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Research Article

ORGANIZATION OF MYELENCEPHALON (MEDULLA OBLONGATA) OF INDIAN HOUSE WALL LIZARD *HEMIDACTYLUS FLAVIVIRIDIS*

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ABSTRACT
Topological organization of the myelencephalon (medulla oblongata) of Indian house wall lizard has been studied by Eager's method. The myelencephalon (medulla oblongata) is well developed in Indian house wall lizard *Hemidactylus flaviviridis.* The anterior part of the myelencephalon (medulla oblongata) joins with the posterior caudal part of the metencephalon (cerebellum). The posterior part of the myelencephalon (medulla oblongata) joins with the anterior part of the spinal cord. The myelencephalon is developed. The myelencephalon is triangular. It is broad in front by narrow and tapering behind. The thin and highly vascular roof of myelencephalon (medulla oblongata) forms the posterior choroid plexus. Posteriorly, the myelencephalon shows a strong ventral flexure where it passes into the spinal cord.
The rostral part of the myelencephalon has fasciculus longitudinalis medialis, nervus abducens, nervus trigeminus, nucleus cochlearis angularis, nucleus descendens nervi trigemini, nucleus nervi abducentis, nucleus motorius nervi trigemini, pars dorsalis, nucleus motorius nervi trigemini, pars ventralis, nucleus princeps nervi trigemini, nucleus raphes inferior, nucleus reticularis medianus, nucleus vestibularis dorsolateralis, nucleus vestibularis ventromedialis and oliva superior. The caudal part of the myelencephalon includes dorsal fissure, fasciculus longitudinalis medialis, nucleus funiculi dorsalis, nucleus tractus solitarii and ventral fissure.

Keywords: *Myelencephalon, Organization, Eager's Method 1970*

INTRODUCTION
The lizards are among the most commonly spotted of all reptiles. There are over 3500 different types of lizards existing in all climates throughout India. The walls and ceilings are their niche where they walk and live their lives. The house wall lizard *Hemidactylus flaviviridis* belongs to the family Gekkonidae of suborder Sauria or Lacertilia is second largest family of this suborder. It is said that lizards are poisonous except two species *Heloderma suspectum* and *Heloderma hornidum* are poisonous. The lizards are predator of insects hence they are useful for farmers and agriculture. They can be used for pest management.
In our present study the myelencephalon (medulla oblongata) region of the hindbrain of *Hemidactylus flaviviridis* for better understanding of its anatomy and phylogenetic character has been presented.

MATERIALS AND METHODS
Ninety seven adult lizards, Sauria or Lacertilia of both sexes weighing 45 to70 gms were used in this experiment. Animals were kept in the cage in the light and cool atmosphere at a room temperature (25 to 30°C). The experimental lizards were kept isolated in the separate cage from normal animal. Prior to the experiment, the specimens were acclimatized at room temperature for one day. Surgical procedures were performed with sterilized dissecting instruments. The specimens were anaesthetized by immersing with 10% formalin for 10 to 15 minutes prior to the surgery.

Operation Procedure
For perfusion, animals were anaesthetized with chloroform for 2 to 5 minutes. Completely anaesthetized lizard was kept in the operating tray. After fixing the lizard, a small longitudinal incision was made in the middle of the thorax (1 cm). The rib cage was cut open right from the middle to expose the viscera. The thorax was opened to expose the heart. The pericardium was removed. Fine syringe of the perfusion set was inserted in the aorta through the posterior part of the ventricle. First of

all 50 ml of physiological saline (0.75%) was allowed to pass through the aorta to the entire body, lower part of the ventricle was cut and blood was allowed to release. The whole blood of the body was replaced by physiological saline. One hundred ml. of fixative (10% formalin) was allowed to perfuse through the heart in continuation with saline. Precaution was taken to avoid the clotting of the blood which actually leads to incomplete perfusion. After the perfusion of the fixative, the animal becomes totally stretched. Following perfusion for about 15 minutes, the whole brain and spinal cord were dissected out and post fixed in the perfusion fluid at 4°C for twenty four hours. The brain and spinal cord were cut at 40 µm thick on AO HistoSTAT microtome at –20°C. The serial sections were put in section collecting trays containing 2 to 10% formaldehyde solution. For maintaining the serial orders only 5 sections were placed in each bin of the tray. The sections were processed with Eager's method (1970).

Perfusion

This method is conventional technique for preserving the whole animal body by pumping the fixative through the heart in to the whole body, via vascular system. The perfusion is performed by a simple infusion set. This technique works on the gravity flow principle. The perfusion bottle was kept three feet above to the operating table. The infusion set comprises to ordinary infusion set, a bottle with lid having two outlets, in one of them infusion needle was inserted and in other normal injection needle was inserted to avoid air lock. The infusion set comprises of plastic tube, an air column on both side, needle and a stopper.

RESULTS

The myelencephalon (medulla oblongata) is well developed in Indian house wall lizard *Hemidactylus flaviviridis.* The anterior part of the myelencephalon (medulla oblongata) connects with the posterior caudal part of the metencephalon (cerebellum). The posterior part of the myelencephalon (medulla oblongata) connects with the anterior part of the spinal cord. The myelencephalon is developed. The myelencephalon is triangular. This is broad in front by narrow and tapering behind. The thin and highly vascular roof of myelencephalon (medulla oblongata) constructs the posterior choroid plexus. Posteriorly, the myelencephalon presents a strong ventral flexure where it passes into the spinal cord. The sections of myelencephalon from rostral to caudal part (Figs.1-10) includes the following cell masses/ nuclei / structures.

Fasciculus longitudinalis medialis (FLM) :

It is located at the rostral most to caudal mostlevel of myelencephalon region. It is a small region of scattered cells. The cells are small tomedium star shaped. The exact boundary of this cell mass can not be made because of thescattered cells (Figs.1A,B-10A-C).

Nervus abducens (NVI) :

This is situated ventro-laterally to oliva superior (OLS), ventrallyto nucleus reticularis medius (RM) and laterally to nucleus raphes inferior (RAI) (Fig.1A-B).

Nervus trigeminus (NV) :

It is demarcated laterally to vestibularis dorsolateralis (VEDL), latero-dorsally to the nucleus princeps nervi trigemini (VPR) and dorso-lateral in the position(Fig.1A-B).

Nucleus cochlearis angularis (COA) :

This is depicted on dorsal side of nucleus vestibularis ventromedialis (VEVM) and dorso-lateral side of the middle portion (Fig.1A-B).

Nucleus descendense nervi trigemini (VDS) :

It is located almost latero-ventrally to the nucleus motorius nervi trigemini, pars ventralis (VMV) and dorsally to the oliva superior (OLS) (Fig.1A-B).

Nucleus nervi abducentis (VI) :

It is present just below the IVth ventricle. In fact on both sides of FLM densely packed aggregation of cells is differentiated which is motor nucleus of VI cranial nerve. The cells in the caudal region are scattered as compared to rostral region (Fig.3A-B).

Nucleus motorius nervi trigemini, pars dorsalis (VMD) :

This is situated latero-dorsally to the fasciculus longitudinalis medialis (FLM) and ventro-laterally to nucleus princeps nervi trigemini (VPR) and almost in middle part (Fig.1A-B).

Nucleus motorius nervi trigemini, pars ventralis (VMV) :
It is depicted latero-dorsally to the nucleus descendense nervi trigemini (VDS), lateral to the nucleus nervi abducentis (VI) and ventro-laterally to the nucleus motorius nervi trigemini, pars dorsalis (VMD) and dorsally to the oliva superior (OLS) (Fig.1A-B).

Abbreviations used in figures

DF dorsal fissure
FLM fasciculus longitudinalis medialis
V-IV fourth ventricle
NVI nervus abducens
NXII nervus hypoglossus
NV nervus trigeminus
NVIII nervus vestibulocochlearis
AMB nucleus ambiguus
COA nucleus cochlearis angularis
VDS nucleus descendens nervi trigemini
FUN nucleus funiculi dorsalis
FL nucleus funiculi lateralis
XMD nucleus motorius dorsalis nervi vagi
VIIM nucleus motorius nervi fascialis
IXM nucleus motorius nervi glossopharngei
XIM nucleus motorius nervi spinal accessari
VMD nucleus motorius nervi trigemini, pars dorsalis
VMV nucleus motorius nervi trigemini, pars ventralis
VI nucleus nervi abducentis
XII nucleus nervi hypoglossi
VIII-C nucleus nervi vestibulocochleari, pars caudalis
VIII-D nucleus nervi vestibulocochleari, pars dorsalis
VIII-V nucleus nervi vestibulocochleari, pars ventralis
VPR nucleus princeps nervi trigemini
RAI nucleus raphes inferior
RM nucleus reticularis medius
RI nucleus reticularis inferior
SOL nucleus tractus solitarii
VEDS nucleus vestibularis descendens
VEDL nucleus vestibularis dorsolateralis
VETG nucleus vestibularis tangentialis
VEVL nucleus vestibularis ventrolateralis
VEVM nucleus vestibularis ventromedialis
OLS oliva superior
VF ventral fissure

Nucleus princeps nervi trigemini (VPR) :
This is demarcated to the latero-dorsally to the nucleus motorius nervi trigemini, pars dorsalis (VMD) and ventrally to the nucleus vestibularis dorsolateralis (VEDL) and laterally to the nervus trigeminus (NV) (Fig.1A-B).

Nucleus raphes inferior (RAI) :
It is located in the start of the myelencephalon region upto their caudal part. It is situated ventrally to the fasciculus longitudinalis medialis (FLM). It extends antero-posterior with tapering arrangement and is small in size. The cells are compactly arranged and small to medium in size (Fig.1A-B).

Nucleus reticularis medius (RM) :
It is present on the medioventral part of nucleus oliva superior (OLS). In the mediolateral region the VIth nerve are found to enter and RM is scattered up to entering point. RM contains medium sized neurons but at some places large sized neurons are also present (Fig.3A-B).

Nucleus vestibularis dorsolateralis (VEDL) :
This is situated at the superior dorsal part of alar plate. A group of medium sized cells constitute superior vestibular nucleus. The lateral border of superior vestibular nucleus is formed by the middle cerebellar peduncle while the medial border of it is occupied by medial vestibular group of small to medium sized cells. The ventral part is the caudal region of superior vestibular nucleus forms anterior part of lateral vestibular nucleus. At the ventral side it touches the sulcus intermedius dorsalis (Fig.1A-B).

Nucleus vestibularis ventromedialis (VEVM) :
It is located at the caudal part of locus coeruleus (LC). The different neurons are observed in the upper middle and lower part of it. The lower part has medium and small cells. In the middle part only medium sized cells are observed (Fig.1A-B).

Oliva superior (OLS) :
It is depicted ventrally to the nucleus vestibularis ventrolateralis (VEVL) dorso-laterally to the nucleus dorso-laterally to the nucleus descendense nervi trigemini (VDS) and ventro-laterally to the nucleus nucleus nervi vestibulocochleari, pars ventralis (VIII-V) (Fig.3A-B).

Nervus vestibulocochlearis (NVIII) :

This is represented laterally to the nucleus vestibularis tangentialis (VETG) and dorsally to the nucleus nervi vestibulocochleari, pars ventralis (VIII-V) and latero-dorsally to the nucleus vestibularis ventrolateralis (VEVL) (Fig.3A-B).

Nucleus nervi vestibulocochleari, pars caudalis (VIII-C) :

This is located ventrally in between the nucleus nervi vestibulocochleari, pars ventralis (VIII-V), nucleus nervi vestibulocochleari, pars dorsalis (VIII-D) and almost dorso-laterally to nucleus descendense nervi trigemini (VDS) (Fig.3A-B).

Nucleus nervi vestibulocochleari, pars dorsalis (VIII-D) :

It is demarcated to dorsally to the nucleus nervi vestibulocochleari, pars caudalis (VIII-C) and laterally to the nucleus nervi vestibulocochleari, pars ventralis (VIII-V) (Fig.3A-B).

Nucleus nervi vestibulocochleari, pars ventralis (VIII-V) :

This is situated almost dorso-laterally to the oliva superior (OLS) and almost laterally to the nucleus nervi vestibulocochleari, pars dorsalis (VIII-D) (Fig.3A-B).

Nucleus vestibularis tangentialis (VETG) :

This is demarcated dorsally to the nucleus vestibularis ventro-lateralis (VEVL), medially to the nervous vestibulocochlearis (NVIII) and dorso-medially to the nucleus vestibularis ventro-medialis (VEVM). It extends medio-medially. The cells of it are loosely arranged. It has large multipolar and some small sized cells (Figs.3A-B).

N**ucleus vestibularis ventrolateralis (VEVL) :**

The part of nucleus vestibularis ventrolateralis (VEVL) is occupied by many multipolar cells constitute lateral vestibular nucleus. The cells are of large sized. It is called lateral vestibular nucleus of Deiters. The rostral region of it is occupied by superior vestibular nucleus and medial region is bounded by medial vestibular nucleus. The large multipolar and small sized cells are present (Fig.3A-B).

Nucleus motorius nervi glossopharyngei (IXM) :

The cell groupings of it are depicted at the caudal most level of the motor nucleus of facial nerve (VIIM). The medium sized cells constitute a short column up to caudal most level of medulla oblongata (Fig.4A-B).

Nucleus motorius nervi facialis (VIIM) :

This is also present at the caudal region of nucleus motorius nervi trigemini (VM). It consists of stellate shaped neurons and can be divided into medial, dorsal and lateral regions (Fig.4A-B).

Nucleus reticularis inferior (RI) :

It is present in myelencephalon and situated almost mediolaterally to the nucleus raphes inferior (RAI). RI extends from the level nucleus glossopharyngei to the caudal most part of the nucleus vagi (X). The different sized cells are present in this region. The RI can be divided into two as dorsal part (RID) and ventral part (RIV). The dorsal part of reticularis inferior (RID) is more dense as compared to ventral part of reticularis inferior (RIV). The ventral part of reticularis inferior (RI) contains uniformly distributed small sized cells but RID contains medium to small sized cells (Fig.7A-B).

Vestibularis descendens (VEDS) :

It is characterised by the presence of longitudinal fibers originating from lower region of vestibular nucleus and extends caudally to the spinal cord. The cells are not clear but fibers are observed (Fig.6A-B).

Nucleus funiculi lateralis (FL) :

This is located dorsally to the nucleus ambiguus (AMB) and ventrally to the nucleus descendense nervi trigemini (VDS) (Fig.6A-B).

Nucleus ambiguus (AMB) :

It is demarcated ventral to the nucleus funiculi lateralis (FL) (Fig.6A-B).

Nucleus tractus solitarius (SOL) :

This is situated at the caudal level of the facial motor nucleus (VII). It is a conspicuous region. Both left and right SOL regions fuse in the caudal region to form the commissural nucleus of cajal. This can be differentiated into a medial SOL and a later SOL regions. The medial part of SOL contains small densely packed region while the lateral part is less densely packed. The

cells show polygonal shape scattered small to medium and large sized cells are observed (Fig.9A-C).

Nucleus motorius dorsalis nervi vagi (XMD) :

This is demarcated ventrally to the nucleus tractus solitarius (SOL) and dorso-laterally to the fasciculus longitudinalis medialis (FLM) (Fig.7A-B).

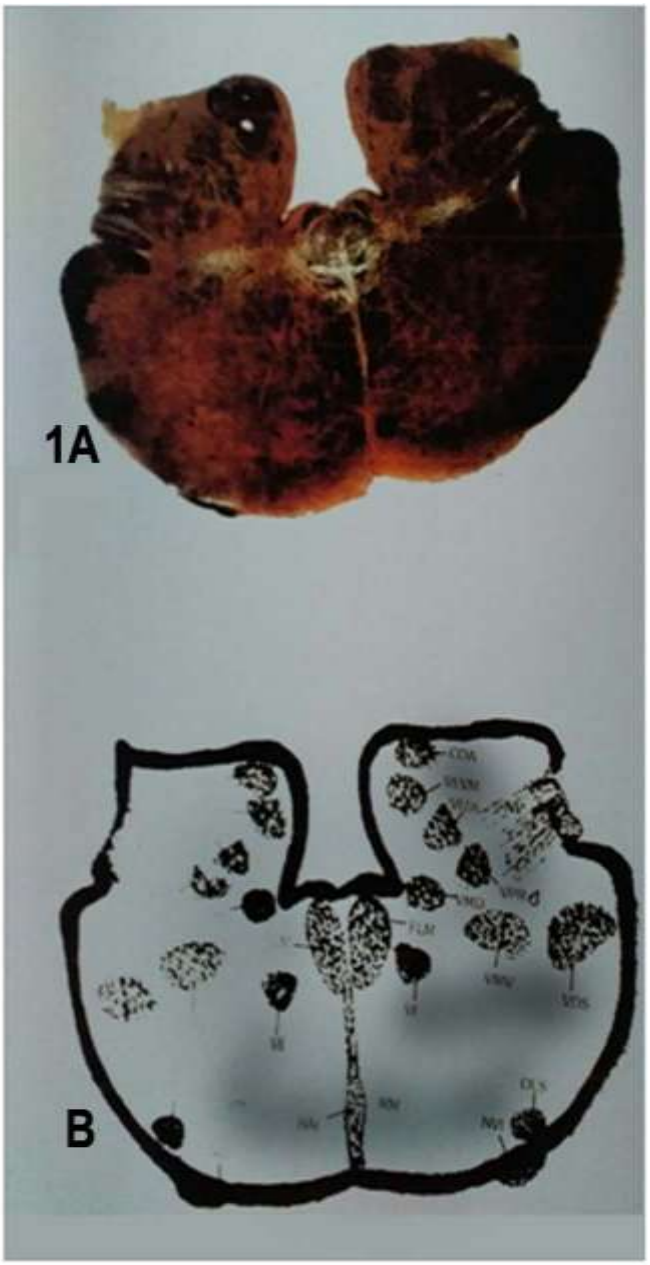

Figure 1A, B

Figure 2

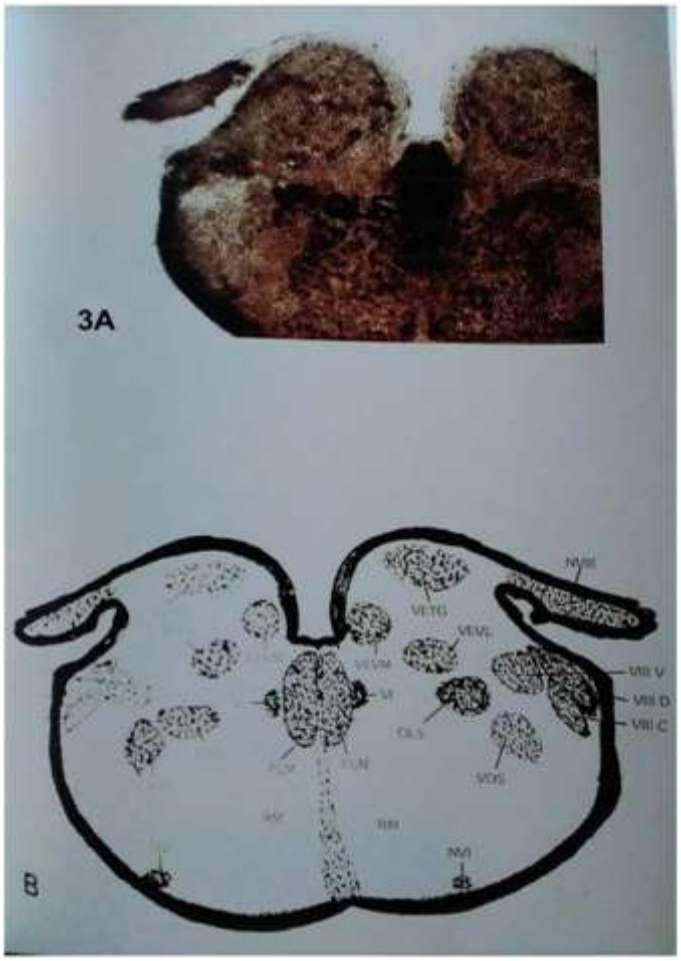

Figure 3A, B

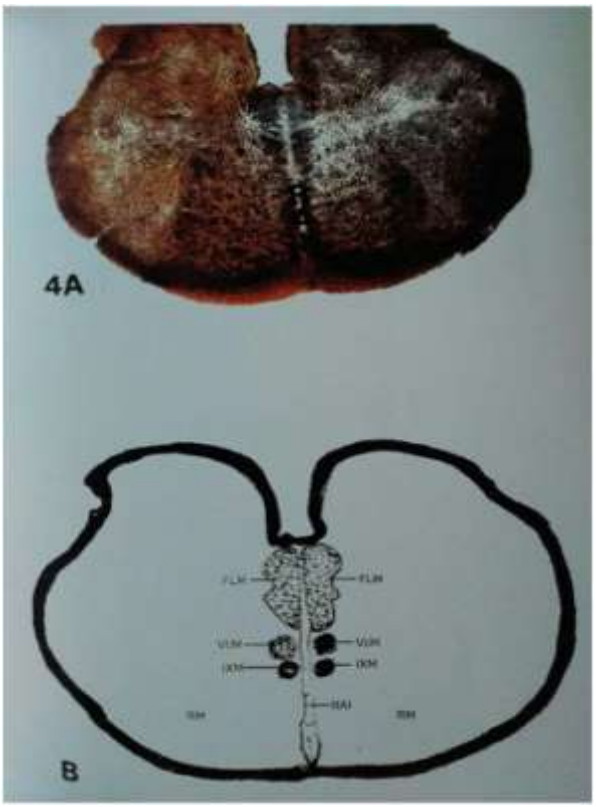

Figure 4A, B

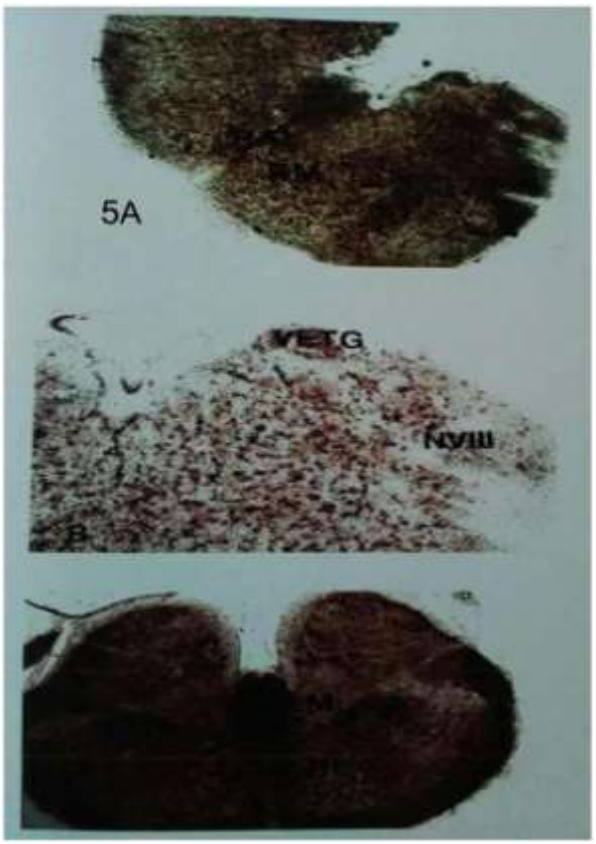

Figure 5A, B, C

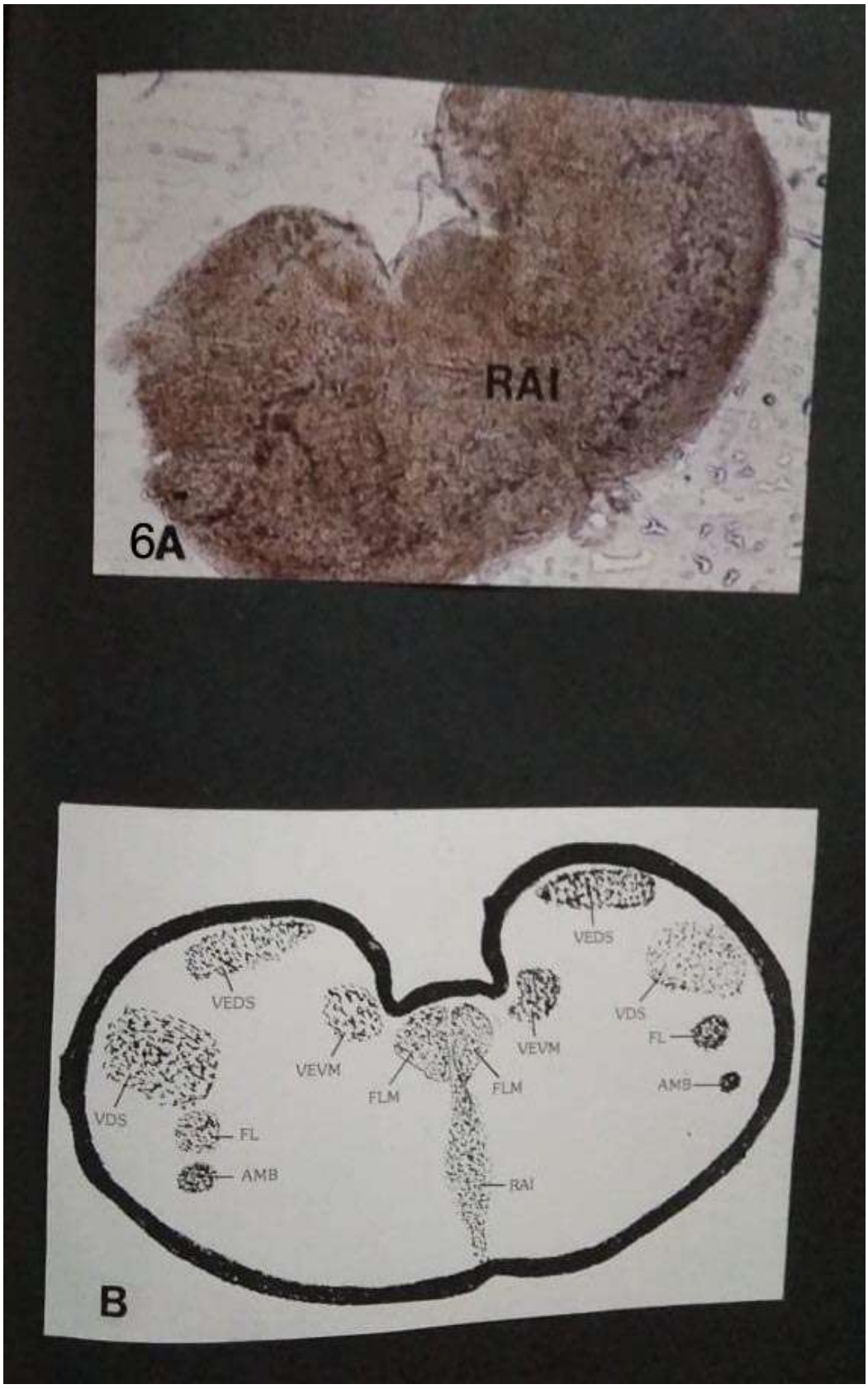

Figure 6A, B

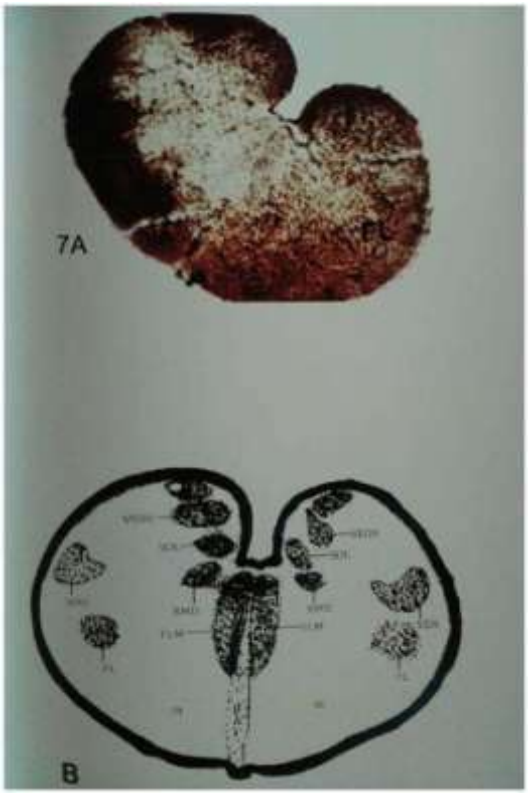

Figure 7A, B

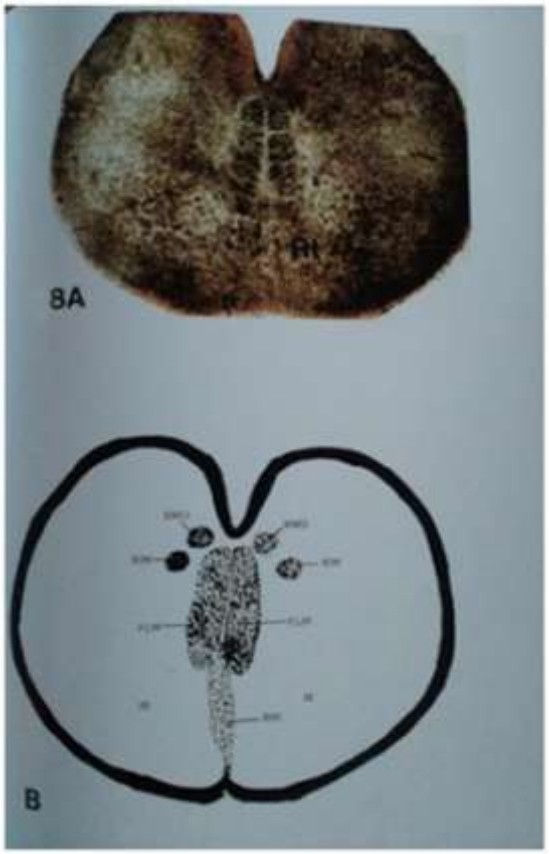

Figure 8A &B

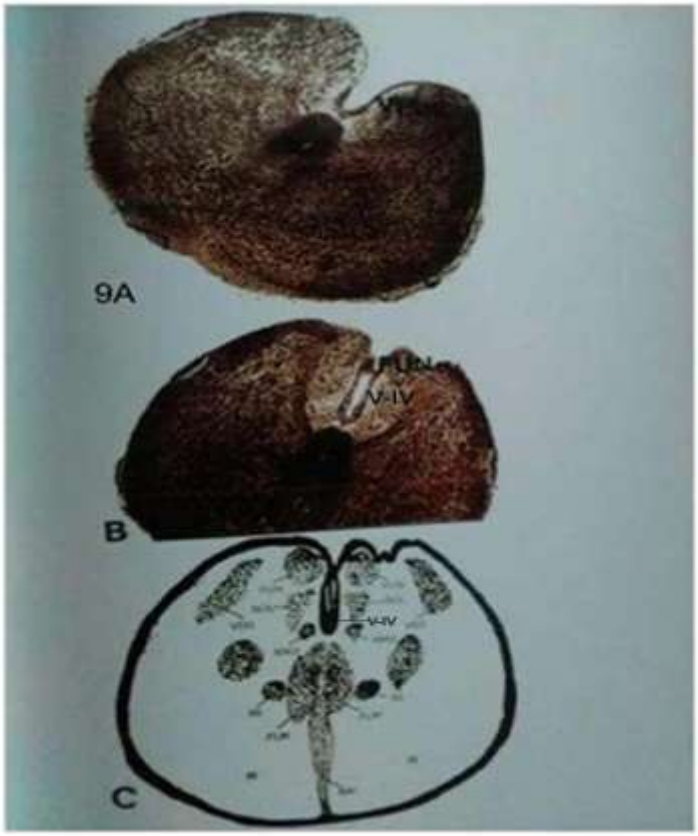

Figure 9A, B, C

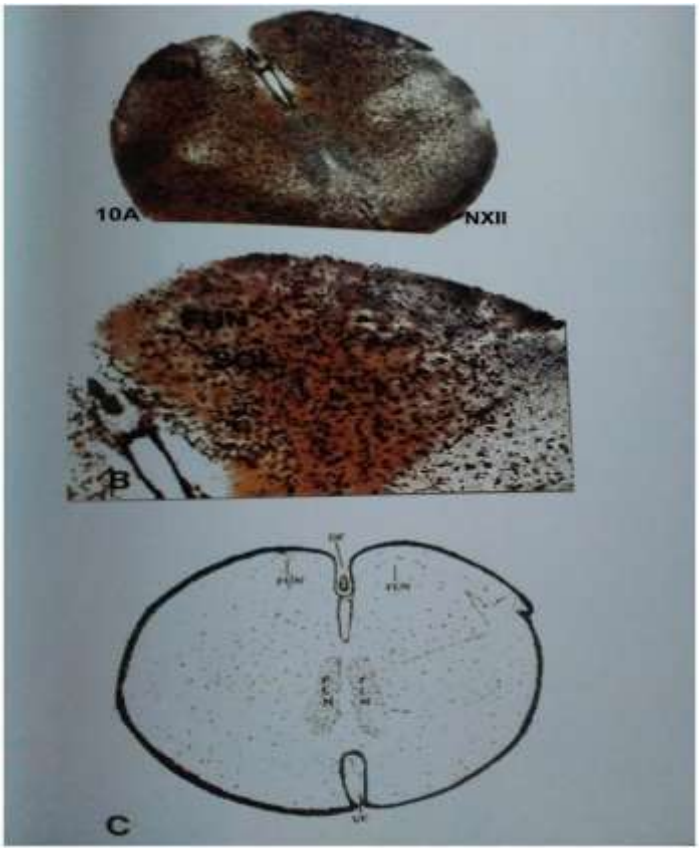

Figure 10A, B, C

Nucleus motorius nervi spinal accessori (XIM) :
This is located antero-medially to the fasciculus longitudinalis medialis and ventro-medially to the nucleus motorius dorsalis nervi vagi ((XMD). This is spherical in shape. It forms a longitudinal column from the caudal level of the myelencephalon. The cells are small to medium in size (Fig.8A&B).
Nucleus funiculi dorsalis (FUN) :
It is represented dorsally to the nucleus tractus solitarius (SOL) and laterally to the nucleus descendense nervi trigemini (VDS) in the dorsal middle portion (Fig.9A-C).
Nucleus nervi hypoglossi (XII) :
This is present in the caudal most region of myelencephalon below the Xth motor cranial nerve nuclei. It extends upto the upper most region of spinal cord. This is situated laterally to FLM. The small to medium and large size cells are observed (Fig.9A-C).
Metacoel (4th ventricle) :
It is **c**avity of rhombencephalon. This is quite big and wide forming rhomboidal shape. The walls are quite thick and extend bilaterally a medial, horizontal basal plate and a lateral alar plate. The rostral part of the fourth ventricle is covered by the cerebellum which can be seen in transverse sections. The caudal part of the metacoel is covered by tela choroidea which is connected to the dorsal part of alar plate and dorso-caudal region of cerebellum (Fig.9B-C).
Nervus hypoglossus (NXII) :
This is located ventro-laterally (Fig.10A).
Dorsal fissure (DF) :
It is a dorso-medially located furrow in between the two nucleus funiculi dorsalis (FUN) (Fig.10A-C).
V**entral fissure (VF) :**
It is depicted to the ventro-medial furrow and ventrally in between two fasciculus longitudinalis medialis (FLM) (Fig.10A-C).

DISCUSSION

The medulla oblongata is well developed in Indian house wall lizard *H. flaviviridis*. The rostral portion of the myelencephalon associates with the posterior caudal part of the cerebellum. The caudal part of the myelencephalon unites with the rostral part of the spinal cord. The medulla oblongata is developed. The myelencephalon is triangular. It is broad in front by narrow and tapering behind. The thin and highly vascular roof of medulla oblongata makes the posterior choroid plexus. Posteriorly, the myelencephalon shows a strong ventral flexure where it passes into the spinal cord.
The nuclear complex of the abducens nerve of monitor lizard *Varanus exanthematicus* consists of the principal and accessory abducens nuclei. The principal abducens nucleus is located just below the fourth ventricle laterally adjacent to the medial longitudinal fasciculus. The accessory abducens nucleus has a ventrolateral position in the brain stem (Barbas-Henry and Lohman, 1988). However, in the present study on Indian house wall lizard the accessory abducens nucleus has not been found. According to Addens (1933) in *Rana catesbeiana* an accessory nucleus is present lateral to the main abducens nucleus. Opdam *et al*., (1976) observed similar structure in frog but described it as a part of lateral reticular zone. The accessory abducens nucleus is also reported in *Bufo marinus* which was described as a part of reticularis medius by Opdam *et al.,* (1976). It seems that in the present study the accessory abducens nucleus is absent because there is no clear demarcation between abducens and reticular formation. The possibility cannot be ruled out that accessory abducens nucleus observed by Addens (1933) and Abbie and Adey 1950) is a part of lateral reticular formation described by Opdam *et al*., (1976).
The motor nucleus of XII cranial nerve – nucleus nervi hypoglossi is found in the caudal most region of rhombencephalon like myelencephalon below the XIth motor cranial nerve nuclei in wall lizard.

Topological position of this nucleus is comparable with that of mammals. This nucleus is developed in *Varanus* comparable with that of mammals. This nucleus is developed in *Varanus* with respect to cells as compared to the present observation in *Hemidactylus*.

Senn (1972) has reported that there are two parts of nucleus nervi hypoglossi – a dorsal and a ventral but this division has not been observed either in frog – *Rana tigrina* (Srivastava and Srivastava, 1992) or in *H. flaviviridis* presently studied. Further studies are required in different groups of animal to find out evolutionary significance of this nucleus.

The brain stem reticular formation has been studied in many species of reptiles (Newman and Cruce, 1982). They have found that reticular neurons in crocodilians and snakes are larger than those found in lizards and turtles. The reticular formation is divided into seven nuclei. A reticularis inferior (RI) is found in myelencephalon, a reticularis medius (RM) in the caudal two third of the metencephalon and a reticularis superior in the rostral metencephalon and caudal mesencephalon. Reticularis inferior can be subdivided into a dorsal and a ventral region. All reptilian species possess reticularis inferior (dorsal) and reticular medius but ventral portion of reticularis inferior is absent in turtles. These divisions are clearly observed in the present investigation on Indian house wall lizard but quite variable in appearance. The myelencephalic raphes nucleus is also quite variable in its morphology among the different reptilian families. A reticularis ventrolateralis observed in the present study is also found in snakes and teiid lizards.

It is concluded that fewer number of nuclei in reticular formation of old reptilian lineages and more number of nuclei in modern reptiles are found. Certain reticular nuclei are present in those reptiles in which prominent axial musculature is found (Newman and Cruce, 1982; Newman *et al*., 1983).

The motor nuclei of nerve IX are located ventrally in the rhombencephalon and are constituted medially by the large celled glossopharyngeal part of nucleus ambiguus and laterally by the small celled nucleus salvivatorius inferior in *Varanus exanthematicus* (Barbas-Henry and Lohman, 1984). Although the divisions of nucleus nervi glossopharyngei have not been observed in the present investigation on Indian wall lizard.

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