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A Forebrain Atlas and Stereotaxic Technique for the Lizard, *Anolis carolinensis*

NEIL GREENBERG
Department of Zoology, University of Tennessee, Knoxville, Tennessee 37916

ABSTRACT A forebrain atlas and stereotaxic neurosurgical techniques were developed for use in anatomical and behavioral experiments on the green anolis lizard *(Anolis carolinensis)*. Green anoles are convenient and robust experimental subjects with a rich behavioral repertoire, the social components of which are partly under hormonal control.

The technique and atlas were devised to conduct neuroethological investigations of the effect of lesions on species-typical display behavior. The atlas consists of 12 transverse sections from an average size adult male. The figures (4–15) are based on Nissl material and supplemented with fiber-stained material from adjacent sections. They appear at the end of the article. Limitations on the accuracy of stereotaxic coordinates are discussed and tables of correlative nomenclature for principal telencephalic and diencephalic nuclei are provided.

Among lizards, the diurnal, visually oriented Iguanids are the most amenable to study, and of these, the green anole, *Anolis carolinensis,* is the most studied. This species has a rich behavioral repertoire, most of which can be elicited in seminatural laboratory habitats, and it exhibits social activity with distinctive displays (B. Greenberg and Noble, '44; Crews, '75; Greenberg, '77a) that are partly under hormonal control (Crews, '75). With the use of microtechniques, this New World lizard is also an excellent subject for combined neurophysiological and neuroanatomical investigations (Greenberg et al., '79). To facilitate such research this report describes the forebrain of *A. carolinensis* in stereotaxic coordinates and provides a methodology for the placement of devices in the brain.

Valuable reviews of the reptilian forebrain have been published by Goldby and Gamble ('57) and Northcutt ('78), who also provided a useful summary of the variation within the Lacertilia. An architectonic analysis of a related member of the Family Iguanidae, *Iguana iguana,* was provided by Northcutt ('67); and a schematic atlas for this species was published by Distel ('76). The diencephalon of *I. iguana* was analyzed in detail by Butler and Northcutt ('73).

Detailed archetectonic studies on the diencephalon and midbrain of *Anolis carolinensis* were published in 1933 by Huber and Crosby. Twenty years later Armstrong et al. ('53) published on the telencephalon of other species of *Anolis* with special reference to the olfactory apparatus, correcting errors made by earlier authors (Crosby and Humphrey, '39). Detailed descriptions of the preoptic and hypothalmic areas of *A. carolinensis* were included in a comparative essay by Crosby and Woodburne ('40). The anatomy of the cranial nerves was described by Willard ('19) and the cranial motor nuclei investigated by Gillaspy ('54).

An important impediment to functional neuroanatomical studies on lizards is the lack of information about normal behavior. Specialized and time-consuming ethological techniques are required to index their behavioral patterns and to ascribe function to these with any confidence. This has been partly relieved by recent detailed ethograms and behavioral inventories (e.g., Brattstrom, '71; Distel, '78; Greenberg, '77b) and partial ethograms stressing thermoregulatory (DeWitt, '71; Greenberg, '76; Heath, '65) and social behavior (Crews, '75; Greenberg, '77a; Noble and Bradley, '33). Learning in lizards was reviewed by Brattstrom ('78) and Burghardt ('77). The behavior of *A. carolinensis* has been described by Crews ('75), Evans ('36, '38), B. Greenberg and Noble ('44), Greenberg ('77a), and Noble and Bradley ('33).

Anolis carolinensis are small, easy to handle, economical to maintain, and are robust subjects for surgical procedures. They are easily captured in the field or readily available from commercial suppliers. It is one of the most broadly distributed of the anoles, the largest genus of reptiles of the Americas. It is the only member of the genus which is native to the continental United States and ranges from North Carolina to Florida, west to southeastern Oklahoma and central Texas (Conant, '75). This species may reach a maximum body size (snout-to-vent) of 75 mm. Detailed information is available about their biology, ecology, and natural history (Gordon, '56). Specimens utilized in our laboratory are from southern Louisiana, where they occur in high densities in ecotonal areas of the coastal plains (Gordon, '56).

METHODS

Stereotaxic technique

A headholder for *Anolis carolinensis* was adapted from a Kopf Small Animal Stereotaxic instrument (Fig. 1). The apparatus provides a bite plate covered with a thin layer made of dental elastic impression material into which the lizard's teeth are pressed by a forked clamp with a rubber strap stretched between the tines as it is lowered over the animal's snout. Additional support is provided by blunt ear-bars which are freshly tipped with fast-setting dental impression material (e.g., light-bodied permlastic, Kerr Corp., Romulus, MI) in order to avoid injuring the tympanic membrane. Since hypothermia is used to obtain anesthesia, the instrument is provided with an adjustable tray for packing the lizard's body in crushed ice.

The horizontal reference plane along the same line as the edge of the upper jaw is provided by the bite plate; anterior/posterior, and lateral measurements utilize the center of the cornea of the parietal eye located on the top of the head as a zero point (Fig. 2). Measurements on five anesthetized individuals indicate that the surface of the brain is 0.5 mm below the zero point.

Surgical techniques

Because of tail autotomy and seasonal variations in fat stores, snout-to-vent (S-V) length is more reliable than weight as an index of size and maturity in iguand lizards. Lizards initially operated on varied from 59 to 69 mm S-V. For consistency in stereotaxic coordinates and to minimize relative size effects on behavioral tests, we came to limit the size of experimental subjects to 63–65 mm S-V. To conduct surgery, a subject was placed in a bed of crushed ice for a minimum of 10 minutes. When all

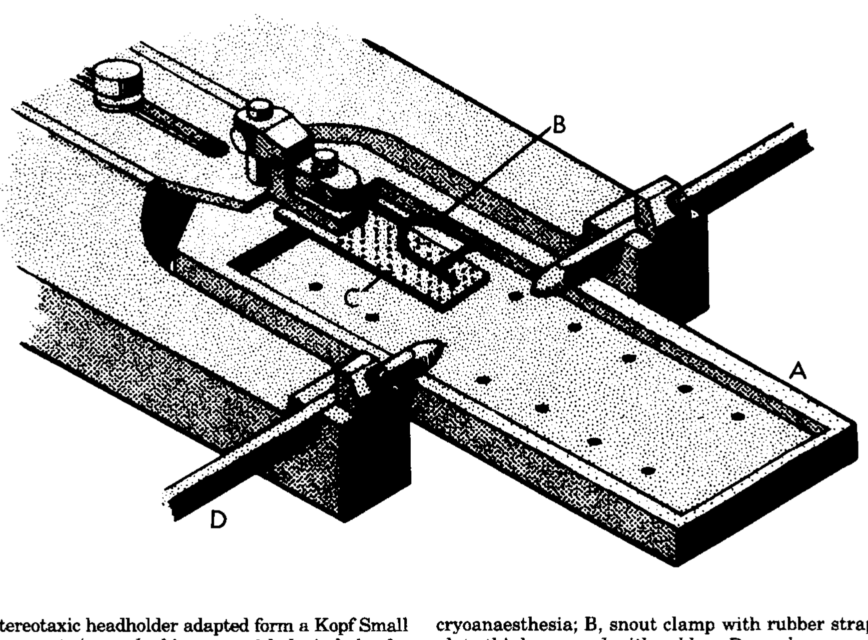

Fig. 1. Stereotaxic headholder adapted form a Kopf Small Animal Instrument. A, crushed ice tray with drain holes for cryoanaesthesia; B, snout clamp with rubber strap; C, bite plate thinly covered with rubber; D, ear-bar.

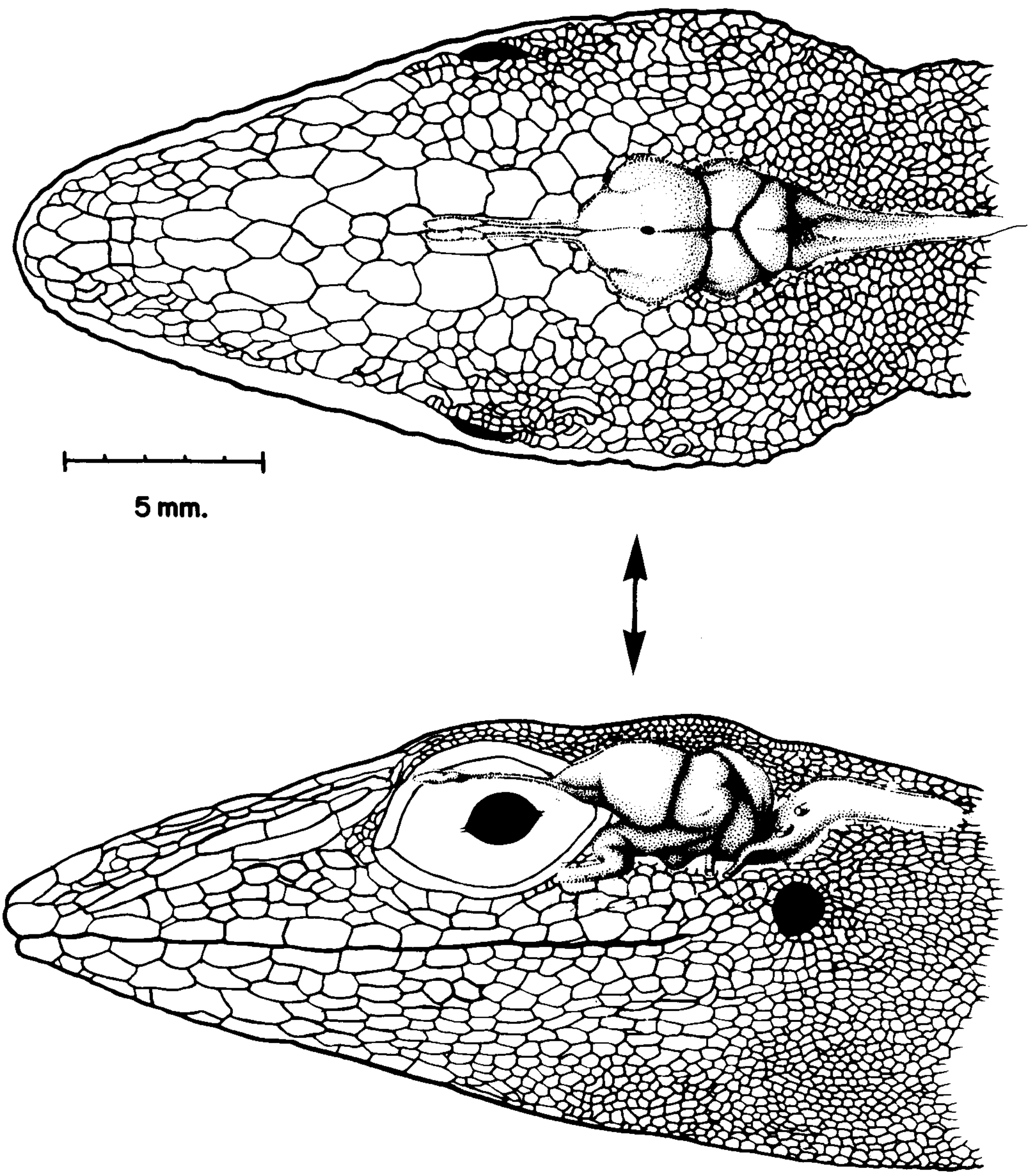

Fig. 2. Position of brain in cranium of lizard. Arrow indicates level of parietal eye used as the stereotaxic zero point.

signs of muscular activity ceased, it was transferred to the tray of the head-holder and again packed in ice. A sponge beneath a drain in the ice tray absorbed melting ice. The upper jaw of a lizard was pressed gently into the bite plate. The headholder was then adjusted until a natural resting posture was obtained and the earbars were positioned alongside the tympanic opening. Several drops of fast-setting dental impression material were placed between the head and earbars and then the bars were tightened to within 2 mm of the tympanic opening. The impression material conforms to the contours of an individual's head and sets in 10 minutes; after surgery it easily peels off.

Histological techniques

Lizards were sacrificed by injection with an overdose of Nembutal. To flush blood and fix tissue, transcardial perfusion of 0.9% saline followed by 10% formalin in 0.9% saline was performed with a 27-gauge needle connected by flexible tubing to a hypodermic syringe. The animals were then decapitated, the lower jaws removed, and the head skinned and placed in 10% formalin with sucrose for at least 2 days. The brains were cut in situ. Prior to embedding, a cranium was placed in 5% formic acid for 24–30 hours to decalcify, a procedure that did not compromise the quality of subsequent staining. Heads were embedded in gelatin-albumin or gelatin and transverse serial frozen sections were prepared on a freezing-sliding microtome set at 25 or 50 μm. To obtain transverse sections, the edge of the jaw was exposed and lined up with the vertical edge of a drafting triangle placed on the track of the microtome blade. Trial sections through the snout allowed correction for symmetry.

The atlas figures were prepared from the decalcified head of a 64-mm lizard imbedded in gelatin-albumin. Two guide tracks were placed beneath the jaw parallel to the horizontal plane to provide an independent horizontal reference point. Once the cranial vault was revealed, all sections were saved. Alternate sections were stained with cresyl violet for the Nissl material and the Weil stain for myelinated fibers. Several brains were prepared in the sagittal and horizontal planes for comparison. For the atlas illustrations, the left hemisphere of alternate Nissl-stained sections were photographed alongside a mirror-image photo in which the principal nuclei were delineated. To represent fiber tracts, adjacent Weil sections were projected onto acetate sheets overlying the photographs of Nissl sections, and drawn in place.

RESULTS AND DISCUSSION

Structural variability

The coordinates of three forebrain points were obtained along the anterior/posterior axis of 15 subjects (body size 63–65 mm) to indicate brain variability that might be expected in routine procedures (Fig. 3). The data indicate that an electrode can be placed in a 0.35-mm structure with high reliability. The greater variability in the coordinates of the posterior pole of the telencephalon was attributed to the relative lack of support from adjacent tissue, causing mechanical displacement of that portion of the brain during handling.

Limitations on stereotaxic accuracy

The average size of mature, vigorous males in commercial shipments was 60–68 mm. For most experimental procedures, males 63–65 mm were used. The atlas individual was 64 mm.

Since the brain grows more slowly than surrounding cranial tissue (Jerison, '73:28), the brain, supported by membranes and cartilage, becomes progressively more loosely supported within the skull. Thus the natural resting posture of the subject in the headholder is important because tension on the spinal cord can pull the entire brain caudally within the cranium.

The anterior/posterior position of the parietal eye shifts allometrically caudal as individuals grow, but within any given size class

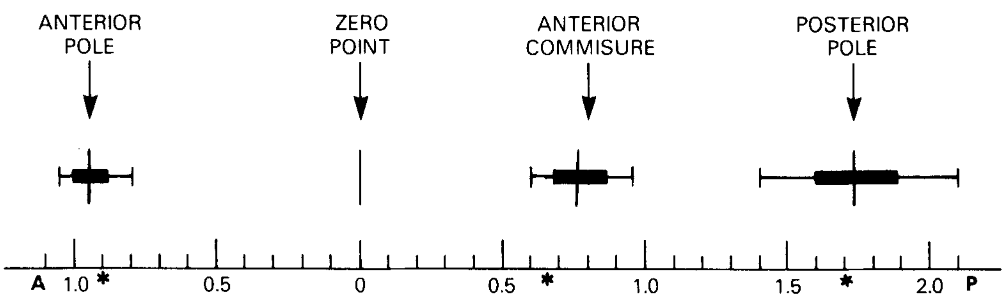

Fig. 3. Variability in the coordinates of three forebrain landmarks in 15 animals (body size 63–65 mm) relative to the zero point. The vertical line through a dark bar indicates the mean stereotaxic position of the specified landmark; the dark bar indicates one standard deviation on each side of the mean; the entire bar indicates the complete range of variation. Asterisks beneath the scale indicate the landmark coordinates in the atlas.

may be expected to be constant (J. Roth, personal communication).

Shrinkage was studied in canary brains after a similar perfusion technique, and after embedding and staining mounted sections (Stokes et al., '74). Less than 5% variation was observed when treated material was compared to fresh or perfused unstained material.

Nomenclature

Since there is as yet no complete architectonic study of the brain of *Anolis carolinensis* to guide the identification of telencephalic and diencephalic structures, terms were selected from recent reports on other lizards in which topological and in some cases architectonic information was sufficiently clear to allow generalization. Where ambiguity as to probable homology exists, the least specific term was utilized. For example, the nucleus of the lateral olfactory tract, identified in most lizards, is not clear in *A. carolinensis* although it is likely related to nucleus Al of Armstrong et al. ('53). On the other hand, nucleus sphericus (NS), conspicuous in the posterior dorsal ventricular ridge (PDVR) of most other lizards, is represented by a very small cell group that is clear in the atlas specimen and only three of 14 other brains examined. Preliminary retrograde degeneration experiments on olfactory and vomeronasal connections in *A. carolinensis* indicate a clear pathway that dissipates in the ventral neuropil of the PDVR at the level at which the NS would be expected (Greenberg and Switzer, unpublished data).

The reptilian DVR, the "strio-amygdaloid complex" of several authors (e.g., Goldby and Gamble, '57; Armstrong et al., '53), often has its posterior area (PDVR) identified as amygdala, in which NS is the most prominent structure. Some recent authors continue in this conservative but flexible tradition and regard NS as one of the cell groups within the PDVR (e.g., Northcutt, '81; Voneida and Sligar, '79), while others have identified PDVR as a distinct nucleus (Northcutt, '67) sometimes within a "basal" DVR (Balaban, '78; Ulinski and Peterson, '81). Kuhlenbeck ('77) locates NS within a posterior epibasal complex. Because of the confusion latent in these alternative uses of the term, the *Anolis* atlas retains PDVR in the more conservative sense. In *A. carolinensis* and other species that lack a distinct sulcus neostriaticus (Ariens Kappers, '21) or cytological criteria (Northcutt, '78) to indicate the boundary between ADVR and PDVR, the area is identified by a reduced cell density, which becomes obvious caudal to the level of the anterior commissure.

Correlative nuclear nomenclature of several lizard species is provided in Tables 1 and 2 for pallial and subpallial structures. The terms indicate only a few possible ambiguities. The uncommon designation, "Zone A of the ADVR" (ZA), has been utilized to identify a distinct area on the medial margin of ADVR, distinguished by Northcutt ('78) as a target of an ascending auditory pathway in *Iguana*. The "lateral area of the ADVR" (ADVR, lat) is similarly unfamiliar and is used here to designate the subpallial component of the dorsolateral cortex (CxDL), also identified in *Iguana*

TABLE 1. Pallial nomenclature in lizards

Current usage in *Anolis carolinensis*			Armstrong et al. ('53)	Northcutt ('67)	Northcutt ('78)	Distel ('76)
Abbrev.	Structure	Location	*Anolis* species	*Iguana iguana*	*Iguana iguana*	*Iguana iguana*
CxD	dorsal cortex	A0.6-P1.4	dorsal cortex	cortex dorsomedialis	dorsal cortex, divisions C1, C2	cortex dorsalis
CxDL	dorsolateral cortex	A0.6		cortex dorsolateralis		cortex dorsolateralis
CxL	lateral cortex	A0.2-P1.2	piriform cortex	cortex pyriformis	lateral cortex	cortex lateralis
CxM, lc	medial cortex, large-celled div.	A0.2-P1.6	hippocampal cortex large-celled part	hippocampus, pars dorsalis	medial cortex, dorsal division (C1)	cortex dorsomedialis
CxM, sc	medial cortex, small-celled div.	A0.2-P1.6	hippocampal cortex, small-celled part	hippocampus, pars dorsomedialis	medial cortex, ventral division (C2)	cortex medialis
DMI	dorsomedial interposition	PO.4-P1.6			dorsal cortex, division C3	

TABLE 2. Subpallial nomenclature in lizards

	Current usage in *Anolis carolinesis*		Armstrong et al. ('53)	Northcutt ('67)	Distel ('76)	Northcutt ('78)
Abbrev.	Structure	Location	*Anolis* species	*Iguana iguana*	*Iguana iguana*	*Iguana iguana*
ADVR	anterior dorsal ventricular ridge	A0.6-P1.2	hypopallium	hyperstriatum anterius	hyperstriatum anterius	dorsal ventricular ridge, anterior div
ADVR, lat	anterior dorsal ventricular ridge, lateral area	A0.4-P0.4		cortex dorsolateralis	cortex dorsomedialis [sic]	
AON	anterior olfactory n.	A0.6	anterior olfactory n., pars lateralis	n. olfactorius anterior	n. olfactorius anterior	
BNac	bed n. of the anterior commissure	P0.6		n. commissurae anterioris	n. commissurae anterioris	
BNhc	bed n. of the hippocampal commissure	P0.6		n. commissurae hippocampi	n. commissurae hippocampi	
BNst	bed n. of the stria terminalis	P0.6				
NA 1	n. A1	A0.2-P0.6	amygdaloid n.1	hyperstriatum posterius [?]	hyperstriatum posterius [?]	
NA 3	n. A3	P0.2-P0.6	amygdaloid n. 3	neostriatum [?]	neostriatum [?]	
NAcc	n. accumbens	A0.2-P0.4	paleostriatum medialis	n. accumbens	n. accumbens + [ventromedial] paleostriatum	n. accumbens
Ndb	n. diagonal band	AP0.0	n. diagonal band	n. diagonal band of Broca	n. diagonal band of Broca	n. diagonal band of Broca
NDL Sep	n. dorsolateralis of the septum	P0.4-P0.8	ventromedial n of paraterminal body	n. parolfactorius medialis	n. parolfactorius medialis	septal nuclei
NS	n. sphericus	P0.6	amygdaloid n. 2	n. sphaericus	n. sphaericus	n. sphericus
NVM Sep	n. ventromedialis of the septum	A0.2-P0.6	dorsolateral n. of paraterminal body	n. parolfactorius lateralis	n. parolfactorius lateralis	septal nuclei.
PDVR	posterior dorsal ventricular ridge	P0.6-P1.2		hyperstriatum posterius	hyperstriatum posterius	dorsal ventricular ridge, posterior div.
Ps	paleostriatum	A0.4-P0.4	paleostriatum lateralis, small-celled part	paleostriatum	paleostriatum	striatum
Ps (lat)	paleostriatum, lateral area	P0.2-P0.4		neostriatum	neostriatum	striatum
Ps, lc	paleostriatum, large-celled area	AP0.0-P0.2	paleostriatum lateralis, large-celled part			
Tub olf	olfactory tubercle	A0.6-P0.2	olfactory tubercle	tuberculum olfactorium	tuberculum olfactorium	olfactory tubercle
VMN	ventromedial n. of the PDVR	P0.6-P1.0	amygdaloid n. 4	ventromedial nucleus	n. ventromedialis	n. ventromedialis
ZA	zone A of the ADVR	P0.2-P1.0				sensory zone A of ADVR

TABLE 3. Diencephalic nomenclature in lizards

Current usage in *Anolis carolinensis*			Butler and Northcutt ('73) *Anolis carolinensis*	Cruce ('74) *Tupinambis nigropunctatus*	Distel ('76) *Iguana iguana*	Northcutt ('78) *Iguana iguana*
Abbrev.	Structure	Location				
DHN	dorsal hypothalamic n.	P1.0-P1.2	n. dorsolateralis hypothalami	n. dorsolateralis hypothalami	n. dorsolateralis hypothalami	n. dorsolateralis hypothalami
DLN	dorsolateral n	P1.0	n. dorsolateralis anterior	n. dorsolateralis anterior	n. dorsolateralis anterior thalami	dorsolateral n.
DMN	dorsomedial n.	P1.0-P1.2	n. dorsomedialis	n. dorsomedialis	n. dorsomedialis thalami	dorsomedial n.
Hab	habenula	P0.8-P1.4	n. habenularis medialis [3 divisions recognized]	n. habenularis [2 divisions recognized]	n. habenularis	habenular n. [2 divisions recognized]
LGN	lateral geniculate n.	P0.8-P1.2	n. geniculatis lateralis [3 divisions recognized]	n. geniculatis lateralis [2 divisions recognized]	n. geniculatis lateralis	lateral geniculate n.
LHA	lateral hypothalamic area	P1.4	n. lateralis hypothalami	lateral hypothalamic area	n. lateralis hypothalami	
LMN	lentiform mesencephalic n.	P1.4	n. lentiformis mesencephali	n. lentiformis mesencephali		n. lentiformis mesencephali
LTN	lentiform thalamic n.	P1.4	n. lentiformis thalami [2 divisions recognized]	n. lentiformis thalami pars plicata	n. lentiformis thalami [2 divisions recognized]	
MN	mammillary n.	P1.6		n. mammillaris [2 divisions recognized]		
NM	n. medialis	P1.2	n. medialis	n. medialis pars anterior	n. medialis thalami	medial n.
NP	n. periventricularis	P1.0-P1.4	n. periventricularis	n. paraventricularis hypothalami	periventricular hypothalamic n.	
N Rot	n. rotundus	P1.2	n. rotundus	n. rotundus	n. rotundus	n. rotundus
PHN	posterior hypothalamic n.	P1.4-P1.6	n. periventricularis [posterior, ventral]	n. posterior hypothalami	n. lateralis hypothalami	
PMN	premammillary n.	P1.2-P1.4		n. premammillaris		
PGN	pretectal geniculate n.	P1.4	n. geniculatus pretectalis	n. geniculatus pretectalis	n. geniculatis pretectalis	n. geniculatus pretectalis
POA	preoptic area	P0.2-P0.8	n. preopticus	preoptic area [2 divisions recognized] n. periventricualris preopticus	n. praeopticus	
SCN	suprachiasmatic n.	P0.6		n. suprachiasmaticus		
VMA	ventromedial area	P1.4	area ventromedialis	area ventromedialis	area ventromedialis thalami	
VMH	ventromedial hypothalamus	P1.0-P1.6	n. ventralis hypothalami	n. ventromedialis hypothalami	n. ventralis hypothalami	ventromedial hypothalamus
VMTN	ventromedial thalamic n.	P1.0-P1.2	n. ventromedialis	n. ventromedialis thalami	n. ventromedialis thalami	n. ventromedialis thalami

(Northcutt, '67), that appears to merge with ADVR and become less distinct at more posterior levels. This area may be Area C of Northcutt ('78), identified as the possible recipient of visual information relayed through nucleus rotundus. Diencephalic structures are named in Table 3. Support for the identification of the suprachiasmatic nucleus, the bed nucleus of the stria terminalis, and mammillary nuclei derives largely from Crosby and Woodburne's report on the hypothalamus ('40: Figs. 47, 51). Although several other telencephalic structures invite comparison with possible homologs in other species, the proposal of such hypotheses must await completion of detailed architectonic studies.

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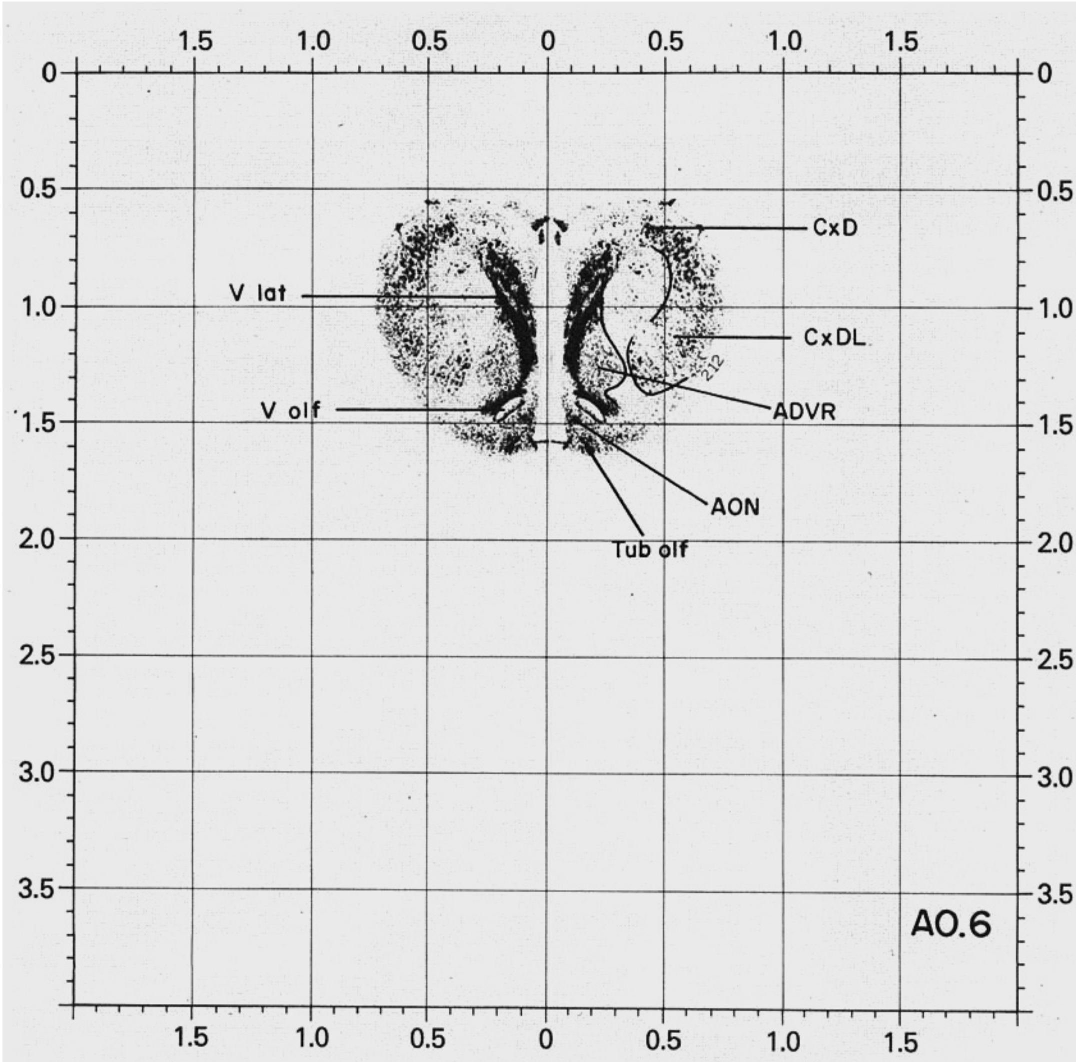

Fig. 4. Level A0.6.

ADVR	anterior dorsal ventricular ridge
AON	anterior olfactory nucleus
CxD	dorsal cortex
CxDL	dorsolateral cortex
Tub olf	olfactory tubercle
V lat	lateral ventricle
V olf	olfactory ventricle

Figs. 4–15. Transverse sections through the forebrain of *Anolis carolinensis*. Stereotaxic coordinates are in millimeters. Figures were prepared of sections at 0.2-mm intervals anterior (A) or posterior (P) to the zero point (AP 0.0).

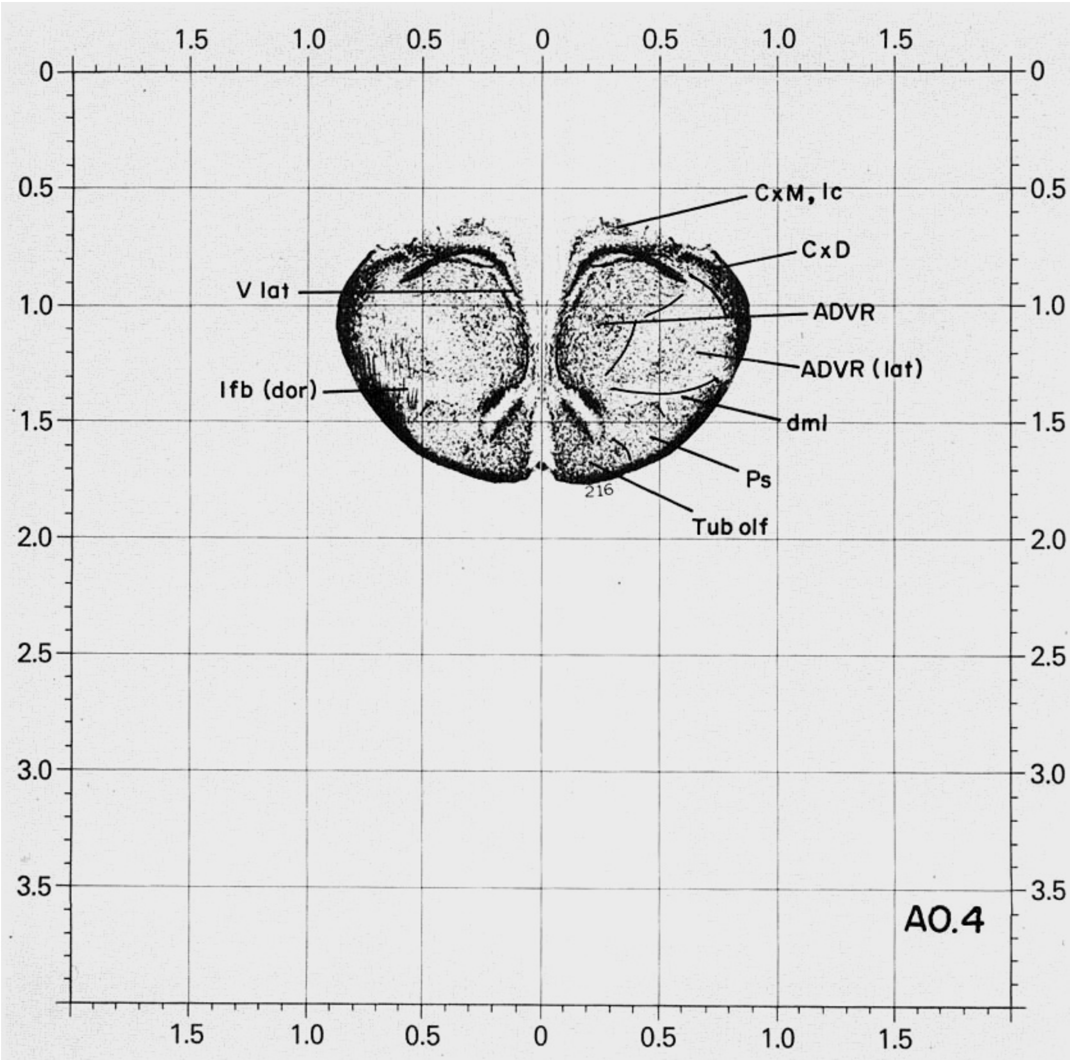

Fig. 5. Level A0.4.

ADVR	anterior dorsal ventricular ridge	dml	dorsal medullary lamina
ADVR (lat)	anterior dorsal ventricular ridge, lateral area	lfb (dor)	lateral forebrain bundle, dorsal peduncle
CxD	dorsal cortex	Ps	paleostriatum
CxM	medial cortex	Tub olf	olfactory tubercle
		V lat	lateral ventricle

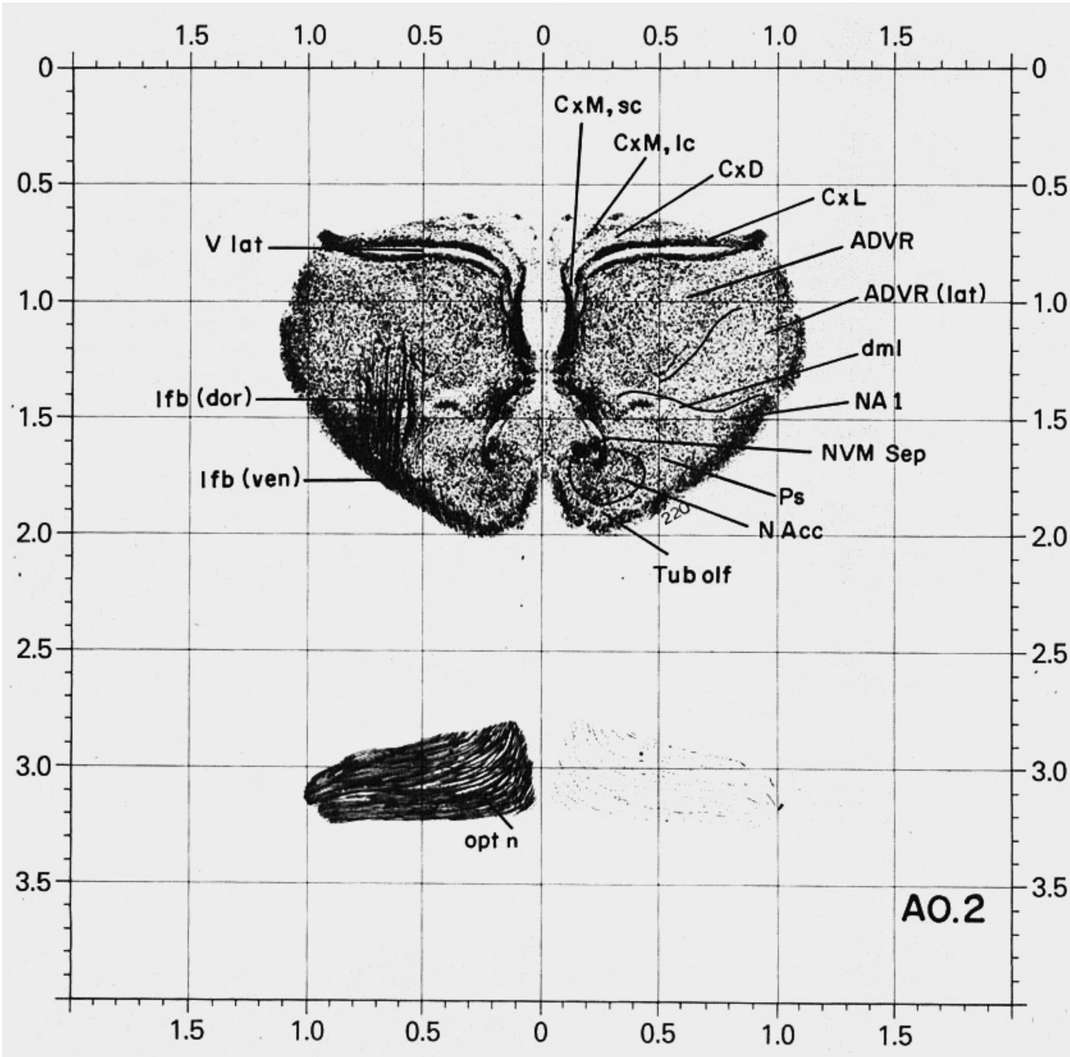

Fig. 6. Level A0.2

ADVR	anterior dorsal ventricular ridge
ADVR (lat)	anterior dorsal ventricular ridge, lateral area
CxD	dorsal cortex
CxL	lateral cortex
CxM, lc	medial cortex, large-celled division
CxM, sc	medial cortex, small-celled division
dml	dorsal medullary lamina
lfb (dor)	lateral forebrain bundle, dorsal peduncle
lfb (ven)	lateral forebrain bundle, ventral peduncle
N Acc	nucleus accumbens
NA1	nucleus A1
NVM Sep	nucleus ventromedialis of the septum
opt n	optic nerve
Ps	paleostriatum
Tub olf	olfactory tubercle
V lat	lateral ventricle

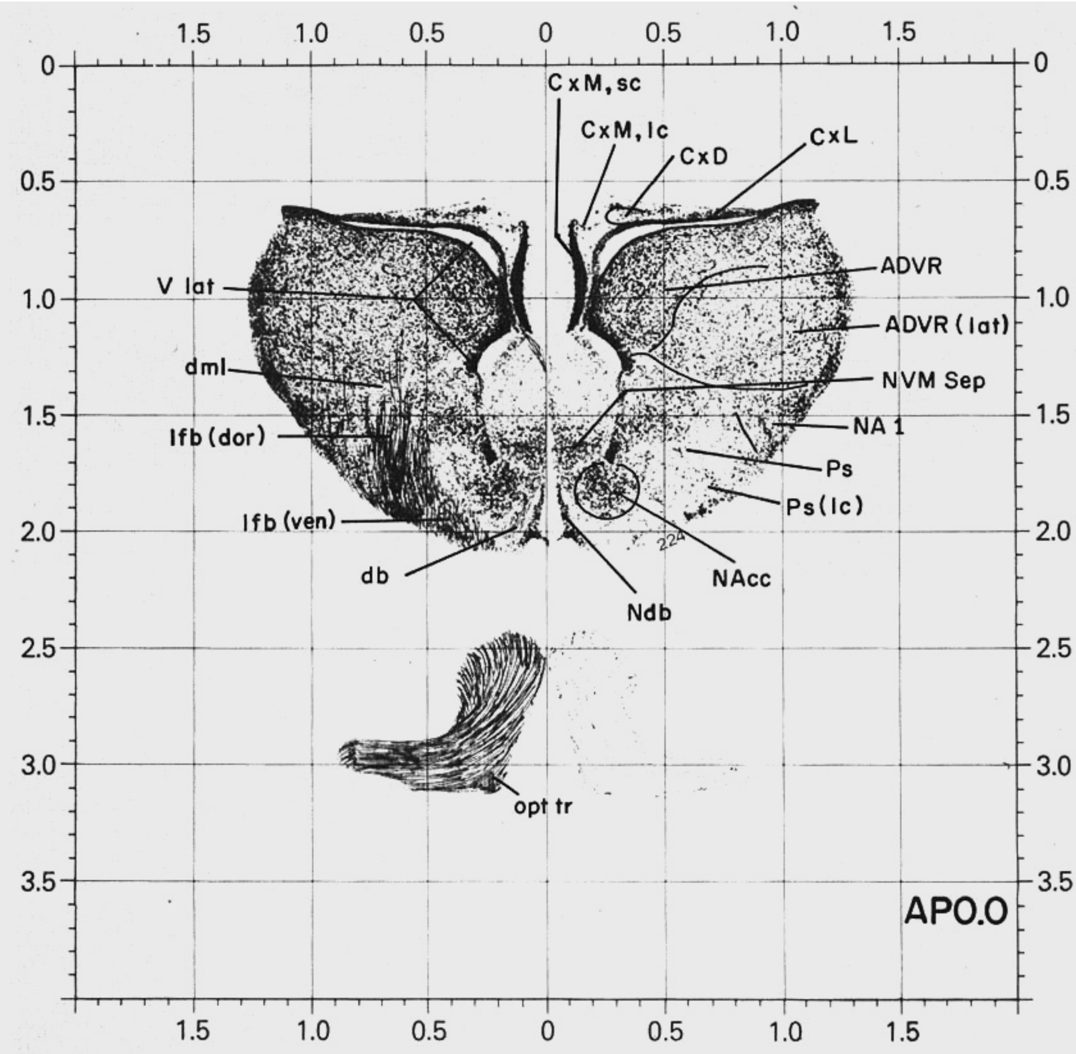

Fig. 7. Level A0.0.

ADVR	anterior dorsal ventricular ridge	lfb (ven)	lateral forebrain bundle, ventral peduncle
ADVR (lat)	anterior dorsal ventricular ridge, lateral area	N Acc	nucleus accumbens
CxD	dorsal cortex	NA1	nucleus A1
CxL	lateral cortex	Ndb	nucleus of the diagonal band
CxM, lc	medial cortex, large-celled division	NVM Sep	nucleus ventromedialis of the septum
CxM, sc	medial cortex, small-celled division	opt tr	optic tract
db	diagonal band	Ps	paleostriatum
dml	dorsal medullary lamina	Ps (lc)	paleostriatum, large-celled area
lfb (dor)	lateral forebrain bundle, dorsal peduncle	V lat	lateral ventricle

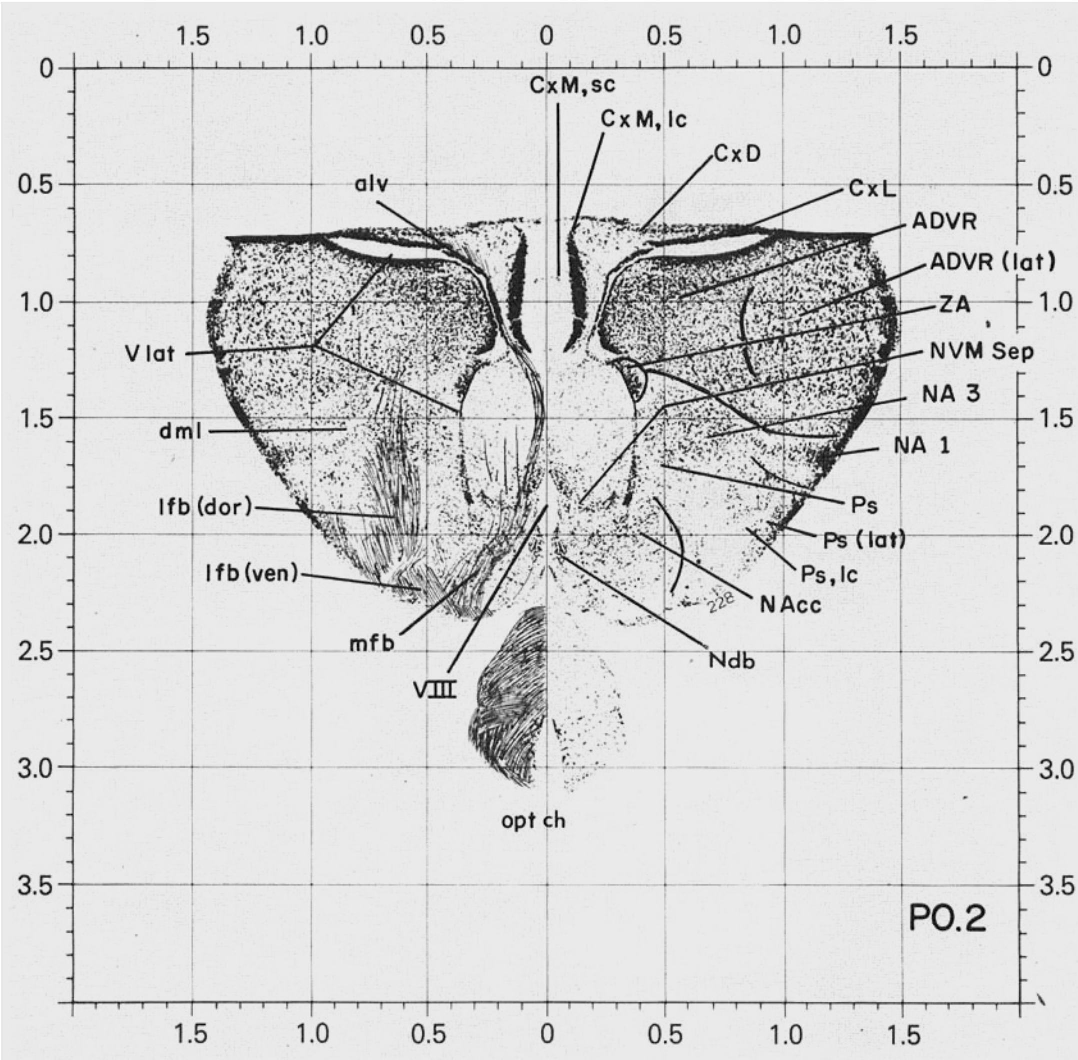

Fig. 8. Level P0.2.

ADVR	anterior dorsal ventricular ridge	NA1	nucleus A1
ADVR (lat)	anterior dorsal ventricular ridge, lateral area	NA3	nucleus A3
		N Acc	nucleus accumbens
alv	alveus	Ndb	nucleus of the diagonal band
CxD	dorsal cortex	NVM Sep	nucleus ventromedialis of the septum
CxL	lateral cortex	opt ch	optic chiasm
CxM, lc	medial cortex, large-celled division	Ps	paleostriatum
CxM, sc	medial cortex, small-celled division	Ps (lat)	paleostriatum, lateral area
dml	dorsal medullary lamina	Ps, lc	paleostriatum, large-celled area
lfb (dor)	lateral forebrain bundle, dorsal peduncle	V lat	lateral ventricle
lfb (ven)	lateral forebrain bundle, ventral peduncle	V III	third ventricle
mfb	medial forebrain bundle	ZA	zone A of the ADVR

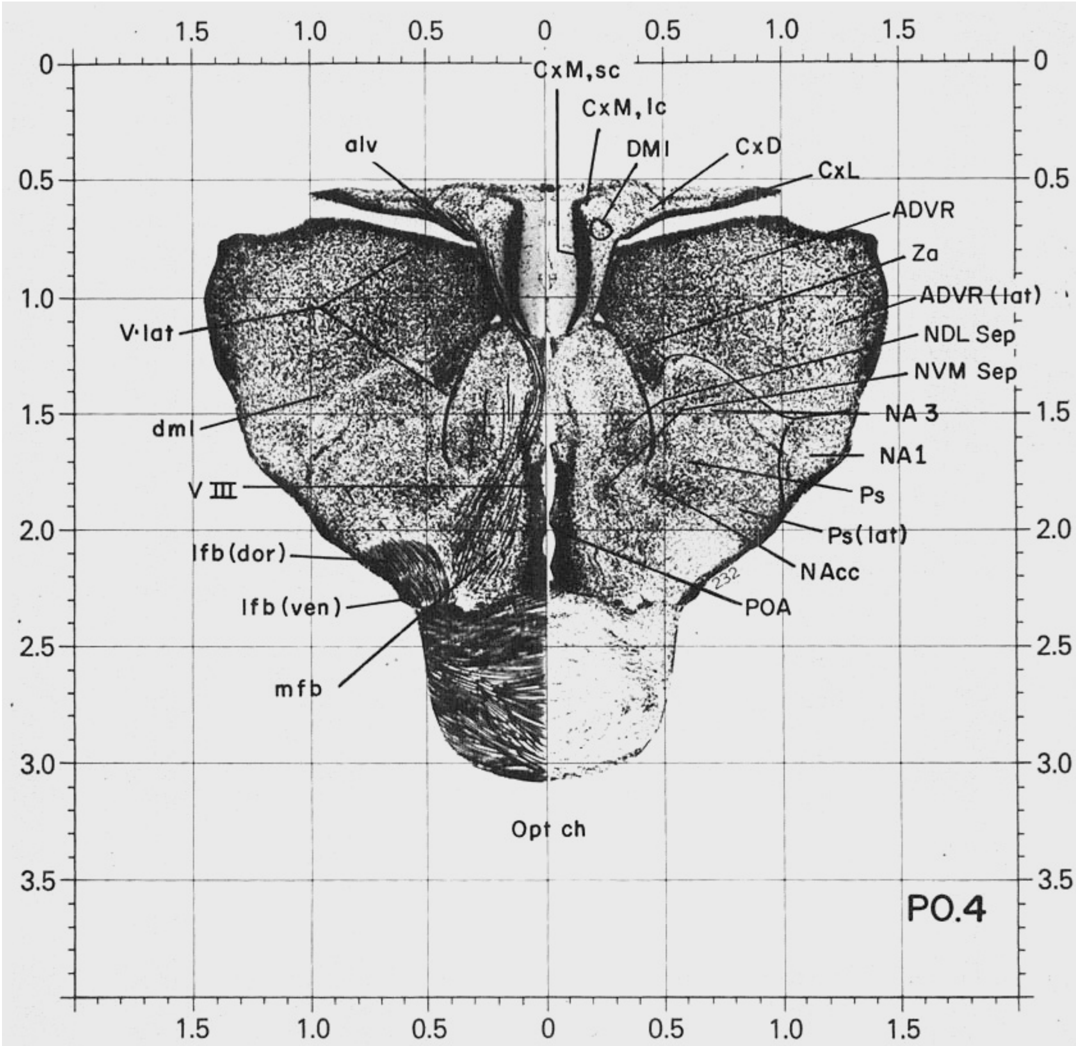

Fig. 9. Level P0.4.

ADVR	anterior dorsal ventricular ridge, medial area	mfb	medial forebrain bundle
ADVR (lat)	anterior dorsal ventricular ridge, lateral area	NA1	nucleus A1
alv	alveus	NA3	nucleus A3
CxD	dorsal cortex	N Acc	nucleus accumbens
CxL	lateral cortex	NDL Sep	nucleus dorsolateralis of the septum
CxM, lc	medial cortex, large-celled division	NVM Sep	nucleus ventromedialis of the septum
CxM, sc	medial cortex, small-celled division	opt ch	optic chiasm
DMI	dorsomedial interposition	POA	preoptic area
dml	dorsal medullary lamina	Ps	paleostriatum
lfb (dor)	lateral forebrain bundle, dorsal peduncle	Ps (lat)	paleostriatum, lateral area
lfb (ven)	lateral forebrain bundle, ventral peduncle	V lat	lateral ventricle
		V III	third ventricle
		ZA	zone A of the ADVR

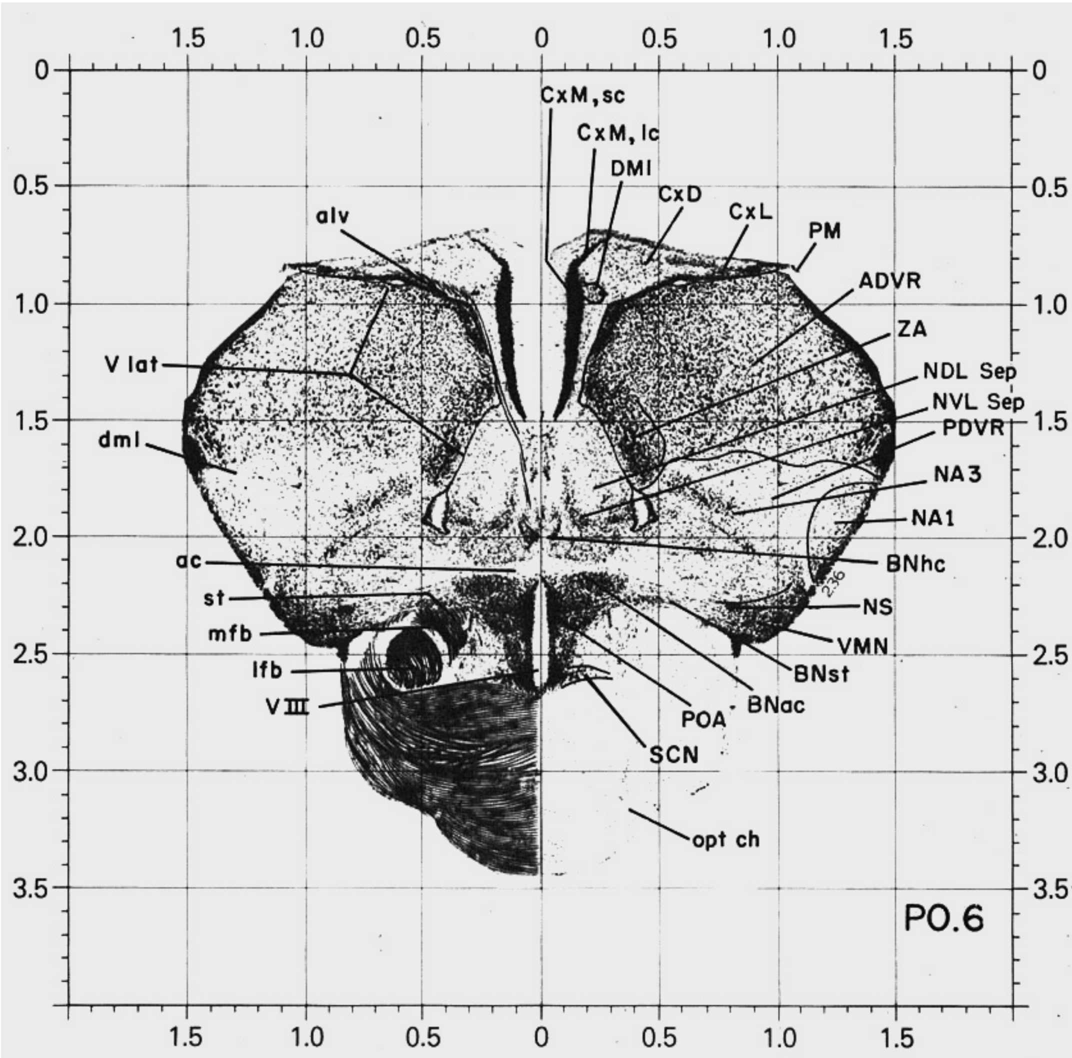

Fig. 10. Level P0.6.

ac	anterior commissure
ADVR	anterior dorsal ventricular ridge
alv	alveus
BNac	bed nucleus of the anterior commissure
BNhc	bed nucleus of the hippocampal commissure
BNst	bed nucleus of the stria terminalis
CxD	dorsal cortex
CxL	lateral cortex
CxM, lc	medial cortex, large-celled division
CxM, sc	medial cortex, small-celled division
DMI	dorsomedial interposition
dml	dorsal medullary lamina
lfb	lateral forebrain bundle
mfb	medial forebrain bundle
NA1	nucleus A1
NA3	nucleus A3
NDL Sep	nucleus dorsolateralis of the septum
NS	nucleus sphericus
NVM Sep	nucleus ventromedialis of the septum
opt ch	optic chiasm
PDVR	posterior dorsal ventricular ridge
PM	pallial membrane
POA	preoptic area
SCN	suprachiasmatic nucleus
st	stria terminalis
V lat	lateral ventricle
V III	third ventricle
VMN	ventromedial nucleus of the PDVR
ZA	zone A of the ADVR

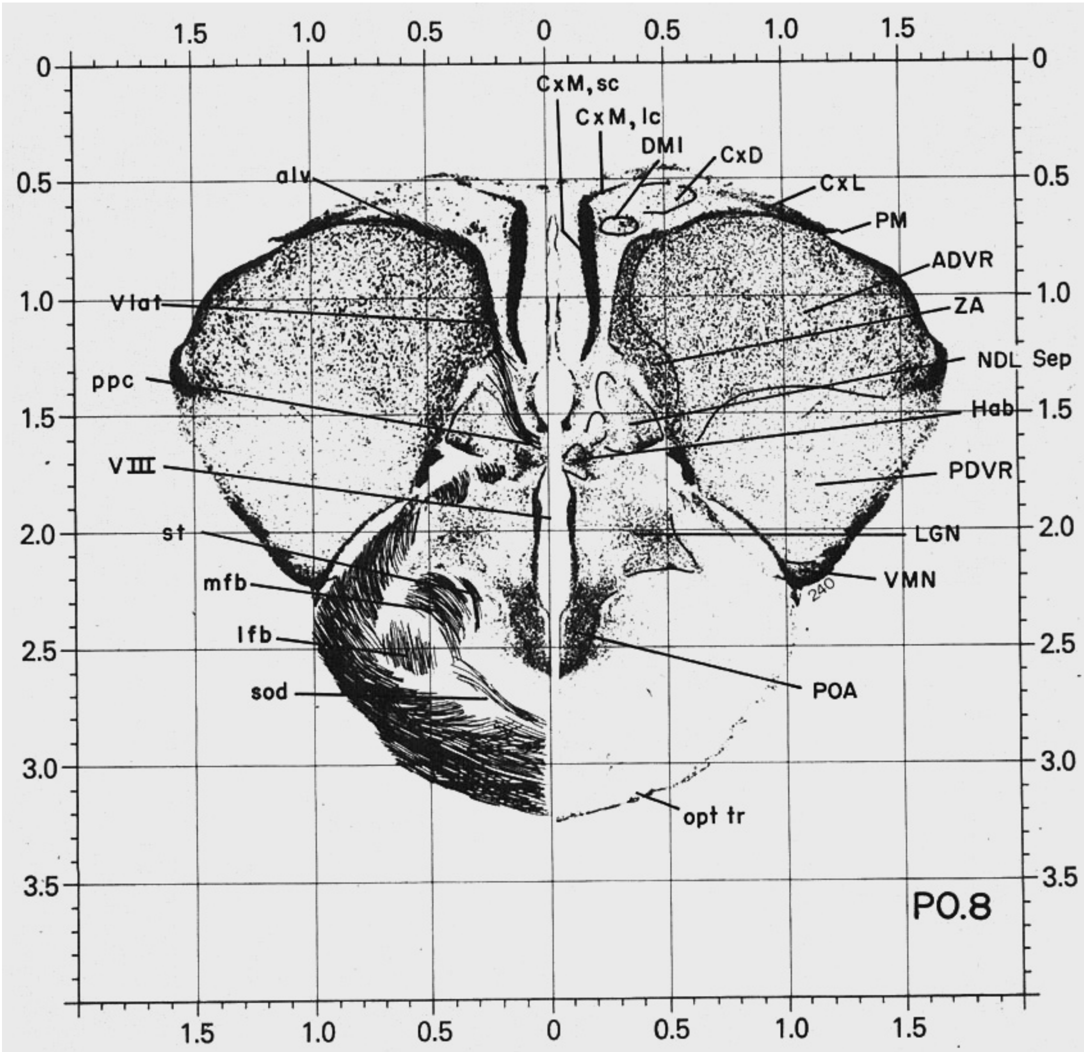

Fig. 11. Level P0.8.

ADVR	anterior dorsal ventricular ridge	opt tr	optic tract
alv	alveus	PDVR	posterior dorsal ventricular ridge
CxD	dorsal cortex	PM	pallial membrane
CxL	lateral cortex	POA	preoptic area
CxM, lc	medial cortex, large-celled division	ppc	posterior pallial commissure
CxM, sc	medial cortex, small-celled division	st	stria terminalis
DMI	dorsomedial interposition	sod	supraoptic decussation
Hab	habenula	V lat	lateral ventricle
lfb	lateral forebrain bundle	V III	third ventricle
LGN	lateral geniculate nuclei	VMN	ventromedial nucleus of the PDVR
mfb	medial forebrain bundle	ZA	zone A of the ADVR
NDL Sep	nucleus dorsolateralis of the septum		

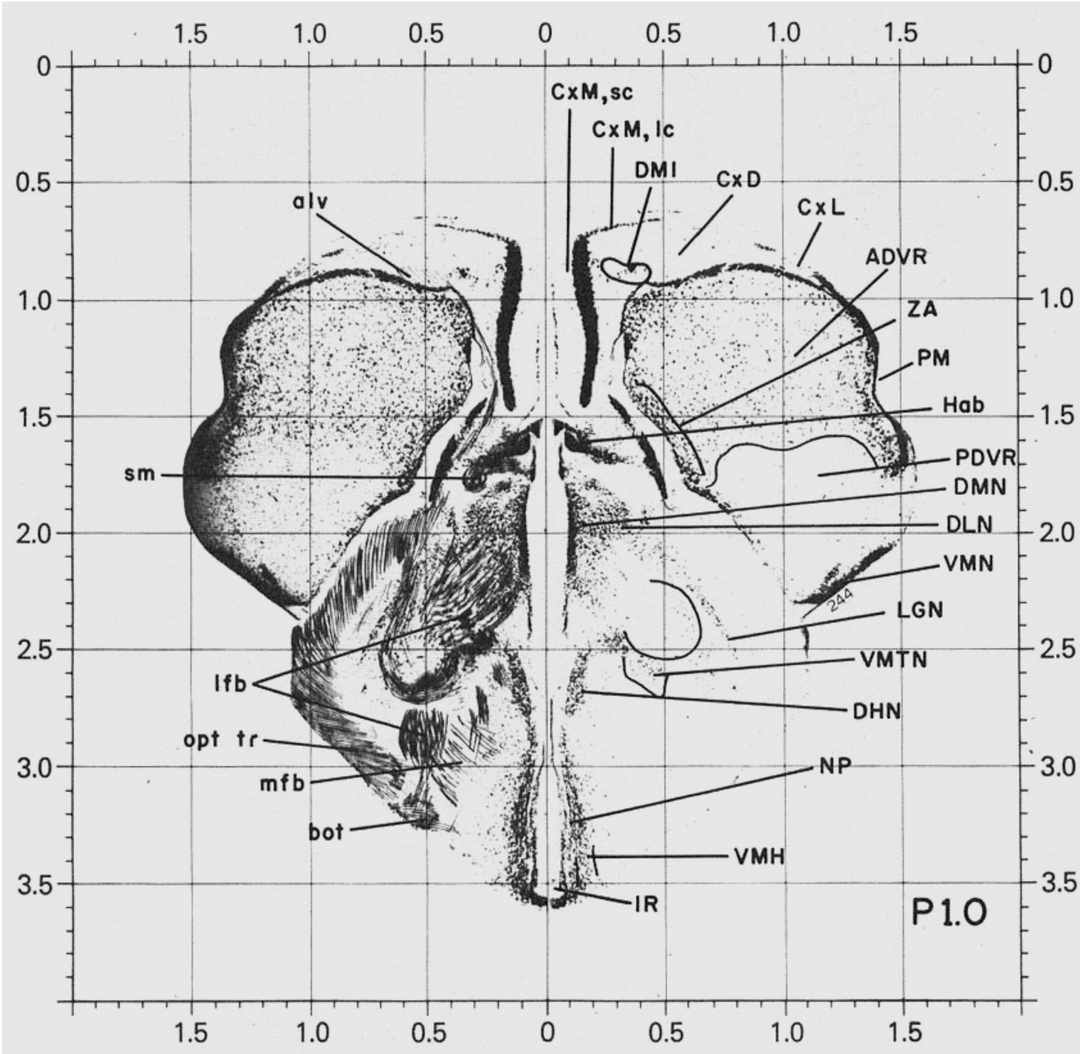

Fig. 12. Level P1.0.

ADVR	anterior dorsal ventricular ridge	lfb	lateral forebrain bundle
alv	alveus	LGN	lateral geniculate nucleus
bot	basal optic tract	mfb	medial forebrain bundle
CxD	dorsal cortex	NP	nucleus periventricularis
CxL	lateral cortex	opt tr	optic tract
CxM, lc	medial cortex, large-celled division	PDVR	posterior dorsal ventricular ridge
CxM, sc	medial cortex, small-celled division	PM	pallial membrane
DHN	dorsal hypothalamic nucleus	sm	stria medullaris
DLN	dorsolateral nucleus	VMN	ventromedial nucleus of the PDVR
DMI	dorsomedial interpositin	VMH	ventromedial hypothalamus
DMN	dorsomedial nucleus	VMTN	ventromedial thalamic nucleus
Hab	habenula	ZA	zone A of the ADVR
IR	infundibular recess		

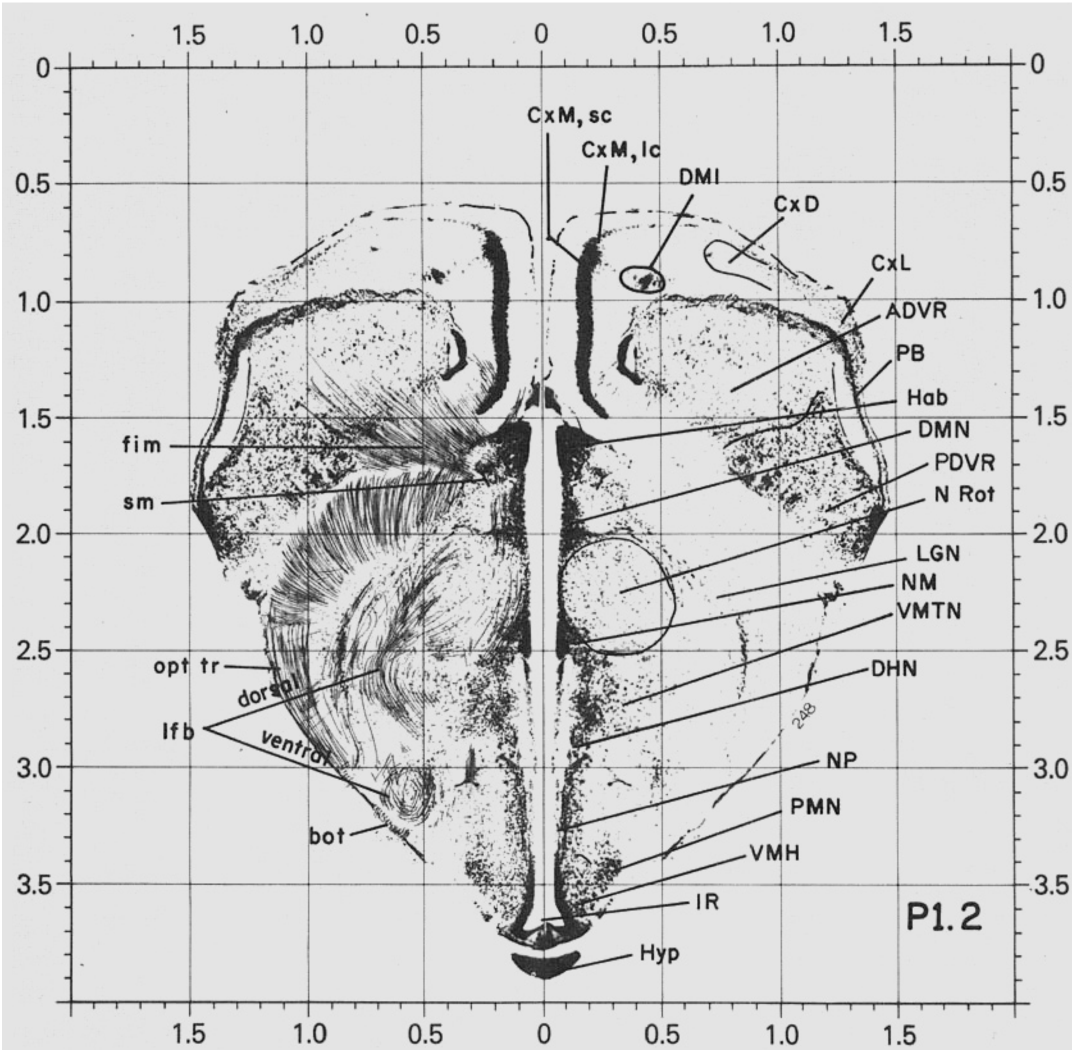

Fig. 13. Level P1.2.

ADVR	anterior dorsal ventricular ridge	lfb	lateral forebrain bundle
bot	basal optic tract	LGN	lateral geniculate nucleus
CxD	dorsal cortex	NM	nucleus medialis
CxL	lateral cortex	NP	nucleus periventricularis
CxM, lc	medial cortex, large-celled division	N Rot	nucleus rotundus
CxM, sc	medial cortex, small-celled division	opt tr	optic tract
DHN	dorsal hypothalamic nucleus	PB	pallial bridge
DMI	dorsomedial interposition	PDVR	posterior dorsal ventricular ridge
DMN	dorsomedial nucleus	PMN	premammillary nucleus
fim	fimbria	sm	stria medullaris
Hab	habenula	VMH	ventromedial hypothalamus
Hyp	hypophysis	VMTN	ventromedial thalamic nucleus
IR	infundibular recess		

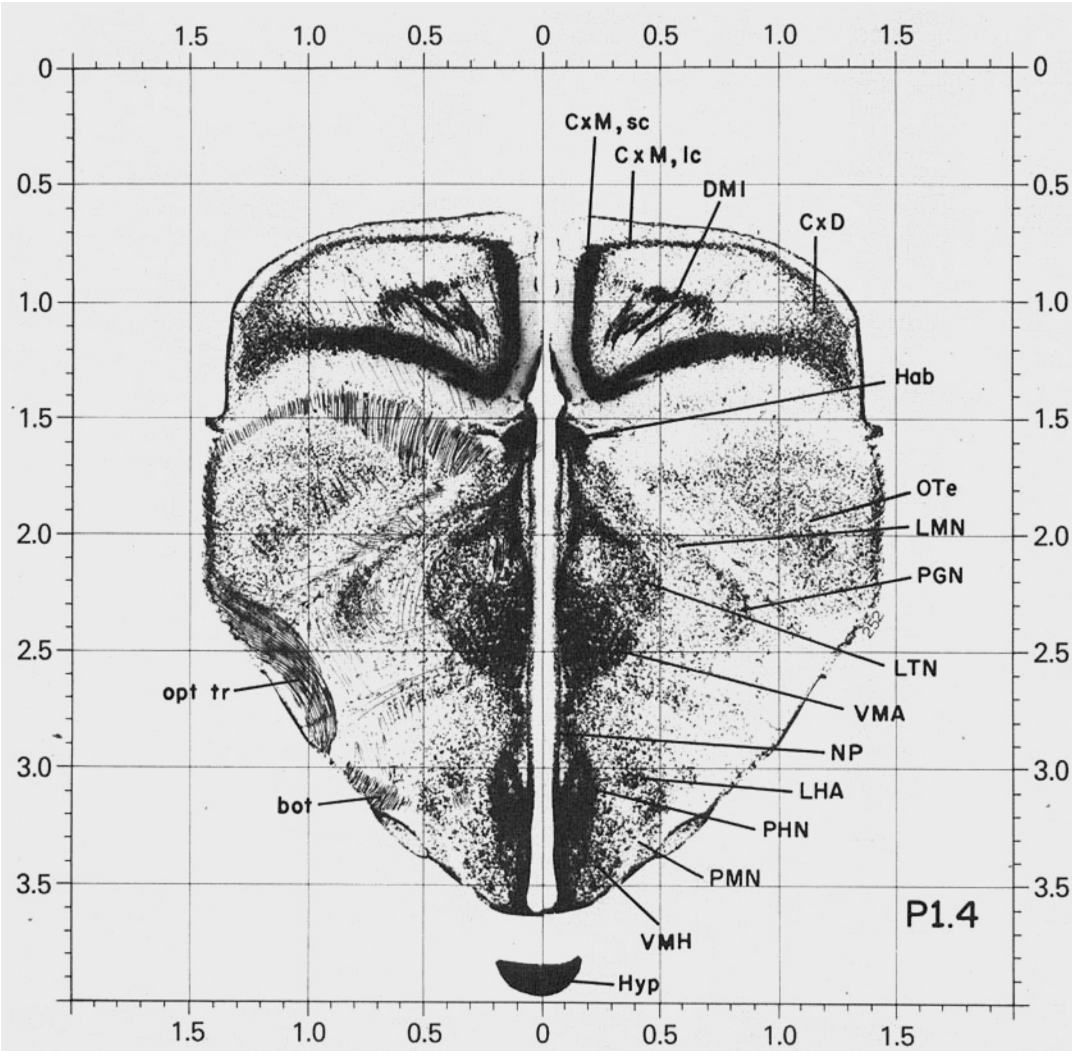

Fig. 14. Level P1.4.

bot	basal optic tract	LTN	lentiform thalamic nucleus
CxD	dorsal cortex	NP	nucleus periventricularis
CxM, lc	medial cortex, large-celled division	opt tr	optic tract
CxM, sc	medial cortex, small-celled division	OTe	optic tectum
DMI	dorsomedial interposition	PGN	pretectal geniculate nucleus
Hab	habenula	PHN	posterior hypothalamic nucleus
Hyp	hypophysis	PMN	premammillary nucleus
LHA	lateral hypothalamic nucleus	VMA	ventromedial area
LMN	lentiform mesencephalic nucleus	VMH	ventromedial hypothalamus

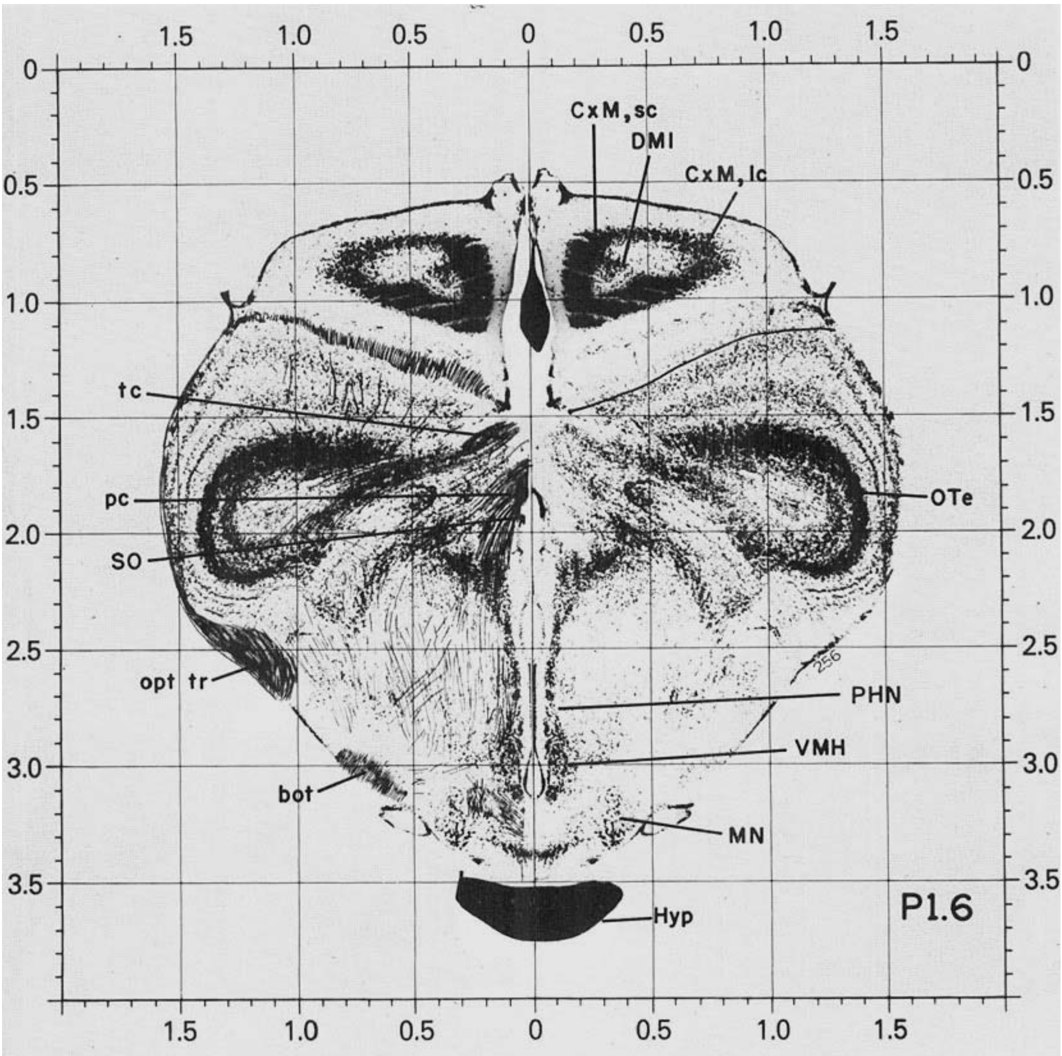

Fig. 15. Level P1.6.

bot	basal optic tract	OTe	optic tectum
CxM, lc	medial cortex, large-celled division	pc	posterior commissure
CxM, sc	medial cortex, small-celled division	PHN	posterior hypothalamic nucleus
DMI	dorsomedial interposition	SO	subcommisural organ
Hyp	hypophysis	tc	tectal commissure
MN	mammillary nuclei	VMH	ventromedial hypothalamus
opt tr	optic tract		