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Running in a running wheel substitutes for stereotypies in mink (*Mustela vison*) but does it improve their welfare?

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ABSTRACT

This experiment investigated whether access to a running wheel affects the development of stereotypies during restricted feeding and whether selection for high or low levels of stereotypy affects the use of the running wheel. Sixty-two female mink kept in standard cages and selected for high or low levels of stereotypy were used. Thirty of these females had access to a running wheel whereas thirty-two female mink had no access to running wheels. The number of turns of the running wheel, behaviour, feed consumption, body weight and the concentration of plasma cortisol were measured during the winter period. Mink with access to a running wheel did not perform stereotypic behaviour and mink selected for a high level of stereotypies had more turns in the running wheel than mink selected for low levels of stereotypies. Mink with access to a running wheel used the running wheel for the same amount of time as mink without access to a running wheel performed stereotypies, and the daily rhythms of the two types of activity were identical with a peak around feeding time. No other behavioural differences between stereotyping and non-stereotyping mink were found and neither was there any difference in plasma cortisol. Due to the similarities between stereotypies and wheel running it is not possible unambiguously to conclude that access to a running wheel improve the welfare of the mink.

1. Introduction

It has been demonstrated that when given the opportunity, mink (Hansen and Jensen, 2006) and many other animal species are willing to run in a running wheel (reviewed in Sherwin, 1998). The animals are spontaneous, intense and persistent in their use of the running wheel, which has given rise to the assumption that the animals enjoy this activity. It has been suggested that the use of a running wheel may reflect, e.g. the general activity of the animals, their desire to perform exploratory behaviour, migration and stereotypy. However, a consensus of why many animal species appear to enjoy running in a running wheel has not yet been found, but certain characteristics appear to apply in general: (1) when given access to the wheel, the animals immediately make use of it; (2) they are strongly motivated to use the running wheel; (3) they use the running wheel for a considerable part of their active time. Furthermore, the animals' use of the running wheel may be affected by various environmental factors indicating that the use is elastic (Sherwin, 1998).

The activity of the animals in the running wheel can be described as a repetitive and monotonous pattern of movement without any obvious purpose, and thus the description does not differ from the definition of stereotypy (Mason, 1991). However, the development of the two patterns of movement differs. Stereotypies develop gradually over time, whereas the animals immediately make use of the running wheel when given access to it. Stereotypic behaviour is an abnormal behaviour which is common in captive animals, but seems to be absent in the wild. Stereotypic behaviour is often assumed to indicate reduced

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welfare (Broom and Johnson, 1993; Lawrence and Rushen, 1993). Consequently, environmental enrichments that reduce stereotypic behaviour may in general improve the welfare of the animals. However, the relation between stereotypies and welfare can be obscured by several factors. In their paper, Mason and Latham (2004) discussed four important factors that affect the implication of stereotypy as a welfare indicator and emphasize three main implications for use of stereotypy in welfare assessment. "First, systems that lead to stereotypy are indeed likely to be worse than systems that do not. Second, simple stereotypy score should never be used as a sole index of welfare. Third, it is clearly vital not to overlook the potential problems of animal with low or absent stereotypies".

Stereotypies in mink can have many different forms; pacing along the cage sidewall, complex movement patterns in the cage including somersaults, rolling, jumping up and down or stationary forms were the body is lifted vertical, head-twirling or licking on the wire mesh. About 80% of the stereotypies in mink are in the form of pacing. In the wild, mink searching for prey move to and from across small areas (Gerell, 1969). In the standard cage environment the stereotypic pacing movement patterns are primarily observed during the winter period, when the selected breeding females are slimmed by restricted feeding in order to prepare them for mating and reproduction (Damgaard et al., 2004).

Stereotypies as well as activities in a running wheel can be changed through genetic selection (Hansen et al., 2006; Lightfoot et al., 2004). Hansen et al. (2006) found a heritability of 0.26 for stereotypies in mink based on selection for or against stereotypic behaviour during four generations, and the difference in stereotypy between the two lines was significant. However, despite the strong genetic factor, the percentage of stereotyping mink decreased over generations in both lines, possibly due to improved feeding routines (Jeppesen, 2007). Many investigations have shown that the feeding routines affect the occurrence of stereotypic behaviour in mink (Damgaard et al., 2004). In mink there is a negative genetic correlation between body weight and stereotypies and a positive genetic correlation between body weight and staying in the nest box (Hansen et al., 2008). However, the heritability for mink staying in the nest box was just as high as the heritability for stereotypy (Hansen et al., 2008). Thus, it is possible that selection for stereotypies in mink is the same as selection for a generally high level of activity which may be further affected by the feeding routine. Moreover, it is possible that a high level of activity in a limited area will enhance the development of patterns of movement that appear stereotypical. If this assumption is correct, we would expect that giving mink access to a running wheel would prevent the development of stereotypic behaviour because running in a running wheel is an activity of high priority that mink are willing to work to get access to (Hansen and Jensen, 2006). Furthermore, mink selected for a high level of stereotypy will be expected to use the running wheel more than mink selected for a low level of stereotypy. If running in a running wheel substitutes for stereotypy, it is possibly that the two patterns of activity share a common motivation and therefore we compared the daily rhythm of the two activities and the concentration of plasma cortisol in mink with access to a running wheel and mink performing stereotypies.

2. Materials and methods

2.1. Animals and housing

The experiment was performed from November 2004 to March 2005. Thirty female mink were housed permanently in standard cages (W: 30 cm × H: 45 cm × L: 91 cm) with access to a running wheel (W: 28 cm × D: 53 cm) via an opening in the back wall of the cage (Plates 1 and 2). In addition thirty-two female mink were housed permanently in standard cages but without access to a running wheel. The cages with and without a running wheel alternated.

Half of the female mink with and without access to a running wheel had been selected for high levels of stereotypies (line HS) and the other half of the females had been selected for low levels of stereotypies (line LS; Jeppesen, 2007). From weaning in July and until November each female had been housed pair wise with a male, but the males were pelted in November and the females remained

Plates 1 and 2. Access to the running wheel via the back wall of the standard cage (1) and the running wheel fitted on the back wall of the cage (2).

thereafter solitary in the cages. All the mink had permanent access to a wooden nest box (W: 28 cm × H: 20 cm × L: 23 cm) covered with straw. From the top of the nest box the mink were able to draw straw through the wire mesh roof and into the nest box.

2.2. Feeding

The mink had free access to water from a drinking nipple and the mink were fed with standard mink feed from the local feed kitchen. During the entire growth period, the amount of feed was adjusted on the basis of the feed leftovers found on top of the cage 2 h before feeding. If all the feed had been eaten, the amount of feed was increased by 20 g per cage, and if there was more feed left than they could possibly eat before being fed again, the amount of feed was reduced by 20 g per cage. Thus, the mink were fed *ad libitum* during the entire growth period.

According to previous standard farm procedure, in the beginning of January the amount of feed was reduced to 80% of *ad libitum* consumption in order to slim the mink before flushing. In the beginning of February some of the females were still rather fat, and therefore from 4 to 25 February the allocation of feed was adjusted on an individual basis in order to bring the females in a more adequate condition. From 26 February all females were fed *ad libitum*.

The amount of feed allocated on an individual basis was recorded daily during weeks 2, 3, 4, 6, 7 and 8 and the body weight of the females was recorded on 17 November, 2–3 February, 23–24 February and 3–4 March.

2.3. Behaviour

The activity (number of turns) of the mink in the running wheel was continuously recorded, and the number of turns per hour per day per animal were automatically recorded on a computer during three periods: (1) 31 January–6 February; (2) 18 February–25 February; (3) 28 February–3 March. Furthermore, the behaviour of each female was recorded once as 24-h video recordings in the period 18 February to 23 February. The video recordings were observed, and the behaviour performed by the females was registered every 10 min as; in nest box, in running wheel, unspecified activity, feeding, inactivity, and stereotypies. Each behavioural element was calculated as percentage of total behavioural observations. Stereotypic behaviour was defined as repetitive, unvarying and apparently functionless behaviour patterns (Ödberg, 1978; Mason, 1991). In this experiment repetitive was defined as at least five repetitions. Due to a power cut, only 54 of the 62 females were recorded on video (with running wheel: LS = 12, HS = 14; without running wheel: LS = 13, HS = 15).

2.4. Blood parameters

Blood samples were collected on 2–3 February, 23–24 February, and 3–4 March for analysis of plasma cortisol. The blood samples were taken from vena cephalica antebrachii after a period of fasting of 4–12 h. Whole blood was collected in plastic tubes with added K-EDTA, stored on ice and centrifuged within 1 h at 2000 × *g* for 20 min at 4 °C. The plasma was separated from the blood cells and stored at −20 °C until analysis for cortisol. The plasma concentration of cortisol was determined by solid-phase radio immuno assay (Diagnostic Products Corporation, Los Angeles, USA) according to the manufacturer's instructions. The minimum amount of cortisol detectable was 5.5 nmol/l. Intra-assay coefficients of variation were estimated as 7.1%, 5.6% and 4.6%, inter-assay coefficients of variation as 2.7%, 3.6% and 5.5% at 71.0 nmol/l, 160.0 nmol/l and 333.6 nmol/l of plasma cortisol, respectively.

2.5. Statistical methods

The differences in the measured parameters in relation to selection line, access to running wheel, and time of year were calculated by means of the Proc Mixed procedure from SAS (SAS Institute Inc., 1996). The model used for body weight, allocation of feed, and plasma cortisol included the fixed effects of stereotypy level (selection line), running wheel and time of year, and interactions between stereotypy level and running wheel and between running wheel and time of year. Furthermore, in the model for the plasma cortisol concentration activity (frequency of stereotypies, running wheel activity), body weight, body weight loss and allocation of feed were included as co-variates as well as significant interactions between fixed effects and co-variates.

In the model regarding wheel running activity (mean number of turns per hour) the effects of selection line, hours (1–24 h), and period (January 31–February 6; February 18–25; February 28–March 2) were included. In the models regarding different behavioural elements from the video recordings the fixed effects of selection line and running wheel and interaction between these effects were included.

The percentages of the different behavioural elements (average per 24 h) were analysed using the Proc Genmod procedure from SAS. In the model regarding the behavioural elements unspecific activity in the cage, in the nest box and feeding, the effects of selection line, running wheel and interaction between these effects were included. For the stereotypic behaviour and observations of mink in the running wheel only the effect of selection line was included because only mink without access to a running wheel performed stereotypies and only mink with access to a running wheel performed running activity.

The circadian rhythms of the behavioural elements and of the activity in the running wheel were estimated as the mean development per 24 h for the females in the different treatments groups. The estimations were based on the estimated values for the fixed effects in a daily three-faced mixed model. Consequently, the estimation in every hour for each treatment group has a single value.

A spearman's rank correlation test was used to test for correlations between stereotypic behaviour, body weight, number of turns in the running wheel, amount of feed and the level of plasma cortisol.

Table 1
Percentage of the different behavioural elements observed every 10 min during 24 h video-recording sessions from18 February to 23 February. Values are means ± S.D.

	Selection line LS (low stereotypy)		Selection line HS (high stereotypy)	
	Without running wheel n = 13	With running wheel n = 12	Without running wheel n = 15	With running wheel n = 14
Unspecified activity	13.1 ± 12.9	8.2 ± 7.0	10.9 ± 13.8	10.5 ± 9.3
In nest box	71.7 ± 12.6	75.1 ± 11.1	68.8 ± 18.6	69.2 ± 10.6
Passive	0.1 ± 0.3	0.0 ± 0.0	0.0 ± 0.2	0.0 ± 0.0
Feeding	3.0 ± 1.2	2.3 ± 1.7	2.4 ± 1.9	3.1 ± 3.0
Stereotypies	12.0 ± 8.2	0.0 ± 0.0	17.1 ± 11.0	0.0 ± 0.0
In running wheel	–	14.4 ± 9.7	–	17.1 ± 8.2

3. Results

3.1. Behaviour

All the 30 females with access to a running wheel used the wheel, but none of the 26 females observed on video performed stereotypic behaviour. However, stereotypic behaviour was observed on video in 24 out of the 28 females without access to a running wheel, and significantly more in line HS than in line LS (X_1 = 21.84; $P < 0.0001$; Table 1). Within selection line HS the percentage occurrence of stereotypies in females without access to a running wheel was not different from the percentage use of the running wheel in females with access to the wheel (HS: X_1 = 1.13; P = 0.29). However, in selection line LS the mink tended to use the running wheel more than they performed stereotypic behaviour (LS: X_1 = 3.64; P = 0.056). There was no difference between selection lines in their use of the running wheels (X_1 = 2.56; P = 0.11). Additionally, the females in line LS used the nest box significantly more than the females in line HS (X_1 = 17.54; $P < 0.0001$). The females in line LS without access to a running wheel spent significantly more time in unspecified activities than the LS females with access to running wheel (X_1 = 15.35; $P < 0.0001$), whereas access to the running wheel did not affect the unspecified activity in line HS (X_1 = 0.11; P = 0.74). No differences in passive behaviour or feeding behaviour were found between females with and without access to a running wheel nor between females selected for high and low levels of stereotypies.

The daily rhythm of being in nest box, wheel running and stereotypies is shown in Fig. 1. The figure demonstrates that the daily rhythm did not differ between selection lines or between females with or without access to a running wheel as regards to in nest box (Line: $F_{1,48.1}$ = 3.17; P = 0.081; Wheel: $F_{1,48.1}$ = 0.49; P = 0.49). The daily rhythm of stereotypies was not significantly different from the daily rhythm of wheel running activity ($F_{1,51.8}$ = 0.00; P = 0.96) and the daily rhythm of these two forms of activity did not differ between lines ($F_{1,51.7}$ = 2.96; P = 0.091). No interactions between selection lines and access to wheel were found.

3.2. Activity in the running wheel

In Fig. 2a, b, and c the activity in the running wheel of the females is shown for the three periods (1: 31 January–6 February, 2: 18 February–25 February, and 3: 28 February–4 March). The number of turns was significantly affected by period ($F_{2,2182}$ = 44.07; P = 0.0001), selection line ($F_{2,2182}$ = 79.88; P = 0.0001) and time of day ($F_{23,2182}$ = 53.19; P = 0.0001). There was no interaction between selection lines and periods ($F_{2,2182}$ = 1.36; P = 0.26).

The females selected for a high level of stereotypy had more turns in the running wheel than the females selected for a low level of stereotypies, regardless of the period. At the end of the slimming period (period 2), the females performed more turns in the running wheel than in the beginning of February (period 1; P = 0.001) and more than in the beginning of March (period 3; P = 0.0001). The females also had more turns in the running wheel in period 1 than in period 3 (P = 0.0001). The number of turns in the running wheel increased from around 6.00 h and peaked immediately before feeding. The mink were fed between 10.00 and 11.00 h, at which time the number of turns in the running wheel decreased markedly. In periods 1 and 2, a slight increase was observed around sunset (16.45–17.30 h) and again around midnight. These minor increases in activity were reduced in period 3, where the mink were once again fed *ad libitum*.

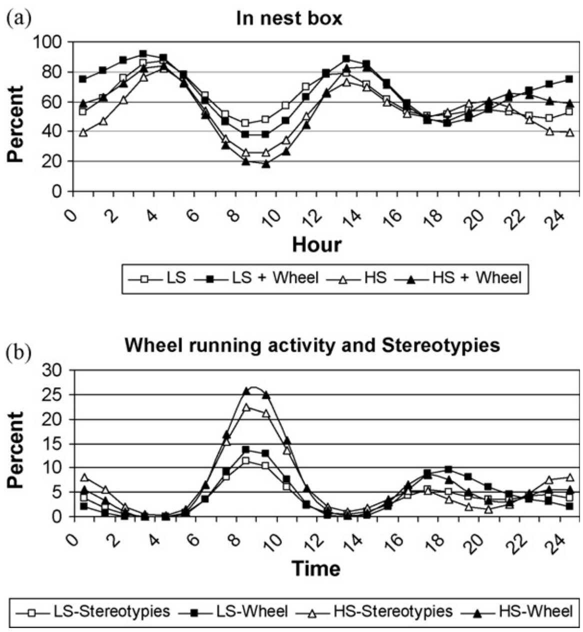

Fig. 1. Mean daily rhythm of being in the nest box (a) and of wheel running activity and stereotypies (b) in females from the two selection lines (LS, HS) with (+ Wheel) and without access to a running wheel.

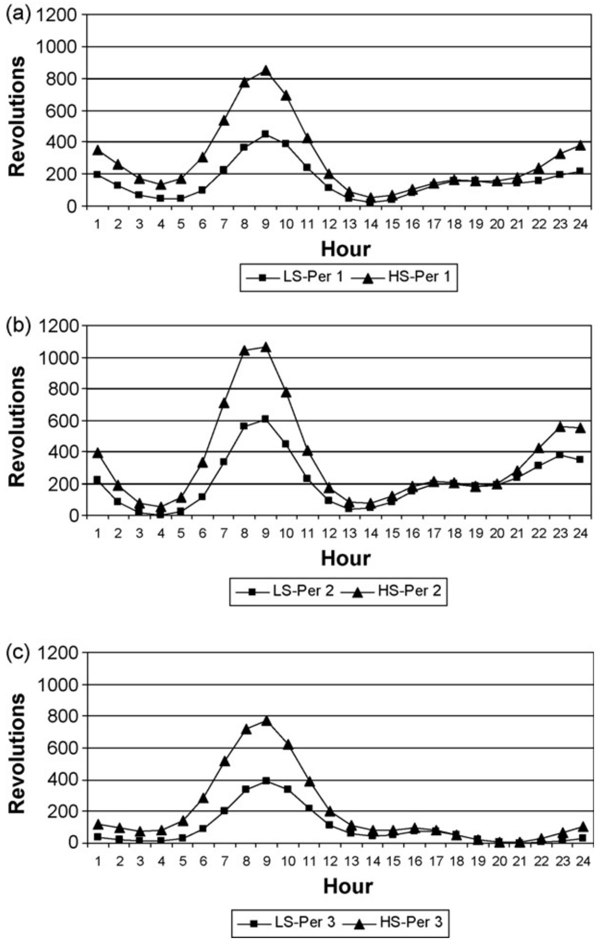

Fig. 2. Mean number of turns in the running wheel per hour during three periods (a) Period 1: 31 January–6 February, (b) Period 2: 18 February–25 February, (c) Period 3: 28 February–3 March in the two selection lines LS and HS.

3.3. Growth performance

As a result of the change in the amount of feed allocated to the females, their body weight changed significantly during the period from 17 November to 3 March ($F_{3,136}$ = 68.61; P = 0.0001). Furthermore, the change in body weight was affected by selection line, and whether or not they had access to a running wheel ($F_{1,235}$ = 13.84; P = 0.0002; Fig. 3). When having access to a running wheel, there was no difference in the body weight between selections lines ($t_{24,6}$ = 1.02; P = 0.32). However, when the mink did not have access to a running wheel, the females selected for low levels of stereotypies weighed significantly more than the females selected for high levels of stereotypies ($t_{24,7}$ = 2.41; $P < 0.024$). Females selected for low levels of stereotypies weighed less when they had access to a running wheel than when they had not ($t_{23,5}$ = 5.90; P = 0.001), whereas the access to a running wheel did not affect the weight of females selected for high levels of stereotypies ($t_{23,5}$ = 0.45; P = 0.66).

The body weight correlated negatively with the frequency of observed stereotypies ($r = -0.51$; $P < 0.01$) and the number of turns in the running wheel ($r = -0.66$; $P < 0.01$).

3.4. Allocation of feed

Significantly more feed was allocated to the females with access to a running wheel than the females without access to a running wheel ($F_{1,89}$ = 95.59; P = 0.0001; Fig. 4). The difference in the amount of feed between females selected for high and low levels of stereotypies was not significant, but the females selected for high levels of stereotypies tended to have more feed allocated than females selected for low levels of stereotypies ($F_{1,18}$ = 3.58; P = 0.074). There was no interaction between the selection lines and access to running wheel ($F_{1,89}$ = 0.25; P = 0.62).

There was no significant correlation between amount of feed and stereotypies, but a positive correlation between

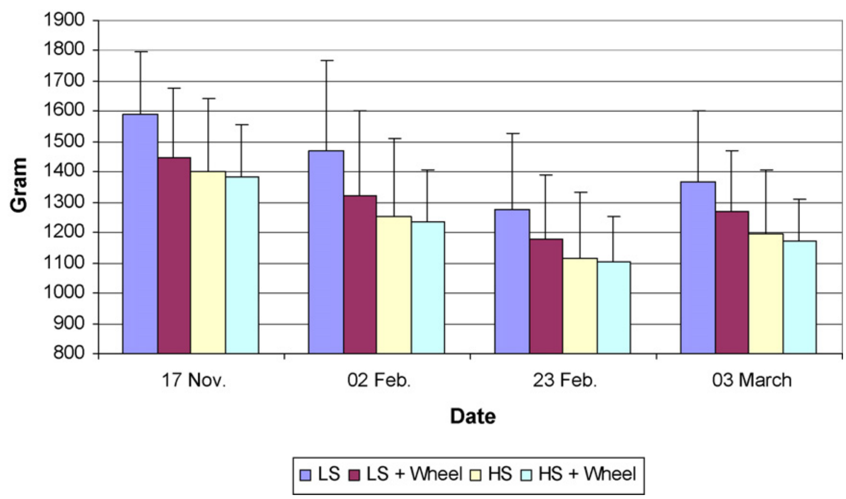

Fig. 3. Development in the body weight of females selected for low levels of stereotypies (LS) and high levels of stereotypies (HS) and with (+ Wheel) and without access to a running wheel during the period from 17 November to 3 March. Values are least square means and S.E.M.

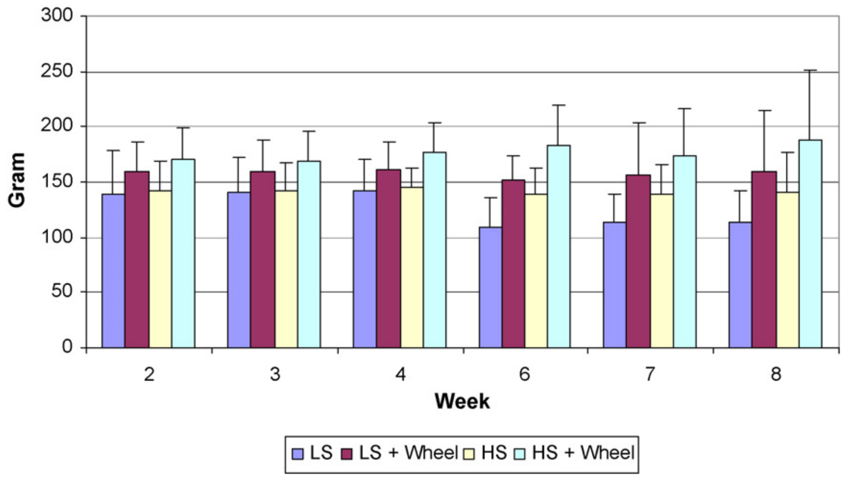

Fig. 4. Mean amount of feed per day (grams/female) calculated per week for the two selection lines (LS, HS) with (+ Wheel) and without access to a running wheel in weeks 2, 3, 4, 6, 7 and 8. Values are least square means and S.E.M.

amount of feed and number of turns in the running wheel was found ($r = 0.61$; $P = 0.001$).

3.5. Plasma cortisol

The frequency of stereotypies or wheel running as percentage of observations had a significant effect on the level of plasma cortisol ($F_{1,50} = 4.0$; $P = 0.051$) but there was no effect of selection line ($F_{1,50} = 1.79$; $P = 0.19$) or access to wheel ($F_{1,50} = 0.52$; $P = 0.47$) and there was no interaction between selection line and access to wheel ($F_{1,50} = 0.36$; $P = 0.5539$) or between these treatment factors and activity (frequency of stereotypies or wheel running) (Table 2).

Furthermore, the body weight loss in February ($F_{1,49} = 3.43$; $P = 0.070$), the actual body weight ($F_{1,49} = 4.07$; $P = 0.049$) and amount of feed offered ($F_{1,50} = 3.31$; $P = 0.074$) had effect on the level of cortisol, but only the effect of body weight was significant. There were no interactions between the treatment factors selection line and access to running wheel and body weight, body weight loss and amount of feed offered, respectively. These results indicate that the effects of activity and body weight on plasma cortisol did not differ between mink with or without access to running wheel or between selection lines.

When the lowest body weight was measured (23–24 February), there was a significant negative correlation between the level of cortisol and body weight in females with and without access to a running wheel ($r = -0.31$; $P < 0.05$). However, the correlation was not significant 2–3 February and 3–4 March.

Table 2
Concentration of plasma cortisol in females with and without access to a running wheel at samplings on 2–3 February, 23–24 February, and 3–4 March. Values are means ± S.D.

	February 2–3	February 23–24	March 3–4
Cortisol (nmol/l)			
Access to running wheel $n = 30$	34.54 ± 21.16	40.86 ± 32.52	43.08 ± 39.14
Without running wheel $n = 32$	33.53 ± 22.25	41.28 ± 28.02	43.05 ± 36.55

4. Discussion

Access to a running wheel appears to prevent the development of stereotypies in the female mink and the same effect has previously been found in mice (Brandt and Kavanau, 1965). Based on the occurrence of stereotypy as a sole index of welfare the result indicates that access to a running wheel may improve the welfare of the mink.

All the mink used the running wheels and it has previously been shown that mink are willing to work for access to a running wheel (Hansen and Jensen, 2006) which indicates that the mink are highly motivated to perform wheel running. High levels of motivation for performing a particular behaviour and development of abnormal behaviour if the performance of the highly motivated behaviour is prevented indicate a behavioural need (Vinke et al., 2008). Even though it may appear a little odd to talk about a behavioural need for an unnatural behaviour as wheel running, it is possible that wheel running activity do have reinforcing qualities which may substitute for highly motivated natural behaviour which the mink is not able to perform in the present situation. However, a possible welfare improving effect of the running wheel was not confirmed by other behavioural differences between mink with and without access to running wheel neither were there differences in their levels of plasma cortisol.

A higher level of total and free corticosterone during the active period (dark phase) has been found in mice selected for high wheel running activity compared to control mice (Malisch et al., 2008).

Furthermore, selection for high wheel running activity also increased the activity when the selected mice were kept in standard housing cages in the absence of running wheels.

In our experiment we found that females selected for high levels of stereotypies (line HS) had more turns in the running wheel than females selected for low levels of stereotypies (line LS). The number of turns in the running wheel peaked at the end of the slimming period and was lowest when the mink were fed *ad libitum* in the beginning of March. This difference in wheel running activity between HS and LS mink could not be confirmed by the video recordings of the minks' use of the running wheel in the last part of the slimming period. However, the video recording of mink without access to running wheel showed more stereotypy in line HS than in line LS. The increased frequencies of stereotypy and wheel running activity in line HS were not reflected in a higher level of plasma cortisol in line HS than in line LS, but the frequencies of stereotypy or wheel running activity had an almost significant effect on the level of plasma cortisol. The results confirm that restricted feeding increases stereotypy or wheel running activity irrespectively of the genetic potential for activity and that this increased activity increases the plasma cortisol level. However, the increased level of cortisol as a result of energy-demanding activity can only be related to extreme levels of activity (Lane, 2006). For some of the mink females with or without access to running wheel, this situation may prevail during the last part of the slimming period in that a negative correlation was found between body weight and level of cortisol and between body weight and stereotypy and number of turns in the running wheel, respectively. Furthermore, the body weight had a significant effect on the plasma cortisol level with the slimmest females having the highest plasma cortisol level. The results demonstrate that the slimmest females were the most active, and it is possible they were subjected to physiological stress.

The physiological stress level was not related to the presence or absence of the running wheel and it can be questioned whether wheel running is just another type of stereotypic behaviour.

Furthermore, the mechanisms behind stereotypic behaviour are poorly understood and it has been recommended not to use stereotypy as a sole index of welfare (Mason and Latham, 2004). Therefore, it can be questioned whether access to a running wheel actually improved the welfare of the mink during restricted feeding.

The running wheels were used mainly during the farmed mink's normal activity periods, which are in agreement with previous results regarding the daily activity rhythm of farmed mink (Hansen and Jensen, 2006; Hansen and Møller, 2008). The number of turns in the running wheel increased primarily up to feeding time and was at its highest when the feed restriction was strongest. The same effect of feeding time and feeding intensity on wheel running has been shown on rats (Richter, 1927; Gross, 1968). It was quite remarkable that the use of the running wheel corresponded to the occurrence of stereotypies in mink without access to a running wheel both in the occurrence and timing. The results indicate that wheel running activity as well as stereotypy in mink is closely related to the mink's normal activity rhythm and that strong feeding motivation enhances both types of activity. A positive correlation between stereotypies in carnivores kept in captivity and their minimum home range size had been shown (Clubb and Mason, 2003) and Clubb (2001) found that the distance travelled in the wild was correlated with the distance run in a wheel in wild caught caged carnivores, although this was based on a small sample size. The results indicate a possible common motivation behind the performance of both wheel running and stereotypy in mink.

Both stereotypy and wheel running can be defined as repetitive, unvarying and functionless (Ödberg, 1978; Mason, 1991). They are both characterized as abnormal behaviour (Mason, 1991; Sherwin, 1998).

Stereotypies in mink may have many different forms. None of the different forms of stereotypies were observed in mink with access to running wheel. Due to the increased exercise both types of activity decrease the level of body fat and probably increase the physiological condition but with the potential to be fatal (Altemus et al., 1993). They can both develop and persist in enriched environments (Würbel, 2006), and may be potentially rewarding (Würbel, 2006). The level of stereotypies and wheel running can be predicted by the home range size (Clubb, 2001) and both changed by genetic selection (Hansen et al., 2006; Lightfoot et al., 2004).

These similarities between stereotypy and wheel running and the finding that mink selected for high levels of stereotypy performed more wheel running than mink selected for low levels of stereotypy indicate that wheel running in the future may be used as a potential tool for investigating the motivation behind stereotypic behaviour.

It is assumed that stereotypies develop because the captive environment restrict natural behaviour or do not stimulate the mink to display their natural behaviour (Broom and Johnson, 1993). In our experiment all mink were kept in standard cages without any extra enrichment but it seems unlikely that the extension of the cage area (due to the running wheel) alone could prevent the occurrence of stereotypic behaviour. Previous experiments with doubling or quadrupling of the standard cage size did not reduce stereotypic behaviour in mink (Hansen, 1988; Hansen et al., 1994, 2007). It seems more likely that it is the actual wheel running activity in itself that prevent the development of stereotypies in mink. Not because wheel running is a natural behaviour but because wheel running possibly is self-reinforcing due to muscle stimulation and perhaps subject to a positive feedback loop (Sherwin, 1998) as when the mink perform natural appetitive feed searching behaviour. Do stereotypies in mink during restricted feeding have the same rewarding properties as wheel running?

In the present experiment all female mink were fed restrictively and were all highly motivated for feeding. A lower body weight and higher food consumption in mink with access to a running wheel indicate that running wheel activity is an even more energy demanding activity than stereotypy.

Access to a running wheel increase the daily travelling distance compared to the distance that would be covered during normal locomotion (Hogan and Roper, 1978) and during restricted feeding wheel running can be directly linked to loss of body weight, stomach lesion and, ultimately, death in laboratory rats (Altemus et al., 1993). Altemus et al. (1993) have suggested that repetitive, maladaptive behaviour may be a valid animal model of obsessive-compulsive disorder.

Sherwin (1998) suggests in his review, that wheel running may be maladaptive and abnormal in that it is performed as a direct consequence of the contrived nature of the wheel or laboratory environment and conclude, although wheel running may be an artefact of the wheel itself, it is self reinforcing and performed as a behaviour on it own right, rather than as a substitute or redirected behaviour.

Due to the similarities between stereotypies and wheel running and because the only difference between mink with and without access to running wheel was the occurrence of stereotypy it is not possible unambiguously to conclude that access to a running wheel improve the welfare of the mink in the present situation. However, increased activity in form of stereotypy or wheel running are related to increased feeding motivation and may be a useful tool for identification of food related problems and possible reduced welfare at farm level.

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