SECTION 'C'.

COSMOCERCACAKASHMIRENSIS.

FOTEDAR, 1959.
INTRODUCTION.

Only a limited number of nematodes have been so far reported from Amurans in India. Karve (1944) described nematode, \textit{Cosmocercoides bufonis} from \textit{Bufo himalayanum}. Fotedar (1959) reported for the first time \textit{cosmocerca Diesing, 1861} from a toad \textit{Bufo viridis} of Kashmir and described a new species, \textit{C. kashmirensis}. Again in 1960 he described a new species of \textit{oxysemantium}, \textit{O. srinagarensis} from the same host. Earlier Karve (1927) reported \textit{O. macintoshi} (stewart, 1914) from \textit{Bufo stomaticus}, \textit{Bufo melanostictus} and \textit{Rana tigrina} in India. Fotedar (1965) reported \textit{Rhabdias bufonis} (Schrank, 1783), Stiles and Hassal, 1905 for the first time from Indian region. The worms were recovered from \textit{Bufo viridis} of Kashmir which is a common host of the parasite. Baer (1930) described an immature form of \textit{Rhabdias escheri} from body-cavity of \textit{Uraeotyphlus oxyurus} from South India. Gupta (1960) reported \textit{Rhabdias ranae} Walton, 1929 from \textit{Rana tigrina} in East Pakistan. Lal (1944) for the first time described a new trichostrongylid nematode, \textit{Eswaldecruzia indica} from \textit{Bufo melanostictus}. Gupta (1960) described \textit{E. melanosticti} from \textit{Bufo melanostictus} in East Pakistan. Rao et Singh (1954) described \textit{Strongyleides bufonis} from \textit{Bufo melanostictus} in India.
As many as fourteen oxyurid nematode genera listed below have been so far reported from various Amphibians of different parts of the world:

<table>
<thead>
<tr>
<th>Genera</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharyngodon</td>
<td>Diesing, 1861</td>
</tr>
<tr>
<td>Thelandros</td>
<td>Wedl, 1861</td>
</tr>
<tr>
<td>Cosmocerca</td>
<td>Diesing, 1861</td>
</tr>
<tr>
<td>Aplectana</td>
<td>Railliet et Henry, 1961</td>
</tr>
<tr>
<td>Cosmocercella</td>
<td>Steiner, 1924</td>
</tr>
<tr>
<td>Cosmocereoides</td>
<td>Wilkie, 1930</td>
</tr>
<tr>
<td>Nevraraplectana</td>
<td>Ballesteros Marquez, 1945</td>
</tr>
<tr>
<td>Paracosmocerca</td>
<td>Kung et Wu, 1945</td>
</tr>
<tr>
<td>Pseudaplectana</td>
<td>Yamaguti, 1961</td>
</tr>
<tr>
<td>Oxysomatium</td>
<td>Railliet et Henry, 1913</td>
</tr>
<tr>
<td>Neoxraillietnema</td>
<td>Ballesteros Marquez, 1945</td>
</tr>
<tr>
<td>Neoxysomatium</td>
<td>Ballesteros Marquez, 1945</td>
</tr>
<tr>
<td>Neoxysomatooides</td>
<td>Yamaguti, 1961</td>
</tr>
<tr>
<td>Raillietnema</td>
<td>Travassos, 1927</td>
</tr>
</tbody>
</table>

Of the above genera Aplectana is regarded as a synonym of Oxyomatium by many workers, including Fetedar (1960), who gave a review of the previous work and established the synonymy. Two more genera, Neoxysomatium and Nevraraplectana Ballesteros Marquez, 1945 are also regarded by Fetedar as having insufficient generic features to separate their species from the genus Oxyomatium.
COSMOCERCA KASHMIRENSIS is the most common nematode parasite of Bufo Viridis in Kashmir, inhabiting its rectum and rarely intestines. It was in view of the absence of a detailed morphological account of any amphibian nematode parasite that the writer was promoted to undertake the present studies of Cosmocerca Kashmirensis, the material of which is readily available.

The present contribution pertains to a detailed morphological and histological study of several systems of female worms of the species. The study is based on the whole mounts and serial sections. Male reproductive system was studied only from the whole mounts. The life-cycle of the worm is described in Section IV. It includes the study of eggs, their developmental stages, I- and II-stage larvae and the mode of infection to the host.
COSMOCERCA  Diesing, 1961  

Synonyms:  
Nematoxys  Schneider, 1866 Partim  
Ananconus  Railliet at Henry, 1916.  

Genus Cosmocerca was proposed by Diesing, 1861, for the species C. ornata. Railliet et Henry (1916) placed C. trispinosa as the genotype and placed Diesing's C. Ornata as its synonym. Railliet at Henry (1916) called Oxyurus ornata of Dujardin 1845 (nec. Diesing, 1861) as C. ornata.

**GENERIC DIAGNOSIS.**

Cosmocercidae : Cosmocercinae. Mouth with three small lips; small pharynx present; oesophagus with slight prebulbar swelling; well-developed posterior bulb. Lateral alae present.

**M A L E:** Male Caudal tip with a fine spike or with three distinct points; Pre-anal and Post-anal papillae present; Variable number of Compound papillae with sub-cuticular thickenings—plectanes located ventrally in two rows in front of cloaca; each plectane with a central papilla and one or two concentric cuticular tubercles; spicules short and equal; gubernaculum present.
FEMALE.

Posterior extremity usually terminating into a long process; vulva in front of middle of body; eggs in ripe females embryonated; uterine branches apparently opposed.

Parasitic in intestine and rectum of Batrachians.

Fotedar (1959) gave a list of seventeen species of *Cosmocerca* which were described till then and are reproduced below. He considers *C. australiensis* Johnston and Simpson, 1943 and *C. propinqua* Johnston and Simpson, 1943 as doubtful species of *Cosmocerca*, because of the absence of any description of their males. As regards *C. banyclensis* Chabaud and Compana-Rouget, 1955, Fotedar considers it to be species of *Cosmocercella* because of the presence of cuticular expansion in male caudal end. It is accordingly deleted here from the list of species of *Cosmocerca*.

**LIST OF SPECIES OF COSMOCERCA.**

1. *C. trispinosa* Railliet and Henry, 1916

   Synonyms: *Oxyuris Ornata* Walter, 1856. nec. Dujardin, 1845.

   *Cosmocerca ornata* (Walter, 1856) Diesing, 1861.

   in *Rana temporaria*, *Triturus alpestris*.

   Europe.

   13-14 pairs of placetanes in four rows.

   2-3 post-cloacal plectanes.

2. *C. brasiliense*, Travassos, 1925 in *Bufo Crucifer*.

   *Hyloides guentheri*, *Hyla faber*, *H. Millaris*.

   Brazil.
9-11 pairs of plectanes in two rows and 5 pairs of small additional plectanes including three pairs pre-cloacal and two pairs post-cloacal.


4. *C. commutata*. Diesing (1851), Diesing 1861
   Synonyms *Ascaris commutata*, Diesing, 1851
   *Oxyurus ornata*, Weimland, 1859.
   *Nematoxyys Commutatus* (Diesing, 1851) V. Linstow, 1889.
   in *Rana esculenta, R. temperaria, Bufo viridis, Bufo bufo, Salamandra atra*. Brazil, Europe.
   Tail conical. 14 pairs of plectanes in two rows.

5. *C. japonica*. Yamaguti, 1938 in *Rana nigromaculata, R. rugulosa, R. japonica, Bufo melanostictus*. Japan, Formosa. 5 pairs of plectanes each with a semi-circular crown of 6 tubercles; single spicule with two segments. Excretory pore bulbar or slightly post-bulbar.


8. **C. longicauda** (V. Linstow, 1885) Railliet et Henry, 1916  
**Synonyms**: *Nematoxyx longicampa*.  
V. Linstow, 1885; in *Triturus alpestris, T. Cristatus, T. vulgaris*. Europe.  

5 pairs of plectanes in two rows each with an incomplete ring of tubercles. Reduced spicules.

10. **C. ornata** (Dujardin, 1845) Railliet and Henry, 1916  
**Syn.** *Nematoxyx ornata* Dujardin, 1845 nec Haeckel, 1856 nec Diezing 1861  
*in Rana esculenta, R. temporaria, Bufo bufo, B. viridis*. Europe.  
2-4 rows of plectanes with 5-8 pairs in each rows, 2 pairs of post-cloacal additional small plectanes. Body papillae in longitudinal series.

11. **C. parva** Travassos, 1925 in *Blesia nasus*. Brazil.  
5 pairs of plectanes in two rows and terminate relatively more anterior to cloacal opening. 2 series of body papillae.

12. **C. pulcherrima** Ivaniski, 1940 in *Bufo viridis*. U.S.S.R.  
8 pairs of plectanes in two rows. Spicules probably reduced.

13. **C. timefojevi** Skarbilovich, 1950 in *Rana* and *Bufo* species. U.S.S.R.  
8-10 pairs of plectanes in two rows, well developed spicules and gubernaculum.

7 pairs of plectanes in two rows, one small additional plectane post-cloacal. Lateral alae absent.


17. **C. freitasi** Jorge da Silva, 1954 in *Hyla fuscevaria;* Brazil. Description not available.
MATERIAL AND METHODS

The toads for the collection of *Cosmocerca kashmiensis* were brought to the laboratory from time to time from different areas around Srinagar like Nishat, Hazwan, Bemina, Ganderbal and the University Campus where naturally-infected toads are found in large numbers. It was interesting to note that in my collection the toads from the same area showed gradual increase in the infection. Starting from May, peak infection was recorded in August and September. The infection showed a gradual decrease after September.

<table>
<thead>
<tr>
<th>Date</th>
<th>No. of hosts examined</th>
<th>No. of hosts infected</th>
<th>Total No. of worms obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-5-1966</td>
<td>10</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>7-6-1966</td>
<td>10</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>4-7-1966</td>
<td>10</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>11-8-1966</td>
<td>10</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>2-9-1966</td>
<td>10</td>
<td>16</td>
<td>35</td>
</tr>
<tr>
<td>7-10-1966</td>
<td>5</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>4-11-1966</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
The hosts were brought alive and dissected in the laboratory for collection of parasites. The intestines were removed and split longitudinally before placing them in a dish containing water. The sediment was cleared by water and parasite collected. The usual site of the parasite was found to be rectum and rarely the distal part of ileum. The worms were cleared for examination in Lactophenol and glycerine. 70% alcohol and small amount of glycerine was used as medium for preservation. When sufficiently cleared in Lactophenol a few drops of 70% alcohol was added around coverslip to bring out the details of small papillae and plectanes. Glycerine was also used for clearing the worms. Worms preserved in glycerine alcohol could be as such conveniently examined without clearing them any more in glycerine. For permanent mounts worms cleared in glycerine were mounted in glycerine jelly. For microtomy the worms previously fixed were thoroughly washed and passed through usual reagents for dehydration and finally to xylene and wax. Ciderwood oil was also used for clearing and oil removed by chloroform or acetone. The wax embedding was allowed for twenty-four hours. 5-7 μ thick serial sections were cut and Mallory's triple stain used.
EXTERNAL CHARACTERS

The worms are slender, of medium size and circular in cross-section. The females are larger and thicker. The posterior end of two sexes differs in shape and external features. The male caudal end is provided with papillae and plectanes, which are lacking in females. The alae are present, being narrow and lateral in position. They extend from anterior third of oesophagus to the region of plectanes in males but in females they extend beyond the anus terminating a short distance in front of caudal tip. Cuticular transverse striations are not well marked. 24-26 body papillae are arranged on dorsal and ventral aspect of male body. (Fig 1-4A)

The mouth is surrounded by three small lips which in turn bear six papillae - 2 of which are amphids. At the base of lips near the oesophagus are three small red-shaped chitinized elements. No leaf-crown, teeth or plates are present here. Pharynx is not fully differentiated from anterior end of oesophagus. The oesophagus is a cylindrical muscular organ and has the tri-radiate lumen. The posterior end is swollen into sub-globular and a valvulated bulb. No oesophageal glands are seen.

The excretory pore is anterior to bulb and is surrounded on one side by a semi-circle of small rod-like refractile structures. Cervical papillae are not seen.
The nerve-ring is about the middle of oesophagus.

Male tail is strongly curved ventrally and is characterised by the presence of plectanes of which there are 19 in two irregular rows, located ventrally in front of cloaca. Simple male caudal papillae are also present. Details of the structure and arrangement of plectanes and variations in their number and those of simple papillae are given in the section dealing with the reproductive system. (Fig 5-5c)

The female tail in a fixed specimen is straight and gradually pointed. The vulva is in front of middle of body. The female system is prodelphic. The eggs are embryonated only in gravid females (Fig. 1,2).
## TABLE - II

**BODY MEASUREMENTS** (Twenty-five selected specimens) (in mm)

### FEMALE

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body length</td>
<td>5.0 - 7.2</td>
</tr>
<tr>
<td>Width</td>
<td>0.34 - 0.56</td>
</tr>
<tr>
<td>Pharynx length</td>
<td>0.03</td>
</tr>
<tr>
<td>Length of Oesophagus including bulb</td>
<td>0.58 - 0.67</td>
</tr>
<tr>
<td>Oesophageal bulb size</td>
<td>0.14 - 0.17 x 0.12-0.15</td>
</tr>
<tr>
<td>Head - Excretory pore distance</td>
<td>0.30 - 0.44</td>
</tr>
<tr>
<td>Head - Vulva-distance</td>
<td>2.5 - 3.5</td>
</tr>
<tr>
<td>Head - Nerve-ring distance</td>
<td>0.15 - 0.23</td>
</tr>
<tr>
<td>Tail length</td>
<td>0.6 - 0.11</td>
</tr>
<tr>
<td>Eggs</td>
<td>0.06 - 0.11 x 0.005 - 0.068</td>
</tr>
</tbody>
</table>

### MALE

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body length</td>
<td>4 - 5.2</td>
</tr>
<tr>
<td>Width</td>
<td>0.40 - 0.50</td>
</tr>
<tr>
<td>Pharynx length</td>
<td>0.020 - 0.030</td>
</tr>
<tr>
<td>Length of Oesophagus including bulb</td>
<td>0.44 - 0.57</td>
</tr>
<tr>
<td>Oesophageal bulb size</td>
<td>0.10-0.14 x 0.09-0.12</td>
</tr>
<tr>
<td>Head - Nerve-ring distance</td>
<td>0.14 - 0.21</td>
</tr>
<tr>
<td>Head - Excretory pore distance</td>
<td>0.22 - 0.38</td>
</tr>
<tr>
<td>Tail length</td>
<td>0.30 - 0.50</td>
</tr>
<tr>
<td>Spicule-length</td>
<td>0.24 - 0.29</td>
</tr>
<tr>
<td>Gubernaculum-length</td>
<td>0.17 - 0.22</td>
</tr>
<tr>
<td>Lateral alae width</td>
<td>0.019 - 0.021</td>
</tr>
<tr>
<td>Plectane</td>
<td>0.075</td>
</tr>
</tbody>
</table>
The body-wall of *Cosmocerca Kashmirensis* is composed of three main layers, cuticle, sub-cuticle (hypodermis) and the muscle layer. All these three layers are so closely bound together that they give the appearance of a single layer.

**Cuticle.**

The cuticle is the external non-cellular layer of the body-wall. It is laterally thickened and extended in the form of lateral alae which commence at a short distance behind anterior end and terminate near the caudal region of the body. Besides lateral alae and body-wall papillae the next external cuticular specializations in *Cosmocerca Kashmirensis* is in the form of rosette-like plectanes in kinder region of male worm. Each plectane, described in detail later, under reproductive systems, has a central genital papilla which is surrounded by two concentric rows of cuticular tubercles and below provided with characteristic sub-cuticular thickenings.

The cuticle in all nematodes has a complicated histological structure and that of *Cosmocerca Kashmirensis* is no exception. The worm being small the various cuticular layers are accordingly extremely narrow and their differentiation made with some difficulty. As many as eight layers were counted under high-power oil-immersion. These are:-(Fig. 7).
1. External Cortical Layer.
2. Internal Cortical Layer.
3. Fibrillar Layer.
5. External Fibre Layer.
6. Middle Fibre Layer.
7. Internal Fibre Layer.

These layers can be condensed to three basic regions the Cortex, Matrix and Fibre layers. The cuticle is thickest in the caudal region and its various layers were accordingly examined in this region. The total thickness of the cuticle varies from 5 - 10 μ.

CORTICAL LAYERS.

The external Cortical Layer is not differentiated into outer dense and inner less dense layer in the present worn. There is, however, slight differentiation between the external and internal Cortical Layers. The external layer is composed of dense material seen more or less in the form of bands, the internal layer is less dense and more or less spongy.

FIBRILLAR LAYER.

It is a narrow layer and composed of an indistinct network of reticulate fibrillae. These fibres are not seen extended to the Cortical and Matrix layers.

MATRIX LAYER (Homogenous Layer).

It has a distinct spongy mass and is relatively better developed than other layers (Approx. 2.5 μ thick).
FIBRE LAYERS.

Three indistinct and narrow layers can be identified in this region. These are composed of Connective tissue with minute fibres in different directions. Total thickness of fibre layer is more or less equal to that of Matrix layer.

BASAL LAMELLA OR BASAL MEMBRANE.

It is a thin layer hardly .5 \( \mu \) thick which forms an internal binding of the cuticle.

Among Oxyurids Martini (1912, 1916) was first to study the cuticle of *Oxyuris equi*. According to him the cortical layers in the worm are followed by Fibrillar layer and two layers of fibre-layers which are embedded in Matrix layer. In all nematodes the Cuticle wherever studied by different workers has shown a many layered structure. Variations have, however, been recorded in the number and arrangement of various layers. It was Siebold (1952) who first found a many-layered Cuticle in case of *Ascaris Lumbricoides* Bommel 1894, 1895) and Goldschmidt (1905) made further studies on the Cuticle of *Ascaris*. *Ascaris Lumbricoides* is known to have nine distinct layers in its cuticle, there being an additional boundary layer immediately beneath Matrix layer and interpreted as a condensation layer.

The Fibrillar layer and its ramifications extended to the external cortical layer and Matrix layer was regarded by Toldt (1899-1912) to be a system of 'Feeding Channels'.

This view was, however, not agreed to by Goldschmidt (1905) and subsequent workers who considered this layer as a supporting one. This was confirmed in view of the fact that Peptic-hydrochloric acid-digestion tests resulted in the dissolution of only Matrix and Fibre layers. The Fibrillae (feeding channels of Toldt) continued to remain there attached to the Cortical layer.

The Cuticle of other nematodes have the same fundamental structure and vary but slightly in their number of fibre-layers and thickness and arrangement of various layers. Chitwoods' (1937) gave a review of the work done on the nematode-cuticle and referred briefly to the observations of the workers on various nematodes. Recently in India Ansari and Basir (1964), in their monograph on Setaria Cervi recorded eight layers in its cuticle as is the case in the present worm. The matrix and the fibre layers are more or less equal in thickness and form the major part of the cuticle in the present worm.

Nature of Cuticle.

According to Chitwood and Chitwood (1937) the cuticle towards the beginning is a part of living cells and various layers are formed as a result of protoplasmic condensations in the external part of hypodermis (Sub-cuticula). They do not agree with the views of Müller (1936) who regarded cuticle as a secretion. In view of the Complex chemical and histological structure of the nematode cuticle Chitwoods' views have gained approval from all other workers.
Earlier there was a considerable controversy over the chemical nature of nematode cuticle. Lassaigne (1843) regarded *Ascaris* cuticle to be of the nature of Chitin. Flury (1912) found it to be of a substance simpler to Keratin, but Magath (1919) regarded it to be made of Cornein. Mueller (1929) working on *Ascaris*, concluded that its cuticle was formed of two substances which according to him could not be identified with any known chemical compound.

Sukataaschoff (1899) on the basis of peptic digestion tests showed that cortical layer was different from Matrix and the Fibre-layers were resistant to the peptic digestion. These results were confirmed by Reichard (1902) and later (1929) found that matrix and fibre-layers were more soluble in standard solvents than were the cortical layers. It was Chitwood (1936) who first gave a detailed account of the chemical composition of nematode cuticle on the basis of his work in *Ascaris lumbricoidea*. He identified at least five distinct substances, namely, Albumin (water soluble protein), Gluco protein, Fibroid (matricin), Collagen and keratin. Of these matrix was formed of matricin, fibre-layers of collagen and external cortical layer of Keratin.

Johnson (1968), on the basis of his Bromphenol Blue (HgBPB) test for protein and periodic Acid Schiff Reagent (PAS) test for Carbohydrates, found that external cortical and matrix are weakly positive for protein and negative for Carbohydrates, internal cortical layer moderately positive for protein and Carbohydrates and
fibrillar layer weakly positive or negative for protein in different regions and weakly positive for Carbohydrates.

**SUB CUTICULA.**

The Sub-Cuticula, also referred to as hypodermis, follows immediately after the cuticle. It is a thin syncytial layer containing a granular substance. It protrudes into the pseudocoel in the form of four longitudinal bands or chords. These are named according to their positions: mid-dorsal, mid-ventral and two laterals (Fig. 8). Chitwood (1937) describes the hypodermis as a delicate protoplasmic tube which is externally covered by cuticle and internally thickened in the form of four longitudinal chords. The regions between the chords are known as interchordal areas. The lateral chords are fairly conspicuous and can be even seen externally as faint lines in living worms when examined under binocular microscope. The sub-cuticula is more or less absent in anterior and posterior ends where the musculature appears to be in direct contact with the cuticle. Additional chords like two sub-dorsals and two sub-ventrals, which are commonly found in free living nematodes, have been recorded in some parasitic nematodes as in *Setaria Cervi* by Ansari and Basir (1964). No such sub-median chords are present in *Cosmocerca Kashmirensis*. The nuclei are not seen in the interchordal areas but are confined to the Chords only. (Fig. 8 and 12). Chitwood (1937) describes the typical arrangement of nuclei in chords in simplest nematodes in these words; "In anterior body region dorsal and lateral chords contain one row of
nuclei while Ventral Chord contains two rows of nuclei. In the remaining body region except tail the dorsal chord is without nuclei, the lateral Chord contains three rows of nuclei while the ventral chord contains two rows of nuclei*. Variations to this have been, however, recorded both in number of nuclei and their arrangement of rows in free-living and parasitic forms. In Cosmocerca Kashmirensis the nuclei are roughly arranged in two rows in lateral chords in the Oesophageal region. In addition to well-developed nuclei, there are also some scattered groups of very small and indistinct nuclei. Their presence indicates the possible increase in the number of nuclei in adult stage due to the nuclear divisions. The nuclei seen in ventral and dorsal chords are not only fewer in number but their arrangement is also not very clear nor constant as seen in various sections. Apathy (1893-, 1894) recorded in the interchordal areas of Ascaris minute fibrillae forming a network and their fibrils found to be continuous with the adjacent muscle-cells. Apathy considered these fibrillae to be motor-processes connecting the muscles. Gold Schmidt (1906) showed that the said fibrillae had only a supporting function and passed not only into the chords but also radially into the Cuticle. Martini (1916) recorded longitudinal, Circular and radial fibrillae in the Chordal region of Oxyuris. In the present worm no such fibrils could be seen.

The lateral chords commence near the anterior
end at the level of the beginning of Oesophagus in the form of two low ridges. Soon they increase in their height and extend posteriorly in the form of well-developed ridges (Figs. 8-12).

The two lateral chords divide the pseudocoel into dorsal and ventral halves. In the region of Oesophagus the two chords are very well developed and meet each other at the level of nerve-ring, thus encircling it and also giving an extra-support to the Oesophagus. The two chords bend more or less ventrally to join the Ventral Chord in the region of excretory pore and thus enclose the excretory apparatus. This is also true in the region of vulva in females where the vagina is partly supported by their extension. The lateral chords in the remaining region are relatively low, being conspicuously so in the caudal region where they are very much flattened and spread out. As seen in transverse sections each chord has three narrow canals which do not have their own walls, but appear as elongated cavities running through the granular substance of the two chords. Of the three canals one is in the centre, thus dividing the tissue of partition wall into dorsal and ventral half. The granular mass of each chord is formed of loose vacuolated and spongy tissue, but at the base and in the interchordal areas where the sub-cuticula is closely applied to the inner margin of cuticula, it is formed of dense granular structure. As already stated the nuclei are restricted only in the region of chords. These are arranged roughly in two rows, one on either side of the partition wall. Some scattered nuclear groups are also
present, but they are scanty and not well marked. No cell-walls are seen, nor is there any definite cytoplasm around the nuclei. Each lateral chord encloses a lateral longitudinal nerve (Fig. 12).

The ventral chord arises shortly behind the level of lateral chords. It continues up to the end of Caudal region. It is slightly modified in the region of nerve-ring, excretory pore and Vulva. Both excretory pore and vulva open through this chord. In the region of rectum it is pushed to one side to allow the anus to open. Histological study of the chord reveals the presence of a few nuclei as seen in transverse section. The arrangement of nuclei is also not clear. It encloses Ventral Longitudinal nerve.

The dorsal chord is smaller than the other chords. It commences shortly behind the level the beginning of lateral chords. Being low and inconspicuous its presence is hardly noticed in all sections. It does not protrude inwards beyond the height of muscle-cells. Like Ventral, it encloses dorsal longitudinal nerve. At the level of nerve-ring it extends to join the two lateral chords (Fig. 24). The arrangement of nuclei is also not clear as in ventral chord. While a few nuclei are seen in anterior region of the chord no such nuclei are seen in the remaining body-region.

The origin of Sub-Cuticula is as doubtful as that of cuticle. Various views have been put forth
regarding the origin of sub-cuticula. It is generally called a hypodermis because of the presence of an Outer Cuticle and the conspicuous absence of any true cellular epithelium in direct relation with the exterior. Stewart (1906) preferred to call it epidermis. Hamann (1892) regarded it to be ectodermal but Strassen (1904) believed it to be Mesodermal in origin. Detailed study of various stages of development is found necessary to determine the exact origin of Sub-Cuticula. Till then it may be convenient to retain the terms Sub-Cuticula.

Kemnitz (1912) and Martini (1916) on the basis of their work on Ascaris and Oxyuris respectively found that the Sub-Cuticula was the chief storage place of Glycogen and fats. Kemnitz found fat-droplets and glycogen in abundance in the interchordal and chordal areas of the Sub-cuticula of Ascaris.

Sylvester Johnson (1968) studied Toxascaris Lestonina (Linstow, 1902) Railliet and Henry, 1911 and on the basis of Bromphenol Blue (HgBPB) test for proteins and Periodic Acid Schiff Reagent (PAS) test for carbohydrates recorded that the Sub-cuticula contains most of the Carbohydrates as compared to other parts of the body-wall. Both chordal and inter-chordal region were found to be very rich in Carbohydrates. As regards proteins chordal regions gave positive results.
SOMATIC MUSCULATURE.
(BODY WALL MUSCULATURE).

The musculature of Cosmocerca Kashmirensis includes the muscles of body-wall (somatic musculature) and specialized muscles of various organs (Visceral musculature). The following description pertains to the somatic musculature which forms the third layer of body-wall. The visceral muscles are dealt with separately with various systems of the Worm.

BODY WALL MUSCLE LAYER.

Immediately beneath and closely adhered to the Sub-Cuticula (hypadermis) is a single layer of muscle-cells. These are arranged in four distinct groups or sectors due to the presence of four sub-cuticular chords which extend inwards and intercept the muscle-layer at mid-dorsal, mid-ventral and two lateral regions of the worm (Figs. 9-11). According to their positions the four muscle-groups, as clearly seen in T.S. of the Worm, are two sub-dorsal and two sub-ventral sectors.

The muscle-cells in each sector are shallow and do not have conspicuous fibrillar portions. The cells project inwards rather inconspicuously as blunt knobs when seen in transverse sections of the Oesophageal and intestinal regions. Their number in each sector varies from 6-12 which is more than the typical number of 2-4 in meromyarian forms (Fig. 9-11). With this increased number approaching the Polymyarian forms,
the cells still continue to be platymyarian in being shallow and more or less flat and their fibrillar portions not extending up the sides of cells into the Pseudocoel. However, in a limited part of the intestinal region the muscle-cells show that their fibrillar part extends partly up the sides and bear a groove to enclose the Sarco-plasmic part of the cell. Such cells are, therefore, shallow Coelomyarian and not typically coelomyarian in this region (Fig. 11 a and 13 a).

Each muscle-cell in the Oesophageal region and major part of intestinal region is shallow and has its fibrillar portion mostly restricted towards the sub-cuticular region and this represents a typical platymyarian forms. The fibrillar portion bears alternating bands of what are known to be formed of Contractile and non-contractile substance. Supporting fibrils are present in the non-contractile bands. The sarcoplasmic part bears the nucleus and an indistinct network of supporting fibrils. The processes connecting the sarcoplasmic part of muscle-cell with nerve fibres could not be detected in the present study. In the said shallow Coelomyarian type of muscle-cells seen in a limited part of the intestinal region, the sarcoplasmic part of each cell is only slightly bulged inwards and the fibrillar part is extended up its sides only partly. The cells, however, continue to be shallow and are thus
at a transitional stage. These cells are neither fully Coelomyarian nor typically platymyarian.

**NEMATODE MUSCULATURE.**

It was Schneider (1860 and 1866) who first initiated the studies on the nematode musculature and coined some useful descriptive terms on the basis of the number, structure and arrangement of muscle-cells. Common terms still in use after Schneider are: Holomyarian: Continuous muscle-layer divided into two main zones by two lateral Chords; Platymyarian: muscle-cells short and flat having their fibrillar portion limited to basal part parallel to Sub-cuticula and not protruding into pseudocoel; Coelomyarian: muscle-cells with their sarcoplasmic part well protruded into pseudocoel and their fibrillar part extending up to their sides and having a groove with sarcoplasmic part in between; Meromyarian: number of muscle-cells few typically 2 - 4 or 5, and Polymyarian: muscle-cells numerous in each sector.

According to Schneider, the number and shape of muscle-cells is of taxonomic importance in classifying the nematodes. Meromyarian forms were mostly found to be platymyarian, and polymyarian forms to be Coelomyarian. Subsequently it was found that this could not be the basis of separating nematodes into distinct groups in view of many transitional forms which were recorded.
in closely-related platymyarian and Coelomyarian forms. Martini (1903, 1906 and 1909) showed that Polymyarian Nematodes were meromyarian and platymyarian in their first larval stage. It was pointed out by Martini that polymyarity and Coelomyarity were the result of later development. In view of these observations it was thought that platymyarian and meromyarian nematodes were of primitive type. This view does not hold true universally because both platymyarian and Coelomyarian forms are known in closely related nematode species and groups. Chitwood and Chitwood (1937) in their review of nematode musculature have mentioned such forms which confirms this fact. For example, any two closely-related trichostrongylids, Ostertagia and Haemonchus, the former is typically platymyarian and meromyarian but the latter has both four sub-lateral large platymyarian and 40 - 48 sub-median small Coelomyarian muscle-cells as seen in T.S. at middle region of body. Such diversities have been recorded not only among closely-related forms but in different regions of the body of the same nematode. This is clear from the musculature of present species of Cosmocerca Kashmiriensis also. Chitwood and Chitwood (1934) have, however, shown that in Rhabditina group has only platymyarian and meromyarian type of nematodes. Similarly spirurina and Dictyophymatina include only polymyarian forms.
as stated by Chitwood and Chitwood (1937).

While form and number of muscle-cells have no bearing on the relationship of various nematode, Chitwood and Chitwood (1937) indicate that these are not entirely without any evolutionary significance. According to them evolution from meromyarian and platymyarian musculature has taken place in most of larger groups and that meromyarity is indicative of the degree of primitivity.

Cosmocercidae is known to include meromyarian forms, but present studies on the musculature of Cosmocerca Kashmirensis shows that the number of muscle-cells in each sector is 6 - 12. The typical number of meromyarian forms, as already stated, is only 2 - 4 or 5 large cells in each sector. Moreover the muscle-cells in the present form are platymyarian in Oesophageal and most of the intestinal region and shallow Coelomyarian in a limited part of intestinal region.

In Oxyuris, a related form of Cosmocercids, Martini (1916) recorded only 2 - 5 muscle-cells in each sector. The muscle-cells here are of platymyarian and meromyarian type.

Keeping in view the said facts it may be safely concluded that the number and form of muscle cells has neither any bearing on the relationship of various nematode groups nor any evolutionary significance.
It may also be found necessary to modify the terms used for the description of nematode-musculature.

**PSEUDOCOEL.**

Like all other nematodes the body-cavity of *Cosmocerca Kashmirensis* is a pseudocoelome. There is a membrane-like tissue of varying thickness in the form of a network of nucleated strands which surrounds the Viscera and separates them from the pseudocoel. The muscle-layer of body wall also has a delicate lining of the same tissue. Goldschmidt (1906) named it "Isolation Tissue". Chitwood and Chitwood (1937) name it as pseudocoelomic membranes. Several mesenteries of similar connective-tissue strands arise from the Oesophagus and extend to muscle-layer in the present worm. In the region anterior of Oesophageal bulb the pseudocoel is more or less completely filled with connective tissue (Fig. 15b–192f).

In the Oesophageal region is also present a large but diffused nucleated pseudocoel-cell. It is located more or less dorsal to bulb and embedded in the fibrous network surrounding the Oesophagus. The pseudocoel-cell has been recorded in many parasitic nematodes. Chitwood and Chitwood (1937) find it practically universal in Phasmidia and in free-living order Chromadoroidea of Aphasmidia. It was described in detail by Gold Schmidt (1906) in *Ascaris*
Lumbricoides, by Martini (1916) and Chitwood and Chitwood (1933) in Oxyarid worms, Oxyuris equi and Cephalobellus Papiliger respectively. It is from the dorsal pseudocoel cell in Oesophageal region that the "Isolation Tissue" or the nucleated strands of pseudocoelomic membranes are said to extend anteriorly and posteriorly in the pseudocoel.

The pseudocoel is filled with pseudocoelomic fluid. As clear from sections of fixed specimens the fluid is seen in the form of a coagulated masses of granules and globules which stains deeply with haematoxylin. The granular mass also shows cavities of different sizes in them. No cells or nuclei are present in the fluid. Although free wandering or migratory cells are not present in the pseudocoel of a nematode, a fixed number of two, four or six large cells called pseudocoelomocytes have been recorded in several parasitic nematodes. These cells have a fixed position and are usually found in relation to the longitudinal chords in the pseudocoel. Four such cells have been recorded in Ascaris and Oxyuris and similar cells have been seen in the present worms. These cells are usually stellate and bear numerous terminal bodies. Their function is still doubtful. Chitwood's (1937) state that these cells may be purifying the body-fluid in some manner. According to Chitwood's (1937) their function as phagocytes was ruled out because injected particles of india ink or
bacteria (Escherichia Coli) were found simply to adhere to the terminal organs of stellate coelomocytes but never actually phagocytized. Hurlauz (1947) finds these cells to have an Oxidative function.

DIGESTIVE SYSTEM.

The mouth is terminal and bordered by three moderately developed lips— one dorsal and two sub-ventral. In all there are found Cephalic papillae of which two are dorso-lateral and small and two are Ventro-lateral and large— as seen in an enface view.

The mouth leads into a short vestibule or buccal capsule. It is lined by cuticle and has a reduced tri-radiate lumen with three sclerotized tri-radiate rod-like structures supporting its base. It is feebly surrounded by the Oesophageal tissue and bears poorly-developed muscle fibres. This region of digestive tract between the mouth opening and the anterior end of true Oesophagus is often named as stoma. It measures 0.01 mm in length in the present worm (Fig 14b).

The Oesophagus is one of the most conspicuous part of the digestive tract. It is basically rhabditoid and is divisible into a long cylindrical corpus; short narrow Isthmus and a well-developed valued bulb. The region of the corpus immediately in front of Isthmus is slightly wider than the remaining anterior region of the corpus anteriorly. This part of corpus represents
the primitive enlarged metacorpus of some nematodes like *Rhabditis*. Histologically this region is, however, found to be similar to anterior part of Corpus in the present worm.

The lumen of Oesophagus is *Cosmocerca Kashmirensis* is tri-radiate as is characteristic of other nematodes. It has a cuticular lining but there are no special thickenings to mark the attachment points of radial muscles. In a transverse section the Oesophagus shows three sectors— one dorsal and two sub-ventrals which correspond to the position of three Cephalic lips, and alternate with the three rays of the said triradiate lumen. In corpus each ray of the lumen ends in a small marginal tube. No such marginal tubes are seen in the bulb (Fig. 15-16).

The Oesophagus has a syncytial epithelium. The muscle-fibres in the Oesophagus are mainly the radial fibres which do not show any special arrangement. The fibres are evenly spread out from the rays of lumen to the exterior without any concentration into groups or bundles nor any significant attachment points towards the sides of the lumen. There are also short marginal fibres connected with the ends of rays of lumen. The three Oesophageal glands— One dorsal and two ventrolateral are uninnucleated. The dorsal one apparently opens near the basal part of buccal capsule and the two sub-ventral glands open near the end of corpus. The glands are much branched and their presence and
branching is evident in the sections at different levels of the Oesophagus.

In the corpus there are in all six marginal nuclei in one group and twelve radial nuclei in two groups of six each. In the bulb the number of marginal nuclei is six and that of radial nuclei twelve both arranged in two groups. Three larger gland nuclei are also seen in this region. The nerve-cell nuclei are present but they are small and indistinct. Their number and arrangement could not be determined accurately (Fig. 16-16C).

Somato- Oesophageal muscles are specialized muscles associated with the Oesophagus. These muscles arise near the nerve-ring and extend from the Oesophagus to the muscle-layer. In all these are found sub-median muscles (Fig. 14 A).

MEASUREMENTS (in m.m.)

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<th>CORPUS (LENGTH)</th>
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<tr>
<td>0.41</td>
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<td>0.44</td>
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<td>0.46</td>
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At the junction of Oesophageal bulb and intestine is the Oesophago-intestinal valve. In the basal region of the bulb the lumen is specially thickened and sclerotized. It shows several rays and is followed by the valve. The valve is lodged in the lumen. The muscle fibres remain attached to the lumen. Two to three nuclei are seen in the valve. The valve is a continuation of Oesophagus and is regarded as a modified part of the Oesophagus (Fig. 17).

The intestine, also called the mesenteron, commences as a broad tube. It soon narrows down to accommodate itself to the reproductive organs during its posterior course. The intestinal wall consists of a single layer of epithelial cells. The inner surface of which facing the lumen is differentiated into a bacillary layer. The bacillary layer is followed by sub-bacillary layer beyond which each cell shows differentiation into protoplasmic zone bearing the nucleus. The intestine of the present worm according to the number of intestinal cells and the shape of lumen can be said to be polycytous and isocytous. Chitwood (1937) introduced such descriptive terms as polycytous for nematodes having a limited number of intestinal cells not exceeding 20 - 25 in a section; myriocyctous having hundred or more cells in a section; isocytous. When lumen is smooth, not raised into projections or plical; anisocytous when lumen is raised into projections or plicae. In the present worm the 'polycytous' and 'isocytous' condition can be said to be there all through the intestine except in posterior narrower region where the lumen shows slight projections bringing it nearer to anisocytous (Fig. 8b, 19).

As already stated the intestinal wall is formed of a single layer of epithelial cells. Various layers seen in the intestinal wall are actually due to the differentiation of various zones in each epithelial cell (Fig. 20). BACILLARY AND SUB BACILLARY LAYERS. The internal border
of epithelial-cells bear cilia-like structures, and
form the bacillary layer. The 'Bacilli' appear to be
fused thus giving the impression of a compact layer.
Beneath this layer is the sub-bacillary layer which
has fine granules and stains deeply.

**PROTOPLASMIC ZONE.**

Beneath sub-bacillary layer is the
protoplasmic zone of epithelial cells which is further
differentiated into inner ectoplasm of dense cytoplasm
and the remaining endoplasm. In the latter is the nucleus
and some indistinct strands (plasma strings) and
Vacuoles.

**BASAL LAMELLA.** is a thin homogenous layer in direct
contact with the external surface of epithelial cells,
actually as an external sheath of the intestine.

**INTESTINE-RECTAL VALUE.**

The end of intestine is marked by the
presence of intestine-rectal value. In this region the
epithelial cells are much smaller and devoid of bacillary
zone. The lumen is narrow in this region and the value
is formed as a projection into the rectal lumen. The
Sphincter muscles control the Valve. Being a continuation
of the intestine the value is endodermal.

The Somato-intestinal muscles are seen
in the region of intestino-rectal value in the form of
two bands arising from the muscle layer of body-wall
in the sub-ventral sectors. The two muscle bands, each
having a nucleus extend across the pseudocoel to the
Ventral surface of the intestine (Fig. 18).

**RECTUM.**

Its lumen is lined with Cuticle. The epithelial
cells beneath cuticle are large and without bacillary zone.
Distally the lumen is very much reduced. It opens outside
ventrally at the anus. In the region following the
intestino-rectal value the lumen of rectum is irregular.
The cuticle lining of the rectum and continuous with that
of body-wall. At the anus the cuticle is, however, thicker.
Three rectal glands are present near the junction of
intestine and rectum (Fig. 21 A).

**DEPRESSOR ANI.**

It is actually one muscle which extends from
the body-wall of the Candal region to the dorsal wall
of posterior region of rectum. It is meant to elevate
the dorsal wall of rectum. Another muscle _dilatator ani_
has been described in _Setaria Cervi_ which is said to be
ventral in position. It could not be seen in the present
worm.

In male worms the male duct enters rectum
on Ventral side, immediately behind the level of
intestino-rectal value. The rectum is, therefore, known
as Cloaca in males.
The excretory system of nematodes has been a subject of controversial views because of its varied structure in different nematodes. It was Bajanus (1817) who first discovered a pair of lateral canals in the lateral chords of Parascaris Equorum. These are now known as the lateral excretory canals, but Bojanus (1817) and Cloquet (1824) regarded them as circulatory blood-vessels. Blanchard (1847) injected Ascaris Lumbricoides and found a large ovoid body in the left lateral chord which he thought to be the heart and lateral canals as two blood-vessels.

Mehlis (1831) recorded an opening of a gland near the anterior end of Contracaecum Spiculigerum which he regarded as a salivary gland.

It was Schneider (1858-1866) whose contribution was the beginning of a better understanding of the system. He observed that the Ovoid body recovered by Blanchard was actually a large nucleus in the wall of a lateral canal. He also found that the lateral canals opened to the exterior through a ventral pore, now known as the excretory pore. He concluded that this system was associated with the excretion of waste-products.

Nassanov (1897) injected a dye into the body cavity of nematodes and recorded the concentration of the dye in lateral chords and intestines and assigned
both these structures the function of excretion in addition to the normal digestive function of the latter. Giovin (1902) observed the movement of the injected stain in lateral canals and out through the excretory pore. Goldschmidt (1906) gave a detailed account of the system in *Ascaris*. He recorded a strand of tissue around lateral excretory canals in each chord which he referred to as Kidney. The granules recorded by him in the tissue were regarded by him as the excretory products. Chitwood (1933) found small traces of Urea in the fluid coming out of excretory pore of *Ascaris*.

As already stated the excretory system has a highly variable structure in nematodes. Different types or systems have been recognized. One of the common types is the H-shaped system or Oxyuroid type, in which the two lateral excretory canals of the two lateral chords are extended anteriorly and connected ventrally with the excretory sinus by two transverse ducts. The sinus is connected with the excretory pore by a cuticle-lined terminal excretory duct or vesicle. The two lateral canals are extended anteriorly as two anterior canals, thus giving the system an H-shape. Variations to this system have also been recorded, mainly in the length of terminal excretory duct.
This system is generally met with in oxyuroids and Spiruroids. Another type is the Rhabditoid type which is more or less similar to the first type in being \(H\)-shaped, but the sinus has two sub-ventral excretory glands. This system is seen in Rhabditids and Strongylids.

**ASCARIDID TYPE.** is yet another system which forms an inverted \(\mathcal{U}\)-shaped system. It is a modified type of the above system in which the two anterior canals are absent. This is common in Ascarids, Filariods, some Spiruroids and some free-living forms.

**ASYMMETRIC TYPE.** of excretory system, as seen in some free-living nematodes like Aniskiinae and Tylenchoidea, is a modification of the above inverted-\(U\)-system in which there is only one lateral excretory canal.

Yet another type of excretory system in nematodes is recorded in some free-living forms like Chromadorina and Enoploidea in which the system is represented by a single ventral, excretory gland-cell. It is usually elongated and connected directly with the excretory pore without any cuticle-lined duct or reservoir. An ampulla is, however, present near the pore.

In *Cosmocerca Kashmirensis* the excretory system is of a simple \(H\)-system of the Oxyuroid type.
The two lateral canals lie within the two lateral chords near the inner margin. Their wall is two-layered, formed of an outer granular and inner membranous layer. No nuclei are seen in the wall. (Fig. 12)

The two excretory canals meet the excretory sinus rather directly, there being practically no transverse ducts. The sinus is located in the excretory bridge which is formed by the union of lateral and ventral chords at the level of excretory pore. The sinus has a large nucleus on one side. The two lateral chords near their union with the excretory sinus are extended anteriorly for a short distance as two anterior canals thus forming a typical H₂-system of the Oxyuroid type.

The excretory pore is located in front of the Oesophageal bulb on the ventral side. The terminal excretory duct connecting the excretory pore with the excretory sinus is reduced here in the form of a rounded vesicle, which is lined with a thin layer of cuticle. The two nuclei of the terminal excretory ducts are not seen. A circular Sphincter muscle near the junction of sinus and the terminal excretory duct or vesicle is apparently absent (Fig. 22, 23).
The sexes are separate in *Cosmocerca Kashmirensis*. The sexual dimorphism is not only limited to size, with males smaller than females, but the males are also easily distinguished from females in having a strongly-curved caudal end and provided with several pairs and solitary caudal papillae and two rows of well-developed plectanes in front of cloacal aperture.

Characters of various parts of reproductive system, like the position of vulva, number and disposition of gonads and uteri, shape of male caudal end, its papillae and other accessory structures including spicules and gubernaculum are often used for taxonomic purposes in nematodes. Rauther (1918) divided nematodes into two orders– Hologonia and Telogonia, on the basis of the proliferation of germ-cells. In the former group the proliferation extends along the whole length of gonad (ovary and testis). The germinal zone is extended along the entire length of gonad and there is only one gonad in each sex. The well-known rachis of a nematode gonad is also absent here. This group is represented only by Trichuroidea and Dictophymatoidea. Telogonia includes all other parasitic nematodes and several free-living nematode groups. Here new germ-cells originate only at the proximal end of gonad. *Cosmocerca Kashmirensis* falls under the group Telogonia.

Contd...
FEMALE REPRODUCTIVE SYSTEM.

Following the descriptive terms first introduced by Seurat (1913-1920) Cosmocerca Kashmirensis can be said to be primarily amphidelphic and didelphic, the uteri near its origin at vagina are opposed and hence amphidelphic. Didelphic term is used here because of the presence of two complete genital tubes including two ovaries and two uteri (Fig. 3b).

Various parts of the female system are: Vulva, Vagina, Uterus, Seminal receptacle, Oviduct and Ovary. The Vulva is more or less equitorial 2.4 - 3.5 m.m. from the anterior end. It is lined with cuticle and leads into Vagina. The Vagina is also lined with thin layer of cuticle. The vagina is not divisible into vagina vera and vagina uterina, there being only vagina vera which is directed anteriorly for a short distance where it directly bifurcates into two uteri. As already stated two uteri are opposed at least for some distance. The posterior uterus is wholly in posterior half of the body but the anterior uterus may be partly in anterior half of the body. Both the Ovaries are, however, in anterior half of the body.

OVARY. The two ovaries are in loose coils in anterior half of the body. In young immature worm their disposition is very clearly seen. They extend to the posterior end of intestine. The Ovary of posterior uterus is invariably posterior to other ovary (Fig. 3b).

Each ovary is a tubular structure and consists of an epithelial layer and a germinal cord. It is divisible
into proximal germinal zone and distal growth zone (Fig-25, 26). The germinal zone is shorter than the growth zone. As seen in cross sections, the rachis could not be clearly seen, the germinal cells do not show distinct cell-walls in the proximal region. Here the cells are in a state of rapid divisions. Towards the blind end of the ovary the epithelium is not clearly seen.

GROWTH ZONE. The oogonia have increased in size and appear more or less rectangular in outline. The oogonia soon become spherical and are found packed in this region. Each cell has a distinct cell-wall with a distinct nucleus in the centre. The epithelium of this zone is thicker when compared to germinal zone.

oviduct. The ovary leads insensibly into the Oviduct, there being no marked difference in the diameter. Its wall consists of a outer layer of muscle-fibres and inner layer of epithelial cells. The epithelial cells are well developed and project into the lumen of oviduct as seen into cross-sections. The muscle-fibres apparently help the eggs to move forwards. (Fig 27).

uterus. The receptaculum seminis which is said to precede the uterus is not clearly marked here. The proximal part of uterus may be acting as receptaculum seminis for fertilization of eggs. The wall of each uterus consists of an Outer contractile cells and an inner layer of low
epithelial cells. The lumen of uterus is filled with a gelatinous mass which probably helps in the movement of eggs (Fig. 28). In gravid worms the uteri are fully packed with broadly oval thin shelled eggs. In mature worms the eggs are apparently unsegmented but in semi-gravid worm the division of the egg cell is evident. In fully-gravid worms the major part of uteri are filled with embryonated eggs.

VAGINA.

The vagina which connects the two uteri to the vulva is a thick-walled muscular tube lined internally by cuticle. At the junction with vulva, the vagina is surrounded by Circular muscles which act as spherical muscles.

The vulva is bordered by the protruding cuticle on outside. It is also lined with the cuticle (Fig. 29).

MALE REPRODUCTIVE SYSTEM.

The male reproductive system consists of a single testis which is usually reflexed and continued posteriorly in the form of a tubular seminal vesicle followed by vas deferens which joins with the rectum posteriorly to form cloaca (Fig. 3 a).

Having only one testis Cosmocerca Kashmirensis is monorchic. The testis like the ovary is divisible into distal germinal and proximal growth zone. As male system was studied from whole mounts the two zones could not be studied. The seminal vesicle and vas deferens do not show
any marked difference in their diameter and it is difficult to distinguish the two. The Vas deferens, however, narrows down posteriorly into apparently muscular ejaculatory duct which enters the rectum dorsally to open into the cloaca.

The spicules, two in number, are well developed and highly chitinized and more or less equal in size. Each spicule has a characteristic bend at its middle length. Each spicule measures 0.25 - 0.29 mm in length. The gubernaculum is triangular with a broad proximal base and sharply-pointed distal end. Its margins are heavily chitinized. It measures 0.2 - 0.23 m.m. in length and 0.085 - 0.09 m.m. in width at its base (Fig. 5b).

SIMPLE PAPILLAE.

(a) POST-CLOACAL PAPILLAE.

The post-cloacal papillae are arranged in pairs dorsally and ventrally and irregularly scattered singly in the lateral region. There are in all 4 - 5 pairs of ventral and 3 - 4 pairs of dorsal papillae. A single pair of papillae is also present near the distal end of tail, several solitary papillae numbering 6 - 8 are present laterally in the post-cloacal region (Fig. 5).

(b) PRE-CLOACAL PAPILLAE.

The pre-cloacal papillae are arranged in to sub-ventral rows and commence a short distance anterior to plectanes. These papillae become gradually smaller anteriorly and become indistinct at about the beginning of last quarter of body-length (Fig. 5).
(C) BODY - PAPILLAE.

The body-papillae are well developed in anterior third of male body beyond which they become extremely small and indistinct. The papillae are arranged both dorsa-ventrally and are spread irregularly (Fig. 1, 2).

PLECTANES.

The plectanes are characteristic of the genus Cosmocerca. Each plectana has a central sensory papilla which is surrounded by cuticular tubercles. There is also a characteristic sub-cuticular thickening which is extended on either side of the plectana. The plectanes of an allied genus Cosmocercoides are similar to those of the genus Cosmocerca but do not possess any sub-cuticular thickenings. These are also commonly known as "Compound caudal papillae".

In Cosmocerca Kashmiriensis there are in all nineteen plectanes of which sixteen are arranged in two regular or irregular sub-ventral rows in front of the cloaca (Fig. 5). The remaining three plectanes are invariably smaller and located near the proximal end of two rows of said plectanes. These are simple rosettes which resemble the compound caudal papillae of the genus Cosmocercoides in having no sub-cuticular thickenings. Their position may vary from the typical position of two sub-ventral and one lateral, all the three rosettes may be close to each other in the sub-ventral region or they may be apart and arranged in a triangle. In some specimens are 7 pairs fully-developed plectanes and three rosettes are recorded. Rarely the rosettes were found to be absent (Fotedar and Tikoo-
1966). Each plectane has a central large papilla which is surrounded by two concentric rings of 15-20 cuticular tubercles. The tubercles of outer ring are larger than those of the inner ring. The sub-cuticular thickening is extended on either side of the plectane antero-posteriorly, each extended part of thickening measuring 30 -35 \( \mu \) in length and 15 \( \mu \) in width. The plectane proper is 20 -25/\( \mu \) in diameter (Fig. 5 C).
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COSMO CERCA KASHMIRENSIS FOTEDAR, 1959.

PLATES LVII - LXVII

PLATE NO. LVII. Fig. 1. Entire female worm.
Fig. 2. Entire male worm.

PLATE NO. LVIII. Fig. 3. Entire female worm.
Fig. 3-a. Entire male worm.
Fig. 3 b. Female specimen.

Plate No. LIX. Fig. 4. Entire female worm.

PLATE NO. LX. Fig. 3-a. Entire male worm.

PLATE NO. LXI. Fig. 3 b. Entire female worm.
Fig. 4-4a. Anterior end of worm.

Plate No. LXII. Fig. 5. Male caudal end.
Fig. 5 b. Spicules and gubernaculum.

PLATE NO. LXIII. Fig. 5-c. Plectanes.
Fig. 6. Female tail end.

PLATE. NO. LXIV Fig. 7. Body wall as seen from T.S. Worm.
Fig. 8. T.S. worm at the level of nerve-ring.

PLATE NO. LXV. Fig. 9-10. T.S. Worm showing muscles cells, intestine and chords.

PLATE NO. LXVI Fig. 11. T.S. Worm showing muscle cells, intestine and chords.
Fig. 11 A. Part of T.S. Worm showing muscles.

PLATE NO. LXVII. Fig. 11 a. T.S. showing muscles Chords and intestine.
Fig. 12. Structure of lateral chord in T.S. of worm.
PLATE NO. LXVIII.  
Fig. 12-a.  T.S. lateral Chord.

PLATE NO. LXIX.  
Fig. 13.  T.S. Somatic muscle cell.

Fig. 13 a.  Part of T.S. Worm showing somatic musculature.

Fig. 13 b.  T.S. worm through Oesophageal region.

PLATE NO. LXX.  
Fig. 13 c.  T.S. worm through Oesophageal region.

Fig. 13 d.  Part of T.S. Oesophageal region of worm showing mesenteries.

PLATE NO. LXXI.  
Fig. 14.  T.S. worm showing connective tissue.

Fig. 14 a.  T.S. Worm passing through somato-Oesophageal muscles.

PLATE NO. LXXII.  
Fig. 14 b.  Enface view of worm.

Fig. 15.  T.S. through Oesophageal lumen of worm.

PLATE NO. LXXIII.  
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PLATE NO. LXXIV.  
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Fig. 17.  T.S. through Oesophago-intestinal valve.

PLATE NO. LXXV.  
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Fig 18 a.  T.S. worm showing intestine and pseudo- Coelomic granules.
PLATE NO. LXXVI.  

Fig. 18 b.  T.S. Intestine through posterior region of worm.

Fig. 19.  T.S. intestine through anterior region of worm.

PLATE NO. LXXVII.  

Fig. 20.  T.S. of an epithelial cell of the intestine.

Fig. 21.  T.S. worm showing rectum, oviduct and uterus.

PLATE NO. LXXVIII.  

Fig. 21 a.  T.S. worm showing rectum and pseudo-coelomic granules.

PLATE NO. LXXIX.  

Fig. 21-A.  T.S. through Rectal glands.

Fig. 22.  Arrangement of Canals Excretory canals in the worm.

PLATE NO. LXXX.  

Fig. 23.  T.S. through excretory pore.

Fig. 24.  T.S. worm at level of nerve-ring.

PLATE NO. LXXXI.  

Fig. 25.  T.S. through germinal zone of ovary.

Fig. 26.  T.S. through growth zone of Ovary.

Fig. 27.  T.S. through Oviduct.

PLATE NO. LXXXII.  

Fig. 28.  T.S. through uterus.

Fig. 29.  T.S. showing sphincter muscles of vagina.
PLATE LXXXIII

PHOTOMICROGRAPHS.

PLATE NO. LXXXIII. 1. Male Caudal end.
2. Plectane.
3. T.S. Worm showing somatic musculature.