The Old School, Brewhouse Hill, Wheathampstead,
Hertfordshire AL4 8AN, UK
www.ufaw.org.uk

Animal Welfare 2015, 24: 193-201
ISSN 0962-7286
doi: 10.7120/09627286.24.2.193

The reliability of welfare assessment according to the WelFur-protocol in the nursing period of mink (Neovison vison) is challenged by increasing welfare problems prior to weaning

BIF Henriksen* and SH Møller

Aarhus University, Dept of Animal Science, Blichers Allé 20, Postboks 50, DK-8830 Tjele, Denmark
* Contact for correspondence and requests for reprints: Britt.Henriksen@anis.au.dk

Abstract

*The objective of this study was to test the hypothesis that the body condition of the mink dam, the frequency of dirty nests, frequency of injuries and diarrhoea change significantly with the day of assessment, post-partum, within the data collection period from parturition to weaning, influencing the scores of WelFur at criteria level, but not at principal level or the overall category of mink (*Neovison vison*) welfare according to the WelFur-Mink protocol. Data from a representative sample of around 120 dams and litters on four farms were collected three to four times in the period stipulated by the WelFur-Mink protocol. WelFur-scores between 0 (worst) and 100 (best) were calculated, aggregated and compared at criteria and principal level. The score for the criterion, 'Absence of prolonged hunger' dropped from 86 to 38 after about five weeks of lactation, affecting the principal score 'Good feeding', but not by enough to affect the estimated welfare classification. The score for the three other measures also varied with date of assessment but not enough to affect the classification. However, the observed change in the four measures we focused on indicates that a change in the overall WelFur classification can occur if these or other measures change a little more for the better or worse. Possible solutions to this could be reducing the time window for assessment, development of a valid correction factor or to stratify the visits into an early, middle and late visit on a farm within the three registration periods.*

Keywords: *animal welfare, body condition score, diarrhoea, housing, injuries, mink production*

Introduction

WelFur is an on-farm welfare assessment system for foxes (*Vulpes* spp) and mink (*Neovison vison*) based on the principles developed in Welfare Quality® (Mononen *et al* 2012). Welfare Quality® has set up 12 criteria, covering four principles for good animal welfare (Table 1). The protocol for mink is based on 22 measures taken on breeders, during lactation and in late growth in order to cover all phases of production. Mink are strictly seasonal and these phases of production take place therefore in three different periods of the year. The measures are aggregated into scores across the three production periods, then for 12 criteria, four principles and an overall classification per farm (Botreau *et al* 2012).

Due to the seasonal production, all kits are born within few weeks of each other in late April/early May (Møller *et al* 2003). Therefore, the time window for assessment of welfare during the nursing period (period 2) is limited to approximately seven weeks from parturition to weaning, and the date of assessment is highly correlated with age of the kits. Mink kits grow from 10–11 g at birth to 520–655 g at weaning after about eight weeks (Hansen 1997). This requires a very high milk yield from the dam and a successful transition of the kits to solid food and to the drinking water system. Lack of success in this critical and demanding period, with great changes both for the mother and the kits, increases the risk of health problems and aggression between the mink (Møller 1993; Brink & Jeppesen 2005). Therefore, we expect a number of potential welfare problems in this period to be age-dependant, potentially implying a dependency on the date of assessment of welfare of both the dam and the kits. The data collection period in WelFur-Mink in the reproduction period is between May 5th and July 1st, or to when weaning begins. When WelFur-Mink is applied in practice, such an age-dependency, due to changes in management and biology of the mink during lactation, is a challenge to the reliability of the welfare assessment. The dependency of the date of assessment is mainly expected within the following four welfare criteria.

Absence of prolonged hunger

Due to the high milk production, the dam loses bodyweight during the lactation period. That is especially pronounced after four weeks of lactation, when the dam reaches an upper limit for feed consumption and starts mobilising body reserves to produce milk for her kits (Hansen 1999), increasing the risk of very thin dams.

Table 1 The WelFur principles of welfare, with the underlying criteria and measurements.

Principle	Criterion	Measurements
1 Good feeding	1 Absence of prolonged hunger	Body condition score
	2 Absence of prolonged thirst	Continuous water availability; measured by: Type of watering system; Functioning and cleanliness of the water points
2 Good housing	3 Comfort around resting	Access to a nest-box, Resting quality of the nest-box/resting area
	4 Thermal comfort	Protection from exceptional weather conditions, Nest-box material and bedding/nesting material
	5 Ease of movement	Space available for moving (area and height)
3 Good health	6 Absence of injuries	Skin lesions or injuries to the body
	7 Absence of disease	Mortality, Diarrhoea, Lameness or impaired movement, Obviously sick animals
	8 Absence of pain induced by management procedures	Killing methods for pelting of mink, Killing methods for individual mink
4 Appropriate behaviour	9 Expression of social behaviours	Social housing in the growth period (period 3), Age and procedures at weaning in the summer period (period 2)
	10 Expression of other behaviours	Stereotypic behaviour, Cage enrichments, Fur chewing
	11 Good human-animal relationship & 12 Positive emotional state*	Frequency and duration of handling and transportation, Temperament test

* The two criteria are based on the same measurements.

Comfort around resting

To ease the kits' access to food they are fed on the lid of the nest-box from around four weeks of age, increasing the risk of dirty nests and decreased resting quality of the nest box.

Absence of injuries

The kits are dependent on the mother's milk until they start to drink water at about six weeks of age (Møller & Lohi 1989; Brink & Jeppesen 2005). The kits' need for water increases, and just before they start drinking from the watering system, the risk of saliva licking from the dam's mouth, aggression and injuries among the kits increase (Møller & Lohi 1989; Brink & Jeppesen 2005; Clausen & Larsen 2012). Danish mink housing systems provide water from a nipple at the end of the cage, opposite the nest. Additional water for the kits has been shown to advance water intake and reduce saliva licking (Møller & Lohi 1989; Brink & Jeppesen 2005). Therefore, some farmers install some kind of additional water supply during this period in addition to saturating the feed with water.

Absence of disease

The kits are at risk of 'sticky kits' (ie diarrhoea and excessive secretion from the cervical apocrine glands caused by astrovirus) (Clausen & Dietz 2000; Englund *et al* 2002), before they start to eat solid feed around four weeks of age. After this age, the risk of 'normal' diarrhoea caused by *E. coli* bacteria increases.

The objective of this study was to examine changes during lactation (measured as the average kit's age) in:

• The mink dam body condition score — a change is expected after about four weeks of lactation due to mobilisation of body fat reserves;

• The prevalence of dirty nest-boxes — we expect it to change around four weeks of lactation, due to feeding on the nest-boxes from this age, to ease the kits' access to food;

• The prevalence of injuries — we expect the frequency of injuries to increase, especially at five weeks of age, just before the kits start to drink water; and

• The prevalence of diarrhoea — the kits might get diarrhoea just after they start to eat solid food at about four weeks of age, and there is a risk of sticky kits before they start to eat.

The hypothesis is that the prevalence of very thin mink dams, of dirty nests, of injuries and of diarrhoea change significantly with the date of assessment within the data-collection period, influencing the scores of WelFur at the criteria level. We further expect, however, that the number and magnitude of changes will not be enough to change the welfare score at the principal level or the overall category of welfare according to the WelFur-Mink protocol.

Materials and methods

Target and study population

The target population was all mink on the approximately 1,450 production farms in Denmark in the nursing period from parturition to weaning of the kits. The study population was mink in the nursing period at four mink farms in Central Jutland. The study sample consisted of about 120 cages with one dam and her kits per farm per day of observation. A sample of 120 cages is found to be enough to get a representative sample of animals from a mink farm, independent of farm size (Rousing *et al* 2012). The study sample was taken in order to be representative regarding colour type of mink, primi- and multiparous dams and

https://doi.org/10.7120/09627286.24.2.193 Published online by Cambridge University Press

Table 2 WelFur-classification of farms regarding welfare (revised from Mononen *et al* 2012).

Category	Required score values
Best current practice	Score 55 on all four principles, and more than 80 on at least two
Good current practice	Score 20 on all four principles, and more than 55 on at least two
Acceptable current practice	Score 10 on all four principles, and more than 20 on at least three
Unacceptable current practice	If the minimum standard 'Acceptable current practice' is not met

housing conditions on the farm. The study unit was a cage with a dam and her kits.

In the summer of 2012, data were collected three to four times per farm, in the period from parturition to weaning, in accordance with the WelFur-Mink protocol. The average and median date of birth is April 30th and more than 95% of litters are born within ± 7 days (Møller, personal communication 2014). To evaluate the importance of which date we assessed the farms, the day of observation is therefore defined as average day, post-partum (pp), equal to date in May (ie with the mean day of birth set to April 30th). The first assessment was about one week post-partum, and the farms were assessed again every two weeks until they began weaning.

Description of variables

Four farms were included in the study. One farm was Aarhus University's research farm at Foulum, Denmark, the other three were private farms run under production conditions. Four experienced observers collected data from the four farms, while data were recorded by an assistant. One of the observers visited two farms and one farm was visited by two observers each collecting and recording data on half the farm. The same observers returned to the same farms for each visit during the nursing period, while the assistant sometimes differed. In total, 506 cages were observed, and the same cages were observed at each visit. A total of 1,554 cage observations were obtained of which 28 were after weaning; ie the dam was removed from the cage at the last visit. The total number of kits observed in the study on all four farms was 2,731 kits, with 44 kits fewer at the first visit and 78 kits fewer at the last visit. Not all kits in all litters were counted at the first visit, and some of the kits were moved (cross-fostering due to litter size) or euthanised due to disease, injuries etc at the last visit.

Missing data were treated in the following way: if information about the number of kits in the cage was missing, the minimum number of kits observed in the same cage in the previous or following visits was included. The WelFur protocol was still under development in 2012, and the final protocol was finished in 2013. The calculations are based on the final protocol. The temperament test was not included in the protocol in 2012, but was reintroduced in the final protocol, and data are therefore needed for the calculation of welfare scores. Mean values from the temperament test in the nursing period on nine mink farms in 2011 (hereafter called 2011-farms) were therefore included in the aggregation into WelFur-scores. Data from these nine farms were collected in another study in 2011 in connection to the WelFur project (Mononen *et al* 2012). Three of the four project farms in the present study were among the nine 2011-farms.

The main mink colour type in the study population is brown (BRW). The research farm only had BRW in the study sample, while the other farms had different colour types.

Scoring and aggregation

In the WelFur-Mink assessment, a score is calculated for each welfare measure based on the registrations on each farm in each period. These scores are aggregated into scores across periods, then into 12 criteria scores and a score for the four principles (Botreau *et al* 2012; Mononen *et al* 2012). Table 1 gives an overview of the WelFur principles of welfare with the underlying criteria and measures. The scores at each level have values between 0 (worst) and 100 (best). The overall classification of a farm in WelFur is based on the same combination of the four principle scores in four categories as used in Welfare Quality®. In order to stress that the welfare assessment relates to the current farm animal production systems and views of animal welfare in the society, the terms are changed from 'Excellent', 'Enhanced', 'Acceptable' and 'Not classified' in Welfare Quality® to 'Best current practice', 'Good current practice', 'Acceptable current practice' and 'Unacceptable current practice' in WelFur. The score values required for classification into the different categories are shown in Table 2.

Each measurement in the WelFur protocol was scored at each assessment in order to investigate changes with age of the kits. The four measurements expected to change the most are 'Body condition score', 'Dirty nests', 'Injuries' and 'Diarrhoea including sticky kits'. These measurements are part of the criteria 'Absence of prolonged hunger' (Body condition score), 'Comfort around resting' (Dirty nests), 'Absence of injuries' (Injuries) and 'Absence of disease' (Diarrhoea including sticky kits). The score of other measurements from the nursing period, included in the respective criteria, was set to the average value of the assessments on the four farms. The WelFur protocol is based on aggregation across three periods, while our calculations are for one period only. We therefore used average values from WelFur-assessment on the nine 2011-farms for the other two periods (winter and autumn) to simulate how the measurements that

Table 3 Explanations of variables used in the statistical calculations.

Variable	Explanation
Days post-partum (pp)	Counted as days from April 30th (the mean day of birth) to the day of visit. There were visits on 12 days pp (3, 8, 9, 10, 22, 23, 24, 35, 36, 44, 51, and 52). In the statistical calculations the visits until 23 days pp (Figure 1[a]) up till 36 days pp (Figure 1[c]) were grouped into one category. This was done if there were no or very few observations of 'responses' (poor welfare outcome measures) the respective days. (nominal variable)
Body condition score	BCS of the dam only, values too thin = 1, ok = 0, Dichotomous (binary variable). 'Too thin' means dams in BCS 1 on a scale from 1–5
Dirty nests	Dirty nests got the value = 1, if ok, 0, Dichotomous (binary variable)
Injuries	If mink (kits or adult) with injury in the cage = 1, if not, 0, Dichotomous (binary variable). The injuries can be on a WelFur-scale from 1 (unhealed injuries with a diameter < 10 mm or minor healed lesions, for example, missing less than half the tail), 2 (unhealed injuries with a diameter ≥ 10 mm and ≤ 30 mm, or major healed lesions, for example, missing more than half the tail) to 3 (unhealed injuries with a diameter > 30 mm or major unhealed injuries, for example missing more than half the tail)
Diarrhoea	If observed diarrhoea or the disease sticky kits, value 1, if not, 0, Dichotomous (binary variable)

change with age of the kits contribute to the annual score per criterion, per principle and to the overall classification.

In order to evaluate if there are other measurements in the nursing period that influence a change at criteria and principal level, or a change in the overall classification with the age of the kits, we inserted the actual farm values for all measures in the aggregation at each visit in the lactation period of 2012. For missing values, data from the 2011-farms were inserted.

Statistical analysis

The following dichotomous outcome variables were studied: Body condition score (very thin = 1 or not = 0), dirty nests (present = 1 or not = 0), injuries (observed = 1 or not = 0) and diarrhoea (observed = 1 or not = 0). Table 3 gives an overview of the variables in the statistical analysis. The main interest was in characterising the probabilities of each of those outcomes in terms of kits' age. This was done by using logistic binomial mixed models in which the dependent variables were each of the outcomes above and the kits' age entered as a discrete explanatory variable. The models contained a random component representing the farm where the animals were raised, representing in this way a possible effect of farm and accounting for possible dependency of observations of animals raised on the same farm. The logistic binomial mixed models were adjusted using the package lme4 (Bates *et al* 2014) of the statistical software R (R Core Team 2014) and the *P*-values of the likelihood ratio tests were calculated using parametric bootstrap (Davidson & Hinkley 1997; Faraway 2006). A null hypothesis of a hypothesis test was rejected (and the correspondent effect was declared statistically significant) when the *P*-value of the test was less than 5%.

The Kruskal-Wallis test was used to evaluate a change in the calculated welfare score per criterion and per principle at around five weeks of lactation (mean age of the kits = 35 days).

Results

Descriptive results

In general, there was low prevalence of critical welfare observations across measurements. Observations of very thin animals (BCS = 1) were all after 23 days pp, and the last observation without very thin animals (all BCS = 0) were at 35 days pp (Figure 1[a]). Observations of dirty nests ('Dirty nests' = 1) and observations of injuries ('Injuries' = 1) were also mainly at the end of the lactation period, after 36 days pp (Figure 1[b] and [c]). Diarrhoea or sticky kits ('Diarrhoea' = 1) were mainly observed at farm 1 after the kits began to eat solid food around 28 days pp (Figure 1[d]).

Analytical results at measurement level

The prevalence of very thin animals increased significantly from 24 days pp ($P < 0.001$) (Figure 1[a]), and the prevalence of dirty nests increased significantly from 36 days pp ($P < 0.005$) (Figure 1[b]). There was a significantly higher amount of mink with injuries after 36 days pp ($P < 0.001$) (Figure 1[c]). There were nearly no injuries until 36 days pp, after which mainly kit injuries less than 10 mm in diameter were observed. There was no relationship between observation of injured adults and date of visit. Farm four had no observations of sticky kits or diarrhoea. To be able to run the analysis of the effect of kits' age on the prevalence of diarrhoea, farm four is excluded from the analysis due to very few observations of sticky kits and diarrhoea. There was significantly higher prevalence of diarrhoea after about 34 days pp ($P < 0.001$) (Figure 1[d]).

Analytical results at WelFur criteria level

The calculated score of the WelFur criterion 'Absence of prolonged hunger' dropped significantly from 86 to 38 after 35 days pp, which is around five weeks pp ($P = 0.001$) (Figure 2). There was a slight decrease in the criterion score

https://doi.org/10.7120/09627286.24.2.193 Published online by Cambridge University Press

for 'Comfort around resting' with average kits' age (Figure 2), with a significant difference in the score after 35 days pp compared with earlier in the lactation ($P = 0.015$). There was no significant change in the criterion score 'Absence of injuries' at around 35 days pp ($P = 0.132$), but there seems to be a change later in lactation (Figure 2). The change in the WelFur-score is due to an increase in kit injuries while there was no relationship between observation of injured adults and date of visit. There was a slight decrease in the WelFur score of the criterion 'Absence of disease' in the last period of lactation (Figure 2), but there was no significant difference between the scores before or after 35 days pp ($P = 0.370$).

WelFur principle and overall category level

The estimated overall score for the principles 'Good feeding' and 'Good housing' decrease significantly at around 35 days of kits' age ($P = 0.001$ and $P = 0.016$, respectively), while the other principle scores did not change significantly with age (Figure 3). All the farms had their principle score values above 20, and at least two of the principles had score values over 55. Therefore, the estimated WelFur classification was 'Good current practice' for all farms during the whole nursing period.

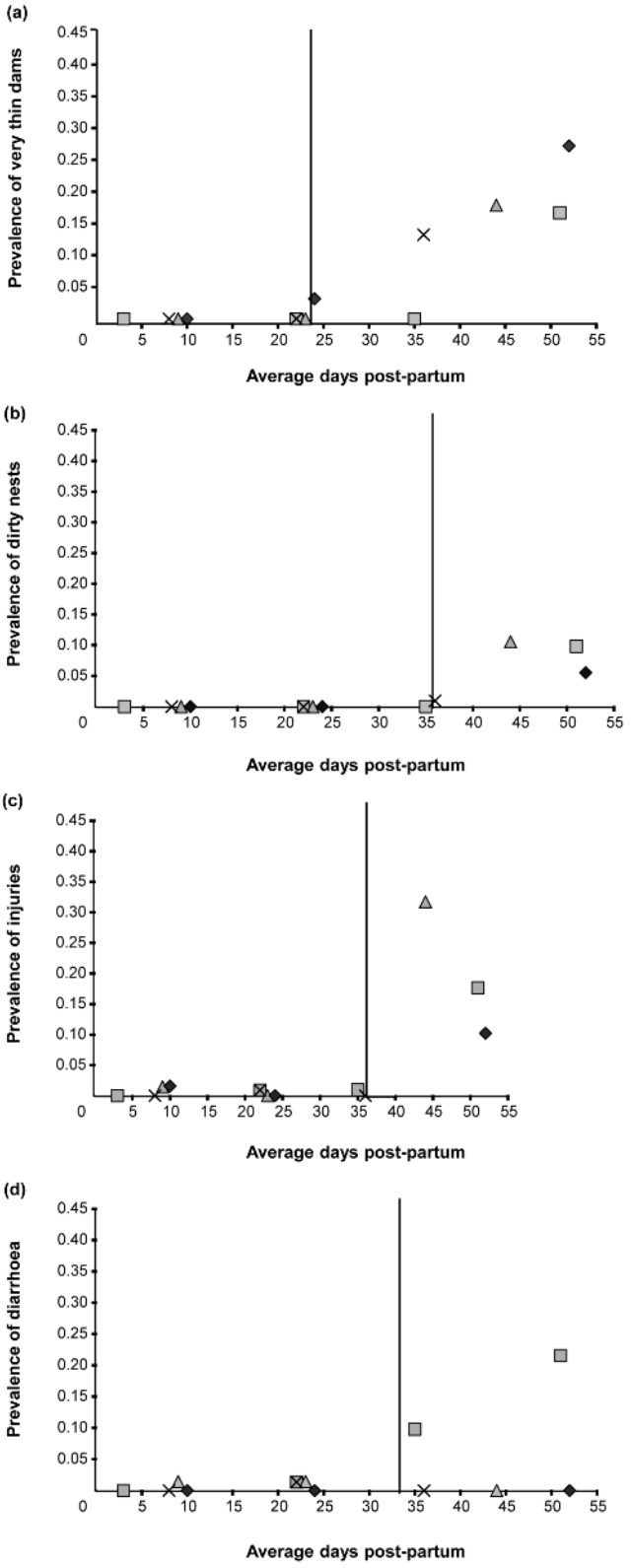
When including the actual values for all measurements in the nursing period, the measurements of 'Nest-box material and bedding/nesting material' and 'Cage enrichments' changed significantly with kits' age due to lack of straw at the end of the nursing period. This influenced the criterion 'Thermal comfort' but not 'Expression of other behaviour' significantly, while this was not enough to affect the estimated overall classification of farms (Figure 4).

Discussion

We accept the hypothesis that the body condition of the mink dam, the frequency of dirty nests, frequency of injuries and diarrhoea change significantly with the date of assessment within the data collection period from parturition to weaning, influencing the scores of WelFur at criteria level. We also accept, however, that as expected, these changes are not large enough to change the estimated overall classification for the farms between the dates of visit.

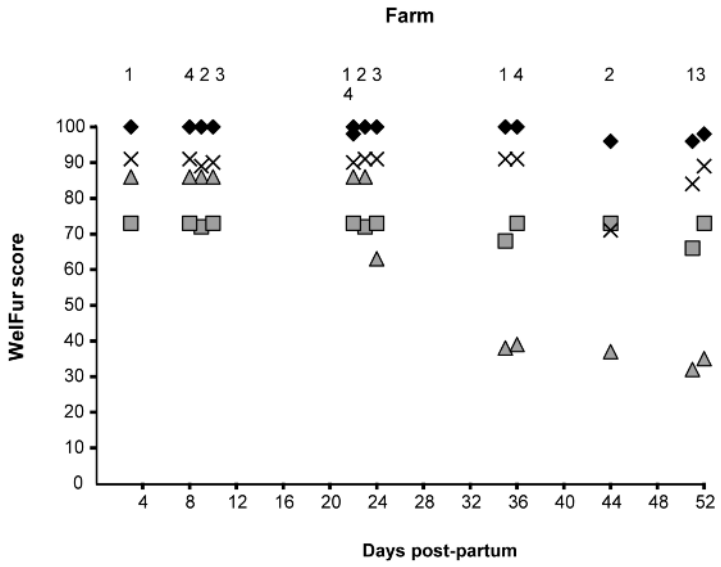
The effect that days pp have on the frequency of very thin dams corresponds with our expectation based on the knowledge of the dams reaching their upper limit for feed consumption at around four weeks of age (Hansen 1999). Figure 1(a) shows that all observations of very thin animals were after four weeks post-partum, and mainly at the end of the observation period. The score for the criterion 'Absence of prolonged hunger' is calculated from the percentage of very thin dams, and a drop in the criterion score as shown in Figure 2 corresponds to the higher frequency of very thin dams after about four weeks of lactation. Very thin dams have low welfare, and the WelFur assessment system accepts only a few percent in the sample before the score of welfare for this criterion is reduced dramatically (WelFur 2013). Therefore, the increase from no very thin dams to 15–40% of the sample (Figure 1[a]) explains the significant

Figure 1



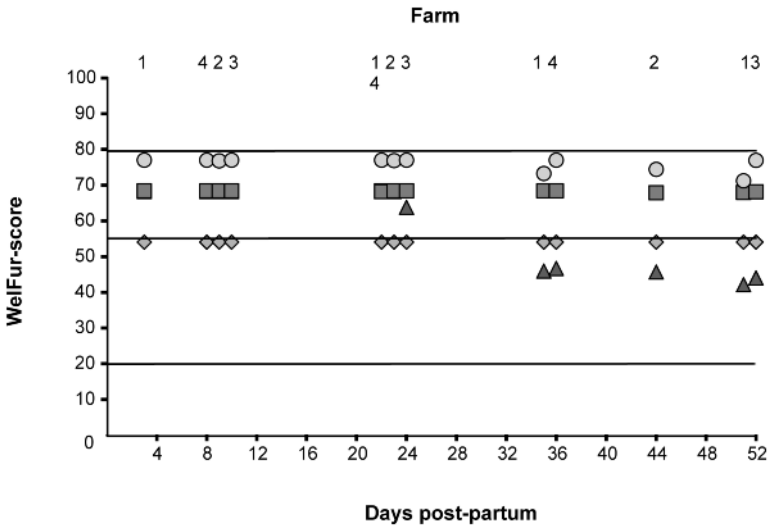
The prevalence of (a) very thin mink females (Body condition score = 1), (b) dirty nests, (c) cages with injured animals and (d) cages with animals with diarrhoea (including sticky kits) in the lactation period, at different days post-partum on four farms. Approximately 120 dams with litters were observed per farm. The lines indicate where the prevalence appears to change. Farm 1 = ■, farm 2 = ▲, farm 3 = ♦ and farm 4 = ×.

Figure 2



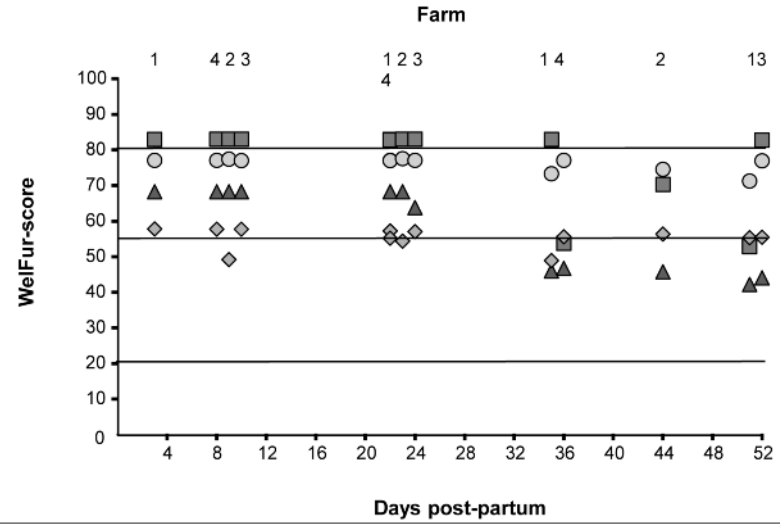
WelFur-Mink score for the criterion of 'Absence of prolonged hunger' = ▲, 'Comfort around resting' = ♦, 'Absence of injuries' = × and 'Absence of disease' = ■ in relation to date of assessment (Mononen *et al* 2012).
Each dot represents the criterion score for one farm, except average kits age 22 which represents criterion score from two farms with identical score values. WelFur score 100 is the best score indicating high welfare, and score 0 is the lowest.

Figure 3



Estimates of WelFur-scores of the four principles of welfare using average farm values except for the four welfare measurements under investigation: 'Body condition score' (BCS), 'Dirty nests', 'Injuries' and 'Diarrhoea including sticky kits'. The dark lines indicate the thresholds for the overall classification of mink farms. Every average day post-partum represents score values for one farm. WelFur score 100 is the best score indicating high welfare, and score 0 is the lowest. The principle of welfare: 'Good feeding' = ▲, 'Good housing' = ■, 'Good health' = ○ and 'Appropriate behaviour' = ♦.

Figure 4



Estimates of WelFur-scores of the four principles of welfare, using actual values for each farm for all welfare measurements. Every average day post-partum represents score values for one farm, based on the actual values of all measurements. WelFur score 100 is the best score indicating high welfare, and score 0 is the lowest. The dark lines indicate the thresholds for the overall classification of mink farms. The principle of welfare: 'Good feeding' = ▲, 'Good housing' = ■, 'Good health' = ○ and 'Appropriate behaviour' = ♦.

https://doi.org/10.7120/09627286.24.2.193 Published online by Cambridge University Press

drop in the calculated welfare score at the criteria level, as well as at the principal level.

When the kits are about four weeks old, all farmers in this investigation feed the mink on the lid of the nest-box to ensure access to food for the kits. The risk of dirty nest-box resting areas is confirmed in this study, where we found significant effect of the kits' age on the frequency of dirty nests. As the frequency of dirty nests is only one of four recorded resting qualities of the nest-box, and with the measurement 'Access to a nest-box' also contributing to the criterion 'Comfort around resting', the effect on the criterion score was low, even though it was significant.

We found that the frequency of injuries was significantly affected by the average age of the kit, but did not change the welfare score of the criterion 'Absence of injuries' from 35 days of age. A change in the frequency of injuries was expected. One of the farms visited at day 44 pp had significantly lower criterion score than the farms visited later in the lactation period, at day 51 and 52 pp. If the kits start fighting and the farmer observes injuries, the injured kits will be treated, moved or euthanised. Furthermore, the farmer may divide the litter into one group with the dam, and one group with the rest of the kits. Separating big litters will reduce the fighting and the amount of injuries (Clausen & Larsen 2012). Fighting amongst kits decreases after the kits have learned to drink around six weeks of age (Brink & Jeppesen 2005). However, as the three last visits were to three different farms, we cannot conclude if the difference in injuries after day 36 pp is a difference between the farms or a general difference with days pp. Therefore, specific investigations into the development in injuries during late lactation in mink will be needed to clarify this.

We found a significant effect of days pp on the prevalence of diarrhoea due to diarrhoea on one of the farms from 35 days pp. This change in prevalence of diarrhoea with age did not lead to any significant change in the score for the criterion 'Absence of disease'. Diarrhoea is one of four measurements that form the criterion 'Absence of disease', and the change in prevalence of diarrhoea would have to be larger in order to make a significant change at criteria level.

The criterion 'Absence of prolonged hunger' affects the principle score 'Good feeding', which is the principle with the lowest score value. The principle of 'Good health' did not vary systematically with days pp despite the variation in the measurement 'Injuries'. This is partly because the incidence was low and partly because 'Injuries' is only one of eight measurements included in the three criteria that constitute the principle.

In addition to the four measurements investigated in the present study, lack of bedding material late in the lactation period also had an influence on the score values. When the kits are fed on the lid of the nest-box from four weeks pp, the nest-box cannot be covered with bedding material to keep the nest-box warm. This reduces the welfare score for 'Nest-box material and bedding material' in WelFur. At the beginning of the nursing period, the need for bedding material is crucial for nest building to keep the kits warm; however, the importance decreases with the kits' age. At the end of the nursing period, the kits have grown quite big, have gained the ability to maintain their body temperature, will to some extent keep each other warm in the nest-box, and the average ambient temperature has increased. The kits are, therefore, less sensitive to cold and draught when fed on the lid of the nest-box, and the risk of cold is lower. It can therefore be argued that lack of bedding material after four weeks pp has less influence on the welfare of the mink, and that it should not affect the overall score significantly. However, according to the present WelFur-Mink protocol, lack of bedding material increases the risk that the total number and magnitude of changes in late lactation could, in some cases, be sufficient to change the welfare score at the principal level or the overall category of welfare.

Ordinarily, the dams will lose bodyweight during lactation due to the high milk production and mobilisation of body fat reserves mainly after four weeks of lactation. In this period, very thin dams usually have sufficient feed but are unable to sustain the energy requirement for lactation without mobilising too much of their body reserves. This is a welfare problem for the actual animal, although the term 'Prolonged hunger' may seem an inaccurate description. It is important that the dam is in ideal condition for sustaining lactation without mobilising too much body reserves towards the end of lactation. This ability could be included in the breeding strategy.

Based on previous studies in the WelFur project, we knew that repeated data collection from four farms, with 120 dams and litters per farm, would be possible for practical reasons, and that this sample would be enough to show the overall picture of how the different WelFur score values and classifications change with the kits' age. As some of the measurements occurred very seldomly, a larger sample size would, however, have been preferable.

Implications for the assessment of animal welfare using the WelFur-Mink protocol

Estimation of the overall WelFur classification shows that no major changes in the welfare assessment are observed in the observation period. Consequently, there is no need for concern regarding the overall reliability of the assessment protocol developed to be robust and, as far as possible, independent of changes in the conditions during observation, such as observer identity, weather conditions, time of day and also date of assessment within the time window defined. However, the observed change in the four measurements we focused on, as well as in other measurements, indicates that changes in the overall WelFur classification could occur if these or other measures had changed a little more for the better or worse. Actually, such changes do happen when a 5% indifference threshold is applied to the principle score values before estimating the overall classification. This is normal procedure in Welfare Quality® to account for the uncertainty of the assessment. This will lead to a change in the classification from 'Best current practice'

to 'Good current practice' at the end of the lactation period for three of the four farms. If the assessment is to be fully independent of the day of assessment post-partum, it is therefore necessary to consider ways to handle the difference between assessment in the first and last part of the time window for all, or some, of the measurements. One option could be to limit the time window for welfare assessment to June (approximately 28 days pp till weaning). This would ensure that the main welfare risks can be assessed in a more reliable and robust manner. This would, however, drastically limit the feasibility of the WelFur-Mink protocol because the number of assessors needed to carry out the assessments would double and no longer correspond to the numbers needed for the other two annual assessments. Alternatively, a correction factor might be developed to correct for the date of assessment, especially regarding the dams' body condition. There might be similar challenges in the other two production periods, with increasing risk of lower WelFur-score towards the end of the assessment periods. If this is documented, another option could therefore be to stratify the visits so that all the farms have one visit in the beginning of an assessment period, one in the middle and one at the end of a period. If such options are not possible, then the acceptable variation in overall classification must be discussed in more detail in relation to the reliability of the protocol. This discussion should also consider the alternative of not including the nursing period in future WelFur assessment protocols.

Animal welfare implications

Our findings further contribute towards improving the overall reliability of the welfare assessment procedure of mink farms using the assessment system, WelFur, in the lactation period. WelFur assessment of mink farms can reveal to farmers challenges regarding the welfare of their mink and where this may be improved via procedural changes. Knowing the effect of the day of assessment post-partum will allow the mink farmer and his advisors to interpret the results correctly, and not disregard risk factors that were not prevalent on the day of assessment.

Conclusion

Our hypothesis that the body condition of the mink dam, the frequency of dirty nests, frequency of injuries and frequency of diarrhoea change significantly with the day post-partum within the period from parturition to weaning is shown to be true and, therefore, the WelFur score on criteria level, depends on the date of assessment. Estimation of a WelFur score per principle also indicates a change with the date of assessment. The overall category did, however, not change with days pp. Further analyses are needed to evaluate the need for reducing the time window for assessment, stratify the visits between the three periods or development of a valid correction factor, so that this important period can be maintained in the general WelFur assessment of mink farms.

Acknowledgements

This study was financed by Aarhus University and European Fur Breeders Association. We thank Bente Krogh Hansen and Maria Sylvest Blæsbjerg from Kopenhagen Fur, and Steffen Werner Hansen and Jens Malmkvist from Aarhus University, Department of Animal Science for contributing with collecting data on the mink farms; Rodrigo Labouriau, Aarhus University, Department of Molecular Biology and Genetics, for statistical consultation; the farmers for their contribution with information and kindly letting us into their farm.

References

Bates D, Maechler M, Bolker B and Walker S 2014 *lme4: Linear mixed-effects models using Eigen and S4. R package version 1.0-6.* http://CRAN.R-project.org/package=lme4

Botreau R, Gaborit M and Veissier I 2012 Applying Welfare Quality strategy to design a welfare assessment tool for foxes and mink farms. *Scientifur 36*: 460-468

Brink AL and Jeppesen LL 2005 Behaviour of mink kits and dams (*Mustela vison*) in the lactation period. *Canadian Journal of Animal Science 85*: 7-12. http://dx.doi.org/10.4141/A04-028

Clausen TN and Dietz HH 2000 Mastitis in the lactating mink female (*Mustela vison S.*) and the development of 'greasy kits'. *Acta Veterinaria Scandinavica 41*: 243-247

Clausen TN and Larsen PF 2012 Impact of weaning age on kit performance. *Scientifur 36*: 336-340

Davidson AC and Hinkley DV 1997 *Bootstrap Methods and their Application*. Cambridge University Press: Cambridge, UK. http://dx.doi.org/10.1017/CBO9780511802843

Englund L, Chriql M, Dietz HH and Hedlund KO 2002 Astrovirus epidemiologically linked to pre-weaning diarrhoea in mink. *Veterinary Microbiology 85*: 1. http://dx.doi.org/10.1016 /S0378-1135(01)00472-2

Faraway JJ 2006 *Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models*. Chapman & Hall/CRC: Boca Raton, FL, USA

Hansen BK 1997 Mink kit growth performance in the suckling period: I. Environmental factors affecting body size of kits. *Acta Agriculturae Scandinavica - Section A: Animal Science 47*: 82-90. http://dx.doi.org/10.1080/09064709709362374

Hansen BK 1999 Mink dam weight changes during the lactation period - II. Energy consumption and plasma concentrations of thyroid hormones and insulin. *Acta Agriculturae Scandinavica Section A-Animal Science 49*: 65-72. http://dx.doi.org/10.1080/09064709942 4114

Møller SH 1993 Minktævers og hvalpes ædeadfærd i relation til foderets placering i dieperioden NJF Utredning/Rapport nr 92. *NJF Seminar nr 239*. 22-24 September 1993, Oslo, Norway. [Title translation: Eating behaviour of mink females and kits in relation to the placement of the feed in the nursing period]

Møller SH, Hansen SW and Sørensen JT 2003 Assessing animal welfare in a strictly synchronous production system: the mink case. *Animal Welfare 12*: 699-703

https://doi.org/10.7120/09627286.24.2.193 Published online by Cambridge University Press

Møller SH and Lohi O 1989 *Drikkeadfærd og vægtudvikling hos mink med drypvandingssystem*. Dansk Pelsdyravlerforening: Faglig årsberetning, Denmark. [Title translation: Drinking behaviour and weight gain in mink with a drip-watering system]

Mononen J, Møller SH, Hansen SW, Hovland AL, Koistinen T, Lidfors L, Malmkvist J, Vinke CM and Ahola L 2012 The development of on-farm welfare assessment protocols for foxes and mink: the WelFur project. *Animal Welfare 21*: 363-371. http://dx.doi.org/10.7120/09627286.21.3.363

R Core Team 2014 *R: A language and environment for statistical computing*. R Foundation for Statistical Computing: Vienna, Austria. http://www.R-project.org

Rousing T, Møller SH and Hansen SW 2012 WelFur-mink: on-farm welfare assessment of mink (*Neovison vison*): effect of sample size on animal based measures. *Scientifur 36*: 420-425

WelFur 2013 *Welfare assessment protocol for mink*. European Fur Breeders' Association. www.efba.eu