

د راسة مورفولوجية وهسيولوجية للجهاز العصبي المركزي  
للطور اليافع للعقرب بوداس كوينكسترياتوس  
٣ - الخلايا العصبية الأفرافية

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يتناول هذ البحث د راسة الخلايا العصبية الأفرافية فى الجهاز العصبي المركزي للطور اليافع للعقرب بوداس كوينكسترياتوس الذى جمع من منطقة أبو رواش بالجيزة وقد أمكن تقسيم تلك الخلايا الى ثلاثة أنواع ا ، ب ، د تختلف فى الشكل والحجم وفى خصائصها الصبغية . كما انه يختلف توزيع وعدد تلك الخلايا الأفرافية العصبية فى الأجزاء المختلفة من الجهاز العصبي المركزي . ولا حظنا بوضوح تبعثر تلك الخلايا فى العقد العصبية المختلفة وعدم وجودها فى أماكن محددة على هيئة تجمعات متماسكة كما هو معروف فى الحشرات . ولقد ناقشنا العلاقة بين الشكل والوظيفة لكل من الخلايا . وفى حقيقة الأمر تشكك كثير من العلماء فى تقسيم تلك الخلايا العصبية الأفرافية الى اربع انواع فقط بناءً على الشكل والموصفات الصبغية . بمعنى أن هذا التقسيم الى اربع انواع فى الشكل يمتد الى تقسيمها الى افراز اربع انواع من "الهرمونات" فقط . وهذه النقطة بالذات كانت موضع د راسة فى قسم علم الحيوان بجامعة أسيوط حيث سجلت دورات النشاط لكل نوع من أنواع تلك الخلايا العصبية الأفرافية فى خنفساء الماء فى فترة النمو بعد الجنينى . وتبين ان دورات نشاط هذه الخلايا تختلف من مكان لآخر طبقاً للجنس وعمر الحشرة . وأستخلص من ذلك أن ما يسمى بالخلايا "ب" مثلاً طبقاً للشكل والموصفات الصبغية فى حقيقة الأمر نوعاً واحداً من الخلايا من وجهة النظر الفسيولوجية أى أنه وظيفياً يمثل عدد من الخلايا . ويجب أن يعتمد على الدراسات

الفسيولوجية ودراسات بيولوجيا الخلية لتخقيق كنه أفراز كل خلية من هـ هذه  
الخلايا العصبية الأفرافية .

وقد رفض فى العمل الحالى رأى بعض الباحثين من أن الأربعة أنواع  
من الخلايا العصبية الأفرافية تمثل مراحل فى دورة أفرافية لنفس الخلية . بناء  
على أنه عند فحص مجموعة من خلايا " ب " مثلا فى مكان معين فأنها تظل نفس  
الخلايا فى اية طور من أطوار النشاط البيولوجى للحيوان .

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**STUDIES ON THE MORPHOLOGY AND HISTOLOGY OF THE CENTRAL  
NERVOUS SYSTEM OF THE ADULT OF THE EGYPTIAN SCORPION**

**BUTHUS QUINQUESTRIATUS (H.E)**

**III- NEUROSECRETORY CELLS**

(With One Table & 11 Figs.)

By

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(Received at 1/3/1984)

**SUMMARY**

3 types of neurosecretory cells A, B and D were recognized. The number and distribution of each type varies in the different localities of the central nervous system. The morphological and physiological classification of those neurosecretory cells were discussed.

**INTRODUCTION**

Neurosecretory cells have long been described in insects (WEYER, 1935, ARVY and GABE 1947, ARVY 1956, HIGHNAM 1958, 1961, GELDIAY, 1959, ROWELL, 1976, and ANWAR and ISMAIL, 1979 and RAABE 1982). In that case authors interested in the histology of the central nervous system of insects had classified those cells into four types A,B,C and D, and they depend in that classification on the morphological structure of the cell as well as its staining affinities or qualifications.

In the literature, several apacific stains such as Ewen's paraldehyde fuchsin, Gomori's chrome-Haematoxylin-phloxin and Heiden-hain's-azan stain were described to demonstrate such types.

In the first two papers of this series (KHALIL et al. 1984 a and b) the general morphology and histology of the central nervous system of the adult of the Egyptian scorpion, Buthus quinquestriatus (H.E) was discussed in detail.

The aim of this third article is to investigate the morphology, classification and distribution of the neurosecretory cells of that central nervous system.

In fact, some authors (THOMSEN, 1965; ABU-HALAWA, 1976) have suspected the validity of the classification of those cells of 4 types. Those authors suspected that either those four types of cells represent in fact successive steps of a secretory cycle of one and the same cell, or each type of those cells represent in reality a number of physiologically different types of cells, but which types are similar morphologically and in staining affinities.

Some light will be thrown, in the present contribution, on the problem of the morphological and physiological classification of those neurosecretory cells.

**MATERIAL and METHODS**

Mature adult scorpions (6.5-7.5 cm of Buthus quinquestriatus were collected from Abu-Roach in Giza governorate during May and June and were kept under Laboratory conditions in glass containers. They were fed on small insects (like cockroaches and crickets) and land isopods and they

also were supplied with a source of water.

For the demonstration and differentiation of neurosecretory cell types, material was stained by Ewen's paraldehyde-fuchsin (EWEN, 1962), Delphin's stain (DELPHIN, 1968), chrome-alum haematoxylin-phloxin of GOMORI (1953) and Heidenhain's Azan stain (PANTIN, 1962). Ewen paraldehyde-fuchsin was not as suitable as Delphin's stain and chrome alum haematoxylin-phloxin.

## RESULTS

### TYPES OF NEUROSECRETORY CELLS

If we take the types found in the case of insects as a reference, it was found that, in the case of the scorpion studied, cells comparable to types A,B and D of insects are found, while cells similar to those of type C of insects were not identified (Fig. 1).

#### Type A cells:

Those are the smallest type of neurosecretory cells (Fig. 2,4,6); the dimension of each of which is 16-20  $\mu$ . Each cell possesses a rounded nucleus which is about 8-10  $\mu$  and contains a pair of distinct nucleoli, while the cytoplasm contains distinct coarse granules; some of those granules form a distinct layer covering the outer surface of the nucleus. Depending on the staining affinities of those cells, they could be differentiated from the other types of neurosecretory cells, since they give dark grey colour when stained by chrome-alum haematoxylin of Gomori, red colour by Heidenhain's Azan stain, bluish green colour by Delphin's stain and purple with Ewen's stain. Those cells are fewer in number than the other two types and they are distributed and located in the cephalothoracic nerve masses and the nerve ganglia.

#### Type B cells:

The diameter of each of those cells is 25-30  $\mu$ . The nucleus is spherical and its diameter is about 10  $\mu$ ; it contains a pair of large and brightly stained nucleoli. The secretory material of those cells is in the form of coarse granules, (Figs. 2,5,7). Sometimes that secretory material appears in vacuoles. In fact, those cells have some of the morphological characteristics of unipolar neurons. Those B cells are always present in groups of four to six cells each. They are stained red with Heidenhain's Azan stain, pink with Gomori's chrom haematoxylin-phloxin stain and mauve with Ewen's stain. The secretory granules are stained pink while the ground cytoplasm is stained green when using Delphin's stain.

#### Type D:

Those cells are the largest type of neurosecretory cells (Fig. 3,5,8) with a diameter ranging between 45-55  $\mu$ . However, some of those cells are called the giant D cells and their diameter reaches 90-100  $\mu$ . Holmgren (1914) noticed slender, tubular and branched extensions of glial cells inside the cytoplasm of those D cells. Those extensions are usually called the trophospongia and sometimes they are named the canals of Holmgren. The nucleus of such type of cells is spherical and central, and it contains two prominent nucleoli, while the cytoplasm is granular. Those cells are stained mauve with Heidenhain's Azan and Gomori's chrom haematoxylin-phloxin stain, green by Delphin's stain and faintly stained with Ewen's stain.

### DISTRIBUTION OF NEUROSECRETORY CELLS

#### The brain and suboesophageal ganglion:

For descriptive purposes only, and on the bases of morphological and staining characteristics, one should repeat again that the neurosecretory cells are classified into three types A,B and D.

## NEUROSECRETORY CELLS OF THE CENTRAL NERVOUS SYSTEM OF THE SCORPION

In Fig. (10) the neurosecretory cells of the type A are given the symbol of a black triangular spot while the neurosecretory cells of type B are given the symbol of a circular spot and finally, the neurosecretory cells of type D are given the symbol of a squarish spot. Each spot in the figure represents two or three cells. The distribution of those cells in the anterior, lateral and posterior sides of the cellular cortex of the protocerebrum, tritocerebrum and lateral sides of rostral mass are shown in the figure. In fact, in the present work it is avoided to classify the distribution of those neurosecretory cells into evident more or less compact groups, as in the case of insects, because of the apparent, more or less, non-condensed together distribution of those cells.

It is obviously seen that in the dorsal most level of the suboesophageal ganglion there is found a pair of groups of neurosecretory cells which are located in the antero-lateral regions, and a second pair of smaller groups which are located in the postero-lateral regions. A horizontal section in the suboesophageal ganglion, at the level of the walking leg nerve tracts, shows four successive lateral pairs of groups of neurosecretory cells, which most probably, corresponds to the walking legs nerve tracts. A fifth smaller pair of groups of neurosecretory cells are located posterior most on the lateral sides of the suboesophageal ganglion. Finally, a median group of neurosecretory cells is located in the posterior corner of the suboesophageal ganglion. In Horizontal sections below the horizontal level of the tracts of the lateral walking legs nerves, the remainder of the above mentioned groups neurosecretory cells could be still seen.

### The mesosomatic and metasomatic ganglia:

Fig. 11 and table 1: represents the density and distribution of each type of neurosecretory cells in the different body ganglia. The products of those neurosecretory cells found all over the ganglionic structures of the central nervous system are either poured in the blood sinusoids as shown by histological investigation or in the extracellular spaces as shown by histochemical techniques, (Fig. 9), or in both. Further, droplets of the neurosecretory products were identified in the neuropile mass.

## DISCUSSION

Neurosecretory cells were first discovered by SPIEDEL (1919) in the spinal cord of elasmobranchs. Since that time other authors confirmed the presence of such neurosecretory endocrinal cells in other vertebrate and invertebrate groups. HANSTROM (1931) confirmed the presence of neurosecretory cells in crustacea. WEYER (1935) described neurosecretory cells in insects. The latter two authors were followed by many other authors. On the bases of the morphological characteristics and staining affinities of the cell, JOHANSON (1958 a,b) classified the neurosecretory cells into four types which he termed A,B,C and D types, that classification was used many authors such as GELDIAY (1959); PANOV (1964); DELPHIN (1962) and WIGGLESORTH (1970). However in a yet unpublished work in our department (KHALIL and ABDELAL) on the histology and activity of the neurosecretory cells in the brain of the water beetle *Cybister tripunctatus* throughout its postembryonic development, it was shown that one and the same type of neurosecretory cell showed different patterns or programs of secretion in different localities but of the same developmental stage of the insect a fact which meant, in that work, that the neurosecretory cells of one type according to morphological and staining affinities characteristics can not represent, from the physiological point of view, a single endocrinal gland. Therefore what is called B type of cells may represent more than one type, and the question of the real classification of those neurosecretory cells according to function can not be solved except by comparing different biological activities with the program of activities of those cells or by the direct identification of the hormones secreted by those cells.

In fact, the invalidity of the simple morphological classification of those cells into a number of types was a matter of suspicion by several authors. THOMSEN (1965) who threw doubt on the classification of neurosecretory cells according to their staining affinities and suggested that the differences in the histological picture of the cells represent differences in the physiological stage of the same cell during its secretory cycle. DELPHIN (1965) pointed out that the intensity of the stain depends, to some extent, on the method staining and differentiation, as well as on the duration of oxidation. EWEN (1962) concluded that the colour produced by paraldehyde fuchsin (PF.) is a variable personal observation. BULLOCK and HORRIDGE (1965) stated that staining reactions alone provide an inadequate basis for conclusion regarding the occurrence of neurosecretion. ABU-HALAWA (1976) concluded that the different types of neurosecretory cells referred to above as A,B,C were found to be different phases in the secretory cycle of one and the same type of cells. The authors of the present work believe that the latter opinion of Abu-Halawa is incorrect, because a "B" cell mass in insects for example remains so at any stage of development. If that mass represent a secretory stage, then, one should find different cellular composition of that mass at different stages of development.

For practical reasons one can say that, in the case of the scorpion investigated, only neurosecretory cells which are called by insect morphologist type A,B and D are identified, but type C is missing. Axons of neurosecretory cells were noticed pouring their neurosecretory products in the blood sinusoids distributed in the neuropile masses. However, neurosecretory material was also identified, depending on histochemical technique, in the extracellular spaces, so it was concluded that the neurosecretion is either poured in the blood sinusoids or in the extracellular spaces or in both. The extracellular spaces lead to the haemolymph (WIGGLESWORTH, 1960). Secretory structures associated with the brain, which structures could be similar to corpora allata and corpora cardiaca of insects or to Schneider's organ of araneida (arachnids), were not identified in the present work. However, POLICE (1903) described "stomatogastric ganglia" situated in contact with the oesophagus of the scorpions. GABE (1955) mentioned that some neurosecretory material is stored in the stomatogastric ganglia of Police. BULLOCK and HORRIDGE (1965) mentioned that the stomatogastric ganglia are homologous with the neurohaemal organ of the insect corpora cardiaca. The application of Gomori's chrome-alum haematoxylin phloxin and Ewen's paraldehyde fuchsin stains did not demonstrate the presence of such a structure in the scorpion studied. Neurosecretory organ, which is connected with moulting was described by HABIBULLA (1961) in the young scorpion, Heterometrus.

In the present work, the distribution of the different types of neurosecretory cells is not confined to definite localities, as in the case of insects mentioned in numerous previous works (BULLOCK and HORRIDGE, 1965; PANOV, 1976 and ANWAR and ISMAIL, 1979) a fact which compelled the present authors to record on charts the more or less random distribution of those cells. GABE (1955) worked on different species of arachnids described protocerebral neurosecretory cell group situated posterior to the globuli cells of the corpora pedunculata (mushroom body). BULLOCK and HORRIDGE (1965) mentioned that in arachnids there are generally found two bilateral groups in the protocerebrum, two in the tritocerebrum (cheliceral ganglion) and one bilateral group in each neuromers of the suboesophageal nerve mass. HABIBULLA (1970) described in the brain of the scorpion Heterometrus three groups of neurosecretory cells; medial group, lateral group and a group outside the pars intercerebralis near the optic lobes (masses). In all the above mentioned works about the presence of definite groups of neurosecretory cells, the examination of the figures given did not satisfy the present authors of the correctness of that classification into groups, but on the contrary it further emphasized their opinion about the random distribution of those cells.

## NEUROSECRETORY CELLS OF THE CENTRAL NERVOUS SYSTEM OF THE SCORPION

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#### EXPLANATION OF FIGURES

- Fig. (1):** Diagrammatic figure of the neurosecretory cells  
 A = Type A neurosecretory cell  
 B = Type neurosecretory cell  
 D = Type D neurosecretory cell
- Fig. (2-8):** Photomicrographs, showing different types of neurosecretory cells by different neurosecretory stains  
**Fig. 2:** A and B types stained with Ewen's stain (X 400).  
**Fig. 3:** D type stained with Ewen's stain (X 400).  
**Fig. 4:** A type stained with Delphin's stain (X 400).  
**Fig. 5:** B and D types stained with Delphin's stain (X 400).  
**Fig. 6:** Type A stained with Gomori's stain (X 400).  
**Fig. 7:** Type B stained with Gomori's stain (X 400).  
**Fig. 8:** Type D stained with Gomori's stain (X 250).
- Fig. (9):** Transverse section of abdominal ganglia, showing the neurosecretory nerve fibres pouring neurosecretory material in the extracellular spaces. DelOhin's stain (X 400).  
 (Ass = Association cells, EXCSF = Extra cellular space, NF = nerve fiber).
- Fig. (10):** Localization of neurosecretory cells in the brain and suboesophageal ganglion.  
 a-b. dorsal region of the protocerebrum.  
 c-d. ventral region of the protocerebrum.  
 e-f. dorsal region of the tritocerebrum.  
 g-h. ventral region of the tritocerebrum.  
 i-j. dorsal region of the suboesophageal ganglion. (pedipalpal ganglion).  
 k-l. Middle region of the suboesophageal ganglion.  
 m-n. ventral region of the suboesophageal ganglion.



## NEUROSECRETORY CELLS OF THE CENTRAL NERVOUS SYSTEM OF THE SCORPION

- Fig. (11): Localization of neurosecretory cells in the mesosomatic and metasomatic ganglia.  
 1- A mesosomatic ganglion, 2- Ametasomatic ganglion,  
 3- The last metasomatic ganglion.  
 a- Anterior region of each ganglion. b- middle region of each ganglion.  
 c- posterior region of each ganglion.

Table (1)  
 The relative numbers of neurosecretory cells in

a- Mesosomatic ganglia			
Neurosecretory cell type	A	B	D
Anterior region	8	12	3
Middle region	5	6	3
Posterior region	-	5	-
Total number	13	23	6

b- Metasomatic ganglia			
Neurosecretory cell type	A	B	D
Anterior region	-	5	10
Middle region	11	12	5
Posterior region	5	10	5
Total number	16	27	20

c- Last metasomatic ganglion			
Neurosecretory cell type	A	B	D
Anterior region	5	10	10
Middle region	4	16	11
Posterior region	5	11	10
Total number	14	37	31

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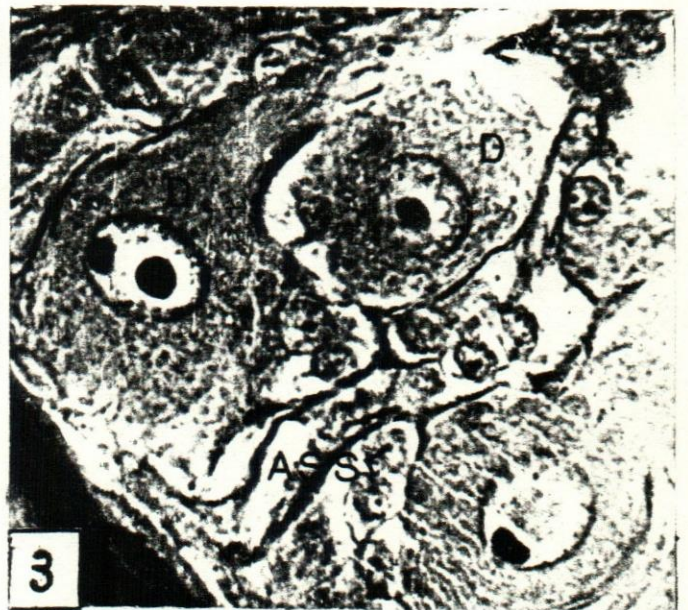
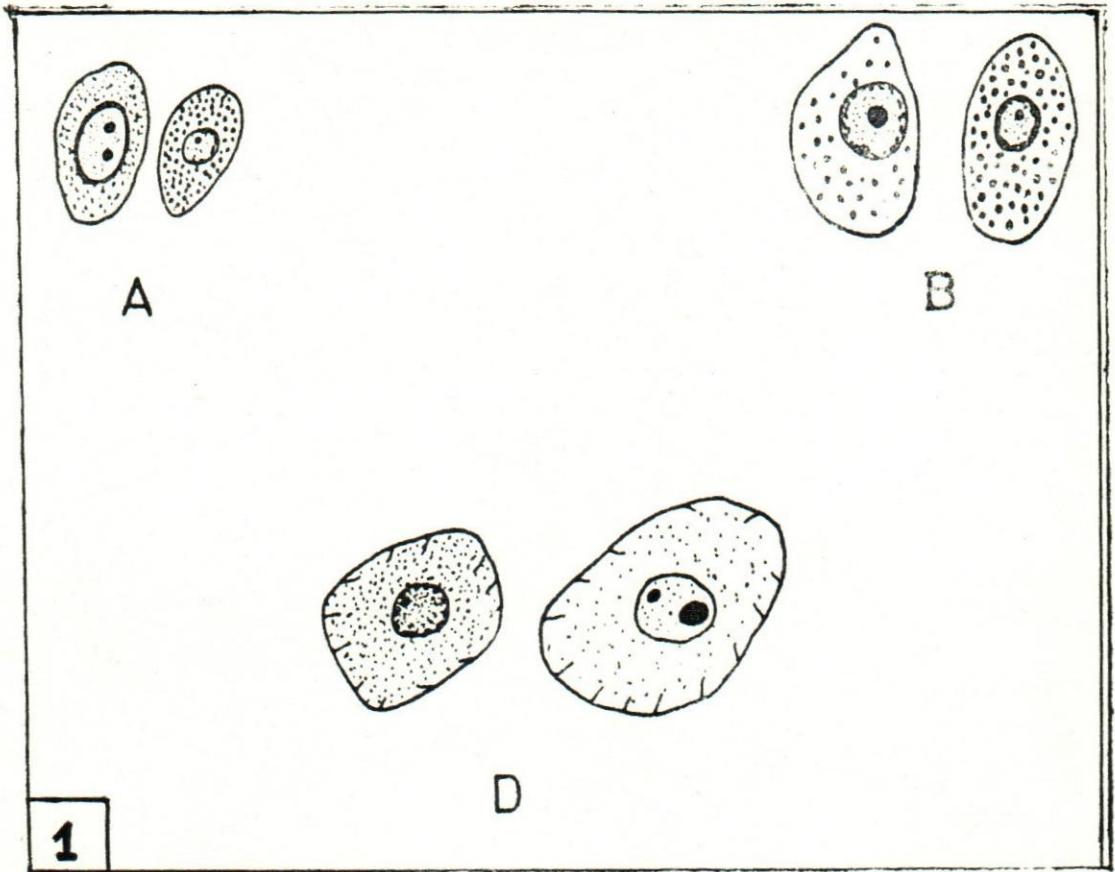
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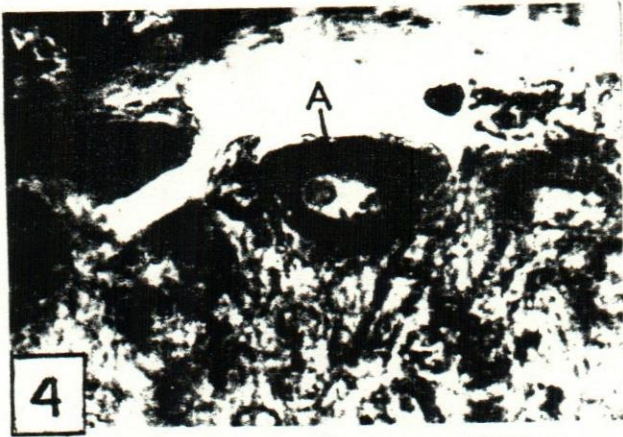
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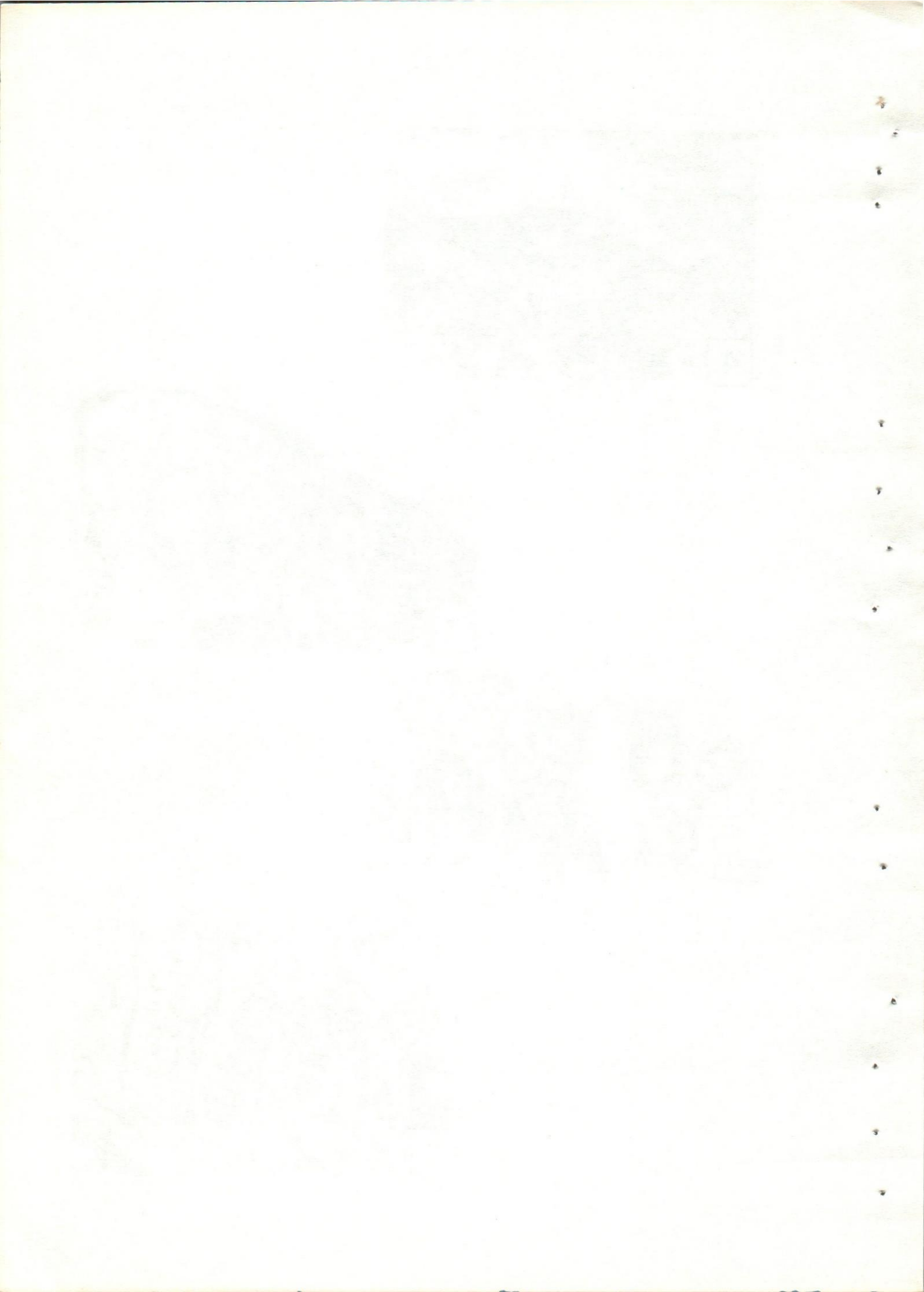
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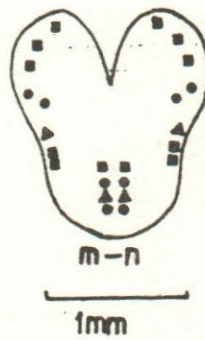
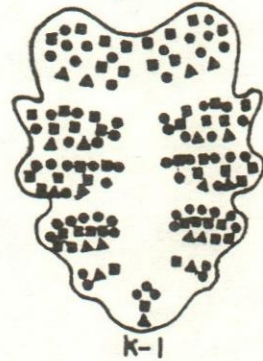
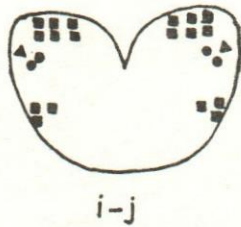
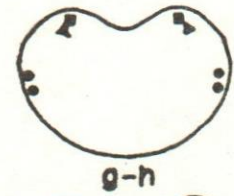
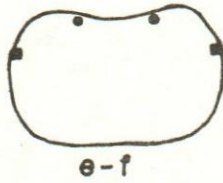
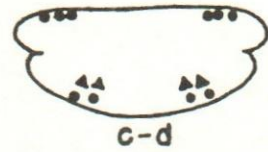
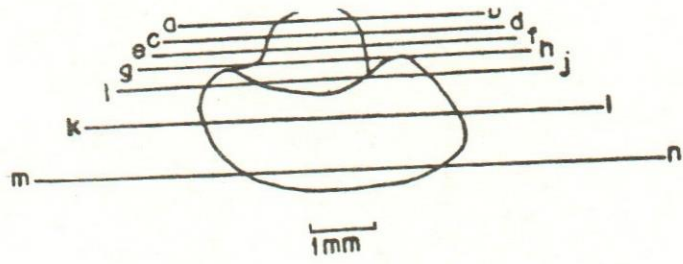








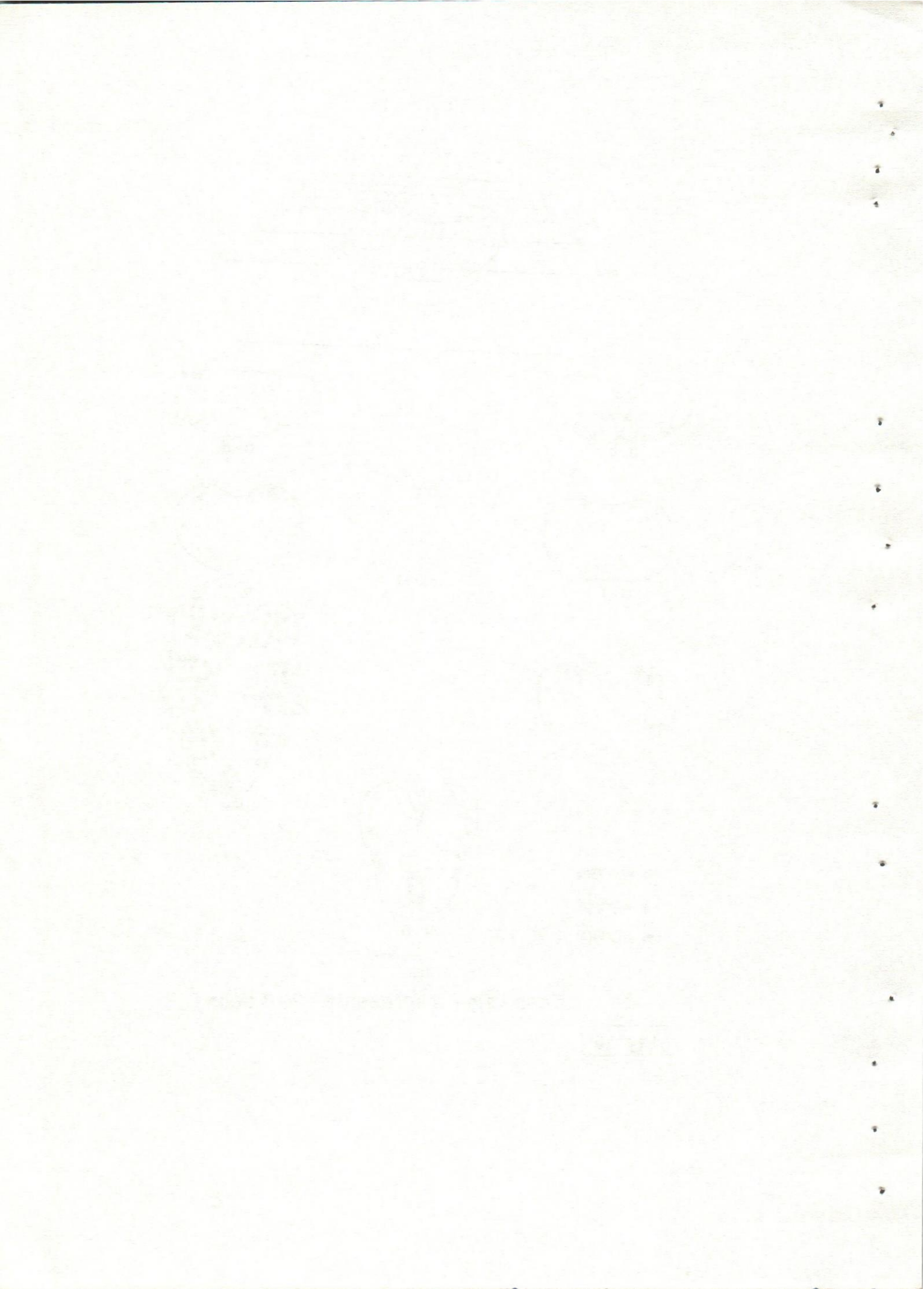




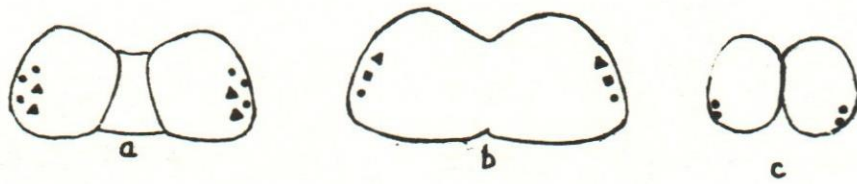
- ▲ = A Type
- = B Type
- = D Type

Each sign represents 2-3 cells

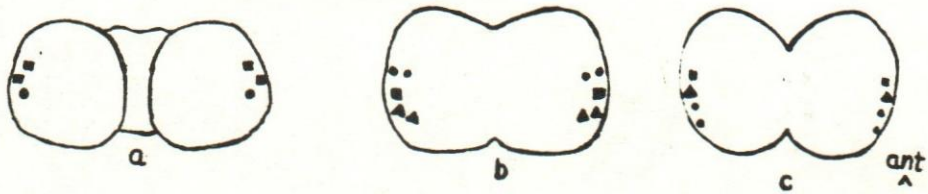
**Fig: 10**



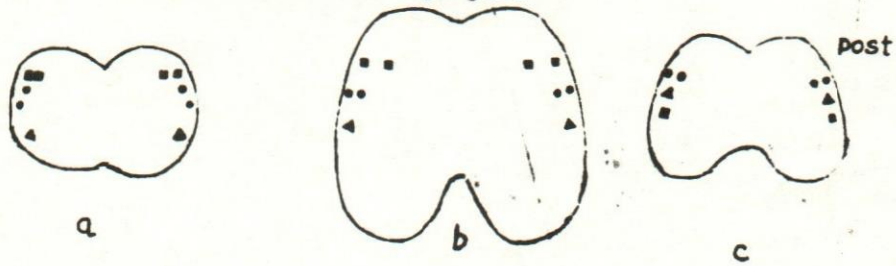
1- Amesosomatic ganglion.



2- Ametasomatic ganglion.



3- The last metasomatic ganglion.



- ▲ = A Type
- = B Type
- = D Type

0.2 mm.

**Fig: 11**



17