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Structure and Topography of Dorsal Funiculus Nuclei in European Bison

BUDOWA I TOPOGRAFIA JĄDER POWRÓZKA GRZBIETOWEGO ŻUBRA

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The study was carried out on the ***medulla oblongata*** of 4 European bison aged from 6 months to 8 years. Histological preparations were stained by the methods of Nissl and Klüver-Barrera. The nuclei of the dorsal funiculus in the bison were divided into three separate cell columns: ***nucleus gracilis, nucleus cuneatus*** and ***nucleus cuneatus accessorius***. In the European bison the best developed nucleus was the accessory cuneate, where tracts were ending for deep sensitivity from the area of the head, neck and anterior surface of the chest. *Nucleus gracilis* receiving stimuli from the hindlegs, tail and posterior part of the trunk was least well developed, and significantly smaller than *nucleus cuneatus* receiving stereognostic stimuli from the foreleg.

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1. INTRODUCTION

The present work is a continuation of the studies on the cytoarchitectonics and topography of the nervous centres in the brain stem of the European bison. The purpose of the study was the morphology of the nuclei of the dorsal funiculus where tracts conducting deep sensory stimuli are ending. These important nervous centres are relatively young in phylogenesis, and they appeared first in reptiles (Clara, 1959). In mammals they are, as a rule, well developed but, as demonstrated by the studies published so far, fairly significant difference in their structure were found between closely related animals (Lewandowski, 1953; Welento, 1957; Goller, 1965, and others). In the neuroanatomical literature no information has been found on the dorsal funiculus nuclei in European bison.

2. MATERIAL AND METHODS

The study included the ***medulla oblongata*** of four European bison from the Białowieża herd aged from 6 months to 8 years. The material was fixed in

formalin, dehydrated in ethanol series and embedded in paraffin. The *medulla oblongata* specimens were cut into transverse sections 15 μm thick. The sections were stained by the methods of Nissl and Klüver-Barrera.

3. RESULTS

The nuclear complex of the dorsal funiculus of European bison is formed by three clearly separate neuronal columns: *nucleus gracilis* or *Golli (Ng)*, *nucleus cuneatus* or *Burdachi (Nc)* and *nucleus cuneatus accessorius* or *Monacowi (Nca)*.

Nucleus gracilis (Fig. 1—2 and 4—6 Plate XVI) is a homogenous cell column, not very well demarcated from the surrounding tissue, situated in the dorsomedial part of the caudal part of the *medulla oblongata*. The caudal pole of the *Ng* is at the height of the caudal end of the hypoglossus nucleus. In the rostral direction the nucleus disappears several tens of μm caudally to the top of *calamus scriptorius*.

In cross-sections the caudal pole of *Ng* is a small rounded cell group situated in the dorsomedial part of the *medulla oblongata* above the *canalis centralis*. In the rostral direction the nucleus increases in size, mainly in dorsal and ventral directions assuming the shape of a vertically elongated cell group situated on the medial side of *Nc*. It is separated from the latter nucleus by a well visible band of fibres parallel to the long axis of the brain stem. In the rostral part the *Ng* is shifted gradually laterally, moving away from the midline of the medulla and comes to lie nearer to *Nc*. Rostrally the separation of *Ng* from *Nc* is less evident than in the caudal part, and in certain preparations both nuclei are even in contact. Near the rostral pole the number of cells forming the *Ng* decreases gradually, and the nucleus disappears caudally to the caudal end of the fourth ventricle. The rostral pole of *Ng* is formed by isolated scattered cells near the medial surface of *Nc*.

The cell structure of the *Ng* in European bison is differentiated. Most cells are triangular in shape, intensely staining, 30—40 μm in size, filled with a great number of small tigroid granules. Less numerous are large multipolar perikaryons 45—60 μm in size, with coarse granules of tigroid, and fusiform perikaryons 70—90 μm long. The fusiform cells have a very characteristic structure of the tigroid, near the nucleus the tigroid is present as coarse granules, while in the tapering ends of the perikaryon the tigroid is arranged in longitudinal bands. Moreover, the *Ng* contains few rounded cells, 15—25 μm in size, with coarse tigroid granules situated at the periphery of the perikaryon. All *Ng* cells have spherical clear nuclei with dark, centrally situated nucleolus.

Nucleus cuneatus (Fig. 2, 3) is an elongated column of cells situated in the dorsal part of the *medulla*. Its length is equal to that of the *Ng*, but the whole nucleus is shifted somewhat rostrally. In its caudal part the *Nc* appears at the height of the pole of the dorsal parasympathetic nucleus, and rostrally it disappears several tens of μm caudally to the top of the *calamus scriptorius* in the dorsal part of the floor of the fourth ventricle.

On transverse sections the caudal pole of *Nc* is formed by few scattered cells, situated on the lateral side of *Ng*. Rostrally the nucleus increases rapidly in size, and its cells occupy a large area in the dorsal part of the *medulla oblongata*. The caudal pole of the *Nc* reaches much lower than the caudal pole of *Ng*. At half the length of *Nc*, slightly caudally, at the lateral side of this nucleus the *Nca* appears. The rostral half of the *Nc* fills the irregular space between *Ng* and *Nca*. The rostral pole of *Nc* is formed by few, irregularly situated cells. They lie on the medial side of *Nca* and disappear rostrally to *calamus scriptorius*.

Nc is formed by loosely and irregularly arranged cells of identical size and shape as the cells of *Ng*. The cell structure of both nuclei is, however, not identical. In the *Nc* the number of large multipolar cells is relatively much higher, while the small triangular cells are less numerous than in *Ng*.

Nucleus cuneatus accessorius (Fig. 2—3 and 7—9 Plates XVI and XVII) is the longest and best developed nucleus in the dorsal funiculus of the European bison. The nucleus lies in the dorsolateral part of the *medulla oblongata* caudally to the fourth ventricle (the caudal one-third of the *Nca*) and below the floor of the fourth ventricle (rostral two-thirds of the nucleus). The caudal end of the *Nca* lies at a near distance posteriorly to half the length of *Nc*, and its rostral pole disappears at the height of the rostral pole of the inferior olivary nucleus. The length of *Nca* is over twice that of *Ng* or *Nc*.

On transverse cross-sections the caudal pole of *Nca* is formed by two rounded groups of cells situated at the lateral side of *Nc*. Rostrally these groups fuse, the nucleus increases rapidly in size assuming a broad oval shape. *Nca* cells fill the whole dorsolateral area of the *medulla oblongata*. At half its length the nucleus divides into two groups: ventral and dorsal. This division continues over a long distance. Only near the rostral pole both these groups fuse. The rostral end of the *Nca* is formed by a rounded group of cells situated at the ventrolateral side of the caudal vestibular nucleus. The caudal part of *Nca* lies on the medial side close to the *Nc*, and the rostral half of the nucleus lies laterally and ventrolaterally to the caudal vestibular nucleus.

Nca is formed by cells whose perikaryons vary in size and shape. Most of them are fusiform cells 35—90 μm long, with tigroid arranged in bands, and pear-shaped cells 25—50 μm in size, with coarse tigroid granules. Less numerous are multipolar cells 40—50 μm in size, containing fairly numerous coarse tigroid granules. Moreover, in *Nca* single triangular cells 25—35 μm in size, with a large amount of tigroid of foamy consistence are present. All *Nca* cells have a spherical clear nucleus with centrally situated dark staining nucleolus.

4. DISCUSSION

A characteristic feature of the nuclei of the dorsal funiculus in the European bison is a very well developed *Nca*. In this nucleus tracts are ending which transmit the stereognostic stimuli from the head, neck and anterior part of the chest. In the European bison it is twice as long as the remaining nuclei of the dorsal funiculus, and in the rostral part is divided into a dorsal and a ventral cell group. In cattle (Goller, 1965) and dog (Hoffman, 1955) the *Nca* is as long as the *Ng*, and in man it is even much shorter (Ziehen, 1934; Olszewski & Baxter, 1954). The cell structure of the *Nca* in the European bison is more complex than in domestic cattle, and certain other mammals. Besides triangular, multipolar and fusiform perikaryons described in cattle (Goller, 1965; Welento, 1957) and coypu (Szteyn, 1962) the *Nca* of the European bison contains fairly numerous round and pear-shaped cells. In the European bison particularly the caudal part of the nucleus is very well developed. In the European bison one-third of the *Nca* lies caudally to the *calamus scriptorius*, while in cattle (Goller, 1965) only one-seventh part of this nucleus lies in the part of the medulla oblongata caudally to the fourth ventricle.

In the European bison the *Ng* is a column of cells of the same length as *Nc*, but its cross-section is smaller and contains less neurons. The studies of other authors showed that in most mammals, similarly as in European bison, the *Nc* was better developed than the *Ng* (Ogawa, 1928; Yoda, 1940; Lewandowski, 1953, and others). This is explained by greater skill of the anterior extremities observed, as a rule, in most mammals, and the nervous pathways for deep sensitivity from these extremities end in the *Nc*, while similar pathways from the hindquarters, that is also from the less skilled posterior extremities, reach the less well developed *Ng*. In the available literature only Welento (1957) and Goller (1965) studying the nuclei of the dorsal funiculus in cattle observed inverse proportions, that is a better development of *Ng* in relation to *Nc*. Welento (1957) explained this observation as a result of reduced skill of the anterior extremities in cattle during phylogenetic development. In the European bison the *Ng* is a homogenous column of cells, while in certain mammals a division of this nucleus has been observed. Yoda

(1940) discerned in the *Ng* of cats a small-cell dorsal part and a ventral part containing large perikaryons. The division of *Ng* into a lateral and a medial cell group has been described by Bischoff (cit. after Hoffman, 1955) in rats and kangaroos. This author supposed that the medial part of the nucleus is connected with deep sensitivity stimuli arriving from the very well developed and very strong tail of these animals.

The *Nc* of the European bison, similarly as that in other mammals is shifted slightly rostrally, in relation to *Ng*. The much better development of *Nc* in relation to *Ng* suggests that the stereognostic stimuli arriving through the cuneate fasciculus to the *Nc* are in the European bison much more abundant (anterior extremity) that those transmitted along the *gracilis fasciculus* to the *Ng* (posterior extremity, tail and hindquarters).

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EXPLANATION OF PLATES

Plate XVI

Photo. 1. Cross-section of ***medulla oblongata*** at the height of the middle parts of *Ng* and *Nc*.

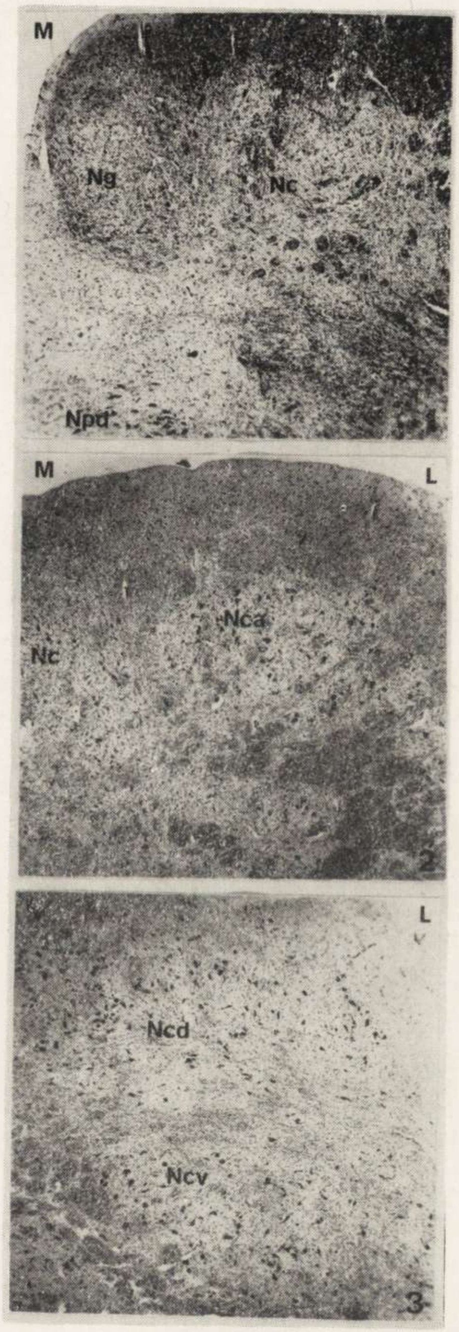
Photo. 2. Cross-section of ***medulla oblongata*** at the height of the caudal part of ***Nca***.

Photo. 3. Cross-section of ***medulla oblongata*** at the height of the middle part of ***Nca***.

Photo. 4—6. *Ng* cells. Photo. 7—9. *Nca* cells.

Plate XVII

L — lateral side, M — medial side, *Nc* — ***nucleus cuneatus***, *Nca* — ***nucleus cuneatus accessorius***, *Ncd* — dorsal cell group of ***nucleus cuneatus accessorius***, *Ncv* — ventral cell group of ***nucleus cuneatus accessorius***, *Ng* — ***nucleus gracilis***, *Npd* — ***nucleus parasympathicus dorsalis***.



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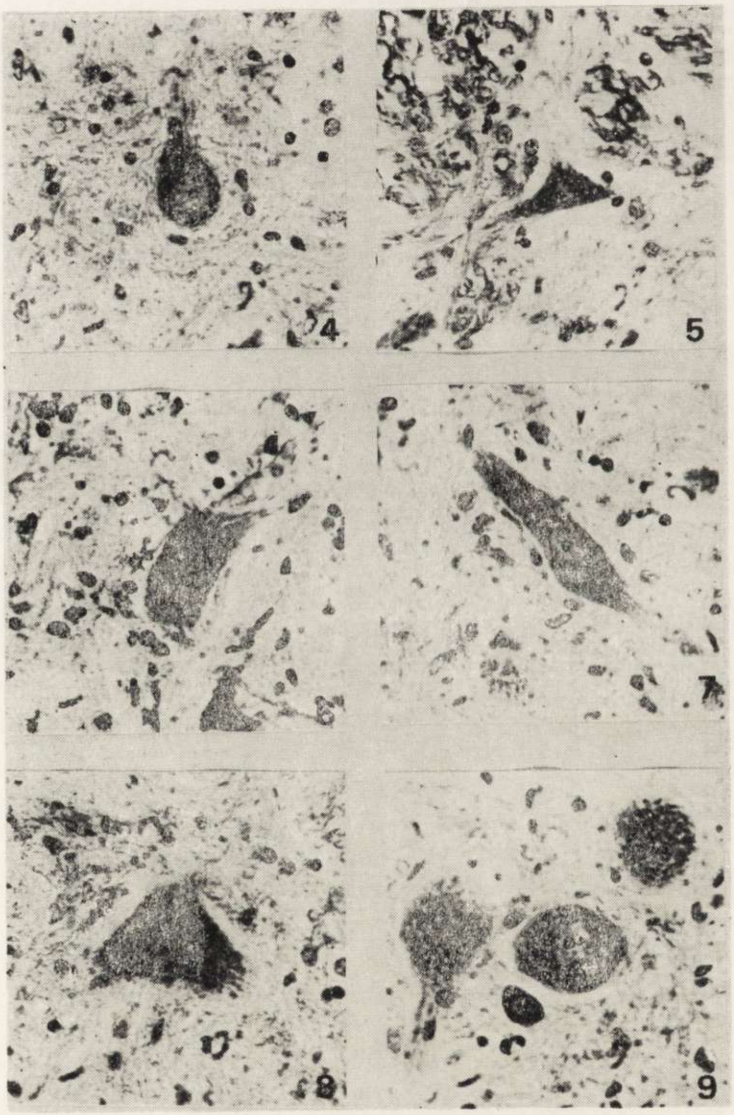

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