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Anatomy. — *"The Arrangement of the motor roots and nuclei in the brain of Acipenser ruthenus and Lepidosteus osseus."* By F. THEUNISSEN. (Communicated by Prof. L. BOLK).

(Communicated in the meeting of February 28, 1914).

In the Folia Neurobiologica of 1912 DROOGLEEVER FORTUYN [1]) described the arrangement of the motor roots and nuclei in the brain of an osseous Ganoïd. Amia calva.

He came to the conclusion that Amia in many respects resembled the Selachian type, though few points of analogy with the Teleosts were found.

Of the other Ganoïds as yet no adequate description exists as far as concerns the motor roots and nuclei. Valuable descriptions of the nervous system of Ganoïds are given by GORONOWITSCH [2]) and JOHNSTON [3]) (Acipenser), KINGSBURY [4]) and ARIËNS KAPPERS [5]) (Amia calva and Lepidosteus), but these articles contain rather a general account of the brain, the papers of JOHNSTON and KINGSBURY more specially of the sensory systems.

The Institute for Brainresearch possesses a complete series of the brain of Acipenser ruthenus, which has enabled me to study the relations of the motor system of this animal and to compare my results with those obtained by DROOGLEEVER FORTUYN in Amia Calva.

We are greatly indebted to Prof. MINOR in Moskow for our material of Acipenser ruthenus.

The results of my researches mapped out topographically after KAPPERS's method exhibit a striking resemblance with those obtained by DROOGLEEVER FORTUYN, and provide a new argument for classifying Amia with the Ganoïds.

My series, stained after WEIGERT-PAL with a contra-stain of para-carmine and alternating with a VAN GIESON series, enabled me to

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1) DROOGLEEVER FORTUYN, Notiz uber den Eintritt der motorischen Nervenwurzeln in die Medulla Oblongata und über die Lage der motorischen Kerne bei Amia Calva, L. Folia Neurobiol Bnd. VI, S. 27.

2) GORONOWITSCH Das Gehirn und die Cranialnerven von Acipenser ruthenus. Morphologisches Jahrbuch. Bnd. 13, 1888

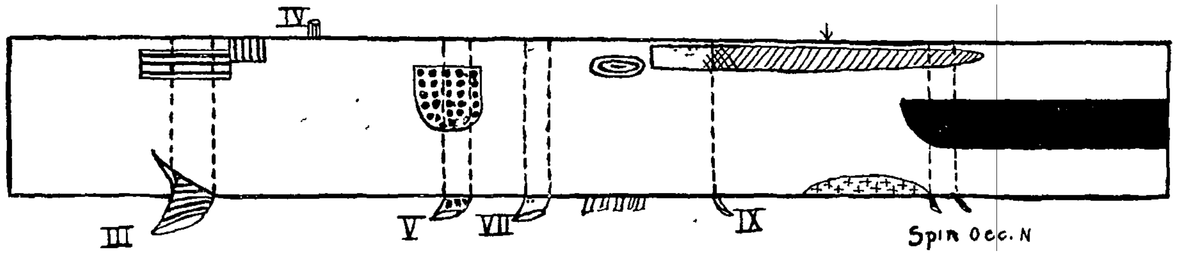
3) JOHNSTON, The Brain of Acipenser. G FISCHER, Jena, 1901.

4) KINGSBURY, The structure and morphology of the Oblongata in Fishes. Journ. of Comp. Neur. Vol. VII.

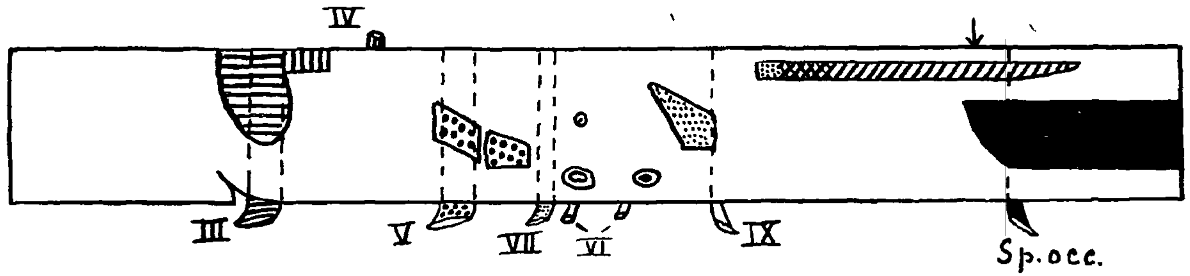
5) ARIENS KAPPERS, Untersuchungen über das Gehirn der Ganoiden Amia Calva und Lepidosteus osseus. Abhandl der Senck. Naturf. Gesellschaft in Frankfurt a. M. Bnd. 30, 1907.

EXPLANATION.

= nucl. paramedianus sive oliva inferior.



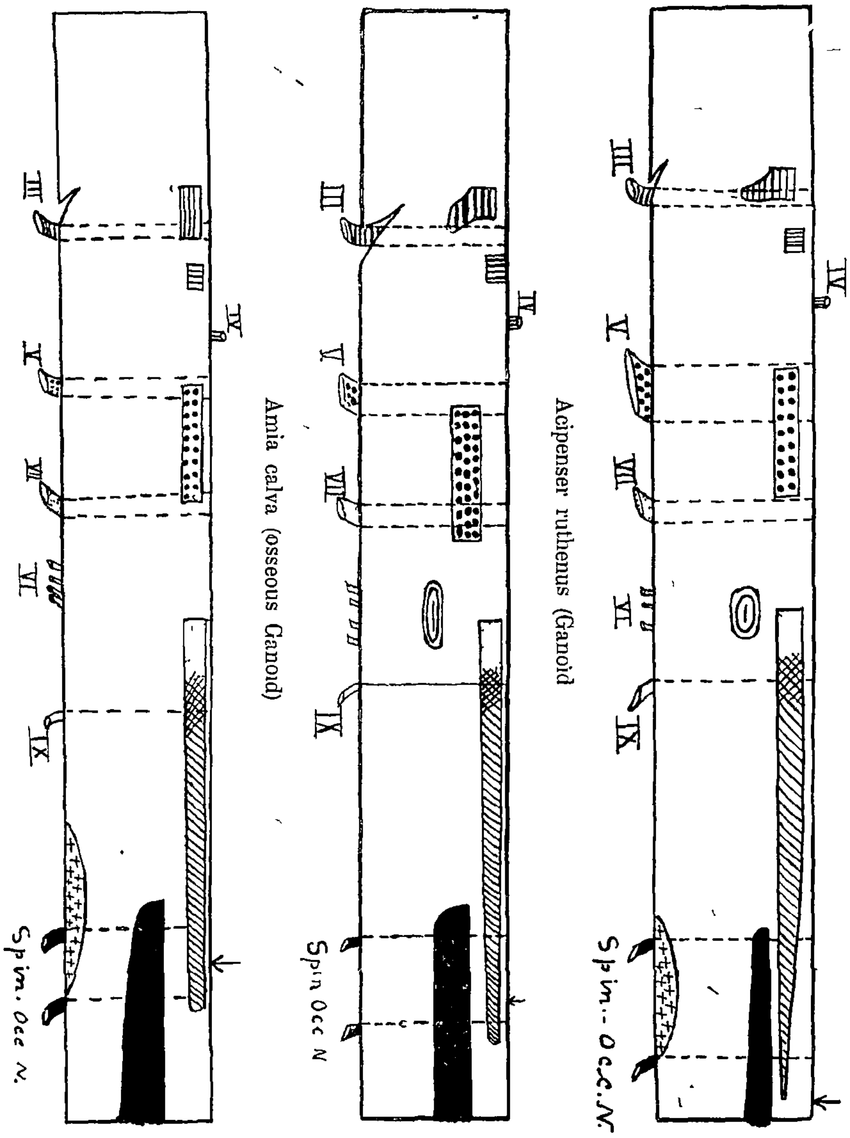
Scyllium (Selachian).



Tinca (Teleost).

Fig 1. (The arrow indicates the place of the calamus scriptorius).

trace with a great amount of exactness the course of the motor roots and the position of their nuclei, which, brought in relation to the sensory systems of this animal, provided new contributions to the doctrine of neurobiotaxis.



Acipenser ruthenus (Ganoid

Amia calva (osseous Ganoid)

Lepidosteus osseus, 5 c m. (osseous Ganoid).
(Fig. 2). (The arrow indicates the place of the calamus scriptorius).

In Fig. 1 I give two reconstructions, one of a Selachian (Scyllium) and one of a Teleost (Tinca), and in Fig. 2 I give the topographical reproductions of the three Ganoïds as yet examined.

In Acipenser the III nerve enters the brain as usual directly behind the lobi inferiores. Its nucleus has a dorsal position, dorso-laterally from and between the fasciculi longitudinales dorsales; but very few cells reach a somewhat more ventral position than in scyllium, thus slightly indicating the process which in Teleosts gives rise to the formation of a real ventro-median nucleus. The same was the case in Amia. The dorso-lateral part of the nucleus extends some distance in front of the entrance of the III root.

Some distance in front of it, new cells of a much larger type appear, belonging to the large reticular type and probably constituting the homologue of CAJALS[1]) "foco intersticial" in mammals and birds, also described by DE LANGE[2]) in Reptilia, which sends its axones in the posterior longitudinal fascicle.

The III nucleus finishes caudally near the posterior limit of its root entrance.

The IV nucleus lies some distance behind the III, separated from it by the tractus cerebello-mesencefalicus dorsalis, which passes here from the valvula cerebelli into the mesencephalon.

Such a separation has never yet been found in Selachii, but occurs rather often in Teleosts. The nucleus is small and its root lies a good deal farther caudad, as is also the case in Amia.

In the region of the trochlear nucleus large reticular cells are rarely found, and I get the impression that these large cells in Acipenser, as in other animals (v. HOEVELL)[3]), tend to group together in definite regions.

Also the position of the motor V nucleus shows a great resemblance with that of Amia, in so far as in both the nucleus retains a dorsal position over its entire length. The nucleus has moreover the same length in the two, though in Amia it begins a little caudad from the frontal line of entrance of its root and extends a little behind the VII root entrance.

Next to the trigeminus nucleus, along the lateral border of the fasciculus longitudinalis posterior, we find a great quantity of large

1) El sistema nervoso del hombre y de los vertebrados, Tomo II p. 551, Fig. 505 and Trabajos, Tomo VII: Ganglios de la substancia reticular del bulbo p 279 Fig. 9.

2) Das Zwischenhirn und das Mittelhirn der Reptilia. Folia Neurobiologica Vol. VIII p. 134, Fig 57 and p. 135 Fig. 58

Cyclostomes these large reticular cells have been found in front of the Oculomotor nucleus (comp. a. others TRETJAKOFF Arch. f. mikr. Anat. 1909, Bnd. 74).

3) J. J. L. D. Baron v. HOEVELL. Remarks on the reticular cells of the oblongata in different vertebrates. Proc. of the Kon. Akad. v. Wet Amsterdam; April, 1911.

reticular cells. Whether these cells are connected with secondary neurones of the desc. V is difficult to tell. It seems as if several of their dendrites reach into the region of the sensory V.

It may be remembered that also VAN HÖEVELL found a large quantity of reticular cells in the trigeminal and praetrigeminal region in the classes of vertebrates which he examined.

The VII root of Acipenser enters the bulb directly behind the motor V nucleus. After having reached the floor of the fourth ventricle it pursues its course in a median direction and successively shifts onto the lateral top of the fasciculus longitudinalis dorsalis, as is also the case in sharks, Teleosts and several Reptilia.

Where the motor VII root makes its caudal curve, that is in the region of the VIII, a group of large reticular cells is found next and under the fasciculus longitudinalis posterior, corresponding to VAN HÖEVELL's nucleus reticularis medius.

The whole VII nucleus is continuous with the IX and X, with which it forms the posterior visceral column, as also occurs in Amia and in Selachii. A partial (Cyprinoïdae, Pleuronectidae) or total (Lophius) isolation of the VII nucleus from the posterior viscero-motor column as is found in Teleosts does not occur in Acipenser.

The posterior viscero-motor column has a dorsal position and extends a good distance caudad beyond the frontal limit of the spino-occipital column. It reaches farther caudad than in Amia, although neither here nor there a musc. trapezius is developed (FÜRBRINGER)[1]). Consequently we may not consider the caudal part of this nucleus as nucleus accessorius as is the case in sharks.

More ventrally and more medially — near the ventrolateral border of the fasciculus longitudinalis posterior in and frontally from the region of the facialis nucleus the abducens-nucleus is found, which has three rootlets, which leave the brain between the VII and IX root. Just as in Amia the nucleus does not lie so ventrally as in Teleosts, nor is there a division into two chief groups as is fairly constant in bony fishes. The nucleus does not however lie as dorsally as in sharks.

The glossopharyngeus nucleus is continuous with the VII nucleus frontad and the X nucleus caudad. All its cells remain near the ventricle. The vagus nucleus has no special characteristics and resembles in every respect the nucleus of the IX. The spino-occipital column is the direct continuation of the motor column of the spinal

1) Vergleichende Anatomie der Wirbeltiere mit Berücksichtigung der Wirbellosen.

cord. The two frontal rootlets are thin and their cells remain very dorsal, more as in Selachii than in Teleosts.

On the frontal level of the spino-occipital column a quantity of large reticular cells is found, which we may compare with the nucleus reticularis inferior in Rays. (Comp. VAN HÖEVELL). As in these animals a *central* inferior reticular nucleus (lying in the raphe, as occurs in all the higher vertebrates from Reptiles to Man) hardly occurs here: the cells keep a lateral position. Considering the differences which Amia as well as Acipenser exhibits when compared with Teleosts, we find as the most striking the less ventral position of the oculomotor and abducens nucleus and the absence of a division of the latter into two chief cell groups. A frontal isolation or ventral displacement of the VII nucleus does not occur.

All of these characteristics are easily understood if we compare the sensory systems and their reflex paths in these animals.

Concerning the less ventral extension or position of the III and VI nucleus, it may suffice to remark that the ventral tecto-bulbar tracts are not nearly so well developed in Acipenser (and Amia) as in bony fishes. The tectum opticum itself is relatively smaller (compared with the underlying midbrain and thalamus) than in most of the bony fishes and reminds us more of the condition found in sharks. No doubt this smaller development of the ventral tecto-bulbar paths is the reason of the less ventral migration of the eye muscle-nuclei mentioned above.

This fact may at the same time explain why the abducens nucleus keeps a relatively caudal position.

We know that a hypertrophy of the ventral tecto-bulbar tracts is not only correlated with a very ventral abducens nucleus, but equally causes a more frontal position, at least of its frontal division as is specially shown in Pleuronectidae [1]).

Concerning the position of the facial nucleus in these Ganoïds and its resemblance in this respect with Selachii the following explanation must be given:

In his excellent paper on Acipenser (l.c. p. 31) JOHNSTON remarks that from the sensory IX—X lobi (in which also the sensory VII root finishes) a secondary ascending fibres-tract runs along the descending V. According to his description, this tract (MAYSER's: "vagotrigeminale Bahn") is still unmyelinated in Acipenser, which

1) Compare KAPPERS, The migrations of the V, VI, and VII nuclei and the concomitating changes in their root fibres. Verh der Kon. Akad. v. Wetensch. 1910, Deel 16, 2de Sectie, and Folia Neurobiol. Ergänz. Heft Vol. VI, 1912.

corresponds to our experience that this tract cannot be traced in Weigert-preparations.

In most Teleosts this tract is very considerably developed and HERRICK has described it there in a masterly way under the name of *ascending* secondary gustatory tract.

It is this tract which has the greatest [1]) influence on the ventral shifting and perhaps on the frontal isolation of the VII nucleus in Teleosts. It can even be demonstrated that the ventral migration of that nucleus (as well as of the V nucleus) is more conspicuous and more complete in those Teleosts, where this gustatory tract is more developed.

On account of this fact it is not astonishing that in animals where the *ascending* gustatory system is only relatively poorly developed a ventro-frontal migration of the VII nucleus has not yet occurred. It seems probable to me that in Ganoïds as in Selachii the secondary neurones of the sensory VII—IX—X nuclei are partly short intercalating neurones, while the longer secondary neurones of the viscerosensory nucleus may have chiefly a *descending* character.

It seems useful to me to give here also the topographic reconstruction of a young specimen of Lepidosteus osseus which the Institute received from Mr. EDW. PHELPS ALLIS in Menton.

I had at my disposition two specimens, of 5 and 10 c.m. The specimen of 5 c.m. being better preserved, I shall only give the reconstruction of this. I may add, however, that the 10 c.m. specimen did not differ in any principal point from this, so that I got the conviction that the definite arrangement of the motor nuclei is already present in the 5 c. m. specimen as far as concerns its principal features.

Also in Lepidosteus the oculomotor nucleus extends a considerable distance in front of the level of its root. The cells lie on the dorso-lateral border of the fasciculus longitudinalis, very near the ventricle. There is a difference in so far that the slight indication of a ventro-medial nucleus present in the fullgrown Amia and Acipenser fails in this young Lepidosteus. Perhaps this difference is due to the young stage of development.

As in the other ganoïds there is a considerable gap between the III and IV nucleus, although the tractus cerebello-mesencefalicus dorsalis does not run between it. [2]) The trochlear root lies again a good deal behind its nucleus.

[1]) Not the only influence though Some other tracts (e. g. an ascending sensory tract from the cervical region) may also run near the descending V.

[2]) Since there is no real valvula cerebelli in Lepidosteus this tract, if present, takes a more caudal course.

The trigeminus nucleus has the same dorsal position and length as in Acipenser and Amia. Its sagittal topography recalls rather that in Acipenser than in Amia.

The abducens leaves the same between the VII and IX roots with four rootlets as was the case in Amia.

The location of its nucleus could not be stated with exactness, the position of the cells being too diffuse amongst the reticular cells of that region. It resembles, however, the position in the other Ganoïds in so far as its cells do not form two well defined groups as occurs in bony fishes, nor do they have such a ventral position as in Teleosts. The posterior viscero-motor column has the same position as in the other ganoids. Its frontal limit is nearly the same, the caudal extension seems a little shorter, which may be due to the young stage of development.

It contains the motor VII, IX, and X nuclei, but the cells are not equally large everywhere: groups of large cells alternate with groups of smaller cells, of which the motor character is not so conspicuous. It may be that this means a little discontinuity in this motor column. It does not however give us sufficient evidence, to speak of isolation of different nuclei.

The position of the spino-occipital rootlets and cells resembles very much that found in Amia.

On an average it may be said that Lepidosteus shows principally the same type in the arrangement of its motor roots and nuclei as the two other Ganoids.

A few words may be added concerning a structure at the base of the medulla oblongata near the spino-occipital rootlets: the *nucleus paramedianus* or *oliva inferior*.

In this region the dark aspect of the tegmental part of the bulb changes for a lighter one in the Weigert-Pal preparations, owing to an enlargement of the grey matter consisting of small, more or less spindle-shaped cells and a sort of "gelatinous" substance. The caudal and frontal limits of this structure are not sharp, but the bulk of it extends in the places indicated at the base of my topographic schemes by little crosses.

From this structure a crossed myelinated fibre tract runs along the lateral border of the oblongata to the region where the cerebellum joins the bulb. Also JOHNSTON (l. c. p. 16) describes such crossed fibrae arcuatae externae.

The character of this crossed cerebellar connection, the sort of cells that constitute the nucleus paramedianus and its topographic relation, prove that we have to consider it as a primitive oliva inferior.

It seems as if ventral axones coming from the spinal cord end in it. This caudal tract consists of thin fibres provided with only a small myeline sheath and makes the impression of being ascending in character.

Whether this can be a primitive homologue of HELLWIG's triangular tract, which occupies a similar position in the mammalian cord and oblongata, cannot be said.

It is interesting to see that this structure is already so well developed in the young Lepidosteus.

DROOGLEEVER FORTUYN has not indicated its limits in his map of Amia. It has neither been possible to me to mark its limits with any amount of exactness in this animal. The structure is so diffuse and little circumscript in Amia that its exact topography cannot be given in WEIGERT or VAN GIESON preparations. It is certainly smaller and less pronounced, which is not astonishing since Acipenser and Lepidosteus are excellent swimmers and Amia leads a more quiet life, as is also indicated by its name "mudfish". [1])

Resuming my results concerning the arrangement of the motor roots and nuclei in Acipenser and Lepidosteus, and comparing them with Amia on one side and with Scyllium and Tinca on the other, I may conclude.

Amia Calva, Acipenser and Lepidosteus osseus resemble each other closely, and differ as well from the Selachii as specially from the Teleosts.

They differ from the Teleosts by the very dorsal position of the motor VII nucleus and by the continuity of the motor column of the VII, IX, and X nuclei, by the less ventral position and more diffuse structure of the abducens nucleus, the entirely dorsal position of the V nucleus and the little ventro-medial migration of the oculomotor nucleus. On an average they resemble much

[1]) I will call attention to the possibility that the nucleus paramedianus of fishes is rather the homologue of the ventro-medial accessory olive than of the regular oliva inferior (comp. also KAPPERS, Folia Neurobiologica Sommerergänzungsheft, Bnd. VI, 1912) on account of the fact, mentioned by BROUWER (Archiv. Psych. Bnd. 51), that the ventro-medial accessory olive has connections with the vermis cerebelli, not with its hemispheres, and that the cerebellum of sharks and other fishes is probably the homologue of the vermis.

It is an interesting fact that this ventro-medial accessory olive of mammals enlarges greatly in cetaceans, where it is again the dominating part of the inferior olive (comp. KANKELEIT, Zur Vergl. Morphologie der unteren Säugetier-olive, Inaug. Diss. Berlin 1913) This, and the fact that in fishes it is probably the only part of the inferior olive that occurs, might lead us to believe that the ventro-medial accessory olive is chiefly related with the musculature of the trunk and the tail.

more the selachian type of arrangement from which they only differ by the constant gap between the oculomotor and trochlear nucleus, the more dorsal position of the trigeminus nucleus and the less dorsal extension of the abducens cells and roots.

Physiology. *"On esophageal auscultation and the recording of esophageal heart sounds"*. By Dr. C. E. BENJAMINS. (Communicated by Prof. Dr. H. ZWAARDEMAKER).

(Communicated in the meeting of February 28, 1914).

When performing an esophagoscopy our notice is surprisingly attracted by distinct considerable pulsations at 32—35 c.m. from the incisor teeth. Here an expansion may repeatedly be seen to appear and to disappear rapidly after some complex to-and-fro motions. Anatomically it has been shown that in this very place the left auricle is located against the esophagus, from which it is separated only by the pericardium, and, therefore, admits of immediate experimentation.

Following the lead of RAUTENBERG [1]) and MINKOWSKI [2]) I availed myself of this circumstance by taking along this path cardiograms as illustrated in Fig. 5. The results achieved in this investigation, which was conducted in a way differing from the method generally employed, will be given elsewhere. In this paper I propose to publish my experience about the esophageal heart sounds.

I first wish to give some preliminary details of the technique of examination. To the extremity of a strong grey india-rubber tube (75 c.m. long, 5 m.m. bore, thickness of the rubber 1 m.m.), graduated from 20—40 c.m., a knob-shaped appendage is fitted. Over this appendage a rubber finger stall (from which the hard rim has been removed) is tied so as to leave an elongation of 3—4 c.m.

The subject, whose pharynx had, or had not, been sprinkled beforehand with a spray of a 5 % cocain solution, to which some drops of adrenalin had been added, swallows the lubricated tube without difficulty, only being aided a little as at the insertion of a stomach-tube. When the tube is inserted as low as ± 35 c.m. from the labial curve, it is adjusted by means of a T-piece to the binaural stethoscope. (The T-piece has to protect the tympanic membranes the moment the subject displays signs of choking). When he keeps quiet, the T-piece is closed with the finger, so that we hear distinctly

1) RAUTENBERG. Die Registrierung der Vorhofpulsation von der Speiseröhre aus. Deutsches Arch. f. klin. Medicin 1907. Bd. 91. S. 251.

2) O. MINKOWSKI Die Registrierung der Herzbewegungen am linken Vorhof. Berl. klin. Wochenschr. 1907. No. 21.