MACROSCOPIC STRUCTURE OF THE NUTRIA BRAIN

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The macroscopic features of the nutria (*Myocastor coypus*) brain are described. Brains from young and adult animals of both sexes were studied with special attention given to the cerebellum. Several schemes proposed for subdividing the mammalian cerebellum and for naming the subdivisions are briefly reviewed. Possible reasons for the lack of consistency in cerebellar nomenclature are offered.

The nutria, also commonly referred to as the swamp beaver and coypu, is native to South America. The subspecies found in the southern United States is recognized by Osgood (1) and Ashbrook (2) to be *Myocastor coypus bonariensis*. The nutria found in the Gulf Coast area are descendants of a nutria colony which was introduced into Louisiana in 1937 (2). Since then the nutria has extended its range slowly but steadily northward. Being a semi-aquatic rodent, the nutria has primarily followed rivers and tributaries. Recently the nutria has been reported to be inhabiting certain areas of southeastern Oklahoma (3).

In recent years the use of the nutria as a laboratory animal has received attention. Laboratory experiments involving the nutria and suitable anesthetic procedures have been described by several investigators (4-8).

A survey of the literature showed that little work has been done on macroscopic features of the nutria brain, especially those of the cerebellum. There have been numerous schemes proposed for the description of the mammalian cerebellum. Many share basic similarities, but most differ as to designation and nomenclature of the cerebellar subdivisions. In this study, the scheme used incorporates a new method for designating the cerebellar fissures with certain basic ideas of earlier proposals.

MATERIALS AND METHODS

Specimens studied included brains of both sexes, taken from the young and the adult. After sacrificing the nutria with an overdose of anesthetic, the head and neck were dissected from the body and temporarily fixed in 10% formalin. After study of the topographical features was completed, sagittal sections of the brains were made. The reference points for making the medial sagittal sections were the longitudinal pyramidal fissure of the medulla oblongata and the optic chiasma of the diencephalon.

After sectioning, the mesial surfaces of several of the brains were stained according to procedures of Hewitt (9) and Waldman and Michaels (10). In addition to these methods, the cerebellum was also stained with acetocarmine.

The external and internal structures of the nutria brain were photographed and drawings were made from tracings of the photographic negatives.

RESULTS AND DISCUSSION

Description of the nutria brain.

The nutria brain is a slightly elongated structure with prominent olfactory bulbs, a lissencephalous (convolution-free) cerebrum, and cerebellum consisting of numerous fissures and lobules. The olfactory bulbs, cerebrum, and cerebellum are situated in the same longitudinal plane, with the spinal cord being deflected ventrally at an angle of approximately 40 degrees.

Dorsal view (Fig. 1). The paired olfactory bulbs are ovoid-shaped with their posterior dorsal border partially covered by the cerebrum. The cerebrum is a heart-shaped structure separated into paired cerebral hemispheres by this longitudinal cerebral fissure. Located laterally on each side of this fissure are, usually, three pairs of slight depressions in the cerebral cortex. In some of the brains studied these depressions were quite distinct, while in others they were absent.

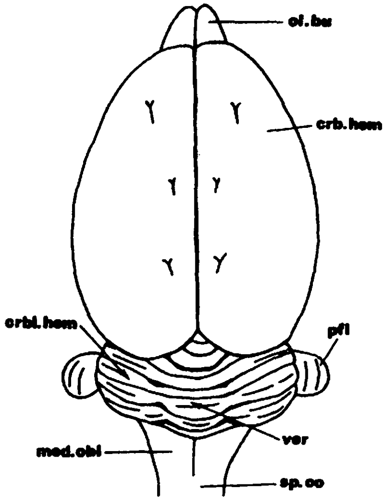

FIGURE 1. Dorsal view of the nutria brain.

The cerebrum and cerebellum are separated by the transverse cerebro-cerebellar fissure. The cerebellum consists of a median portion (vermis) and two distinct cerebellar hemispheres. Extending from the ventrolateral surface of each hemisphere is the very prominent paraflocculus. Portions of the medulla oblongata extend posteriorly from beneath the ventral surface of the cerebellum.

Lateral view (Fig. 2). The olfactory bulbs are separated from the cerebrum by the rhinal fissure, which also marks the lateral boundary of both the olfactory tract and the pyriform lobe of the cerebrum. The paired olfactory tracts extend posteriorly from the olfactory bulbs to join with the pyriform lobe at the level of the optic chiasma and hypophysis. On the lateral cerebral surface of some brains was a shallow depression extending posterodorsad, termed the lateral sulcus in many mammalian orders. However, this depression did not seem to be a consistently typical feature of the nutria cerebrum.

The most prominent cranial nerves visible from the lateral view are the optic (II) and trigeminal (V). Distinctly visible are the paraflocculi, which extend lateroocaudad from the cerebellar hemispheres; the *flocculi* are located slightly anterior and ventral to these.

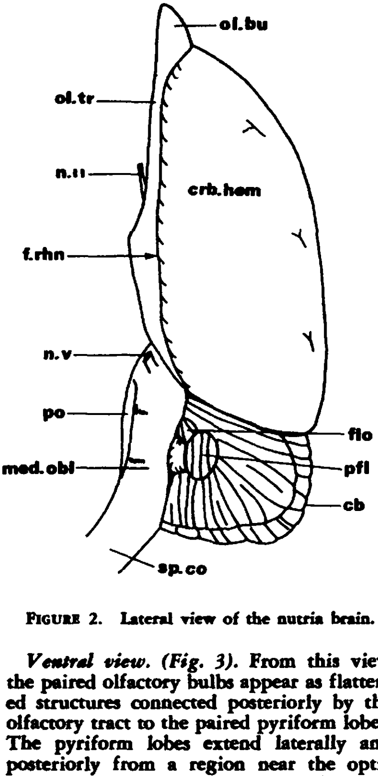

FIGURE 2. Lateral view of the nutria brain.

Ventral view. (Fig. 3). From this view the paired olfactory bulbs appear as flattened structures connected posteriorly by the olfactory tract to the paired pyriform lobes. The pyriform lobes extend laterally and posteriorly from a region near the optic chiasma. Immediately posterior to the optic chiasma is the hypophysis with its associated infundibulum and mammillary body.

The oculomotor nerves (III) are visible caudad to the mammillary body; they are bounded laterally by the paired crus cerebri of the medulla oblongata, which are partially concealed by the pyriform lobes of the cerebrum. Posterior to the crus cerebri is the transversely directed pons of the metencephalon. Extending anteriorly from the pons is the trigeminal nerve (V), the most prominent of the cranial nerves. Located posterior to the pons and separated from it by a transverse groove is the trape-

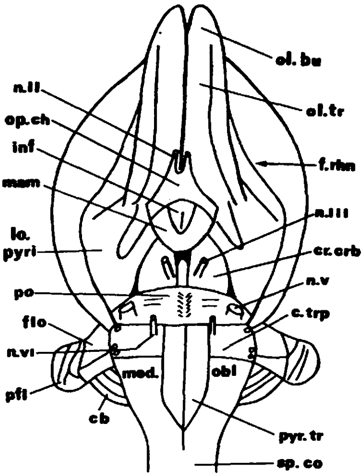

FIGURE 3. Ventral view of the nutria brain.

zoid body. The paired abducens nerves (VI) have their origins near the junction of the trapezoid body and pyramidal tract. The medulla oblongata tapers posteriorly to join with the spinal cord.

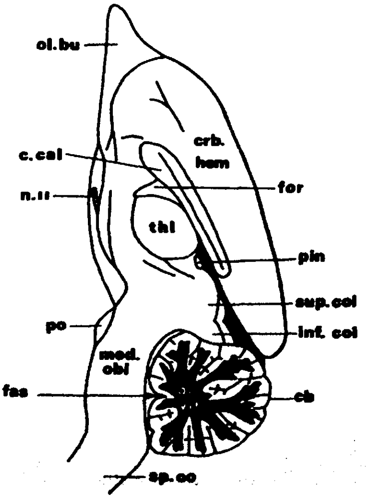

FIGURE 4. Midsagittal view of the nutria brain.

Midsagittal view (Fig. 4). Internally, the cerebral cortex extends posteriorly and folds over the surface of two prominent bulges, the superior and inferior colliculi. The corpus callosum is situated medially and is directed slightly anteroventrad. Near the anterior end of the corpus callosum is a bundle of projection fibers commonly referred to as the fornix. Immediately posterior to the fornix is the circular thalamus. Dorsally, the pineal body is situated between the superior colliculus and the thalamus. In certain specimens, the superior and inferior colliculi were visible dorsally between the cerebellum and cerebral hemispheres.

Description of the cerebellum.

Several schemes concerning the structure and nomenclature of the mammalian cerebellum have been proposed (11-27). The major differences in these schemes are based upon: (a) the designation of either two or three cerebellar lobes; (b) distinction or no distinction between the vermis and the cerebellar hemispheres; (c) the numbering of the cerebellar lobules; (d) designation of areas where the paraflocculi and flocculi are connected to the lateral hemispheral extensions of the vermis; (e) insistence by some investigators that the highly specialized nomenclature of the human cerebellum is applicable to that of all mammalian orders.

Until the early 1960's, the cerebellar nomenclature proposed by Larsell (19, 20), was generally accepted by most investigators. However, in recent years Dillon's (25, 26) scheme of cerebellar nomenclature has begun to receive recognition. Larsell designated two main cerebellar divisions, the corpus cerebelli and the flocculonodular lobe. According to Larsell, these two cerebellar divisions consist of ten lobules which he designated as I through X. Dillon has proposed that the cerebellum consists of an anterior and a posterior lobe, with each lobe divided into four lobules, *i.e.*, lobules designated I through VIII.

In this study of the nutria cerebellum, two major cerebellar lobes are described, an anterior and a posterior lobe, each of which consists of four lobules. Certain of these vermian lobules also have lateral extensions which form the cerebellar hemispheres. Externally, it is difficult to determine the area which comprises an individual lobule; therefore, the method for describing the cerebellar lobules is based upon the internal subdivisions of the cerebellum. The lobules are designated I through VIII, beginning anteriorly at the fastigium (a depression of the ventral surface of the cerebellum) and numbering consecutively. The anterior lobe is composed of lobules I through IV, while lobules V through VIII comprise the posterior lobe. The fissures are also designated in a similar manner by using the letters A through G. Originally, the cerebellar fissures were named according to the order in which they first appeared during the embryonic development of the cerebellum. However, more recent investigations have shown the order of embryological appearance of the cerebellar fissures to be different from that noted earlier (15, 16, 18, 21, 23, 25, 26). Therefore, the retention of the terms fissura prima and fissura secunda, as used in the original nomenclature, is no longer a valid method of designation. For comparative purposes, however, the traditional nomenclature of the lobules and fissures will be noted in parentheses.

Criteria used in determining which anatomical features constitute a lobule in the nutria cerebellum are the following: (a) there must be a relative independence of the cerebellar lobules, with each lobule being demarcated from the neighboring lobule by a fissure which extends internally and ends in close proximity to the central medullary body of the arbor vitae; (b) there must be only one main medullary ray from the central medullary body extending into the lobule; (c) most importantly, this main medullary ray must be a direct branch of the central medullary body, not one of its numerous sub-branches. In this study, the word "sublobule" will be used to designate those lobular divisions which are present on the external surface of the cerebellum, and the word "folia" will be used to indicate subdivisions of the cerebellar lobules occurring internally within a fissure.

Cerebellar Subdivisions (Fig. 5-9). Lobule I (lingula) is situated between the fastigium and fissura A (precentral). The major individual variation in this lobule is encountered in the branching pattern of the medullary ray and in the size of the sublobules. Lobule II (Dillon's innominata) is separated from lobule III (centralis) by fissura B (intracentral). The main individual variation in this lobule is in the angle at which the medullary ray extends from the central medullary body of the arbor vitae. Lobule III is separated from lobule IV (culmen) by fissura C (preculminate). The variations observed in this lobule are similar to those of lobule II. Lobule IV, the largest lobule of the anterior lobe, is bounded posteriorly by fissura D (prima). This fissura has received much attention as a primary morphological landmark of the mammalian cerebellum.

In the nutria cerebellum, lobule I is the only vermian lobule of the anterior lobe which does not have lateral hemispheral extensions. The hemispheral portions of lobules II, III, and IV extend laterally toward the cerebellar peduncles and flocculi.

The largest lobule of the nutria cerebellum is lobule V (declive). Lobule V is

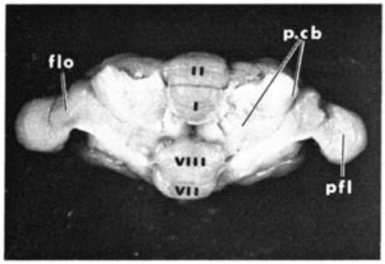

FIGURE 5. Anterior view of the nutria cerebellum.

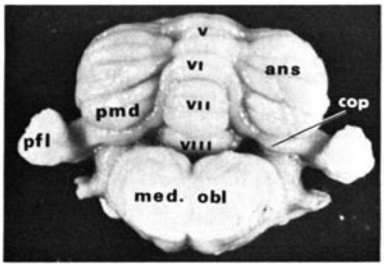

FIGURE 6. Posterior view of the nutria cerebellum.

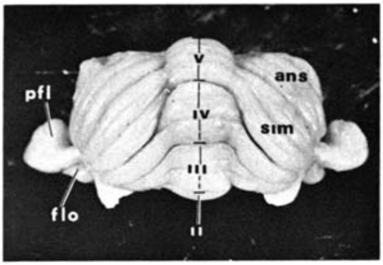

FIGURE 7. Ventral view of the nutria cerebellum.

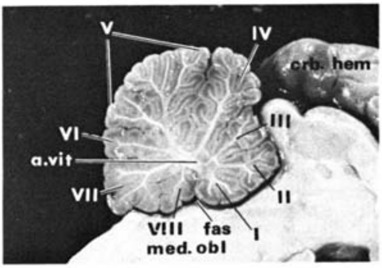

FIGURE 8. Midsagittal view of the cerebellar lobules of the nutria.

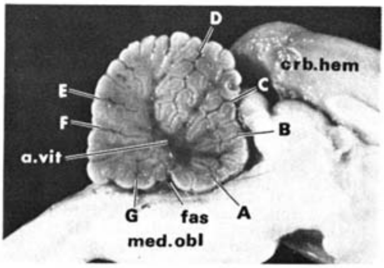

FIGURE 9. Midsagittal view of the cerebellar fissures of the nutria.

bounded anteriorly by fissura D and posteriorly by fissura E (prepyramidal). The lateral extensions of this lobule comprise the major portion of the cerebellar hemispheres. Many investigators of the anatomy of the mammalian cerebellum have divided the hemispheral portions of this lobule into three regions, normally designated as the simplex, ansiform, and paramedian portions of lobule V. For comparative purposes, these regions are designated in the illustrations of the nutria cerebellum. The greatest individual variation associated with lobule V is in the number of folia and sublobules.

Lobule VI (pyramis) is separated from lobule VII (uvula) by fissura F (secunda). The vermian and hemispheral portions of this lobule resemble an inverted "u" which extends laterally to connect with the flocculi and paraflocculi. Normally, the lateral extensions of this lobule, the copula pyramis, consist of only one portion, but in some nutria specimens the hemispheral extensions consisted of two branches.

Lobule VII is separated from lobule VIII (nodulus) by fissura G (posterolateralis). Lobule VIII is bounded posteriorly by fissura G and anteriorly by the fastigium. The very inconspicuous extensions of lobules VII and VIII consist of myelinated fiber tracts with no cortical covering. The hemispheral extensions of these two lobules converge and pass laterally to connect with the flocculi and paraflocculi.

Some investigators have proposed that the vermian and hemispheral portions of the mammalian cerebellum are distinct structures separated by longitudinal fissures (paramedian fissures) (28, 29); others have indicated that this is not correct (11-16). In the nutria cerebellum, the vermian and hemispheral portions are not separated by longitudinal fissures into separate and distinct structures. The cortex of these structures is continuous from one side of the cerebellum to the other, with the only major exception being encountered in very old nutria where there was a rather distinct depression between the vermis and each cerebellar hemisphere of lobule V. However, upon careful surface inspection, it was observed that the cortex was not interrupted but was continuous from one hemisphere to the other.

In the nutria brain, the paired paraflocculi extend laterally and are directed posteriorly from the ventrolateral surface of the cerebellar hemispheres. These round structures are suspended by a fibrous stalk which appears to be a direct continuation of the cerebellar peduncles. Normally, there are six cortical layers associated with each of the paraflocculi. From a lateral view, the cortical layers of the paraflocculi seem to be arranged in two groups: three on the dorsolateral surface and three on the ventrolateral surface. However, there does not appear to be enough division to designate both a dorsal and a ventral paraflocculus. Morphologically, there is very little individual variation in the external configuration of these structures.

The flocculi are also paired structures located anteroventrad to the paraflocculi. Great variation in the morphological form of these structures was encountered in this study. In approximately one-half of the cerebella examined, the flocculi consisted of only a single cortical layer, while in the remainder the flocculi were ovoid-shaped structures which consisted of two or three layers of cortex.

In order to illustrate the correct internal configuration of the nutria cerebellum, it was necessary that the midsagittal section be made in the exact medial plane. Riley (15, 16) was one of the first investigators to emphasize the importance of making an exact medial section, but many investigators have chosen to ignore the importance of Riley's statement. It is very likely that certain discrepancies in some descriptions of the cerebellum have resulted from the failure to observe an exact medial section. In this study several sections of the nutria cerebellum were made slightly to either side of the medial plane of the vermis. As a result: (a) lobules II and III appeared to have a common origin; (b) lobule IV appeared to consist of two main branches; (c) lobule VI appeared to be a sublobule of lobule V; (d) lobule VII was reduced in size. A description of these views would be vastly different from a description of an exact midsagittal view.

ABBREVIATIONS IN FIGURES

a. vit, arbor vitae
ans, ansiform portion of lobule V
c. cal, corpus callosum
c. trp, corpus trapezius (trapezoid body)
cb, cerebellum
cop, copula pyramis
cr. crb, crus cerebri
crb. hem, cerebral hemisphere
crbl. hem, cerebellar hemisphere
f. rhn, rhinal fissure
fas, fastigium
flo, flocculus
for, fornix
inf, infundibulum
inf. col, inferior colliculus
lo. pyri, pyriform lobe
mam, mammillary body
med. obl, medulla oblongata
n. II, optic nerve
n. III, oculomotor nerve
n. V, trigeminal nerve
n. VI, abducens nerve
ol. bu, olfactory bulb
ol. tr, olfactory tract
op. ch, optic chiasma
p. cb, cerebellar peduncles
pfl, paraflocculus
pin, pineal body
pmd, paramedian portion of lobule V
po, pons
pyr. tr, pyramidal tract
sim, simplex portion of lobule V
sp. co, spinal cord
sup. col, superior colliculus
thl, thalamus
ver, vermis
I — IV, cerebellar lobules of the anterior lobe
I, lingula
II, innominata
III, centralis
IV, culmen
V — VIII, cerebellar lobules of the posterior lobe
V, declive
VI, pyramis
VII, uvula
VIII, nodulus
A — G, cerebellar fissures
A, fissura precentral
B, fissura intracentral
C, fissura preculminate
D, fissura prima
E, fissura prepyramidal
F, fissura secunda
G, fissura posterolateralis

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