A C T A T H E R I O L O G I C A

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Bulbus olfactorius and *Bulbus olfactorius accessorius* in the Roe Deer

[With Plates VI — VIII]

The olfactory bulb in the roe-deer *Capreolus capreolus* (Linnaeus, 1758) is formed from two main parts: the olfactory part and the olfactory peduncle. The olfactory part is formed by the following strata: *stratum fibrosum, stratum glomerulorum olfactoriorum, stratum granulosum externum, stratum granulosum internum.* The olfactory peduncle of the olfactory bulb is formed from the anterior part of *nucleus olfactorius anterior* and from *tractus olfactorius lateralis* and *tractus olfactorius intermedialis.* The central part of the olfactory bulb is occupied by *ventriculus olfactorius.* In the roe-deer *bulbus olfactorius accessorius* is located in the mediodorsal wall of *bulbus olfactorius.*

I. INTRODUCTION

Many studies dealing with the cyto- and fibro-architectonics of *bulbus olfactorius* and *bulbus olfactorius accessorius* are to be found in available literature, and these organe have been described in relation to many species of animals. The majority of the numerous studies on this subject refer to the structure of these parts of the rhinencephalon in mammals, as follows: in the rabbit (Young, 1936), bat (Humphrey, 1936), mole (Johnson, 1957), mice and dog (Ramon y Cajal, 1955), rat (Allison, 1953), cow and sheep (Gadamski, 1966, 1967), pigs and wild boar (Hereć, 1966, 1967) goat (Łakomy, 1967) horse (Eustachiewicz, 1966) and many others.

No description has however yet been found in literature of the structure of *bulbus olfactorius* and *bulbus olfactorius accessorius* in roe-deer. A knowledge of the structure of these parts of the rhinencephalon in the roe-deer will make comparison possible with the structures of these organs already described in such domestic animals as: the cow, sheep, pig and horse.

II. MATERIAL AND METHODS

The material used for this study was formed by the cerebrum of shot roe-deer. The material was fixed in 1:10 and 1:4 water solutions of formalin, 10 days in each solution. The dehydrated material was embedded in paraffin and sectioned in the frontal plane at 15 microns. Every third section was taken for examination. The preparations were stained by Klüver and Barrery's method.

III. RESULTS

1. *Bulbus olfactorius*

The olfactory bulb is the part of the rhinencephalon projecting furthest forward. It takes the form of a clavate thickening flattened dorso-ventrally. The posterior part of the dorsal surface of *bulbus olfactorius* is contiguous with the neopallium. The nasad end and also the whole ventral surface lie in the olfactory pit of the ethmoid bone. Two main parts can be distinguished in the olfactory bulb: the olfactory part and the olfactory peduncle. The olfactory part corresponds to Young's olfactory formation, and is formed from concentrically arranged strata. It is, as it were, superimposed on the olfactory peduncle. The olfactory part forms the nasad end of the olfactory bulb, the anterior small part of the dorsal surface, partly the lateral and medial surfaces and the whole ventral surface. The posterior boundary of the olfactory part is defined by *fissura circularis*. The peduncle of the olfactory bulb is formed by the anterior olfactory nucleus and the *tracti olfactorii lateralis et intermedialis*. *Bulbus olfactorius accessorius* lies on the medial side of *bulbus olfactorius*. The olfactory part of *bulbus olfactorius* is formed from several strata concentrically overlapping each other.

1.1. *Stratum fibrosum* (Photo 1) is formed by the olfactory threads which run in compact bundles from the olfactory nasal cavity. The olfactory threads, after reaching the external surface of the olfactory bulb, separate in the form of a broom and after a short course end in the layer of *glomeruli olfactorii* (Photo 1, 2). The olfactory threads reaching the olfactory bulb vary in thickness. The thinner threads enter the *stratum fibrosum* close to each other, while the thicker threads are further apart.

1.2. *Stratum glomerulorum olfactoriorum* (Phot. 2) lies under the preceding layer and is formed by faintly staining *glomeruli olfactorii* similar to islets. These islets vary in shape (triangular, fusiform, oval) and are situated fairly closely together. The spaces between the glomeruli are filled by densely arranged granular cells (Photo 2). Some of the granular cells penetrate into the interior of the glomerules. The larger olfactory glomerules form single, and the small glomerules double or treble bands. The olfactory glomerules are the place of the synaptic connection of olfactory neurites and the dendrites of mitral and cristate cells.

1.3. *Stratum granulosum externum* (Photo 1, 2) lies medially in relation to the preceding layer. It is formed mainly by granular cells of medium size staining fairly intensively, occurring in the greatest numbers in the peripheral part. The external margin of the layer is

irregular, as the granular cells penetrate deep into *stratum glomerulorum olfactoriorum*. The medial margin of *stratum granulosum externum* is relatively regular in structure. It is formed by mitral cells and granular cells. The mitral cells (Photo 9) are several times bigger than the granular cells. They are multiradiate cells in which the nucleus, nucleole and coarse granular or haemoconial tigroid matter can be seen. They stain more intensively than the granular cells surrounding them and are distributed in a single row. The granular cells occuring in this part of the external fibrose layer are larger than the remaining granular cells and are round or oval in shape. They lie round the mitral cells but are, however, less intensively stained than they are. About $^2/_3$ of the central part of the external granular layer is occupied by the external molecular layer. It is formed by the dendrites of the mitral and cristate cells, a small number of granular and cristate cells and by a few mitral cells. The cristate cells (Photo 10) are triangular, piriform or fusiform and are larger than the granular cells. A few mitral cells which occur in the molecular layer are smaller and more elongate than the typical mitral cells lying near the medial margin of *stratum granulosum externum*.

1.4. *Stratum granulosum internum* (Photo 3, 4) is the thickest layer of the olfactory part of the bulb. It lies medially in relation to the other layers. It consists of granular cells of small and medium size, round or oval in shape. The granular cells forming the external part of the layer (about half its thickness) are arranged in elongated islets alternately situated concentrically (Photo 3). On the periphery these islets are longer and more regularly arranged, but towards the centre they become smaller and are less regularly arranged. The inner part of the layer (Photo 3, 4) extends almost to *ventriculus olfactorius* and is composed of granular cells irregularly arranged. The fibres forming *plexus nervosus* are arranged in this part of *stratum granulosum internum* (Photo 4, 5). On the periphery of *stratum granulosum internum* immediately under the mitral cells lies the thin *stratum moleculare internum* formed, according to Ramon y Cajal, by lateral dendrites of the mitral cells.

1.5. *Ventriculus olfactorius* (Photo. 5) is a nasad extension of the lateral ventricle of the cerebrum. It is most extensive in the nasad part, but towards the rear passes into a narrow duct. In the nasad part its outline is round or oval in the cross-section. It is lined, like the cerebral cavities, with a layer of ependymal cells. Between *stratum granulosum internum* and the layer of ependymal cells there is the thin *stratum periventriculare* formed by faintly staining cells, which are slightly larger than the neighbouring granular cells. Thin fibrils running in different directions are visible in *stratum periventriculare*.

1.6. *Plexus nervosus* (Photo. 4, 5) is situated in the periventricular part of *stratum granulosum internum*. *Plexus nervosus* occupies the central part in the nasad section of *bulbus olfactorious* before *ventriculus olfactorious* appears (Photo. 4). In the medial part of the bulb *plexus nervosus* forms a closed ring situated round *ventriculus olfactorius*. In the posterior part of the bulb, on the dorsal side, *pars olfactoria* begins gradually to disappear, and *plexus nervosus* simultaneously with it. Towards the rear *plexus nervosus* therefore appears in cross-sections as an increasingly small sector of a ring. *Plexus nervosus* passes at the level of disappearance of *pars olfactorius* into *tracti olfactorii intermedius et lateralis*.

Plexus nervosus is formed of nerve fibres of two kinds: thin and thick, which are evenly intertwined with each other and run anterior--posterior, parallel to the long axis of *bulbus olfactorius*. Near the place of transition into *tracti olfactorii* the nerve fibres run diagonally anterior-posterior. Simultaneously the nerve fibres, which at first are intertwined with each other, form into separate bands. The thin nerve fibres lie near *ventriculus olfactorius* and the thick nerve fibres on the exterior from them.

1.7. *Tractus olfactorius lateralis* (Photo. 7) takes the form of a thick band composed of thick nerve fibres. It runs from *bulbus olfactorius* in the direction of the piriform lobe. It begins with a sharp wedge in the dorsal wall of the bulb at the place where *pars olfactoris* disappears. Towards the rear *tractus olfactorius lateralis* becomes gradually thicker and wider, as the number of nerve fibres forming it increases. In the nasad section of the bulb *tractus olfactorius lateralis* lies in the dorsal wall and is of almost uniform thickness. In the medial part of *bulbus olfactorius* this tract lies in the dorsal and lateral wall of the bulb. Part of the fibres of *tractus olfactorius lateralis*, situated in the dorsal wall of *bulbus olfactorius*, shift in a lateral direction. This part of the tract is thus relatively thin, while the part lying in the lateral wall is more strongly formed. In the posterior part of *bulbus olfactorius*, *tractus olfactorius lateralis* lies in the dorsal, lateral and ventral wall of the bulb. The lateral and ventral parts are most strongly formed, and the dorsal part less strongly. *Tractus olfactorius lateralis* forms the external layer of the olfactory peduncle. In a small anterior part it adjoins *tractus olfactorius intermedius*. Its distal part adjoins *nucleus olfactorius anterior*.

1.8. *Tractus olfactorius intermedius* (Photo. 7) takes the form of a band of irregular structure. It begins simultaneously with the *tractus olfactorius lateralis* in the dorsal wall of *bulbus olfactorius*, forming a sharp wedge, gradually enlarging backwards. In the anterior part this

tract takes the form of a fairly thick band, widening in a posterior direction, composed of thin nerve fibres. In the central and posterior part of the bulb the structure of *tractus olfactorius intermedius* is irregular. It is situated in the lateral, and partly in the ventral and dorsal, wall of *bulbus olfactorius*. The band of nerve fibres forming *tractus olfatorius intermedius* in these sections is convex on the lateral side, but concave from the medial side. *Tractus olfactorius intermedius,* for the small anterior section, lies between *tractus olfactorius lateralis* and *stratum periventriculare*. In the central and posterior section of *bulbus olfactorius,* however, its external surface is in contact with *nucleus olfactorius anterior* and its medial surface with *stratum periventriculare*.

1.9. *Nucleus olfactorius anterior* (bulbous part) begins in front of the anterior margin of *bulbus olfactorius accessorius*. Four parts can be distinguished in it: *pars dorsalis, pars lateralis, pars ventralis* and *pars medialis*. *Pars dorsalis* projects furthest forwards. *Pars dorsalis* lies between *tracti olfactorii lateralis et intermedius*. Its anterior end is divided, as the two cell groups protecting furthest forwards are not connected with the whole of *nucleus olfactorius*. In cross-sections a small group of cells appears first of all on the medial side of the dorsal wall of *bulbus olfactorius*. This group takes the form of a short band which continues to appear in several microscopic sections and then disappears. Slightly further to the rear of this group of cells there is a similar group lying in the middle of the dorsal wall of *bulbus olfactorius*. Like the preceding group it continues to appear for several microscopic sections. The true *nucleus olfactorius anterior* begins at the rear of this second group of cells. The anterior end of *pars dorsalis* takes the form of a sharp wedge widening in a posterior direction. After reaching the whole breadth of the dorsal wall of *bulbus olfactorius, pars dorsalis* of *nucleus olfactorius anterior* runs in the form of a wide band to the end of *bulbus olfactorius*. At this level *pars dorsalis* passes in two branches into the grey matter of neopallium. In cross-sections the band forming *pars dorsalis* of *nucleus olfactorius anterior* is straight or almost straight in the anterior section, but in the distal part it is more or less folded. *Pars dorsalis,* widening in a lateral direction, passes into *pars lateralis nucleus olfactorius anterior. Pars lateralis* in turn, after reaching the ventral wall of *bulbus olfactorius,* passes into *pars ventralis*. In frontal sections *pars lateralis* of *nucleus olfactorius anterior* takes the form of a thick and generally folded cell band. The angle forming the place of transition of *pars dorsalis* into *pars lateralis* is mainly composed of large multiradiate cells. On the exterior from the main mass of *pars lateralis* of *nucleus olfactorius anterior* lies a thin lamella composed of cells

similar to those forming the main mass of the nucleus. This lamella is relatively long. It is more strongly formed in the anterior part. Towards the rear it divides into two groups, of which the dorsal group disappears earlier and the ventral continues further and ends in front of the posterior margin of *bulbus olfactorius*. *Pars ventralis* is the best formed part of *nucleus olfactorius anterior*. It takes the form of a wide and thick band of cells. In frontal sections it can be observed to be slightly folded. *Pars medialis* is formed by the transition of *pars dorsalis* and *pars ventralis* into the medial wall of *bulbus olfactorius*. The part of *pars medialis* which is formed by the widening of *pars dorsalis* projects further forwards. At the level of the posterior limit of *fissura circularis nucleus olfactorius anterior* takes the form of a ring encircling *ventriculus olfactorius*. *Nucleus olfactorius anterior* (Photo 6, 12) is formed by small, medium and large multiradiate cells.

2. *Bulbus olfactorius accessorius*

This is a small flattened formation which lies on the medial wall of *bulbus olfactorius* (Photo. 8). It is composed of layers similar to those composing the olfactory part of *bulbus olfactorius*.

2.1. *Stratum fibrosum* of *bulbus olfactorius accessorius* is formed by the small terminal part of the vomeronasal nerve. This nerve, after reaching the external surface of *bulbus olfactorius accessorius* branches in the shape of a broom, like the olfactory threads forming *stratum fibrosum*.

2.2. *Stratum glomerulorum olfactoriorum* is formed by a relatively wide band of *glomeruli olfactorii*. These glomerules are loosely connected and do not form the characteristic islets found in the true *bulbus olfactorius*. They stain more weakly than the glomeruli of the true bulb, so that the limits of the glomeruli are defined more by the granular cells which penetrate between the glomerules, and in a few cases into their interior also.

2.3. *Stratum granulosum externum*. The external surface of this layer is formed by small granular cells which penetrate in large numbers between *glomeruli olfactorii*. The internal margin of the layer is formed by mitral and granular cells. The mitral cells of *bulbus olfactorius accessorius* are smaller than in the true bulb. They are arranged in a relatively broad band composed of 3—4 rows of mitral cells, which do not, however, lie on one level. *Stratum moleculare* lies, as it does in the true bulb, in *stratum granulosum externum*. It is formed by the dendrites of mitral cells and a few granular and cristate cells. This layer is relatively well developed.

2.4. *Stratum granulosum internum* is weakly developed in comparison with the same layer of the true *bulbus olfactorius*. It is formed by a thin band of densely arranged granular cells.

IV. DISCUSSION

The stratiform structure is a characteristic feature of *bulbus olfactorius* and *bulbus olfactorius accessorius*. The various layer of the olfactory part of the olfactory bulb in the roe-deer are similar in structure to those in other mammals (horse, cow, sheep, pig, wild boar, goat and others).

In the majority of the species of mammals examined, and also in the roe-deer, the central part of the olfactory bulb is occupied by the olfactory ventricle, which is an extension nasad of the lateral ventricle of the cerebrum. The absence of *ventriculus olfactorius* or presence of the ependymal lining only without a lumen was found by Humphrey (1936) in the bat *Tadarida mexicana*, but the formation of the various layers and parts in the bat's olfactory bulb, despite the lack of an olfactory ventricle, did not greatly differ from the formation of corresponding elements in other mammals possessing *ventriculus olfactorius*.

The *nucleus olfactorius anterior* in the roe-deer takes the form of a ring closing from the anterior toward the rear. *Nucleus olfactorius anterior* was shown to be similar in formation in other mammals also (Young, 1936; Humphrey, 1936; Hereć, 1966, 1967; Gadamski, 1966, 1967; Łakomy, 1966 and others). Both in the roe-deer and in other mammals the *nucleus olfactorius anterior* can be divided into four parts: *pars dorsalis, pars ventralis, pars lateralis* and *pars medialis*. In the roe-deer two short bands composed of cells such as occur in the nucleus lie in front of the basic mass of the anterior end of this nucleus. They have been described jointly with *pars dorsalis* of *nucleus olfactoris anterior*, since both the location and similar cellular composition of these groups permitted of including them in this part of the nucleus. Young (1936) considers similar formations in the rabbit as splinters of *nucleus olfactorius anterior*. Crosby & Humphrey (1941), on the other hand, divide *pars dorsalis* of *nucleus olfactorius anterior* in man into three parts: first, second and third, the third part forming the basic nuclear mass of *pars dorsalis*. On the exterior from the main nuclear mass of *pars lateralis* in the roe-deer lies a thin and relatively long lamella composed of cells similar to those which occur in *nucleus olfactorius anterior*. Similar groupings of cells on the exterior from *pars lateralis* of *nucleus olfactorius anterior* were described as *pars externa*

by Young (1936) in the rabbit and by Humphrey (1936) in the bat *Tadarida mexicana*. Crosby & Humphrey (1941) did not however find *pars externa* in an adult man.

Plexus nervosus and *tracti olfactorii lateralis* and *intermedius* in the roe-deer are formed similarly to those in the majority of mammals.

Bulbus olfactorius accessorius occurs in the majority of the species examined so far. In the roe-deer it is fairly well developed, as it is in fact in the horse (Eustachiewicz, 1966), cow and sheep (Gadamski, 1966; 1967), pig and wild boar (Hereć, 1966; 1967), goat (Łakomy, 1966) and others. It is not, however, similarly formed in all the species examined, for instance in the mole, *Scalopus aquaticus machrinus* (Johnson, 1957) there are no mitral cells in *bulbus olfactorius accessiorius*. The latter does not occur in all the species of mammals so far investigated. Jawłowski (1957) could not establish its occurrence in the marten, pole-cat and weasel. In the same way Humphrey (1936) found when examined *Tadarida mexicana* that it does not occur in this species. It does not occur in adult humans, as shown by Crosby & Humphrey (1941) who only found certain differentiation of cells and their subsequent disappearance in a human embryo.

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OPUSZKA WĘCHOWA I OPUSZKA WĘCHOWA DODATKOWA SARNY

Streszczenie

Materiałem do pracy było mózgowie odstrzelonej sarny, *Capreolus capreolus* (Linnaeus, 1758). Materiał utrwalono w roztworze wodnym formaliny 1:10 i 1:4 po 10 dni w każdym. Odwodniony materiał, zatopiony w parafinie krojono w płaszczyźnie czołowej na skrawki grubości 15 mikronów. Preparaty barwiono wg metody Klüvera i Barrery.

Opuszka węchowa sarny jest najbardziej do przodu wysuniętą częścią węchomózgowia. Ma ona postać maczugowatego zgrubienia spłaszczonego grzbietowo--brzusznie. W opuszce węchowej sarny można wyróżnić dwie zasadnicze części: część węchową oraz szypułę węchową. Część węchowa opuszki węchowej sarny jest utworzona z kilku koncentrycznie nakładających się na siebie warstw. Najbardziej zewnętrznie leży warstwa włóknista (Fot. 1). Przyśrodkowo od warstwy włóknistej leżą kolejno: warstwa kłębków węchowych (Fot. 1, 2), warstwa ziarnista zewnętrzna (Fot. 1, 2) oraz warstwa ziarnista wewnętrzna (Fot. 3, 4). Szypułę węchową opuszki węchowej tworzą: jądro węchowe przednie (Fot. 7, 12) oraz szlaki węchowe boczny i pośrodkowy (Fot. 6). Centralną część opuszki węchowej zajmuje komora węchowa wysłana jedną warstwą komórek ependymalnych. U sarny w przyśrodkowej ścianie opuszki węchowej leży opuszka węchowa dodatkowa. Budowa jej przypomina strukturę opuszki węchowej właściwej.

EXPLANATION OF PLATES

Plate VI & VII

Photo 1, 2, 3, 4, 5. Cross-section through strata of *bulbus olfactorius.* Magn. approx. 90×.

Photo 6. Cross-section through *nucleus olfactorius anterior.* Magn. approx. 90×.

Photo 7. Cross-section through *tracti olfactorii lateralis et intermedius.* Magn. approx. 90×.

Photo 8. Cross-section of *bulbus olfactorius accessorius.* Magn. approx. 90×.

Plate VIII

Photo 9. Mitral cells of *bulbus olfactorius.* Magn. approx. 350×.

Photo 10. Cristate cells of *bulbus olfactorius.* Magn. approx. 600×.

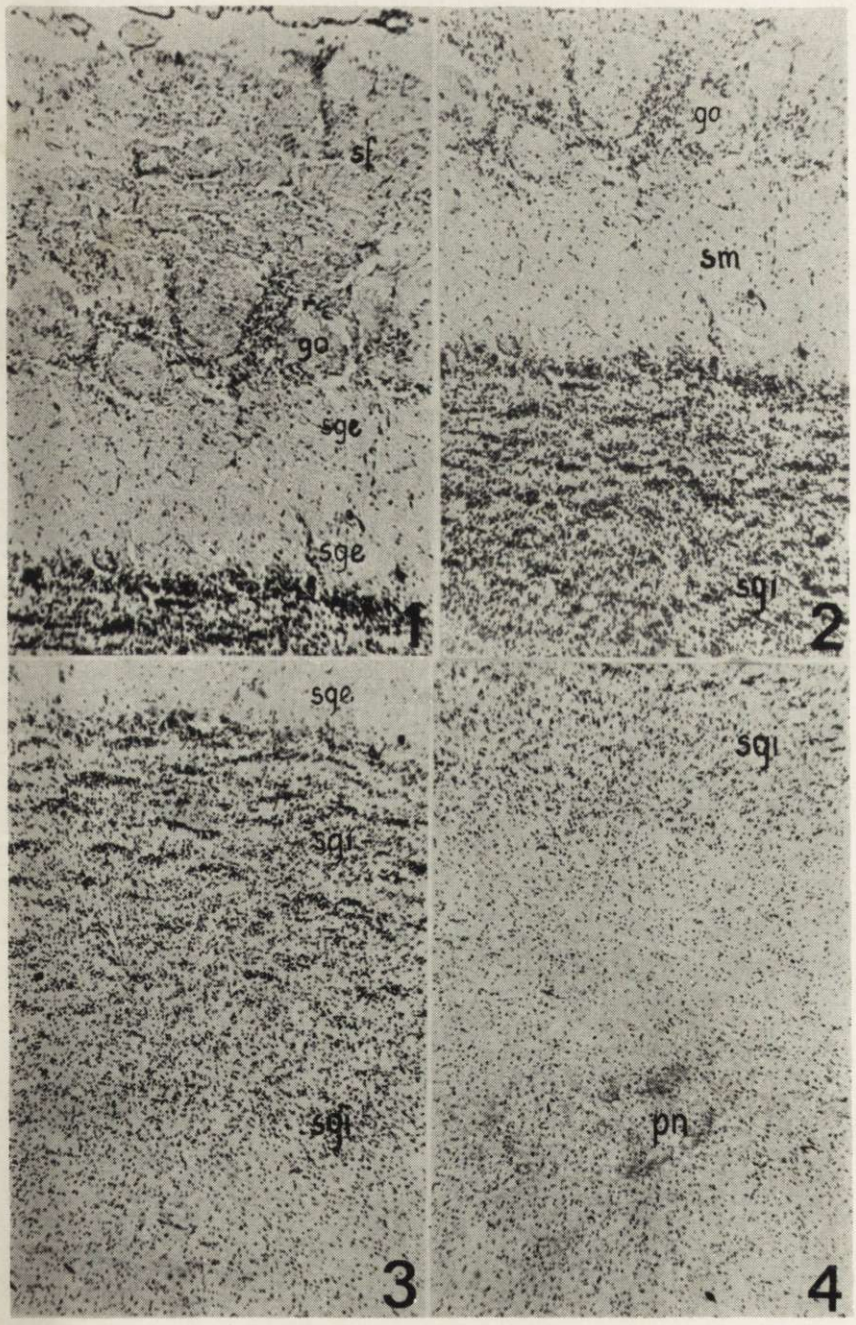
Photo 11. Mitral cells of *bulbus olfactorius accessorius.* Magn. approx. 350×.

Photo 12. Cells of *nucles olfactorius anterior.* Magn. approx. 350×.

Explanation of abbreviations used in descriptions of photographs:

boa — *Bulbus olfactorius accessorius,*
go — *Gromeruli olfactorii,*
kno — Cells of *nucleus olfactorius anterior,*
mo — Mitral cells of *bulbus olfactorius,*
moa — Mitral cells of *bulbus olfactorius accessorius,*
noa — *Nucleus olfactorius anterior,*
pn — *Plexus nervosus,*
sz — Cristate cells,
sf — *Stratum fibrosum,*
sge — *Stratum granulosum externum,*
sgi — *Stratum granulosum internum,*
sm — *Stratum moleculare,*
sp — *Stratum periventriculare,*
toi — *Tractus olfactorius intermedius,*
tol — *Tractus olfactorius lateralis,*
vo — *Ventriculus olfactorius.*

Photographs made in the photographic laboratory of the Department of Animal Anatomy, Veterinary Faculty.



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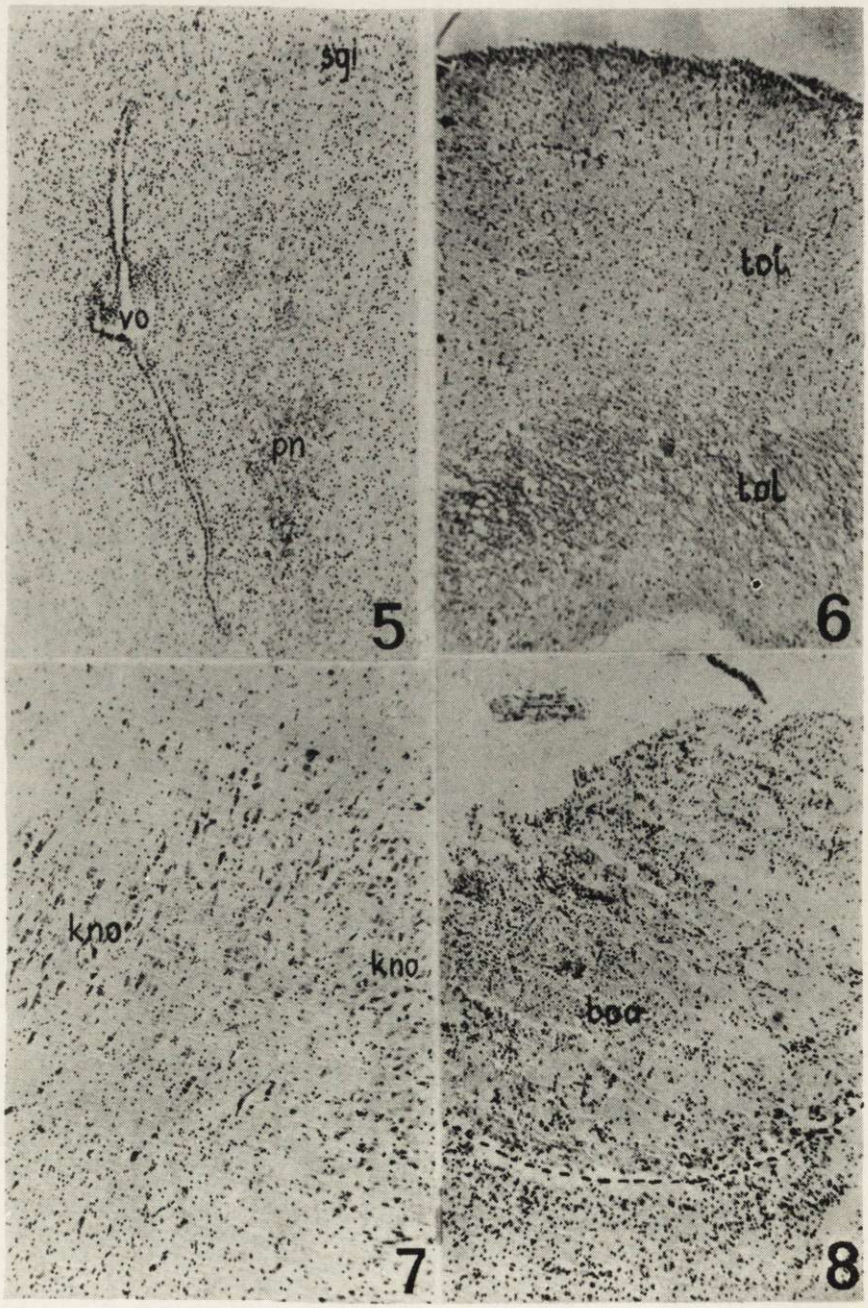

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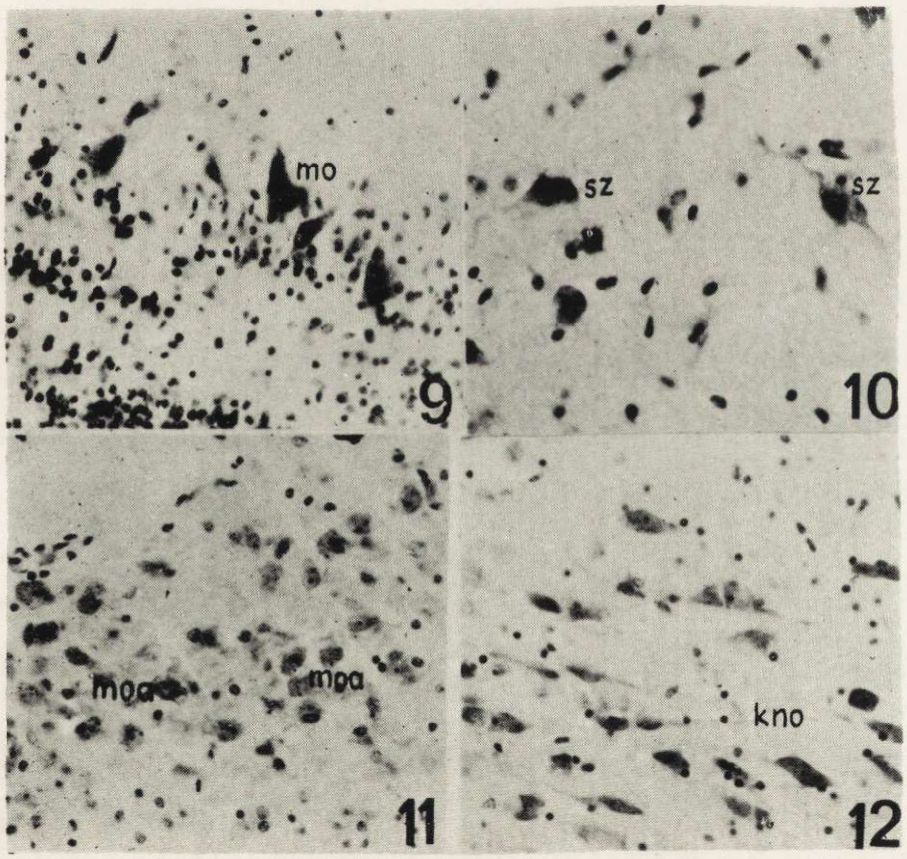

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