concern adult mink and give no insight into the possible impact of the resource on the behaviour of juveniles. It is also possible that the additional resources offered in these studies are not sufficiently relevant to mink to alter their behaviour.

Although some measures may have more impact than others at certain moments, the present study focuses on the integrated set of measures and does not aim to give insight into the effect of each individual modification. We are of the opinion that a new housing system for farmed mink should improve upon the more general properties of housing, such as complexity and variability, which cannot be achieved through the introduction of an individual measure only (see also Nimon & Broom 1999). We expect, in particular, that it is the simultaneous presence of different stimuli and procedures that creates a more behaviourally relevant environment for farmed mink; in addition, elements relevant for different ages, sexes and seasons should be included in the housing system.

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