The status of the American mink (*Neovison vison*) in the Netherlands

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Abstract: The American mink (*Neovison vison*) is a north American mustelid that has been farmed for its fur in Europe since the 1920s. It has been feral in the Netherlands since 1958. This paper discusses its distribution, diet, the indications for reproduction, and whether feral animals are born in the wild or are escapees. The American mink mostly occurs in areas where many mink are kept in farms. The largest distance between an observation and the nearest farm was 45 km. Sixteen animals caught by muskrat control officers were dissected. The stomach content of the 16 animals revealed a diet of amphibians, birds and small mammals. The dissections gave no clues about reproduction: one of three males was sexually active, but none of the 13 females showed placental scars, a thickened uterus or signs of lactation. Only one observation of reproduction in the wild was received. Isotope analyses of teeth and nails indicate that the animals generally only stay feral for a short period of time before being caught. The ratios of carbon and nitrogen isotopes of the wild caught animals were very close to the isotope ratios of ten reference animals from a fur farm, except for one adult female, whose teeth isotope values were different from the farm animals and as such she seems to have remained in the wild for longer and was possibly born in the wild. In general however most animals are caught shortly after escaping and only remain in the wild for a short period of time. It seems that feral mink stem from constant escapes and that muskrat control removes these feral animals. Thus, the existence or development of a feral population in the Netherlands is unlikely, especially since it is planned to phase out mink farming by 2024.

Keywords: stable isotope analysis, mink farms, feral populations.

Introduction

The American mink is a mustelid that has been farmed for its fur in Europe since the 1920s. The species quickly became feral with the first escapees reported in Sweden. Today wild populations are established in Austria, the Baltic States, Belarus, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Norway, Poland, Portugal, Spain, Sweden and the UK (Bonesi & Palazon 2007). There have also been reports of feral animals from Hungary, Luxembourg, the Slovak Republic and Slovenia, but it remains unclear if these form reproducing populations. Feral animals have also been reported in Belgium but there is no viable population (Van Den Berge & De Pauw 2003, Van Den Berge & Gouwy 2009). American mink are an invasive species and can have a large impact on biodiversity (Bonesi & Palazon 2007). Although first sighted in the wild in the Netherlands in 1958 (Koenders 1958), it has been unclear what the ecology of the

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Dutch mink is, and if the animals originate from farms or if they reproduce in the wild and form populations. In the Netherlands, the species is farmed with a yearly turnover of 3.5 million pelts, and thus individuals (Nederlandse Federatie van Edelpelsdierhouders).

Stable isotope analysis of animal tissues can be used to study the trophic relations or the origin of diet items of these animals (Kelly 2000). The ratio of stable isotopes, for example between carbon atoms with 12 and 13 nuclei, varies between habitats, for example between sea and fresh water. In Denmark isotope ratios were used to determine the origin of mink living in the wild. Animals in fur farms are fed with food containing sea fish, giving them an isotope ratio that resembles salt-water, whilst feral animals feed on freshwater prey giving them a freshwater isotope ratio. Ratios in carbon and nitrogen in teeth, nails and hair can be used to distinguish between feral and farm animals, as the ratio shifts when animals escape and live in the wild (Hammershøj et al. 2004, Hammershøj et al. 2005). Nails and hair are renewed much more quickly than teeth so analysing the stable isotopes in nails or hair can indicate if an animal has changed its diet from marine sources to terrestrial/freshwater sources within the last two months, whilst teeth indicate the origin of the animal (Hammershøj et al. 2005).

The aim of this study is to explain the occurrence of feral American mink in the Netherlands. We investigate this by comparing the spatial distribution of American mink sightings to the locations of fur farms, and by using stable isotopes and post-mortem analysis to check if feral animals had lived in the wild for a long or short period of time and to see if any of the wild caught animals had reproduced.

Methods

Distribution, relation to fur farms

We map and describe observations of mink by civilians from the National Flora and Fauna Database (precision of location in 1, 100, or 1000 metres), by-catches from the National Coordination Centre for Muskrat Control (precision 5000 metres) and data on the number and location of farmed mink (Statistics Netherlands). The latter are only available at the municipal level so the interpretation of data was done on this scale. The most recent data available during the study was from the year 2004. For that reason, we used the distribution data from the decade preceding this date (1998-2008) and by-catch data from 2008. The relation between the number of animals farmed and caught or observed was tested in a subset of those municipalities where animals were kept, caught or observed, using Pearson's rho.

Post mortem study and isotope analyses

Mink carcasses were collected from muskrat control officers of the Water board (Waterschap) Peel en Maasvallei and through the network of volunteers of the Dutch Mammal Society. The condition, diet and reproductive status of each of the 16 collected animals were studied following a standard protocol for mink post mortems established by the institute of Alterra in Wageningen.

General characteristics

The following measurements were taken: length, tail length, weight and hind foot-length.

Condition

The physical condition of the animals was determined in three ways: (1) the amount of subcutaneous fat was estimated on a scale from 1 (little fat) to 8 (a lot of fat); (2) the amount of fat surrounding the kidneys was estimated, also on a scale from 1-8 and (3) the mesenterium was weighed. As the latter is partly dependent of the size of the animal,

this was indexed by dividing the weight of the mesenterium by the head-body length.

Diet

Recognisable parts in the stomach content were identified to species or taxon. For each taxon, the volume percentage of the total content was estimated.

Reproduction

For male minks, the epididymis was carved with a scalpel, pressed on a glass slide, and then observed under a microscope to check for sperm cells. Females were checked for signs of lactation, such as bald patches around the nipples and swollen nipples. The uterus was also checked for embryos and placental scars, and the ovaries were checked for corpora lutea.

Isotope analyses

Teeth and nails were collected from all animals. As a control, ten animals from a fur farm close to Nijmegen in the province of Gelderland, the Netherlands were sampled. Isotope ratios were determined using 'Stable Isotopes in the Nature Laboratory' (SINLAB) (Canadian Rivers Institute, University of New Brunswick, Fredericton, New Brunswick, Canada, E3B 5A3). The teeth and nails were incubated for 6 hours in deionised water at 100 °C, rinsed in deionised water and allowed to air dry. Teeth were ground in a mortar and 5–7 mg samples were taken for analysis. Nails were ground in a ball mill. The samples were weighed into tin capsules and loaded into a PN150 auto-sampler. Samples were converted to gas through combustion in a Carlo Erba NC2500 and carried to a mass spectrometer via continuous flow systems using helium as a carrier gas.

Samples were analysed for $d^{13}C$ and $d^{15}N$ values using either a Thermo-Finnigan Delta Plus isotope-ratio mass spectrometer (Bremen, Germany) interfaced to an Elemental Analyser via a Conflo II. Combustion occurred in a quartz tube filled with chromium oxide and silver cobaltous oxide at a temperature of 1050 °C. A second quartz tube set at 650 °C was filled with fine copper wire and used to reduce the nitrogen oxides (NxOx) to N_2. CO_2 and N_2 peaks were separated while passing through a standard 4 m GC column held at 50 °C. A water trap of magnesium perchlorate & silica chips was located immediately before the GC column to remove water. Data were gathered using IsoDat NT 2.0 software. Carbon and nitrogen data for animal tissues were corrected to the IAEA (International Atomic Energy Agency) scale with three standards – NICOTINAMIDE, BLS, and SMB-M. Data for sediments and plant material were corrected with three standards CMS, AQM, and EPS. SPL was used as a check standard. All of these standards were calibrated against IAEA Vienna Peedee Belemnite Carbonate (VPDB) and atmospheric nitrogen for carbon and nitrogen, respectively. The ratio of heavy (^{13}C) to light (^{12}C) carbon in the sample was then calculated following equation 1, where R_{sample} is the $^{13}C/^{12}C$ ratio of the sample and $R_{standard}$ is VPDB. The ratio of heavy (^{15}N) nitrogen to light (^{14}N) nitrogen in the sample was calculated following equation 2, where R_{sample} is the ratio of $^{15}N/^{14}N$ of the sample and the $R_{standard}$ is atmospheric nitrogen.

Equation 1:
$$d^{13}C = [(R_{sample}/R_{standard})-1]*1000$$

Equation 2:
$$d^{15}N = [(R_{sample}/R_{standard})-1]*1000$$

Results

Distribution

Figure 1 shows the distribution of farmed American mink in the Netherlands. In 2004,

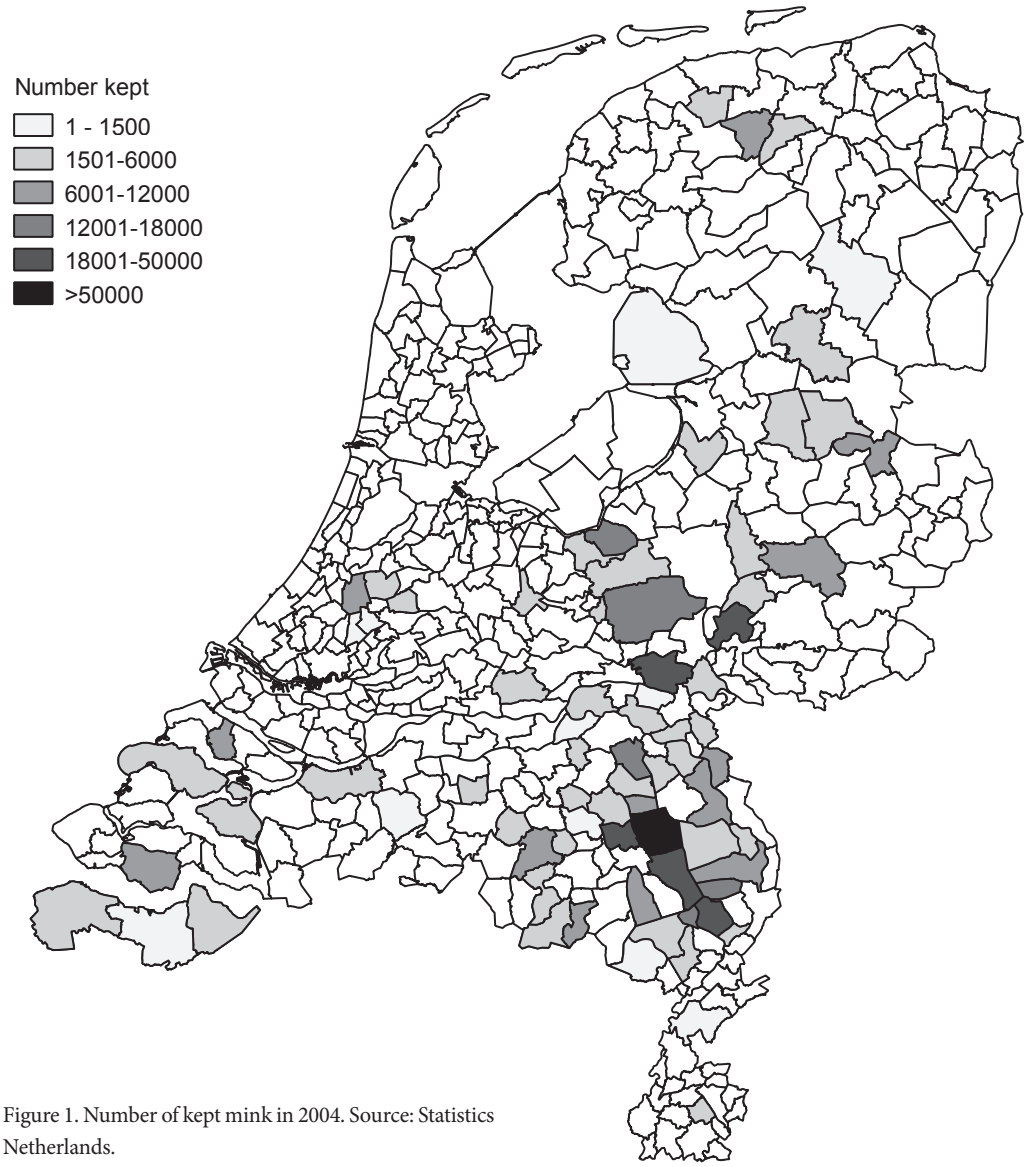

Figure 1. Number of kept mink in 2004. Source: Statistics Netherlands.

616,332 mink were kept for breeding in 180 farms. In 2008, 145 mink were caught as by-catch during the catching of 187,000 muskrats (*Ondatra zibethicus*) (figure 2). As a reference, there were 226 by-catches of polecat (*Mustela putorius*), an indigenous, but less aquatic mustelid. A few of the locations of by-catches are striking, given the locations of mink farms. In the Province of Zeeland, animals are farmed, but no by-catches were reported.

There were 1250 observations of American mink in the period of 1998-2008 (figure 3). Usually the observations were of one or a few animals. There was one observation of an adult female carrying a juvenile (see cover photo of this issue). As a reference point, during the same period there were 7007 observations of one or more polecats.

There is a weak positive relation between the number of animals farmed and the number of observations in a municipality (r_{Spear-}

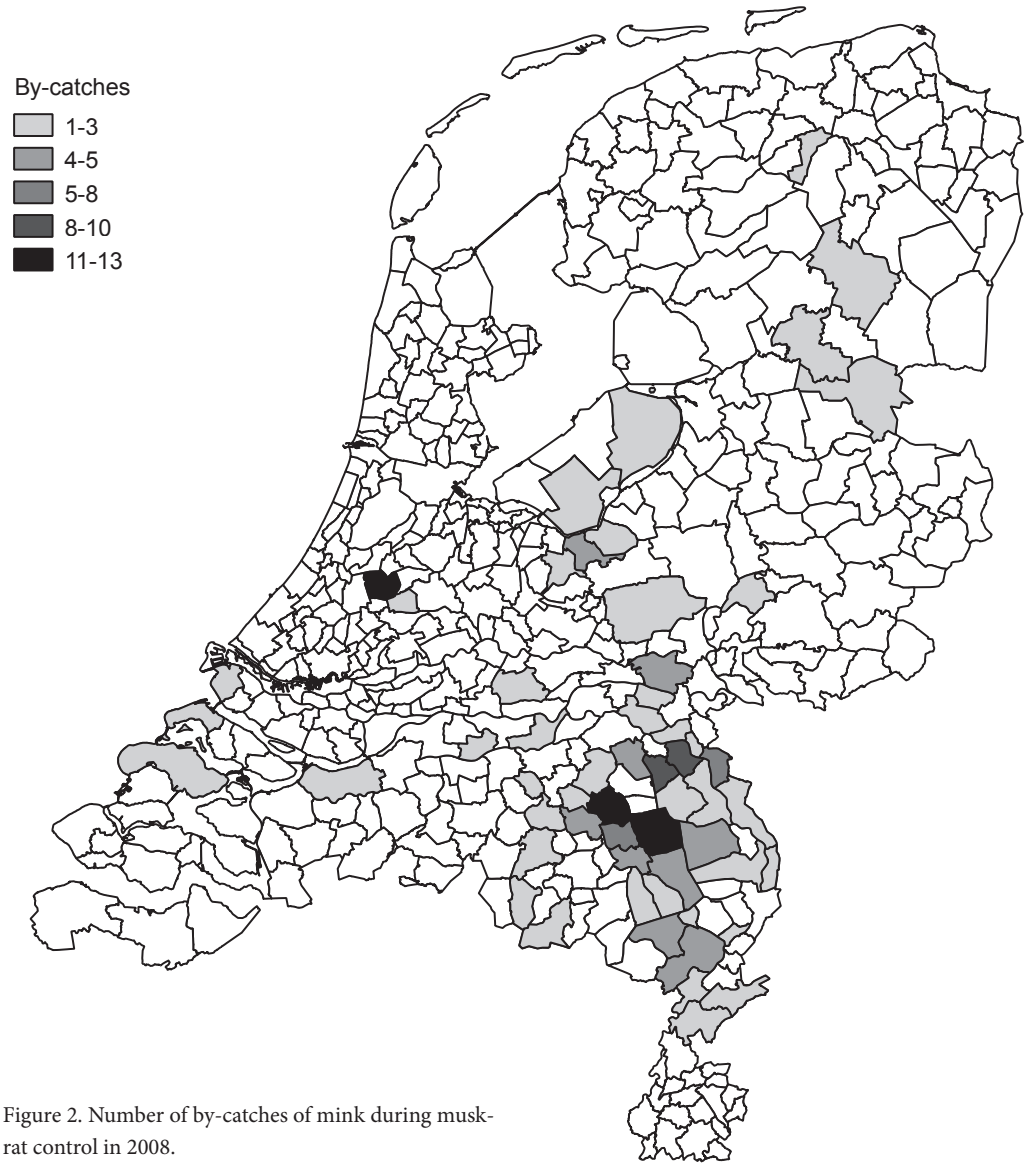

Figure 2. Number of by-catches of mink during muskrat control in 2008.

$_{man}$=0.21, *P*=0.02) and the number kept and number caught in a municipality ($r_{Spearman}$=0.37, *P*=0.001; figure 4). The largest distance between an observation and the nearest farm was 45 km.

Post mortem

Twelve animals were gathered by volunteers or from the by-catches by muskrat control officers from Waterschap Peel en Maasvallei in 2009 and 2010. From these animals, isotope ratios from teeth and nails were determined. Post mortem data from another four animals were available from post mortems in the period 2001-2008. However, one female was a traffic victim that was so flattened that only a pelt and skull were left.

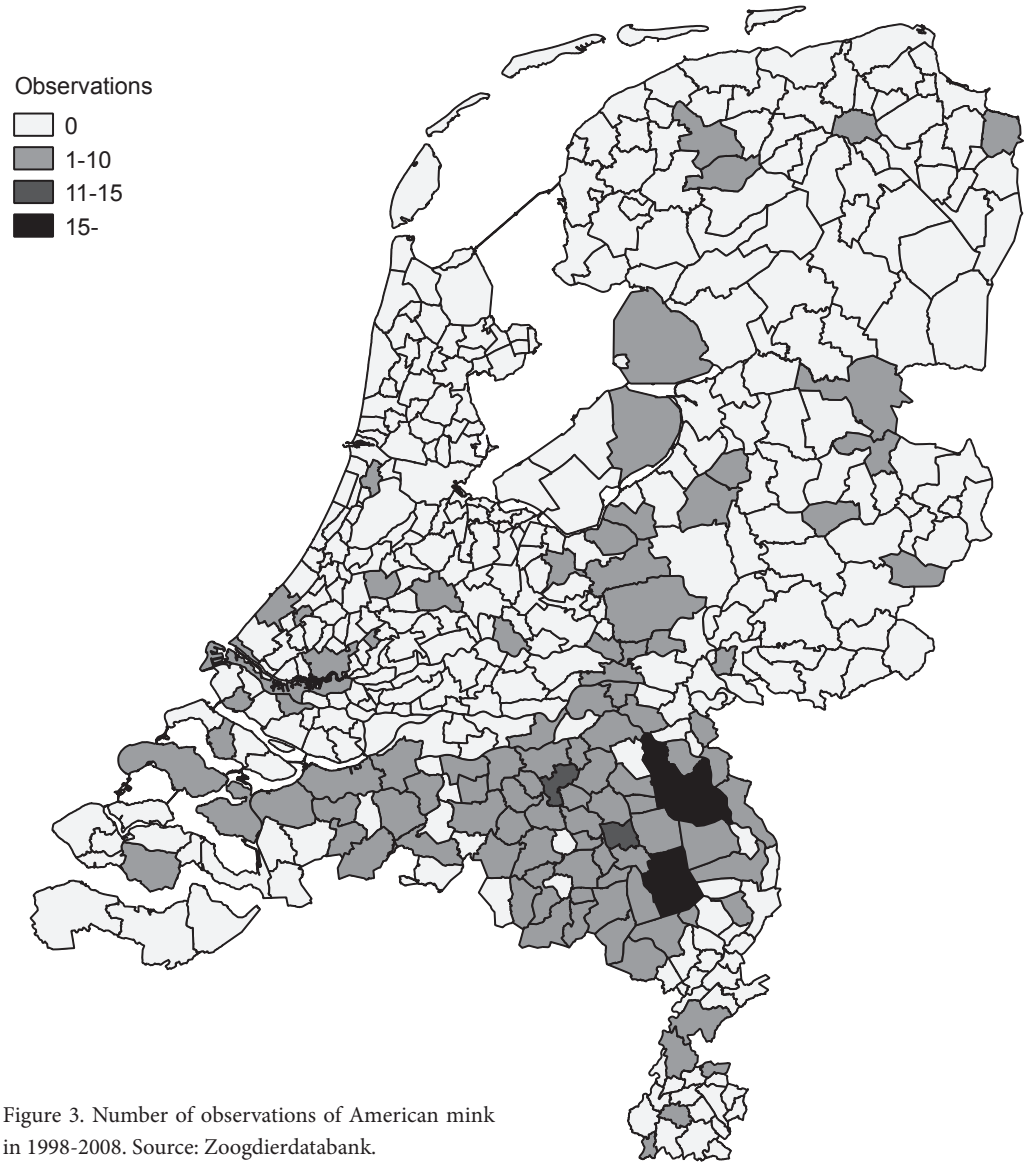

Figure 3. Number of observations of American mink in 1998-2008. Source: Zoogdierdatabank.

Sex and age

All animals were fully grown, but judging from the teeth wear, most animals were quite young. There were three male and 13 female mink. Only one male mink showed strong wear on its teeth (score 8 on a scale from 1-8). Most animals were gathered in winter, three animals in early spring, and two in summer.

Condition

Judging from the three indicators for body fat, most animals were in good condition (table 1). Scores for subcutaneous fat were generally high. Both the scores for kidney and subcutaneous fat showed a relation with the amount of mesenterial fat (kidney-mesenterial: $r_{Spearman} = 0.52$, $P=0.05$; subcutaneous – mesenterial: $r_{Spearman} = 0.63$, $P=0.01$). Most animals were in

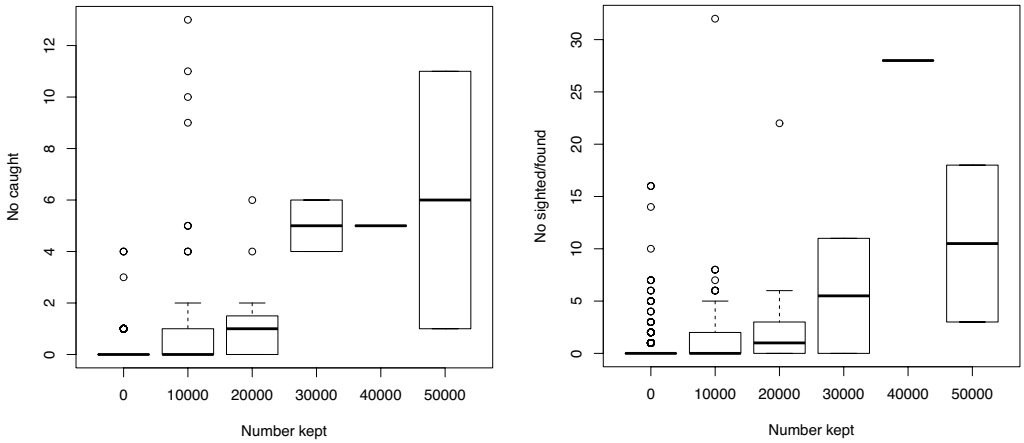

Figure 4. Number of by-catches in 2008 (left) and numbers observed from 1998 to 2008 (right) as a function of animals farmed in the municipality (0: no animals kept, 10000: 1 to 10,000, 20000: 10,000-20,000, etc.). Thick line: median, box: 25% to 75% percentiles, horizontal lines: range; circles: outliers.

good condition, only female ALT10-038 could be considered as in a poor condition, although this maybe because she died in January.

Diet

Of the 16 mink, eight had an empty stomach. One animal was a traffic victim and was not complete so there was no stomach to analyse. The stomachs of two animals contained a small rodent, one contained a mammal that could not be identified, three contained a bird, and one contained a toad and a mammal that could not be further identified.

Reproductive status

Only one of the three studied male animals had free sperm in the epididymis. This animal died in December, the two other male animals died in October and November. No signs of past reproduction were found in the female animals: there were no signs of lactation, no embryos and no scars in the placenta. One animal showed corpora lutea on the ovaries, indicating a recent ovulation. Unfortunately, the capture date of this animal was unknown.

Isotope analyses

The isotope ratios for nitrogen and carbon, of both nails and teeth, did not show a large variation between individually farmed American mink ($d^{13}C$ nails: -20.86 ± 0.24; teeth: -19.02 ± 0.13; $d^{15}N$ nails: 7.30 ± 0.38, teeth: 7.96 ± 0.24). The isotope values of the teeth of the mink caught in the wild show a little more variation but still did not differ much from the animals from the farm ($d^{13}C$ teeth: -19.27 ± 0.72; $d^{15}N$ teeth: 9.84 ± 2.12; figure 5), except for one of the animals, a female (code ALT-09.116). This animal was in good condition and had a different nitrogen-isotope ratio in its teeth than either the farm animals or the other wild mink. The ratios in the nails of wild animals were much more varied ($d^{13}C$ nails: -22.55 ± 2.39; $d^{15}N$ nails: 11.79 ± 3.72; figure 6) and there seemed to be a range of values in both carbon and nitrogen isotopes that is different from the farmed animals, indicating a longer stay in the wild, with animals ALT-10.036 and ALT-10.037 most likely to have spent the longest in the wild.

Discussion

There were some problems when it came to

Table 1. Collection number, sex, weight, body length and condition indicators of 15 wild caught mink. X = unable to determine due to missing organ.

Specimen number	Sex	Caught in	Weight (g)	Body length (cm)	Mesenterial fat index (g.cm-1)	Subcutaneous fat (score)	Kidney fat (score)
ALT-01.028	M	November	1860	42.4	X	8	X
ALT-05.035	F	March	955	37.2	0.216	6	4
ALT-08.121	F	April	1130	42.5	0.096	6	6
ALT-08.195	F	November	1346	37.5	0.446	8	7
ALT-09.115	M	December	1645	45.0	0.136	8	2
ALT-09.116	F	October	960	41.5	0.201	8	4
ALT-09.117	M	October	1525	44.5	0.071	4	4
ALT-09.118	F	October	957	34.5	0.083	7	1
ALT-09.119	F	September	1415	44.5	0.078	4	6
ALT-10.035	F	August	1362	40.6	0.223	8	6
ALT-10.036	F	December	1405	38.5	0.308	6	6
ALT-10.037	F	December	1115	39.0	0.087	6	4
ALT-10.038	F	January	885	35.5	0.096	2	2
ALT-10.120	F	January	1234	38.0	0.179	6	4
ALT-10.121	F	November	860	37.0	0.067	4	2

analysing the distribution of fur farms, by-catches and observations since there were no public data on exact locations of fur farms and the numbers of animals kept per farm for each year. This meant that we had to do the analysis based on municipality data. Also, as mink are aquatic and nocturnal, it is likely that the observations reported to the Dutch Mammal Society are an under representation, even when calculated over this long period of time. The analyses would improve with more accurate data, especially with the exact locations of fur farms. Despite this, it was clear that observations and by-catches almost only occur in municipalities with fur farms. More animals were observed or caught in the wild when more animals were kept in the municipality.

A problem with using by-catches for diet analyses was that the catches are often done in live-traps. If the animals are caught at dusk and found in the morning, their stomachs will be empty. Despite this, stomach contents of the animals showed that the feral mink consumed mammals, birds and amphibians. These findings are consistent with observations in other countries (Chanin & Linn 1980, Stubbe 1993, Maran et al. 1998, Fischer et al. 2009).

Post mortem analyses showed no indications of reproduction in the wild. Only one of the males was sexually active, and only one female showed signs of recent ovulations. However, the number of animals is small and mink are strongly seasonal in their reproduction (Stubbe 1993). Only three of the females were found during their normal mating and birth/lactating periods.

The isotope analyses of the teeth and the young age of the animals (indicated by the lack of wear of the teeth) indicate that most of the animals probably originated from fur farms. The isotope ratios of the majority of the teeth of animals in the study were very close to the values from farmed animals. Exceptions were a female that had different carbon and nitrogen ratios in both teeth and nails and was quite old (much teeth wear and a larger size) and a male in very good condition that showed a different carbon isotope ratio in nails and teeth. These two animals were probably in the wild for some time before being caught or run over. Ratios of isotopes in the nails of animals that go from captive to feral

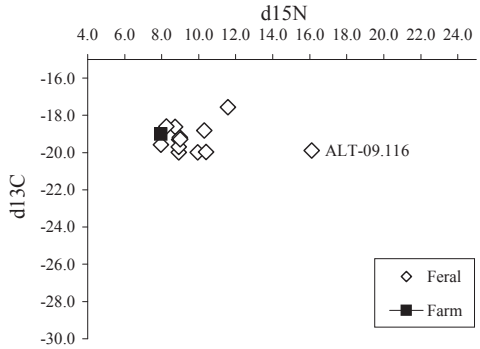

Figure 5. Isotope ratios in teeth of wild-caught mink and farmed mink. Square: mink from farm. Diamond: feral animals.

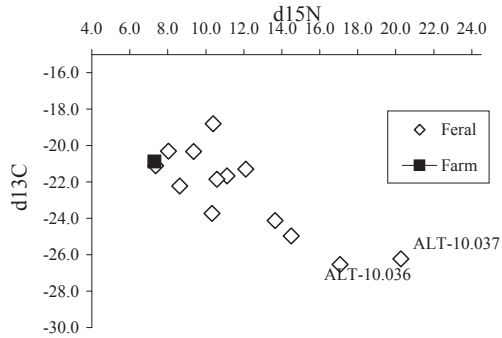

Figure 6. Isotope ratios in nails of wild-caught mink and farmed mink. Square: mean isotope values of 10 mink from farm. Diamond: feral animals.

clearly change within 50 days (Hammershøj et al. 2004). Our data of isotope values in the nails seem to show a pattern that ranges from very similar to completely different to farmed mink, suggesting that the animals we sampled show this change in ratio. Without further data on the isotopes in the food consumed in the wild, it is difficult to estimate for exactly how long the animals were feral.

The isotope ratios of nails and teeth of our farmed animals were consistent with the values found in animals in Denmark: Hammershøj et al. (2004) found d13C values of between -18.2 and -17.2 in teeth and -19.8 to -18.4 in the nails of farmed mink. Therefore, the approach developed in Denmark to determine whether wild caught American mink originated in the wild or on farms, and in the case of the latter, whether they had escaped recently or longer ago, also worked in the Netherlands.

Consequences for management

American mink are an invasive species and can have a large impact on biodiversity (Bonesi & Palazon 2007). However, based on the number of sightings, the number of by-catches, the low number of reproductive signs in the studied animals and the isotope ratios found in the teeth and nails of these animals, it can be concluded that American mink have not established a viable population in the Netherlands. The most probable cause for this is the high intensity of muskrat catchers in the Netherlands. They are unlikely to establish a viable population in the future as the House of Representatives has decided to phase out mink farming by 2024 (Tweede Kamer; 18-12-2012).

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Samenvatting

Status van de Amerikaanse nerts (*Neovison vison*) in Nederland

De Amerikaanse nerts (*Neovison vison*) is een Noord-Amerikaanse marterachtige die sinds de jaren 1920 in Europa gehouden wordt voor zijn vacht. Sinds 1958 is de soort in Nederland in het wild aanwezig. In dit artikel worden verspreiding, reproductie en voedsel besproken, en wordt beoordeeld of in het wild aangetroffen dieren zijn ontsnapt of zijn geboren in het wild. De Amerikaanse nerts komt meer voor in gemeenten waar veel nertsfokkerijen aanwezig zijn. De grootste gevonden afstand tussen een waarneming van een wilde nerts en de dichtstbijzijnde gemeente met een fokker was 45 km. Op 16 dieren, gevangen door muskusrattenvangers, werd een post mortem analyse uitgevoerd. Een aantal magen van dieren was geheel leeg, maar in de gevulde magen werden resten gevonden van amfibieën, vogels en kleine zoogdieren. Er werden geen aanwijzingen voor voorplanting gevonden: geen van de 13 onderzochte vrouwelijke dieren vertoonde littekens op de placenta, een verdikte uterus of tekenen van lactatie, en slechts één van de drie mannelijke dieren was in de seksueel actieve fase. Overigens werd naar aanleiding van dit onderzoek slechts één melding gedaan van een nestje (zonder bewijsmateriaal). Analyse van de koolstof- en stikstofisotopen van nagels en tanden van de nertsen liet zien dat de onderzochte dieren slechts korte tijd in het wild verbleven tot ze gedood werden: de ratio's van de twee isotopen leken in de meeste gevallen sterk op die van de isotopen van tien referentiedieren van een nertsenfarm. Een adult vrouwtje had isotoopwaarden in de tanden die afweken van die van de dieren van de fokkerij, en is daarom mogelijk in het wild geboren. Hoewel een van de onderzochte dieren langer in het wild aanwezig was en daar zelfs mogelijk geboren was, concluderen we dat de meeste in het wild gevonden die-

ren ontsnapte dieren zijn, die kort in het wild verblijven en veelal als jong dier worden gevangen. Het lijkt erop dat waarnemingen van wilde Amerikaanse nertsen in Nederland bestaan uit steeds nieuwe ontsnappingen die als "gewenste bijvangst" door de intensieve muskusrattenbestrijding worden weggevangen, en dat het bestaan of toekomstige vestiging van een wilde, voortplantende populatie onwaarschijnlijk is.

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