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Research Article

ORGANIZATION OF HYPOTHALAMUS OF INDIAN HOUSE WALL LIZARD *HEMIDACTYLUS FLAVIVIRIDIS*

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ABSTRACT
Topological organization of the hypothalamus of Indian house wall lizard has been studied by Eager's method. The hypothalamus is well developed in Indian house wall lizard *Hemidactylus flaviviridis.* The hypothalamus of *H. flaviviridis* commences rostrally from the region where the 3rd ventricle starts and continues caudally as far as the nucleus praemamillaris and the median eminence. Laterally hypothalamus is bound by medial (MFB) and lateral (LFB) forebrain bundles. The lateral forebrain bundle on both the sides is away from the 3rd ventricle and the hypothalamus is laterally expanded. All the hypothalamic nuclei are paired. The hypothalamic nuclei are classified into magnocellular region and parvocellular region.
The magnocellular region is divided into nucleus supraopticus (SON) and nucleus paraventricularis (PVN). The parvocellular region is differentiated into nucleus suprachiasmaticus (SCN), nucleus commissurae anterioris (NAC), lateral preoptic area (LPA), nucleus of the preoptic recess (NPOR), subventricular gray (SVG), nucleus periventricularis anterior (APV), nucleus periventricularis posterior (PPV), nucleus hypothalamicus periventricularis (HPE), nucleus microcellularis (MC), nucleus subfornicalis (SF), nucleus arcuatus (A), nucleus ventralis tuberis (VT), nucleus hypothalamicus ventromedialis (VMH), paraventricular organ (PVO), nucleus of the paraventricular organ (NPVO), nucleus hypothalamicus dorsomedialis (DMH), nucleus hypothalamicus lateralis (LH), nucleus hypothalamicus medialis (MH), nucleus hypothalamicus posterior (HP), nucleus praemamillaris (P), nucleus dorsalis recessus infundibuli (DRI), nucleus intermedius recessus infundibuli (IRI) and nucleus ventralis recessus infundibuli (VRI).

Keywords **:** *Hypothalamus, 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 hypothalamus region of the diencephalon of the forebrain 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 to 70 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 (1cm). 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 become 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 hypothalamus is well developed in Indian house wall lizard *H. flaviviridis*. The hypothalamus starts rostrally from the region where the 3rd ventricle (V-III) commences. This continues caudally as far as the nucleus praemamillaris (P) and the median eminence (ME). Laterally hypothalamus is bound by medial (MFB) and lateral (LFB) forebrain bundles. The lateral forebrain bundle (LFB) on both the sides is away from the 3rd ventricle (V-III). The hypothalamus is laterally expanded. All the hypothalamic nuclei are paired. The hypothalamic nuclei are divided into two as magnocellular and parvocellular regions.

The magnocellular region is classified into two nuclei as supraopticus and paraventricularis.

(a) Nucleus supraopticus (SON):

The largest cluster of magnocellular cells occupies the supraoptic position. It is demarcated as nucleus supraopticus. This is conspicuous. It starts anteriorly just up to optic chiasma. This is demarcatted in to : rostral, medial and lateral (Fig.1A&D).

(b) Nucleus paraventricularis (PVN):

This is depicted at antero-lateral margin of the third ventricle and dorsally to the nucleus hypothalamicus periventricularis. It is conspicuous magnocellular region (Fig.2C).

The parvocellular region is differentiated into the following 23 nuclei.

(a) Nucleus suprachiasmaticus (SCN):

It is located dorsal to the optic chiasma and ventral margin of the lateral forebrain bundle. This is easily recognized in transverse sections as an oval-shape. The several small, compactly arranged cells of polymorphic appearance form this nuclear portion (Fig.1A&D).

Abbreviations used in figures

AC anterior commissure
LFB lateral forebrain bundle
LPA lateral preoptic area
ME median eminance
MFB medial forebrain bundle
A nucleus arcuatus
NAC nucleus commissurae anterioris
DRI nucleus dorsalis recessus infundibuli
DMH nucleus hypothalamicus dorsomedialis
LH nucleus hypothalamicus lateralis
H nucleus hypothalamicus medialis
PE nucleus hypothalamicus periventricularis
HP nucleus hypothalamicus posterior
VMH nucleus hypothalamicus ventromedialis
IRI nucleus intermedius recessus infundibuli
MC nucleus microcellularis
PVN nucleus paraventricularis
NPVO nucleus of the paraventricular organ
APV nucleus periventricularis anterior
PPV nucleus periventricularis posterior
P nucleus praemamillaris
NPOR nucleus of the preoptic recess
SF nucleus subfornicalis
SCN nucleus suprachiasmaticus
SON nucleus supraopticus
VRI nucleus ventralis recessus infundibuli
VT nucleus ventralis tuberis
OC optic chiasma)
PVO paraventricular organ
PIT pituitary
POR preoptic recess
RC retroinfundibullar commissure
SVG subventricular gray
V-III third ventricle

(b) Nucleus commissurae anterioris (NAC):

This is situated ventral to the anterior commissure and dorsomedially to the third ventricle. It widens but tapers medially. Its cells are small, polymorphic (round or oval) in shape (Fig.1C).

(c) Lateral preoptic area (LPA):

It is demarcated on the dorsomedially to the nucleus periventricularis posterior and medially to the nucleus suprachiasmaticus. This extends antero-posteriorly. It is formed of scattered neurons. The cells of it are small to medium in size (Fig.1B&D).

(d) Nucleus of the preoptic recess (NPOR) :

This is situated in the area dorsomedially to the optic chiasma and medially to the preoptic recess. It is closely associated with the extension of the third ventricle. This is divisible into a small, compact, rather larger group of nerve cells. The cells of this are small to medium in size (Fig.1D).

(e) Nucleus subventricular gray (SVG):

It is located midventral to the third ventricle just above the mid-dorsal of the optic chiasma. The neuronal elements are small to medium in size (Fig.1C).

(f) Nucleus periventricularis anterior (APV):

This is depicted dorsomedially to the third ventricle, ventromedially to the nucleus commissurae anterioris and dorsally to the nucleus preoptic recess. It is spherical in shape. The cells are densely packed. The shape of the cells is small to medium (Fig.1D).

(g) Nucleus periventricularis posterior (PPV):

It is demarcated dorsally to the optic chiasma, dorsomedially to the nucleus preoptic recess and medially to the lateral preoptic area. This extends antero-posteriorly with tapering arrangement. The cells are compactly arranged. These are small to medium in size (Fig.1D).

(h) Nucleus hypothalamicus periventricularis (HPE):

This is situated medially to the third ventricle and dorsally to the nucleus arcuatus. It extends dorso-ventrally with tapering arrangement. This is bigger in size. The neurons of it are small to medium in size (Fig.2C).

(i) Nucleus microcellularis (MC):

It is represented dorsally to the optic chiasma and medially to the nucleus arcuatus. This extends medially. It is divisible in to anterior and posterior divisions. The cells of this are small to medium in size (Fig.3D).

(j) Nucleus subfornicalis (SF):

This is located ventro-medially to the nucleus periventricularis-anterior and dorsomedially to the nucleus periventricularis posterior. It extends medially. This is spherical in shape. The cells consist of a few large neurons associated with fibers of the fornix (Fig.3B).

(k) Nucleus arcuatus (A):

It is formed of large neuronal complexes. This is divided in to two as lateral and medial divisions. It is situated at the basomedial side of the third ventricle and ventrally to the nucleus hypothalamicus lateralis. This extends dorso-ventrally (Fig.2C).

(l) Nucleus ventralis tuberis (VT):

This is situated above the optic chiasma, in the basal part of the tuberal region and ventrally to the third ventricle. It extends medially with tapering arrangement. The cells of it are small and compactly arranged (Fig.2C).

(m) Nucleus hypothalamicus ventromedialis (VMH):

It is located baso-medially to the third ventricle, medially to the nucleus ventralis tuberis and ventrally to the nucleus hypothalamicus periventricularis. This extends medially. The neurons are widely distributed. The cells of this are compactly arranged (Fig.4D).

(n) Paraventricular organ (PVO):

Its position is medially to the third ventricle and ventromedially to the dorsomedial hypothalamic nucleus. This extends dorso-ventrally with tapering arrangement. The cells of it are small to medium in size (Fig.4D).

(o) Nucleus of the paraventricular organ (NPVO):

This is depicted medially to the paraventricular organ (PVO) and ventrally to the nucleus hypothalamicus dorsomedialis. It extends antero-posteriorly. This is demarcated in to a medial and a lateral divisions (Fig.4C&D).

(p) Nucleus hypothalamicus dorsomedialis (DMH):

It is located dorso-medially to the third ventricle and dorsally to the nucleus paraventricular organ. This extends antero-posteriorly with broadness. The neurons of this are small to medium in size (Fig.4D).

(q) Nucleus hypothalamicus lateralis (LH):

This is situated dorsomedially to the nucleus arcuatus, medially to the nucleus hypothalamicus ventromedialis and medially to the optic chiasma. It extends antero-posteriorly. The cells of it are small to medium in size (Fig.4C).

(r) Nucleus hypothalamicus medialis (MH):

It shows ventrally to the nucleus hypothalamicus dorsomedialis and dorsally to the nucleus dorsalis reccessus infundibuli. This extends anteroventrally. It is oval in shape. The neurons of this are small to medium in size (Fig.5D).

(s) Nucleus hypothalamicus posterior (HP):

This is depicted medially to the nucleus arcuatus, dorsomedially to the nucleus ventralis tuberis and basomedially to the third ventricle. It extends antero-posterior in tapering form. The cells of it are compactly arranged and small to medium in size (Fig.5A).

(t) Nucleus praemamillaris (P):

It is situated dorsally to the nucleus hypothalamicus ventro-medialis and mediodorsally to the

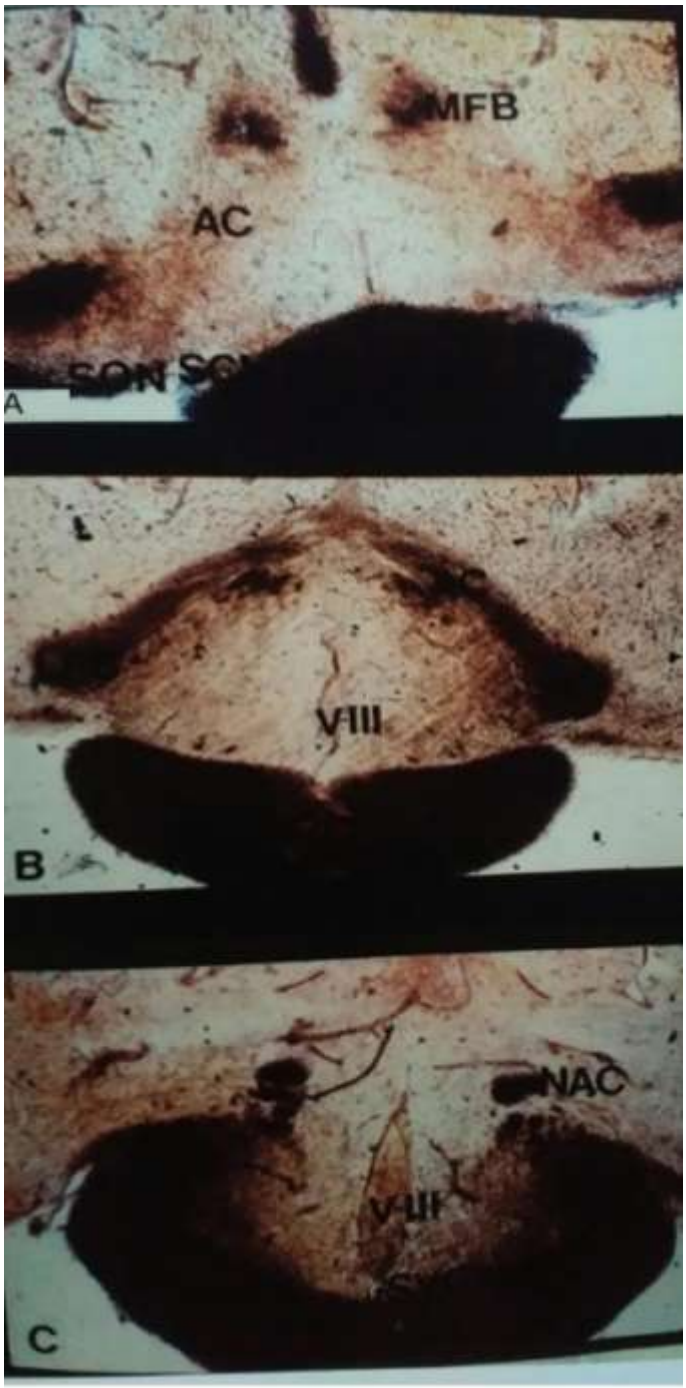

Figure 1A-C

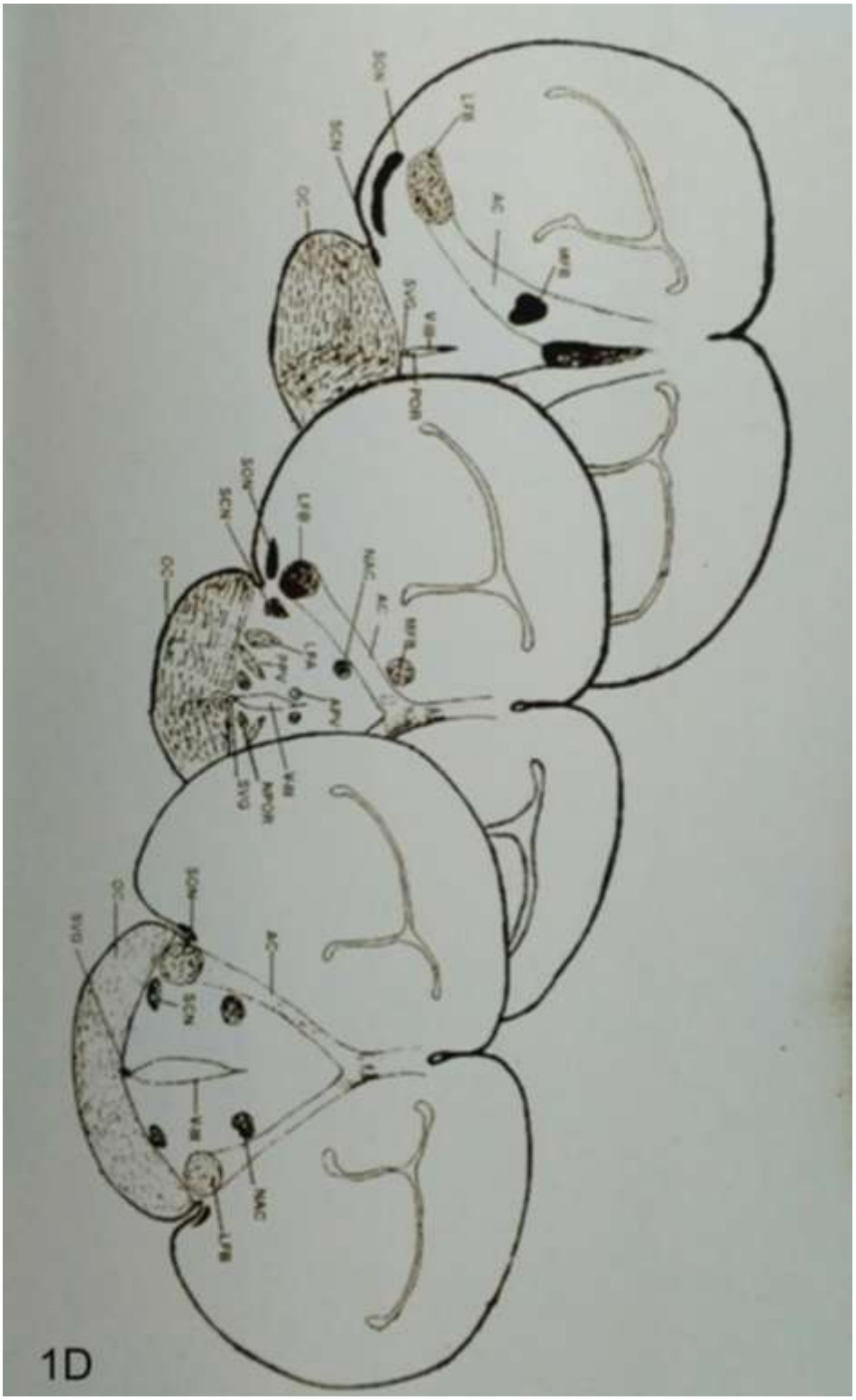

Figure 1D

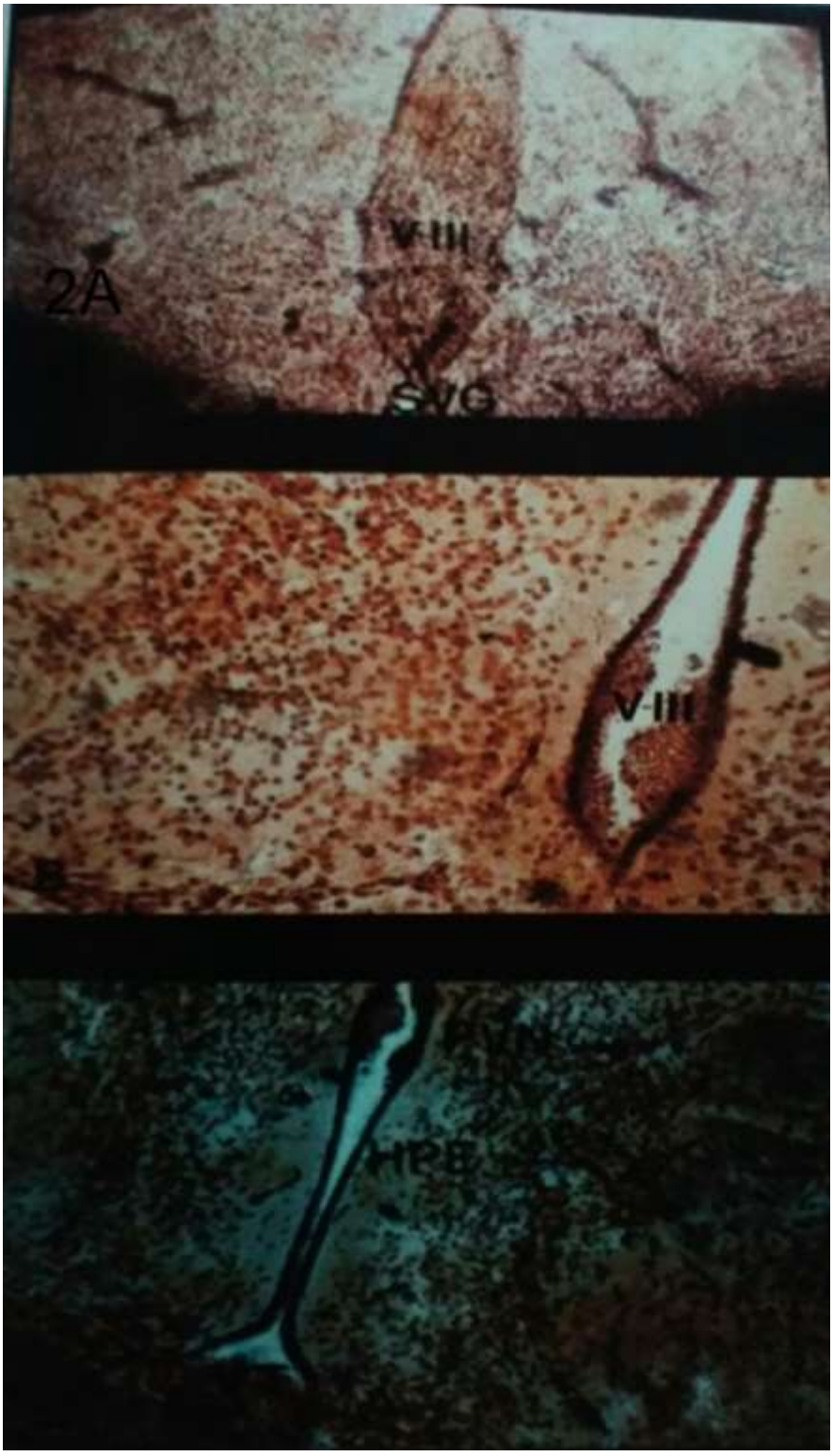

Figure 2

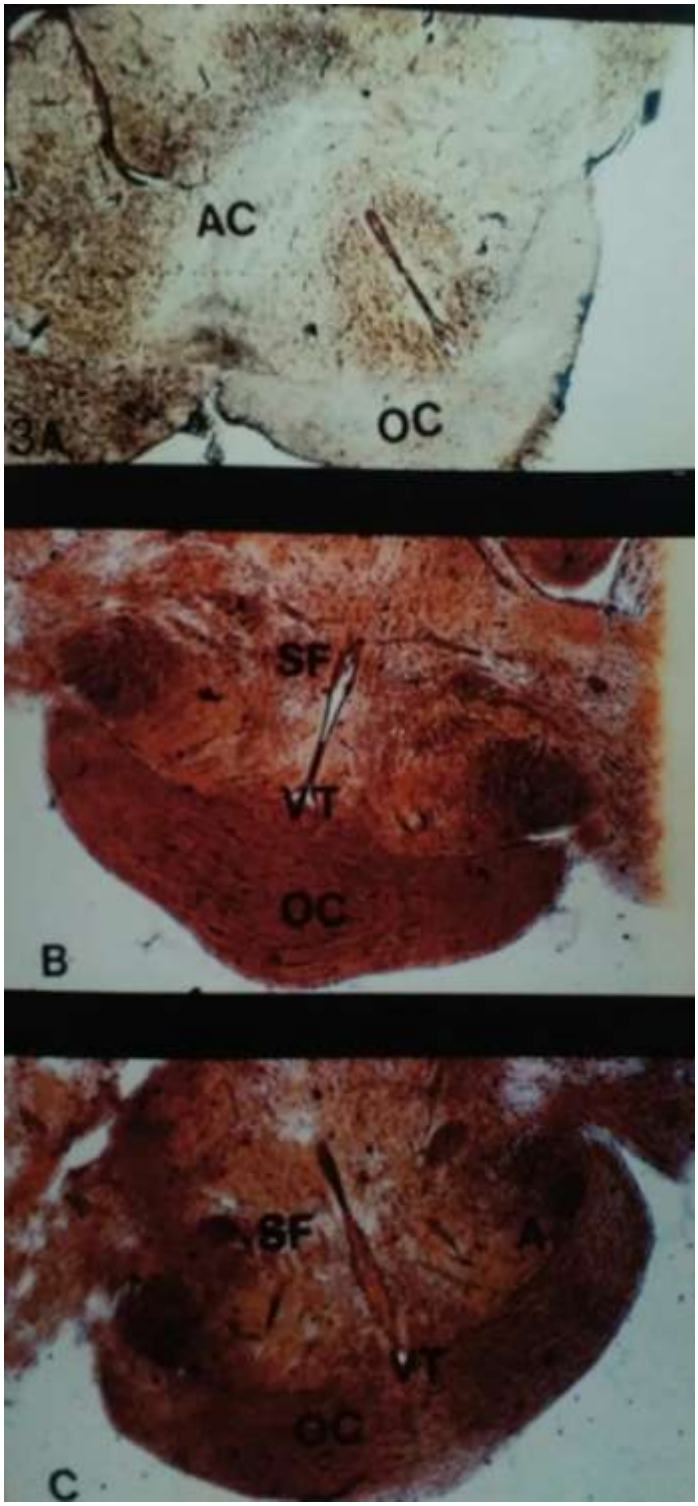

Figure 3A-C

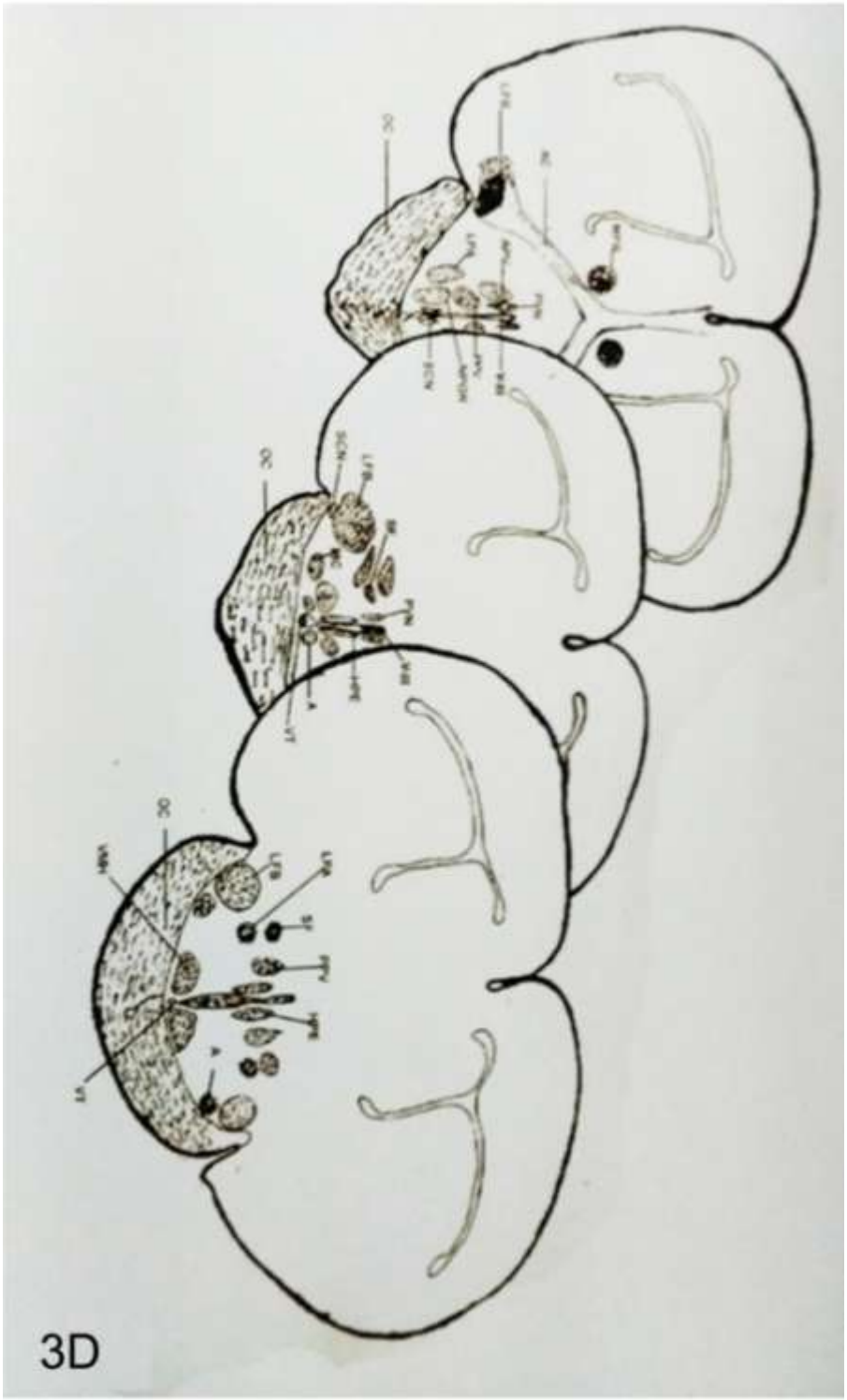

Figure 3D

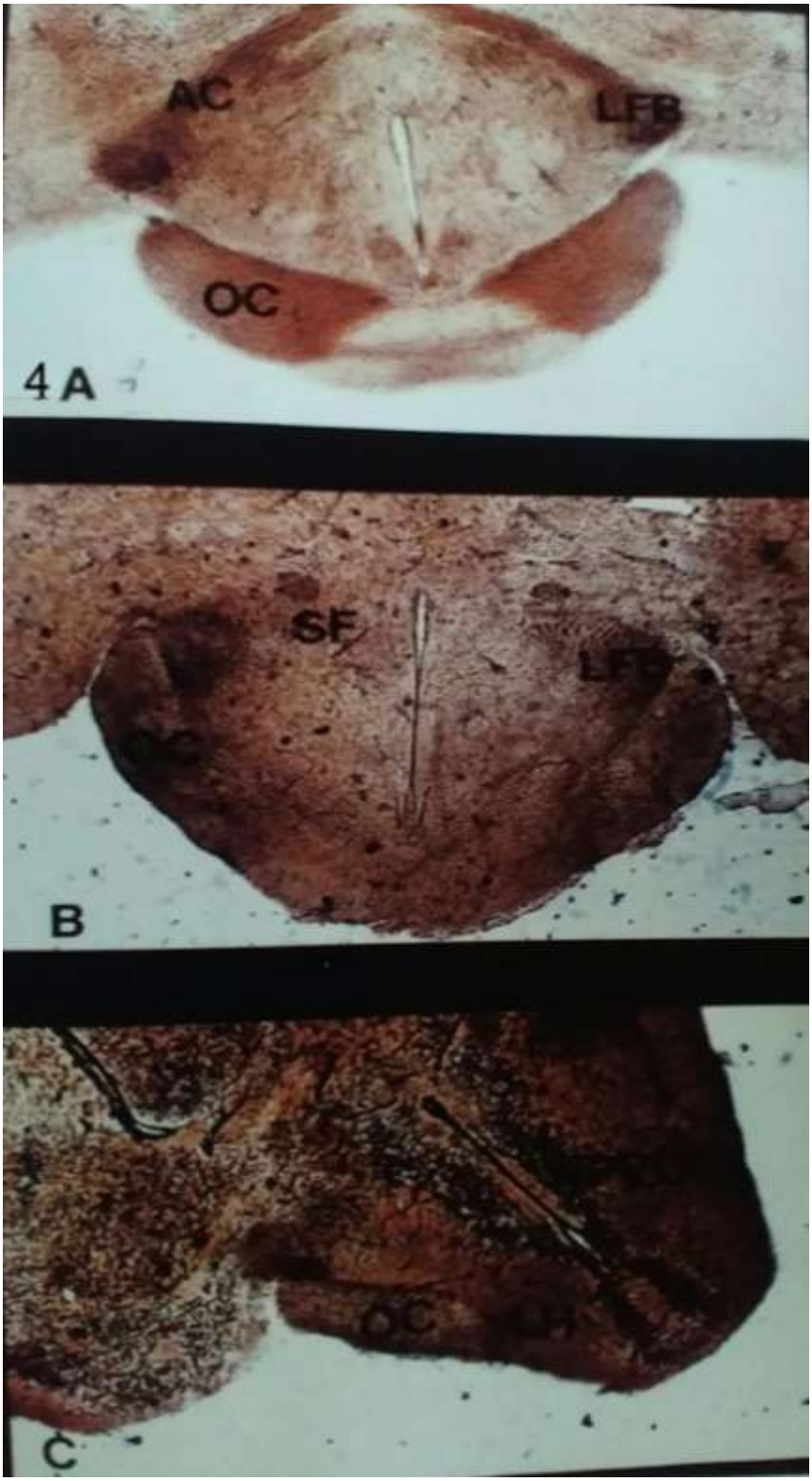

Figure 4A-C

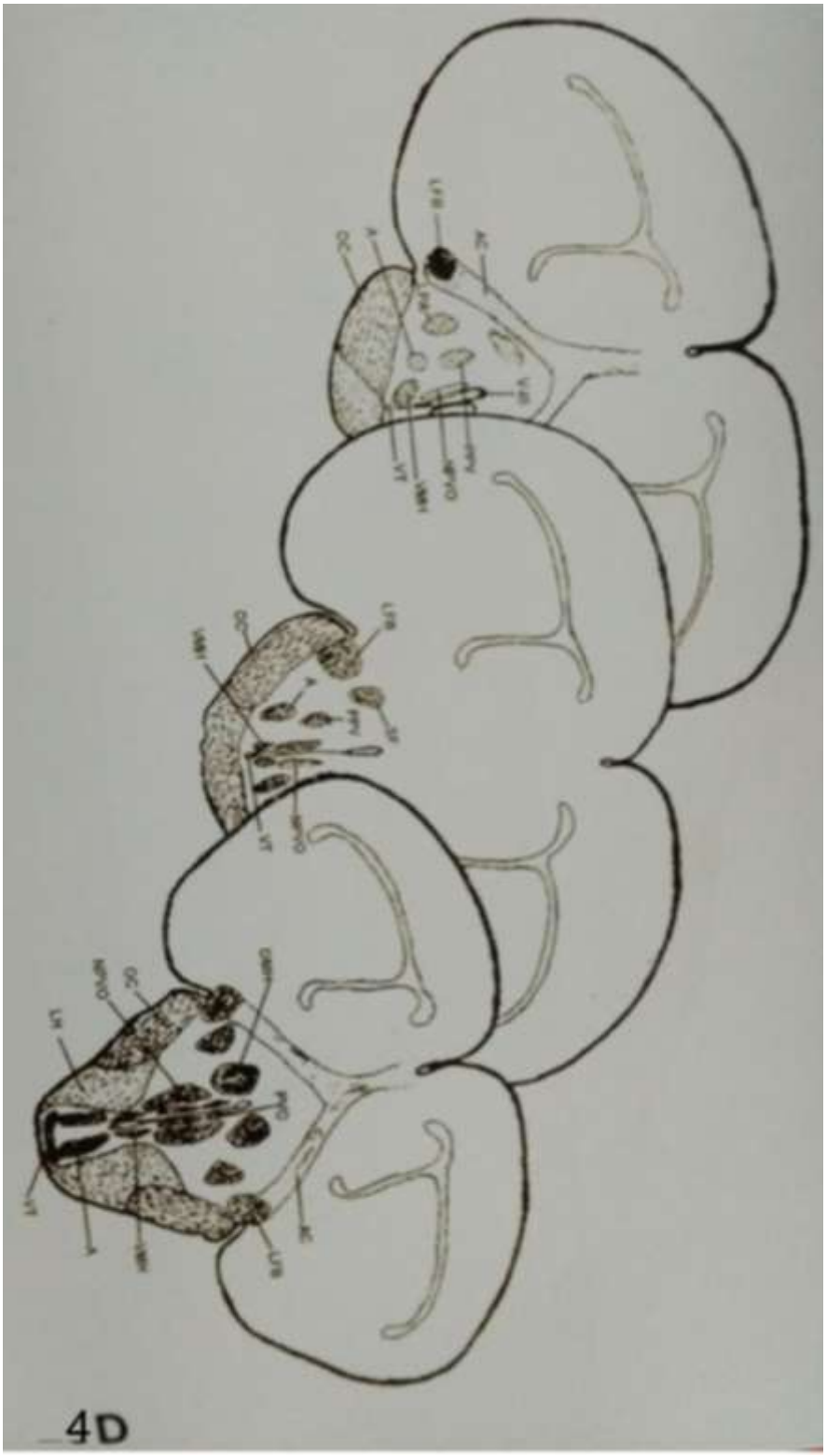

Figure 4D

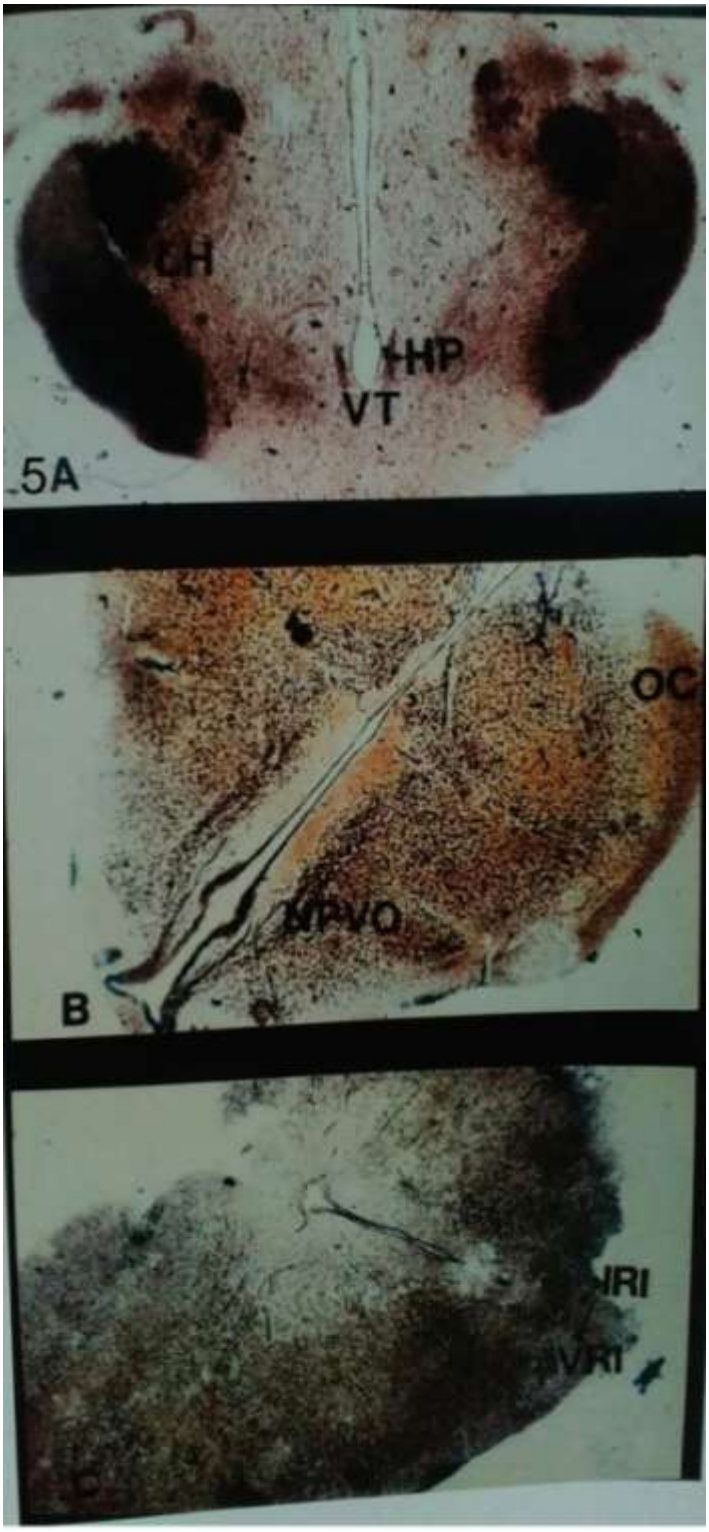

Figure 5A-C

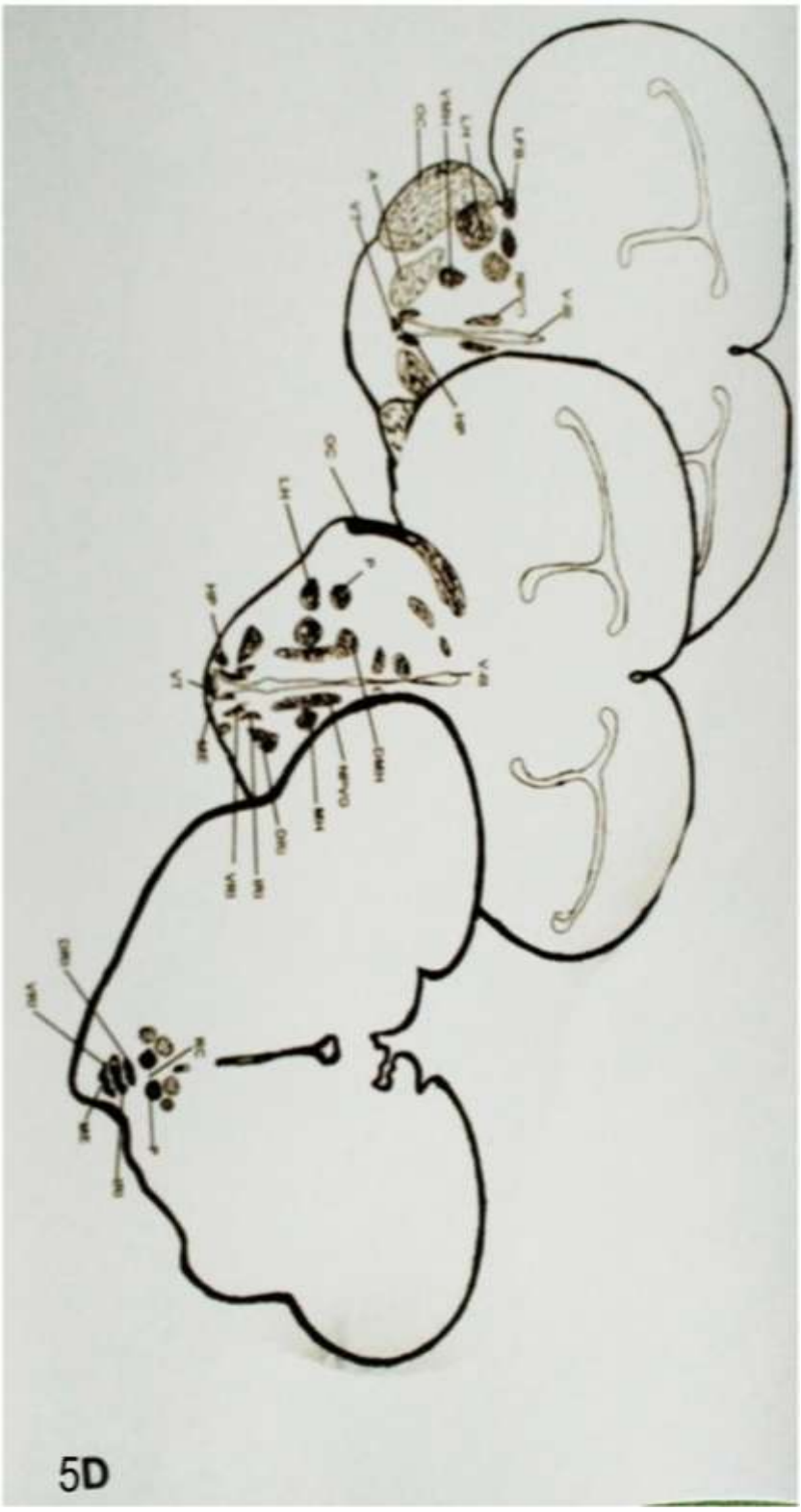

Figure 5D

nucleus hypothalamicus lateralis. This is spherical in shape. The neurons of this are small to medium in size (Fig.5D).

(u) Nucleus dorsalis recessus infundibuli (DRI):

This is located ventrally to the nucleus hypothalamicus medialis, medially to the third ventricle and dorsally to the nucleus intermedius recessus infundibuli. It extends medially. The cells of it are small to medium in size and densely packed (Fig.5D).

(v) Nucleus intermedius recessus infundibuli (IRI):

It is depicted ventrally to the nucleus dorsalis recessus infundibuli and dorsally to the nucleus ventralis recessus infundibuli. This extends medially. The cells of this are scattered and small to medium in size (Fig.5C&D).

(w) Nucleus ventralis recessus infundibuli (VRI):

This is located dorsally to the median eminence and ventrally to the nucleus intermedius recessus infundibuli. It extends medially. The cells of it are densely packed and are small to medium in size (Fig.5C&D).

DISCUSSION

The hypothalamus is well developed in Indian house wall lizard *H. flaviviridis.* The hypothalamus of *H. flaviviridis* begins rostrally from the portion where the 3rd ventricle starts. It continues caudally as far as the nucleus praemamillaris and the median eminence. Laterally hypothalamus is bound by medial (MFB) and lateral (LFB) forebrain bundles. The lateral forebrain bundle on both the sides is away from the 3rd ventricle. The hypothalamus is laterally expanded. All the hypothalamic nuclei are paired. The hypothalamic nuclei are separated into magnocellular region and parvocellular region. The magnocellular region is discriminated into nucleus supraopticus (SON) and nucleus paraventricularis (PVN). The parvocellular region is divided into 23 nuclei.

The magnocellular region is not differentiated into pisces and amphibians (Prasada Rao *et al*.,1993 and Prasada Rao *et al*.,1997). In crocodile – *G. gangeticus* (Subhedar *et al*.,1989), turtle – *L. puntata granosa* (Dwivedi and Prasada Rao,1992), lizard- *Calotes versicolor* (Prasada Roa and Subhedar,1977), crocodile (Subhedar *et al*.,1989) and also *Hemidactylus flaviviridis* (Haider and Sathyanesan,1974), the magnocellular region is found to include nucleus supraopticus (SON) and nucleus paraventricularis (PVN).

The nucleus supraopticus (SON) is divided into rostral, medial and lateral regions in crocodile, studied by Subhedar *et al*. (1989) and in *Hemidactylus flaviviridis* studied by Haider and Sathyanesan (1974).

In crocodile and cobra, nucleus retrochiasmaticus (RCN) has been additionally observed by Subhedar *et al*. (1989) and Prasada Rao *et al.* (1981) which has not been found in turtle, garden lizard and wall lizard presently studied. The present observations with respect to nucleus paraventricularis (PVN) are in line with the previous observations in crocodile, turtle, cobra and garden lizard.

It has been reported that in the ring necked snake – *Diadophis punctatus* (Philibert and Kamemoto, 1965), the iguanid lizard – *Dipsosaurus dorsalis* (Gesell and Callard,1972), the wall lizard – *Hemidactylus flaviviridis* (Haider and Sathyanesan,1974), the garden lizard - *Calotes versicolor* (Prasada Roa and Subhedar,1977) and also *Naja naja* (Prasada Roa *et al*.,1981) both supraoptic (SON) and paraventricular (PVN) nuclei are found in the hypothalamus differentiated clearly in the present observation also.

The neuronal aggregations in the supraopticus nucleus (SON) in the present study correspond with the *Calotes versicolor* (Prasada Rao and Subhedar,1977) because in both cases the dense arrangement of cells having large number has been observed. However, this nucleus in *G. gangeticus* (Subhedar *et al*.,1989) is larger in size but neurons are the scattered. It is also observed

in *Naja naja* (Prasada Rao *et al*.,1981). The nucleus paraventricularis (PVN) studied by Prasada Rao and Subhedar (1977) in *Calotes* presents similarity with the present study having loosely arranged cells but in *Naja naja* (Prasada Rao *et al*.,1981) large number of polygonal neurons are found in PVN. It seems that magnocellular region of hypothalamus presents homology in *H. flaviviridis* presently studied and *Calotes versicolor* studied by Prasada Rao and Subhedar (1977).

In some reptiles it has been observed by Philibert and Kamemoto (1965), Haider and Sathyanesan (1974), Prasada Rao and Subhedar (1977) that bridge cells are found between SON and PVN. However, these are absent in the cobra (Prasada Rao *et al*.,1981) and in the ring-necked snake (Philibert and Kamemoto,1965). In the present investigation on Indian wall lizard neurons are clearly observed between SON and PVN. It is also characteristic of avian hypothalamus (Oksche and Farner,1974).

The two accessory magnocellular nuclei namely nucleus retrochiasmaticus and nucleus circularis have been reported in cobra (Prasada Rao *et al*.,1981). It may be substitution for the bridge cells. These are absent in snake. In the present observation on wall lizard, bridge cells are observed but accessory magnocellular nucleus circularis is absent. In *H. flaviviridis* presently studied, and also by Haider and Sathyanesan (1974) three divisions of the SON have been observed and the caudal part of SON may be compared with the nucleus retrochiasmaticus of cobra reported by Prasada Rao *et al*.,1981).

Some neurosecretory neurons were observed in the median eminence in the lizards *Acanthodactylus* (Oehmke and Oksche,1974; Oksche and Farner,1974) and *Calotes versicolor* (Prasada Rao and Subhedar,1977) and presently studied Indian wall lizard. Zaloglu (1973) put forward a view that seasonal difference should be taken into consideration. Although the reproductive cycle was not studied in the present investigation but no change in these neurons could be observed in the different individual animals sacrificed at different months.

In the parvocellular region, 24 nuclear entities are found in the crocodile, *Gavialis gangeticus* (Subhedar *et al*.,1989), 22 neuronal aggregations in the cobra – *Naja naja* (Prasada Rao *et al*., 1981)); 23 in turtle; 15 in garden lizard – *Calotes versicolor* (Prasada Roa and Subhedar,1977). In the present observations 23 neuronal groups are found. Haider and Sathyanesan (1974) have not taken into consideration the parvocellular region of *Hemidactylus flaviviridis* which has been studied presently. The parvocellular hypothalamic nuclei are essential for nervous control of endocrine functions (Oksche and Farner,1974). The present observation on wall lizard and other lizards studied shows the importance of parvocellular regions in the nervous control of endocrine functions.

The nucleus preopticus of cyclostome, fish, and amphibians is homologous to the nucleus supraopticus and nucleus paraventricularis of reptiles (Scharrer and Scharrer,1954) which has been observed in the present study.

The nucleus anterior commissure observed in the hypothalamus of the many reptilian brains (Crosby,1917; Huber and Crosby,1926; Crosby and Woodburne,1940; Prasada Rao *et al*.,1981) has been observed in the present study.

The nucleus microcellularis anterior and nucleus microcellularis posterior are thought to be integral components of a larger microcellular entity described by Prasada Rao and Subhedar (1977) in *Calotes*, has been observed in the present study.

The nucleus periventricularis hypothalami reported by Ariens Kappers *et al*. (1936); Butler and Northcutt (1973); Senn (1974) appeared to be a part of nucleus periventricularis posterior of cobra (Prasada Rao *et al*.,1981) is observed in *Hemidactylus flaviviridis* presently studied. The nucleus subfornicalis, present in *Calotes* (Prasada Rao and Subhedar,1977) has been demarcated in the present observation which is absent in other reptiles. The presence of this nucleus only in lizard shows some importance of this group with respect to other reptilian species.

In *Calotes versicolor* (Prasada Rao and Subhedar,1977), in aves (Oksche and Farner,1974) in rats Szentagothai *et al*. (1968)), the nucleus hypothalamicus ventromedialis and nucleus hypothalamicus dorsomedialis is conspicuous. It is comparable to that in tegu lizard (Cruce,1974) and *Hemidactylus flaviviridis* presently studied.

The nucleus hypothalamicus medialis of the present study is comparable to that in *Calotes* (Prasada Rao and Subhedar,1977). This is also found in birds and mammals (Szentagothai *et al*.,1968; Oksche and Farner,1974) but absent in some other reptilian species.

The nucleus arcuatus proper, located in the hypothalamus of house wall lizard and also *Calotes* (Prasada Rao and Subhedar,1977) has not been demarcated in the majority of reptiles previously studied. The presence of such nuclei shows the importance of lacertilian reptiles.

The nucleus ventralis tuberis is only described in *Calotes* (Prasada Rao and Subhedar,1977) and presently studied wall lizard *Hemidactylus*.

Although nucleus posterior hypothalami mapped by Cruce (1974) in tegu lizard, which is not located in *Calotes* (Prasada Rao and Subhedar,1977) has been observed in Indian house wall lizard.

The paraventricular organ is found to be well developed in cobra – *Naja naja* (Prasada Rao *et al*., 1981), was not observed in *Calotes* (Prasada Rao and Subhedar,1977) but is demarcated by ependymal neurons in the present observation. This is also the characteristic, described as sulcus lateralis infundibuli in *Iguana* (Butler and Northcutt, 1973). This sulcus was not observed in tegu lizard – *Tupinambis* (Cruce, 1974) but found in turtle – *Chrysemys picta* (Parent and Poitras, 1974) and two species of *Lacerta* (Marschall,1980).

The nucleus hypothalamicus lateralis of the present investigation in *Hemidactylus flaviviridis* resembles similar to that of *Calotes* (Prasada Rao and Subhedar,1977) and other reptiles (Ariens Kappers *et al*.,1936; Butler and Northcutt,1973; Senn,1974; Prasada Rao *et al*.,1981).

The nucleus recessus infundibuli of Hypothalamus in *Hemidactylus flaviviridis* – Indian house wall lizard presently studied is well developed and is differentiated into three regions namely dorsal, intermediate and ventral regions (nucleus dorsalis recessus infundibuli DRI, nucleus intermedius recessus infundibuli IRI and nucleus ventralis recessus infundibuli VRI). This nucleus is observed in *Calotes* (Prasada Rao and Subhedar,1977) but not found in other vertebrates (Szentagothai *et al*., 1968; Oehmke,1971a,b; Butler and Northcutt,1973; Senn,1974; Peter and Gill,1975).

The nucleus praemamillaris present at the posterior region of Indian house wall lizard has been topographically located in other reptilian species (Ariens Kappers *et al*.,1936; Cruce,1974; Prasada Rao and Subhedar,1977; Subhedar *et al*.,1989; Dwivedi and Prasada Rao,1992). In addition to this a praemammillaris nucleus is also observed in the present observation as located by previous investigations in different reptiles.

It is interesting to note that the hypothalamus of Indian house wall lizard – *Hemidactylus flaviviridis* presently studied is rich in nuclear organization and is comparable with *Calotes* (Prasada Rao and Subhedar,1977). It has been mentioned that hypothalamus of *Calotes* resembles with that of highly developed varanidae (Oksche,1978).

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