

MORPHOLOGY INVESTIGATION OF THE MINK'S BRAIN (*MUSTELA VISON*)

MILANOVIĆ VALENTINA*, MRVIĆ VERICA**, TEODOROVIĆ V**, MILOSAVLJEVIĆ P**,
PROKIĆ B** and AVDIĆ R***

*University of Pristina, Faculty of Agriculture, Kosovska Mitrovica, Serbia

**University of Belgrade, Faculty of Veterinary Medicine, Serbia

***University of Sarajevo, Faculty of Veterinary Medicine, Bosnia and Hercegovina

(Received 6th June 2012)

The mink is a strict carnivore and a seasonal breeder, which may be used as an experimental model for other carnivores. Using anatomical methods, 32 brains of the N. American mink were examined. It was found that the brain consists of four ventricles. Also, it was noted that the posterior horn was missing and that the olfactory recess was present in the lateral ventricle, a large-size interthalamic connection was present in the third ventricle, and a flat, necklace like bottom in the fourth ventricle. Only recently, the ins and outs of the mink's anatomical structure have begun to absorb the attention of anatomists. Apparently, it is related to the fact that fur animals, among them the mink, are being domesticated. For this reason and because of easy access to the material, the purpose of brain dissection is to familiarize with the three dimensional structure of the brain and teach one of the great methods of studying the brain: looking at its structure.

Key words: brain, mink, morphology, Mustela vison

INTRODUCTION

Mustela vison is 0.7 to 1.1 kg in weight and its bushy tail accounts approximately one-third to one-half of its 46 to 76 cm length. Males can weigh up to twice as much as females (Mc Vey *et al.*, 1993). Its neck and body are long and thin, and supported by short sturdy legs. The mink has a long, sleek body about two feet long. It has short, stubby legs, a long neck, small ears and eyes and a long, thick tail. In fact, one third of the mink's length is its tail. It has brown to black fur with white fur on its chin and a little bit of white fur on its throat. Its dark chestnut brown fur is interrupted by occasional white spots on the undersides. Its fur is very soft and thick and covered with oily guard hairs that make the mink's coat waterproof. The mink has slightly webbed feet (Chapman and Feldhamer, 1982). *Mustela Vison* has been used for decades as a sensitive indirect bioindicator for the assessment of mercury contamination of terrestrial ecosystems (Yates *et al.*, 2005), as well as sentinels in environmental monitoring (Persson *et al.*, 2012).

Mink are generally solitary with association occurring only between the female and her young of the year (Mc Vey *et al.*, 1993). Average litter size is 4-5 (Wren, 1986). They mostly feast on rodents, amphibians, crustaceans and birds. Its diet *a/so* consists largely of fish caught in inland waters, and birds and mammals in the vicinity of rivers and lakes (Bartoszewicz and Zalewski, 2003). Any vertebrate larger, equal or smaller in size to the mink is fair prey. Being nocturnal animals, American mink do most of their hunting at night, but will come out in the daytime. Due to the American mink's extremely sharp canines they kill by biting their prey in the back of the neck. The location of the mink, also shapes its food supply. They also target frogs, freshwater mussels, snakes, clams, tadpoles, mice and muskrats having the ability to follow them underwater and into their burrows. Many North American minks are also cunning and vicious enough to kill marsh rabbits, as well. Dens are located on tree roots and old beaver lodges (Burns, 1964). It sometimes stores extra food in its den. The mink digs its den in river banks or it finds a hollow log or an abandoned beaver or muskrat den. It never uses the same den for long (Burns, 1964; Wren, 1991). Competent swimmers, they often hunt prey in water (Whitaker, 1980). Females tend to have a harder time than males hunting larger prey such as muskrats and rabbits, and are more limited in their diets (Mc Vey *et al.*, 1993). Literature offers little data on the brain (Pilleri, 1967) and cerebral blood supply (Brown, 1968) in the mink, an animal increasingly bred for exploitation. Brains of the N. American mink were studied for the arteries of the base of the brain. Two arterial circles were isolated: the larger cerebral circle and the smaller medullar circle. These were connected by the basal artery of the brain. It was found that in cerebral circle, its left part was larger, whereas in medullar circle, it was the right part that was larger. Also, the capacity was larger in the caudal part of medullar circle than in its rostral part. (Goscicka *et al.*, 1995).

American mink are extensively bred on farms for their fur. Mink farmers control attributes such as reproductive efficiency and the colour, size and quality of pelts. As a result, domesticated mink have changed morphologically and behaviourally compared to their wild counterparts. For example, domesticated mink are bred to be larger than wild mink. They also have unintended characteristics, such as behavioural traits like aggression that are genetically linked to pelt colour. Thus, several differences in skull dimensions between wild and domestic mink have also been noted (Hadžiselimović and Dilberović, 1975). Other than larger size, the most marked difference appears to be a shortening of the muzzle in domestic mink (Kruska and Sidorovich, 2003). This may be a pedomorphic effect, or the shortened muzzle may be associated with a change in diet.

Studies have also shown an increased frontal skull height in domestic mink. The post-orbital region of domestic mink may also be narrowed. Finally, brain size and braincase volume of domestic mink appear to be reduced (Tamlin *et al.*, 2009). Also, observation and evolution indicate that there are many similarities between the mink's brain and the brain of similar animals (Mrvić, 1995). In general, being able to locate important structures in the mink's brain will be of great benefit to understanding how structures are related to each other in the dog's brain. If the

same structure exists in both brains (and most structures are the same), they are in the same relative location. For this reason, we have undertaken a study of the morphology of the mink's brain, being of the opinion that our results will contribute to comparative anatomy of the nervous system in the carnivore.

MATERIAL AND METHODS

The investigation was carried out on 32 one-year old mink brains of both sexes, sacrificed for economic reasons. Prepared skulls were kept in 10% formalin for 90 days. Subsequent to careful extraction, the brains were stored in a preservative solution, 6% formalin for 60 days. The brains were rinsed under a slow stream of running water before proceeding with the dissection. The procedure is divided into three main sections: examination of the exterior of the brain, examination of the mid-sagittal plane of the brain, and examination of two frontal cuts. In addition to the direction, the brain as a three dimensional object can be divided into three planes. There is the frontal or coronal planes which divide front from back. It can divide the brain and any location, as long as it divides the brain from front to back. Next are the saggital planes which divide the left from the right of the brain. In the figure, the most important saggital plane is illustrated as the mid-sagittal plane. However, as with the frontal planes, any plane that is parallel to the mid-sagittal plane, is also a saggital plane. The last planes are the horizontal planes that divide the brain in to top and bottom portions. These planes are illustrated with samples in the illustrations below.

RESULTS

The average weight of brains from one-year old animals was 9.41 g. The length of the basal part of brain, from the rostral edge of the *bulbus olfactorius* to the root of the first pair of cervical nerves was approximately 4.5 cm. The widest part of the brain, in the area of the central third of *lobus piriformis*, was approximately 2.4 cm.

Observed dorsally, the mink brain is almost triangular in shape. The hemispheres are separated by fissure longitudinalis which is clearly expressed. *Bulbi olfactorii* are prominent frontally, while aborally on the dorsal cortex *sulci cruciati*, transversally positioned are also clearly expressed. On the dorsal part of cerebrum, a slight asymmetry of brain gyri can be seen.

The long posterior part of *sulcus rhinalis* has a more horizontal position in the mink (Fig. 1) differing from the dog and fox where it has a vertical position. The anterior part of *sulcus rhinalis* proceeds into *sulcus olfactorius* that is well expressed, almost vertical and parallel to *sulcus praesylvius*.

On the lateral side of the brain rostral to *sulcus preasylvius*, lies *gyrus proreans* which is much smaller in the mink than in the dog. *Sulcus sylvii* is positioned at an angle and in the mink comprises *sulcus rhinalis* with an angle of approximately 45°, whereas in the dog and fox it forms an angle of about 90°. The anterior, medial and posterior parts of *sulcus ectosylvii* are well expressed, as well as related parts of *gyrus ectosylvii*.

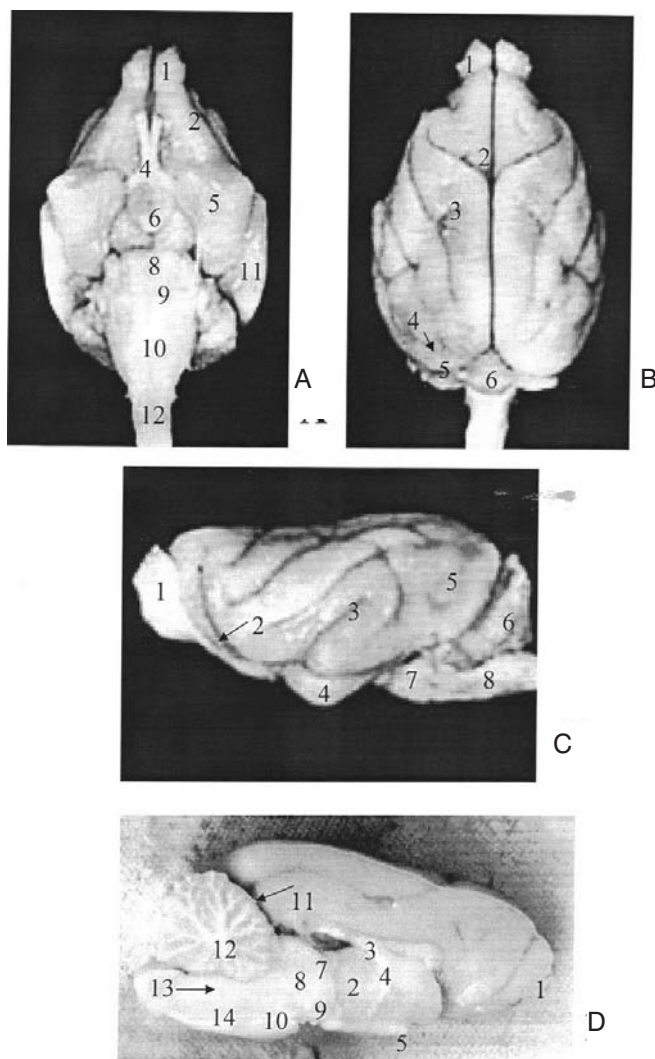


Figure 1. A-1. *Bulbus olfactorius*, 2. *Tractus olfactorius lateralis*, 3. *Trigonum olfactorium*, 4. *Schiasma opticum*, 5. *Lobus piriformis*, 6. *Corpus mamillaris*, 7. *Pedunculi cerebri*, 8. *Pons*, 9. *Pyramis*, 10. *Medula oblongata*, 11. *Fissura transversa cerebri*, 12. *Medula spinalis*
 B-1. *Bulbus olfactorius*, 2. *Fissura longitudinalis cerebri*, 3. *Fissura transversa cerebri*, 4. *Vermis cerebelli*, 5. *Hemisphaeri cerebelli*, 6. *Medula spinalis*
 C-1. *Bulbus olfactorius*, 2. *Sulcus rhinalis lateralis*, 3. *Fissura Sylvii*, 4. *Lobus piriformis*, 5. *Fissura transversa cecebri*, 6. *Cerebellum*, 7. *Pons*, 8. *Medula oblongata*
 D-1. *Bulbus olfactorius*, 2. *Massa intermedia (adhesion interthalamica)*, 3. *Corpus callosum*, 4. *Fornix*, 5. *Schiasma opticum*, 6. *Ventriculus tertius*, 7. *Lamina quadrigemina (Lamina tecti)*, 8. *Aqueductus mesencephali seu Sylvii*, 9. *Pedunculi cerebri*, 10. *Pons*, 11. *Fissura transversa cerebri*, 12. *Cerebellum*, 13. *Ventriculus quartus*, 14. *Medulla oblongata*

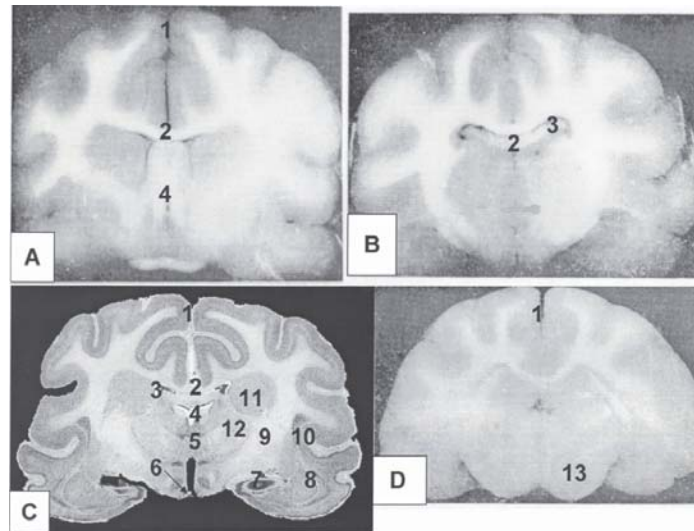


Figure 2. A,B,C,D-1. *Fissura longitudinalis cerebri*, 2. *Corpus callosum*, 3. *Ventriculus lateralis*, 4. *Ventriculus tertius*, 5. *Massa intermedia*, 6. *Corpus mamillare*, 7. *Hypocampus (Pes hippocampi)*, 8. *Corpus amygdaloideum*, 9. *Capsula interna*, 10. *Capsula externa*, 11. *Nucleus anterior ventralis*, 12. *Nucleus medialis dorsalis*, 13. *Pedunculus cerebri*

The anterior and middle parts of *suprasylvian sulcus* are marked, while the posterior part of the mentioned sulcus fades away towards the occipital pole. For this reason, the posterior part of the *parasylvian gyrus* is not clearly separated for the marginal gyrus on the occipital pole of the cerebrum.

The marginal sulci and gyri cerebri are not clearly differentiated in the mink which represents a difference in the appearance of the cerebral cortex of the mink when compared to the dog (Miler *et al.*, 1969; Mrvić, 2003). *Bulbus olfactorius*, *tractus olfactorius*, *gyrus olfactorius medialis* and *lateralis* which extend to *lobus piriformis* all well developed in the basal part of the brain. The anterior rostral sulcus clearly separates the rhinencephalon from the neopallium. *Lobi piriformes* at the base of the brain are very marked due to their size and shape and are separated from the temporal parts of the neopallium by the posterior rostral sulcus. The medial edges of *lobus piriformis* are markedly concave, because of which *crura pedunculi* are wider and shorter than in the dog. The pons is well expressed and encompasses the lateral roots of the fifth pair of cranial nerves. The pyramids are clearly seen on the ventral aspect of *medulla oblongata*.

Pes hippocampi and *fimbriae hippocampi* can be seen in the ventral root of the lateral ventricle. The shape, size and relationship of the cerebellum to the cerebrum are similar to that in the dog. The well-developed vermis is clearly separated from the hemispheres. Distribution and number of lobules of the vermis the same as in the dog. *Lobulus paramedianus* is well developed and projects laterally towards the temporal bone.

Sulcus callosi is clearly visible in a medial cross-section of the mink brain. *Gyrus cinguli* is not clearly separated from the marginal gyri of either the splenial or the genual or the ectogenual gyri. *Sulcus hippocampi* clearly separated *gyrus dentatus* from *gyrus corporis callosi*. *Corporus callosum* and the fornix are well developed. Lamina quadrigemina (*Lamina tecti*) is also well developed while the *collicules rostrales* and *abstrales (seu caudales)* are almost joined. *Colliculi abstrales* lies almost vertically on the anterior part of the cerebellum. The relationship between medullary stria is the same as in the dog.

A transversal cross-section of the brain (Fig. 2) in the area of the optic chiasm clearly shows the rostral part of the lateral ventricles and the third ventricle.

Capsula interna is located lateral to nucleus caudatus while lateral to it lies nucleus lentiformis, capsula externa and capsula extrema. A transversal cross-section of the brain in the area of *corpus mamillare*, shows *crus pedunculi* lying lateral to the nuclei, while *tractus opticus* is even more lateral. *Thalamus opticus* is well developed and joined to *massa intermedia*. *Corpus fornicis* can be seen beneath *corpus callosum*.

A cross-section made rostral to pons shows *gyrus dentatus*, while pes hippocampi lies dorsally and laterally.

DISCUSSION

Spatio-temporal coexistence of American mink and several different animals, all in the carnivora order, offers an interesting point of view in terms of their comparison. Coexistence of American mink and European polecat (*M. putorius*) has been matter of numerous studies (Brzezinski et al., 2010). This appears to be possible in habitats offering sufficient food and shelter, but where these resources are less abundant, interspecific competition may lead to the decline and exclusion of the weaker competitor. Such a relationship was recorded in the case of American mink and otter: the increasing otter population caused the decline of the American mink (Bonesi and Macdonald, 2004a).

There is direct and indirect evidence that domesticated ferrets (*Mustela furo*) can successfully interbreed with both European polecats (*M. putorius*) and steppe polecats (*M. eversmannii*), producing viable hybrid offspring (Wren et al., 1986; Mc Vey et al., 1993). By extension, since steppe polecats can interbreed with black-footed ferrets (*M. nigripes*) (Williams et al. 1996), at least a possibility exists that domesticated ferrets and/or European polecats can also interbreed with the endangered species. What this means is that relationships between these four polecats species are so close that minor genetic differences do not prevent successful interbreeding (that is, hybridization). This is important, because it shows that evolutionary differences between these species are minor, suggesting a relatively recent divergence from a common ancestor (Kidd et al., 2009). Indeed, the black-footed ferret, as a separate species, is less than 100,000 years old, and may be as young as 20,000 years or less (Lair et al. 2002, Williams et al. 1996, Raj JU et al., 1990). While enough differences are considered to exist allowing the classification of each as a separate species, they really are not that much different. There is significant controversy regarding polecat phylogenetics,

with some suggesting that the black-footed ferret is a subspecies of the steppe polecat, and others suggesting all polecats comprise a single holarctic species and differences are attributable to geomorphic adaptation (Williams *et al.* 1996, Lair *et al.* 2002). These polecats are all about the same size. They share a very similar physiology, produce about the same number of offspring per litter, follow similar reproductive strategies, experience similar life histories, and subsist on prey that typically shelters in burrows or underground (Chapman *et al.*, 1982; Bonesi and Macdonald, 2004b).

For this reason, taxonomists have classified the three polecats, and the domesticated ferret into a single supergenus, *Putorius* (Williams *et al.*, 1991; 1996). Recent works suggest the relationships between the domesticated ferret and the European and steppe polecats are so close that the wild progenitor cannot be determined. Nearly identical changes occur in just about every mammal species that has been domesticated, including carnivores (dogs, cats, ferrets, mink, fox, raccoon dogs, skunks), rodents (rats, mice, cavies, hamsters) and bears (Hadžiselimović and Dilberović, 1975). Also, these changes were found in species like lagomorphs (rabbits), artiodactyls (cattle, sheep, goats, pigs, camels, llamas), and perissodactyls, such as horses and donkeys (Hadžiselimović and Dilberović, 1973).

For our purposes, the results of those genetic interactions can easily be seen and quantified, and those measurable changes shall be the focus of our attention. The cerebrum of the mink is almost triangular shape. The frontal pole of the hemispheres is narrow, compressed bilaterally, while the occipital pole is blunt. Deep sulci cruciate which are longer and deeper than in dogs are characteristic of the dorsal side of the cerebrum. On the lateral side, sulcus rhinalis has a lateral position and its caudal part together with sulcus sylvii comprises an angle of 45°. Marginal sulci and gyri are not differentiated in the mink, which represents a difference in the appearance of mink's brain when compared to the dog. The ventral side is characterized by well developed olfactory bulbs and tracts and piriform lobe. The *lobus piriformis* is elongated, its oral part is broader than aboral, and its medial border is concave. The pyramids are convex prominent, rounded and bundled. The shape, size and relationship of the cerebellum to the cerebrum are similar to that in the dog. Lobus paramedianus and ansiformis are well developed, while the parafloccular ventral limb is more developed than in the dog. Mediosagittal and transversal sections clearly show, in addition to the ventricles, parts of the *basal nuclei*, especially *corpus striatum*, as well as well developed *thalamus* and *hypothalamus*.

Address for correspondence:
Verica Mrvić, DVM, PhD
Department of Anatomy
Faculty of Veterinary Medicine
Bulevar oslobođenja 18
Belgrade, Serbia
E-mail: vrmrvic@vet.bg.ac.rs

REFERENCES

1. Bartoszewicz M, Zalewski A, 2003, American mink *Mustela vison* diet and predation waterfowl in the Slonsk Reserve, western Poland, *Folia Zool*, 52, 225-38.
2. Brown JO, 1968, Some observation on the cerebral arterial circles of mink (*Mustela vison*), *Anat Rec*, 161, Issue 3.
3. Blomström A, Widén F, Hammer A, Belák S, Berg M, 2010, Detection of a novel astrovirus in brain tissue of mink suffering from shaking mink syndrome using viral metagenomics, *J Clin Microbiol*.
4. Bonesi L, Macdonald D, 2004a, Impact of released Eurasian otters on a population of American mink: A test using an experimental approach, *Oikos* 106, 9-18.
5. Bonesi L, Macdonald DW, 2004b, Differential habitat use promotes sustainable coexistence between the specialist otter and the generalist mink, *Oikos* 106, 509-19.
6. Brzezinski M, Marzec M, Zmihorski M, 2010, Spatial distribution, activity, habitat selection of American mink (*Neovison vison*) and polecats (*Mustela putorius*) inhabiting the vicinity of eutrophic lakes in NE Poland, *Folia Zool* 59, 183-91.
7. Chadzypanagiotis D, 1975, Arteries of the surface of the cerebral hemisphere in the cat, *Folia Morph (Warsz)*, 34, 323-36.
8. Chapman JA, Feldhamer GA, Thompson BC, 1982, Wild Mammals of North America, The Johns Hopkins University Press, 1147.
9. Drekić D, Jablan Pantić O, Miladinović Ž, 1981, Morphological properties of Mink's brain, *Folia Morph*, 29, 2.
10. Goszcicka D, Stankiewicz W, Szpinda M, 1995, The arteries of the base of the brain in the N. American mink (*Mustela vison*), *Arch Vet Pol*, 35, 145-51.
11. Hadžiselimović H, Dilberović F, 1975, Izgled mozga medveda, *Folia Anatom*, 4.
12. Hadžiselimović H, Dilberović F, 1975, The aspect of the limbic system in some wild animals, Publication of the association of Yugoslav anatomists, Sarajevo.
13. Hadžiselimović H, Dilberović F, 1973, O izgledu mozga lisice, *Folia Anatom*, II, 3-4.
14. Haines KJR, Evans DR, O'Brien M, Evans HE, 2009, Accumulation of mercury and selenium in the brain of river otters (*Lontra canadensis*) and wild mink (*Mustela vison*) from Nova Scotia, *The Science of the total environment*, Canada.
15. Kidd AG, Bowman J, Lesbarreres D, Schulte-Hostedde AI, 2009, Hybridization between escaped domestic and wild American mink (*Neovison vison*), *Mol Ecol*, 18, 1175-86.
16. Kruska DCT, Sidorovich VE, 2003, Comparative allometric skull morphometrics in mink (*Mustela vison*) of Canadian and Belarus origin, *Mammal Bio*, 68, 257-76.
17. Lair S, Barker IK, Mehren KG, Williams ES, 2002, Epidemiology of neoplasia in captive black-footed ferrets (*Mustela nigripes*), 1986-1996, *J Zoo Wildl Med*, 33, 204-13.
18. McVey M, Hall K, Trenham P, Soast A, Frymier L, Hirst A, 1993, Wildlife Exposure Factors Handbook, (1st ed), US Environmental Protection Agency, Washington DC. Miller ME, Christesen G, Evans HE, 1969, Anatomy of the Dog, W.B. Saunders Company Philadelphia, London.
19. Mrvić V, 1995, Topografija, vaskularizacija i inervacija ženskih polnih organa malog zelenog majmuna (*Cercopithecus aethiops sabeus*). Doktorska disertacija, Fakultet veterinarske medicine, Univerzitet u Beogradu.
20. Mrvić V, 2003, Atlas komparativne anatomije domaćih životinja, Beograd.
21. Persson S, Brunström B, Bäcklin B-M, Kindahl H, Magnusson U, 2012, Wild mink (*Neovison vison*) as sentinels in environmental monitoring, *Acta Vet Scand*, 54.
22. Pilleri G, 1967, Das Gehirn von *Mustela vison* und *Mephitis mephitis* (*Carnivora, Mustelidae*), *Rev Suisse Zool*, 160, 141-58.
23. Raj JU, Hillyard R, Kaapa P, Anderson J, Gropper M, 1990, Pulmonary vascular pressure profile in 2-3-week-old, 5-6-week-old and adult ferrets, *Respir Physiol*, 82, 307-15.
24. Tamlin A, Bowman J, Hackett D, 2009, Separating wild from domestic American mink *Neovison vison* based on skull morphometrics, *Wildl Biol*, 15, 266-77.
25. Whitaker JO, 1980, The Audbon Society Field Guide to North American Mammals, New York, 745.

26. Williams ES, Anderson SL, Cavender J, Lynn C, List K, Hearn C et al., 1996, Vaccination of black-footed ferret (*Mustela nigripes*) x Siberian polecat (*M. eversmanni*) hybrids and domestic ferrets (*M. putorius furo*) against canine distemper, *J Wild Dis*, 32, 417-23.
27. Williams ES, Thorne ET, Quan TJ, Anderson SL, 1991, Experimental infection of domestic ferrets (*Mustela putorius furo*) and Siberian polecats (*Mustela eversmanni*) with *Yersinia pestis*, *J Wildl Dis*, 27, 441-5.
28. Wren CD, Stokes PM, Fischer KL, 1986, Mercury levels in Ontario mink and otter relative to food levels and environmental acidification, *Can J Zool*, 64, 2854-9.
29. Yates DE, Mayack DT, Munney K, Evers DC, Mayor A, Kaur T et al., 2005, Mercury levels in mink (*Mustela vison*) and river otter (*Lontra canadensis*) from northeastern North America, *Ecotoxicology*, 14, 263-74.

MORFOLOŠKA ISPITIVANJA MOZGA KANADSKE LASICE (*MUSTELA VISON*)

MILANOVIĆ VALENTINA, MRVIĆ VERICA, TEODOROVIĆ V, MILOSAVLJEVIĆ P,
PROKIĆ B i AVDIĆ R

SADRŽAJ

Kanadska lasica je karnivor, koji jednom godišnje daje 4-5 mladunaca, koji se koriste kao eksperimentalni model. Za anatomska ispitivanja, koristili smo 32 mozga oba pola kanadske lasice. Utvrdili smo da se u mozgu nalaze 4 komore, kao i kod ostalih sisara. Ustanovili smo da posteriorni rog bočne komore nedostaje, kao i da postoji olfaktorni izdanak bočne komore. Šira površina između talamusa je takodje ustanovljena u trećoj moždanoj komori, kao i udubljenje četvrte moždane komore. U poslednje vreme kao eksperimentalna životinja, kanadska lasica postaje predmet interesovanja anatoma kao i naučnih istraživača u velikom broju laboratorija. Takođe, divlje životinje postaju sve više domestikovane, a među njima je i kanadska lasica.

