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Is the Mink Domesticated?

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1. General introduction on domestication

Domestication is without any doubt the most comprehensive, oldest, and probably also one of the most fascinating biological "experiments" of humanity.

For various reasons, the domestication of animals and plants may not be considered as an experiment in the strict, scientific meaning of the term. First of all, doubts concerning the nature of the (genetic) basic material are not rare. For instance, it was recently shown that all known breeds of dogs are monophyletic, i.e. they stem from one and the same wild species, the wolf (Canis lupus) and not also from the jackal, coyote or the fox (Parker et al., 2004). Furthermore, in spite of the most recent domestication history (such as that of the fox, mink, etc.), there was no question of any preset objective, let alone of an experimental protocol, in the modern meaning of the term.

It therefore comes as no surprise that the results of such "experiments" have led to widely varying interpretations concerning the biological mechanisms of domestication.

Like evolution in general, domestication is a process, the result of which is fully known to us, but the origin and workings thereof still elude us partially.

The variability within species, among which domesticated species constitute an extreme example, lies not only at the basis of the classic Darwinian theory of evolution, but ironically enough, also at the most fundamental contesting thereof (i.e. a new species has never been seen to originate within this extensive variability of intraspecies domesticated animals, at least not in theory and according to a classic concept of species).

According to Darwin, species formed through natural selection, starting from a variability that is specific to each species. It was precisely domesticated species (especially pigeons) that Darwin used as a model to describe variability when developing his insights. He was keenly aware however of the distinction between the so-called artificial selection from which domesticated animal species originated, and the natural selection that resulted in the wild type of a species. In this connection, it is important that he drew no essential distinction between the "substrates" of both selection processes, namely the variability inherent in the species.

On the other hand, the same variability has inspired hypotheses according to which domestication has a "mutation enhancing" or even "mutation directing" effect, whereby mutations are changes in the hereditary material (DNA) that are in principle accidental.

The unmistakable differences between domesticated animals and their respective wild types are in other words purportedly not (only) the consequence of a different selection pressure, but also of another type of variability. The emergence of such hypotheses becomes more understandable when we take a closer look at the typical domestication phenomena.

According to Goeffroy Saint-Hilaire (1772-1844), domesticated animals are productions of man and therefore differ greatly from their wild forebears in many aspects, such as appearance (morphological), function (physiological), and behaviour (ethological) – all on the basis of genetic differences.

2. Domesticated animal characteristics

a. Morphological changes

A typical example of a morphological change is the change in size. There are giants and dwarfs among dogs, rabbits and horses. For example, a dog can weigh between 1 and 70 kg; a wolf between 20 and 75 kg.

In addition, we note changes in proportions. These can range from short-leggedness in dogs and sheep, to anomalous skull shapes (broadening, shortening and bending is common among domesticated animals), with changed tooth position (close to each other, crooked or out of line), to size-related proportion differences (allometry) and "Wuchsformen" (growth forms). External enlargement or diminution of the ears and lop-ears occurs frequently in rabbits, pigs, sheep and dogs.

Numerous changes are possible concerning the fur or feather colour. As regards pigmentation, albinism occurs, as well as certain spot patterns (Dalmatians) or the belted pattern (a white band as a belt across a coloured barrel) in cows, pigs, chickens, horses, rabbits, minks and reindeer. But also the hair form and hair distribution pattern can change, e.g. angorism in sheep, goats, rabbits, cats and dogs.

Finally, tissues and organs can also change. Some animals have less developed senses and a relative decrease of brain weight by 30% (especially in the forebrain and caudal parts). Others have more pronounced muscle development with a lower content of dry matter and an increase in fat/flesh ratio. And there are also changes in the bones such as change of length, compactness and more or less vertebrae. For instance, the pig has more vertebrae than the wild boar, and not to forget: a curly tail.

Not all these changes can be attributed to modifications under the influence of captivity or the changed environment in which domesticated animals are kept. Most changes are also actual genetic changes.

b. Physiological or functional changes

In addition to the morphological changes in domesticated animals, there are also physiological or functional changes. In general, we notice enhanced fertility and even a shift of sexual rhythms, e.g. a shift from a time-bound or seasonal rut and heat to a continuous reproduction situation. Furthermore, changes can also occur in the feed conversion and in the fat/flesh ratio.

c. Behavioural or ethological changes

Changes in the physiological and above all the biological environment (food, absence of predation, diseases, other interactions between animals and humans) bring about changes in behaviour too. Territorial behaviour decreases while hierarchical behaviour increases. Nevertheless, the fundamental social organisation is purportedly retained, but this is sometimes difficult to assess, because we do not know the wild forebear of a number of domesticated animals (e.g. cattle). Furthermore, a geographic variation is at times perceptible in the behaviour of the wild forebears of domesticated animals. Wolves from Northern Europe and Eurasia, for instance, are real herd animals, and do not have the same behaviour as wolves in the Mediterranean which are not herd animals, although they belong to the same species.

Extreme care must however be taken about the alleged “behaviour degeneration” of domesticated animals because in many cases they are not capable of surviving in “nature.” The assessment is made from a certain frame of reference and it can be argued just as well that only few “wild” animals can survive in an apartment.

We may state by way of conclusion of this very brief overview, that the changes that occur during the domestication of animal species are extraordinarily multifaceted and profound. Furthermore, many changes appear strikingly to run over the boundaries of species, genes or even orders and classes, and to have led to parallel domestication characteristics. This is referred to as “homologous variability” by some authors, and has led some to the theory of “typical domestication mutations,” meaning that not all mutations are accidental genetic changes, but that they can be “directional.”

This has brought us to a subsequent important point, namely the causes and mechanisms of domestication.

3. Domestication mechanisms

As already stated in the introduction, it is precisely the changes in domesticated animals compared with their wild forebears that set Darwin on the track of his theory of evolution by natural selection.

The question about the definition of domestication is therefore essentially linked to the question about the coming into being of domesticated characteristics, and thereby immediately also to the question as to the causality thereof.

We wish to point out at the outset that we will deal with domesticated characteristics chiefly from the animal, as a biological mechanism, and not from the primitive human communities that managed to exercise one or another form of cultural control on their environment and on plants and animals.

We must first state that only relatively few animals are really domesticated; mammals, and also birds, have up to now provided the most important domesticated animals, from the cultural-historical and economic perspective, but also from the biological perspective, because of the time (and thus the number of generations) in which the selection has already been able to play out. But even among mammals and birds, only certain species are concerned and not others. It is moreover worth noting that the species hunted by primitive man are not, or not necessarily, those that later became domesticated.

It is therefore stated that certain animals have a certain predisposition to become domesticated. This predisposition consists of showing a *chiefly hierarchical behaviour pattern* and a certain form of *neotony*. Neotony is the retention of juvenile (morphological, functional and ethological) characteristics in the adult stage, whereby a greater degree of flexibility is retained and thus a greater capacity to adapt to changing environmental conditions. In the beginning of the domestication process of animals such as the horse, the cow, the sheep, the dog, etc., breeding and selection by man apparently did not play such a prominent role. Nevertheless, the variability in size and shape apparently increases already very early in this process. Here, the basic material, namely the small number of animals, is very important. Inbreeding (thus homozygosis and the appearance of unusual characteristics) and genetic drift (the colonisation and establishment effect) occur, and this forms the basis for unusual gene combinations.

The question is whether this is sufficient to explain what is known as "homologous variability" and at the same time also the conclusion that some of the aforementioned domestication phenomena are never observed in wild types. Are there typical "domestication mutations," or should we look for other possible explanations based on the universality principle according to which mutations are by definition accidental genetic changes?

The recent domestication of the silver fox by Russian researchers (Belyaev, 1979) is very relevant in this connection, as it has unequivocally shown the scope of "tamed behaviour" as a selection criterion.

Although in the initial domestication of animals there was certainly no question of any experimental protocol or objective, the (subconscious) selection on tameness has apparently been a constant throughout the entire history of domestication. As already mentioned in the previous paragraph, it concerns the tendency to choose less aggressive, docile and even "sympathetic" specimens of a species over aggressive of timid animals. The rather recent experiments of Novosibirsk show that this tendency is difficult to underestimate.

The silver fox has been bred in captivity in Russia already since the turn of the century, and these bred foxes on which no selection was carried out are pretty much identical to the foxes living in the wild. Their behaviour is timid to aggressive in 30% of the cases. Only 10% of the individuals are calm or even inquisitive. A domesticated experiment was carried out in the 1960s where the only selection criterion used was tame behaviour to humans, with a semi-quantitative tameness score of –4 to +4. The population not selected had a score of –0.96, while after 18 generations of selecting on the basis of tameness, this score attained +2.38. After some 20 generations, the selected animals were completely different, even in comparison with the tamest animals from ordinary breeding farms. They sought contact actively with humans, licked hands and face, wagged their tale and "barked" like dogs.

A number of morphological and physiological phenomena occurred in the complex of changes associated with behaviour selection, which were related to the outlined behaviour changes, but which had never been the subject of any selection in themselves. The breeding season for instance became longer and some females even had two litters per year, an unprecedented phenomenon in foxes. New morphological characteristics occurred which had never before been observed in animals in the wild or in captivity (although they had been observed in certain breeds of dogs), such as an upward curling tail, lop-ears, brown spots round the ears, while the frequency thereof was 2 to 3 times higher than expected on the basis of spontaneous mutations.

Subsequent research showed that various hormone concentrations differed greatly in tame animals (lower corticosterone, higher oestrogen and progesterone, higher hypothalamic serotonin) and this shift in neuroendocrine status purportedly caused numerous apparently independent characteristics owing to its pleiotropic effect (1 gene determines several characteristics) during ontogenesis.

The striking similarities between the results of this domestication experiment and the results of historical domestication (e.g. dogs) lead us to suppose that in certain cases, selection played a decisive role in determining the end product for behaviour characteristics.

Furthermore, this informs us about the speed with which typical domesticated animal characteristics can occur, namely after 20 to 30 generations or 30 to 200 years, depending on the size and thus the generation time of the animals. The speed of the domestication process at once explains why so few transitional forms of animals in the domestication process are found in Neolithic settlements.

The three basic elements in the evolution process of living organisms – isolation, genetic variation and selection – also have a fundamental role in the domestication process. There is clear human intervention especially in isolation and selection. It is therefore clear that we can make no distinction, on the basis of the universality principle, between domestication and biological evolution phenomena as regards the principle of operation. The fact that no new species have yet come into being through domestication has to do with the time span involved in species formation (and species formation begins always with breed formation, which does occur during domestication), and also with the definition of the concepts of species and breed.

4. Are minks domesticated now?

4.1. Background history

If domestication is defined as a directional management of an animal species by man, whereby man is in a social and dominant relationship with the animal, and this dominant relationship enables man to intervene in various life and reproduction stages with certain objectives in mind, then domestication has indeed taken place in a more recent past with the fox, raccoon, chinchilla, mink, etc.

Nachtsheim and Stengel (1997) cite such instances as examples of recent domestication, while Castle and Moore had, already in 1946, cited a series of colour mutations in minks as a typical consequence of their domestication, whereby spontaneous variation in fur characteristics, where it occurs, will be noticed and perpetuated through crossbreeding. They described already 25 mutants that were not found in the wild.

Not only the mink (Mustela vison) but also another species of this family had already been domesticated previously, namely the ferret, known in its domesticated form as Mustela furo L. The wild forebear of the ferret is often mentioned as being the wild steppe polecat (Mustela eversmanni, Lesson 1827), but it is not certain whether this is actually the case. The two possible candidates as the wild form are the aforementioned M. eversamanni and M. putorius, or the wild European polecat; neither, however, is found in North Africa, while Strabo, already in 20 AD, had mentioned the ferret and described it as stemming from Libya. Already in the first century before Christ, Pliny described how the ferret was used -- and had in fact been brought purposely to the Balearic Islands -- to hunt rabbits that were wreaking havoc to the crops of the colonists. The ferret as a specialised hunter of animals that live in holes would never have become a reliable, widespread domestic animal without the rabbits that it hunted.

Minks (Mustela vison) were already bred in captivity as of 1866 and foxes as of 1879 in North America, and in Europe as of 1930.

Breeding in captivity is still not the same as domestication, as directional selection is operated in the latter case. Experimental domestication was carried out in Novosibirsk (Belyaev, 1979), and a little later for the mink as well, at different places (Russia, Denmark, Canada, Norway).

4.2. Domestication characteristics in minks

4.2.1. Fur colour

The "domesticated" mink was selected artificially for the colour characteristics of its fur, but also for size and temperament (Kruska and Sidorovich, 2003).

Many colour variants are obtained exclusively inbred lines, because the colour is recessive with regard to standard brown. The "albino" is the first white form that arose in the domesticated mink (with black extremities just as are found in the rabbit or cat as pets).

Recently, De Jonge (2008) reported 35 colour mutations and fur colour differences and variations with regard to the wild mink.

It is very relevant, in this connection, that only 15 years of selection (i.e. 15 generations) on tameness went together with typical colour patterns (diverging from the wild form) in the fur and an increasing hereditary tendency for white.

4.2.2. Reproduction

As already mentioned under domesticated animal characteristics, domestication entails enhanced fertility, and a shift or widening of seasonal breeding (pigs, sheep) is often observed in domestication.

In the case of the mink (Mustela vison) the very short breeding season (March to the beginning of May) grows longer as rut or sexual heat occurs earlier in the domesticated form (Klochkov and Trapezov, 2009). There is no difference between the two in number of ovarian follicles, but the stimulation of the ovary is less sensitive to – and therefore less dependent on – photoperiodic stimulation. On the other hand, a higher fertility rate is reported in the domesticated mink (Braastad, 1992). A specific phenomenon in this species (M. vison), in both the wild and domesticated form, is its very variable gestation period, i.e. from 38 to 76 days with an average of ±50 days (Shackelford, 1952), while the size of the litter can vary widely, from 4-6 and much more, even as many as 17 (Burton, 1976; Schakelford, 1952).

This has to do with the phenomenon of superfetation and postponed implantation (Murphy, 1992).

Superfetation can actually result from postponed implantation, namely 2 (or more?) ovulation waves can follow each other, and in successive mating, the young will be born at the same time, but because of postponed implantation, the embryos of the different ovulation waves take a different amount of time to develop fully. As different successive covers take place, the young from 1 litter can also come from different fathers. The minimum interval for successful crossbreeding requires 6 days between 2 ovulations, because of the time needed for a recruited follicle to grow into a follicle capable of ovulation (diameter > 1.0 mm). The postponed implantation is determined not by the follicle itself, but by uterine factors (cytokines and/or uterine proteases) (Murphy, 1992; Braastad, 1992).

4.2.3. Brain development

A reduction in brain volume and especially relative brain volume is nearly generally observed in the classic domesticated animals from times immemorial, e.g. ±30% (25-34%) in sheep, pigs, dogs, cats, ferrets, and 14% in ducks and guinea pigs (Kruska, 1996; Kruska and Schreiber, 1999; Nachtsheim and Stengel, 1977).

This is already 20% in the “domesticated” mink (Kruska and Schreiber, 1999), while other organs such as the heart and spleen are also reduced in size – something observed in other domesticated animals as well.

In his extensive study into the effect of domestication on brain development in the mink, Kruska (1996) points out on the basis of intra-specific allometric methods that the brain volume was smaller in the bred mink, irrespective of body weight, age or sex, compared with its wild form.

This refers to a more general phenomenon, namely that domestication reduces brain size, including in the mink, and that this concerns especially specific components of the brain, namely the ones that have to do with sensory perception and movement. In other words, the reduction differs and is not proportional for different parts of the brain.

Examples of proportional reduction in the domesticated mink compared with the wild form:

Medulla oblongata	-16.6%
Cerebellum	-25.0% (the movement centre)
Mesencephalon	-29.1%
Diencephalon	-19.4%
Telencephalon	-18.3%
Neocortex	-17.8%
Olfactory bulb	-39.7%

Furthermore, the cranium of the domesticated mink has on the contrary been reported to be larger, albeit with a narrowed postorbital constriction (Tamlin, et al., 2009), following on the literature which also reports numerous cranium size and shape changes during the domestication process of most domesticated animals.

4.2.4. Behaviour

Repeated reports have been and are being made about the fact that breeding foxes in captivity and selective breeding lead to very important behaviour differences in general and with regard to humans in particular. This was shown in the clearest terms in what has become a classic and celebrated domestication experiment by Belyaev (1979) in Novosibirsk with foxes.

This appears to be the case with minks as well, which should not come as a surprise, as they have been bread in a similar way in breeding farms since 1866 (De Jonge, 2008).

Such behaviour changes in the mink with regard to humans have actually been described (Shakelford, 1984), namely a change from fear of humans to curiosity (Hansen and Möller, 2001).

Wild minks in captivity withdrew to their nest box when humans appeared; now most bred minks pay little attention to human presence. This may be related to the reduction of the hippocampus in the brain, i.e. the component that plays a prominent role in emotional behaviour, aggressiveness, concentration, etc. (Kruska, 1996).

Braastad (1997) established that heritability coefficients (h^2 as a measurement for heritability varying between 0 and 1) were found for different behaviour parameters that varied from 0.01 to 0.17 (which is moderately high). He developed a domestication index, a linear function of behaviour reactions to humans using the principal components analysis (a statistical method). The selections for the domestication of the mink in Russia (Trapezov, 2000) and in Denmark (Hansen, 1996) also mention reduced flight distance in the presence of people and lower blood cortisol levels – typical of changes associated with domestication in the hypophysis-adrenal cortex system (Kharlamoud and Gulevitch, 1991, cited by Braastad, 1992).

These lower cortisol levels were found in different domesticated animals, in particular also in foxes in the domestication experiment conducted in Novosibirsk (Belyaev, 1979).

The behaviour changes in these foxes were also connected to a higher serotonin content in the brain. Although this aspect has not yet been investigated in minks, Braastad (1992) established that injecting hydroxytryptophan, a precursor of serotonin, reduced the predatory tendency of minks towards rats. This could also indicate that more serotonin is present in the brain of less aggressive domesticated minks, just as in the case of the domesticated fox.

4.3. Domestication mechanisms and problems in the domestication of the mink

The question as to whether the mink is or is not domesticated is essentially connected to the question of the appearance of domestication characteristics, and thereby at once also with the question as to the causality thereof.

The importance of "tame behaviour" was already discussed extensively in part 3, regarding the recent domestication of the silver fox (Belyaev, 1979). In principle, the same phenomenon and mechanism have occurred in the mink, and this has also been confirmed by experimental domestication and selection for tameness (De Jonge, 2008).

Fifteen years of selection for tameness went together in fact with typical and diverging colour patterns in the fur compared with the wild type, and the hereditary tendency for white increased.

The hereditary tendency and variability changed during domestication through the disappearance or relaxation of natural selection, which was replaced by artificially directed selection through inbreeding and genetic drift (cf. island evolution, namely the colonisation and establishment effect). Both of the latter form the basis for unusual gene combinations.

Through intense unidirectional selection and the relaxation of natural selection in minks in captivity (namely feed supplementation, absence of predation, and no competitive partner selection), less desired genotypes (that go together with declined fitness in nature) and their allele frequency increase (Price, 1984, Belliveau et al., 1999). Colour variants, for which selection is also operated, often go together with other changes (owing to the pleiotropic effect of genes), which reduce fitness in nature.

Consequently, on the basis of the domestication mechanisms known at this time, the bred mink must be considered as a domesticated form, in view of human influence in its genetics and biology, as outlined above.

Tamlin et al. (2009) use a different name in the nomenclature for what they consider as 2 sub-species (a subspecies is in biology what a breed is in animal breeding, yet unlike breeds, a subspecies is given a 3rd name next to the name of the species; they continue, however, to belong to the same species).

Thus, the wild mink is referred to as Mustela vison energumenos
and the bred mink as Mustela vison f. domesticus.

In this connection, it is worth mentioning that a typical domestication characteristic such as brain volume reduction, including in the mink, although it did not occur in animals that were kept in captivity in zoos for several generations, was not used in the least for selection for human purposes.

Species-related problems in the domestication of the mink

As often happens in zoology, the biological nomenclature is anything but clear, and several species names often circulate, whereby the wild form is at times still given another name, as a result of which that they are times interpreted as a separate species (e.g. in the case of sheep, goats, chickens).

In view of the fact that the classic concept of species entails that all animals belonging to one species potentially constitute one reproductive community, and cross-bred species (often, although not always) have no fertile offspring, it is important to reflect on the question of the domestication of the American mink (Mustela vison).

The older literature on the mink already contained references to this biological classification (Villemin, 1956).

The mustelidae best known to us have 34 teeth and no webs between the toes.

- Mustela nivalis: weasel

- Mustela erminea: ermine

- Mustela putorius: polecat

- Mustela putorius furo: ferret (domesticated polecat).

The steppe ferret or steppe polecat is also mentioned as Putorius putorius eversmanni in Elseviers Zoogdierengids [Elsevier's Dictionary of Mammals], and is sometimes also mentioned as Mustela eversmanni (Lesson, 1827), namely the wild forebear of the domesticated ferret known as Mustela furo L., but it would be better to call it only Mustela putorius furo, as it forms one reproductive community with its wild form, namely the polecat and/or steppe polecat.

A similar situation (and confusion) occurs also with minks. They are mustelidae with 36 teeth and partial webs between the toes of the rear paws.

The wild mink is found in North America and Canada and it is mentioned in Elseviers Zoogdierengids [Elsevier's Dictionary of Mammals] as Mustela vison; the European mink is Mustela lutreola and is nearly as big as the American variety, with the same mating season, but the litter size is smaller and postponed implantation is not mentioned. Furthermore, M. lutreola is also referred to as “le vison” in Villemin (1956), and the question has been raised whether they belong to the same species (already in 1927 by Henri, cited by Villemin (1956)).

The most important differences apart from the abovementioned reproduction physiology is the fact that in the American mink, the lower lip and the chin are white-spotted and in the European mink the upper lip is usually as well. Furthermore, the wild mink in Europe, even in France, is still confused with Mustela putorius (“le putois” or polecat).

The thesis that the “domesticated mink” is purportedly completely sterile when crossbred with its wild form, where this occurs, is therefore not only doubtful, but drawn completely out of the blue, and perhaps due to an interpretation of the confusing nomenclature concerning species and subspecies.

The fact that the domesticated mink stemming from the American mink (Mustela vison, but recently also Neovison vison, Kid et al., 2009), forms one reproductive community with the American wild mink, but also with the European wild mink (Mustela lutreola) which is described as a different species, means that they can be considered as one species, yet in which 2 wild subspecies occur. All these names are used to refer to “the mink.”

This discussion concerning the nomenclature of a concept of species is relevant in connection with escapes or voluntary releases (e.g. by animal rights activists) of bred, domesticated minks. This has led to semi-wild populations in their non-natural habitat.

These exotic species have reduced the local endemic mustelidae (as a family!) especially through competition for food in North America, Europe, Iceland, and South America (Bonesi and Palazon, 2007; Reynolds et al., 2004).

Furthermore, there is potential crossbreeding between wild and domesticated populations of the same species, whereby the “evolutionary integrity” (i.e. the future sustainability or fitness) of the populations concerned is threatened.

When “domesticated animal alleles” (genotypes with lesser fitness) are introduced in wild populations through escapes or releases, they can seriously reduce the fitness of the natural populations, so that their chance of survival is also impaired.

In a recent study in Canada, Bowman et al. (2007) for instance stated that some 38% of the minks captured in the wild were of domesticated origin, while crossbreeding between domesticated and wild forms and also back cross breeding (cross-bred x wild or cross-bred x domesticated) amounted to ±28% of the captured population based on micro-satellite – DNA loci and Bayesian analysis and principal component analysis of allele frequencies (Kidd et al. 2009).

The fact that the domesticated mink forms one reproductive community (thus one and the same species) with the American wild mink and probably also with the European wild mink, must not however be used as an argument to assert that the bred mink is still a wild animal in captivity.

All domesticated animals form one reproductive community, thus one species with their wild forebear if the latter still exists, at least. This is also the case for this other member of the Mustelidae family, the ferret (Mustela putorius furo), which is perfectly crossbred with its wild form, but has been domesticated for some 2000-2500 years already, with a typical reduction of relative brain volume of 30%.

A reduction of 20% has already been reached for the mink also, and 120 years or 80 generations are more than enough to attain a high degree of typical domestication. The fact that no new species have emerged through domestication has to do with the time span needed for species to form – which is very long (and species formation always begins with breed formation, which does take place during domestication), and also with the definition and even the confusion of the concept of species and breed (and the nomenclature around them).

5. Conclusion

By way of a general conclusion, we can state that, based on a number of typical domestication characteristics such as changes in fur colour, the lengthening of the mating season, the reduction in brain volume and behaviour changes, and by analogy to changes in these characteristics in animals known to us from time immemorial, the bred mink is unmistakably a domesticated animal.

The parallel phenomena in domestication experiments on the mink as were observed in the classic domestication experiment by Belyaev (1979) concerning silver fox, strengthen this conclusion even more, if needed.

Minks form a reproductive community with their wild form, and in that sense, no new species is formed in the domestication process (as opposed to different breeds, which are formed), but that is the case with all domesticated animals, including those that were domesticated 5,000 – 10,000 years ago. There is therefore not the slighted doubt any more as how to answer the question, namely with an unequivocal yes, minks are domesticated, on a morphological, physiological, genetic and ethological basis and research.

References

Belliveau, A.M., Farid, A., O'Connell, M., and Wright J.M., 1999
Assessment of genetic variability in captive and wild American mink (Mustela vison) using microsatellite markers.
Canadian J. of Anim. Sci., 79, 7-16.

Belyaev, D.K., 1979
Destabilizing selection as a factor in domestication.
J. of Heredity, 70, 301-308.

Bonesi, L. & Palzon, S., 2007
The American mink in Europe: status, impact and control.
Biol. Conserv., 134, 470-483.

Bowman, J., Kidd, A.G., Gorman, R.M. & Schulte-Hostedde, A.I., 2007
Assessing the potential for impacts by feral mink on wild mink in Canada.
Biol. Conserv., 139, 12-18.

Braastad, B.O., 1992
Progress in the ethology of foxes and mink.
Norwegian J. Agric. Sci., 9 (suppl.), 487-504.

Burton, M., 1976
Elseviers Zoogdierengids.
Elsevier, Amsterdam-Brussels, 256 pp.

Castle, W.E. & Moore, L., 1946
Mutations of mink under domestication.
J. Heredity, 37, 137-145

De Jonge, G., 2008
Effecten van domesticatie en nieuwe technologie in de nertsenhouderij
De pelsdierhouder, Nov./Dec. 2008, 301-303.
In Scientifur. Vol. 32 (4), pp. 63-63, by Trapezov, O.V.

de Rond, J., 2010
Personal communication.

Einarsson, E.J., 1992
History, progress and challenges in the breeding and genetics of mink and foxes.
Norwegian J. Agric. Sci., 9 (suppl.), 29-38.

Hansen, S.W., 1996
Selection for behavioural traits in farm mink.
Appl. Anim. Behav. Sci., 49, 137-148.

Hansen, S.W. and Möller, S.H., 2001
The Application of a temperament test to on-farm selection of mink.

Acta Agriculturae Scandinavica, Anim. Sci. Suppl., 30, 43-98

Herre, W., 1955
Domestikation und Stammegeschichte
In Heberer, G., “Die Evolution der Organismen.”

Herre, W., Frick, H., & Röhrs, M., 1962
Über Ziele, Begriffe, Methoden und Aussagen der Haustier Kunde.
In “Zur Demestikation und Frühgeschichte der Haustiere.”
Int. Symposium Kiel, 1961, 240 pp.
G. Fischer Verlag, Stuttgart, p. 800-56.

Kidd, A.G., Bowman, J., Les barreres, D., and Schulte-Hostedde, A.I., 2009
Hybridization between escaped domestic and wild American mink (Neovison vison)
Molecular Ecologg., 18, 1175-1186.

Kruska, D., 1996
The effect of domestication on brain size and composition in the mink (Mustela vison)
J. Zool. Lond., 239, 645-661.

Kruska, D. and Schreiber, A., 1999
Comparative morphometrical and biochemical-genetic investigations in wild and ranch mink (Mustela vison)
Acta Theriologica, 44(4), 377-392.

Kruska, D.C.T. and Sidorovitch, V.E., 2003
Comparative allometric skull morphometries in mink (Mustela vision Schreber, 1777) of Canadian and Belarus origin; taxonomic status
Mammalian Biology – Zeitschrift für Säugetierkunde, 68, 257-276.

Malmkvist, J. and Hansen, S.W., 2002
Generalization of fear in farm mink, Mustela vision, genetically selected for behaviour towards humans.
Anim. Behaviour, 64, 487-501.

Murphy, B.D., 1992
Progress and challenges in the physiology of reproduction in forbearing carnivores.
Norwegian J. Agric. Sci., 9 (suppl.), 17-29.

Nachtsheim, H. and Stengel, H., 1977
Vom Wildtier zum Haustier, 3rd edition.
Verlag Paul Parey, Berlin, 156 pp.

Price, E.D. and King, J.A., 1968.
Domestication and adaption.
In Hafer, E.S.E. “Adaptation of Domestic Animals”

Price, E.O., 1984
Behavioural aspects of animal domestication.
The Quarterly Rev. Biol., 59, 1-31.

Reynolds, J.C., Short, M.J., and Leigh, R.J., 2004
Development of population control strategies for mink, Mustela vison, using floating rafts as monitors and trap sites.
Biol. Conserv., 120, 533-543.

Röhrs, V.M., 1962
Biologische Anschauungen über Begriff und Wesen der Domestikation.
In "Zur Demestikation und Frühgeschichte der Haustiere."
Int. Symposium Kiel, 1961, 240 pp.

Schakelford, R.M., 1967
Genetics of the ranch mink.
Hoffman Publications Inc., New York.

Tamlin, A.L., Bowman, J. and Hackett, D.F., 2009.
Separating wild from domestic Neovison vison based on skull morphometrics.
Wildlife Boil., 15(3), 266-277.

Trapezov, O.V., 2000
Behavioural polymorphism in defensive behaviour towards man in farm raised mink (Mustela vison)
Scinetifur, 24, 103-109.

Trut, L.N., 1999
Early canid domestication: the farm-fox experiment
American Scientist, 87(2): 160-169.

Villemin, M., 1956
Le vison.
Vigot frères Editeurs, Paris, 338 pp.

Wright, S., 1978
The relation of livestock breeding to theories of evolution.
J. Anim. Sci., 46(5), 1192-2000.