قســـــــم : التشريح والهستولوجى ـ كلية العلوم البيطرية ـ جامعة بانت ـ الهند .
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د راسة تشريحية للعصب الاستحيائى فى ذكور الماعـــــــــــز

برم براكـــــاش، ســـنج

استهد فت الد راسة توضيح مصد ر وسلوك وتوزيع العصب الاستحيائى فى ذكور الماعز. وقد أثبتت النتائج أن هذا العصب يتكون من الفرع الأسفل من الثانى والثالث والرابع من العصب العجزى ولكنه يميل اكثر فى الخروج من الجزء العجزى الثالث. .وهذا العصب يستقبل فروع صغيرة من العصـــــب لاسى اكيا ويكى وسجل العدد الكلى لألياف هذا العصب وأظهر الفحص السيتولوجى للألـــــاف أن القطـــر يتراوح بين ٨-١٠ ميكرون .

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ANATOMY OF THE PUDENDAL NERVE IN THE MALE GOAT (Capra aegagrus)

(With 4 Figures)

By

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SUMMARY

The origin, course and distribution of the pudendal nerve (N. pudendus) have been studied in the male goat. It is formed by the convergence of the ventral rami of the second, third and fourth sacral spinal nerves, mostly contributed by the third sacral segment. It receives an anastomotic slender ramus from the sciatic nerve near the lesser ischiatic foramen. The total fibre count and the diameter spectra of the myelinated nerve fibres in the N. pudendus and its rami have also been investigated. The histograms of the fibres at the selected levels revealed distinct unimodality with a peak around 8-10 um.

INTRODUCTION

The mammalian pudendal nerve (N. pudendus) is the principal nerve supply to the perineum and external genitalia. Gross anatomical studies on its origin, course and distribution have been reported in cattle (KITCHELL et al., 1955; LARSON and KITCHELL, 1958), buffalo (PRAKASH et al., 1980), horse (GETTY' 1975), dog (HAVELKA, 1928; MILLER et al., 1964) and sheep (KITCHELL et al., 1955; LARSON and KITCHELL, 1958). KITCHELL et al., (1955) observed the fibre-size spectrum of the dorsalnerve of the penis in the ram, bull and steer. PRAKASH et al. (1980) reported the number and diameter spectra of the myelinated nerve fibres in N. pudendus and its rami in the buffalo. Apparent lack of information on the course and structure of the pudendal nerve in the male goat prompted this study. This information would be useful and essential in anaesthetization of the penis for surgical intervention.

MATERIAL and METHODS

Six male goats of about 18 months of age were randomly selected irrespective of their breed and weight. The goats were anaesthetized and exsanguinted through the polyethylene cannulated right common carotid artery and then perfused with 10% neutral formalin solution after hoisting the animal in natural position. After 48 hours of embalming a systematic dissection was carried out to study the origin, course and distribution of N. pudendus. The tissues for histological studies were collected from another group of six male goats. Immediately after exsanguination of each animal, about 1.5 cm long samples of nerve segments were isolated between ligatures and collected from the following rami viz. ventral rami of 2nd, 3rd and 4th sacral spinal nerves (Nn. sacrales II, III et IV), proximal and distal cutaneous rami (Ramus cutaneus proximalis et distalis), the portion of pudendal nerve after the emergence of the proximal and distal cutaneous rami, anastomotic ramus of the sciatic nerve, the deep perineal nerve (N. perinealis profundus), the pudendal nerve at the level of ischial arch, the dorsal nerve of penis (N. dorsalis penis), and the superficial perineal nerve (N. perinealis superficialis). These nerve segments were gently stretched on stainless steel wire frames and impregnated with freshly prepared 1% osmium tetroxide solution. These were processed by the paraffin tissue technique employing the dioxane schedule. From the osmium impregnated nerves, 6 um thick sections were cut, cleared in xylene and mounted in DPX mountant. For each nerve, the total number and external diameter (e.d.) of the myelinated nerve fibres were obtained on the lines of PRAKASH and TEWARI (1972). From these data, the diameter percent spectra of the fibre-populations were determined and histograms prepared.

RESULTS

Fig. 1 shows the origin and course of the pudendal nerve. Fig. 2 depicts the histograms representing the diameter-percent spectra of the myelinated nerve fibres collected at various levels of the pudendal nerve as described in

the preceding section.

Gross anatomical dissections demonstrated that the pudendal nerve in the male goat originates by the confluence of parts of the ventral rami of the second, third and fourth sacral spinal nerves. The ventral ramus of the third sacral nerve was found to be the single largest component of the pudendal nerve. The cross-section of the third sacral nerve contains 10,240 ± 524 myelinated nerve fibres, whereas the second and fourth sacral nerves contribute 2210 ± 310 and 5020 ± 312 fibres, respectively. A large percentage of f ibres (63.3 - 68.4%) attain an external diameter (e.d.) between 8-10 um with less percentages in the adjacent ranging between 2-6 um and 12-16 um (Fig. 2,a-c).

After the union of the aforesaid radicles from the sacral nerves, the pudendal nerve passes caudoventrally on the medial surface of the broad sacrotuberal ligament to the level of lesser ischiatic foramen. It receives an anastomotic branch from the sciatic nerve near the lesser ischiatic foramen. The nerve then runs caudally to the ischiatic arch, turning around it and continuing cranioventrally undercover of the M. ischiocavernosus. Cranial to the insertion of the M. ischiocavernosus, the pudendal nerve gains the dorsal aspect of the penis and is divided into two terminal branches, viz. the dorsal nerve of the penis and the superficial perineal nerve.

The following rami of the pudendal nerve were observed:

1. Ramus cutaneus proximalis: Is the first ramus of the pudendal nerve arising slightly cranial to the lesser ischiatic foramen. It courses caudodorsally over the lateral aspect of the broad sacrotuberal ligament and emerges out of the pelvic cavity through the dorsal part of lesser ischiatic foramen. It turns ventral between the M. biceps femoris and M. semitendinosus and innervates the skin over the M. semitendinosus. The cross-section of Ramus cutaneus proximalis reveals that it contains 3510 ± 265 medullated nerve fibres. The majority of these fibres (63.24%) have a diameter of 8-10 um (Fig. 2, d).

2. Ramus cutaneus distalis: Originates below the preceding nerve and runs caudad to the ischiorectal fossa medial to the dorsal prominence of the ischiatic tuber. The average number of myelinated fibres in this ramus is found to be 5830 ± 278. Size-percent frequency histogram shows the maxima between 8-10 um at this level as well (Fig. 2, f). The Ramus cutaneus distalis emerges through the ischiorectal fosa and divides into medial, middle and lateral rami, respectively. The medial ramus unites with its fellow of the opposite side and innervates the caudal scrotal wall. The middle ramus innervates the skin over the M. semimembranosus while the lateral ramus travels ventrad between the Mm. semimembranosus and semitendinosus and innervates the skin over this region.

3. N. perinealis profundus: Is given off by the pudendal nerve, caudal to the origin of the Ramus cutaneus distalis. It runs along the ventral border of the M. levator ani and divides into a number of fine rami to innervate the Mm. bulbo-cavernosus, ischiocavernosus, sphincter ani externus and urethralis. The average number of myelinated nerve fibres in this nerve is seen to be 2510 ± 187. The majority of these (61.74%) have an e.d. of 8-10 um (Fig. 2, i).

4. N. dorsalis penis: Is one of the terminal rami of the pudendal nerve. It closely follows the dorsal surface of the penis and ramifies within the glans penis. It also gives few fine rami to the distal-fourth of the M. retractor penis. The general architecture of the cross-section of the N. dorsalis penis is shown in Fig. 3. Closely packed, medium-sized myelinated blackened fibres are seen along which, few larger ones with thick myelin sheaths and few smaller ones are uniformly interspersed. The intervals between the myelinated fibres are filled with a yellowish meshwork characteristic of osmicated unmyelinated nerve tissue. This nerve, on an average, consists of 3007 ± 212 myelinated nerve fibres. About 64.84% of these myelinated fibres are in the range of 8-10 um (Fig. 2, k).

5. N. perinealis superficialis: Is the second terminal ramus of the pudendal nerve, giving off cranial to the insertion of M. ischiocavernosus. The nerve divides into scrotal and preputial rami. The scrotal ramus courses cranially and innervates the lateral scrotal wall and septum scroti. The preputial ramus divides into many fine rami which terminate in the preputial membrane and the skin of the prepuce. The general architecture of N. perinealis superficialis is shown in Fig. 4. This nerve in average contains 4016 ± 261 myelinated nerve fibres. Of these the 8 um fibres constitute 35.1%, while 27.51% of the fibres are of 10 um. Thus, a total of 62.61% of the fibres are 8-10 um (Fig. 2, l).

DISCUSSION

The pattern of origin, course and distribution of N. pudendus in the goat appears to be in general agreement with that obtained in other domestic animals. It this species, it is usually formed by the ventral rami of second, third and fourth sacral nerves; the largest contribution is from the third sacral segment. This is in conformity with the findings of KITCHELL et al. (1955) in the cattle and sheep, and PRAKASH et al. (1980) in the buffalo. According to LINZELL (1959), its origin in sheep and goats was extremely variable. It might arise from the ventral rami of third and fourth sacral nerves and in exceptional cases, from that that of the second and third sacral nerves. They had also seen it arising from the ventral rami of the third, fourth and fifth sacral nerves in sheep. A prefixed origin of the pudendal nerve by the first sacral segment has been described in the dog by HAVELKA (1928).

Through quantitative estimation of the total number of myelinated nerve fibres, it has been confirmed in this study that the third sacral segment, in average, contributes the maximum number of fibres (10,240 ± 524), whereas the second and fourth sacral segments provide 2210 ± 318 fibres, respectively. The majority of these fibres (63.3 - 68.4%) have an external diameter (e.d.) of 8-10 um and their dominance in the sacral segments has been ascertained by the unimodal spikes shown by the selected rami of the pudendal nerve (Fig. 2). PRAKASH et al. (1980) observed in the buffalo that the second, third and fourth sacral segments contributed 4017, 13,248 and 7484 myelinated fibres, respectively.

In ram and bull (LARSON and KITCHELL, 1958) the Ramus cutaneus proximalis of the pudendal nerve gave off medial and lateral rami but these rami could not be observed in the goat. This is in agreement with the observations of PRAKASH et al. (1980) in the buffalo. The Ramus cutaneus proximalis innervates the skin over the M. simitendinosus in the goat as in the case of buffalo (PRAKASH et al., 1980). However, HABEL (1966) described this area to be innervated by the caudal cutaneous femoral nerve in cattle. In the goat the Ramus cutaneus proximalis contains 3510 myelinated nerve fibres. Of these 8 um fibres constitute 37.6%, while 25.64% of the fibres are of 10 um. Thus, a total of 63.24% of all these myelinated fibres are of 8-10 um. In the buffalo this ramus had 5906 myelinated nerve fibres with a peak at 2-4 um (PRAKASH et al., 1980).

It has been observed that the Ramus cutaneus distalis in the goat emerges through the ischiorectal fossa and divides into medial, middle and lateral rami similar to the observations made by HABEL (1966) in cattle. However, LARSON and KITCHELL (1958) in rams and bulls, and PRAKASH et al. (1980) in buffaloes described only 2 rami-medial and lateral. In the buffalo, the number of myelinated fibres in this ramus was seen to be 6947, with more than 70% fibres having an e.d. of 2-4 um (PRAKASH et al., 1980). In the goat, this ramus contains 5830 (mean value) myelinated fibres. 61.74% of these fibres are in the range of 8-10 um. It is evident from this study that the pudendal nerve just before giving off the N. perinealis profundus receives an anastomotic slender ramus from the sciatic nerve near the lesser ischiatic foramen. This is in agreement with the observations of KITCHELL et al. (1955) in rams and bulls, and GHOSHAL and GETTY (1970) in goats. However, HABEL (1966) described that this ramus anastomosed either with the pudendal nerve or the deep perineal nerve. In the present study, the total numbers of myelinated nerve fibres of the pudendal trunk after giving off the Ramus cutaneus distalis and those of the anastomotic ramus of the sciatic nerve have been counted to the tune of 8100 ± 367 and 1618 ± 101, respectivbely. Also, the fibres of the N. perinealis profundus and those of the pudendal nerve at the level of ischial arch were found to be as many as 2510 ± 187 and 7101 ± 302, respectively. Thus, there is a definite correlation between the aggregate of the former two counts with the sum of the latter two counts. This indicates that in the goat, the anastomotic ramus from the sciatic nerve anastomoses only with the pudendal nerve.

The distribution pattern of the N. dorsalis penis and N. perinealis superficialis in the goats is similar to the findings of LARSON and KITCHELL (1958) and GETTY (1975) in male bovines, and PRAKASH et al. (1980) in buffaloes. However, the preputial ramus of the N. perinealis superficialis had been termed as the posterior cutaneous preputial ramus by LARSON and KITCHELL (1958). In the present study, the N. dorsalis penis has been found to contain 3007 ± 212, whereas the N. perinealis superficialis, in average, consists of 4016 ± 261 myelinated nerve fibres. The maximum percentage of these fibres are found to range between 8 to 10 um. There are no fibres over 16 um of external diameter. According to KITCHELL et al. (1955) the total counts for the N. dorsalis penis were

3087 for the ram, 4033 for the bull and 5070 for the steer. PRAKASH et al. (1980) noted that in the buffalo it had 4192 medullated fibres with 2.98% being larger than 10 um. In the literature, there seems to be no comparable data on the calibre spectra in other ruminants.

It may be concluded from this study that the pudendal nerve at all the selected levels exhibits a distinct unimodality distribution of myelinated nerve fibres with the peak between 8-10 um. Based on their diameter these fibres would quality for A-alpha group with conduction velocities ranging from 48-60 met/sec. Since the electrical excitability and susceptibility of the fibres to blocking agents depend on their diameter, the A-alpha group of fibres in the goat are less resistant to blocking agents (RFANZ and IGGO, 1968).

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REFERENCES

Franz, D.N. and Iggo, A. (1968): Conduction failure in myelinated and nonmyelinated axons at low temperatures. J. Physio., 199, 319-345.

Getty, R. (1975): Sisson and Grossmans Anatomy of the domestic animals, 5th ed., pp. 686-687; 1147-1149, W.B. Saunders company. Philadelphia.

Ghoshal, N.G. and Getty, R. (1970): The lumbosacral plexus of the goat (capra hircus). Iowa State J. Sci., 45, 269-275.

Habel, R.E. (1966): The topographic anatomy of the muscles, nerves and arteries of the bovine female perineum. Amer. J. Anat., 119, 79-96.

Havelka, F.(1928): Plexus lumbo-sacralis u. psa (in Czech with German summary: Plexus lumbo-sacralis des Hundes). Vysoka skola veterinarni Biologiche, 7, 1-40.

Kitchell, R.L.; Campbell, B. Quilliam, T.A. and Larson. L.L. (1955): Neurological factors in the sexual behaviour of domestic animals. Proc. Meet. AVMA, 92nd, pp. 177-189, Minneapolis.

Larson, L.L. and Kitchell, R.L. (1958): Neural mechanisms in sexual behaviour. II. Gross neuroanatomical and correlative neurophysiological studies on the external genitalia of the bull and the ram. Am. J. Vet. Res., 19, 853-865.

Linzell, J.L. (1959): The innervation of the mammary glands in the sheep and goat with observations on the lumbosacral autonomic nerves. Quart. J. exper. Physiol., 44, 160-176.

Miller, M.E.; Christensen, G.C. and Evans, H.E. (1964): Anatomy of the dog, 2nd ed., p. 611, W.B. Saunders Company. Philadelphia.

Prakash, P.; Rao, G.S. and Ghosh, R.K. (1980): Anatomical studies on the pudendal nerve in the Indian buffalo (Bubalus bubalis). Anat. Anz., 147, 76-84.

Prakash, P. and Tewari, A.N. (1972): A study on the fibre spectrum of the vagus nerve in the buffalo (Bubalus bubalis). I Pars Cervicalis. J. anat. Soc. India, 21, 46-51.

EXPLANATION OF FIGURES

Fig. (1): Diagram showing the disposition of pudendal nerve, left view.

1. M. coccygeus; 2. M. levator ani; 3. M. sphincter ani externus;
4. M. retractor penis (cut); 5. M. ischiocavernosus;
6. M. bulbospongiosus; 7. 7. M. recto-coccygeus; Cy_1 -Cy_3 = 1st coccygeal through 3rd coccygeal vertebrae; S. Sacrum; L . Ventral ramus of 6th lumbar nerve; S_1-S_4 = Ventral rami of 1st through 4th sacral nerves; Oc. Os Coxae. The selected levels a to l at which nerve samples were collected for histological study are indicated in Figure 2.

Fig. (2): Histograms showing diameter-percent distribution of the myelinated nerve fibres of the pudendal nerve at various levels:

a) sacral spinal nerve 2 (ventral ramus); b) sacral spinal nerve 3 (ventral ramus);
c) sacral spinal nerve 4 (ventral ramus); d) proximal cutaneous ramus;
e) the portion of pudendal nerve after giving off the proximal cutaneous ramus;
f) distal cutaneous ramus; g) the portion of pudendal nerve after giving off the distal cutaneous ramus; h) ramus of sciatic nerve;
i) deep perineal nerve; j) pudendal nerve at the level of ischial arch;
k) dorsal nerve of penis; l) superficial perineal nerve.

Fig. (3): Photomicrograph of cross-section of the dorsal nerve of penis, showing myelinated fibres. (1% osmium tetroxide stain. Oc. 10 x Ob. 43).

Fig. (4): Photomicrograph of cross-section of the superficial perineal nerve, showing myelinated fibres. (1% osmium tetroxide stain. Oc. 10 x Ob. 43).

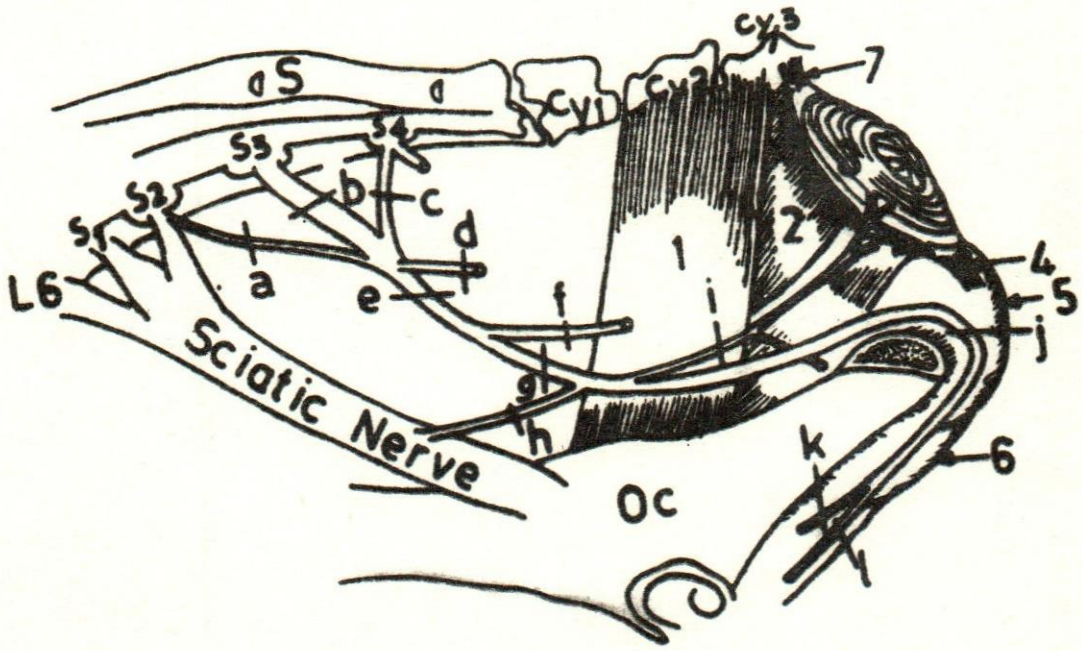
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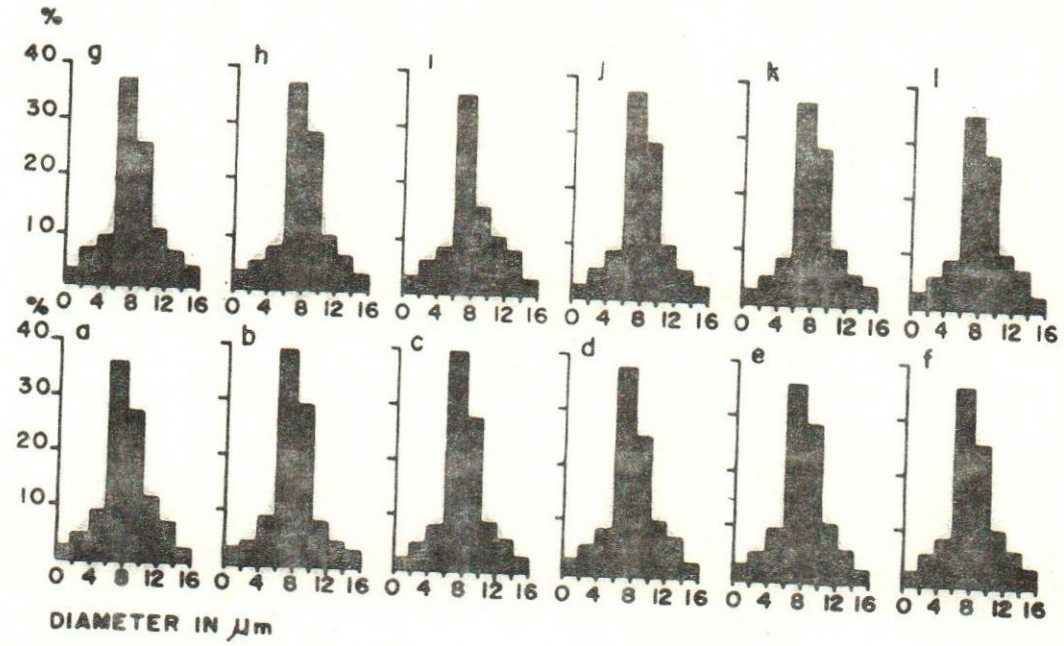
Fig (1)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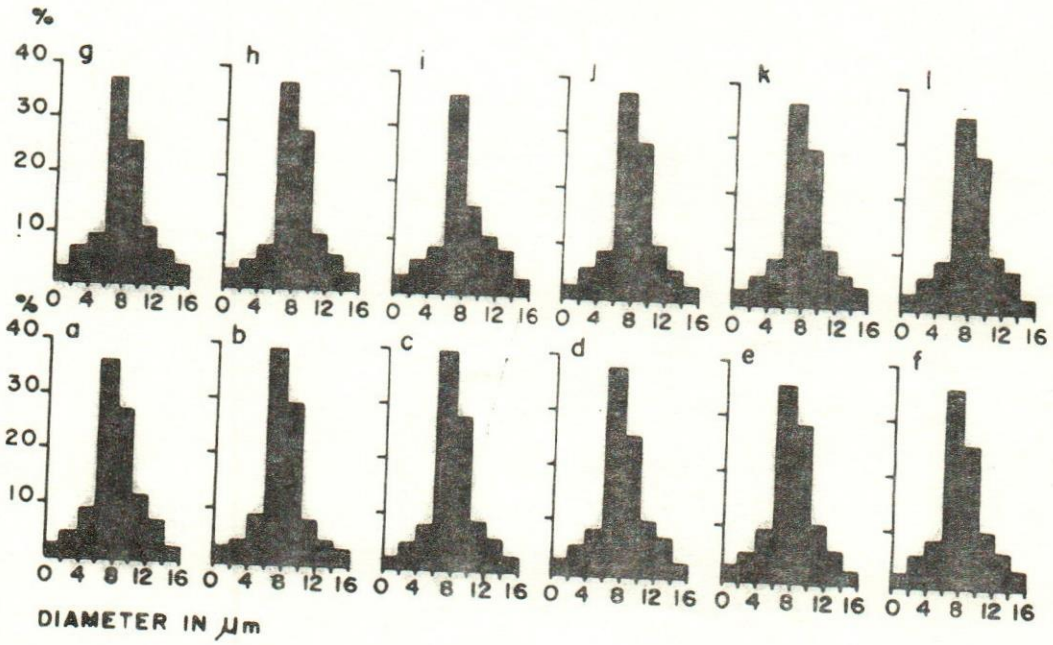
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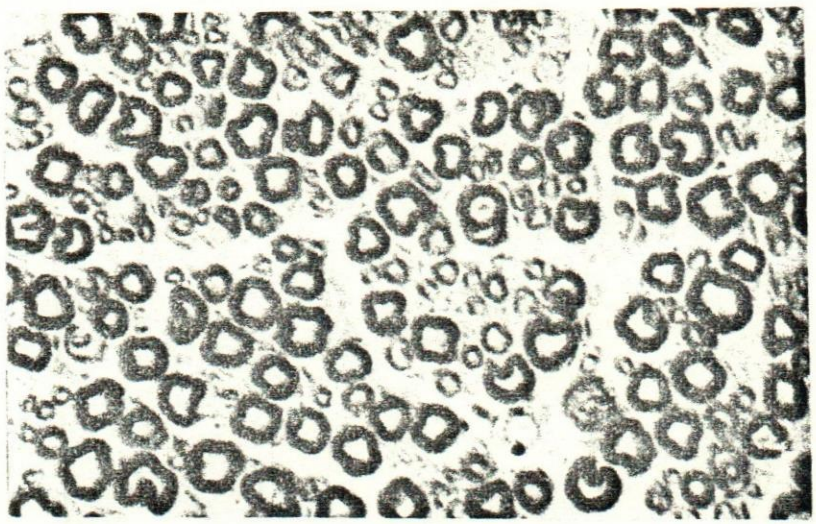
Fig. (2)



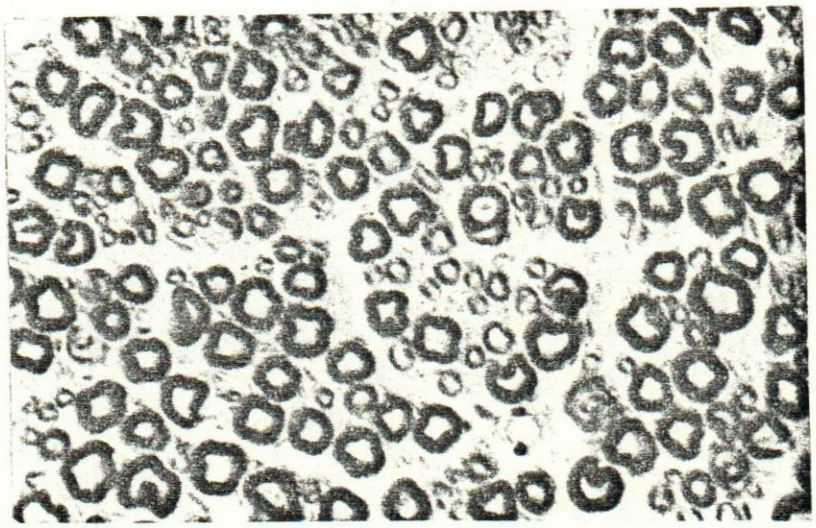
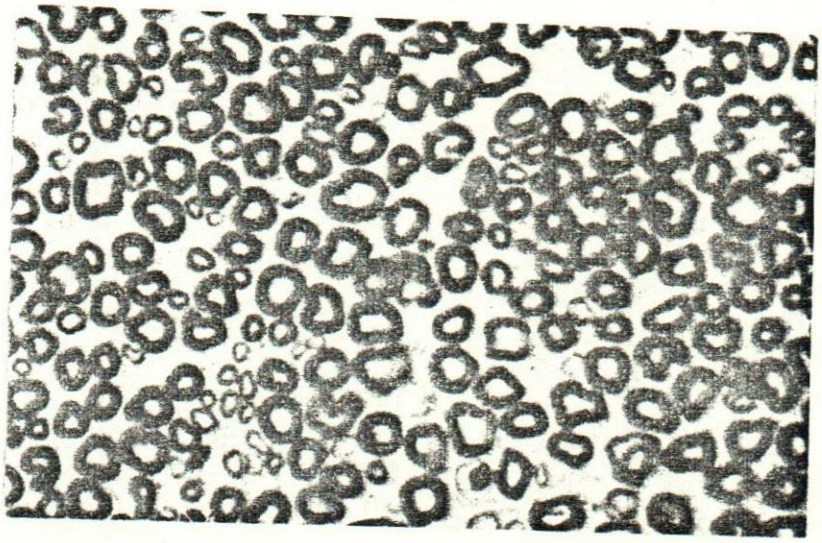


Fig (3)



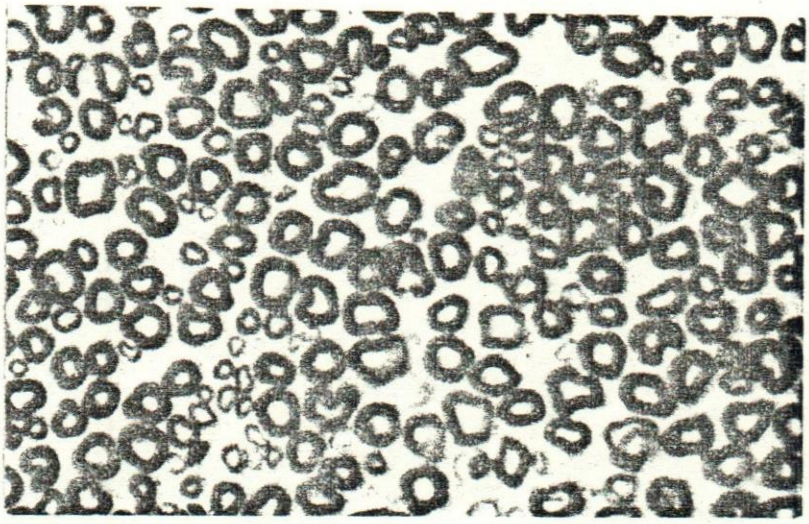


Fig (4)