DCA - NATIONALT CENTER FOR FØDEVARER OG JORDBRUG
AARHUS UNIVERSITET

Fødevarestyrelsen

Vedrørende rapport om "Group housing of mink"

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Fødevarestyrelsen (FVST) har i mail af 5. juli 2013 bedt DCA – Nationalt Center for Fødevarer og Jordbrug om at udarbejde en faglig rapport vedrørende dyrevelfærdsmæssige forhold ved gruppeindhusning af mink.

Baggrunden herfor er, at Regeringen i efteråret 2012 indgik en aftale om veterinærområdet (Veterinærforlig II). Af veterinærforligets aftaletekst fremgår følgende: *"I forligsperioden vil fødevareministeren udarbejde en analyse, i dialog med relevante parter, hvor faglige, juridiske og økonomiske forhold i relation til gruppeindhusning afdækkes. Analysen vil blive forelagt forligspartierne, med henblik på evt. indgåelse af en tillægsaftale"*. Til dette formål har FVST nedsat en arbejdsgruppe, der består af repræsentanter fra Fødevareministeriet og Finansministeriet. Det fremgår af arbejdsgruppens kommissorium, at analysen bl.a. skal afdække effekten ved et forbud.

I bestillingen fra FVST anmodes DCA om at besvare at række spørgsmål i forbindelse med gruppeindhusning. Rapportens konklusioner vil indgå i arbejdsgruppens endelige indstilling, der vil blive forelagt forligskredsen med henblik på en evt. indgåelse af en tillægsaftale til forliget.

Den vedlagte rapport er udarbejdet af Steen Henrik Møller, Jens Malmkvist og Steffen Werner Hansen, alle Institut for Husdyrvidenskab.

Med venlig hilsen

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Group housing of mink

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0. Introduction to mink and group housing

In nature, adult mink (*Neovison vison*) are solitary, coming together only at mating time. They are territorial and defend their home range by scent marking and aggression towards mink of the same sex. A male territory can overlap that of several females, whereas overlap between mink of the same sex is not reported (e.g. Dunstone, 1993; Gerell, 1970). The solitary and territorial lifestyle of mink in nature forces the young mink to leave the territories occupied by their mothers. Dispersal happens in the autumn, when the juveniles are 12 – 16 weeks old (Dunstone, 1993). Based on these characteristics of the mink, it has been common and recommended in Scandinavia, to house adult mink (older than 7 months) singly in one cage and juveniles during the growth period from separation (July) to pelting (November) in pairs of one male (♂) and one female (♀) per cage. Alternatively, juveniles can be housed alone in a cage, which is common in North America from September to pelting or in groups of more than two, which has been common especially in the Netherlands in the growth period. On farms, the territory is restricted to the cage, and juveniles housed more than one in a cage are prevented from dispersal. Many experiments with social group housing of mink have been performed in cages that are different from the traditional ones. Consequently, the effects of groups are often confounded with cage complexity and additional enrichments; therefore, it is often not possible to separate the effect of each factor based on these studies.

1. A definition of group housing – how is group housing defined?

Group housing of mink is defined as opposed to single or pairwise housing. One definition is therefore three or more mink in the same cage. However, in relation to the solitary and territorial nature of the adult mink, we adopt a more relevant definition of group housing as 'two or more mink of the same sex in one cage'. The definition is relevant for all adult mink and becomes relevant for juvenile mink from the age of about 12 weeks at which time dispersal begins in feral mink (Dunstone, 1993).

2. A description of the different forms of group housing used in Denmark? The description should be supported by illustrations.

a. Different cage designs

The present Danish legislation (2006) and EU recommendations (1999) claim that if more than two young mink are housed in the same cage, then the minimum area of the cage (2550 cm^2) must be enlarged with 850 cm^2 per extra mink and extra supervision of the mink is then mandatory. The enlargement of

the cages may be provided by connecting Danish standard cages (30 cm x 90 cm) with holes made in the partition between neighbouring cages, hereafter called “row cages” (Figure 1) or by placing an extra cage (W: 30 cm x L: 70 cm) on top of a standard mink cage and making a pathway to the upper floor hereafter called “climbing cages” (Figure 2).

Figure 1. Row cages. The wooden panel in the partition between the cages can be lifted up allowing the mink access to the neighbouring cage.

Figure 2. Climbing cages viewed from side (at left) and front (at right).

According to European and Danish regulations, it is allowed to house five mink in two connected standard cages (5400 cm^2) because the first two mink must have 2550 cm^2 while three extra mink must have 3*850 = 2550, in total 5100 cm^2. Three connected standard cages (8100 cm^2) allow for eight juveniles together and so on. By connecting standard cages, the mink potentially – if the nest box entrances are kept open – has access to the same number of nest boxes as it has to cages, because each cage is provided with an attached nest box. In a climbing cage (a standard cage (e.g. 2700 cm^2) plus a top cage (e.g. 30 cm x 55 cm = 1650 cm^2) = 4350 cm^2), four juveniles are allowed. In contrast to mink housed in row cages, mink in climbing cages usually have access to only one shared nest box. Nest boxes attached to climbing cages need to be large enough to accommodate the number of mink in the cage.

In principle, one can construct three or four floors of climbing cages or connect up to six standard cages in the row system. To our knowledge, mink in Denmark are almost exclusively group housed in two-storey climbing cage systems.

However, there is no registration of the actual number of farms using group housing or of the number of juvenile mink raised in group housing systems. It is assumed that many farmers have some climbing cages and use these as a "buffer" if the number of weaned kits should be larger than expected and larger than they have room for in standard cages. On some farms the use of climbing cages has become the dominant or the only type for housing of juvenile mink.

b. Different number and sex combinations of mink

One practical reason for introducing group housing may arise from the common practice to house one or two juvenile males with an adult female (a dam) in the growth period. Therefore, the surplus of juvenile females has been housed in groups. Apart from this, the number of juveniles and the sex ratio in the group vary between the individual farms. Three or four juvenile females appear to be the most used combination. No registrations are available on the frequency of combinations used, and we expect that many combinations can be found in practice.

In 2012, Hansen and Møller investigated four private farms, selected as having good experience in the use of group housing in Denmark. The farmers were encouraged to use their preferred group composition in climbing cages. All farmers used the combination of four females, while one farm also used the combination of one male plus two female juveniles and another one dam plus two male juveniles. Furthermore, the farmers were encouraged to include a control group of pairs of one male plus one female and an extra test group of two male plus two female juveniles, as this is the best examined combination in scientific studies. The farmers' voluntary choice of group combinations indicates that four females is a popular group composition in practice.

c. Weaning or not, management and feeding routines

Family group housing allows the whole or part of the litter to grow up together with the dam without being separated, and thus potentially makes the weaning animal-based and gradual over a longer period. It has been documented that an artificial and abrupt weaning procedure at about 6 weeks of age affects the welfare of the mink kits negatively (Heller et al., 1988; Mason, 1994; Hansen et al., 1998). In nature, the weaning ends definitively at approximately 16 weeks of age, when the juveniles leave the mother's territory (Dunstone, 1993). According to Danish and European regulation, removal of the dam from the mink kits must not take place before the kits are 8 weeks of age, unless the welfare of the mother or her kits is compromised. Pedersen and Jeppesen (2001) compared various behavioural, physiological and production-related parameters in adult females housed alone after weaning of the kits at 8 weeks of age and adult females housed with their juveniles in the row cage system (tree connected standard cages). Between 82 and 93 % of the dams housed with the juveniles suffered from swollen and/or bitten teats observed when the juveniles were 16 weeks old. None of the dams separated from the kits at the weaning age of 8 weeks had teat problems. In addition, 24-45 % of the family housed dams, but only 0-11 % of the dams without prolonged contact to their juveniles, had damages on the fur or skin. The number of bite marks on the leather side of the pelt was higher in family housed dams than in solitary dams. Also a higher stress hormone

(cortisol) concentration in family housed dams indicated, together with the teat problem, that family housing is a stressor with negative impact on the welfare of the dams.

Hansen & Møller (2012) showed that aggression in groups varied significantly between farms. One farm had significantly more problems with bite marks, wounds and mortality than the three other farms, and according to the farmer, also compared to previous years. One reason for this variation could be an unusually late separation of weaned juveniles to group housing compared to previous years and the other farms in the investigation. The hypothesis was tested in 2012 on the research farm in Foulum and on the farm with problems the previous year. Contrary to our hypothesis, time of group formation (July 1 vs. July 15) was not an important management factor as early group formation decreased bite marks in females at the research farm only, while it increased bite marks in males at the private farm (Møller & Hansen, 2013). Therefore, we rejected the hypothesis that early separation of young mink into group housing in general decreases the number of bite marks. The level of bite marks in males pairwise housed with a female was one fourth, and in the females, one third of the level in group housed mink (Møller & Hansen, 2013).

Several studies have indicated that group housing may increase the competition for resources such as nest box and food (Pedersen et al., 2004; Hänninen et al., 2008a, b; Hansen and Malmkvist, 2011; Hansen, 2012). Experimental studies of mink deprived of the use of their nest boxes have demonstrated that the nest box is of considerable importance to the welfare and production of mink and can be considered as a biological need. Pedersen et al. (2004) compared the behaviour of juvenile mink in two group housing systems - row cages and climbing cages with pair housed juveniles in standard cages. Mink in row cages had access to three cages and three nest boxes, while mink in climbing cages and standard cages only had access to one nest box. Juveniles housed in pairs in standard cages used the nest box more than group housed mink in the row cages, and mink in row cages used the nest boxes more than mink in climbing cages. Sleeping, drinking and eating were significantly reduced in climbing cages compared to standard and row cages. Furthermore, social behaviour and agonistic behaviour were performed more in climbing cages than in row cages and more in row cages than in standard cages. These results demonstrate that group housing increases social interactions and enhances the resource competition, e.g. for nest boxes.

In order to reduce feed competition in climbing cages, the effect of three vs. one feeding place was investigated by Hansen & Malmkvist (2011). Juvenile mink with access to three feeding places consumed more feed than mink with access to one feeding place, and they obtained a higher body weight in September. Males with access to three feeding places produced longer pelts than males with only one feeding place, while this effect was not seen in females. Access to three feeding places also reduced the amount of bite marks compared to one feeding place. The results showed that it is possible to reduce feed competition by increasing the number of feeding places in group housed mink.

In order to reduce the increased aggression level observed in group housed mink, different occupational objects such as plastic tubes and straw briquettes have been tested (Hansen, 2012). Group housed juveniles in climbing cages had access to plastic tubes, straw briquettes or both. Access was either permanent or alternating every two weeks. Group housed juveniles without access to occupational objects were used as control. Mink with access to either or both types of occupational objects had less fur chewing than mink without access. The welfare improving effect of the tested objects justifies that they can be described as environmental enrichments for mink. They did, however, not reduce aggression measured as bite marks or wounds in group housed mink (Hansen, 2012).

3. A description of the production- and management related advantages and disadvantages related to group housing?

a. **Advantages:** The main production and management-related advantage of group housing is the increased stocking density in climbing cage systems (see also section 2b). By adding an extra cage on top of the standard cage, the number of mink in a shed can be doubled from typically 12 to 24 juveniles per six cages battery section. As the shed, the watering system, the slurry system and the nest box are the same, the only extra cost is the top cage.

   It appears that many Danish mink farmers took advantage of this opportunity when other cage types than 30 cm wide standard cages were ruled out by the implementation of the Council of Europe recommendations (1999) in the Danish legislation in 2006. As most farmers could not obtain the necessary permits for extending the farm with new cages, many chose to introduce a number of group housing cages instead of reducing the total number of mink on the farm. In terms of management, the time spent on feeding, adding bedding material and removing manure is reduced as the distances to cover is halved.

b. **Disadvantages:** The main disadvantage of group housing is the increased risk of aggression and thus the increased loss of juveniles during the growth season (see also section 4). In the farmed mink, a social stability must be established between the mink in a cage after the time of dispersal and territoriality, i.e. from September. As the male is almost twice the size and weight of the female in September (Møller et al. 2004) and territorial overlap is tolerated between mink of opposite sex, male plus female, pairs of mink juveniles rarely involve severe aggression. In groups with two or more mink of the same sex, aggression is more frequent, probably related to territoriality and a more difficult formation of social stability between mink of equal size. A recent study of group housing over two years supports – based on bite mark registration – that aggression primarily occurs between cage mates of the same sex (Alemu et al., 2013).

   Based on controlled studies, increased feed competition during group housing may – everything else being equal – lead to reduced body size. However, over a range of studies and under production conditions with varying feed management, the economic value of the pelts from group housed mink is not always reduced. Some find a negative effect of group housing on pelt quality/mink size (Udvalg for avl og teknik, 1979; Hänninen et al., 2008a) while

others do not (Neil, 1985; Aulerich et al., 1991; de Rond & de Jonge, 2008). It should be noted, however, that mink with wounds or injuries will often not produce a pelt because the skin is at risk of breaking at some point in the pelting process. A comparison of pelts ready for sale may therefore be biased in relation to the full economic impact of group housing if the loss of animals during the trail is not considered.

In cases where the level of aggression increases to unusual heights (Hansen & Møller, 2012) the economic loss on missing pelts can be high, because all the production costs have been incurred while no pelts are produced from dead or euthanized mink.

The time needed for inspection of the mink is increased under group housing because it is more difficult to make sure that all animals are inspected. In addition, the variation in feed intake is more difficult to detect when three or more mink are fed per cage compared to two mink per cage.

In case of a contagious disease on a farm, this will be expected to spread more rapidly in group housing systems due to the increased stocking density of mink. Apparently, no health data have been published in relation to group housing other than those related to aggression and mortality. This is probably because contagious diseases are rare in mink production, and experimental farms are generally well vaccinated.

4. Résumé of the international research on animal welfare in mink production systems (in relation to group housing) including:

Introduction

In most studies of the effects of group housing versus traditional housing of pairs in standard cages, it is important to emphasize that it is not only a comparison of the two social group sizes but also of two cage and management systems in which many factors differ. In most studies it is, therefore, not possible to separate the effects of the social environment from the effects of the increased cage complexity. In addition, further effects of +/- weaning, differences in feed allocation, number of feeding places and nest boxes and access to shelves or other occupational object may differ between the two systems. A comparison of group housing and pairwise housing in standard cages makes it difficult to relate the results unambiguously to the number of mink in the cage. However, going through the literature, there seems to be scientific support for the following conclusions.

a. Behavioural differences between juvenile mink housed in groups and in pairs of one male and one female.

Play behaviour

It has been argued that play does not occur under severe stress and, therefore, increased occurrence of play behaviour in mink has been taken as an indication of improved welfare (Vinke et al., 2004). Hansen et al. (1997) compared the behaviour in mink housed pairwise in standard cages with mink in standard row

cages as family groups. An increased frequency of aggression and ego-play (play with own tail or straw) in family mink – without any difference in social play and stereotypic behaviour – leads to the conclusion that family housing in row cages was not a behavioural welfare improvement for mink compared with traditional housing in pairs.

Behavioural differences between juvenile mink housed in climbing cages, row cages (three connected cages) and standard cages were investigated by Pedersen and co-workers (2004). They found no differences in stereotypies, self-grooming or play behaviour between the systems. Vinke and co-workers (2004) found that addition of objects in group housed mink increased object manipulation and reduced social play. The added objects had, however, no significant long term effect on anticipatory activity or stereotypic behaviour, suggesting no effect in terms of stress.

Hänninen and co-workers (2008a) investigated the effect of group and pairwise housing and found that group housed mink had more social interactions, but argued that it was difficult to make a valid differentiation between playful and aggressive motivated social behaviour. Hansen & Malmkvist (2011) analysed video recordings of social interaction in group housed mink (two males plus two females). They made a distinction between aggression (mutual bite exchanges and subsequent escape) and social play (alternately flight and persecution, with bite exchange, that stops without an obvious "winner") and found that the temporal occurrence and frequency of the two types of social interactions were very similar. The research demonstrates that it is difficult to distinguish between aggression and play in mink based on video, and that direct behavioural observations are very time consuming.

Use of nest box

Group housing decreases the mink's use of the nest box compared to mink kept pairwise, which may indicate increased competition for the nest box as a highly prioritized resource (Pedersen et al., 2004; Hagensen & Jeppesen, 2007; Hansen & Jeppesen, 2008; Hänninen et al., 2008a & b; Jeppesen, 2009). Pelts from climbing cages with two nest boxes had fewer bite marks than pelts from climbing cages with one common nest box (Jeppesen, 2009). Studies of mink deprived of the use of their nest boxes have demonstrated that the nest box is of considerable importance to the welfare and production of mink. Mink housed without access to a nest box was exposed to more stress (measured physiologically) and had a higher feed intake than mink with access to a nest box (Hansen & Damgaard, 1992; Hansen et al., 1994).

Measures of elasticity of demand are one way to assess an animal's priority of resources (Hansen & Jensen, 2006). Hansen & Jensen (2002) demonstrated that mink make higher priority to 60 min of access to a nest box than to 20 min of access and lowest preference to 1 min of access showing that mink prefer a longer stay in the nest box. The demand for a nest box and the physiological stress response to deprivation from the nest box indicate that mink have a biological need for access to a nest box. Reduced use of the nest box in group housed mink may be caused by resource competition.

Aggression
Spontaneous fighting in group housed mink correlates with bite marks but occurs very infrequent and is therefore difficult to observe in practice (Jeppesen, 2013). However, aggressiveness can be tested in a competition test were mink after a deprivation period are offered a small amount of feed. In these tests, males deliver more bites than females and females receive more bites than males. Received bites correlated significantly with bite marks observed on body and tail, but not with bite marks in the neck (Hansen & Jeppesen, 2008). The results indicate that bite marks in the neck may be affected by other motivations than aggression, e.g. sexual or play motivation, whereas bite marks on the body and tail are caused primarily by aggression (Hansen & Jeppesen, 2008; Jeppesen, 2013).

The fact that bite marks on the leather side of the pelt actually reflect bites has been documented by applying artificial bites to juvenile mink during the maturation of the winter coat and recognizing these as bite marks when the mink are pelted (Hansen et al., 2013).

Irrespective of group composition, group housing increases the occurrence of aggression compared to mink kept pairwise as observed by the consequences of aggression such as bite marks and wounds (see also answers to question b, c, and d). The increased frequency of bite marks in group housed mink cannot be reduced by use of extra environmental enrichment such as plastic tubes or straw briquettes (Hansen 2012). Furthermore, it was not possible to document that two mink in a climbing cage had less bite marks than two mink kept in a standard cage (Jeppesen, 2009).

Abnormal behaviour – fur chewing
Fur chewing can be reduced through selection against fur chewing and by use of non-social environmental enrichments (Malmkvist & Hansen 2001; Hansen et al., 2007, Malmkvist et al., 2013). Group housing has by some authors been suggested as an environmental enrichment, as group housing may decrease the occurrence of fur chewing, probably due to the increased social stimuli (de Jonge, 1996; Hansen & Houbak, 2005; Hansen & Møller, 2012). However, this positive effect is not uniquely confirmed (Hänninen, 2008a), and the effect of social housing on fur chewing is confounded with late weaning (Hansen et al., 1998; Jeppesen et al., 2000) and/or increased cage complexity (Jeppesen et al., 2000; Hansen et al ., 2007) which is known to decrease fur chewing in mink. Further, it cannot be excluded that activities of higher priority (e.g. fighting in groups with negative welfare impact) may suppress low priority types of behaviour such as grooming and fur chewing.

Abnormal behaviour – stereotypy
Nowadays, the frequency of stereotypy is low during the growth period (Hansen & Møller, 2008; Axelsson et al., 2013; Malmkvist et al., 2013), probably due a better adjustment in the feeding management in accordance to the demand of the individual mink and feeding close to *ad libitum*. Most studies have found low and not significantly different levels of stereotypy in mink kept in groups and in

pairs (Jeppesen et al., 2000; Hänninen et al., 2008 a; Pedersen et al., 2004; Jeppesen, 2009).

Dams housed with their litter in connected row cages (family housing) during the first 12 weeks after delivery showed less stereotypy than dams weaned from their litter at 8 weeks (1 % vs. 7 % of the observations; Pedersen & Jeppesen, 2001). The effect of family housing was confounded with a more complex cage environment and +/-weaning. Hänninen and co-workers (2008 b) also reported less stereotypy in group housed mink than in pair housed mink, possibly as a consequence of a more complex cage environment for the group housed mink and a general feed restriction due to frozen feed in November. At present, the studies do not convincingly link changes in stereotypic behaviour to consequences of the group housing.

Physiological indicators of stress

In order to quantify the stress level in group housed mink, different physiological indicators have been used such as cortisol secreted from the HPA axis, weight of the adrenal gland, eosinophile leucocytes, heterophile/ lymphocyte ratio (H/L) and enzymes (ASAT, ALAT and CK). Commonly, these physiological indicators are interpreted in combination with behavioural indicators of stress and other production related signs.

One challenge when measuring stress in group housed mink is the acute activation of the HPA axis during the catching and blood sampling procedure. Eosinophile leucocytes and H/L are less affected by the acute activation of the HPA axis than cortisol and have, therefore, been used as a measure of the basal level of stress in mink. However, no significant differences between group housed and single housed mink have been found (Hansen & Damgaard, 1991) while pair housed mink were not included in this study.

An increased weight of the adrenals in group housed mink vs. pairs was taken as an indication of increased activity in the HPA axis and thereby increased social stress (Vinke et al., 2002b). Hänninen and co-workers (2008a) found the opposite and a higher cortisol responsiveness to ACTH challenge in mink kept in pairs than in family housed mink when measured just before pelting, but could not repeat the results for group housing (Hänninen et al.,2008b). Several factors may explain this discrepancy in results, among these different timing of the sampling, the size of the animals, the feeding management, activity and different termoregulatory demands across and even within studies. In addition, the weight of the adrenals needs further validation before being used as measure of chronic stress in mink (Hansen & Damgaard, 1991). Females had a higher concentration of plasma cortisol than males under group housing. Besides, females kept in groups of two males plus two females had a higher concentration of plasma cortisol in October and November than females kept single. This result, in combination with an increased activity of the enzymes ASAT, CK and more bite marks, leads to the interpretation that females kept in groups are more physiological stressed than females kept alone (Hansen & Damgaard, 1991).

Likewise, Pedersen and co-workers (2001) found a higher concentration of plasma cortisol in dams housed with the litter than in dams separated from the litter and housed alone, indicating a higher level of stress in family housed dams. No correlation was found between the cortisol level and the mean duration of the catching/blood sampling procedure, suggesting that the cortisol level reflected the housing system. In order to avoid the acute stress reactions during catching and blood sampling, corticoid metabolites can now be measured in faeces reflecting the basal level of cortisol (Malmkvist et al., 2011). However, this measure has not yet been used to quantify the level of stress in group housed mink.

b. Differences in frequency and severity of bite wounds between mink housed in groups and in pairs of one male and one female.

This part deals with bite wounds and injuries to the body observed during the growth period and wounds (Figure 3) observed at a thorough inspection of the bodies after killing at pelting time.

(a) < 1 cm (b) 2.5 cm (c) 5 cm

Figure 3. Wounds at the tail tip (a), tail base (b), and tail base (c).

In many papers on group housing, the number and severity of wounds and injuries is not clearly indicated and the direct relation to pairwise or group housing is unclear. However, some figures are available and these have been summarised in Table 1. The reported number of severe wounds leading to death or euthanasia is often low, e.g. 0.1 % in pairwise housing and 2 % in group housing (Møller, 2011). Both lower (Hänninen et al., 2008a & b, de Rond & van Willigen, 2012) and higher (Pedersen & Jeppesen, 2001; Pedersen et al., 2004; Hansen & Møller, 2012) numbers have been reported, indicating a large variation, especially in group housing systems.

Table 1. Bite wounds (open and healed) in mink juveniles in the growth season in total from four farms. Wounds were scored from 0 (no wound) to 9 (wound larger than 50 mm).

Grouping	Number of mink	With wound	% with wound	Mean score of wounds	
				All mink	With wound
1 ♂ + 1 ♀	398	11	2.76	0.08	3.00
2 ♂ + 2 ♀	181	16	8.84	0.33	3.75
4 ♀	373	30	8.04	0.24	2.97

Calculated from the data set used in Hansen & Møller (2012).

The number of wounds is higher in group housing systems in most experimental studies published (European Commission, 2001; Hansen, 1997; Hansen & Damgaard, 1991; Hansen & Jeppesen, 2008; Hansen & Møller, 2012; de Jonge, 1996, 1999, 2000, cf. EC., 2001; Møller 2003; Møller et al. 2003; Mononen et al. 2000; Pedersen & Jeppesen 2001; Pesso 1968) while the difference is not always significant in small samples (Hänninen et al., 2008a and b). Hansen & Møller (2012) also recorded the severity of wounds on a scale from 0 (no wound) to 9 (wound larger than 50 mm) and whether the wounds were open or healed (see also section 2.c). Although the frequency is higher in group housed mink, the severity of the actual wounds does not differ between housing systems, which has also previously been found by Hansen & Houbak (2005).

c. Differences in frequency of bite marks in the leather side of the pelt between mink housed in groups and in pairs of one male and one female.

Bite marks are visible spots on the leather side of the pelt (Figure 5 a and b) caused by a hard pressure, but not necessarily penetrating the skin (Hansen et al, 2013). In the literature, bite marks are also referred to as scars or black spots. Bite marks can be seen in numbers from zero to hundreds per skin and are therefore conveniently scored in categories. Bite marks have been scored in different ways in different investigations but often in e.g. the neck, body and tail region of the pelt, and usually in a limited number of categories ranging from two (yes/no) to ten (0: none to 9:>45).

Comparing bite marks in pairs and family groups has demonstrated significantly more bite marks in the family groups (Pedersen & Jeppesen, 2001; Hänninen et al., 2008a). More bite marks in groups of juveniles than in pairs of one male and one female have also been found in almost all published studies (Damgaard & Hansen 1996; de Jonge 1996; 1999; 2000, cf. EC., 2001; Hänninen et al. 2008b; Hansen 1997; Hansen & Damgaard 1991; Hansen & Jeppesen 2008; Mononen et al. 2000; Møller 2003; Møller et al. 2003; Pedersen & Jeppesen 2001; Pesso 1968).

Almost all data published have been from mink that are naïve to group housing, i.e. have not been housed and selected in group housing in previous generations. Furthermore, most studies have been performed with two males and two females in a cage, while a preferred farm practice appears to be three or four females. Thus, results in the current literature may overestimate the actual amount of bite marks in practice. Therefore, we recently studied bite marks on four Danish farms, selected due to their commercial application of group housing systems for a number of years (Table 2, Hansen & Møller, 2012).

a. Belly b. Back

Figure 5. Bite marks on the belly or back of the leather side of a female pelt. In this case, the pattern from two or four canine teeth's of a cage mate can be identified for most marks.

Table 2. Sum of bite mark scores from 0 to 9 in the neck, body and tail region for mink kept in different groups on four farms. Not all farms kept all groups.

Farm	Grouping of mink				
	1 ♂ + 1 ♀	1 ♂ + 2 ♀	2 ♂ + 1 ♀	2 ♂ + 2 ♀	4 ♀
A	4.50±4.89 b		8.64±6.30 a		11.55±7.27 a
B	3.58±4.32 b			10.95±8.11 a	6.73±6.54 ab
C	4.27±4.63 b				11.18±7.48 a
D	6.87±7.37 c	10.52±8.64 b		14.87±7.73 a	16.97±8.08 a

Results with different subscript in the same row are significantly different.

On all farms, mink in the control group – one male (♂) + one female (♀) kept in pairs – had less bite marks than the tested combinations of group housed mink. The best group combination in general could not be elucidated from this experiment.

d. Differences in mortality between mink housed in groups and in pairs of one male and one female.

In many papers on group housing, the causes of mortality are not clearly indicated, and the direct relation to pairwise or group housing is unclear. In general, the mortality during the growth season is low, as illustrated in Table 3, for standard Danish farm practice of mainly pairwise housing and experimental data comparing pairwise and group housing. Based on systematic comparison of experimental data, group housing appears to increase the overall mortality (Table 3).

Table 3. Mortality of juvenile mink in the growth season in total and with wounds in a number of investigations.

Source	No. mink	Dead	Mortality %		Mortality from bite wounds %	
			Pairs	Groups	Pairs	Groups
1. CEPROS	60,332	268	0.44		0.01	
2. Clausen 2006	13,000	144	1.11		0.11	
3. Foulum 2007	10,207	111	1.09		0.06	
4. Foulum 2008	11,127	197	1.77		0.10	
5. Foulum 2009	1201	35	0.96	4.41	0.00	2.06
6. Pedersen 2004	335	19	0.0	5.7	0.00	10.00
7. Edelveen 2009-11	3 x 10,755		1.5	1.7-1.8		
8. Farm A, B, C, 2011	822	22	1.67	3.26		
8. Farm D, 2011	410	52	4.63	15.56	4.63	15.56

1. Private farms mainly pairwise housing (Rattenborg et al., 1999); 2. Average of four years (Clausen, 2006); 3. Whole farm; 4. Whole farm, few in group housing; 5. Group selection (2 ♂ + 2 ♀) at Foulum; 6. Pedersen et al., 2004; 7. De Rond & van Willigen, 2012; 8. Calculated from Hansen & Møller, 2012.

5. An evaluation of the international research into the potential for genetic selection for mink that is better adapted to group housing.

Although group housing has been practiced in large scale in the Netherlands since the 1990's, no papers on the potential for genetic selection have been found. The anecdotal evidence available for the results obtained in the Netherlands suggests that selection against bite wounds has reduced the proportion of family housed females with wounds or scars from 18.2 % in 1993 to 2.1–2.5 % in 1999-2000 (EU commission 2001). Recent data indicate that the number of bite wounds and bite marks is no longer systematically higher in group housing than in pairwise housing at the research farm Edelveen in the Netherlands (de Rond & van Willigen, 2012; van Willigen et al., 2012).

Only one selection experiment aimed at increasing mink's adaptation to group housing by genetic selection of mink with fewer bite marks during group housing has been identified (Alemu et al., 2013; Berg & Møller, 2010; Berg et al., 2013; Møller, 2011; Møller & Hansen, 2013). The experiment involved group selection against bite marks using a model with both direct and indirect genetic effects and thus including the genetic variation in bite marks between the animals in the group. A line for low bite mark score and an unselected control line were formed.

Based on results from three years, the traditional heritability was 0.25 while the 'heritability' for bite marks was 0.61 when indirect genetic effects (i.e. additional effect of the social environment) were included in the analysis (Alemu et al., 2013; Berg 2013). The increasing difference between the selection and control line demonstrates the effect of selection (Figure 6) while the modest decline in total bite mark score demonstrates that unknown environmental factors are increasing the bite mark score over the years. According to the theory and models, it can be estimated that without this unknown factor, the selection line could have reached the same level as pair housed within three to four generations.

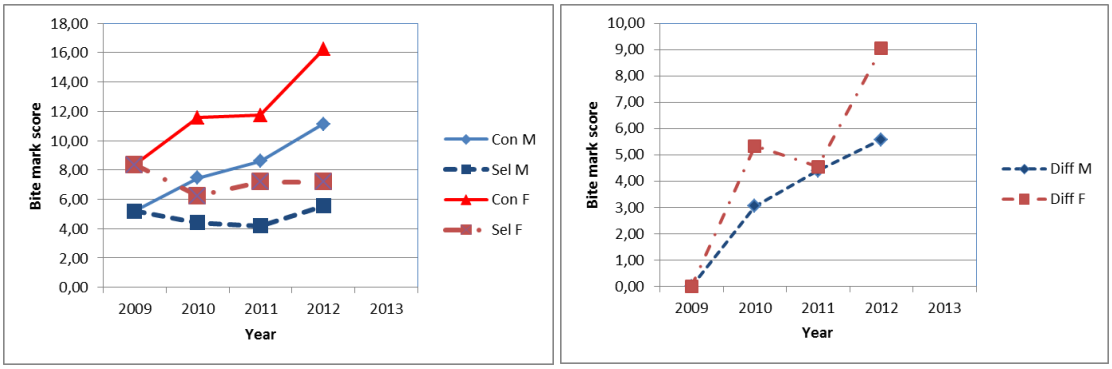

Figure 6. Average sum (to the left) and difference (to the right) in bite mark score between group housed mink of a line selected against bite marks (Sel) and an unselected control line (Con), reported for males (M) and females (F) separately. Sum of bite mark scores from 0 (none) to 9 (> 45) bite marks on the neck, body and tail region of the leather side of pelts in November.

The analysis thus revealed that it is possible to select for fewer bite marks during group housing. However, long-term effects (e.g. in other parts of the production year) or effects on other welfare indicators following selection against bite marks have not yet been published.

The development in wounds followed to some degree the same pattern as seen for bite marks, confirming the relation between bite marks and wounds.

6. A description of the advantages and disadvantages of a ban on group housing.

A Danish ban on group housing of mink would result in an increase in mink kept in pairs (one male – one female) during the growth period. At the European level, this would result in a moderate decrease in the number of group housed mink, based on our information on the moderate proportion of Danish mink in group housing compared to in other European countries. In case of a European ban on group housing, the consequences will therefore apply to a much larger proportion of the world production of mink. To our knowledge, group housing is not in use in North America. This is the background for the listed advantageous, neutral and disadvantageous consequences.

Advantages following a ban on group housing

Category I: Consequences highly likely to occur based on the scientific review:

- Reduced amount of aggression between co-housed mink
- Fewer interventions necessary due to less fighting, reduced separation and treatment or euthanasia
- Reduced resource competition for food and nest box
- Fewer damages and wounds on mink during the growth period
- Reduced mortality during the growth period
- Fewer bite marks on the leather side of the pelts
- Easier surveillance of the individual mink
- A higher number of pelts produced per breeding female, increasing sustainability in the mink production

Category II: Consequences which may occur with some likelihood:

- Reduced social stress in terms of reduced stress hormone concentrations
- Easier to include juveniles in the pool for genetic selection, e.g. making it easier to link heritable traits such as temperament to the individual mink
- Easier use of individual feeding during the growth season
- Reduced disease/infection pressure

For category II effects, the literature is evaluated as less conclusive or the subjects are less well studied. The positive effects in this category may also depend on other factors, such as the management time the farmer allocate per mink, the cage and nest box design and the selection strategy used during breeding.

Disadvantages following a ban on group housing

Category I: Consequences highly likely to occur:

- Farmer's investment in the upper part of group housing cages is lost while new investment in additional cages for mink in the growth period is needed

- A loss of management flexibility to house larger than average litter sizes according to the regulations. This can to some degree be compensated by allowing farms to expand in order to house all offspring of the allowed breeding stock
- The potential of group selection to efficiently decrease bite marks during group housing cannot be further exploited and applied in practice

Category II: Consequences which may occur with some likelihood:

- Increased amount of fur chewing/sucking on the tail; one type of abnormal behaviour
- Some farmers using group housing may move mink production from Denmark to other countries if a ban is only applied nationally

These consequences are based on results from studies and more anecdotal reports, compared to pairs in barren cages. However, the amount of fur chewing is also influenced by the feeding intensity, management and whether the mink have access to additional cage resources.

Neutral effects following a ban on group housing

- Reduced amount of ego-play, the same amount of social play
- Same amount of stereotypic behaviour
- Similar average price per pelt sold

Pairwise housed mink (one male and one female) are able to play as well and develop natural sexual behaviour to be used later in case they are selected as breeders. The amount of social play was not different in mink housed pairwise versus in groups. The studies on stereotypic behaviour do not convincingly link changes to consequences of the group housing. Following a ban of group housing, some farmers may choose to place two mink in climbing cages present at their farm. Only one study has so far compared mink housed pairwise in standard cages and climbing cages, and this study did not demonstrate any difference in welfare between the two systems.

7. A description of the consequences of a ban on group housing for animal health and animal welfare.

A ban on group housing would overall lead to a more stable social environment with less risk of aggression and thereby to improved health and welfare during the growth season.

The list of positive effects on mink health and welfare includes:

- Reduced aggression
- Reduced feeding competition
- Fewer number of wounds and injuries
- Reduced mortality during the growth period
- Easier surveillance of the individual mink, making preventive intervention easier

- Reduced infection pressure in case of contagious diseases

The list of negative effects on mink health and welfare includes:

- Increased amount of fur chewing/sucking on the tail

Procedures used in other types of animal husbandry in Denmark/other countries include the cutting of parts of the animals to make keeping easier/economically feasible (e.g. dehorning, tail docking, beak trimming to reduce damages, castration). No such procedures are used in the commercial mink production – the mink are kept intact. Historically and in pet animals, both castration and claw/canine teeth removals have been suggested as 'solutions' to diminish aggression/fighting. However, these procedures imply negative welfare as well, which should be considered in case suggested implemented to reduce damages and wounds in group housed mink.

Some mink may be better adapted to group housing conditions. The anecdotal evidence from the Netherlands suggests that this strategy has been successful in the period of 15 years since the mandatory introduction of group housing in 1998; however, there exist no published data or impartial investigations convincingly supporting this view. The anecdotal evidence that selection against bite wounds also reduces the number of bite marks is plausible since both are the result of bites. Although the scientific study performed at Aarhus University recently has demonstrated the possibility to select against bite marks, this procedure is at present not feasible for application in practice.

8. A description of other potential advantages and disadvantages of group housing

An advantage of group housing for farmers is that more mink can be fitted into the same space. Thus a ban would increase the need for cages for juvenile mink at the farm, everything else being equal, and the mink farmers should therefore be allowed to build the cages needed.

The initial reason for group housing was the potential for increased social enrichment to the benefit of the welfare of the mink during the growth period. This potential has, however, never been demonstrated as an effect of housing mink in groups.

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