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Structure and Topography of Cerebellar Nuclei in the European Bison

Stanisław SZTEYN, Barbara GAWROŃSKA & Teresa BARSZCZEWSKA

Szteyn S., Gawrońska B. & Barszczewska T., 1986: Structure and topography of cerebellar nuclei in the European bison. Acta theriol., 30, 13: 159—166 [With Plate VI]

A description is given of the topography, formation and cell structure of the cerebellar nuclei in the European bison. Studies were made of the cerebellum in European bison from the Białowieża Primeval Forest. The cerebella were sectioned to 15 μm and stained by the Nissl and Klüver-Barrera methods. Four nuclei were found to occur in the cerebellum of the European bison: *nucleus lateralis, nucleus medialis, nucleus interpositus anterior* and *nucleus interpositus posterior. Nucleus lateralis* is the most strongly formed and *nucleus interpositus anterior* most weakly.

[Teachers Training College, Department of Vertebrates Anatomy, Żołnierska Street 14, 10-561 Olsztyn, Poland]

1. INTRODUCTION

The present study forms one of several carried out on the cerebellum of the European bison, *Bison bonasus* (Linnaeus, 1758), using material obtained from the Białowieża herd of these animals. The purpose of this study was to determine the position, formation and cell structure of the cerebellar nuclei in the European bison. The morphology of the cerebellar nuclei in mammals has been examined by a large number of authors among whom Jansen & Brodal (1958) described the cerebellar nuclei in *Primates*, Flood & Jansen (1961) in the cat, Bujak (1971) in the horse, Jastrzębski (1965) and Szteyn (1966, 1974) in certain rodents and Skrzypiec & Jastrzębski (1980) in insectivores. Cerebellar nuclei have also been examined in several species of ruminants (Szteyn, 1969; Jastrzębski, 1966), which provides the opportunity of comparing them with the cerebellar nuclei of the European bison within the same sub-order or even family.

Nomenclature after Ogawa (1935) has been used in the present paper. This author distinguished four nerve centres in the subcortical substance: *nucleus lateralis, nucleus medialis, nucleus interpositus anterior* and *nucleus interpositus posterior.*

2. MATERIAL AND METHODS

Studies were made of the cerebellum in 4 European bison. The study material was fixed in formalin, dehydrated in ethyl alcohol and embedded in paraffin. The cerebella were sectioned to 15 μm, and every second section taken for examination after being stained alternately by the Nissl and Klüver-Barrera methods.

3. RESULTS

3.1. Nucleus lateralis

Nucleus lateralis (nl — Fig. 1—5, Plate VI) is situated in the lateral part of the medullary substance of the cerebellum. On the medial side of it adjacent to *nucleus interpositus posterior* (in the posterior part) and *nucleus interpositus anterior* (in the anterior part). These last two nuclei separate *nucleus lateralis* from *nucleus medialis*. The anterior pole of this centre is situated at the level of the transverse plane running at a distance of about 0.6 mm forwards from the anterior pole of *nucleus medialis*. The posterior pole lies at a distance of about 1.2 mm forwards from the posterior pole of *nucleus medialis*. *Nucleus lateralis* has an average length of 11.6 mm.

In cross-sections the posterior pole of *nucleus lateralis* is an oval group of cells which rapidly enlarges forwards. Two groups of cells appear at a distance of about 1.6 mm from the posterior pole near nl. One of these groups is situated on the lateral side and the other on the ventrolateral side of *nucleus lateralis*. Both groups rapidly enlarge in a forwards direction and connect at the level of 1/3 of the posterior part of nl. This agglomeration is separated from *nucleus lateralis* by a band of fibres. In a forwards direction this agglomeration gradually approaches *nucleus lateralis* and joins it at a distance of about 3.7 mm from the posterior pole. The lateral part of *nucleus lateralis* is formed by evenly distributed cells, while the medial part of the nucleus is divided up by bands of fibres causing the cells in it to be distributed in the form of islands. Halfway along its length *nucleus lateralis* takes on the shape of a transversely placed letter U, the open side of which is directed dorso-medially. In a forwards direction *nurleus lateralis* gradually changes in shape and becomes a rounded agglomeration of cells. At the same time the size of the nucleus slowly decreases. The anterior pole of the nucleus is similar to a small rounded group of cells which gradually disappears.

Nucleus lateralis is formed of multipolar cells measuring 40—80 μm, spindle-shaped cells measuring 50—70μm along the long axis and rounded cells measuring 25—35 μm. Multipolar cells occur most nu-

merously in the nucleus, and rounded cells are least often observed in *nucleus lateralis*. The cells contain a large spherical nucleus with a nucleolus situated centrally. Tigroid substance occurs in the form of scanty large grains.

3.2. Nucleus medialis

Nucleus medialis (nm — Fig. 1—4 and 6, Plate VI) in the European bison lies in the medullary substance of the vermis, near the saggital plane. The anterior part is adjacent from the lateral side to *nucleus interpositus anterior*, and the posterior part of this nucleus is situated on the dorsomedial side of *nucleus interpositus posterior*. The anterior pole of *nucleus medialis* is situated at the level of the transverse plane running at a distance of about 0.6 mm to the rear of the anterior pole of *nucleus lateralis*. The posterior pole of *nucleus medialis* is situated at a distance of about 1.2 mm to the rear of the posterior pole of *nucleus lateralis*. The average length of *nucleus medialis* is 12.2 mm.

The posterior pole of *nucleus medialis* is formed of a horizontal band of cells lying in the dorsomedial part of the medullary substance of the cerebellum. In cross-sections the nucleus rapidly enlarges in a ventral and lateral direction. At a distance of about 1.3 mm forwards from the posterior pole the nucleus becomes similar in shape to a right-angled triangle, with the right angle directed dorsally and laterally. The dorsal part of the nucleus is divided up horizontally by bands of fibres running through it. These bands disappear at a distance of about 2.5 mm from the posterior pole of nm. Cells are evenly distributed in the ventral part of the nucleus. Halfway along its length its shape gradually changes and becomes a rounded group of cells. Near the anterior pole this nucleus again takes on a triangular shape, then a narrow horizontal band of cells which gradually disappears.

Nucleus medialis in the European bison is formed of loosely arranged multipolar cells measuring 50—70 μm, spindle-shaped cells measuring 30—60 μm along the long axis and a few rounded cellss. The cells contain, a large spherical nucleus with centrally situated nucleolus. Tigroid substance occurs in the form of medium-sized grains.

3.3. Nucleus interpositus posterior

Nucleus interpositus posterior (nip — Fig. 1—3 and 7, Plate VI) is a short band of cells situated in the medullary substance of the cerebellum. The posterior part of the nucleus lies in the ventral part of

the medullary substance then from halfway along its length, shifts upwards and is situated between *nucleus lateralis* and *nucleus medialis*. The posterior pole of *nucleus interpositus* posterior is situated at the level of the transverse plane running at a distance of about 350 μm forwards from the posterior pole of *nucleus lateralis*. The anterior pole of this centre lies at a level of 1/4 of the posterior part of *nucleus lateralis*. The average length of *nucleus interpositus* posterior is 2.3 mm.

The posterior pole of *nucleus interpositus posterior* is formed of a small oval group of cells, which very slowly enlarges and halfway along the length of the nucleus shifts gradually dorsad. At a little distance forwards from half its lentgh, on the dorsal side of nip, a large group of cells appears which accompanies *nucleus interpositus posterior*. This group occupies a larger area and is formed of a larger number of cells than *nucleus intercalatus posterior*. Near the anterior pole this group joins nip, which takes on the form of an elongated band of cells, adhering to the ventromedial margin of *nucleus lateralis*. The anterior pole of the nucleus is formed by cells scattered among nerve fibres, which gradually disappear.

Nucleus interpositus posterior is formed of loosely arranged spindle-shaped cells measuring 35—50 μm along the long axis, multipolar cells measuring 35—45 μm and rounded cells measuring 20—25 μm. Tigroid substance occurs in the form of small and medium-size grains. The cell nucleus is spherical and large, with centrally positioned nucleolus.

3.4. Nucleus interpositus anterior

Nucleus interpositus anterior (nia — Fig. 2—4 and 8, Plate VI) lies in the medullary substance of the cerebellum between *nucleus lateralis* and *nucleus medialis*. The posterior pole of *nucleus interpositus anterior* is situated at a distance of about 1.8 mm forwards from the posterior pole of *nucleus interpositus posterior*. The anterior pole of this nucleus is situated at a little distance forwards from the anterior pole of *nucleus medialis*. The average length of *nucleus interpositus anterior* is 9.1 mm.

The posterior pole of the nucleus is formed by a small oval group of cells which gradually enlarges in a forwards direction. Halfway along the length of *nucleus interpositus anterior*, its lower limit becomes indistinct. In the ventral part of the nucleus the cells are irregularly distributed, as they are separated by bands of fibres. This band occupies considerable space from *nucleus lateralis* to *nucleus medialis*. The general shape of the nucleus does not alter. On the ventromedial side of the anterior part of the nucleus there is a group of cells which accompanies *nucleus interpositus anterior* for a short distance and then

joins it. As from this place *nucleus intercalatus anterior* gradually takes on the shape of a half-moon, the concave side of which is directed medially. The nucleus becomes smaller in the direction of the anterior pole and gradually disappears. The anterior pole of nia is a small oval group of cells situated on the medial side of *nucleus lateralis*.

Nucleus interpositus anterior is formed of loosely arranged multipolar cells maesuring from 30 to 60 μm and spindle-shaped cells measuring from 40 to 60 μm along the long axis. The cells contain a large spherical nucleus with a nucleolus situated centrally. Tigroid substance occurs in the form of large and medium-sized grains.

4. DISCUSSION

There are considerable differences in the formation, topography and structure of the cerebellar nuclei in mammals, frequently even in closely related species. Four nuclei can be distinguished in the cerebellum of the European bison: *nucleus lateralis, nucleus medialis, nucleus interpositus anterior* and *nucleus interpositus posterior*. These nuclei form four clearly separate bands of cells, as they do in domestic ruminants (Jastrzębski, 1966), the roe deer (Szteyn, 1969), nutria (Szteyn, 1966) and horse (Bujak, 1971). In the mole and common shrew, however (Skrzypiec & Jastrzębski, 1980), voles (Jastrzębski, 1965), and beaver (Szteyn, 1974) *nucleus interpositus* is homogeneous and does not divide into *nucleus intercalatus anterior* and *posterior*. Brunner (1971) distinguished only three nuclei in the cerebellum of ungulates, treating *nucleus interpositus anterior* and *posterior* as one centre only. In the European bison *nucleus intercalatus anterior* and *nucleus intercalatus posterior* are quite clearly separated.

Nucleus lateralis in the European bison is strongly formed, although not folded, as in the case of *Primates* (Jansen & Brodal, 1958). *Nucleus lateralis* in the bison, in comparison with *nucleus lateralis* in other representatives of *Bovidae*, has its anterior pole situated furthest forward. In the goat, cow and sheep *nucleus lateralis* begins only halfway along the length of *nucleus interpositus anterior* (Jastrzębski, 1966). The posterior pole of *nucleus lateralis* in the European bison lies in the same position as in sheep (Jastrzębski, 1966), that is, is situated slightly to the rear of the posterior pole of *nucleus interpositus posterior*. *Nucleus lateralis* in the European bison has no contact with *nuclei intercalati*. In the cow and sheep (Jastrzębski, 1966) *nucleus lateralis* is connected by cell pontes with *nucleus interpositus anterior* and *nucleus interpositus posterior*, and in the goat with *nucleus interpositus anterior*. *Nucleus lateralis* in the European bison, as in other ruminants, has

divisions in its course. In the posterior part it is formed by two groups of cells, which in a forwards direction join in one band of cells. *Nucleus lateralis* in the cow, goat and sheep (Jastrzębski, 1966) divides into two groups halfway along its length: the dorsal and ventral groups, which join together in the posterior part. There are also other differences in cell structure in *nucleus lateralis* in the European bison as compared with other ruminants. In the cow and goat this nucleus is formed by medium-sized and small triangular, spindle-shaped and rounded cells, There are only a few large cells. Small and medium-sized cells are only sporadically found in *nucleus lateralis* in the sheep. The majority of cells in this nucleus in the European bison are large multipolar cells measuring from 40 to 80 μm.

Nucleus medialis is the longest of the cerebellar nuclei in the European bison, as it is in the cow and sheep (Jastrzębski, 1966) and roe deer (Szteyn, 1969). It is only in the goat (Jastrzębski, 1966) that *nucleus medialis* is shorter than *nucleus lateralis*. *Nucleus medialis* is a compact band of cells separated from the other nuclei by a distinct cell-free zone. In the European bison *nucleus medialis* does not divide into groups, unlike the analogical nucleus in other species of the Bovidae family (Jastrzębski, 1966). Szteyn (1969) distinguished two parts in the cell structure of *nucleus medialis* in the roe deer: large and small cells. The cells forming *nucleus medialis* in the European bison are most similar in respect of size, shape and structure of tigroid substance to cells of the small-cell part of this nucleus in the roe deer.

Nucleus interpositus posterior is definitely the shortest nucleus among the cerebellar nuclei of the European bison, being only 1/3 the length of *nucleus interpositus anterior*. In domestic ruminants (Jastrzębski, 1966) *nucleus interpositus posterior and nucleus interpositus anterior* are of approximately similar length. The first of these, particularly the posterior part of this nucleus which is situated in the ventral part of medullary substance below the other nuclei, differs from the results of studies by Brunner (1911), Jastrzębski (1966) and Szteyn (1969) on other ungulate species. In the European bison it is formed by two groups of cells, dorsal and ventral. Similar structure of this nucleus was found in the cow and sheep (Jastrzębski, 1966). The cells of *nucleus interpositus posterior* are the smallest of all the cells forming cerebellar nuclei in the European bison. The same applies to the roe deer (Szteyn, 1969). In domestic ruminants, on the other hand (Jastrzębski, 1966) the cells forming *nucleus interpositus posterior* are larger than those occurring in *nucleus interpositus anterior*.

Nucleus interpositus anterior in the European bison is situated in a similar way to that in other mammals (Jastrzębski, 1966; Ohkawa,

1957; Szteyn, 1966, 1969), although distinct differences can be seen in the shape of the nucleus in cross-sections. In the goat, sheep and cow (Jastrzębski, 1966) and nutria (Szteyn, 1966) this nucleus is an oval group of cells flattened dorsoventrally; in the European bison it is an oval with its long axis running vertically. The cell structure of this nucleus in the European bison differs slightly from the analogical nucleus in domestic ruminants (Jastrzębski, 1966), since in the former the nucleus is formed by multipolar and spindle-shaped cells of medium size, containing a large distinct nucleus and tigroid substance in the form of large and medium-sized grains. In domestic ruminants, on the other hand, *nucleus interpositus anterior* is formed by triangular and spindle-shaped cells of small and medium size containing a not very large and indistinct nucleus. Tigroid substance in the cow, sheep and goat (Jastrzębski, 1966) occurs in the form of fine granules.

REFERENCES

1. Brunner H., 1911. Die zentralen Kleinhirnkerne bei der Säugetiere. Arb. Neurol. Wien, *22:* 200—277.
2. Bujak A., 1971: Topografia i cytoarchitektonika jąder móżdżku konia. Pol. Arch. wet., *14:* 613—622.
3. Flood S. & Jansen J., 1961: On the cerebellar in the cat. Acta anat., *46:* 52—72.
4. Jansen J. & Brodal A., 1958: Das Kleinhirn. Handbuch der Mikroskopischen Anatomie des Menschen. Springer-Verlag: 91—162. Berlin.
5. Jastrzębski M., 1965: Jądra móżdżku niektórych *Microtidae (Rodentia).* Annls Univ. M. Curie-Skłodowska, C *20:* 167—178.
6. Jastrzębski M., 1966: Jądra móżdżku przeżuwaczy domowych. Annls Univ. M. Curie-Skłodowska, DD *21:* 263—278.
7. Ogawa T., 1935: Beiträge zur vergleichenden Anatomie des Zentralennervensystems der Wassersäugetiere. Über die Kleinhirnkerne der Pinnipedien und Zetazeen. Arb. Anat. Inst. Sendai, *17:* 63—136.
8. Ohkawa K., 1957: Comparative anatomical studies of cerebellar nuclei of mammals. Arch. hist. Jap., *13:* 21—57.
9. Skrzypiec Z. & Jastrzębski M., 1980: Nerve centres of the cerebellum in the mole and common shrew. Acta theriol., *25:* 25—30.
10. Szteyn S., 1966: Budowa i topografia jąder móżdżku nutrii. Pol. Arch., wet., *10:* 309—320.
11. Szteyn S., 1969: The nuclei of the cerebellum of the roe deer. Acta theriol., *14:* 321—326.
12. Szteyn S., 1974: Cerebellar nuclei in the beaver. Acta theriol., *19:* 143—150.

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Stanisław SZTEYN, Barbara GAWROŃSKA i Teresa BARSZCZEWSKA

BUDOWA I TOPOGRAFIA JĄDER MÓŻDŻKU ŻUBRA

Streszczenie

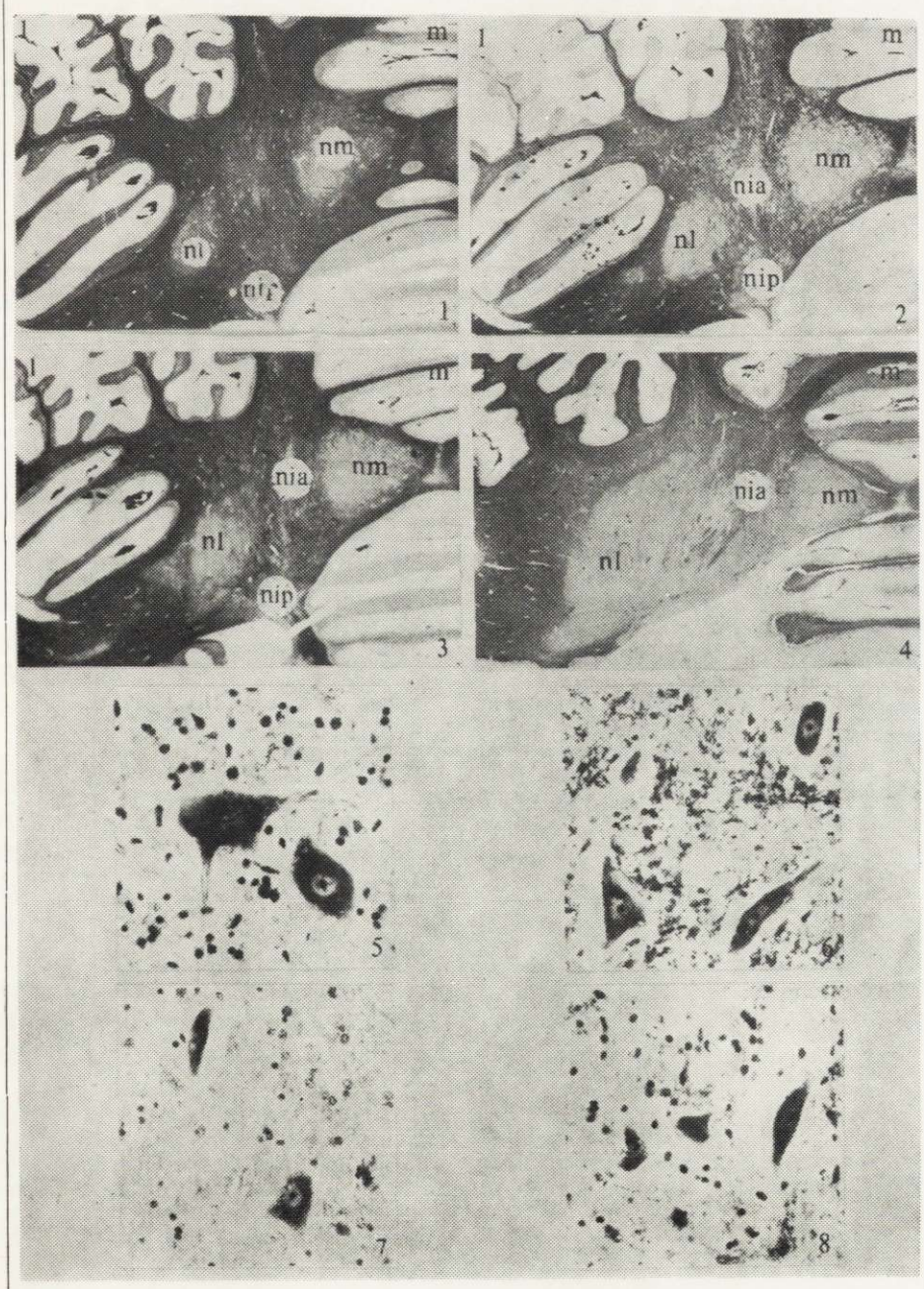
Badania przeprowadzono na móżdżkach czterech żubrów. Móżdżki cięto na skrawki poprzeczne grubości 15 μm. Skrawki barwiono metodami Nissla i Klüver-Barrery. Opisano topografię, ukształtowanie i budowę komórkową jąder móżdżku żubra: *nucleus lateralis* (nl — ryc. 1—5), *nucleus medialis* (nm — ryc. 1—4 i 6), *nucleus interpositus posterior* (nip — ryc. 1—3 i 7) i *nucleus interpositus anterior* (nia — ryc. 2—4 i 8). *Nucleus lateralis* żubra jest silnie wykształcone. W porównaniu z *nucleus lateralis* innych przedstawicieli z rodziny *Bovidae* ma biegun przedni najbardziej wysunięty do przodu. *Nucleus medialis* jest najdłuższym spośród jąder móżdżku żubra i nie wykazuje ono podziału na grupy. W porównaniu z innymi przedstawicielami z rodziny *Bovidae nucleus interpositus posterior* żubra usytuowane jest w dolnej części istoty rdzennej, poniżej pozostałych jąder móżdżku. *Nucleus interpositus posterior* jest zdecydowanie najkrótszym jądrem w móżdżku żubra.

EXPLANATION OF PLATE VI.

Fig. 1. Cross-section of the European bison cerebellum at the level of the posterior pole of *nucleus interpositus posterior*.
Fig. 2. Cross-section of the European bison cerebellum at the level of the posterior pole of *nucleus interpositus anterior*.
Fig. 3. Cross-section of the European bison cerebellum at the level of the anterior pole of *nucleus interpositus posterior*.
Fig. 4. Cross-section of the European bison cerebellum halfway along the length of *nucleus lateralis*.
Fig. 5. Cells of *nucleus lateralis*.
Fig. 6. Cells of *nucleus medialis*.
Fig. 7. Cells of *nucleus interpositus posterior*.
Fig. 8. Cells of *nucleus interpositus anterior*.

Abbreviations

l — lateral side
m — medial side
nia — *nucleus interpositus anterior*
nip — *nucleus interpositus posterior*
nl — *nucleus lateralis*
nm — *nucleus medialis*



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