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The structures and topography of the nuclei of the cerebellum in chinchilla

Budowa i topografia jąder móżdżku szynszyli

SUMMARY

Three cerebellums of chinchillas were taken for the investigation. The collected material was fixed in formalin, dehydrated in ethyl alcohol and embedded in paraffin blocks. Next, the blocks were cut in a transversal plane into 12-µm–thick slices. The slices were stained with cresyl violet and examined under a light microscope. One can distinguish three deep nuclei of chinchilla's cerebellum: dentate nucleus (lateral, *nucleus dentatus s. lateralis*), interposed nucleus (*nucleus interpositus*), fastigial nucleus (medial, *nucleus fastigii s. medialis*). *Nucleus interpositus* located in the central part of cerebellar hemisphere's white substance makes the longest cellular band. *Nucleus medialis* lies in the white substance of the vermis the nearest to the medial plane of the cerebellum. *Nucleus lateralis* of the cerebellum is a distinctly outlined cluster of cells located the most externally in relation to the remaining nuclei. The nuclei of the cerebellum in chinchilla are made up of multipolar cells, oval and of fusiform shape. The distinctly marked predominance of oval cells of the cerebellum's *nucleus lateralis* is worthy noticing, whereas the following predominate in *nucleus interpositus* and *nucleus medialis*: small multipolar cells (20–30 µm) and of medium size (30–40 µm).

Key words: central nervous system, cerebellum, cerebellar nuclei, chinchilla

INTRODUCTION

The cerebellum of mammals takes part in keeping up balance, muscular tone and it is the centre of coordination movement of the organism. Phylogenetico-functionally we divide the cerebellum into noduloflocular lobe also called *archeocerebellum,* which consists of the vermis nodulus and laterally situated hemispheres' floccules, the remaining part of the vermis together with narrow adjoining hemispheres make up so called medullary cerebellum classified as *paleocerebellum*, whereas lateral parts of cerebellar hemispheres phylogenetically the youngest, are called *neocerebellum* [Gołąb 1992, Ganong 1993]. The nuclei of the cerebellum make clusters of grey matter

inside the cerebellum's white substance, they receive inhibitory impulsation from piriform cells of cerebellar cortex and stimulate one of the collaterals of ascending and mossy fibres being in a state of constant tension. The cells of deep nuclei constitute at the same time the source of cerebrofugal exit of nervous ways [Ganong 1993]. Efferent impulsation of cerebellar nuclei always stimulates the target structures (brain trunk and thalamus). The cells of dental nucleus receive nervous fibres from the lateral part of cerebellar hemispheres' cortex, interposital nuclei from the medial part of hemispheres' cortex and vermis cortex, whereas medial nuclei from the cells of vermis cortex [Guoxiang Xiong and Soichi Nagao 2002, Ganong 2003, Sugihara *et al.* 2004]. The projection of the above mentioned areas of cerebellar cortex to the profound nuclei takes part in movement coordination of the defined groups of muscles relating to given cortex areas. The latest research on the function of celleberal nuclei have proved the existance of neurons taking part in the regulation of pulmonary ventilation volume [Xu and Franzier 2002]. It has also been proved that fastigial nuclei (medial) take part in the regulation of eyeballs, excessive cell activation of this nucleus or a lack of inhibition from piriform cells of cortex can be one of the main reasons causing opsoclonus [Helmchen *et al.* 2003]. On account of the function as well as species differences, the cerebellum has been a subject of interest for many scientists of various scientific disciplines. The subject of the investigation was cortex as well as profound nuclei of the cerebellum. The structure and topography of the cerebellum's nuclei was described in domestic animals: in domestic ruminants [Jastrzębski 1966], in horse [Bujak 1971], in cat [Flood and Jansen 1961], in animals living in the wild: roe deer [Szteyn 1969], boar [Bujak 1974], camel [Welento 1979], polar fox [Bujak 1984]. Among rodents, profound nuclei of the cerebellum were described in field vole, bank vole and pine vole [Jastrzębski 1965], nutria [Szteyn 1966], rabbit [Ono and Kato 1938], rat [Kornelliusen 1968] as well as mole and shrew [Skrzypiec 1980]. On the basis of current investigations it has been proved that subcortical grey matter of the cerebellum in mammals is devided into four profound nuclei: dental nucleus, lateral nucleus interpositus, medial interpositus and fastigial nucleus. Some differences are found in the division of cerebellar white substance in rodents, because in some species nuclei interpositus combine, composing one cellular band; thus, not four but three profound nuclei of the cerebellum exist [Jastrzębski 1965]. The aim of this research is to get to know the subcortical structures of the cerebellum in chinchilla. The information included in this paper will be useful in the future for anatomocomparative purposes and will form the basis for experimental research.

MATERIAL AND METHODS

The material for study consisted of three sexually mature chinchillas (two males and female), the body mass about 450g coming from a private farm in Piaski near Lublin, were used in the investigation. The material of the investigation was taken from skinned chinchillas carcasses. The bones of the brain skull of the animals were cut in such way as to expose the cerebellum together with surrounding it cerebral meninges.

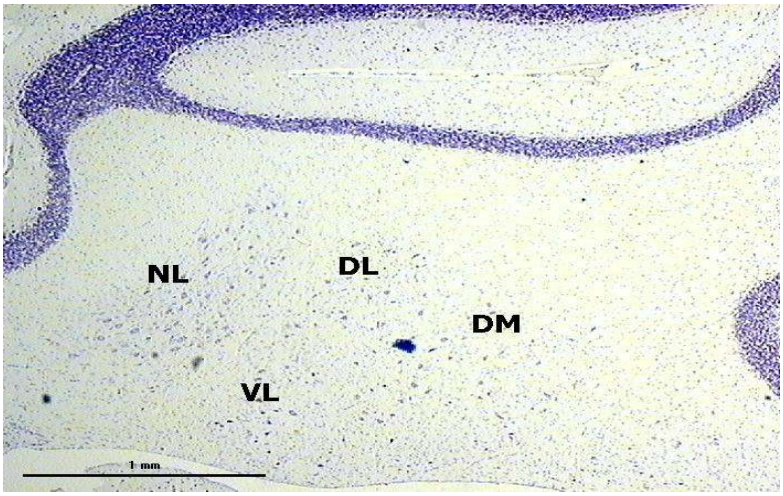
After cutting cerebral meninges and spinal cord after the first pair of medullary neck nerves the cerebellum was taken out in its entirety and was placed in 10% buffered formalin (ph 7.3). After a three-week period needed for fixing nervous tissue, the experimental material was placed in successively increasing dilutions of ethyl alcohol for the dehydration purpose. After dehydrating, the cerebellums in their entirety were placed in embalmed terpentine for 24 hours, next they were removed in order to be divided into smaller fragments. The fragmentation of the cerebellum was carried out by cutting it on the level of presternal groove. The CNS sections prepared in this way were placed in warm paraffin for 24 hours (temp. 56^{o}C), next after the removal paraffin blocks were formed. The blocks after 24-hour cooling were placed in a microtome handle and cut in a transversal plane into consecutive 12-µm-thick slices. Other slices were put into warm water (temp. about 45^{o}C), and were next placed on, defatted and previously covered with 5% of gelatin solution, glass

slides (Medlab, Poland). On each of the glasses about four paraffin preparations were placed. The glasses were filtered with absorbent paper by pressing and placed in wooden boxes, kept at a room temperature (about 48 hours) till the time of their further colouring with violet cresyl.

RESULTS

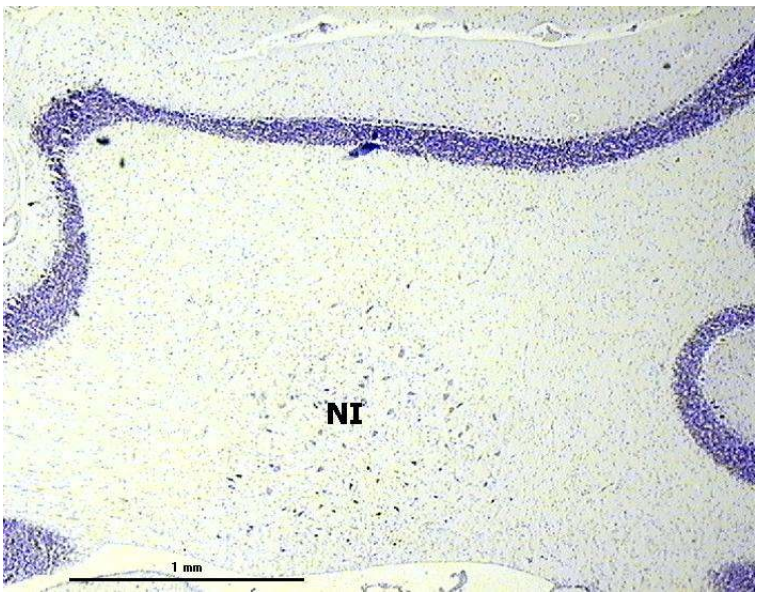
Lateral nucleus, dentate (*nucleus lateralis s. dentatus*)

Lateral nucleus of the cerebellum is a clearly distinguished cellular band lying in the in the lateral part of the cerebellar hemispheres' white substance. The posterior pole is situated at a height of 1/6 of the posterior of nucleus interpositus, taking the shape of a horizontally oval group of several cells in the following cross-section the nucleus elongates and becomes gradually wider and wider bending, in its central part medially (phot. 1) Later towards the front, in the upper part, lateral nucleus gets divided into two groups of cells that join together in the bottom part of the described nucleus, that is why it takes in transversal cross-sections a shape of obliquely positioned letter Y (Pic. 1, Fig. 8, 9). In the following cross-sections the nucleus takes the shape of letter U with arms directed dorsalo-medially (Pic. 1, Fig. 7). The anterior pole of the nucleus reaches as far as 1/3 of nucleus interpositus' anterior. The cells forming *nucleus lateralis* are of medium size (about 30– 40 µm), multipolar and oval, in the central part of *nucleus lateralis* the cells of oval shape predominate (Phot. 5).

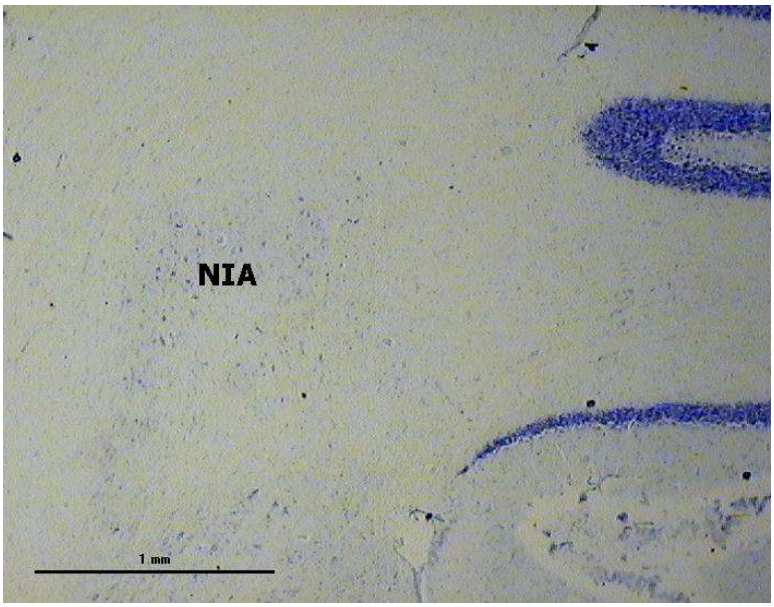


Fot. 1. Przekrój poprzeczny móżdżku na wysokości tylnego bieguna jądra bocznego. NL – jądro boczne móżdżku, jądro wsunięte: DL – grzbietowo-boczna, VL – brzuszno-boczna, DM – przyśrodkowa grupa komórek

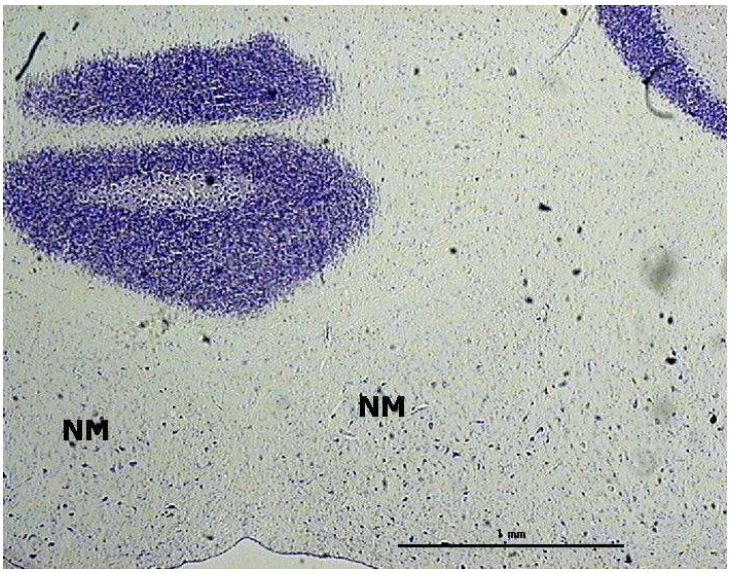
Phot. 1. Transverse section of cerebellum at the level of posterior pole of *nucleus lateralis.* NL – *nucleus lateralis, nucleus interpositus*: DL – dorso-lateral, VL – ventro-lateral and DM – medial group



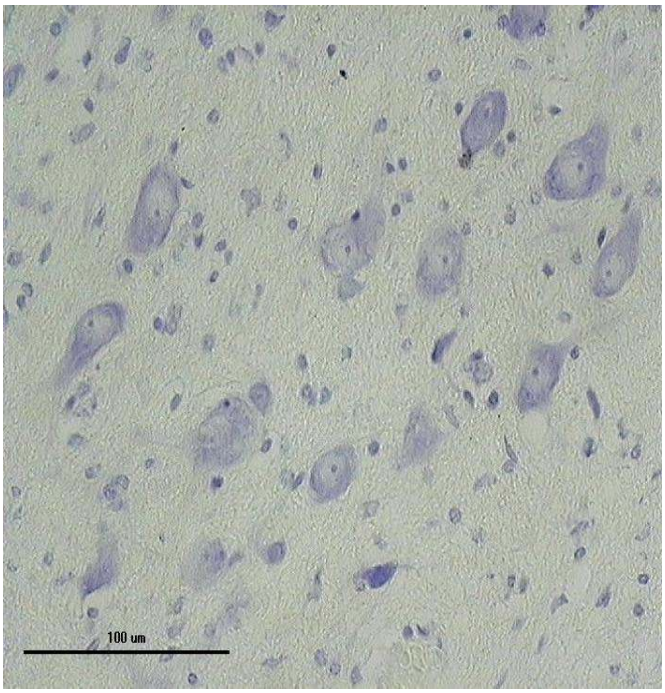
Fot. 2. Przekrój poprzeczny móżdżku na wysokości tylnego bieguna jądra wsuniętego
Phot. 2. Transverse section of cerebellum at level posterior pole of *nucleus interpositus*



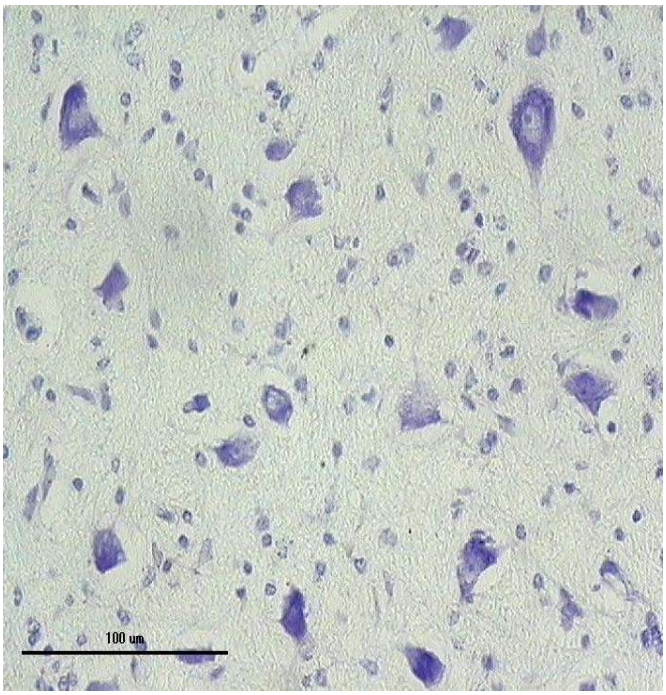
Fot. 3. Przekrój poprzeczny móżdżku na wysokości przedniego bieguna jądra wsuniętego
Phot. 3. Transverse section of cerebellum at level anterior pole of *nucleus interpositus*



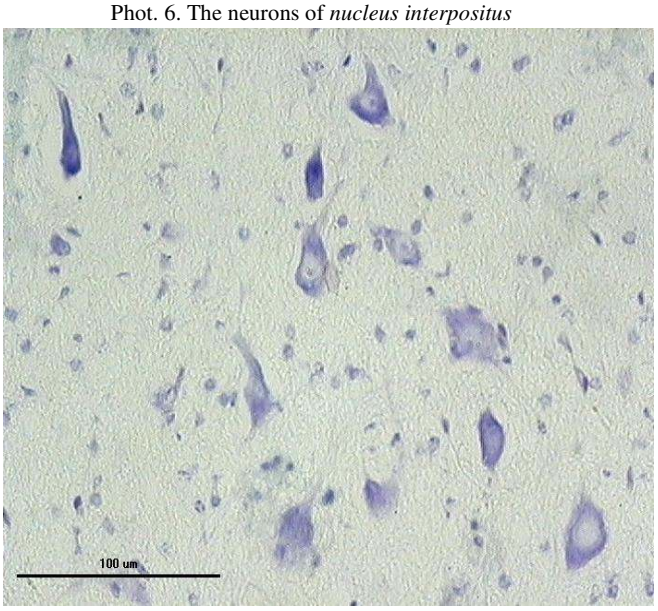
Fot. 4. Przekrój poprzeczny móżdżku – jądro przyśrodkowe
Phot. 4. Transverse section of cerebellum through *nucleus medialis*



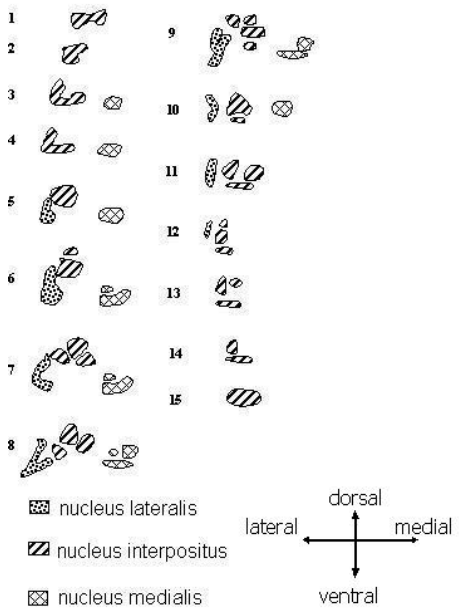
Fot. 5. Komórki nerwowe jądra bocznego
Phot. 5. The neurons of *nucleus lateralis*



Fot. 6. Komórki nerwowe jądra wsuniętego
Phot. 6. The neurons of *nucleus interpositus*



Fot. 7. Komórki nerwowe jądra przyśrodkowego
Phot. 7. The neurons of *nucleus medialis*



Rys. 1. Wzajemne rozmieszczenie oraz architektonika jąder głębokich móżdżku na przekrojach poprzecznych, od przodu (1) w kierunku tylnym (15)
Fig. 1. Mutual distribution and architecture of the cerebellar nuclei in transversal cross-sections, from the anterior (1), towards the posterior (15)

Interposed nucleus (*nucleus interpositus*)

Nucleus interpositus of the cerebellum in chinchilla composes nervous cells' band inside the cerebellar hemispheres' white substance between lateral and medial nucleus. The posterior pole of *nucleus interpositus* is the most posteriorly protruding nervous band, transversally taking an oval shape. It is made up of small and medium-size cells with cross-sections of a triangular shape a bit elongated' definitely strongly stained in relation to the cells of the other groups. The number of cells increases progressively and at the same time the shape of the nucleus changes into irregularly round (Phot. 2). One can later observe the division of *nucleus interpositus* initially into 2 groups of cells: dorsal and abdominal and then into three: dorso-lateral (dorsolateralis), ventro-lateral (ventrolateralis) and medial (medialis) (Phot. 1, Pic. 1 Fig. 11). This nucleus is relatively well-developed and takes up almost the whole part of the cerebellar hemispheres' white substance. At the height of 1/3 of the anterior of lateral nucleus the division into groups becomes less visible and the nucleus as a whole takes an irregularly round shape. Anteriorly from lateral nucleus the nucleus takes in transversal cross-section a shape resembling a horizontally positioned turned letter L (Pic. 1, Fig 3, 4). The anterior pole of *nucleus interpositus* gradually takes a shape of horizontally oval group of cells (Phot 3). Along its entire length, the nucleus is made up of multipolar cells, triangular of medium size (about 30–40 µm) and small (10–20 µm, Phot. 6).

Medial nucleus of the cerebellum, fastigial *(nucleus medialis s. fastigii)*

Medial nucleus of the cerebellum in chinchilla is located in the white substance of the cerebellum's vermis, medially from *nucleus interpositus* (Phot. 4, Pic. 1, Fig 3–10). The posterior pole of n. fastigii takes a shape of a horizontally oval group of cells on both sides of postmedial plane of the cerebellum (Pic. 1, Fig. 10). In other cross-sections one can see the division of the described nucleus into two groups of cells, of a round shape, dorso-medial group made up of multipolar cells and abdomino-lateral transversally taking a horizontally oval shape (Pic. 1, Fig 9). At the height of 1/3 of the posterior of the described nucleus the third group of cells of oval shape appears, located dorsolaterally (Pic. 1, Fig. 8). The anterior pole of the described nucleus takes an irregularly oval shape (Pic. 1, Fig 3, 4, 5). The number of cells in cross-sections gradually decreases, reaching the height of 1/7 of *nucleus interpositus* anterior. The cells forming medial nucleus take a triangular multipolar shape in cross-sections (Phot. 7).

DISCUSSION

For the first time the division of subcortical grey matter of cerebellum into 4 nuclei was made by Weidenreich [1899]. Brunner [1919] suggests the division of mammals on account of the structure of cerebellar nuclei; according to the author, in rodents there appears only one nucleus divided by nervous fibres into groups: lateral and medial. The researchers who in took up the subject of the cerebellar white substance investigation do not share this view [Ono and Kato 1938, Jastrzębski 1965, Szteyn 1965, Kornelliuses 1968]. Jastrzębski [1965], examining the cerebellar nuclei of field vole bank vole and pine vole, proved the existence of three profound nuclei in the cerebellum; he distinguished lateral nucleus, nucleus interpositus and medial nucleus. Analyzing the structure of the cerebellar nuclei in chinchilla the existence of three deep nuclei was also proved. Szteyn [1965], describing the nuclei of the cerebellum in nutria, proved that there exist four nuclei. Similar results were obtained by Ono and Kato [1938], who described the nuclei of the cerebellum in rabbit. While the division of the central part of the cerebellum's white substance into two intercalated nuclei of the cerebellum in nutria can be associated with high specialization of the front limbs which allows carrying out complicated optional movements, the existence of four nuclei in rabbit and domestic mammals proves that the correlation between the structure of nucleus interpositus and a rate of advance of limbs` movement cannot be fully justified [Jastrzębski 1966, Bujak 1967, Welento *et al.* 1979]. The differences concerning the division of subcortical grey matter of the cerebellum are always present in morphological papers, the statements of some authors writing about the nuclei of the cerebellum who describe four nuclei simultaneously claim that lateral intercalated nucleus and medial intercalated nucleus join together. On enclosed illustrations we can see one big group of cells divided without a visible boundary into two parts [Bujak 1974]. Nevertheless, most papers concerning the structure of cerebellar nuclei contain evident information proving the existence of four nuclei separated from one another by white substances bands. In chinchilla and some rodents *nucleus interpositus* is the longest cellular band, while medial nucleus is the shortest [Jastrzębski 1965, Szteyn 1966]. On the other hand, in boar [Bujak 1974], horse [Bujak

1971], polar fox [Bujak *et al.* 1984], the longest cellular band is medial nucleus. The nuclei of the cerebellum in mole and shrew are relatively the most weakly developed [Skrzypiec 1980]. The structure of subcortical grey matter of cerebellum seems to be rather a species feature and the attempts to systematize mammals on account of the development of cerebellar nuclei cannot be justified in literature available nowadays.

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STRESZCZENIE

Do badań pobrano trzy móżdżki szynszyli. Pobrany materiał utrwalono w formalinie, odwodniono w alkoholu etylowym i zatopiono w bloczki parafinowe. Następnie bloczki krojono w płaszczyźnie poprzecznej na skrawki grubości 12 µm. Skrawki barwiono fioletem krezolu i oglądano pod mikroskopem świetlnym. W móżdżku szynszyli możemy rozróżnić trzy jądra: jądro zębate (boczne, *nucleus dentatus s. lateralis*), wsunięte (*nucleus interpositus*) oraz wierzchu (przyśrod-

kowe *nucleus fastigii s. medialis*). Jądro wsunięte, zlokalizowane w środkowej części istoty rdzennej półkul móżdżku stanowi najdłuższe pasmo komórkowe. Najbliżej płaszczyzny pośrodkowej móżdżku leży w istocie rdzennej robaka jądro przyśrodkowe. Jądro boczne móżdżku jest wyraźnie zarysowanym skupiskiem komórek położonym najbardziej zewnętrznie w stosunku do pozostałych jąder. Jądra móżdżku szynszyli są zbudowane z komórek wielobiegunowych, owalnych i wrzecionowatego kształtu. Na uwagę zasługuje wyraźnie zaznaczona przewaga komórek owalnych w jądrze bocznym móżdżku, natomiast w jądrach wtrąconych i w jądrze przyśrodkowym przeważają komórki wielobiegunowe małe (20–30 μm) i średniej wielkości (30–40 μm).

Słowa kluczowe: ośrodkowy układ nerwowy, móżdżek, jądra móżdżku, szynszyla