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Caryophyllidean Cestode Fauna of India

M. HAFEEZULLAH

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CONTENTS

SYSTEMATIC INDEX

INTRODUCTION

As a matter of fact, till recently, little attention was paid to the collection and study of this group of cestodes in India. It was Moghe (1925) who initiated the study in India on this group by describing *Caryophyllaeus indicus* from the common walking cat-fish, *Clarias batrachus* (L.), from Nagpur. Woodland (1926) indicated that the species belongs to the genus *Lytocestus* Cohn, 1908. Acting on this clue, Moghe (1931) redescribed it as *Lytocestus indicus*. Moghe was joined by Mehra who (1930) presented a paper in the 17th Science Congress Association on *Caryophyllaeus kashmirensis* from the fresh water hill stream fish *Schizothorax micropogon* Heckel from near Srinagar, Kashmir. The paper remained in abstract form and its full detail along with illustrations was never published. While discussing its systematic position, Mehra (*loc. cit.*) observed that "this species apparently connects the new two genera *Caryophyllaeus* and *Lytocestus*." Fotedar (1958) described *Adenoscolex oreini* n. gen., n. sp. from the fresh water fish *Oreinus sinuatus* (Heckel) from Kashmir in the family Capingentidae Hunter, 1927, but did not compare this species with *Caryophyllaeus kashmirensis* Mehra, 1930. Mackiewicz (1972) considered *C. kashmirensis* as *species inquirenda* but later on he (1981a) opined that fresh material of this species should be collected from the same host and locality, studied and compared with *Adenoscolex oreini* Fotedar, 1958. Agarwal (1985) considered it as a synonym of *A oreini*. In the present work this species has been considered as species of uncertain status till its fresh material is collected, studied and compared with *A oreini*. Gupta (1961), Gupta and Sinha (1980, 1984), Verma (1971), Gupta and Parmar (1984, 1986, 1990), Gupta and Singh (1984), Agrawal and Singh (1985), Pandey (1973) and Pandey and Tiwari (1989) from Uttar Pradesh ; Murhar (1963), Mackiewicz and Murhar (1972), Shinde (1970), Shinde and Deshmukh (1975, 1980) and Sinde *et al.* (1987) from Maharashtra ; Satpute and Agarwal (1974, 1980 a & b), Niyogi *et al.* (1982), Mackiewicz and Murhar (1972) from Madhya Pradesh ; Rama Devi (1973) from Andhra Pradesh ; Sahay and Sahay (1977) and Kanth *et al.* (1984) from Bihar ; Kundu (1985) and Kundu *et al.* (1985) from West Bengal ; and Gupta (1961) and Chakravarty and Tandon (1989) from Assam have significantly contributed to the Indian fauna of Caryophyllidea. Lynsdale (1956), Singh (1975) and Zaidi and Khan (1976) described one species each from Burma, Nepal and Pakistan. Hafeezullah (1986) reviewed the status of various Indian species of the genus *Djombangia* Bovien, 1926. Agarwal (1985) reviewed the caryophyllid fauna of India, and Mackiewicz (1981a) discussed the status of species of India, Nepal and Pakistan. Nama (1979) reported the occurrence of *Crescentovitus biloculus* (1979) in Rajasthan.

The caryophyllideans form a small group of single-segmented cestode parasites with about 145 described species under 50 genera. These figures include 40 species under 14 genera from Indian region (inclusive of Pakistan, Nepal and Burma). *Bovenia ilishai* Zaidi and Khan, 1976 is the only species known from Pakistan ; so is the case with *Lytocestus* fossilis Singh, 1975 from Nepal ; and *Lytocestus birmanicus* Lynsdale, 1956 has been reported from Burma and India both. *Bovenia nagpurensis* n. sp. was reported by Murhar (1977) from the fish *Clarias batrachus* from Nagpur in the proceedings of the 65th Indian Science Congress held at Bhubaneswar in 1977, but it remained in abstract form ; its full detail was never published. Similarly, accounts of *Morvekia chotanagpurensis* n. gen., *n. sp.* and *Neolytocestus vitellodiscontinuatus* n. gen., n. sp. from *Clarias batrachus* from Chotonagpur was presented by Sahay and Sahay (1977) in the proceedings of the First National Conventions of Indian Helminthologists held at Bhubaneswar in 1977. These taxa also remained in abstract forms ; they were never published in detail. Therefore, these two new genera and new species are not considered in the present work. Johri (1959) described *Hunteroides mystei* as a new caryophyllid genus and species from *Mystus seenghala* (Sykes) in Delhi State. According to Schmidt (1986) this is actually a true cestodarian adding a new genus and new species to the subclass Cestodaria Monticelli, 1891, but Mackiewicz (1981a) and Dubinina (1982) considered it to be *Gephrolina paragonopora* (Woodland, 1923) earlier described from the same host from India. Recently, Chakravarty and Tandon (1989), while giving accounts of caryophyllids from north-easterm region of India, reported *Lytocestus filiformis* (Woodland, 1923) from the fish *Clarias batrachus* from Guwahati (Assam, India), which was originally described from the fish *Mormyrus caschive* from the river Nile (Sudan, Africa). In the same paper they also reported *Lytocestus birmanicus* Lynsdale, 1956 which was originally described from Rangoon, Burma.

HOW CARYOPHYLLIDEA DIFFERS FROM CESTODARIA

Caryophyllids are held apart from cestodarians, another set of monozoic cestodes like (*Amphilina* and *Gyrocotyle*) since the latters have no scolex at all, the positions of male and female gonopores are entirely different, the shelled larva is 10-hooked, and they parasitise turtles also in addition to fishes including marine fishes.

HOW CARYOPHYLLIDEA DIFFERS FROM ORDERS WITH SEGMENTED STROBILA

The polyzoic cestodes strikingly differ from monozoic caryophllideans in being strobilate and segmented usually with one set (or two) of reproductive systems in each segment. They parasitise all groups of vertebrates and intermediate hosts are usually arthropods. Caryophyllids require fresh water oligochaete annelids (usually tubificids) only as intermediate hosts and never need copepods or amphipods to complete their development to the procercoid stage. Polyploidy and parthenogenesis although recorded so far to occur only in some species of caryophyllids but these twin phenomenons are not known in polyzoic cestodes. Further, the caryophyllid genus *Archigetes* completes its life cycle and matures progeneticeally in the invertebrate host (tubificids) itself. This phenomenon also is not known in polyzoic cestodes.

Nature of Caryophyllidea : It is an established fact that, like polyzoic cestodes, the caryophyllid monozoic cestodes do not have germinative cells behind the scolex i.e. in the region of neck which serves as the zone of proliferation and consequent strobilization but it is not satisfactorily known that this monozoic condition of caryophyllids is original and primary or secondarily achieved by dropping segmented strobilate stage. It goes to mean whether they never had a strobilate stage or a strobilate stage existed in them at one time. This dispute gives birth to another question whether the caryophyllid cestodes are progenetic or neotenic. The twin questions are rather easy to answer with respect to *Archigetes* which has a cercomor-bearing stage and in the oligochaete-dwelling stage the gonopore is not functional because of an integumental covering, and in *Archigetes iowensis* these two larval characteristics are lost when ingested by fish. So, the precocious sexual maturity of the procercoid of *A. iowensis* is indeed progenetic. The real difficulty lies with the *Caryophyllaeus*—like caryophyllids where scientific evidences are rather obscure regarding primary or secondary nature of unsegmented strobila and consequent progenesis or neoteny.

Many theories have been propounded by various investigators to solve this difficulty but each theory has its own criticisms also. However, the pseudophyllidean theory enjoys wide acceptance. It postulates that caryophyllids are members of the Order Pseudophyllidea, since the life cycles of the caryophyllideans represent the abbreviated life cycles of pseudophyllideans with the additional occurrence of progenesis (neoteny) at the plerocercoid larval stage in which strobilate stages no longer develop. They are merely precocious progenetic larvae that have dropped the strobilate stage. However, Mackiewicz (1972) summarises the whole problem as follows ; "All of these theories are

subject to criticism but the fact that caryophyllids have : a nonciliated, non-free-swimming larva ; an annelid intermediate host ; a single set of reproductive organs in a non-segmented body, which zoological opinion generally accepts as a condition preceding strobilization ; a large number of species which have scoleces generally unlike any found in strobilate tapeworms, with the possible exception of *Eubothrium* exhibited extensive radiation of morphological types ; a worldwide distribution ; and occur predominantly in primitive, teleost freshwater fishes, argues forcefully in my opinion, for their being regarded as non-neotenic cestodes, distinct from but closely related to the Pseudophyllidea.

If the above analysis is correct then it would appear proper to regard the cercomere-bearing stage of *Archigetes* as a neotenic or progenetic caryophyllid and all others (Plerocercoid-like) as genuine non-progenetic adult stages."

MATERIAL AND METHOD

For correct study of worms, the elucidation of the various internal organ systems of their fresh specimens is essential. This is achieved by adopting their correct processing technique. In this connection the recent manual of Pritchard and Kruse (1982) can be successfully used. However, a brief technique for processing caryophyllid material is given below.

As far as possible, live fresh water fish hosts (specially belonging to the Orders Siluriformes and Cypriniformes) should be examined in order to recover live specimens of caryophyllid cestodes. Dead or iced fish hosts may not give specimens in good condition. Care should be taken that the scolex of the specimen is not lost. The live specimens so obtained should be studied first and shape and structure of the scolex and their variations, if any, noted in the field book. Attempt should also be made to study the position and number of male and female genital pores as well as presence or absence of genital atrium. This is important because these structures may not be studied correctly in the whole mounts.

Fixation : Fixative should not be used on the specimens unless and until contraction has completely stopped, or relaxation and fixation can be done simultaneously depending upon the experience in order to achieve better results. A fixative is a chemical reagent which preserves the specimen in life-like condition without brittleness. However, a perfect fixation is yet to be known. These live specimens are then taken in a small bottle containing cold or hot fixative FA (7% solution of formalin with 3% to 7% glacial acetic acid, the amount of acetic acid being not critical) or AFA (5 prts glacial acetic acid, 10 parts formalin and 85 parts alcohol) or 5% formalin solution whichever

is benificial known through experience. The bottle is then shaken vigorously for about one minute so that the contraction of the specimens stops and they get relaxed and fixed. This fixed material can now be stored in air-tight vials containing 70% alcohol with a little glycerine, and label with collection data inserted therein.

Staining : This material is stained for whole mounts. Before staining, the material may be flattened under coverglass pressure with gentle pressing using the tip of a needle. Overflattening between two slides should be avoided. In order to get good results from whole mounts, staining of the material should be done in borax cormine, acetic carmine, Semichon's carmine or even haematoxylin. It has been found that retrogressive staining yields better results than progressive one. So the material should be overstained with the chosen stain and then gradually de-stained to the desired differenciation. To de-stain overstained specimens, 5% acidulated alcohol in the case of carmine or 5% aquous HCL in the case of haemotoxylin is used. The stained material should be dehydrated in alcohol grades, cleared in clove oil and xylol, mounted in Canada balsam and dried on a regulated hot plate or drying oven at about 56°c. Two labels having details of the host on one and identification of the worm on the other should be affixed on the slide.

Sectioning : For serial sectioning, a part of the material should be separately fixed with FA or 4% formalin. AFA should not be used for this purpose. The unpressed or unflattened material should be used for serial cross-soctioning through testicular region and serial sagittal-sectioning through the posterior quarter of the body. The cross-sections will help determine the position and arrangement of vitellaria with respect to the inner longitudinal muscles and the sagittal sections will tell about the details of the male and female genital ducts as well as the number of genital pores and absence or presence of genital atrium. By following this technique correct and complete study of worm can be made.

All Indian investigators should deposit the holotypes and paratypes of worms with the National Helminthological Collections of the Zoological Survey of India, Calcutta.

GENERALISED MORPHOLOGY AND ANATOMY

Mackiewicz (1972) in his very informative and useful review of world caryophyllids has given their various body shapes (his figs. 1-22 and 41-63) and different structures of scoleces (his figs. 27-40). He (1982) has further furnished additional scolex types (his figs.

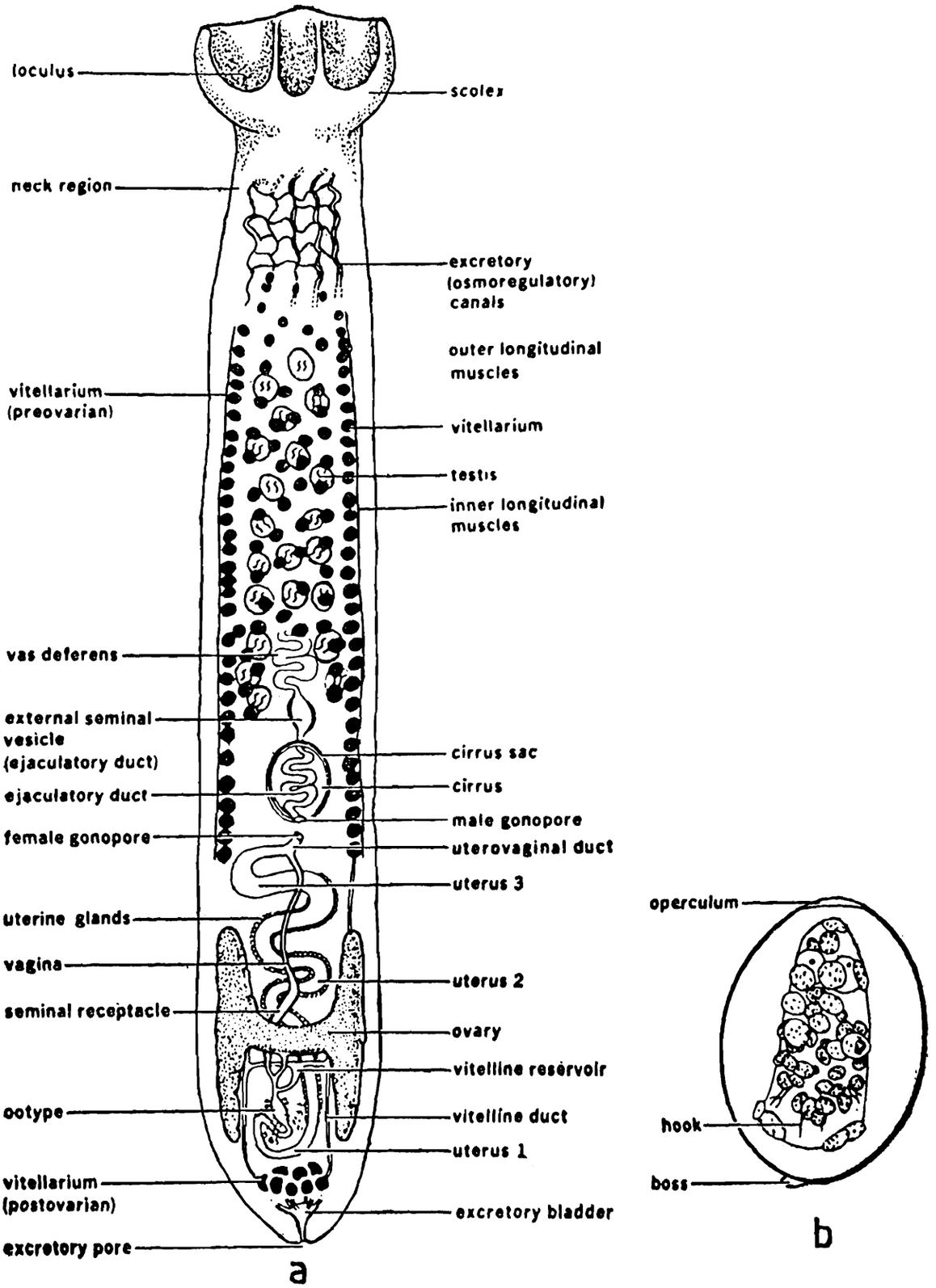

Fig. 1A : Caryophyllidean morphology and anatomy, (After Mackiewicz, 1972).
a. Hypothetical species illustrating principal features.
b. Egg of *Archigetes* sp. showing onchosphere.

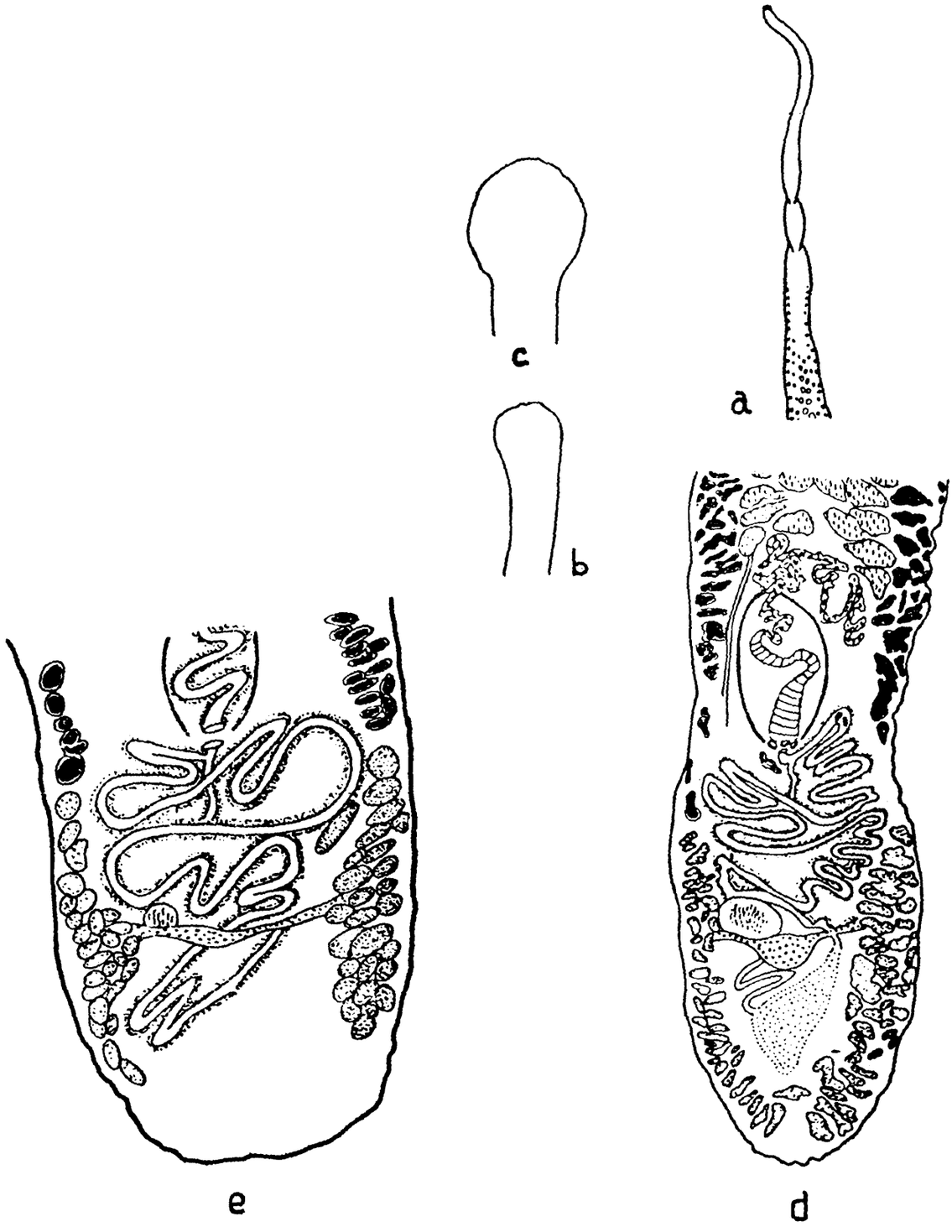

Fig. 1B : Caryophyllidean specimens of a single population.

a, b, c. Variations in scolex shape.

d. Follicles of vitellaria and ovary meeting on one side, not meeting on the other side ; ovarian follicles reaching posterior end of body.

e. Ovarian follicles not reaching posterior end of body.

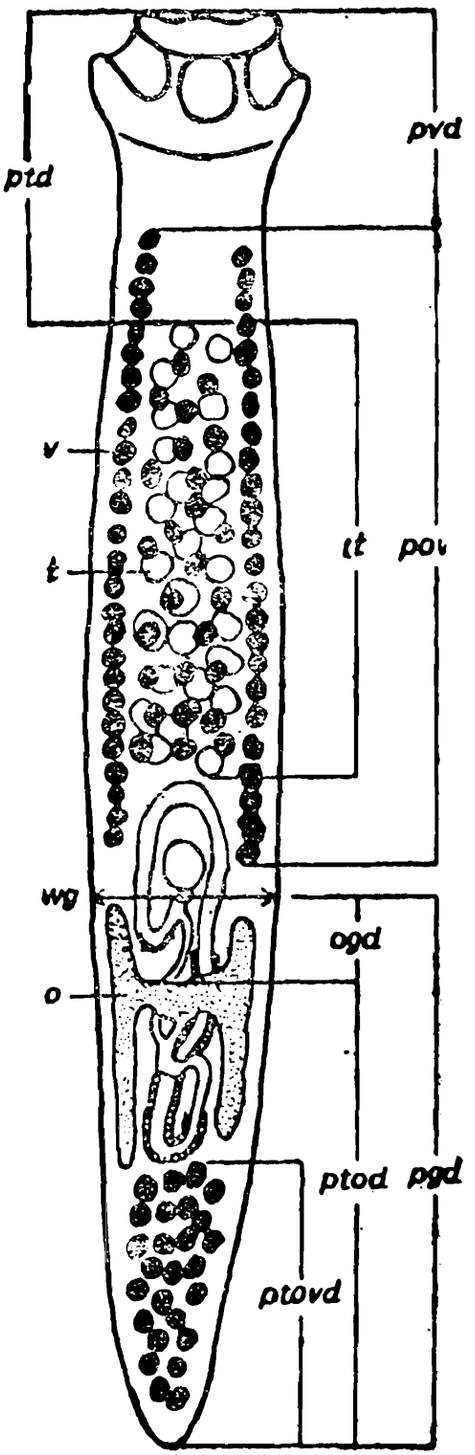

Fig. 2 : Hypothetical caryophyllidean indicating various morphological and anatomical regions (After Mackiewicz, 1982).

pvd—previtellaria distance, *ptd*—pre-testes distance,
povd—pre-ovarian vitellaria field, *tf*—testes field,
pgd—post-gonopore distance, *wg*—width at gonopore,
ogd—ovary-gonopore distance, *ptod*—post-ovarian distance,
ptovd—post-ovarian vitellaria distance, *o*—ovary, *t*—testes and *v*—vitellaria.

IB-IJ) and devised some terminology to describe their shapes and structures. In the same paper, he has attempted to describe various morphological and anatomical regions with the help of suitable terminologies. However, a generalised morphology and anatomy of caryophyllids is briefly furnished here.

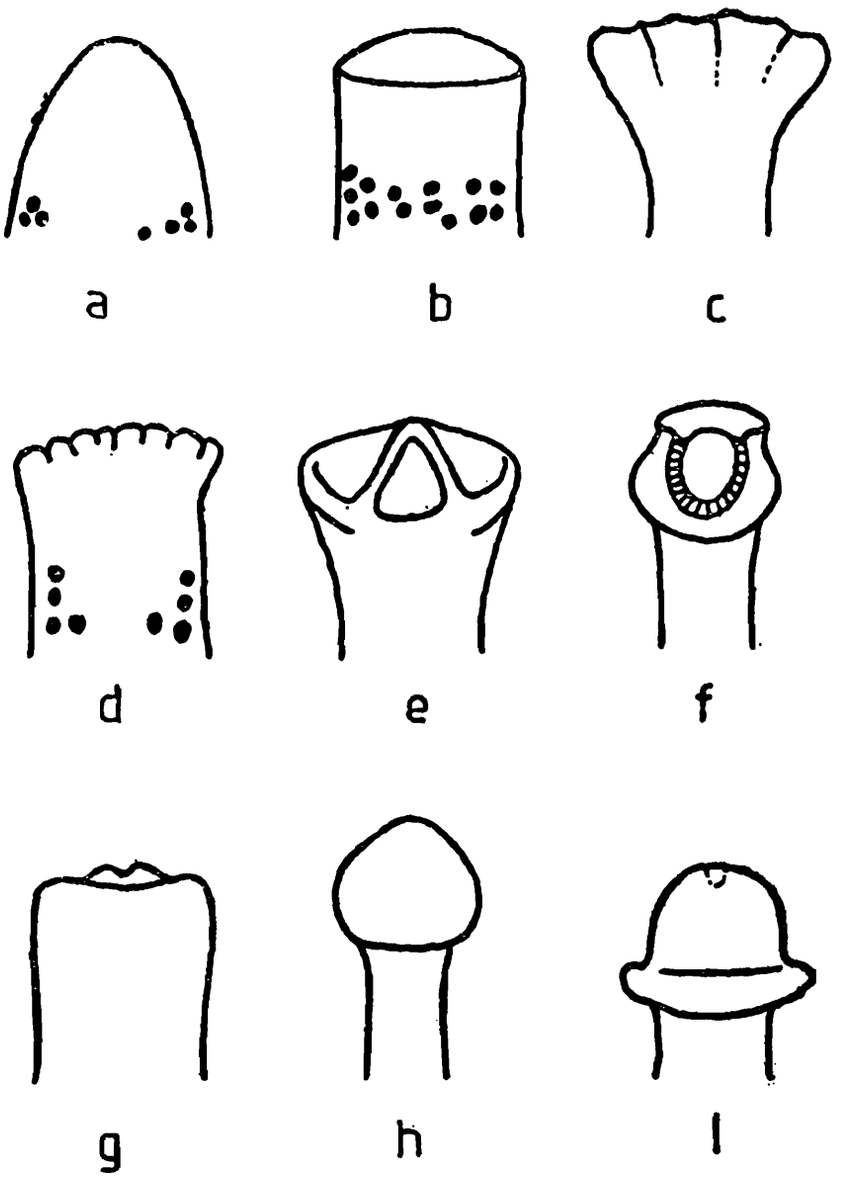

Fig. 3A : Terminology for some scolex types of caryophyllidean genera (After Mackiewicz, 1982).
a. Tholate, b. Cuneiform, c. Cuneicrispitate or Flabellate, d. Cuneifimbriate, e. Cuneiloculate, f. Biacetabulate, g. Monobothriate, h. Bulbate, i. Choanocompanulate.

The bodies of caryophyllidean cestodes are usually long and narrow in shape. They may be broad also (*Djombangia* Bovien, *Notolytocestus* Johnston and Muirhead and

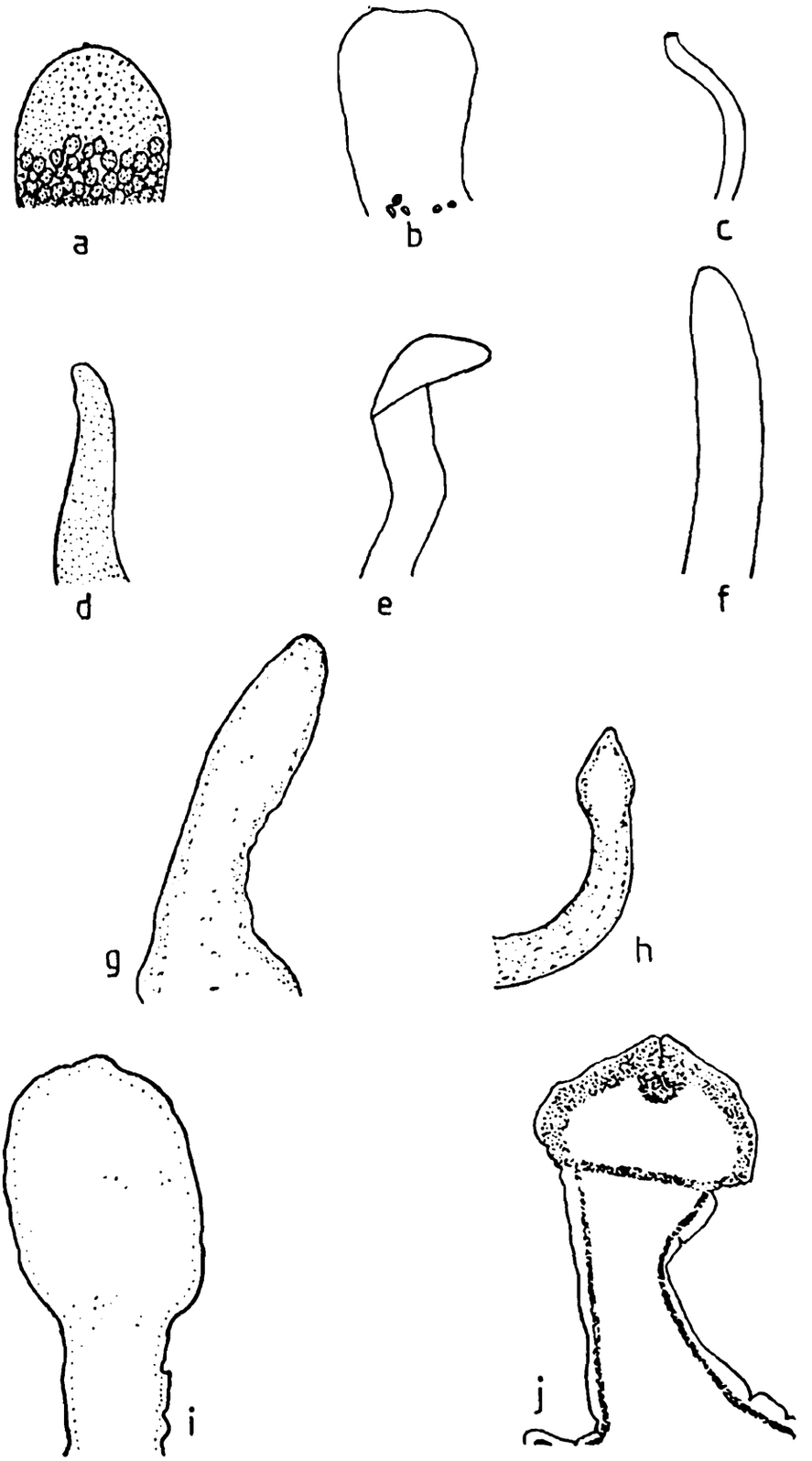

Fig. 3B : Some scolex types of Indian caryophyllideans.

Balanotaenia Johnston). The body is usually distinguishable into *scolex*, *neck* and *strobila* or *main body* (Fig. 2). In some genera e.g. *Balanotaenia*, *Lytocestoides Khawia*, *Notolytocestus*, *Thallophyllaeus*, *Paracaryophyllaeus*, *Huntrella*, *Pliovitellaria*, *Adenoscolex*, *Edlintonia* and *Breviscolex*, the neck is absent or is not distinct from the main body. The neck in caryophyllid monozoic cestodes is different from that in polyzoic cestodes. In the latter, the neck or if it is not present the posterior part of the scolex has *germinal cells* and is known as the region of proliferation which produces a chain of segments each of which contains one or two sets of reproductive organs. Thus, the strobila or main body is segmented and chain-like. Contrarily, in caryophyllid cestodes the neck on the posterior part of the scolex does not act as the region of proliferation. So the strobila is not chain-like and remains unsegmented with only one set of reproductive organs. The neck in this case is short, constriction-like or very long and narrow.

The scoleces in caryophyllids are variously shaped (Figs. 3A, 3B) and are different in structure and specialisation. In its simplest form it may be very short, smooth and indistinguishable from the main body as is found in *Breviscolex*, *Adenoscolex* and *Paracaryophyllaeus*, or it may be globular or ovate, smooth, unspecialised and borne on a long and narrow neck as occurs in *Capingentoides* Gupta, 1961, *Pseudocaryophyllaeus* Gupta, 1961 and *Lytocestus longicollis* Ramadevi, 1973, or it may be globular or ovate with a terminal introvert and concentration of gland cells below the apex as happens in *Djombangia* Bovien, 1926, or it may be bell-shaped with a prominent collar around the base and an apical funnel as in *Caryoaustralus* Mackiewicz and Blair, 1980, or it may be with several furrows, constricted off from body or not as in *Wenyonia* Woodland, 1923, or its anterior margin may be folded or frilled as in *Caryophyllaeus* Muller, 1787 and *Khawia* Hsu, 1935 respectively. Some of the genera have acetabula, sucker, locula, bothria or some combination of them. Thus, the specialisation of scolex is varied, but rostellum and hooks have not yet been reported on any caryophyllid scolex as is found in some polyzoic cestodes. The shape of scolex may also vary within one and the same species (Figs. 29 a, b ; 40 b, c, d ; 46 b ; 1B a, b, c).

Some caryophyllids like *Archigetes iowensis* Calentine, 1962 attain precocious sexual maturity in the coelome of its freshwater oligochaete annelid retaining the larval cercomer with the larval hooks at the posterior end. So, of all the cestodes, only caryophyllids have the examples which mature in an invertebrate.

Generally the male and female gonopores (Figs. 1A, 4) are situated in the posterior part of the body midventrally, say in the last 1/5th to 1/4th of body length, but in *Wenyonia* Woodland, 1923 and *Caryoaustralus* Mackiewicz and Blair, 1980 they are in anterior half of the worm, in latter the gonopore being single. In *Markevitschia* Kulakovskaya and Achmerov, 1965 and *Pliovitellaria* Fischthal, 1951, the gonopores occur a bit posterior to equatorial plane, the latter genus having only one gonopore. In *Djombangia*

the genital pores are located immediately in front of ovarian commissure while in *Balanotaenia* they are behind it. In genera like *Caryophyllaeus*, the female gonopore is present just behind the male pore on the flat ventral surface, there being no common genital atrium (Fig. 4a). In genera like *Atractolytocestus* Anthony, 1958, *Lytocestus* Cohn, 1908 and *Djombangia* Bovien, 1926, the male and female gonopores are separate as in the previous case but both of them are situated in a large shallow depression of body surface called common genital atrium (Fig. 4b). There is a third condition also which

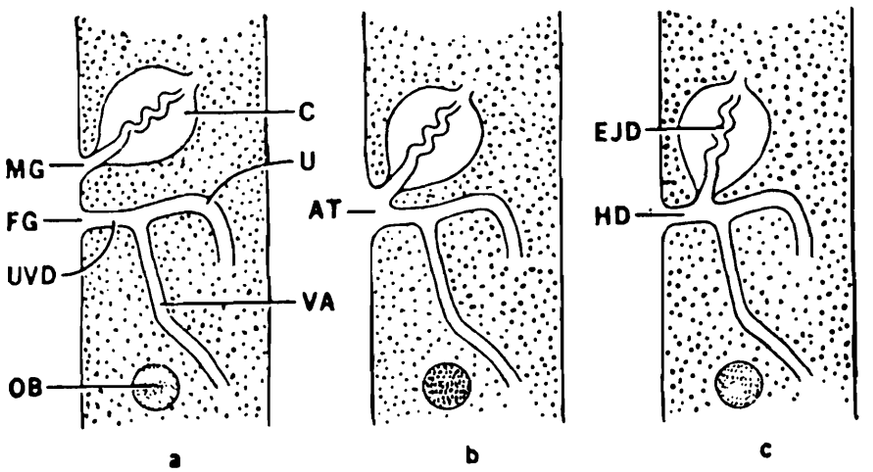

Fig. 4. Gonopore types as shown in midsagittal sections (diagrammatic) (After Mackiewicz, 1972).

Abbreviations:

AT—atrium; C—cirrus; Ejd—ejaculatory duct; FG—female gonopore; HD—hermaphroditic duct; MG—male gonopore; OB—Ovarian bridge or commissure; U—uterus; UVD—uterovaginal duct, VA—vagina.

occurs in genera like *Caryoaustralus*, *Plivitellaria*, *Biacetabulum*, *Caryophylleides* and *Isoglaridacris*. In this case, the terminal male and female ducts first join to form a short hermaphroditic duct which ultimately opens as a single gonopore on the flat ventral surface of the body, there being no common genital atrium as in the second case (Fig. 4c).

REPRODUCTIVE SYSTEMS

Caryophyllids are single-segmented cestodes since there is no *trace of external* or *internal segmentation* in their strobila. The single segment is provided with one set each

of male and female reproductive organs (Fig. 1a). Sexes are *not separate* i. e. *ganochoristcism* does not occur. They are hermaphroditic or monoecious. Generally the male reproductive organs mature first and produce sperms which remain stored till the ovary matures and produces eggs. The maturation of testes earlier than ovary is known as *protandry* or *androgyny*. The reverse of this phenomenon i. e. *gynandry* or *protogyny* is not known in caryophyllids.

Male Reproductive System :

The main male organs are the *testes* which are many and produce *sperms* and the associated ducts and their terminal modifications drain the sperms towards *male pore.*

The testes lie in the medullary zone, extending from anterior to coil of vas deferens upto slightly behind neck (if present) or scolex, except in the family Balanotaeniidae in which they occur in the cortical zone along with vitellaria (Fig. 8d). From each testis arises a fine duct called *vas efferens*. All the *vasa efferentia* unite to form a common coiled *vas deferens* which lies anterior to *cirrus sac* in the central medulla. Before entering the cirrus sac the vas deferens may dialate and become muscular which part is known as *external seminal vesicle*, e. g. in *Archigetes*, *Biacetabulum*, *Monobothrium*, etc., or it may be simple. Within the cirrus sac the vas deferens may form a convoluted *ejaculatory duct* or swell into *internal seminal vesicle* as happens in *Caryophyllaeus laticeps.* In other cases the vas deferens immediately enters into a muscular swollen sac called *cirrus sac* and leads into the *ejaculatory duct.* This is surrounded by a bulbus muscular structure called *cirrus* which is the male copulatory organ and is usually eversible and unspined. The cirrus opens to the exterior ventrally in the three different ways as discussed earlier and shown in Figs. 4a, b, c.

Female Reproductive System :

The main female organ is a single *ovary* which produces ova, the associated glands provide nutrition, membrane and eggshell to the zygote, and the ducts lead the egg to the *female pore.*

Usually the ovary is follicular and in many genera it is H-shaped situated near the posterior end of body except in *Markevitschia*, *Pliovitellaria* and *Wenyonia* in which genera it is situated in the middle-third of the body. It may also be butterfly-shaped, dumbbell-shaped, u- or v-shaped or shaped like an inverted 'A' in different genera. It may be compact also as in the genus *Caryophyllaeides.* The two arms of the ovary are connected by a transverse band called *ovarian commissure.* The *vitellaria* or *vitelline glands* are situated in the cortical field (in the family Lytocestidae, Fig. 8c, c′), in the medullary zone (in the family Caryophyllaeidae, Fig. 8a, a′), partly cortical

and partly medullary (in the family Capingentidae, Fig. 8b, b′), or cortical along with testes (in the family Balanotaenidae) (Figs. 8d, 11b, 12b). So, the occurrence of vitellaria in one field or the other, alone or together with testes is of familial importance.

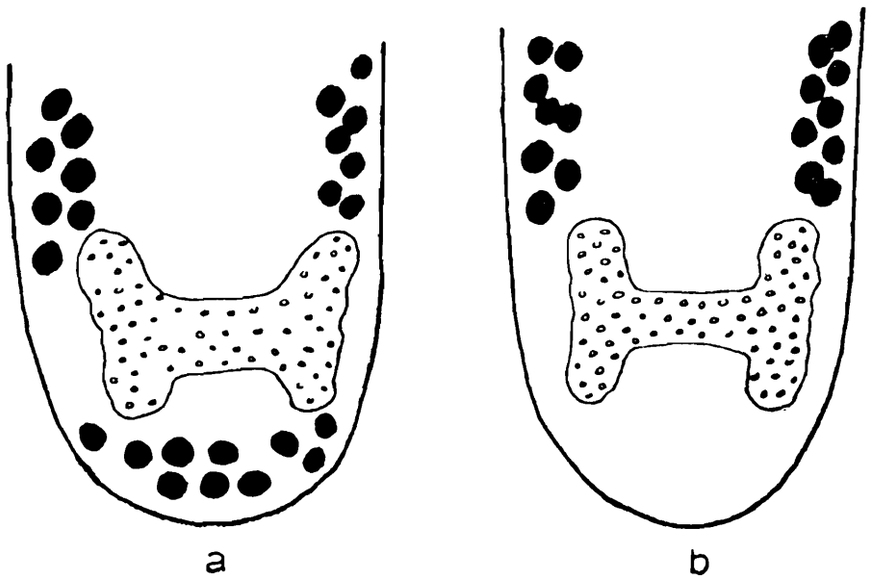

Fig. 5 : a. Postovarian vitellaria present (diagrammatic ; after Schmidt, 1970, 1986).
b. Postovarian vitellaria absent (diagrammatic ; after Schmidt, 1970, 1986).

In certain genera e. g. *Adenoscolex*, *Edlintonia*, *Breviscolex* etc. a group of postovarian vitelline follicles may also be present (Figs. 1A, 5). The vitellaria may extend from behind the neck up to the level of cirrus sac or even beyond posteriorly. In some species the pre- and post-vitelline follicles may be laterally continuous. The vitellarine follicles may be continuous or discontinuous with the follicles of the anterior horns of the ovary in the same species (Figs. 1B e, d). In some specimens the ovarian follicles may not extend up to the posterior end of the body while in others of the same species they intermingle near the posterior end giving the false impression of the presence of post ovarian vitellaria (Figs. 1B d, e). The vitelline glands provide material for the egg-shell formation and nutrition for the developing embryo.

The mature ova leave the ovary through a small duct called *oviduct* which arises from the posterior margin of the ovarian commissure. The oviduct has a controlling sphincter called the *ovicapt*. It receives a duct from *vitelline reservoir* and a *spermioduct* from the *vagina* or *seminal receptacle*. Beyond that the proximal part of the oviduct functions as a chamber where sperms fertilize the ova and thus zygote is formed. As the oviduct passes further posterior it dialates to form *ootype*. The ootype is surrounded by two types of

unicellular glands, the *serous gland cells* which are fewer in number and the *mucous gland cells* which are much more in number. The two types of cells are together called *Mehles' gland.* How eggshell formation takes place in Caryophyllid cestodes is not known with certainty. Probably it takes place as it happens in polyzoic cestodes. The Mehles' glands

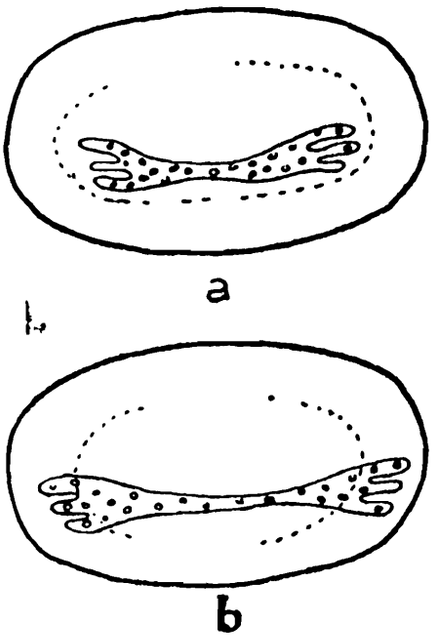

Fig. 6 : a. Ovarian lobes entirely medullary (diagrammatic ; after Schmidt, 1970, 1986).
b. Ovarian lobes party cortical (diagrammatic ; after Schmidt, 1970, 1986).

secrete a very thin membrane around the zygote and the accompanying vitelline cells. The accompanying vitelline cells then form the sclerotin of the eggshell from within. Thus the eggshell formation is completed. The egg then leaves the ootype and passes into a tubular coiled structure known as *uterus.* It then ascends and in the pre-commissural field it gets thrown into lateral coils. The middle part of the uterus is usually provided with gland cells. The proximal and the distal parts are devoid of such cells. The *vagina* is a long tube which posteriorly drains into the oviduct but anteriorly it does not open independently on the ventral surface of the body. Usually it joins with the terminal part of the uterus to form a short *utero-vaginal duct* which communicates to the ventral surface of the body as female pore. The manner of opening of the male and female pores have already been discussed earlier.

OSMOREGULATORY SYSTEM

It is the water balancing system in the body of the worm. Excess of fluid is removed from the body parenchyma and some metabolic waste products are also excreted. This is accomplished by a *protonephridial* type of *paired and interconnected descending and ascending longitudinal canal systems* in which the organ of osmoregulation is *flame cell*. Ultimately the unwanted extra water is excreted out through the *excretory vesicle* and the *excretory pore* at the posterior end. The details of this system are avoided since it is not much of taxonomic importance in Caryophyllidea.

NERVOUS SYSTEM

This system also is not of taxonomic value in caryophyllid cestodes. Moreover, knowledge on this system is very scanty and meagre. There are at least two main lateral nerve cords. Other minute details are not known.

MUSCULAR SYSTEM

The muscle bundles and muscle fibres are well defined in caryophyllid cestodes. The scolex is well supplied with muscle fibres since it has to move actively. Just beneath the

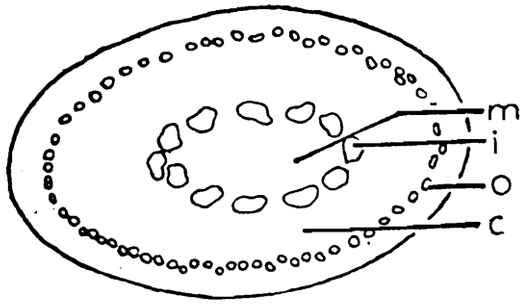

Fig. 7. Muscle bundle arrangement (After Schmidt, 1970)
Abbreviations :
c—cortex ; i—inner muscle bundle ; m—medulla ; o—outer muscle bundle.

cuticle there are *circular cuticular muscles* and internal to it *longitudinal cuticular muscles.* The longitudinal muscle bundles of parenchyma are arranged in two definite layers. The

Inner longitudinal muscle bundles are arranged in a definite ring and divide the cross-section of the body into *inner medulla* and *outer cortex* (Fig. 7). The *outer longitudinal muscle bundles* are also arranged in a definite layer and surround the cortical region. The arrangement of

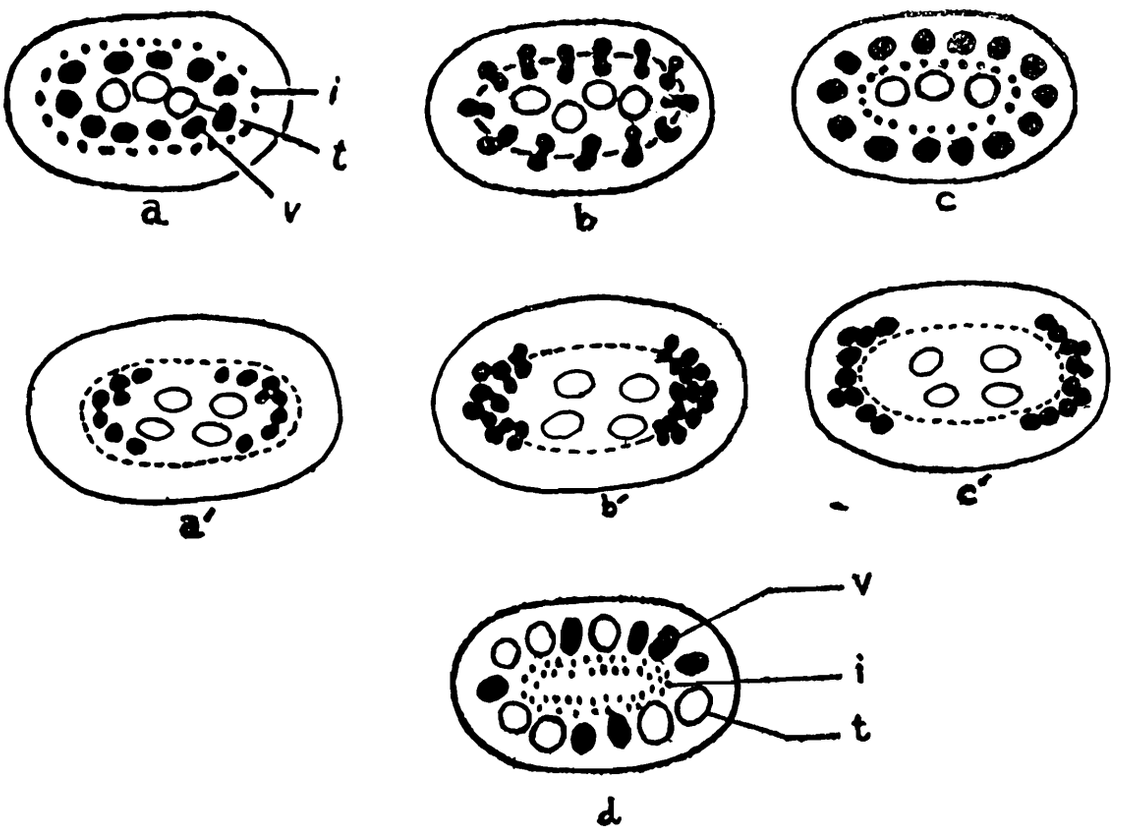

Fig. 8. : Cross-sections illustrating inner longitudinal muscle arrangement for various families (diagrammatic).

Caryophyllaeidae :
a. Vitellaria annular
a' Vitellaria lateral

Lytocestidae :
c. Vitellaria annular
c' Vitellaria lateral

Capingentidae :
b. Vitellaria annular
b' Vitellaria lateral

Balanotaeniidae :
d. Vitellaria and testes cortical.

Abbreviations :
i — inner longitudinal muscle bundles, t — testes ; v — vitellaria.

inner longitudinal muscles in relation to the distribution of vitellaria is of great taxonomic importance, since family classification of caryophyllid cestode depends on this character (Fig. 8).

OUTLINE OF DEVELOPMENT AND LIFE CYCLE

Caryophyllideans are characteristically small, long and narrow cestodes having no true holdfast structure (scolex) and with only one set of reproductive organs. Their body plan is monozoic. They parasitise the intestine of bottom feeding fresh water teleost fishes primarily belonging to the Orders Cypriniformes and Siluriformes, their intermediate hosts invariably being freshwater oligochaete annelids usually belonging to the family Tubificidae. The genus *Archigetes* is the sole exception whose species progenitically attain sexual maturity in the invertebrate hosts without involving vertebrate hosts in the life cycle.

The eggs (Fig. 1 b) are thin-shelled and operculate and have a single ovum and 3-5 vitelline cells. The operculum is very minute and is difficult to see *in utero* with the aid of a microscope. In most species the eggs are discharged in water unembryonated where their development takes place through embryonation and hexacanth embryos or onchospheres are formed, but in *Archigetes*, *Djombangia*, *Wenyonia*, *Huntrella* and *Biacetabulum* the embryonation starts and is completed *in utero*, and when the eggs are expelled out in water the onchospheres have already been formed. A caryophyllid onchosphere has been defined to be an embryo which develops in the egg with a nonciliated membrance and three pairs of hooks, the middle one being the longest. The eggs with onchospheres are ingested by the tubificid intermediate hosts in whose body-cavity further development takes place. The hatching of eggs takes place due to the mechanical pressure applied by the strong stretching and contracting movements of the onchosphere on the operculum of the egg. The onchosphere develops into a procercoid larva which is characterised to be soft bodied with a holdfast structure (scolex), primordia of gonads and a cercomer having the six onchospheric hooks. Wardle and Mcleod (1952) hold that "The procercoid may be described as a solid-bodied larva in which the onchospheric hooks are retained and in which the future holdfast has not yet differentiated". Mackiewicz (1972) seems to disagree with this definition in so far as the differentiation of the holdfast (scolex) is concerned and gives his definition like this: "The infective procercoid is characterised by a cercomer containing the six hooks of the onchosphere, a scolex that does not invaginate and shows a high degree of differentiation that is characteristic of the particular genus and, except for an increase in size, is retained through to the sexually mature stage, and the rudiments of a single set of reproductive organs". This definition of procercoid larva seems to be very comprehensive, complete and meaningful.

As mentioned earlier, a species of *Archigetes* can complete its life cycle progenitically in the coelome of an oligochaete annelid intermediate host itself but it has also been shown beyond any shadow of doubt that a benthic feeding fish may occasionally be

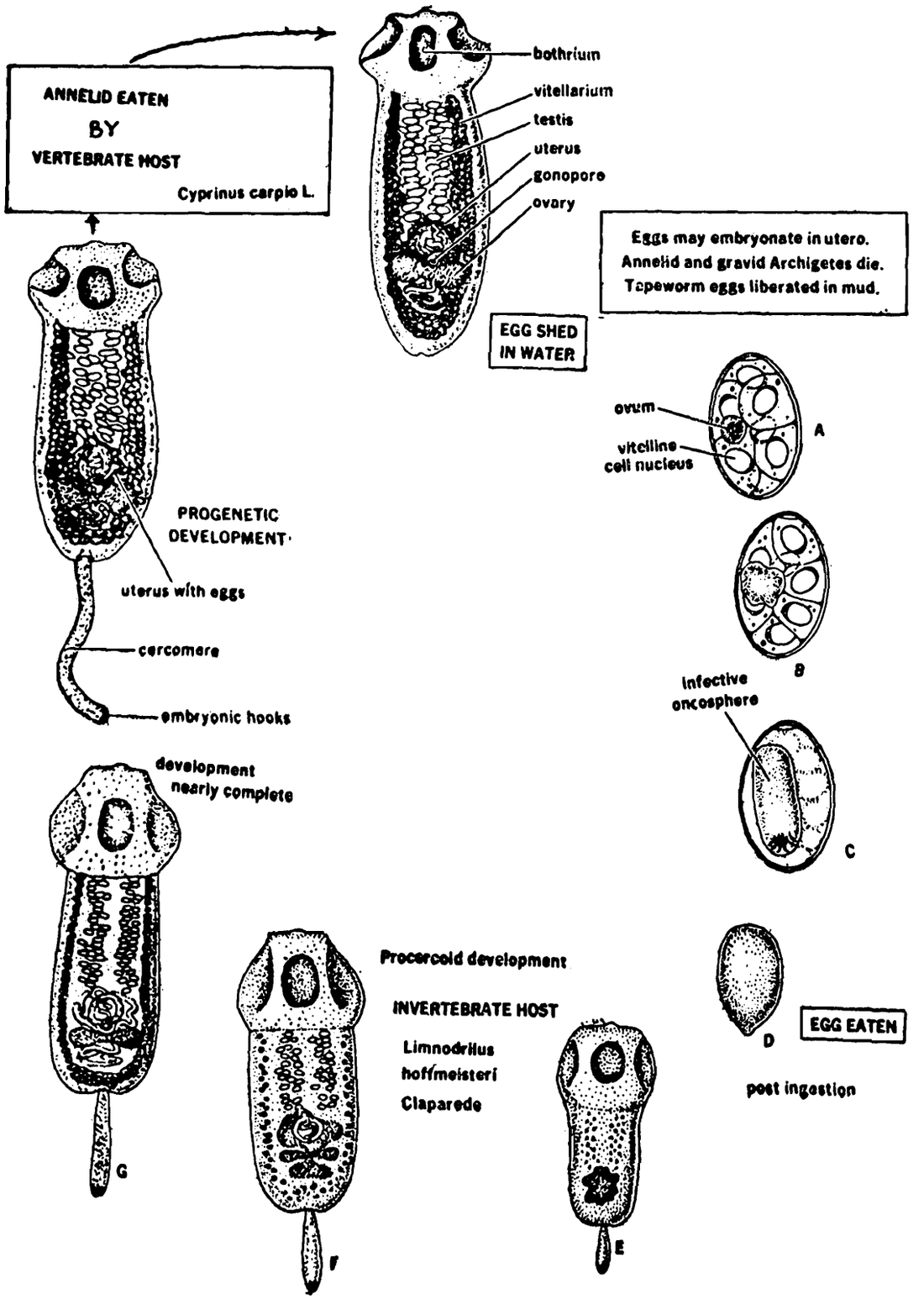

Fig. 9 : Life cycle of *Archigetes iowensis* Calentine, 1962 (Simplified after Mackiewicz, 1972).

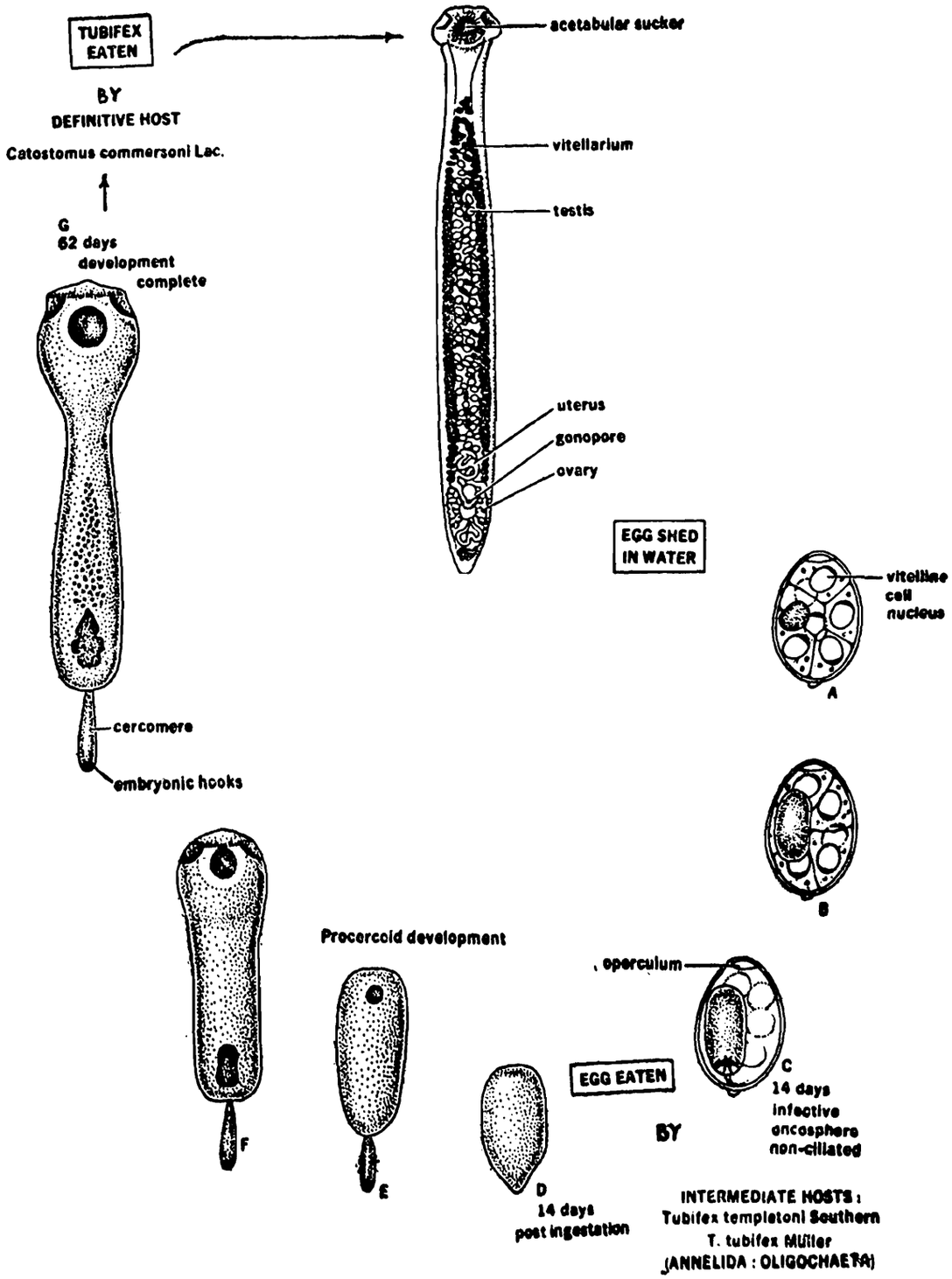

Fig. 10 : Life cycle of *Biacetabulum macrocephalum* McCrae, 1962 (Simplified after Mackiewicz, 1972).

involved in the life cycle if the oligochaete annelid infected with procercoid larva is ingested before the development of the functional reproductive organs in the procercoid. Thus, in literature it has been indicated that invertebrate and vertebrate cycles of *Archigetes iowensis* represent two physiological strains. Szidat (1937) believed that *Archigetes* is the annelid stage whereas *Biacetabulum* is the vertebrate stage.

It is generally accepted and there is no evidence to the contrary that the caryophyllid life cycles involve only the freshwater oligochaete annelids and no other invertebrates as the intermediate hosts.

Mackiewicz (1972) has suggested that at least three types of caryophyllid life cycles can be recognised. They are :

Progenetic type : The life cycle does not involve a vertebrate (fish) host and the procorcoid larva with its differentiated scolex and a cercomer having the six onchospheric hooks develops functional gonads and thus becomes sexually mature in the body-cavity of the invertebrate fresh water oligochaete annelid itself. *Archigetes sieboldi*, *A. limnodrili* and *A. iowensis* are best examples of this type of life cycle. However, *A. sieboldi* and *A. iowensis* can mature in vertebrate (fish) hosts also if the invertebrate hosts harbouring procercoid larvae are eaten by them before becoming progenetic.

Interrupted type : In this type of life cycle, the procercoid larva not only grows to a large size in the intermediate invertebrate host, it is morphologically well developed also but the functional sexual maturity remains checked and interrupted. To break this interruption and to bring it to functional sexual maturity a vertebrate (fish) is required. This happens in *Caryophyllaeus* spp.

Complete type : In this type, the procercoid grows to a large size in the oligochaete annelid with some primordia of germ cells. Further development will not take place in this invertebrate host. At this stage, the annelid harbouring the infective larva or the young procercoid is ingested by a fish host. In the intestine of this vertebrate, the halted growth gets going ahead and eventually sexual maturity is attained. This type of life cycle is exemplified by *Khawia sinensis* and *Caryophyllaeus laticeps*.

SYSTEMATIC ACCOUNT

Class CESTOIDEA Rudoiphi, 1808

Subclass CESTODA Carus, 1863

Order CARYOPHYLLIDEA Beneden *in* Carus, 1863.

Order **Caryophyllidea** Beneden *in* Carus

1863. **Caryophyllidea** Beneden *in* Carus, *Handb. Zool.*, **2 :** 422-600,

Small group of single-segmented cestodes without any trace of external or internal segmentation, with a single set of reproductive organs and having poorly or well defined scolex. Male and female pores separate, occasionally common, lying midventrally at varying positions ; if separate, very close to each other. Body plan monozoic, zone of proliferation behind scolex being absent (unlike polyzoic cestodes), thus chains of progttids or segments not formed. Shelled embryo nonciliated and six-hooked.

Complete diagnosis of the Order is detailed below :

Diagnosis : Body unsegmented, elongate, foliate or oval. Scolex marked off from rest of body or not ; smooth or specialised with folds, shallow grooves, frills, crenulations, shallow bothria or loculi, acetabular suckers, apical disc or introvert etc. Neck formed or not. Male and female gonopores usually separate, rarely common, midventral at varying levels, usually in posterior part of body (in anterior half of body in *Wenyonia* Woodland, 1923 and posterior to ovarian commissure in *Balanotaenia* Johnson, 1924). Common genital atrium present or not. Testes preuterine, usually medullary (Cortical in Balanotaeniidae). Cirrus sac present immediately behind testes. Ovary bilobed (H-shaped, bowtie- or dumbbell-shaped, inverted A-shaped or U-shaped) ; lobes follicular, connected by a transverse bridge called isthmus or commissure. Uterus much coiled in median field, joining vagina terminally before opening outside as female pore just behind male pore, or male and female pores opening outside together as common gonopore. Vitellaria follicular, lateral or surrounding medulla ; cortical, medullary or both. Eggs operculate. Embryo hexcanth. Freshwater oligochaeta annelids serving as intermediate hosts. Definitive hosts freshwater benthic feeding fishes ; only genus *Archigetes* sexually maturing in coelome of a tubificid oligochaete (cercomer present) ; adults of this genus also occur in intestine of freshwater teleost fishes (cercomer absent), specially cyprinids.

Type family : Caryophyllaeidae Leuckart, 1878.

Other families : Lytocestidae Hunter, 1927

Capingentidae Hunter, 1930

Bolanotaeniidae Mackiewiez and Blair, 1978.

Key to families of *Caryophyllidea*

[After Mackiewicz and Blair (1978)]

1. Testes and vitellaria in cortical parenchyma ; neither testes nor vitellaria internal to inner longitudinal muscles ... Balanotaeniidae Mackiewicz and Blair, 1978.

   Testes and vitellaria in separate planes ; testes, vitellaria, or both internal to inner longitudinal muscles ... ... 2.

2. Vitellaria completely in cortical parenchyma ; inner longitudinal muscles separate medullary testes from cortical vitellaria ... Lytocestidae Hunter, 1927.

   Vitellaria either completely in medullary parenchyma or partially in medullary and cortical parenchyma ... ... 3.

3. Vitellaria and testes in medullary parenchyma ; inner longitudinal muscles external to vitellaria ... ... Caryophyllaeidae Leuckart, 1878.

   Vitellaria partially in medullary and cortical parenchyma ; inner longitudinal muscles between adjacent vitelline fallicles ... Capingentidae Hunter, 1930.

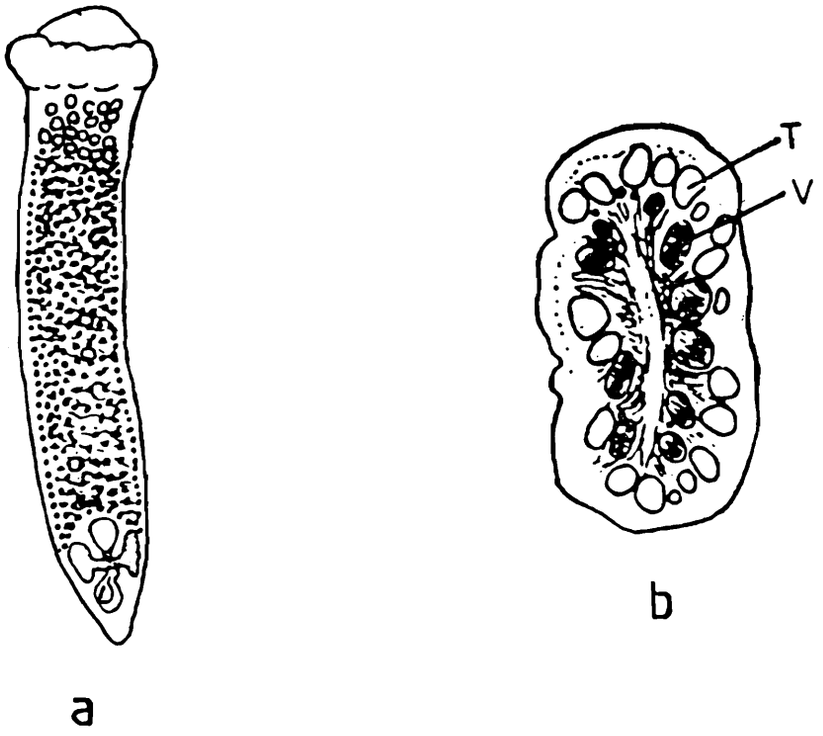

Fig. 11 : *Balanotaenia bancrofti* Johnston, 1924
a. Entire Worm, b. Cross-section.

The family Balanotaeniidae (Figs. 11, 12) has not been reported so far from Indian region. It has been reported only from Australia and Papua New Guinea. The family has been characterised by cortical distribution of vitellaria and testes being external to inner longitudinal muscles, medullary ovary and gonopore slightly anterior, over or posterior to

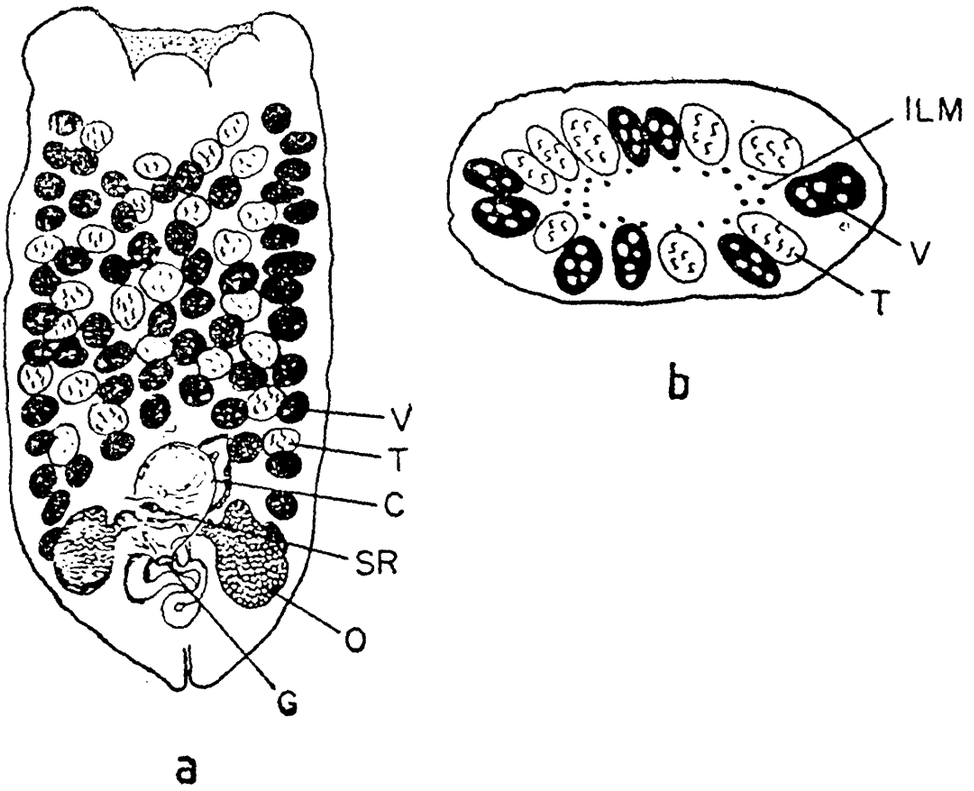

Fig. 12 : *Balanotaenia newguinsis* Mackiewicz and Blair; 1978
a. Entire worm,
b. Cross-section.

ovarian commissure. It includes only one genus *Balanotaenia* Johnston, 1924 and the following two species.

B. bancrofti Johnston, 1924, in *Tandanus tandanus* Mitchel Mithel (Siluriformes : Plotosidae), from Murray Bridge, Murray River, South Australia (Fig. 11).

B. newguinensis Mackiewicz and Blair, 1978, in *Tandanus brevidorsalis* (Gunther), from near Port Moresby, Brown River, Papua New Guinea (Fig. 12).

Family I. CARYOPHYLLAEIDAE Leuckart, 1878

1878. Caryophyllaeidae Leuckart, *Z. wiss. Zool. Suppl.*, 30 : 593-606.
1922. Caryophyllaeinae Nybelin, *Goteburgs Kugl. Veteusk. Vitterh.-Samh. Handb.*, Fjarde Puljden, 26 : 1-228.
1927. Caryaphyllaeinae Hunter, *J. Parasit.*, 14 : 16-26.
1927. Wenyoninae Hunter, *J. Parasit.*, 14 : 16-26.
1952. Wenyonidae : Wardle and Meleod, *The Zoology of Tapeworms*, University of Minnesota Press, Minneapolis, 780 pp.

Diagnosis : Vitellaria entirely medullary being always internal to and surrounded by inner longitudinal muscle layer, typically annularly arranged, occasionally lateral ; gonopore(s) and ovary situated in last fourth of body except *Wenyonia* Woodland, 1923 in which gonopores are in anterior half of body and uterus with a coat of uterine glands. Ovary is in posterior half of body.

Type genus : **Caryophyllaeus** Mueller, 1787.

Key to Indian genera of *Caryphyllaeidae*

Scolex broad, poorly defined, unspecialised, not marked off from rest of body ; neck absent ; testes few, arranged in two parallel longitudinal rows ; uterine coils extending anterior to cirrus sac ; postovarian vitelline follicles present ... ... *Paracaryophyllaeus* Kulakovskaya, 1961.

Scolex oval, well defined, unspecialised, distinctly marked off from body ; neck present, long narrow ; testes numerous, strewn in medulla anterior to cirrus sac ; uterine coils not extending anterior to cirrus sac ; postovarian vitelline follicles absent ... ... *Pseudocaryophyllaeus* Gupta, 1961.

Genus 1. **Paracaryophyllaeus** Kulakovskaya

1961. *Paracaryophyllaeus* Kulakovskaya, *Parazit. Sb.*, 20 : 339-355.

Diagnosis : Scolex broad, smooth, unspecialised, not marked off from rest of body ; neck absent ; testes arranged in two longitudinal rows on each side in medulla restricted much posterior to anterior level of vitellaria ; cirrus sac comparatively small ; ovary H-shaped, medullary ; uterine coils extending anterior to cirrus sac ; genital pores separate ; seminal receptacle present or absent ; vitellaria external and anterior to medullary testes ; postovarian set of vitellaria present. Parasites of cyprinoid fishes. Russia, India.

Type species: *P dubininae* Kulakovskaya, 1961 ; in *Misgurnus angusticaudatus*; Russia.

Key to Indian species of *Paracaryophyllaeus*

Scolex slightly rounded and widened as compared to rest of body ; testes 16-20 in number ; postovarian region comparatively less extensive ... ... *P lepidocephali* (Kundu, 1985)

Scolex truncated, not wider than rest of body ; testes 16-41 in number ; postovarian region comparatively much extensive ... ... *P. ostiobramensis* (Gupta and Parmer, 1984).

1. **Paracaryophyllaeus lepidocephali** (Kundu) n. comb.
(Figs. 13, 14)

1985. *Lytocestoides lepidocephali* Kundu, *Bull. zool. Surv. India*, 7 (2-3) : 285.

Material examined: Host—*Lepidocephalus guntea* (Hamilton), Loach, (Cypriniformes : Cobitidae) ; location—intestine ; localities—Garapota and Canning Town (West Bengal) ; no. of specimens—7+1, on 5+1 slides ; ZSI Regd. Nos. W. 7548/1 to W 7552/1.

Description: Body elongated, 4·77 long, 0·72 wide at ovarian region, slightly narrowing towards both ends. Scolex simple, smooth, unspecialised, slightly widened. Neck absent.

Testes globular, 16-20 in number, 0·14-0·19 in diameter, medullary, arranged in two longitudinal rows in front of cirrus sac (alignment may get disturbed during flattening), anterior extent remaining restricted to a level much posterior to anterior level of vitellaria. Vas deferens in loose coils in front of cirrus sac, surrounded by posteriormost testes. External seminal vericle absent. Cirrus sac comparatively small, globular or slightly oval, situated in anterior part of last third of body, enclosing much coiled ejaculatory duct, opening independently on midventral surface of body.

Ovary H-shaped, medullary ; wings follicular, 0·38-0·45 long, connected by a narrow strip of isthmus. Uterus in lateral coils, extending almost up to or anterior to cirrus sac (in additional material from Canning Town). Seminal receptacle absent. Vagina joining uterus near its distal end forming uterovaginal canal opening as female gonopore just behind male gonopore. Genital atrium undetectable. Shell gland complex behind ovarian isthmus. Vitelline follicles smaller than testes, extending from a little behind scolex to anterior horns of ovarian wings. Postovarian set of vitelline follicles present. Preovarian and postovarian vitellaria are connected by small and narrow follicles lateral to ovary.

Eggs oval, 40-50× 20-30 μm.

Remarks : Kundu (1985) described the present species under the genus *Lytocestoides* Baylis, 1928. A re-examination of the material of this species and the study of additional

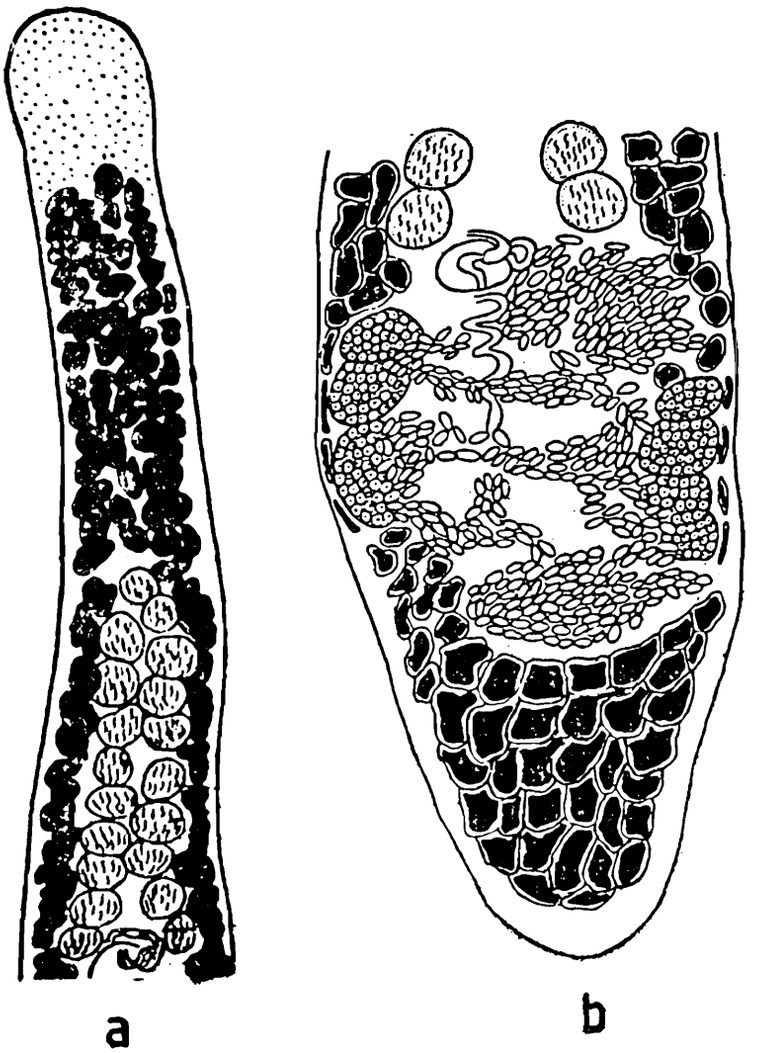

Fig. 13 : *Paracaryophyllaeus lepidocephali* (Kundu, 1985)
a. Anterior half of body (After Kundu, 1985),
b. Posterior half of body (Redrawn from holotype).

material (a broken specimen) from the type host *Lepidocephalus guntea* examined at Canning Town, West Bengal, reveal that the uterine coils extend almost up to level of anterior limit of cirrus sac in Kundu's material whereas they extend anterior to cirrus sac in the additional broken material. The species cannot belong to the genus *Lytocestoides* because its scolex is slightly widened, far less number (16-20) of testes characteristically arranged in two longitudinal rows, remaining restricted much behind anterior level of vitellaria, and the uterus extending anterior to cirrus sac. Thus, the species fits more appropriately in the genus *Paracaryophyllaeus* Kulakovskaya, 1961 rather than in *Lytocestoides*.

The type species *Paracaryophyllaeus dubininae* Kulaskovskaya, 1961 was also described from a cobitid fish from Russia. *P. lepidocephali* (Kundu, 1985) closely resembles the

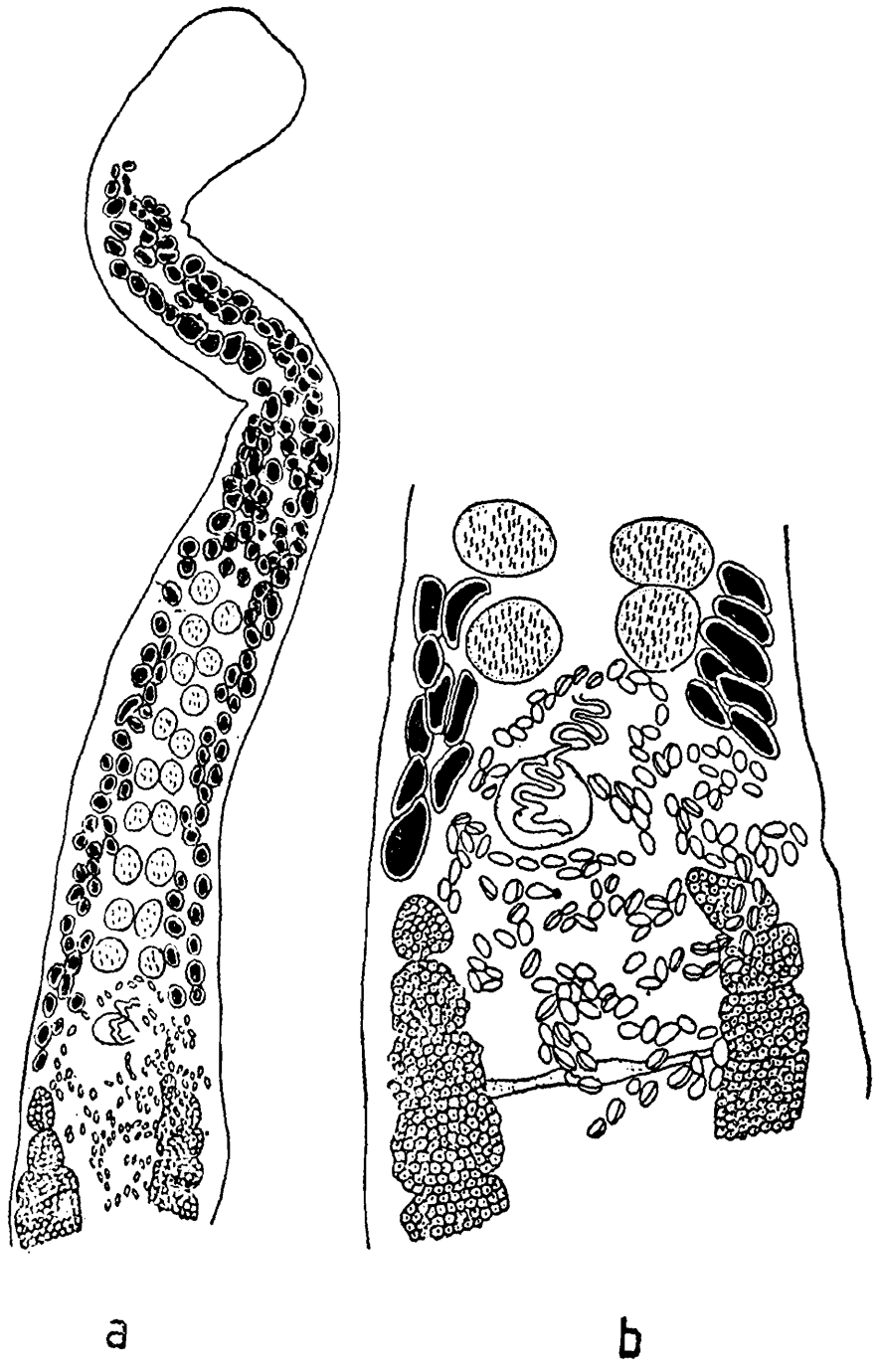

Fig. 14 : *Paracaryophyllaeus lepidocephali* **(Kundu, 1985) from additional material from Canning Town**
a. Anterior half of body,
b. Middle-third of body.

t ype species. Apparently, there seem to be no pronounced morphological differences between t hem, except that in *P. lepidocephali* some vitelline follicles lateral to ovarian wings connect

the preovorian and postovarian sets of vitellaria and the absence of seminal receptacle. The literature on *P. dubininae* could not be made available for adequate comparision.

The discovery of this species from India extends the distribution of the genus *Paracaryophyllaeus* from Palaearctic to Oriental region also.

Distribution: West Bengal : Garapota (District : North 24-Parganas), Canning Town (District : South 24-parganas).

2. **Paracaryophyllaeus ostiobramensis** (Gupta and Sinha) n. comb.

(Fig. 15)

1984. *Pliovitellaria ostiobramensis* Gupta and Sinha, *Indian J. Helminth.*, 36 (1) : 73.

Material examined : Nil.

Host—*Ostiobrama cotio* (Hamilton), (Cypriniformes : Cyprinidae) ; location—intestine ; locality—Lucknow (river Gomti) ; no. of specimens—9 mature + 6 immature, no transverse sections.

Description : Body elongated, 6·87-9·66 long, 0·60-1·05 wide. Scolex undifferentiated from rest of body, poorly defined, truncated, unspecialised (without bothria). Neck absent.

Testes 16-41, in two longitudinal row (Alignment shown disturbed probably during processing), ovoid, 0·06-0·19 in diameter, medullary, extending from much behind (about 2·00-3·00) anterior level of vitellaria to cirrus sac. External seminal vesicle absent. Vas deferens a small straight duct in front of cirrus sac. Cirrus sac 0·01-0·46 × 0·35-0·46, ovoid, situated at 1·93-3·86 from posterior end of body, enclosing much convoluted and bell-shaped ejaculatory duct, opening as male gonopore on midventral surface.

Ovary H-shaped, much anteriorly removed (1·22-2·46) from posterior end of body ; ovarian wings 0·35-0·75 long, connected by an isthmus. Ootype and shell gland complex posterior to ovarian isthmus. Uterus coiled, first descending posteriorly to some distance, then ascending anteriorly up to almost anterior level of cirtus sac (as is evident from Fig. 15b) and then passing posteriorly up to posterior end of cirrus sac joining vagina to form a short uterovaginal canal. Uterovaginal canal opening as female gonopore immediately behind male pore. Seminal receptacle not knowu. Vitellarium follicular, follicles smaller than testes, entirely medullary surrounding testes, extending from some distance behind scolex to cirrus sac. Postovarian set of vitelline follicles present. Preovarian and postovarian vitellaria connected laterally by a row of vitelline follicles.

Eggs oval, 30-49 × 35-48 μm.

Excretory vesicle Y-shaped ; pore terminal.

Remarks : The genus *Pliovitellarium* Fischthal, 1951 is characterised by having one dorsal and one ventral deep acetabulum-like bothria on the scolex, one common genital pore, presence of external seminal vesicle and uterus remaining restricted to posterior level of

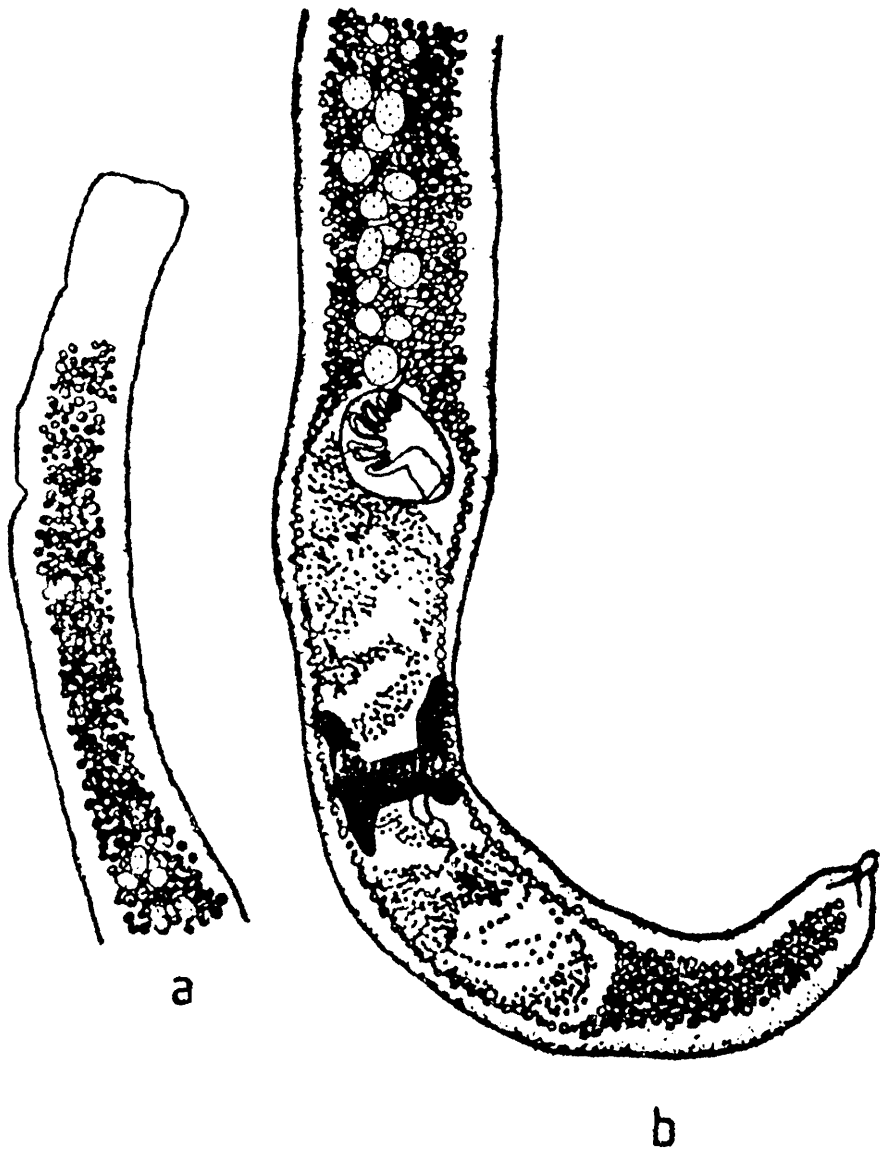

Fig. 15 : *Paracaryophylleus osteobramensis* (After Gupta and Sinha, 1984).
a. Anterior part of body,
b. Posterior part of body.

vitellaria. Judging from Figs. 15a, b, male and female pores appear to be separate, external seminal vesicle is absent, uterus extends almost to anterior level of cirrus sac and the testes commence from a level much behind anterior level of vitellaria.

Moreover, there does not seem to be present a single bothrium on the scolex. In all probabilities it appears to be an artefact of fixation rather than a real acetabulum-like bothrium. Thus, the present species does not appear to be referrable to the genus *Pliovitellarium* Fiscthal, 1951. It fits more appropriately in the genus *Paracaryophyllaeus* Kulaskovskaya, 1961 which has an unspecialised scolex not marked off from rest of body, two longitudinal rows of testes which commence from a level much behind anterior level of vitellaria, uterus extending almost up to anterior level of cirrus sac or even beyond and postovarian set of vitelline follicles.

Thus, there are two species of *Paraceryophyllaeus* from India : *P. lepidocephali* (Kundu, 1985) and *p. ostiobramensis* (Gupta and Parmar, 1984) both from cypriniformes fishes. The latter differs from the former in having truncated and not widened apex of scolex, more number (16-41) of testes and comparatively longer postovarian region of body.

Genus 2. **Pseudocaryophyllueus** Gupta

1961. *Pseudocaryophyllaeus* Gupta, *Proc. helminth. Soc. Washington*, 28 (1) : 43.
1961. *Capingentoides* Gupta, *Proc. helminth. Soc. Washington*, 28 (1) : 46.

Diagnosis : Scolex oval or conical, truncated at apex or not, unspecialised, distinctly marked off from neck behind. Neck present, long, narrow. Testes in most of medullary parenchyma auterior to cirrus sac. External seminal vesicle absent. Ovary H-shaped. Uterus not extending anterior to cirrus sac. Two separate genital pores. Preovarian vitellaria surrounding testes, internal to inner longitudinal muscles. Seminal receptacle absent. Postovarian vitelline follicles absent. Parasites of siluroid fishes, India.

Type species : *Pseudocaryophyllaeus indica* Gupta, 1961, India ; in *Clarias batrachus* (L.) ; India.

3. **Pseudocaryophyllaeus indica** Gupta

(Figs. 16-20)

1961. *Psendocaryophyllaens indica* Gupta, *Proc. helminth, Soc. Wash.*, 28 (1) : 43.
1961. *Capingenioides batrachii* Gupta, *Proc. helminth, Soc. Wash.*, 28 (1) : 46.
1984. *Pseudocaryophyllaeus mackiewiczi* Gupta, V. and Parmar, *Indian J. Helminth.*, (1982), 34 (2) : 136.
1984. *Pseudocaryophyllaeus ritai* Gupta, V. and Singh, *Indian J. Helminth.*, (1983), 35 (1) : 11.
1984. *Pseudocaryophyllaeus lucknowensis* Gupta and Sinha, *Indian J. Helminth.*, 36 (1) : 73.

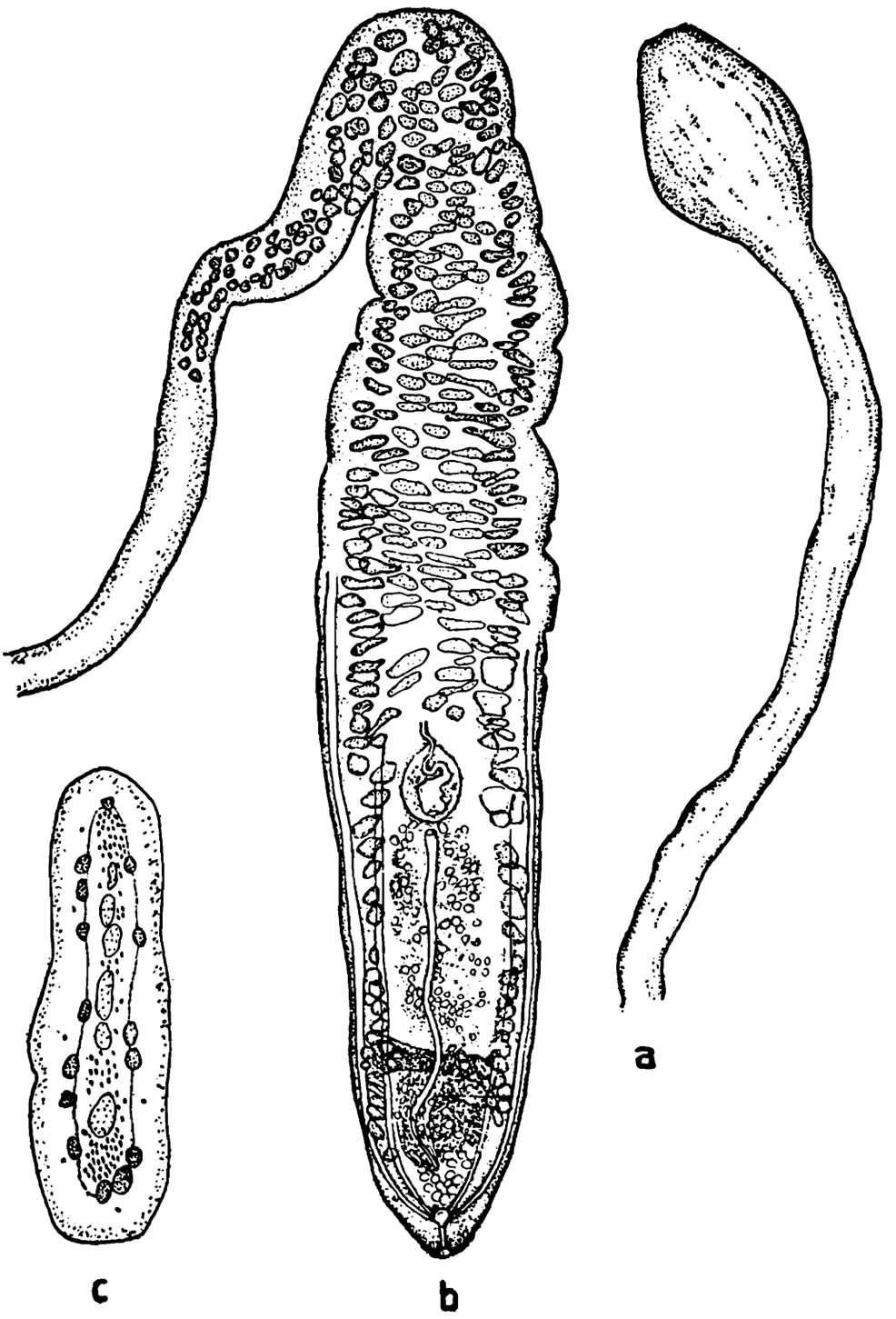

Fig. 16 : *Pseudocaryophyllaeus indica* (After Gupta, 1961)
a. Scolex and part of neck,
b. Main body and part of neck,
c. Cross-section of body.

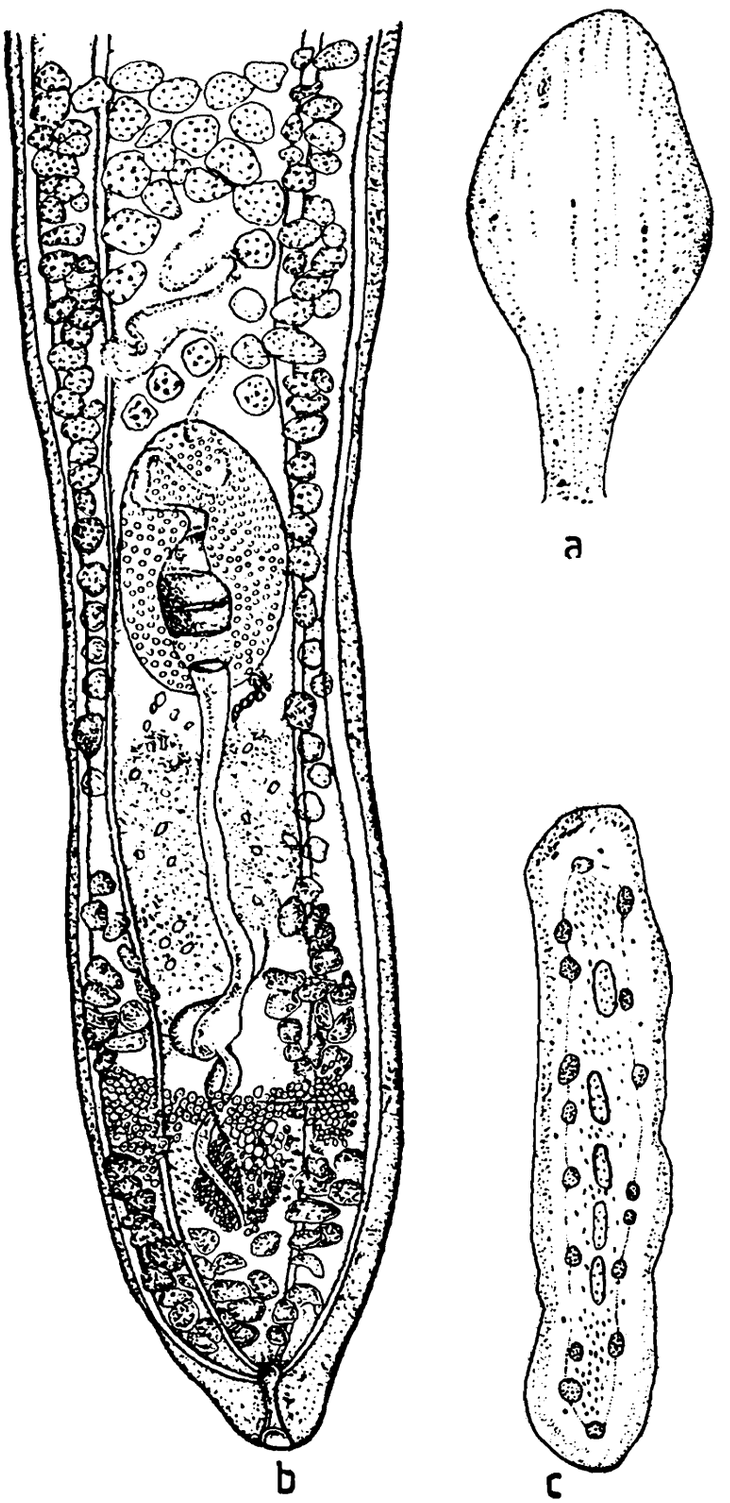

Fig. 17 : *Capingentoides batrachii* (After Gupta, 1961)
a. Scolex,
b. Posterior half of body,
c. Cross-section of body.

Material examined : Nil.

Host—*Clarias batrachus* (L.), Walking cat-fish, (Siluriformes : Clariidae), *Heteropneustes fossilis* (Hamilton), Stinging cat-fish, (Siluriformes : Heteropneustidae) and *Rita rita* (Hamilton), Rita (Siluriformes : Bagridae) ; location—intestine ; localities—Guwahati (river Brahmaputra) ; Lucknow (river Gomti) and Gorakhpur (river Rapti) ; no. of specimens—numerous.

Description : Body elongated, about 13·0-25·0 long, 0·65-1·35 in maximum width. Scolex oval or cone-shaped, truncated anteriorly, distinctly marked off from neck behind. Neck slender, long, 5·04-8·74 long, 0·175-0·365 wide. Trunk or main body cylindrical, 7·48-14·96 long, posterior end rounded.

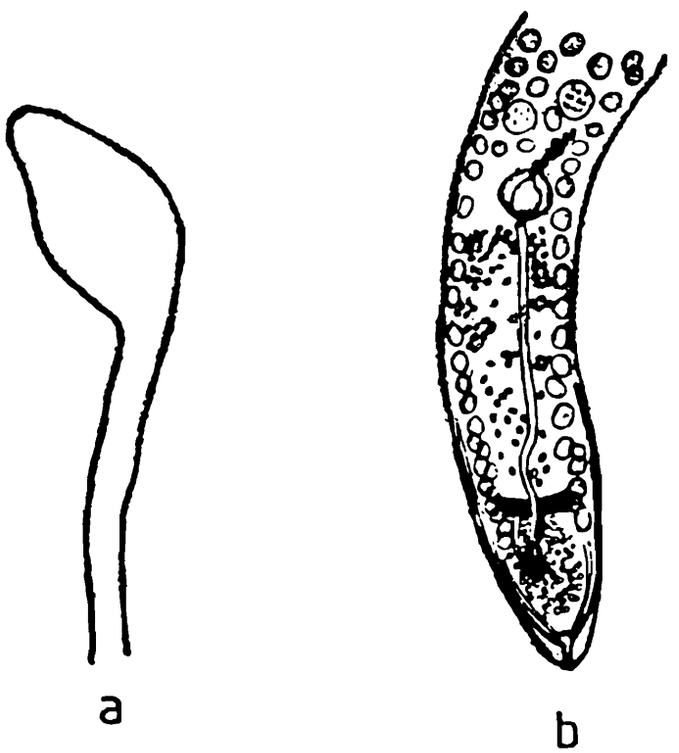

Fig. 18 : *Pseudocaryophyllaeus mackiewiczi* (After Gupta and Parmar, 1984)
a. Scolex and part of neck,
b. Posterior half of body.

Testes numerous, spherical to oval, 0·14-0·28 × 0·06-0·11, medullary, extending from a level behind anteriormost vitelline follicles to cirrus sac, surrounded by annular vitelline follicles. Inner longitudinal muscle layer external to testes and vitellaria. Vas deferens oosely convoluted in front of cirrus sac. External seminal vesicle absent. Cirrus sac large, oval, 0·43-0·61 × 0·26-0·41, enclosing bell-shaped ejaculatory duct, situated at 1·75-2·98 from posterior end of body, opening midventrally by male gonopore.

Ovary H-shaped ; wings strongly follicular, lateral posterior ovarian follicles may not be extending up to posterior end of body, connected by medullary isthmus. Uterus in lateral coils in post- and pre-ovarian parts, with uterine gland cells, not extending beyond cirrus sac. Vagina a slightly convoluted tube running medianly on ventral side, terminally joining with uterus to form a short utero-vaginal canal. Utero-vaginal canal opening mid-ventrally as female gonopore on ventral side just behind male gonopore. No common genital atrium. No seminal receptacle. Vitellaria medullary, internal to inner longitudinal muscle layer, annularly surrounding testes, extending from posterior region of neck to anterior horns of ovarian wings, follicles occasionally continuing with follicles of ovary. Shell gland complex posterior to ovarian isthmus. Eggs oval, 50-60× 35-45 μm.

Main osmoregulatory canals 4, 2 on each side, joining posteriorly forming a short tubular excretory vesicle ; excretory pore terminal.

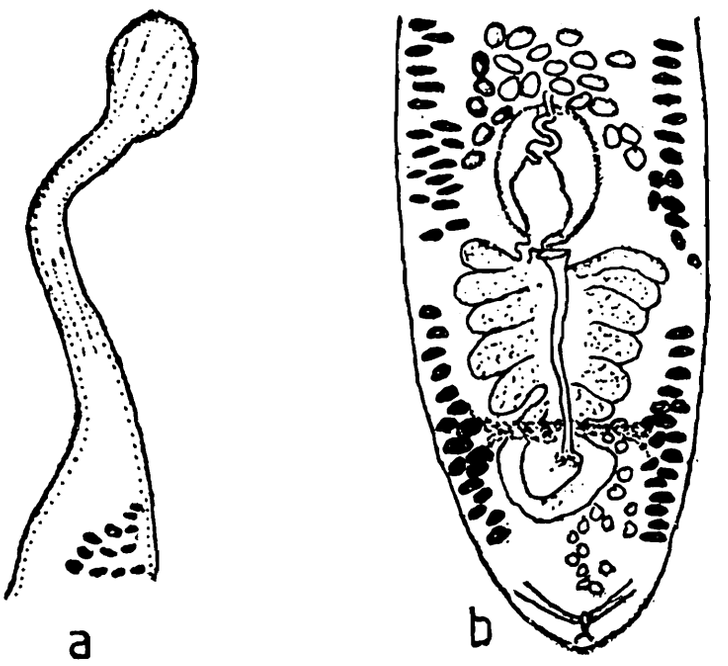

Fig. 19 : *Pseudocaryophyllaeus ritai* **(After Gupta and Singh, 1984)**
a. Scolex and neck,
b. Posterior half of body.

Remarks : Mackiewicz (1981) has re-examined the whole mounts and sections of ***Pseudocaryophyllaeus indica*** Gupta, 1961 and *Capingentoides batrachii* Gupta, 1961, both from the cat-fish *Clarias batrachus* from the river Brahmaputra at Guwahati, Assam. He observes that the inner longitudinal muscle layer is clearly external to the testes and vitellaria in ***P. indica***, and there are no postovarian vitelline follicles in both the species. He

further observes that the scolex, general description and the arrangement of musculature in relation to testes and vitellaria are essentially the same in both the species. That means the male and female gonopores open separately in *Capingentoides batrachii* too, and thus it becomes conspecific with *Pseudocaryophyllaeus indica.* Consequently, *Capingentoides* Gupta, 1961 becomes synonymous with *Pseudocaryophyllaeus* Gupta, 1961.

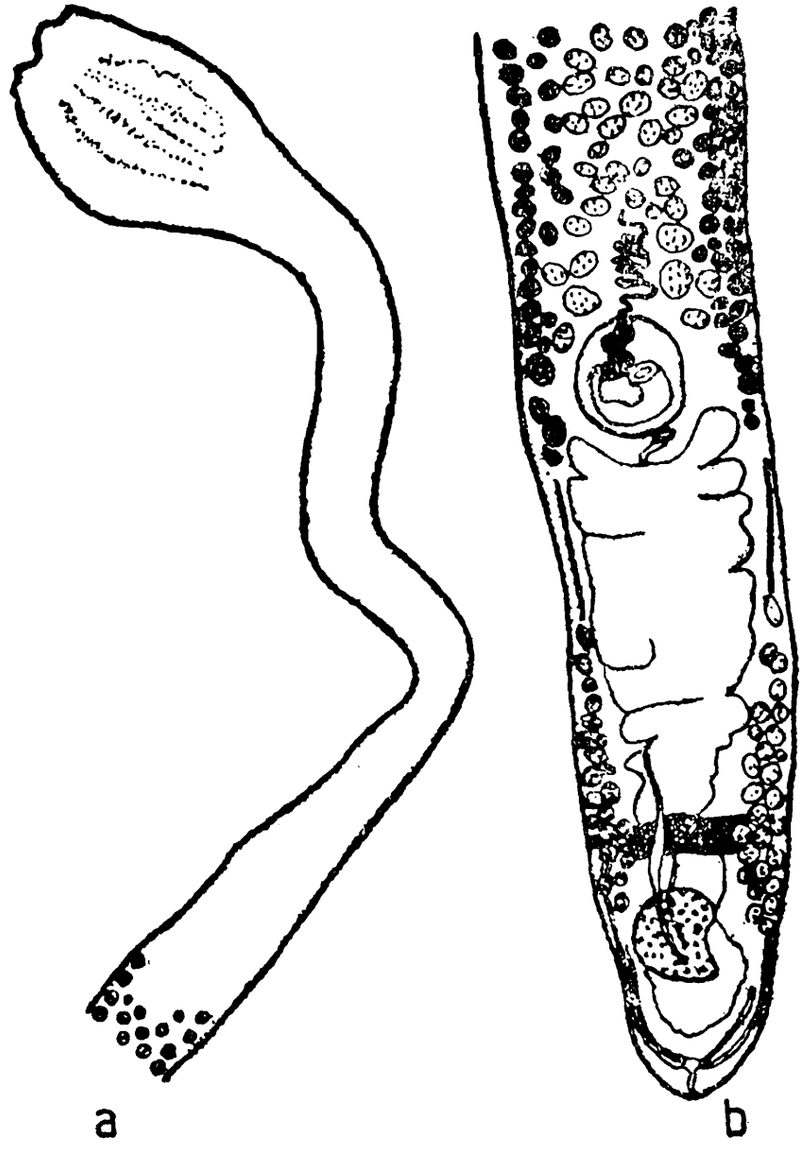

Fig. 20 : *Pseudocaryophyllaeus lucknowensis* **(After Gupta and Sinha 1984)**
a. Scolex and neck,
b. Posterior half of body.

Pseudocaryophyllaeus mackiewiczi Gupta, V. and Parmar, 1984 and *P. lucknowensis* Gupta, S. P. and Sinha, 1984 with distinctly marked off oval scolex followed by long narrow neck and elongated trunk, have been described from the fish *Heteropneustes fossilis* from

river Rapti at Gorakhpur and river Gomti at Lucknow respectively but without studying transverse sections. *P. mackiewiczi* appears to be reported from very young specimens with very few testes (5-10 only). The two species have been differentiated from the type species *P. indica* Gupta, S. P. 1961 on the basis of variable characters which occur either due to age or state of contraction and relaxation at the time of fixation. Hence, both of them are also considered as synonyms of *Pseudocaryophyllaeus indica* Gupta, S. P. 1961. *Pseudocaryophyllaeus ritai* Gupta, V. and Singh, 1984, has been described from the fishes *Rita rita* from Lucknow without studying the cross-sections. It also essentially resembles *Pseudocaryphyllaeus indica* Gupta, S. P, 1961 in scolex neck and general description. Therefore, it is also synonymised with *P. indica.*

Agarwal (1985), however, considers *Pseudocaryphyllaeus indica* Gupta, 1961 as belonging to the family Lytocestidae since on re-examination of the sections of this species he finds vitellaria cortical rather than medullary contray to the re-examination of the material by Mackiewicz (1981). However, till fresh information on muscle—vitellaria relationship becomes available in *P. indica* Gupta, 1961, it is tentatively kept in the family Caryophyllaeidae.

Family II. CAPINGENTIDAE Hunter

1929. Pseudolytocestinae Hunter, *J. Parasit.*, 15 : 185-192.
1930. Capingentinae Hunter, *Illinois biol. Monogr.* II, (1927), 186 pp.
1952. Capingentidae : Wardle and McLeod. *The Zoology of Tapeworms*, University of Minnesota Press, Minneapolis, 780 pp.

Diagnosis : Resembling Lytocestidae in most characters. Vitellaria cortical (external to inner longitudinal muscles) only for one-third to one-half of their length while remainder lying in medulla (internal to inner longitudinal muscles) from where they arise. Gonopores and ovary in last fifth of body. Uterine glands present.

Type genus : *Capingens* Hunter, 1972.

Key to Indian genera of *Capingentidae*

Scolex smooth, wide, truncated or slightly convex, reduced ; anterior extent of testicular field near anterior end of body ; ovary usually butterfly-or bowtie-shaped ... ... *Breviscolex* Kulakovskaya, 1962.

Scolex smooth, wide, slightly convex, not reduced ; anterior extent of testicular field remaining restricted appreciably behind scolex ; ovary shaped like an inverted A ... ... *Adenoscolex* Fotedar, 1958.

Genus 3. **Adenoscolex** Fotedar

1958. *Adenoscolex* Fotedar, *J. Helminth.*, 32 (1-2) : 10.
1981. *Adenoscolex* : Mackiewicz, *Himalayan J. Sci.*, 1 (1) : 7.

Diagnosis : Scolex smooth, unspecilised, slightly widened, not marked off from rest of body. Neck absent. Male and female gonopore separate in posterior seventh of body length. External seminal vesicle absent ; internal seminal vesicle present. Ovary entirely in medullary parenchyma, inverted A-shaped. Uterus not extending anterior to cirrus sac. Seminal receptacle present. Vitellaria mostly dumbbell-shaped, annularly arranged surrounding testes. Post-ovarian vitelline follicles present. Eggs with blunt protuberance near basal end. Parasites of cyprinid fishes.

Type species : *Adenoscolex oreini* Fotedar, 1958, in *Oreinus sinuatus* ; Kashmir ; India.

4. **Adenoscolex oreini** Fotedar

(Fig. 21)

1958. *Adenoscolex oreini* Fotedar, *J. Helminth.*, 32 (1-2) : 10.
1981. *Adenoscolex oreini* : Mackiewicz, *Himalayan J. Sci.*, 1 (1) : 7.
1985. *Adenoscolex oreini* : Agarwal, *Indian Rev. Life Sci.*, 5 : 142.

Material examined : Nil.

Host—*Oreinus sinuatn*s (Heckel), (Cypriniformes : Cyprinidae) ; location—intestine ; locality—Anantnag (Arapat stream), Kashmir ; no. of specimens—several, with Transverse Sections.

Description : Body elongated, 38·00 in maximum length, 2·0 in maximum width, anterior end truncated, posterior end blunt ; worms with testes and without eggs 18·0 × 1·3. Scolex smooth, unspecialised, slightly wider than body width, 1·0 × 2·0, not marked off from body, profusely furnished with gland cells. Neck absent.

Testes numerous, rounded or oval, 0·15-0·23 in diameter, larger than vitelline follicles, medullary, extending from a level some distance behind scolex to cirrus sac. Vas deferens strongly coiled in front of cirrus sac. External seminal vesicle absent. Cirrus sac oval, 0·4-0·575 × 0·325-0·375, enclosing internal seminal vesicle and ejaculatory duct, opening to exterior on ventral surface as male gonopore.

Ovary basically H-shaped, with posterior ends of wings strongly bent inwards (but not fusing together) giving an appearance of inverted 'A', wings connected by

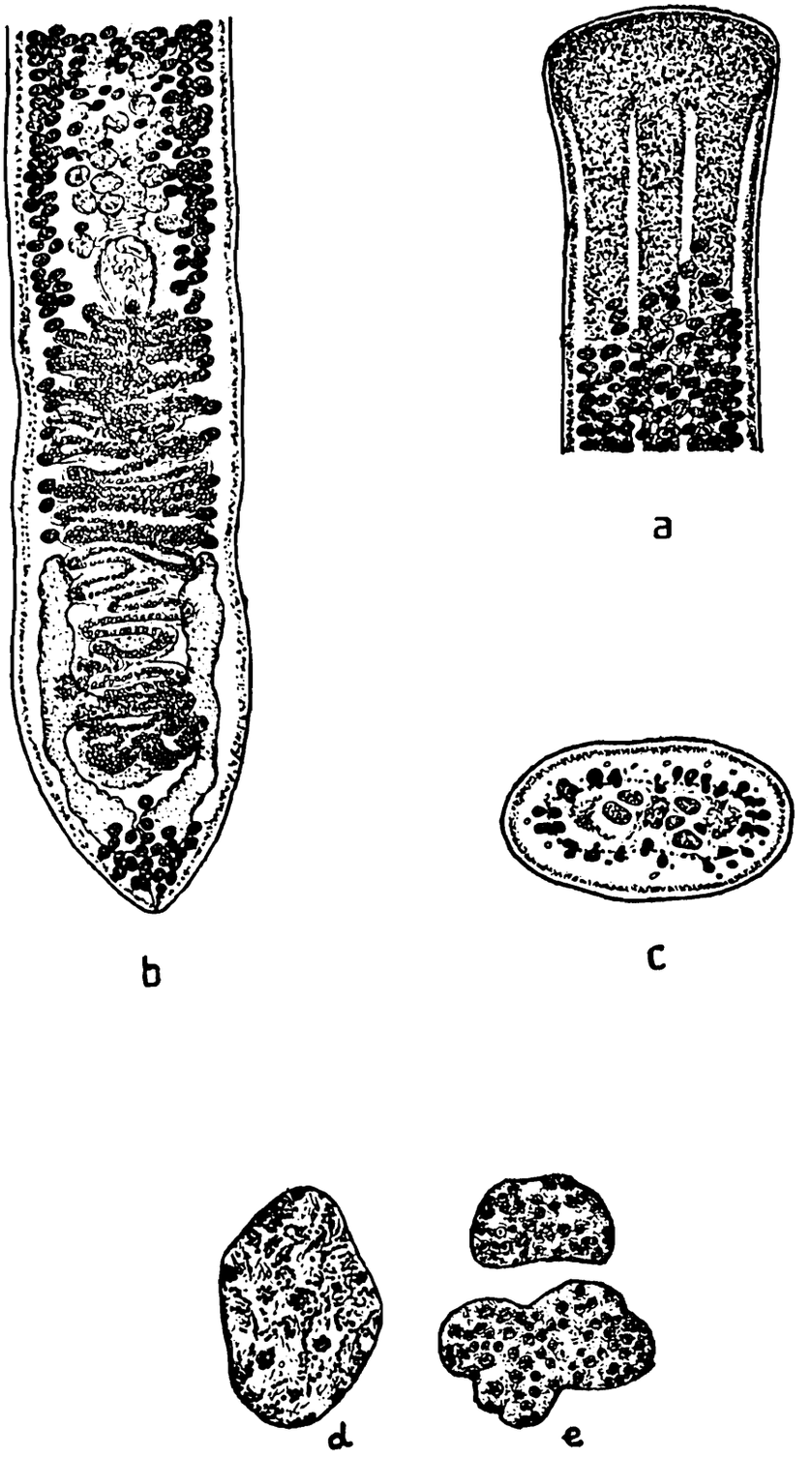

Fig. 21 : *Adenoscolex oreini* (After Fotedar, 1958)

a. Anterior part of body,
b. Posterior half of body,
c. Cross-section of body,
d. Testis,
e. Vitelline follicles in cross-section.

isthmus or commissure, entirely medullary, wings 1·9-2·2 long, 0·25-0·37 wide. Uterus well developed, compactly coiled behind ovarian isthmus, thrown in symmetrically transverse coils anterior to isthmus, posterior coils not surrounded by gland eells while anterior coils with thick coat of them, not extending beyond cirrus sac. Vagina almost a straight tube, ventral in disposition, joining terminally with uterus to form a short uterovaginal canal opening midventrally as female gonopore behind male gonopore. Common genital atrium absent. Seminal receptacle present anterior to ovarian isthmus. Shell gland complex well developed, situated behind isthmus.

Vitellarium follicular, follicles irregular, dumbbell-shaped, 0·075-0·105 in diameter, partly medullary and partly cortical, annular in arrangement, extending from testicular level to posterior level of cirrus sac, then arranged loosely in a single row on each side of uterus terminating in front of anterior horns of ovarian wings. No vitelline follicles lateral to ovarian region. Postovarian set of vitelline fallicles present. Eggs ovoid, mature ones 64-75 × 36-48 μm.

Remarks: The species was never reported again after its original report in 1958. It may be endemic restricted to the cypriniformes fishes of the hill streams of Kashmir. Fotedar (1958) has given a vivid and comprehensive account of this species.

Distribution: Anantnag (Kashmir); India.

Genus 4. **Breviscolex** Kulakovskaya

1962. *Breviscolex* Kulakovskaya, *Doklady Akademii Nauk* SSSR, 143 : 386-388.
1986. *Breviscolex* Schmidt, *CRC Handbook of Tapeworm Identification*, CRC Press, Inc Boca Raton, Florida, 38.

Diagnosis: Scolex smooth, wide, truncated or slightly convex, reduced (very short), not marked off from body behind. Neck absent. Male and Female gonopores separate. Common genital atrium apparently present in posterior part of middle third of body. Anterior level of testicular field near anterior end of body. External seminal vesicle absent. Ovary usually butterfly- or bowtie-shaped. Uterus not extending anterior to cirrus sac. Seminal recepatacle present or not. Vitellaria extending from a little behind anterior testes to anterior ovarian wings, medial and lateral to testes. Postovarian vitellaria present. Parasites of cyprinid fishes. Russia, India.

Type species: *B. orientalis* Kulakovskaya, 1962 : in *Hemibarbus maculatus*, *Chilogobio czarskii*; Amur river basin, Siberia (Russia).

Key to Indian species of *Breviscolex*

Number of testes 50-100	...	*B. naldurgensis* (Shinde *et al.* 1987) n. comb.
Number of testes 200-350	...	*B. aurangabadensis* (Shinde, 1970) n. comb.

5. **Breviscolex aurangabadensis** (Shinde) n. comb.

(Figs. 22-24)

1970. *Lytocestoides aurangabadensis* Shinde. *Marathwada Univ. J. Sci.*, 9 : 173.
1970. *L. aurangabadensis* var. *minor* Shinde, *Ibid*, 9 : 174.
1970. *L. aurangabadensis* var. *minuta* Shinde, *Ibid*, 9 : 175.
1981. *L. aurangabadensis* : Mackiewicz, *Himalayan J. Sci.*, 1 (1) : 6.

Material examined : Nil.

Host—*Barbus kolus* (Sykes), *Labeo calbasu* (Hamilton), (Cypriniformes : Cyprinidae) ; location—intestine ; localities—Godavari river at Paithan and Purna river (locality not given) in Maharashtra ; no. of specimens—Six whole mounts ; no cross-sections.

Description : Body elongated, 4·72-6·5 long, 0·89-1·17 wide, slightly tapering posteriorly. Scolex reduced, wide, broadly rounded, unspecialised, broader than rest of body. Neck absent. Male and female gonopores separate on ventral surface in beginning of last third of body. Common genital atrium not known. Testes follicular, about 200-350 in number, 0·13-0·16 in diameter, medullary, distributed from base of scolex to cirrus sac. Vas deferens in front of cirrus sac. External and internal seminal vesicles not known. Cirrus sac 0·34-0·45 long, 0·21-0·28 wide, situated in begining of posterior third of body, enclosing winding ejaculatory duct and cirrus, opening ventrally as male gonopore.

Ovary bilobed, dumbbell-shaped, in posterior third of body ; ovarian lobes connected by short isthmus, 0·38-0·78 long, 0·17-0·53 wide. Uterine region short, not extending anterior to cirrus sac. Vagina joining uterus near its anterior end to form a short utero-vaginal canal opening midventrally as female pore slightly posterior to male pore. Shell gland complex behind ovarian isthmus. Seminal receptacle not known. Vitellaria annular, extending from anterior level of testes to ovary. Post-ovarian vitellaria present, follicular (originally described as testes). Pre- and post-ovarian vitelline follicles connected by vitellaria lateral to ovarian lobes.

Intrauterine eggs 50-60 × 30-32 μm.

Remarks : Mackiewicz (1981) has examined the material of this species. He found that the specimens were "decomposed" and "compressed", and due to poor condition

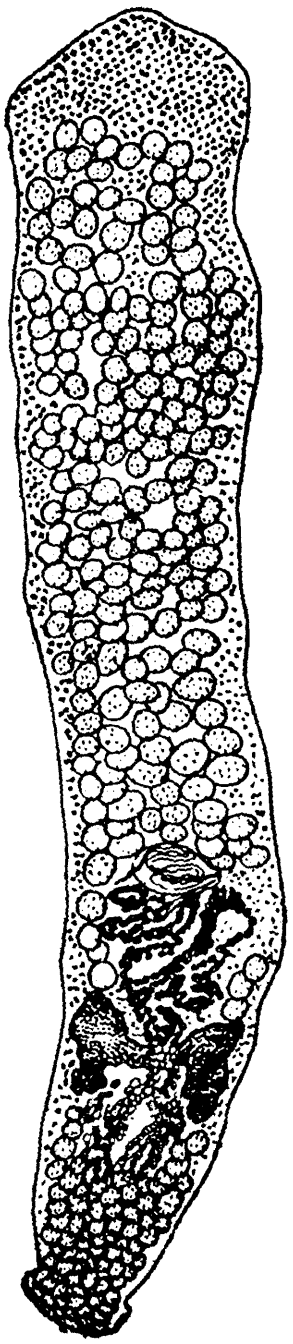

Fig. 22 : *Breviscolex aurangabadensis* **(Shinde)**
Entire worm (After Shinde, 1970).

of the material he was unable to determine its genus. From Figs. 22, 23 & 24 it can be very easily judged that the posterior fon-shaped pseudostructure was formed and in the specimen of Fig. 23 the follicles of testes were pushed in the scolex region due to crushing only during processing. Mackiewicz (in a personal communication dated September 3,

1985) informed me that all testes are preovarian ; there are no postovarian testes, instead there are post-ovarian vitelline follicles in the postovarian region. The follicular nature of

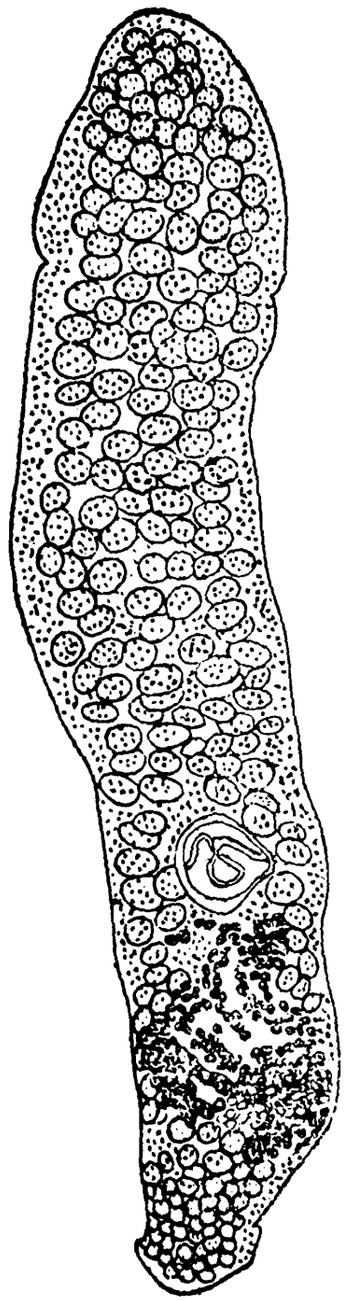

Fig. 23 : *Lytocestoides aurangabadensis minor* **Shinde**
Entire worm. (After Shinde, 1970).

postovarian vitellaria gives the clue that the preovarian vitellaria must also be follicular rather than granular,

Shinde (1970) did not cut cross-sections of the body due to which the position of the inner longitudinal muscle layer in relation to vitellaria is difficult to ascertain, thus inhibiting the determination of the family of the species. As the author has mentioned that the vitellaria are cortical he kept his species in the family Lytocestidae. The original description

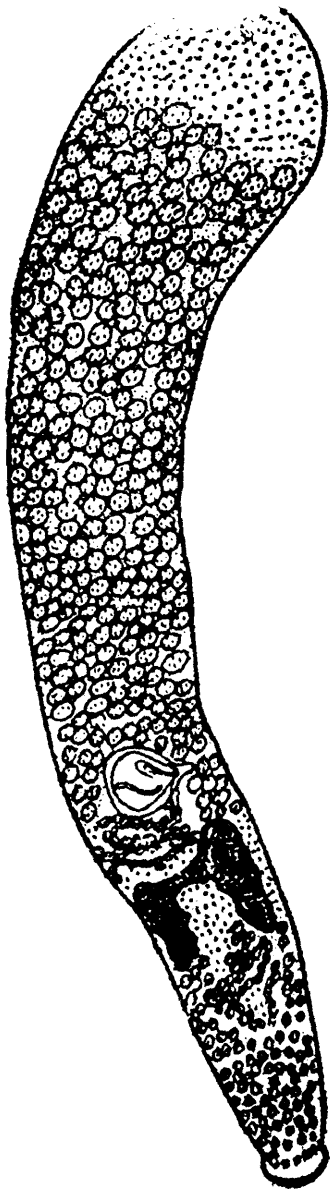

Fig. 24 : ***Lytocestoides aurangabadensis minuta*** **Shinde**
Entire worm (After Shinde, 1970).

of the species is not very reliable. The species may not belong to the family Lytocestidae and genus *Lytocestoides* because its anterior part is not narrower than the rest of the body. On the contrary, the scolex is reduced, wide and broadly rounded and the body tapers gradually towards posterior end only right from wide scolex. In *Lytocestoides* the scolex is

narrow and conical, and body tapers on both sides. It is quite probable that the vitellaria may be partly internal to the inner longitudinal muscle layer surrounding testes and partly outside it. The characters like reduced and widened scolex, the body tapering gradually posteriorly right from anterior end, testes extending to near anterior end of body, presence of postovarian follicles of vitellaria and butterflly-shaped ovary suggest the genus *Breviscolex* Kulaskovskaya, 1962 in the family Capingentidae. As is the case with the genus *Breviscolex*, the present species has also been recovered from a cyprinid fish. Attempt should be made to restudy it by collecting fresh material from the type host and locality. Till then the species *Lytocestoidea aurangabadensis* Shinde, 1970 and *Lytocestoides naldurgensis* Shinde *et al.*, 1987 are tentatively kept in the genus *Breviscolex* under the family Capingentidae.

6. **Breviscolex naldurgensis** (Shinde, Mohekar, Jadav, and Hafeezullah) n. comb. (Figs. 25-26)

1987. *Lytocestoides naldurgensis* Shinde, Moheker, Jadav and Hafeezullah, *Bull. zool. Surv. India*, 8 (1-3) : 198.

1987. *L. mackiewiczi* Shinde, Mohekar, Jadav and Hafeezullah, *Ibid*, 8 (1-3) : 199, (n. syn.).

Material examined : Nil.

Host—*Cirrhina mrigala* (Hamilton), Mrigal, (Cypriniformes : Cyprinidae) ; location—intestine ; locality—Naldurg ; (Dist. Osmanabad, Maharashtra) ; no. of specimens—10+15 ; no cross-sections.

Description : Body elongated, broad anteriorly, gradually tapering posteriorly, 4·77-6·00 long, 1·00-1·55 wide. Scolex short, wide, broadly rounded unspecialised, 0·66 long, 1·50-1·55 wide at base, shape variable. Neck absent. Male and female gonopores on ventral surface in anterior part of second half of body. No common genital atrium.

Testes 50-85 in number, 0·10-0·19 in diameter, in central medulla in a single field, extending from base of scolex to cirrus sac. Vas deferens in front of cirrus sac. External seminal vesicle absent. Cirrus sac small, about 0·30 in diameter, posterior to middle of body, enclosing ejaculatory duct and cirrus, opening as male pore ventrally.

Ovary dumbbell- or butterfly-shaped, lobes connected by narrow isthmus, follicular, medullary, in posterior region of body, 0·33-0·53 long, 0·54-0·77 wide. Uterine region comparatively short, uterus glandular, not extending anterior to cirrus sac. Vagina joining uterus to form a short uterovaginal canal opening ventrally posterior to male pore. Seminal receptacle absent. Vitellaria follicular, follicles smaller than testes, Post-ovarian vitelline

follicles present. Pre- and post-ovarian vitelline follicles continuous lateral to ovary. Intrauterine egg numerous, 56-67 × 33-44 μm.

Remarks : It is not clear from the study of *Lytocestoides naldurgensis and L. mackiewiczi* whether the two species occurred in the same population or they were recovered sepapately. The former has been differentiated from the latter in having less number of testes (50-55 vs 80-85) and in that the lateral vitelline follicles are in a single row rather than two.

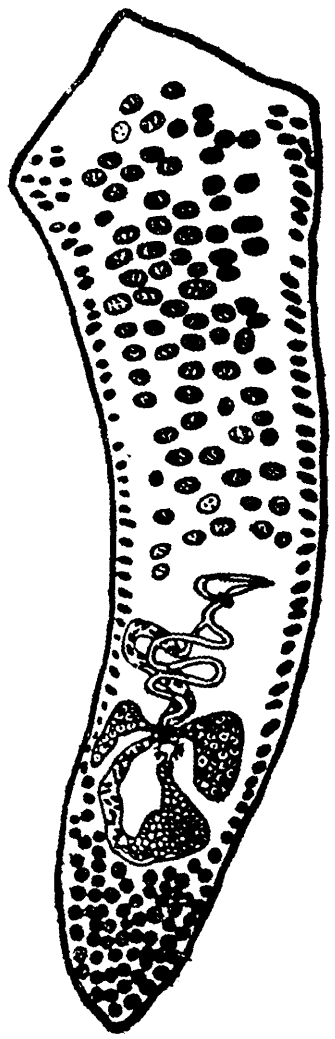

Fig. 25 : *Breviscolex naldurgensis* (Shinde *et al.*)
Entire worm. (After Shinde *et al.*, 1987)

These differences are considered mearge and not morphologically pronouced. These characters may be variable if large populations are studied. Therefore *L. mackiewiezi* has been considered as a synonym of *L. naldurgnesis*.

The comments regarding familly and genus allocations of this species as given under *L. aurangabadensis* are applicable in this case also.

Distribution : Naldurg (Maharashtra State).

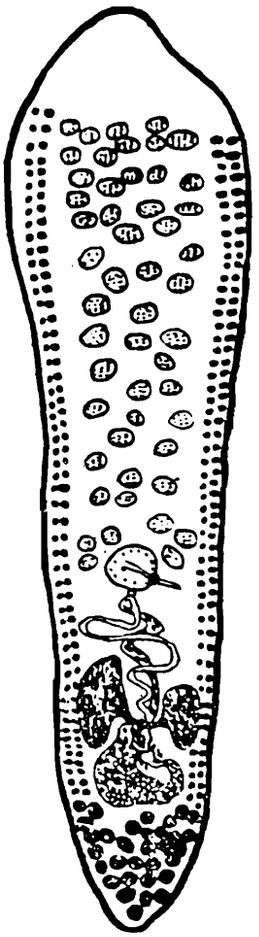

Fig. 26 : *Lytocestoides mackiewiczi* Shinde *et al.*, Entire worm. (After Shinde *et al.*, 1987).

Family III. LYTOCESTIDAE Hunter

1927. Lytocestinae Hunter J. *Parast.*, 14 : 16-26.
1931. Bovieninae Fuhrmann, In : *Handbuch der Zoologie* (W. Kukenthal and T. Krumbach, eds.), pp. 141-416.
1952. Lytocestidae : Wardle and McLeod, *The Zoology of Tapeworms*, University of Minnesota Press, Minneapolis, 780 pp.
1959. Lallidae Johri, *Z. Parasitenkd.*, 19 : 368-374.
1980. Djombanginae Satpute and Agarwal, *Proc. Indian Acat. Parasit.*, 1 : 13-16.

Diagnosis : Vitellaria cortical being external to inner longitudinal muscle layer, annualarly arranged around it and medullary testes in pre-uterine region, occasionally

lateral ; gonopore and ovary usually in last quarter of body ; ovary basically wing- or H-shaped, ovarian arms cortical while isthmus medullary ; uterine glands present.

Type genus : *Lytocestus* Cohn, 1908.

Key to Indian genera of Lytocestidae

1. Post-ovarian vitellaria present ... ... *Lytocestoides* Baylis, 1928.
   Post-ovarian vitellaria absent ... ... 2.
2. Scolex specialised with a terminal pseudobothrium or introvert ; uterine coils reaching nearly as far forward as testes ... *Djombangia* Bovien, 1926.
   Scolex unspecialised ; uterine coils not reaching as far forward as testes ... 3.
3. Vitellaria lateral to testes in cross-section ... *Bovienia* Fuhrmann, 1931.
   Vitellaria annular i. e. surrounding testes ... ... *Lytocestus* Cohn, 1908.

Genus 5. **Lytocestus** Cohn

1908. *Lytocestus* Cohn, *Centralbl. Bakteriol. Parasitenkd.*, 46 : 134-139.
1961. *Lucknowia* Gupta, *Proc. helminth. Soc. Washington*, 28 (1) : 38.

Diagnosis : Scolex unspecialised, distinct or not, not broader than rest of body. Neck formed or not. In cross-section through testicular zone, inner longitudinal muscle layer forming a ring around testes ; outer longitudinal muscle layer also forming a ring internal to nuclear layer of sub-cuticula. Male and female gonopores on ventral surface closely one behind other. No common genital atrium. Longitudinal extent of uterus at most one-third that of testicular field, usually much less, not extending anterior to cirrus sac. External seminal vesicle absent. Ovary bilobed or H-shaped ; ovarian follicles cortical, only ovarian commissure and proximal portions of ducts being medullary. Uterine glands present. Vitellaria cortical, surronnding testes in testicular zone. Post-ovarian vitellaria absent. Seminal receptacle present or not. Parasitic in Mormyriformes. Cypriniformes and Siluriformes. Hong Kong, Burma, India, Singapore, Mollucus, Sudan, Chad.

Type species : *Lytocestus adhaerens* Cohn, 1908 ; in *Clarias fuscus* ; Hong Kong.

Key to Indian species of *Lytocestus*

1. Scolex knob-like, neck long and slender ... ... 2.

   Scolex stumpy, flat or pointed ; neck indistinct or a constriction, very short ... 3.

2. Ovary wing-like ; posterior extent of vitellaria well beyond posterior to female gonopore ; seminal receptacle absent ... ... *L. birmanicus* Lynsdale, 1956.

   Ovary H-shaped ; posterior extent of vitellaria restricted anterior to female gonopore ; seminal receptacle present ... ... *L. longicollis* Rama Devi, 1973.

3. Body robust ; uterus well developed with very thick coat of gland cells ; ovary wing-like with very wide wings ... ... *L. indicus* (Moghe, 1925).

   Body not at all robust ; uterus normally developed with only thin coat of gland cells ; ovary H-shaped with narrow wings ... ... 4.

4. Vitelline follicles three to four times smaller than size of testes ; anterior half or third of body attennuated and usually filiform or ribbon-shaped ; scolex variable in shape, usually narrow and pointed in front ... *L. filiformis* (Woodland, 1923).

   Vitelline follicles only a little smaller than size of testes ; anterior half of body flat, not filiform ; scolex stumpy and bluntly rounded in front ... *L. fossilisi* (Gupta, 1961).

7. **Lytocestus birmanicus** Lynsdale

(Fig. 27)

1956. *Lytocestus birmanicus* Lynsdale, *J. Helminth.*, 30 (2-3) : 88.
1988. *Lytocestus birmanicus* : Chakravarty and Tandon, *Indian J. Helminth.* (*N. S.*), 5 (1) : 43.

Material Examined : Two specimens loaned by Dr. V. Tandon.

Host—*Clarias batrachus* (L.), Walking catfish, (Siluriformes : Clariidae) ; location—intestine ; locality—Guwahati (Assam) but collected from Shillong market (Meghalaya) ; no. of specimens—362 ; collected by R. Chakravarty and V. Tandon, Northeast Hill University, Shillong, Meghalaya.

Description : Body elongated, flattened, 5·28-16·36 long, 0·5-1·45 in maximum width at level of cirrus sac. Scolex globular to lanceolate, 0·46-1·18 long, unspecialised, disctinctly marked off from neck behind. Neck present, narrow, 1·32-5·47 long. Anterior part of trunk (main body) devoid of any organs.

Testes 170-384 in number, medullary, oval or spherical, 0·06-0·21 × 0·02-0·11, extending from a short distance behind anterior vitellaria to cirrus sac. Cirrus sac oval, opening as male gonopore in beginning of last 1/7th of body.

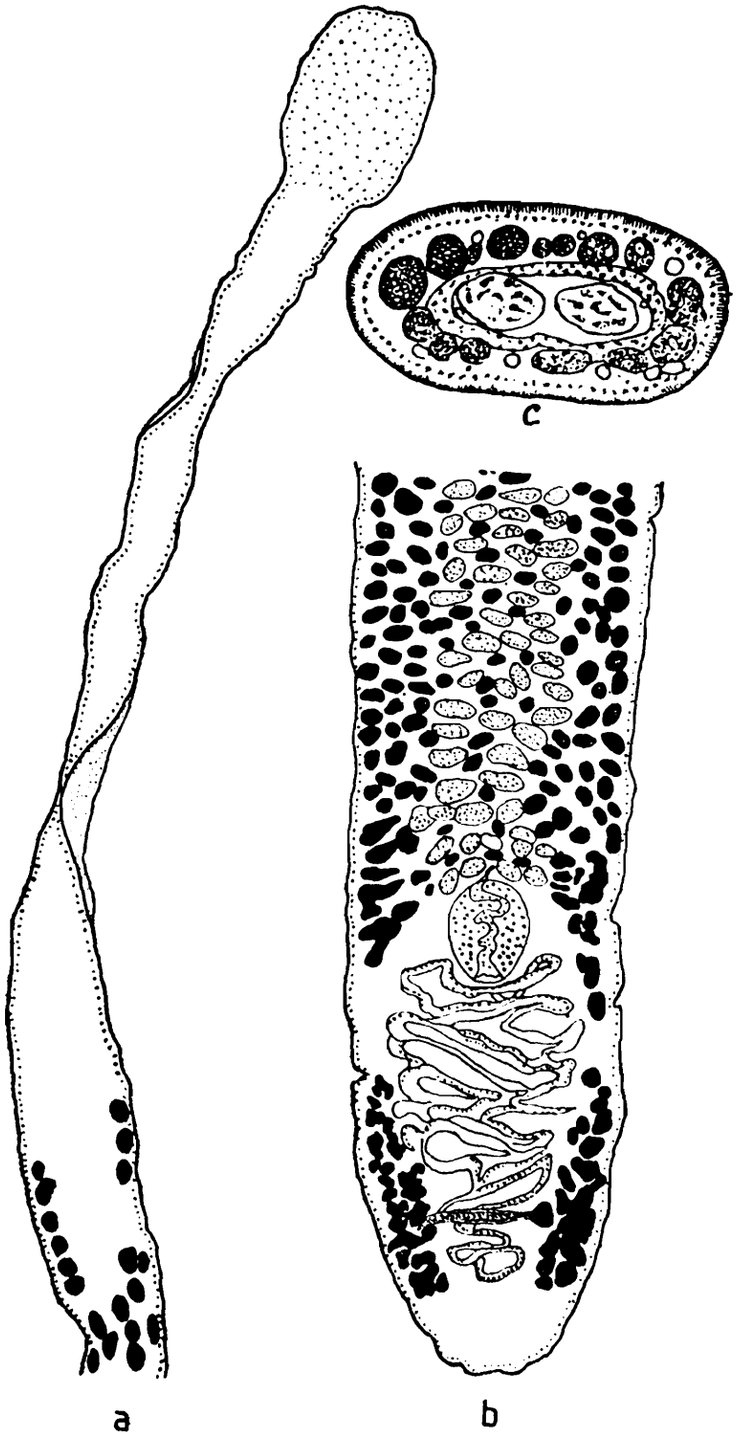

Fig. 27 : *Lytocestus birmanicus* Lynsdale. (Drawn from a specimen loaned by Dr. V. Tandon).
a. Scolex and neck,
b. Posterior half of body,
c. Cross-section of body through testicular region (After Lynsdale, 1956).

Ovary wing-like, near posterior end of body ; wings cortical, follicular, connected by medullary band-like isthmus, 0·33-1·25 long, extending posteriorly to some distance short of posterior end of body. Shell gland complex posterior to ovarian isthmus, inconspicuously small. Uterus in a number of loose coils, glandular, extending up to cirrus sac. Vagina a straight tube, joining distalmost part of uterus to form utero-vaginal canal. Utero-vaginal canal opening immediately behind male gonopore. No seminal receptacle. Vitellarium follicular, follicles transversely elongated, 0·04-0·14 × 0·02-0·10, smaller than testes, cortical, annularly arranged outer to inner longitudinal muscle layer, extending posteriorly beyond level of utero-vaginal pore. Post-ovarian set of vitelline follicles absent. Intra-uterine eggs oval, 50-70 × 20-30 μm.

Remarks : *Lytocestus birmanicus* was originally described by Lynsdale (1956) from the intestine of the fish *Clarias batrachus* (L.) from Rangoon, Burma. Chakravarty and Tandon (1989) recorded it from the same host fish from Guwahati (Assam). Johri (1959) considered *Lytocestus alestesi* Lynsdale, 1956 from the fish host *Alestes nurse* (Ruppell) (Cypriniformes : Characinidae) from river Nile at Khartoum, Sudan, synonymous to *Lytocestus birmanicus* Lynsdale, 1956 from the fish host *Clarias batrachus* (L.) (Siluriformes : Clariidae) from Rangoon on the basis of similarities in the position of the genital apertures, ovary, extent of uterus and other structures including the size of eggs, disregarding the basic morphological differences in their scoleces and size and number of testes in them. In *L. birmanicus* the scolex is well defined, muscular, and knob-like distinctly marked off from the narrow, slender and long neck behind, while in *L. alestesi* the scolex is basically ill-defined and ribbon-like with little trace of a constricted neck. According to Mackiewicz (1962), these scolex differences can not be regarded as artifacts of fixation but they represent basic morphological differences. Additionally, the number of testes in *L. birmanicus* is half as much as in *L. alestesi* owing to smaller in size in the latter. Thus, both the species are quite distinct from each other.

The record of occurrence of this species from one and the same fish host in north-eastern region of India, adjoining to the type locality Rangoon (Burma), is understandable.

Mackiewicz (1962), on re-examination counted 85 to 95 testes in *L. birmanicus* whereas Chakravarty and Tandon (1989) recorded 170-384 testes in it but they are comparatively smaller in size. The posterior extent of vitellaria has been originally described to be at the level of uterovaginal pore whereas in Chakravarty and Tandon's fig. 9 the vitellaria has been shown to extend beyond that level posteriorly. Further, the follicles of vitellaria and ovary have been shown in the same figure not to meet each other whereas originally they have been shown to be continuous.

Distribution : Rangoon (Burma) and Guwahati (India).

8. Lytocestus filiformis (Woodland) Fuhrmann and Baer

(Fig. 28)

1923. *Caryophyllaeus filiformis* Woodland, *Quart J. microsc. Sci.* (*N. S.*), **67** : 447.
1925. *Lytocestus filiformis* : Fuhrmann and Baer, *Proc. zool. Soc. London* (1925) : 79—100.
1956. *Lytocestus alestesi* Lynsdale, *J. Helminth.*, 30 (2-3) : 92.
1962. *Lytocestus filiformis* : Mackiewicz, *Rev. Suisse zool.*, 69 : 735.

Material examined : Two specimens loaned by Dr. V. Tandon.

Host—*Clarias batrachus* (L.), Walking catfish, (Siluriformes : Clariidae) ; location—intestine ; locality—Guwahati (Assam) but collected from Shillong market (Meghalaya) ; no. of specimens—209 : collected by Chakravarty and V. Tandon, North-east Hill University, Shillong, Meghalaya.

Description : Body elongated, flattened, anterior half or third attenuated to a pointed apex, broadest in posterior half, hind end bluntly rounded, 5·94-33·00 long, 0·59-1·65 in maximum width in posterior half. Scolex smooth, not distinctly marked off from neck behind, variable in shape, may be flat or pointed. Neck present, long, slender, 1·98-12·54 long, gradually widening into trunk or main body.

Testes 232-532 in number, spherical or oval, 0·04-0·14 × 0·01-0·08, medullary, extending from behind neck to cirrus sac. Vas deferns indistinct. Cirrus sac oval, in posterior part of body, enclosing coiled ductus ejaculatorius, opening on midventral body surface as male gonopore.

Ovary H-shaped ; arms follicular, cortical, O·53-1·5 long, connected by medullary band shaped isthmus, posterior horns extending to extreme posterior end of body leaving practically no post-ovarian region, anterior horns reaching midlevel of uterine coils. Shell gland inconspicuously small, posterior to ovarian isthmus. Uterine region glandular, very short as compared to testicular region, extending much beyond anterior horns of ovary up to cirrus sac. Vagina joining near its distal end to form a short utero-vaginal canal, opening as female gonopore just behind male gonopore at about 0·73-2·3 from poeterior end of body. Genital atrium absent. Seminal receptacle absent. Vitellaria follicular, follicles smaller (three to four times) than testes, 0·02-0·07 × 0·01-0·04, spherical or oval in shape, cortical, annularly arranged around testes, extending posteriorly up to anterior horns of ovary and becoming lateral only in region of anterior half of uterus. Post-ovarian vitelline follicles absent. Eggs oval, 30-50 × 10-30 μm. Excretory pore terminal.

Remarks : Lynsdale (1956) differentiated her species *Lytocestus alestesi* from *Lytocestus filiformis* (Woodland), both from river Nile, Sudan, mainly in egg sizes and different host fishes. Mackiewicz (1962) observes that "Eggs (*in utero*) vary in their size and shape with respect to fixatives and their position in uterus." He further observes that the

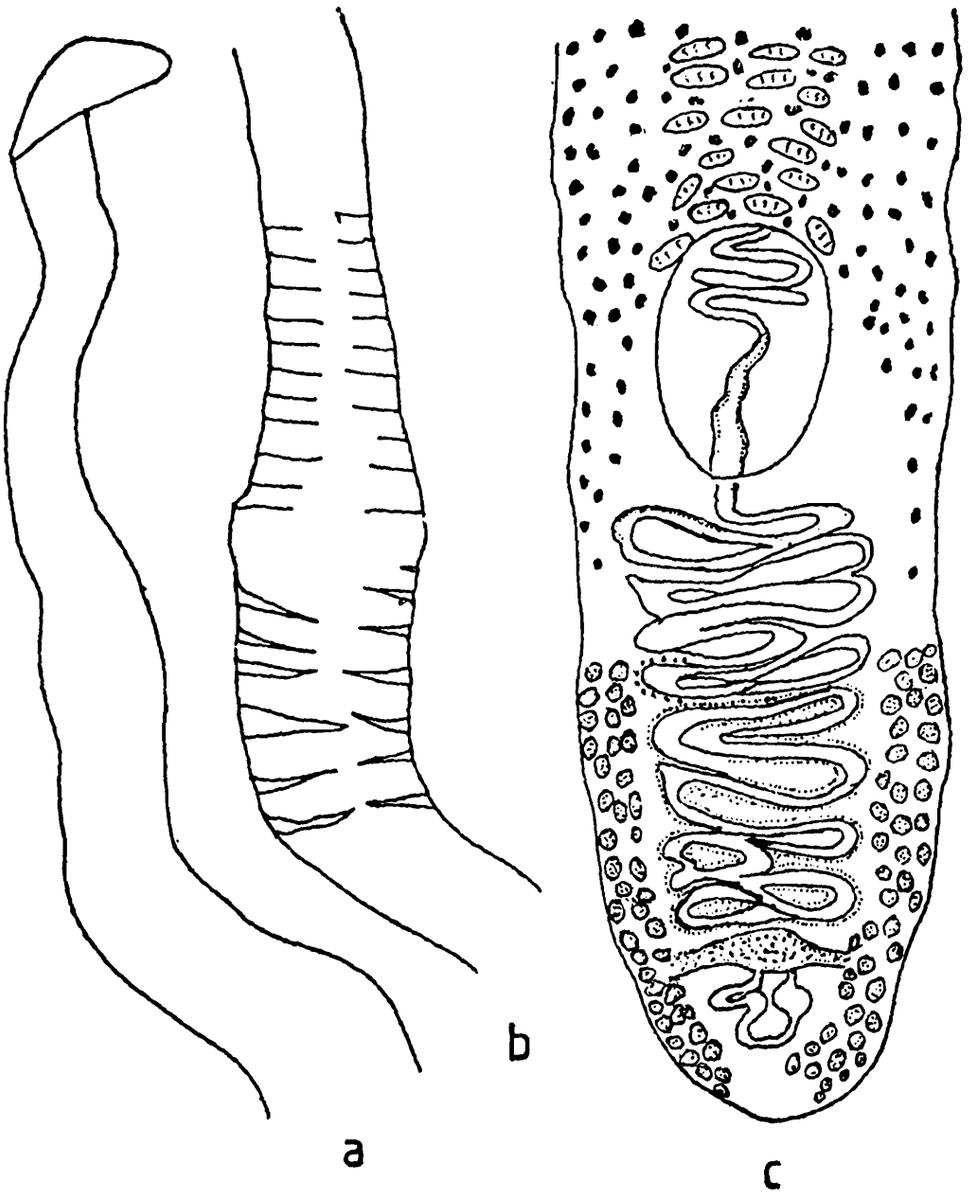

Fig. 28 : *Lytocestus filiformis* (Woodland) (Drawn from a specimen loaned by Dr. V. Tandon).
a&b. Scolex and neck,
c. Posterior half of body.

fish *Mormyrus cashive* L. (Mormyriformes : Mormyridae), the host of *L. filiformis* and the fish *Alestes nurse* (Ruppell) (Cypriniformes : Characinidae), the host of *L. alestesi*, both came from the same river Nile and region Sudan and both are bottom feeders. On a

comparasion of both the species, he concludes that "they have the same body conformations, scolex type, testes and vitellaria relationship, size and ovary type", meaning thereby that there are no pronounced morphological differences between them. Thus, *L. alestesi* Lynsdale, 1956 is a synonym of *L. filiformis* (Woodland, 1923).

Chakravarty and Tandon (1989) described that vitellaria "form a crescent around the testes", a character uncharacteristic of the genus *Lytocestus*. They are perhaps inadvertently in error. Actually, the vitellaria form a ring around the testes. However, they tend to become lateral in posttesticular region.

From the basic morphological characters like body conformation, scolex type, testes and vitellaria relationship, position of genital apertures, ovary type and extent of uterus, it appears that Chakravarty and Tandon (1989) have correctly identified their specimens as *Lytocestus filiformis* (Woodland, 1923). This species has been originally described from the fish *Mormyrus caschive L.* (Mormyriformes : Mormyridae) from the river Nile in Sudan and later reported from *Alestes nurse* (Ruppell) (Cypriniformes: as *Lytocestus alestesi* Lynsdale, 1956 from the same river and from the same region. Its record from an entirely different host *Clarias batrachus* L. (Siluriformes : Clariidae) and from a different zoogeographical region appears difficult to explain. However, its distribution is extended from Ethiopian region to Oriental region also.

9. **Lytocestus fossilisi** (Gupta)

(Figs. 29-33)

1861. *Lucknowia fossilisi* **Gupta, S. P.,** *Proc. helminth. Soc.* Washington, 28 (1) : 39.
1973. *Capingentoides moghei* **Pande,** *Indian J. Zoot.*, 14 (3) : 223.
1975. *Lytocestus fossilis* **Singh,** *Dr. B. S. Chauhan Comm, Vol.*, : 79-82.
1984. *Lytocestoides fossilis* **Kanth, Sinha and Srivastava,** *Indian J. Helminth.* (*n. s.*), 1 (1-2) : 26.
1985. *Capingentoides gorakhnathi* **Agarwal and Singh,** *Indian J. Helminth.* (*n. s.*), 2 (1-2) : 81.

Material examined : Nil.

Host—*Heteropneustes fossilis* (Bloch) ; Stinging cat-fish, (Siluriformes : Heteropneustidae), *Clarias batrachus* (L.), Walking cat-fish, (Siluriformes : Clariidae), *Channa striatus* (Bloch), Striped snakehead, (Channiormes : Channidae) ; location—intestine ; localities—Lucknow (river Gomti). Gorakhpur, Ballia (U.P.), Darbhanga (Bihar), and Kathmandu (river Bagmati, Nepal), no. of specimens—several mature and some immature worms ; collected by respective authors.

Description : Body elongated, flat, 5·8-6·78 long, 1·13-1·3 in maximum width, main body usually tapering into neck and scolex. Scolex stumpy or slightly differentiated into an oval structure, anterior end bluntly rounded, narrower than neck and much so than

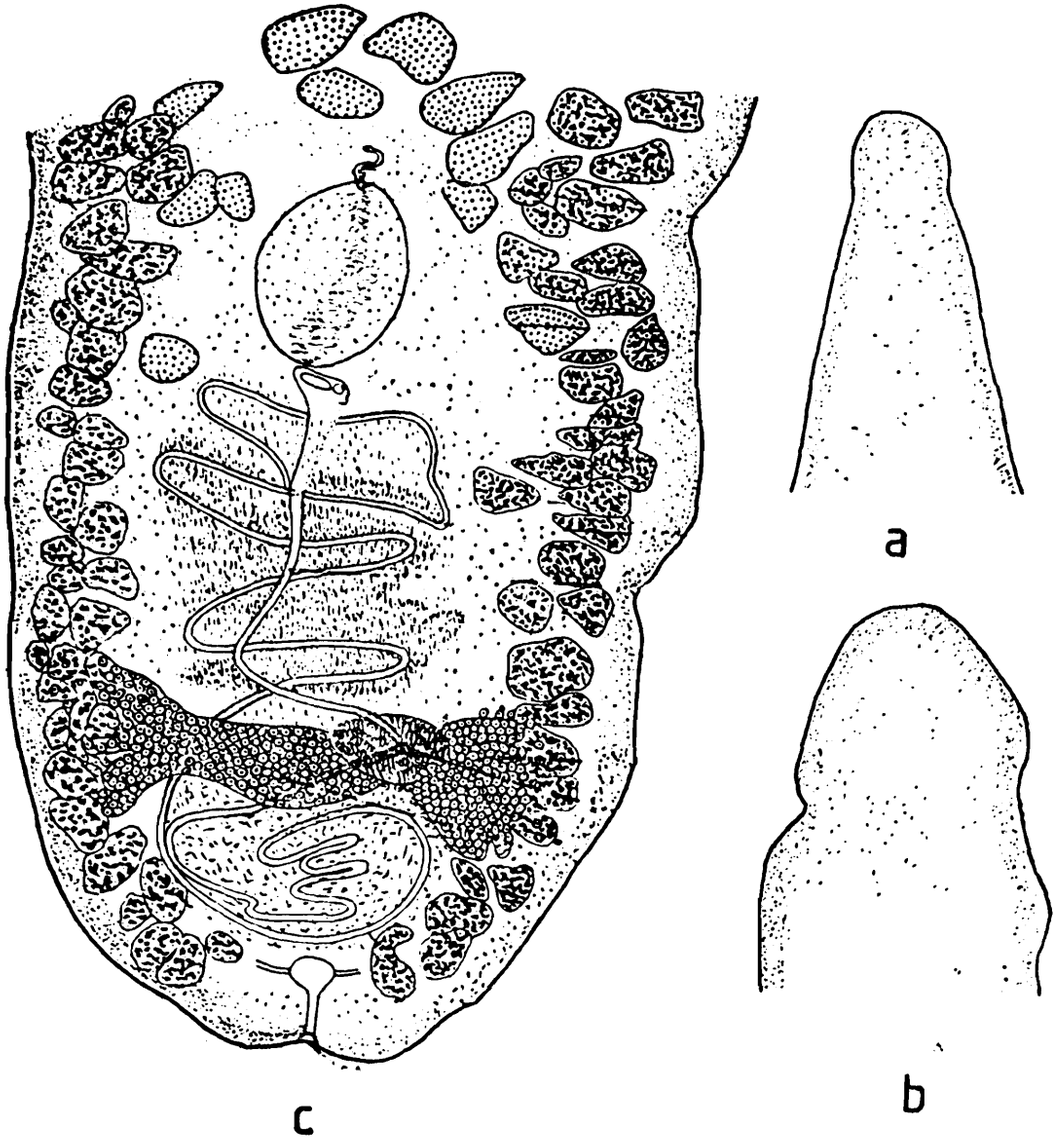

Fig. 29 : *Lytocestus* fossilisi (Gupta). (After Gupta, 1961).
a&b. Scolex variations,
c. Posterior part of body.

main body, unspecialised, 0·348-0·59 long, 0·21-0·48 wide. Neck present, constricted. usually not so, 0·522-1·218 long, 0·365-0·73 wide at base. Male and female gonopores separate opening closely midventrally in last seventh of body length. No common genital atrium.

Testes rounded or oval, numerous, medullary, extending from a level posterior to anterior most vitelline follicles to posterior level of cirrus sac. Vas deferens convoluted

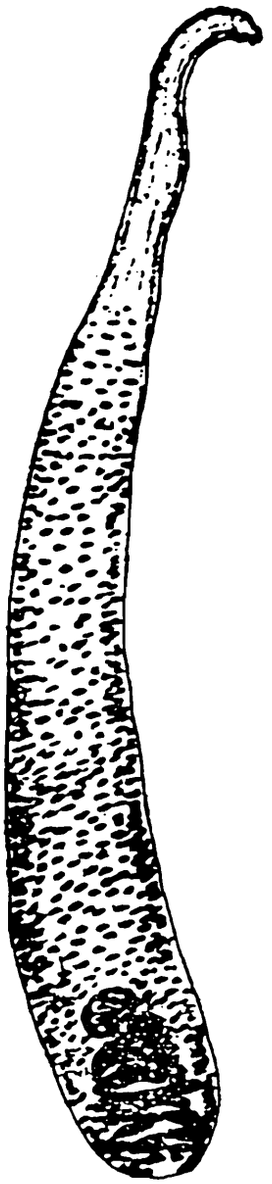

Fig. 30 : *Capingentoides moghei* Pandey
Entire worm. (After Pandey 1973).

in front of cirrus sac. External seminal vesicle absent. Cirrus sac ovoid, large 0·34-0·43 long, 0·27-0·31 wide, enclosing convoluted ejaculatory duct and cirrus, opening outside as male gonopore.

Ovary H-shaped, in posterior region of body ; arms strongly follicular, lateral, cortical, connected by bandshaped medullary isthmus or commisure ; follicles of anterior horns may or may not be continuous with those of vitellarium ; follicles of posterior horns

may or may not be intermingling near posterior end of body. Vitellaria follicular, cortical, annular (i.e. surrounding testes), follicles smaller than testes, extending from a level

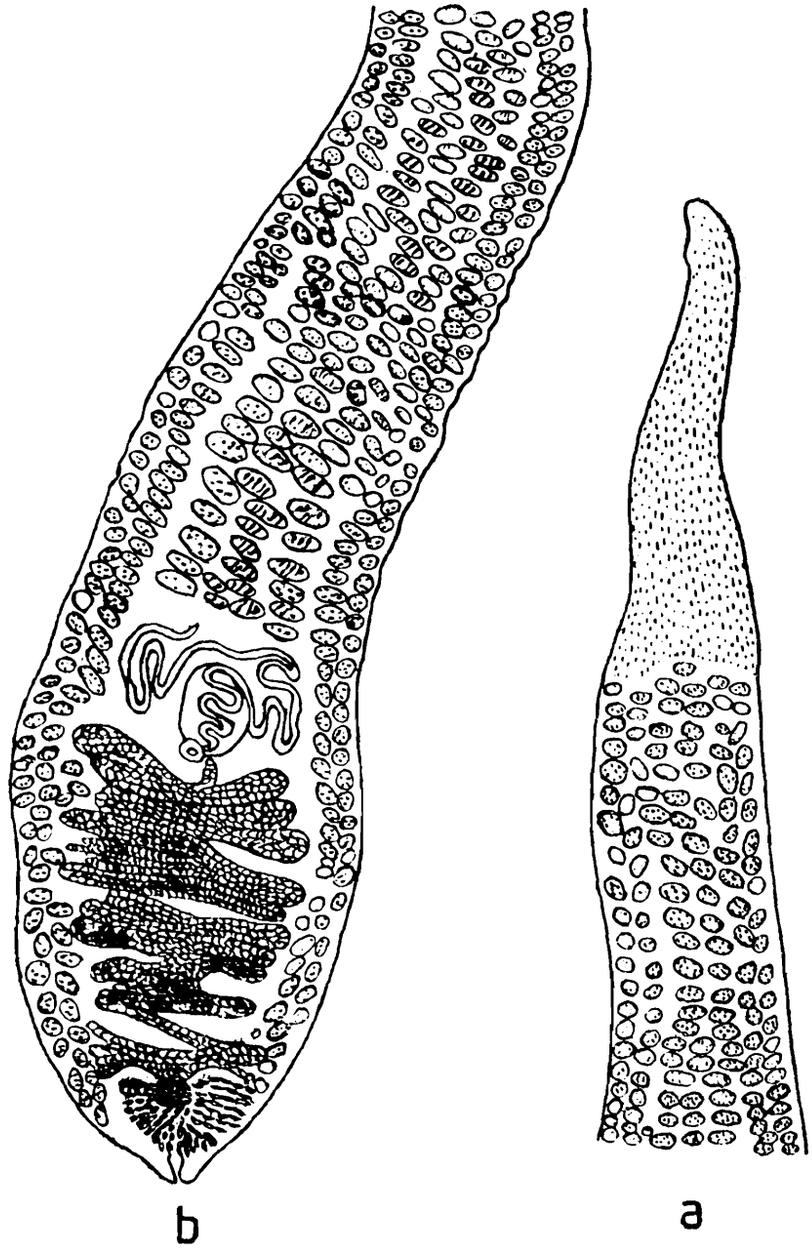

Fig. 31 : *Lytocestus fossilis* Singh. (After Singh 1975)
a. Anterior pard of body,
b. Posterior part of body.

anterior to testicular level to anterior level of follicular ovary. No post-ovarian set of vitelline follicles. Uterus laterally coiled, post-commissural coils descending to excretory bladder, pre-commissural coils reaching slightly posterior to cirrus sac, never extending anterior to it. Uterine glands present. Vagina a narrow tube, midventral to uterus,

joining anteriorly with uterus to form a short utero-vaginal canal, opening as female gonopore on ventral surface slightly behind male gonopore. No seminal receptacle. Shell

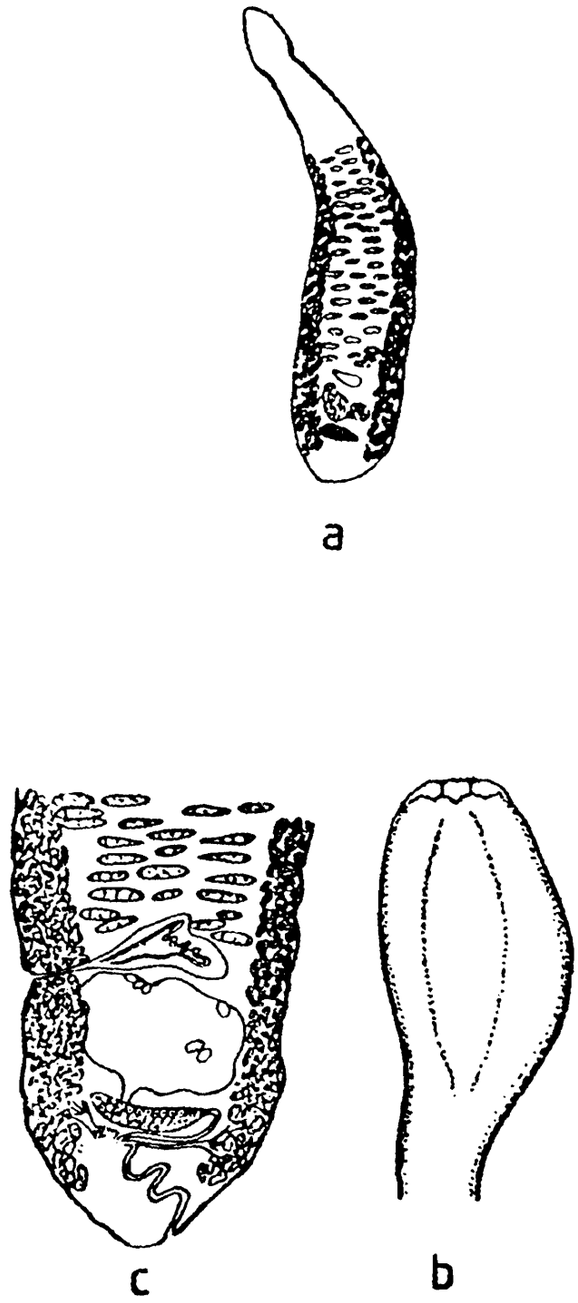

Fig. 32 : *Capingentoides gorakhnathi* Agarwal and Singh 1985 (After Agarwal and Singh 1985).
a. Entire worm,
b. Scolex.
c. Posterior part of body.

gland complex large, on ventral side of ovarian commissure or posterior to it. Eggs oval, 17-18 × 10-11 μm, unfilamented.

Remarks : The species has been described from whole mounts. Transverse sections were not cut. Mackiewicz (1981b) has re-examined the material. According to him the ovary is H-shaped (instead of band-shaped) whose lateral arms are strongly follicular and anteriorly extend up to posterior level of vitellaria and posteriorly reach

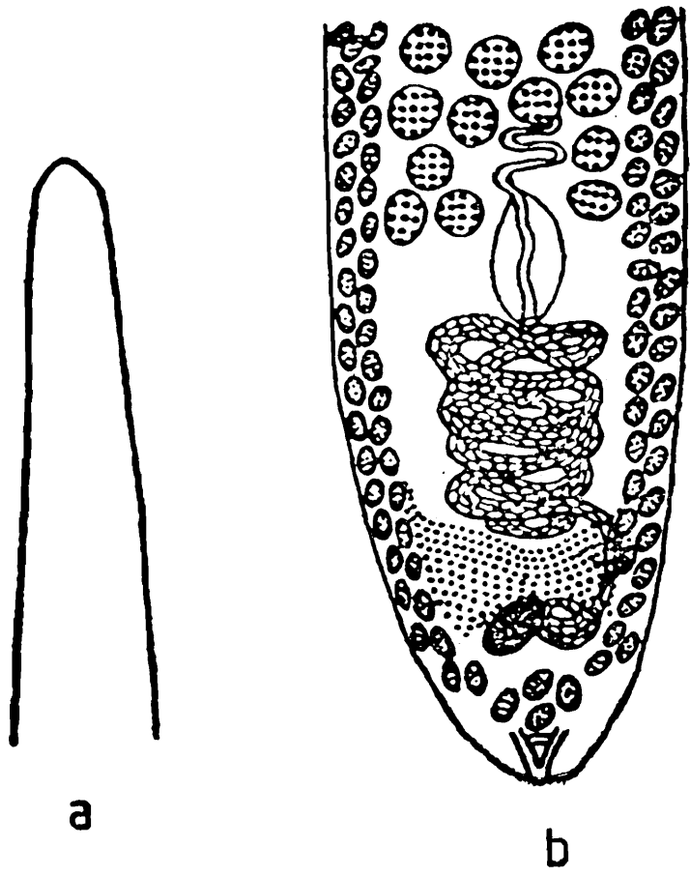

Fig. 33 : *Lytocestodies fossilis* Kanth *et al.* (After Kanth *et al.*, 1984).
a. Anterior part of body,
b. Posterior part of body.

near posterior end of body. There are no postovarian vitelline follicles. These observations obviously indicate that anterior follicles of the ovary may be continuous with those of vitellaria and posterior ovarian follicles were mistook as vitelline follicles. Mackiewicz (1981b) further observes that intrauterine eggs are nonfilamentous and the vitelline follicles are annular (i.e. surrounding testes). He has cautioned that "the systematic status of this genus (*Lucknowia* Gupta, 1961) should be re-examined in the light of the above observations".

Lack of transverse sections of *Lucknowia fossilisi* Gupta, 1961 makes it difficult to know the relationship of vitelline glands with respect to inner longitudinal muscles

and hence the determination of its family also becomes difficult. However, annular and cortical vitellaria suggest the family Lytocestidae for the genus *Lucknowia* as Gupta (1961) has already done. Regarding the status of the genus *Lucknowia* in the family Lytocestidae, one has to take into account the redescription of *fossilisi* Gupta, 1961 as presented above. The characters like unspecialised scolex which is not broader than remainder of body, cortical and annular prevarian vitellaria, absence of postovarian vitelline follicles, separate (although closely apposed) male and female genital pores, absence of common genital atrium, uterine coils not extending anterior to cirrus sac and presence of uterine gland cells suggest the genus *Lytocestus* Cohn, 1908. Thus, *Lucknowia* Gupta, 1961 falls as a synonym of *Lytocestus* Cohn, 1908 and consequently, the species becomes *Lytocestus fossilisi* (Gupta, 1961) n. comb.

Transverse sections of all the species in the synonymic list were not studied but their bodies are similar consisting of usually a stumpy scolex distinctly narrower than the following short neck and a widened and long main body. All of them have been recovered mainly from *Heteropneustes fossilis* except *Capingentoides gorakhnathi* which is from *Clarias batrachus* and *Capingentoides moghei* Pande, 1973 which has been described from an accidential host *Channa striatus*. They all look identical to *Lytocestus fossilisi* (Gupta, 1961) being essentially the same as redescribed above.

Distribution: Uttar Pradesh: Lucknow, Gorakhpur and Ballia; Bihar: Darbhanga; Nepal: Kathmandu.

10. **Lytocestus indicus** (Moghe)

(Fig. 34-35)

1925. *Caryophyllaeus indicus* Moghe, *Parasitology* 17: 222.
1926. *Lytocestus indicus*: Woodland, *Proc. zool. Soc. London*, 1926: 56.
1930. *Lytocestus indicus*: Mehra, *Proc. 17th Indian Sci. Congr. Ass.* (Abstracts): 247.
1931. *Lytocestus indicus*: Moghe, *Parasitology*, 23: 84.
1961. *Pseudolytocestus clariae* Gupta, *Proc. helminth. Soc. Washington*, 28 (1): 43.
1981b. *Pseudolytoestus clariae*: Mackiewicz, *Himalayan J. Sci.*, 1 (1): 7.
1985. *Pseudolytocestus clariae*: Agarwal, *Indian Rev. Life Sci.*, 5: 145.
1988. *Lytocestus marathwadaensis* Shinde and Phad, *Riv. Parassit.*, (1986), 47 (2): 295.
1989. *Introvertus chauhani* Pandey and Tiwari, *Dr. B. S. Chauhan Comm. Vol.*: 141.
1990. *Pseudolytocestus thapari* Gupta and Parmar, *Indian J. Helminth.*, 42 (1): 28.

Material examined: Host—*Clarias batrachus* (L.), Walking Cat-fish, (Cypriniformes: Clariidae); location—intestine; localities—Guwahati, Diamand Harbour, Calcutta; number of specimens—numerous.

Description : Body robust, elongated, flat, 27·0-40·0 long, 2·05-4·4 in maximum width. Scolex stumpy, bluntly rounded anteriorly, much narrower than rest of body,

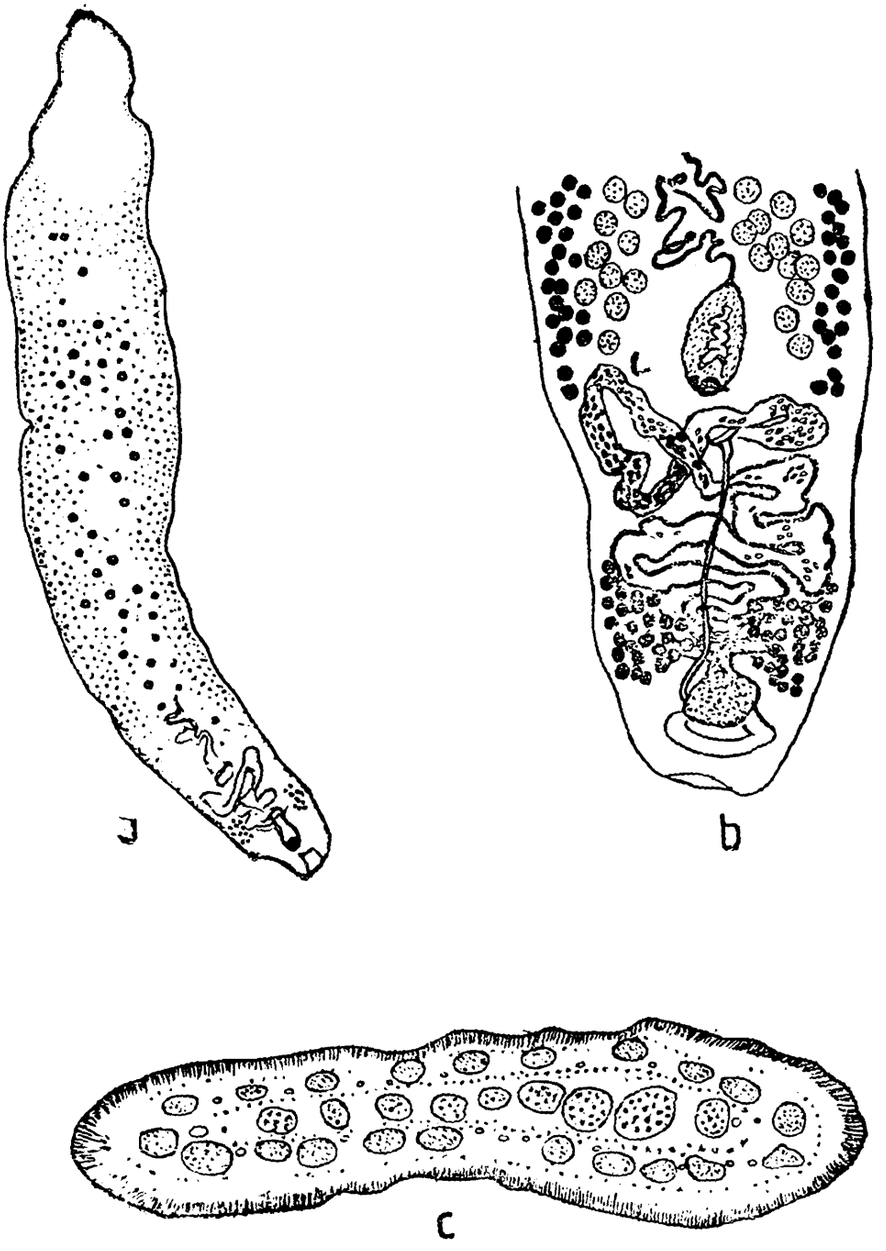

Fig. 34 : *Lytocestus indicus* (Moghe).
- a. Entire worm, (After Moghe, 1931).
- b. Posterior half of body, (After Rama Devi, 1973),
- c. Cross section of body. (After Moghe, 1931).

unspecialised (i.e. bothria, introvert, furrows or grooves absent), 2·65-3·0 long, 1·3 wide in middle. Neck present, a constriction or very short and indistinct. Main body slightly

tapering posteriorly with rounded end. Male and female gonopores mid-ventral in last seventh or eight of body length. Genital atrium absent.

Testes about 212-600 in number, 0·13-0·19 in diameter, medullary, extending from a short distance behind anterior most vitelline follicles to cirrus sac. Vas deferens a much

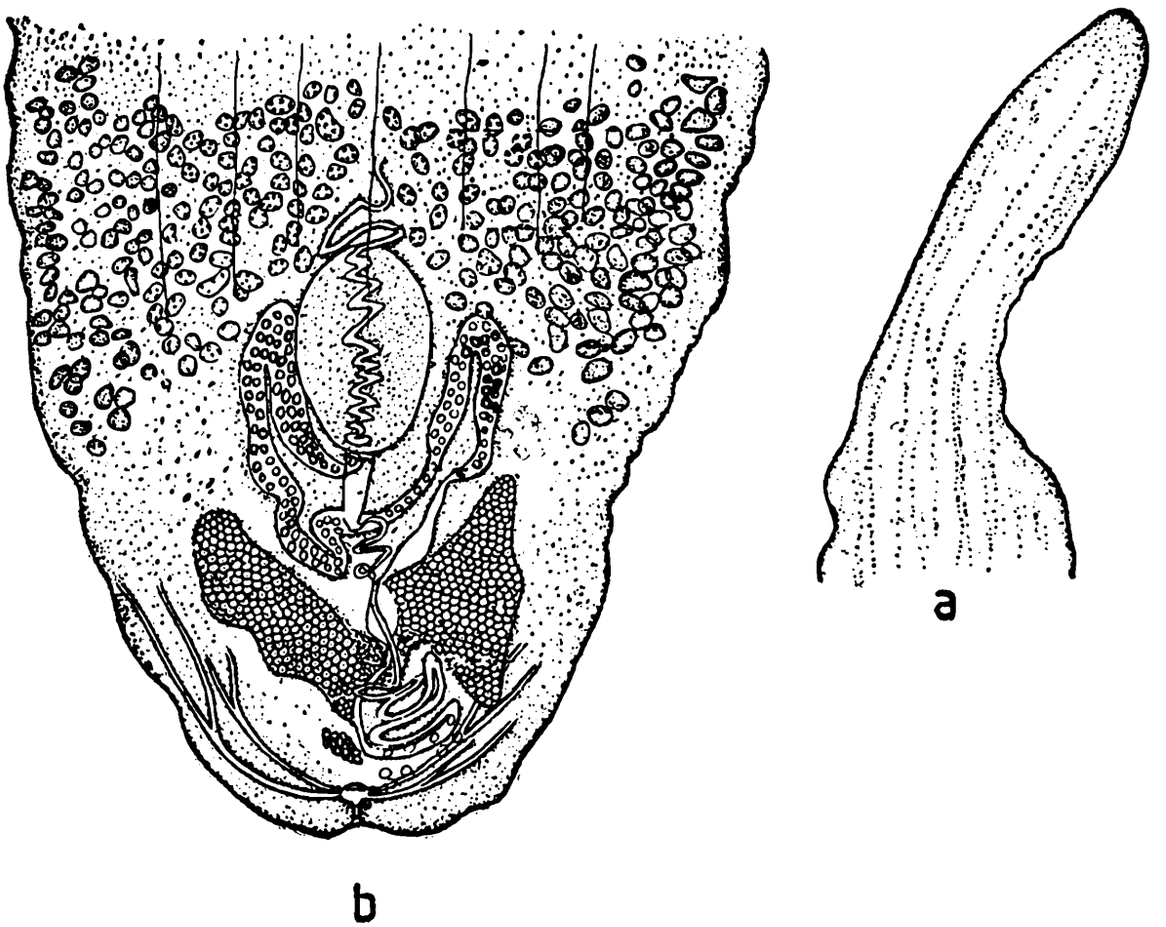

Fig. 35A : *Pseudolytocestus clariae* Gupta. (After Gupta, 1961).
a. Scolex,
b. Posterior part of body.

convoluted narrow tube in front of cirrus sac. External and internal seminal vesicles absent. Cirrus sac prominent, large with thick muscular wall, oval or conical bell-shaped, 0·50-1·04 long, 0·6-0·7 wide, enclosing a coiled and muscular ejaculatory duct, opening as male pore by a slit-like aperture on ventral surface of body.

Ovary bilobed, wing-like, in posterior part of body ; lobes cortical, irregular in shape, consisting of numerous loosely packed follicles, connected by medullary bagpipe-like transverse isthmus ; shell gland complex posterior to ovarian isthmus. Vagina a

narrow and slightly wavy tube, running ventrally along midline, dialating at anterior end. No seminal receptacle. Uterus with thick coat of glandular cells, thrown in lateral coils, extending posteriorly beyond shell gland complex, anteriorly opening into dialated terminal part of vagina to form a short utero-vaginal canal. Utero-vaginal canal opening as female pore a bit posterior to male pore. Vitellaria follicular, cortical, follicles surrounding

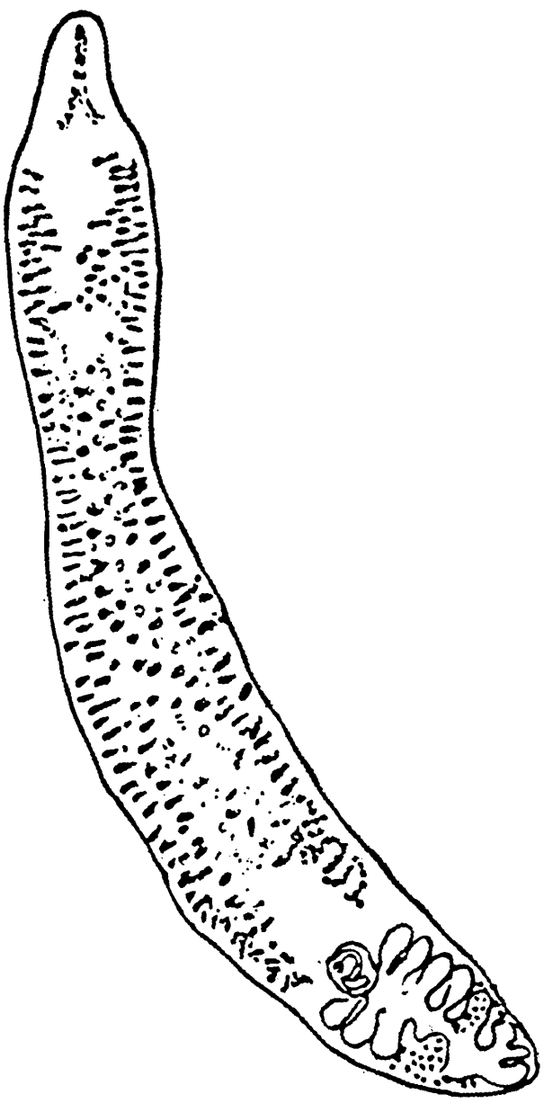

Fig. 35B : *Introvertus chauhani* Pandey and Tiwari.
Entire worm. (After Pandey and Tiwari, 1989).

testes, smaller than latter in size, extending from behind neck to almost level of utero-vaginal pore, remaining restricted much anteriorly from ovarian arms. No post-ovarian vitelline follicles. Intra-uterine eggs oval, 60-88 × 20-44 μm, embryonated.

Osmoregulatory canals 8 pairs (2 marginal, 2 central and 4 median), joining to form excretory vesicle near posterior end ; pore terminal.

Remarks : Moghe (1925) obtained this species from the stomach of the siluroid fish *Clarias batrachus*. He (1931) further mentioned that the worms appear as small knobs attached to the rugose wall of the stomach. Rama Devi (1973) mentions that "Mature and gravid worms make tunnels through the mucous and epithelial layers of intestinal wall and finally are to be found in the serose layer as a white speck." The worms are obtained by rupturing intestinal wall. Niyogi, Gupta and Agarwal (1984) observe that it is a tissue parasite which peneterates through the mucosa to various depths in intestinal wall. Niyogi and Agarwal (1989) observe that *Lytocestus indicus* peneterates "through the mucosa and submucosa to lie close to musculosa, exceptionally reaching the serosa but never perforating it". *Lytocestus indicus* is normally a duodenal parasite of *Clarias batrachus* which is not reported from any other siluroid fish as yet. It occurs in single infection or with some other caryophyllid. It is found almost round the year.

Mackiewiez (1981b) personally examined the single specimen of *Pseudolytocestus clariae* Gupta, 1961 described from the fish *Clarias batrachus* from Brahmaputra river at Guwahati, Assam. He observes that the specimen is contracted, the testes are more than twice the size of the vitelline follicles and the ovary is follicular, not compact as drawn. No sections were cut by Gupta (1961). He further points out that the genus *Pseudolytocestus* Hunter, 1927 is found in the Nearctic region in the fish family Catostomidae, and its report from the oriental region from a divergent fish family Clariidae is unexplainable. Agarwal (1985) considers *Pseudolytocestus clariae* a possible synonym of *Lytocestus indicus*. On the basis of nature (stumpy) of scolex, absence of post-ovarian set of vitelline follicles, testes larger in size than vitelline follicles and wing-like or bowtie-shaped follicular ovary (not H-shaped i.e. elongated and narrow wings with isthmus in almost mid-region of ovarian wings as is found in *Pseudolytocestus*) in *Pseudolytocestus clariae*, I am inclined to concur with Agarwal (1985). *Pseudolytocestus thapari* Gupta, V. and Parmar, 1990 from *Clarias batrachus* from river Gomati at Lucknow is identical to *Pseudolytocestus clariae* except a slight variation in the anterior extent of uterine coils.

Pandey and Tiwari (1989) described *Introvertus chauhani* from the intestine of the fish *Clarias batrachus* from Faizabad (U.P.). Quite obviously, it is a case of misidentification and erroneous description of the material. The species is nothing but *Lytocestus indicus* (Moghe).

Sinha and Rashid-un-Nisa (1981), Chakravarty and Tandon (1989) and Hasnian and Sahay (1989) have reported morphological anomaly involving duplication of body in this species. Ahmad and Sanaullah (1977) reported its occurrence in districts Bogra (Sherpur), Dacca (Demra, Maridder beel and Tongi), Mymensingh (Gauripur), Noakhali (Torabganj,

Ramgati), Rangpur (Vakir beel, Gaibandha) and Sylhet (Shalutaker beel) from Bangladesh.

Distribution : Nagpur (Maharashtra), Raipur (Madhya Pradesh), Lucknow, Mainpuri and Faizabad (U. P.), Visakhapatnam and Hyderabad (A. P.), Guwahati (Assam), Jamshedpur (Bihar), widely found in West Bengal, and districts Bogra, Dacca, Mymensingh, Noakhali, Rangpur and Sylhet (Bangladesh).

11. **Lytocestus longicollis** Rama Devi

(Fig. 36)

1973. *Lytocestus longicollis* Rama Devi, *J. Helminth.*, 47 (4) : 416.
1980. *Lytocestus longicollis* : Shinde and Deshmukh, *Riv. Parassit.*, 41 (2) : 211.
1989. *Lytocestus longicollis* : Chakravarty and Tandon, *Indian J. Helminth.* (*N. S.*), 5 (1) : 46.

Material examined : One without scolex, loaned by Dr. Veena Tandon.

Host : *Clarias batrachus* (L.) Walking cat-fish, (Family Clariidae) ; location—intestine ; localities—Visakhapatnam district, Nagpur and Guwahati ; no. of specimens—173+1+141.

Description : Body long, narrow, 10·8-20·0 long, 0·5-0·84 on maximum width. Scolex unspecialised, variable in shape, spatulate or oblong or swollen pear-shaped, 0·94-1·78 long, 0·48-0·97 wide. Neck present, narrow, long, 5·36-7·6 × 0·17-0·51. Trunk or main body tapering posteriorly, 4·48-9·5 long. Male and female gonopores opening on ventral surface in last tenth or eleventh of entire body length. Common genital atrium absent.

Testes spherical or broadly oval, 0·10-0·16 in diameter, 105-140 in number, medullary, extending from base of neck to cirrus sac. Vas deferens much convoluted. External and internal seminal vesicles absent. Cirrus sac rounded or oval, 0·24-0·31 long, 0·16-0·23 wide, enclosing long and convoluted ductus ejaculatorius, opening midventrally as male pore.

Ovary H-shaped, situated in posterior region of body, lobes cortical, ovarian isthmus medullary, lobes 0·46-0·78 in length, closely packed with follicles. Uterus glandular, thrown in lateral coils, extending upto posterior level of cirrus sac. Vagina a narrow tube, straight or slightly convoluted, joining uterus to form a short utero-vaginal canal ; utero-vaginal canal opening as female pore slightly posterior to male pore ventrally. Receptaculum seminis oval, 0·16 × 0·06, anterior to ovarian isthmus. Shell gland complex and common vitelline duct posterior to isthmus. Vitellarium follicular, cortical, surrounding testes, extending from base of neck to anterior tip of ovary, follicles measuring 0·039-0·07 in diameter. Post-ovarian set of vitelline follicles absent. Follicles of vitellarium and those of ovarian lobes may or may not be continuous.

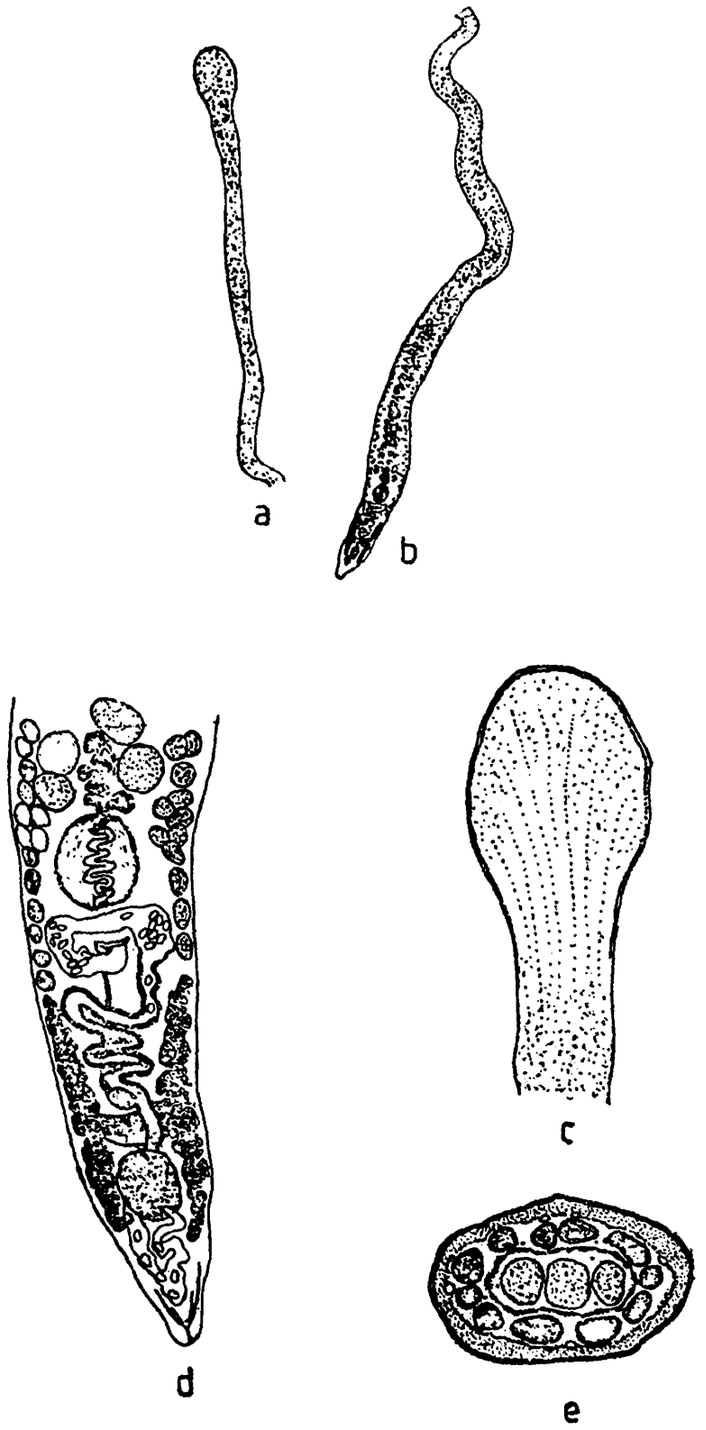

Fig. 36 : *Lytocestus longicollis* Rama Devi (After Rama Devi, 1973).
- a. Scolex and neck,
- b. Main body,
- c. Scolex enlarged,
- d. Posterior half of body,
- e. Cross-section of body.

Eggs oval, 92-109 × 42-55 μm.

Osmoregulatory canals 4 to 5 pairs, uniting posteriorly to form small excretory vesicle ; excretory pore terminal.

Remarks : *Lytocestus longicollis* is characterised by a long, narrow and delicate neck and presence of a seminal receptacle anterior to isthmus. Shinde and Deshmukh (1980) and Chakravarty and Tandon (1989) also reported it from the same host from Nagpur and Guwahati respectively without studying cross-sections.

The present author studied a whole mount of the species by the courtesy of Dr. Veena Tandon. The flattening and staining are excellent, so much as the distributions of testes and vitelline follicles are very clearly and distinctly seen. This author finds that vitelline follicles are cortical and lateral beyond any shadow of doubt, although Chakravarty and Tandon (1989) describe "Vitellaria cortical, in a ring around the testes". No follicles of vitellaria are present medially. In that case their material could be *Bovienia serialis* (Fuhrmann, 1931) only. It is quite possible that they might be having a mixed populations of *Lytocestus longicollis* and *Bovienia serialis*.

Distribution : Visakhapatnam district (A. P.), Nagpur (Maharashtra) and Guwahati (Assam).

Genus 6. **Djombangia** Bovien

1926. *Djombangia* Bovien, *Vidensk. Medd. Dansk naturh. Foren.*, **82** : 167-181.

Diagnosis : Scolex globular or roughly triangular, with a terminal introvert (no sucker or loculi), profusely provided with glandular cells, specially concentrated below apex in circular or semilunar fashion. Male and female gonopores separate. Common genital atrium present on ventral surface near posterior end of body. Testes in lateral medulla, from neck to ovary. External seminal vesicle absent. Ovary bilobed connected by commissure or isthmus, entirely medullary. Uterus in median medulla, extending as far as anterior level of testes or vitellaria, turning back and joining vagina immediately posterior to cirrus sac to form utero-vaginal canal. Vitellaria entirely cortical, lateral. No post-ovarian vitellaria. Receptaculum seminis absent. Eggs small, smooth, embryonated. Parasitic in siluroid fishes. Java, India.

Type species : *Djombangia Penetrans* Bovien, 1926, in *Clarias batrachus* ; Brantas river near Djombang in East Java.

12. **Djombangia penetrans** Bavien

(Fig. 37)

1926. *Djombangia penetrans* Bovien, *Vidensk. Medd. Dansk Naturh. Foren.*, 82 : 167-181,
1974. *Djombangia indica* Satpute and Agarwal, *Indian J. Exptl. Biol.*, 12 (4) : 373.
1977. *Djombangia caballeroi* Sahay and Sahay, *Excerta Parasitologica en memoria del doctor Eduardo Caballero Y Cabellero.* Instituto de Biologia Publicaciones Especials 4. Maxico : 374.
1980. *Djombangia indica* : Satpute and Agarwal, *Proc. Indian Acad. Parasitol.*, 1 (2) : 13.
1985. *Djombangia clariae* Kundu, Bhattacharya anb Datta, *Bull. zool. Surv. India*, 7 (2-3) : 151.

Material examined : Host—*Clarias batrachus* (L.), Walking cat-fish, (Siluriformes : Clariidae), *Hetoropneustes fossilis* (Bloch), Stinging cat-fish, (Siluriformes : Heteropneustidae) ; location—duodenum ; localities—Bongaon and Malda (West Bengal) ; no. of specimens—1+4, on 5 slides ; collected by D. K. Kundu and party on 23.5.79 and 20.3.84 respectively, Z.S.I. Reg. Nos. W 7476/1 and W 7610/1-W 7613/1 ; six specimens on 3 slides from Nagpur (Maharashtra) collected by M. Hafeezullah and party on 25.7.1991 ; 2 specimens from Guwahati loaned by Dr. V. Tandon.

Description : Body milky white when freshly recovered from host, divisible into scolex, neck and flat trunk measuring about 9·00-15·00 long, 3·50-5·50 wide (body proper or trunk about 7·5-11·5 mm long), posterior end broadly rounded. Segment thick with deep denticulations due to contraction after treatment with fixative. Scolex 0·533-1·033 long, 0·88-1·788 wide, globular or roughly triangular, distinctly marked off from rest of body, with a terminal introvert (without sucker or loculi), profusely provided with glandular cells below entire margin, specially concentrated below apex in semilunar or circular fashion without association of any muscle fibers and staining dark giving false impression of feeble sucker. Neck narrow, distinctly separating scolex from trunk, short or long depending upon state of contraction or relaxation when fixed, usually 0·602-1·247 long, 0·516-0·86 wide. Main body or trunk flattened ; fleshy, some anterior most space free from any system organs.

Testes numerous, rounded or ovoid. 0·103-0·165 in diameter, larger than vitelline follicles, strewen in lateral medulla, extending from some distance behind neck to ovarian lobes. Vas deferens tubular, narrow, coiled. External and internal seminal vesicles absent. Cirrus sac globular or oval, 0·731-1·243 long, 0·516-0·721 wide, distinctly discernible in front of ovarian isthmus near posterior end of body, enclosing winding ejaculatory duct, opening as male gonopore in common genital atrium on ventral surface.

Ovary dumbbell-shaped, bilobed ; lobes 0·705-0·962 long, 0·344-0·559 wide, follicular, connected by a strip of isthmus 0·516-0·729 across, situated in posterior part

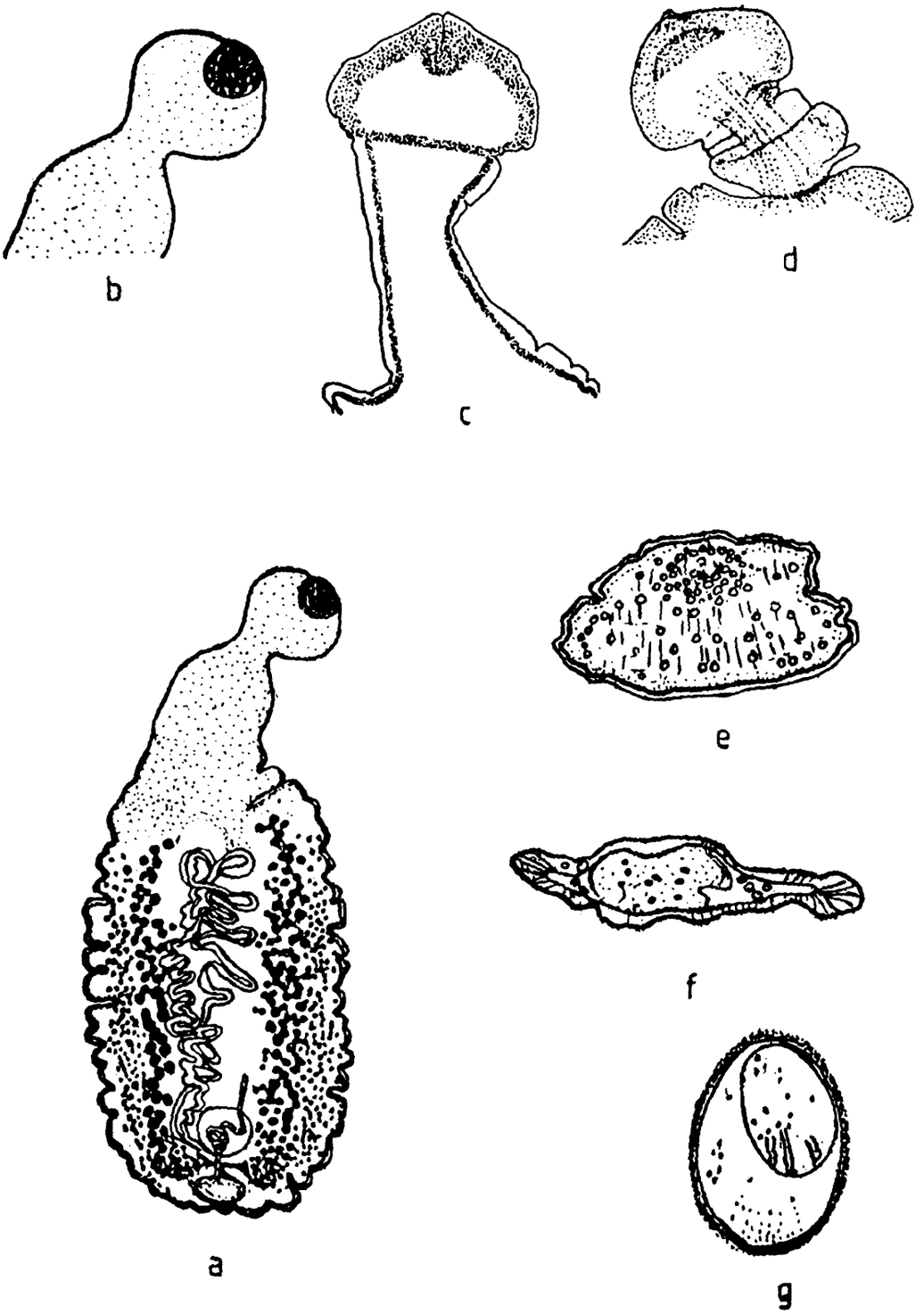

Fig. 37 : *Djombangia penetrens* Bovien.
a. Entire worm, (After Satpute and Agarwal, 1980),
b, c, d. Scolex shapes,
e. Cross-section of scolex showing gland cells,
f. Cross-section of body,
g. Egg with onchosphere.

of body in medullary zone. Ootype and Mehlis' gland complex posterior to ovarian isthmus. Uterus extending in median medulla to almost anterior level of testes, turning back and joining vagina immediately posterior to cirrus sac to form a short utero-vaginal canal. Uterovaginal canal opening as a female pore in common genital atrium behind male pore ventrally. Vagina a long canal, connecting oviduct behind isthmus and utero-vaginal canal. Seminal receptacle absent. Vitellaria spherical to ovoid, 0·86-0·132 in diameter, smaller than testes. cortical, extending from about anterior level of testes to ovarian lobes. Post-ovarian set of vitelline follicles absent.

Eggs thin-shelled, 68-94 × 43-51 μm, smooth (no spines) embryonated ; onchasphere with three pairs of hooks, middle one being largest.

Remarks : Bovien (1926) described *Djombangia penetrans* to possess a small terminal sucker on the scolex. Fuhrmann (1931) checked and found it to be a glandular structure instead of a true sucker. Mackiewicz (1972) verified and found Fuhrmann's study to be correct. Satpute and Agarwal (1974, 1980) described a feeble sucker at the tip of scolex in their species *Djombangia indica* which is obviously a misinterpretation of congregation of glandular cells there. Sahay and Sahay (1977) found a groove or slit-like invagination in apical region of scolex, but the Bongaon, Malda (West Bengal) and Nagpur (Maharashtra) materials show that such an invagination (a pseudostructure) may be an artifact of fixation. Bovien (1926) mentioned that the eggs of *D. penetrans* have fine spines on the surface. Löser (1965) states that they are formed due to the deposition of the secretion of the glandular part of the uterus during the passage of the eggs through it. Sahay and Sahay (1977) found the surface of the eggs in their species *D. caballeroi* from *Heteropneustes fossilis* from Chhotanagpur (Bihar State) as smooth (definitely unspined). Satpute and Agarwal (1974) mentioned the eggs in their species *D. indica* as smooth and without fine spines but when they (1980) published the detailed description of their species from the same material they stated the eggs to be having 3 μ long spines. Kundu *et. al.* (1985) also did not find minute spines on the eggs of their species *D. clariae*. Kundu's material from Malda also does not have spines on the eggs. Chakravarty and Tandon (1985) mention the presence of fine spines on the eggs of their material of *D. penetrans* from Guwahati (Assam State). Mackiewicz (1972) observes that opercles of caryophyllid eggs (measuring 9-16 μ in various species) are difficult to see even with the best optical equipments when they are *in utero*. That is the reason of confusion that some authors described the caryophyllid eggs as non-operculate while others mention them as operculate. So is also the case with fine egg spines measuring 3 μ long only. Therefore, the presence or absence of egg spines in *Djombangia* is interpretational and disputed. Consequently such characters should not be taken into consideration for distinguishing species. Mackiewicz (1972) further observes that seminal vesicle is a transient structure which may be seen when filled with sperms but it may not be seen when exhausted of them.

Disregarding the consideration of the above mentioned structures which are in nature interpretational, disputed, transient or variable, *D. ceballeroi*, *D. indicus* and *D. clariae* are not morphologically distinguishable from the type species *D. penetrans*. Thus, the former three species were considered as synonyms of *D. penetrans* Bovien, 1926 by Hafeezullah (1986), and the same position is maintained.

Distribution : East Java ; India : Assam, W. Bengal, Bihar, Maharashtra and Madhya Pradesh.

Genus 7. **Bovienia** Fuhrmann

1931. *Bovienia* Fuhrmann, *Handbuch der Zoologie* (W. Kukenthal and T. Krumbanch, eds.) Bd. 2 : 141-416.
1963. *Crescentovitus* Murhar, *Parasitology*, 53 : 414. (n. syn.).
1980. *Introvertus* Satpute and Agarwal, *Proc. Indian Acad. Parasitol.*, 1 (2) : 17 (n. syn.).

Diagnosis : Scolex variable in shape, elongated conical, truncated at anterior end or slightly swollen, usually poorly defined, not wider than main body. Main body gradually tapering into scolex. Neck present, long. Male and female gonopores separate, closely apposed, in last quarter of body on ventral surface. No common genital atrium. Testes medullary, surrounded by a ring of internal longitudinal muscles. External seminal vesicle absent. Cirrus unspined. Pre-ovarian vitelline follicles cortical, lateral (in a crescent on each side in cross-section), extending posteriorly to anterior horns of ovarian arms or short of that level. No post-ovarian vitellaria. Ovary basically H-shaped, occasionally posterior-most follicles from posterior ovarian horns intermingling so as to give it a shape like inverted A ; ovarian arms cortical connected by medullary isthmus, extending up to midlevel of pre-ovarian uterine extent. Uterine extent more than twice to four and a half times longer than post-ovarian space, not extending anterior to cirrus sac. Seminal receptacle present or not. Parasites of siluroid and clupeioid fishes. Java, India, Pakistan.

Type species : *Bovienia serialis* (Bovien, 1926) Fuhrmann, 1931 ; in *Clarias batrachus* ; Java, India.

Key to Indian species of *Bovienia*

1. Posterior extent of vitellaria restricted to region of cirrus sac or level of female genital pore ; pre-isthmus uterine extent only somewhat longer than post-isthmus space ; anterior horns of ovary equal or slightly longer than posterior horns ... ... *B. serialis* (Bovien, 1926).

   Posterior extent of vitellaria extending far behind female genital pore ; pre-isthmus uterine extent twice to four times longer than post-isthmus space ... 2.

2. Length of anterior ovarian horns more than three times that of posterior ones ; Seminal receptacle present ... ... *B. ilishai* Zaidi & Khan, 1976.

Length of anterior ovarian horns almost one and a half times more than that of posterior ones ; seminal receptacle absent ... *B. bilocula* (Murhar, 1963).

13. **Bovienia bilocula** (Murhar) n. comb.

(Figs. 38-44)

1963. *Crescentovitus bilocus* Murhar, *Parasitology*, 53 : 414.
1971. *Pseudcapingentoides indica* Verma, *Indian J. Helminth.*, 23 (1) : 72.
1971. *Capingentoides singhi* Verma, *Indian J. Helminth.*, 23 (1) : 76.
1980. *Capingentoides heteropneusti* Gupta, S. P. and Sinha, *Indian J. Helminth.*, (1979), 31 (1) : 65.
1984. *Pseudocapingentoides cameroni* Gupta, S. P. and Sinha, *Indian J. Helminth.*, 36 (1) : 78.
1986. *Capingentoides fotedari* Gupta, V. and Parmar, *Indian J. Helminth.*, (1985), 37 (1) : 31.
1990. *Pseudocapingentoides gomatii* Gupta, V. and Parmar, *Indian J. Helminth.*, 42 (1) : 25.

Material examined : Nil.

Host—*Heteropneustes fossilis* (Hamilton), Stinging cat-fish, (Siluriformes : Heteropneustidae) ; *Clarias batrachus* (L.), Walking cat-fish, (Siluriformes : Clariidae) ; location—intestine ; locality—Lucknow (river Gomati) ; no. of specimens—about 160 mature + 2 immature.

Description : Body elongated, about 20·00-48·00 long, 1·40-2·32 in maximum width in region of uterus, anteriorly gradually tapering into scolex. Scolex variable in shape, elongated conical or truncated at anterior end or slightly swollen, usually poorly defined, narrower than body, followed by neck ; neck long, not marked off from main body behind ; main body cylindrical being more or less of same width except in utero-ovarian zone from where abruptly slightly decreasing in width to blunt rounded posterior end, anteriorly tapering into scolex.

Male and female genital pores separate, closely apposed, 4·12-6·72 from posterior end i.e. 1/7th to 1/5th of body length from hind end. Common genital atrium absent.

Testes about 175, 0·05-0·09 in diameter, rounded to ovoid, medullary, surrounded by a complete ring of inner longitudinal muscle layer, extending from a little behind anterior vitellaria to cirrus sac. Vas deferens loosely convoluted tube in fornt of cirrus sac in medulla. External seminal vesicle absent. Cirrus sac oval, 0·40-0·70 long, 0·23-0·61 wide, at 4·08-6·91 from posterior end of body, enclosing bell-shaped winding ejaculatory duct.

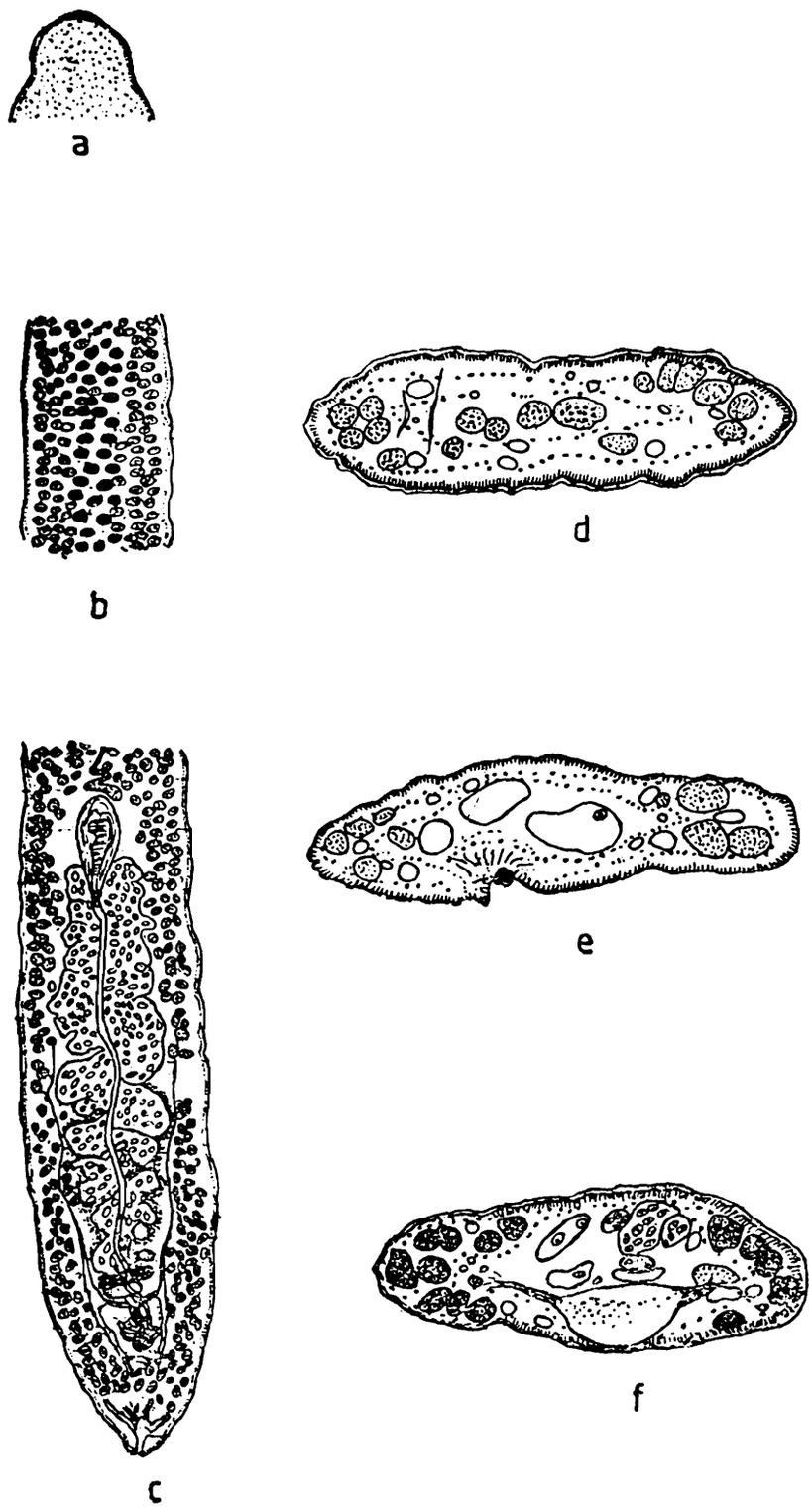

Fig. 38 : *Bovienia locula* **(Murhar). (After Murhar, 1963)**

a. Scolex,
b. Portion of anterior part of body,
c. Posterior half of body,
d. Cross-section of body,
e. Cross-section through opening of cirrus sac,
f. Cross-section through ovarian isthmus.

Ovary H-shaped; arms follicular, lateral, connected by medullary band-shaped commissure or isthmus at 0·78-1·85 from posterior end of body; anterior horns reaching almost midlevel of pre-commissural uterine extent, posterior horns reaching posterior

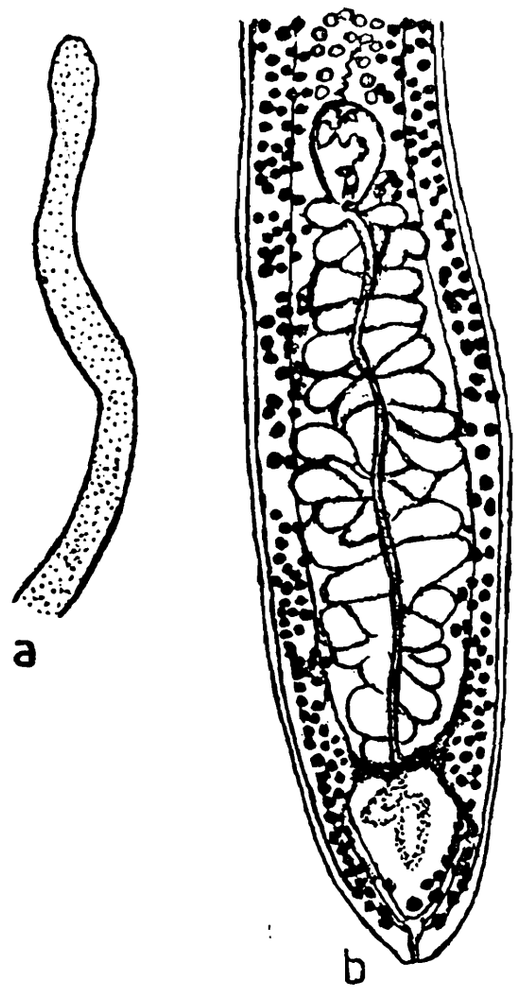

Fig. 39 : *Pseudocapingentoides indica* Verma (After Verma, 1971).
a. Scolex and neck,
b. Posterior half of body.

end of body, occasionally posteriormost ovarian follicles intermingling to give it a shape like inverted A and also giving false impression of presence of post-ovarian vitelline follicles. Vitelline follicles spherical or oval in outline, cortical, arranged laterally in a crescent (in cross-section) extending from a bit anterior level of testes to almost midlevel of pre-commissural uterine extent, sometimes continuous with the follicles of anterior ovarian horns. No post-ovarian median vitelline follicles. Ootype large oval chamber receiving oviduct, common vitelline duct and shell gland cells. Uterus thrown

into close lateral coils, pre-commissural uterine extent more than twice to four and a half times of post-commissural space, not extending anterior to cirrus sac. Vagina slightly undulating narrow tube running in median line on ventral side of body, joining uterus terminally forming short utero-vaginal canal. Seminal receptacle absent.

Eggs operculated, oval, 30-40× 21-25 μm.

Excretory pore terminal.

Remarks : The genus *Pseudocapingentoides* Verma, 1971 is characterised by

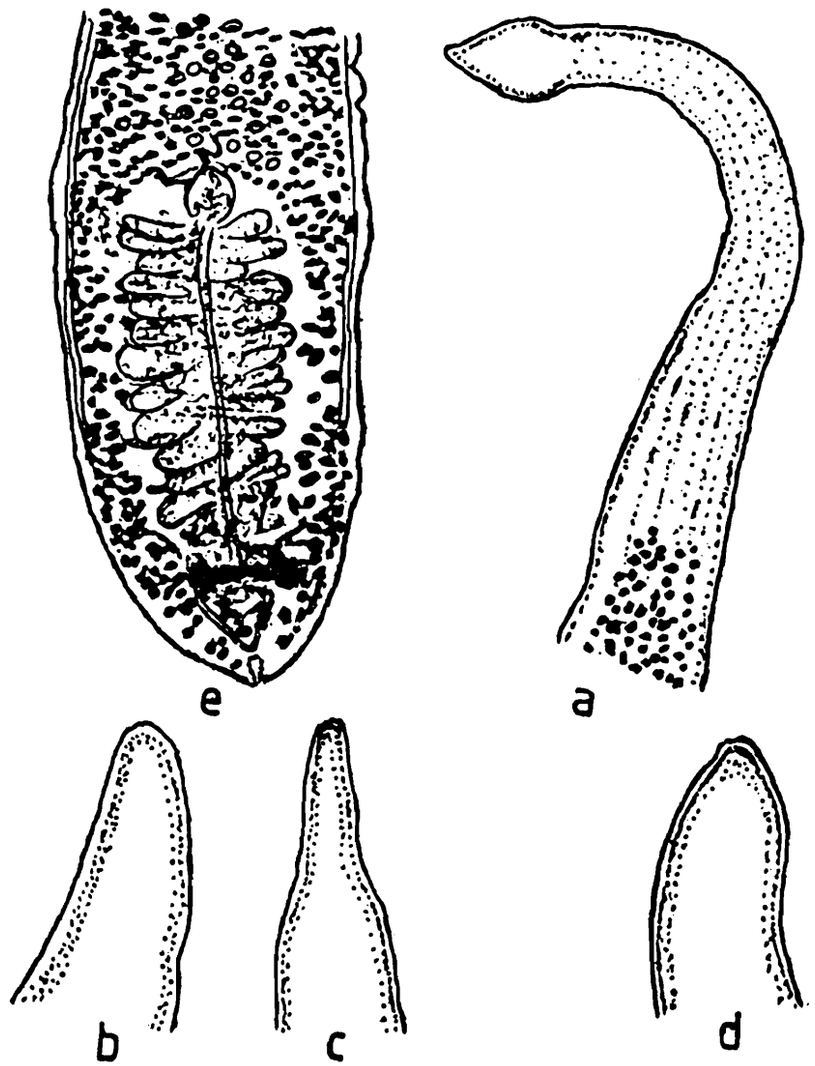

Fig. 40 : *Capingenioides singhi* Verma (After Verma, 1971).
a. Scolex and neck,
b, c & d. Scolex shapes.

having main body gradually tapering into neck and scolex not marked off one from the other, scolex unspecialised, poorly defined, not wider than body, pre-commissural uterine

extent very long being more than twice to four and a half times longer than post-commissural body space or uterine extent almost twice the length of anterior ovarian horns removing genital pores much anteriorly. The genus was placed in the family Capingentidae without studying cross-sections of its material and without ascertaining muscle-vitellaria relationship. In all the above listed six species of the genus *Capingentoides* Gupta,

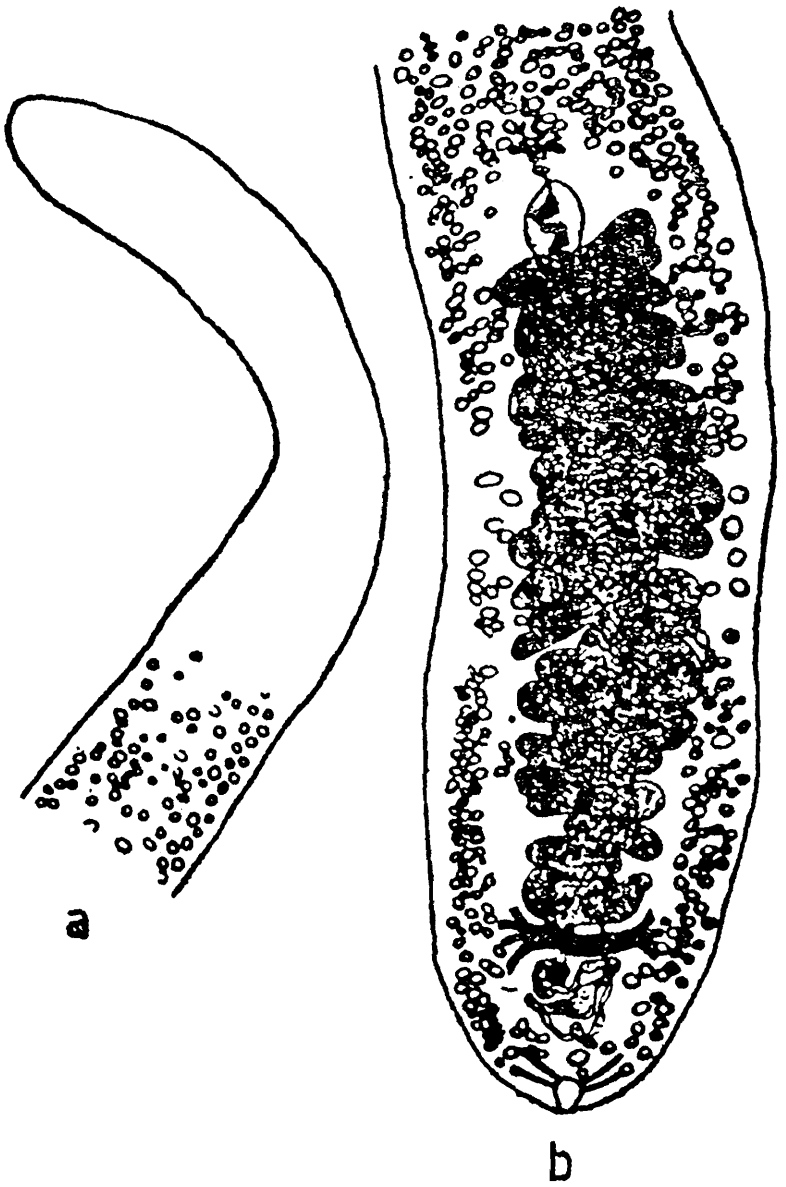

Fig. 41 : *Capingentoides heteropneusti* Gupta and Sinha (After Gupta and Sinha, 1980).
a. Anterior part of body,
b. Posterior half of body.

1961 and *Pseudocapingentoides* Verma, 1971 the vitelline follicles have been described to be spherical to oval in outline and disposed lateral to the testicular field. As the vitelline follicles are not lobed, irregular or elongate in outline, the genus *Pseudocapingentoides*

does not seem to belong to the family Capingentidae. The description that the testes are bounded by vitelline follicles laterally is ambiguous. In the absence of the knowledge of the inner longitudinal muscles, this could be a condition of Lytocestidae

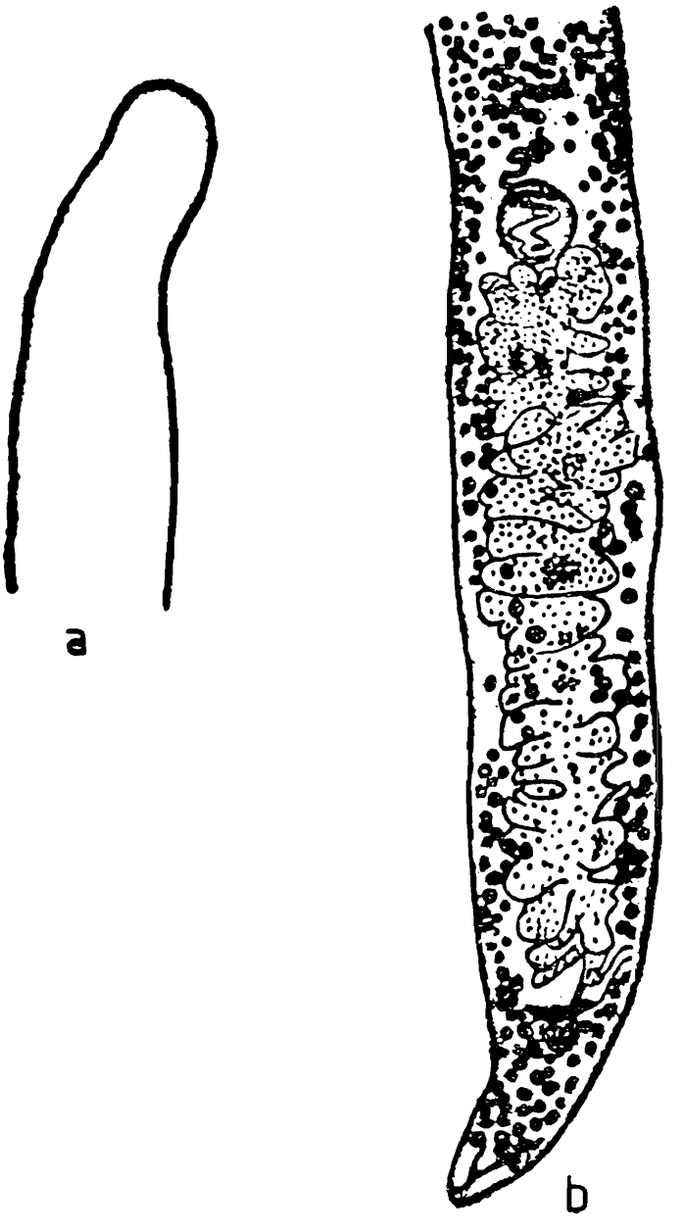

Fig. 42 : ***Pseudocapingentoides cameroni*** **Gupta and Sinha (After Gupta and Sinha, 1984).**
a. Anterior part of body,
b. Posterior half of body.

as well as Caryophyllaeidae. In *Pseudocapingentoides indica* Verma, 1971, ***P. cameroni*** Gupta, S.P. and Sinha, 1984 and *P. gomatii* Gupta, V. and Parmar, 1990 the male and female gonopores open separately but they are very close to each other. This fact itself is strong evidence that *Capingentoides singhi* Verma, 1971, *Capingentoides*

heteropneusti Gupta, S.P. and Sinha, 1980 and *C. fotedari* Gupta, V. and Parmar, 1986 must also be having separate male and female gonopores instead of a single common gonopore which is not supported by any midsagittal section. The investigator is misled because the male and female gonopores are very closely apposed to each other and the expelling eggs cover up the female pore. Further, the vitellaria do not extend from anterior level to posterior end of body. This is evident from Figs. 41b, 42 band 43b of

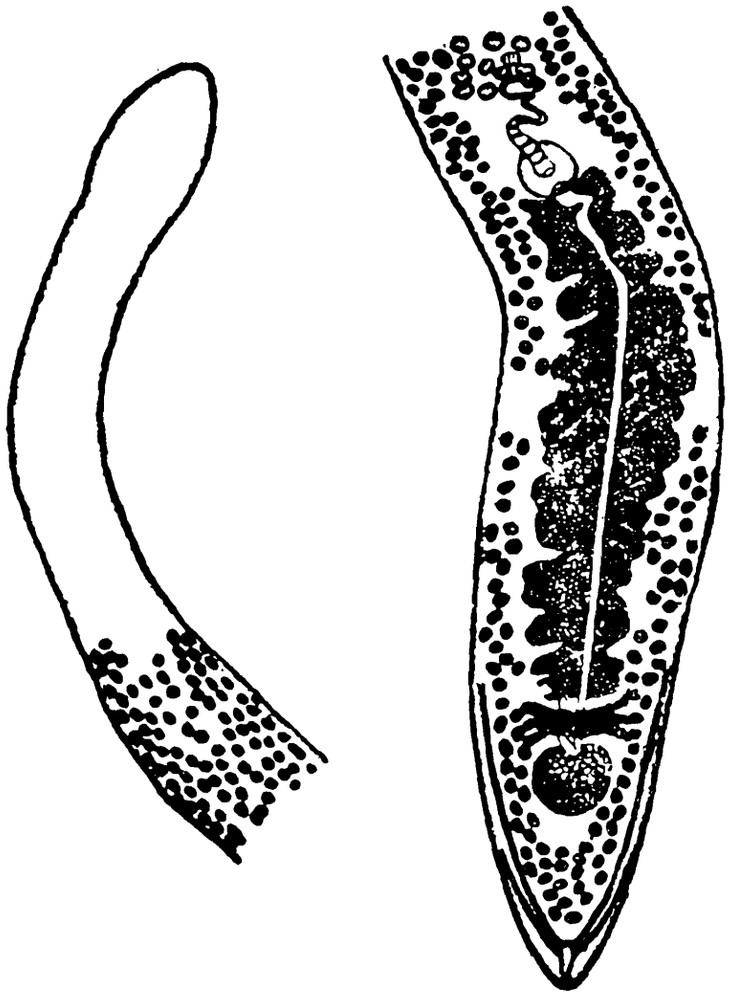

Fig. 43: *Capingentoides fotedari* Gupta and Parmar (After Gupta and Parmar, 1986).
a. Anterior part of body,
b. Posterior half of body.

Capingentoides heteropneusti, *Pseudocapingentoides cameroni* and *Capingentoides fotedari* respectively in which the posterior vitelline follicles do not become continuous with the follicles of the anterior horns of the ovary. Similarly, there are no post-ovarian vitelline follicles. In fact, they are the follicles of the posterior horns of the ovary which occasionally intermingle at the posterior end of the body giving the ovary 'U' or inverted 'A' shape.

Murher (1963) erected the genus *Crescentovitus* with *C. biloculus* as its type species from the stinging cat-fish *Heteropneustes fossilis* from Nagpur (Maharashtra). Its scolex was originally described to have two loculi and a short terminal introvert. Mackiewicz (1981) checked its holotype specimen and found that the loculi "are in fact artefacts on an unspecialised scolex" which means that loculi and terminal introvert are absent in the type species *C. biloculus*. The species name '*biloculus*' is thus a misnomer now. Further, the described constriction separating scolex from neck appears to be an artefact of fixation.

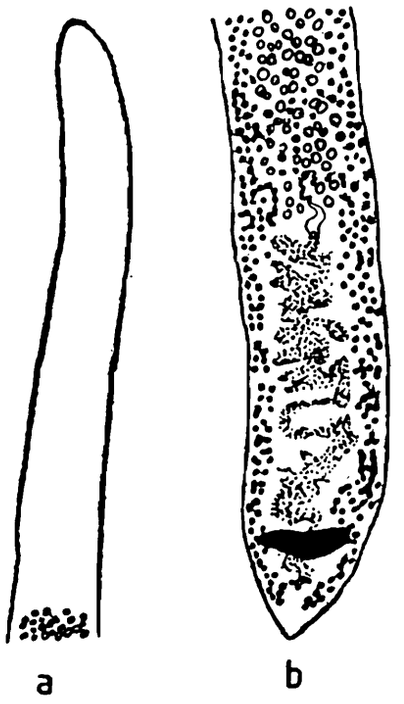

Fig. 44 : *Pseudocapingentoides gomatii* **Gupta and Parmar (After Gupta and Parmar, 1990).**
a. Anterior part of body,
b. Posterior half of body.

Thus, the type species *Pseudocapingentoides indica* Verma, 1971 becomes identical to the type species *Crescentovitus biloculus* Murhar, 1963 in characters like structure of scolex, shape of body, extent of uterus and general descriptions of both. Hence, *Pseudocapingentoides* falls as a synonym of *Crescentovitus* in the family Lytocestidae.

14. **Bovienia ilishai** Zaidi and Khan

(Fig. 45)

1976. *Bovienia ilishai* Zaidi and Khan, *Biologia*, 22 (2) : 158.

Material examined : Nil.

Host—*Macrura ilisha* (Hamilton) syn. of *Hilsa ilisha* (Hamilton-Buchanan), Hilsa shad, (Clupeiformes : Clupeidae) ; location—intestine ; locality—Ghulam Mohammad Barrage, Karachi, Pakistan ; no. of specimens—two worms, no cross-section.

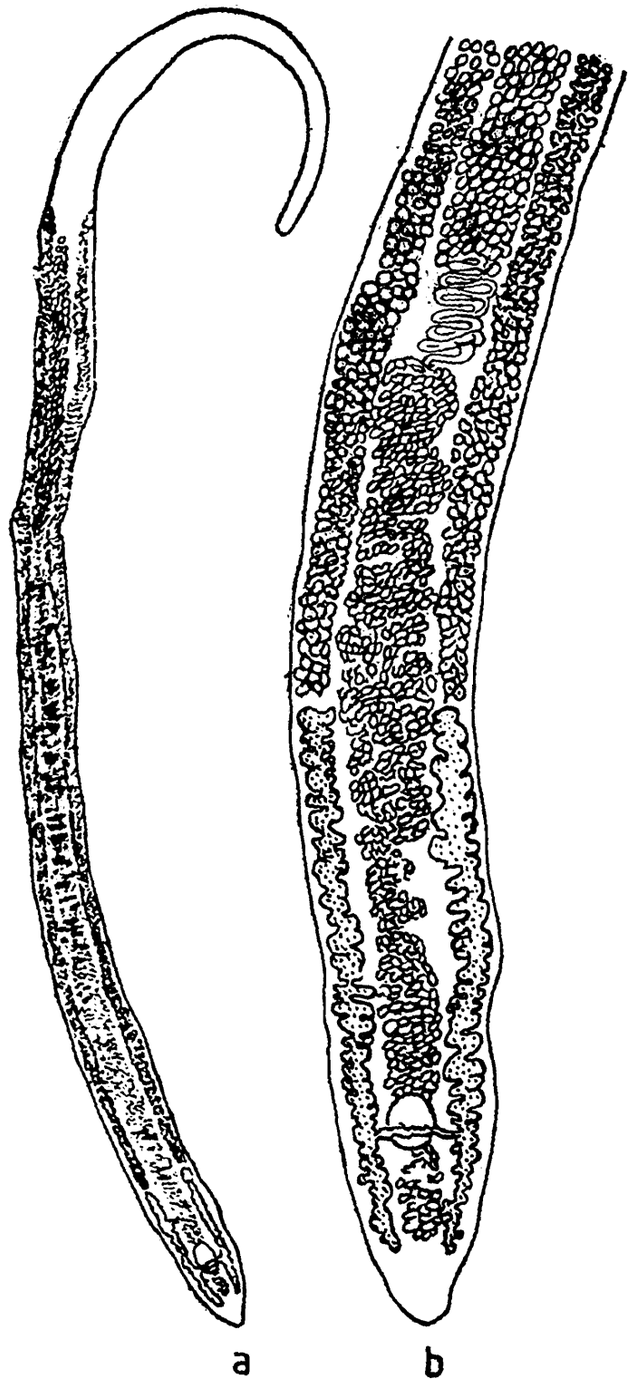

Fig. 45 : *Bovienia ilishai* Zaidi and Khan (After Zaidi and Khan, 1976).
a. Entire worm,
b. Posterior half of body (enlarged).

Description : Body elongated, tapering anteriorly, pointed at posterior end, 15·082-15·972 long, 0·582-0·59 wide. Scolex not marked off from neck, narrower than body, unspecialised. Neck long, narrow. About anterior one-fifth of body devoid of any organ system. Positions of musculatures not known as cross-sections not studied. Male and female gonopores separate, at about beginning of last one-fifth of body. Common genital atrium not known.

Testes numerous, rounded, 0·039-0·019 in diameter, extending in about middle three-fifth of body length in median field, remaining post-eriorly restricted to level of vas deferens. Vas deferens strongly convoluted behind testicular field. Cirrus sac muscular, enclosing sinuous ejaculatory duct and cirrus opening as male gonopore on ventral surface.

Ovary H-shaped, in posterior part of body ; ovarian arms 1·74-1·95 long, 0·112-0·114 wide, follicular, connected by transverse isthmus ; anterior ovarian horns much longer (about 2-3 times) than posterior ones. Uterus closely coiled in median field between female gonopore and level of posterior ends of ovarian arms, pre-isthmus uterine extent almost twice or more longer than anterior horns of ovary, never extending anterior to cirrus sac. Large seminal receptacle present near ovarian isthmus, (illustrated, not mentioned in description). Vitellaria follicular, cortical, lateral on each side, extending from slightly anterior to anterior level of testicular region to anterior horns of ovary, follicles smaller than size of testes. Post-ovarian vitellaria absent.

Eggs 31-36 × 20-23 μm.

Remarks : Serial transverse sections through various regions of body were not cut and studied and therefore position of parenchymal muscles could not be known. This inadequacy affects the determination of the family of the present species. I have simply concurred with Zaidi and Khan (1976) in placing this species in the family Lytocestidae. Caryophyllid cestodes generally parasitise fresh water teleosts belonging to the Orders Cypriniformes and Siluriformes but the report of this species from a migratory fish (living in marine, brakish and fresh water) belonging to the order Clupeiformes is quite unusual. The host fish *Hilsa ilisha* (= *Macrura ilisha*) appears to be an accidental host.

15. **Bovienia serialis** (Bovien) Fuhrmann

(Figs. 46-48)

1926. *Caryophyllaeus serialis* Bovien, *Vidensk. Medd. Dansk. natur. Forening* : *Kobenhaum*, 82 : 157-181.

1931. *Bovienia serialis* : Fuhrmenn, *Handbuch der Zoologie* (W. Kukenthal and T. Krumbach, eds.). Bd. 2 : 141-416.

1972. *Bovienia serialis*: Mackiewicz and Murhar, *J. Parasit.*, 46 (4): 401.
1980. *Introvertus raipurensis* Satpute and Agarwal, *Proc. Indian Acad. Parasit.*, 1 (2): 17.
1982. *Lucknowia indica* Niyogi, Gupta and Agarwal, *Proc. Indian Acad. Parasit.*, 3 (1-2): 17.

Material examined: Nil.

Host—*Clarias batrachus* (L.), Walking cat-fish, (Siluriformes : Clariidae) ; location—intestine ; localities—Nagpur, Ramtek (Maharashtra), Durg, Raipur (Madhya Pradesh), Varanasi (Uttar Pradesh) and Guwahati (Assam) ; no. of specimens—185 gravid and immature worms ; of these 33 gravid and 7 immature ones were studied, 11 were sectioned. Holotype in Helm. Coll., Institute de Zoologie, Neuchatel, Switzerland ; 2 whole mounts in USNM Helm. Coll. No. 72139 ; 2 whole mounts in BMNH Helm. Coll. Nos. 1972 1·3, 1 and 2.

Description: Body elongated, narrow, tapering anteriorly, posterior and pointed, about 14·00-35·00 long, 0·8-1·6 in maximum width, scolex not distinctly demarcated from neck, unspecialised, 0·2-0·4 wide, not broader than body. Neck present, long, narrow. Male and female gonopores in beginning of last eight of body length on ventral surface. Common genital atrium probably absent.

Testes ovoid or spherical, 213-479 in number, 0·05-0·25 in diameter, medullary, extending from slightly behind anterior most vitellaria to coils of vas deferens, surrounded by a ring of inner longitudinal muscles. Vas deferens a much convoluted narrow tube. External and internal seminal vesicles absent. Cirrus sac ovoid, 0·5-0·8 in diameter, anterior to ovary, enclosing convoluted ejaculatory duct and unspined cirrus, opening on ventral body surface as male gonopore.

Ovary H-shaped, situated near posterior end of body ; ovarian arms 1·2-2·3 long, follicular, cortical, connected by transverse medullary isthmus, occasionally follicles of posterior horns of ovary intermingling near posterior end to give ovary an inverted 'A' shape. Uterus thrown in lateral coils in median field, not extending anterior to cirrus sac, pre-isthmus uterine extent somewhat longer than anterior horns of ovary. Vaginal tube narrow, straight. Utero-vaginal canal short, opening as female gonopore close behind male gonopore. Seminal receptacle large, well developed, immediately anterior to ovarian isthmus. Vitelline foilicles cortical, external to inner longitudinal muscles in two lateral rows, pre-ovarian, extending from a level slightly anterior to anterior most testes to region of cirrus sac or female gonopore, follicles 0·06-0·23 in diameter. Post-ovarian vitelline follicles absent.

Eggs 37-42 × 28-31 μm, smooth, operculate.

Osmoregulatory canals 10-13 at mid-region of body, joining to form excretory vesicle near posterior end ; pore terminal.

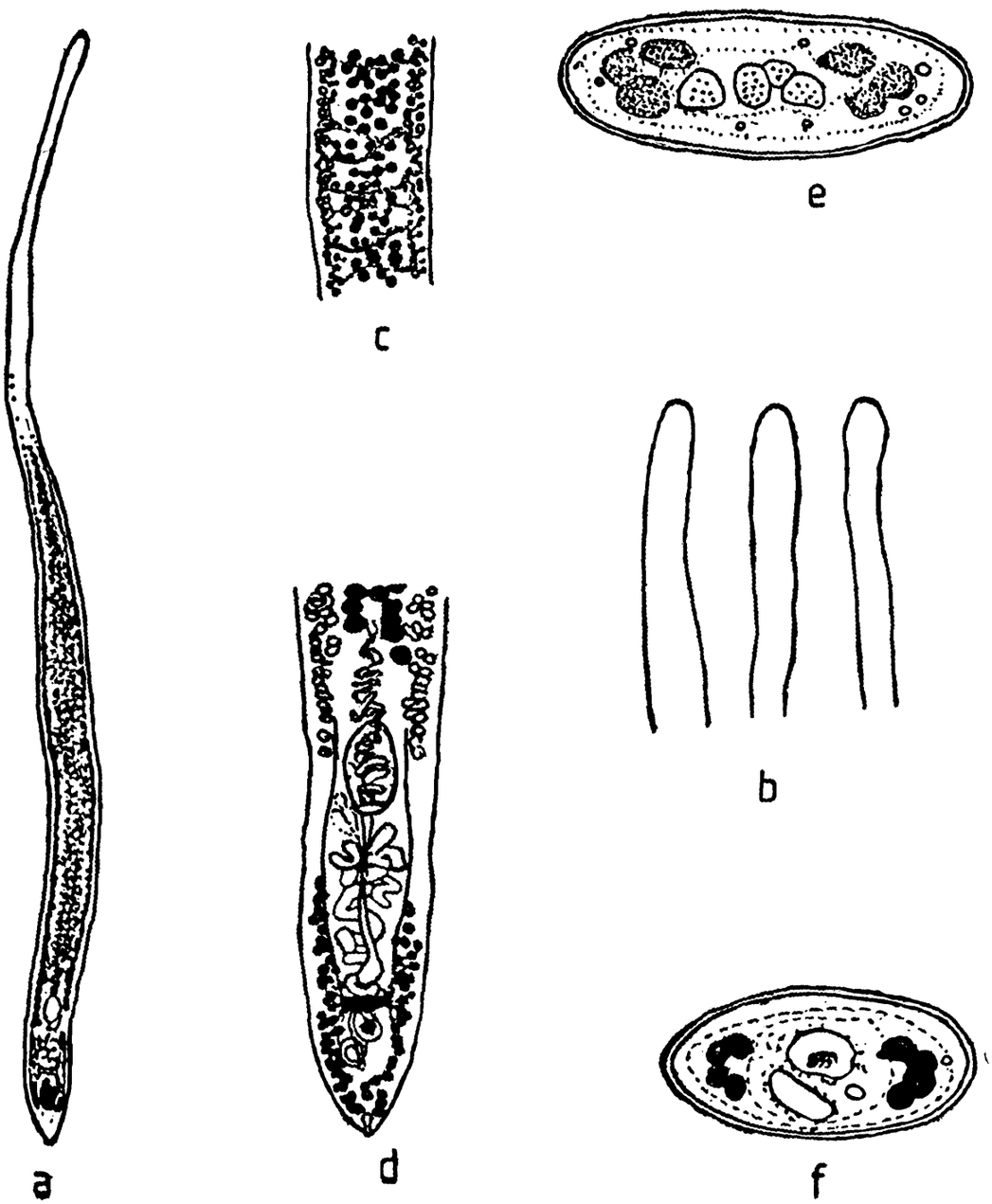

Fig. 46 : *Bovienia serialis* (Bovien). (After Mackiewicz and Murhar, 1972).
a. Entire worm,
b. Scolex shapes,
c. Middle part of body,
d. Posterior half of body,
e. Cross-section through region of testes,
f. Cross-section through region of ovary.

Remarks : Bovien (1926) originally described this species from a single whole specimen and some fragments of others in the genus *Caryophyllaeus*. He collected the material from the cat-fish *Clarias batrachus* (L.) from Java. Fuhrmann (1931) made it the

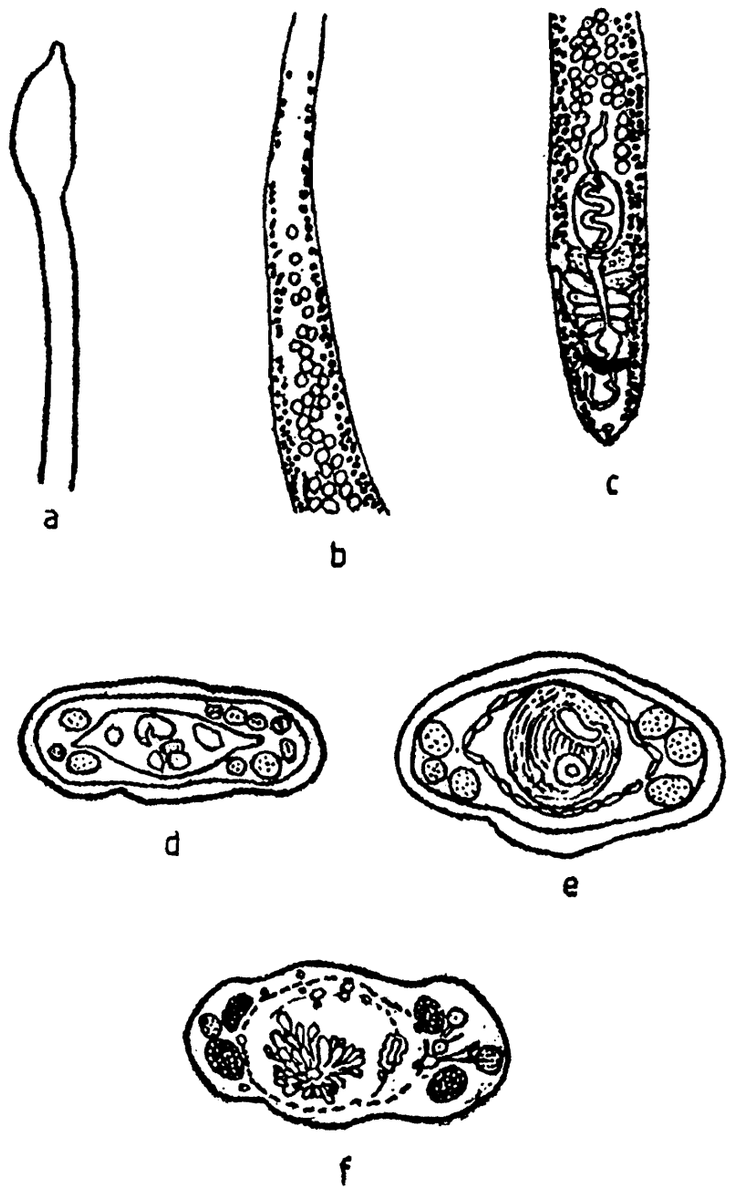

Fig. 47 : *Introvertus reipurensis* Satpute and Agarwal (After Satpute and Agarwal, 1980b).
- a. Scolex and neck,
- b. Middle part of body,
- c. Posterior part of body,
- d. Cross-section through testicular field,
- e. Cross-section through cirrus sac,
- f. Cross-section through ovary.

type species of his new genus ***Bovienia*** but he did not formulate a generic diagnosis. Yamaguti (1959) first and Schmidt (1970) later on attempted to give a diagnosis of the genus but not without gross errors. Mackiewicz and Murhar (1972) not only gave a correct diagnosis of ***Bovienia*** but also redescribed ***B. serialis*** completely and correctly on the basis of material recovered from the type host from Java, Malaysia and India, and thus removed all confusions about it.

Satpute and Agarwal (1980) proposed a new genus ***Introvertus*** and described the type species ***I. raipurensis*** on the basis of the material recovered from the fish ***Clarias***

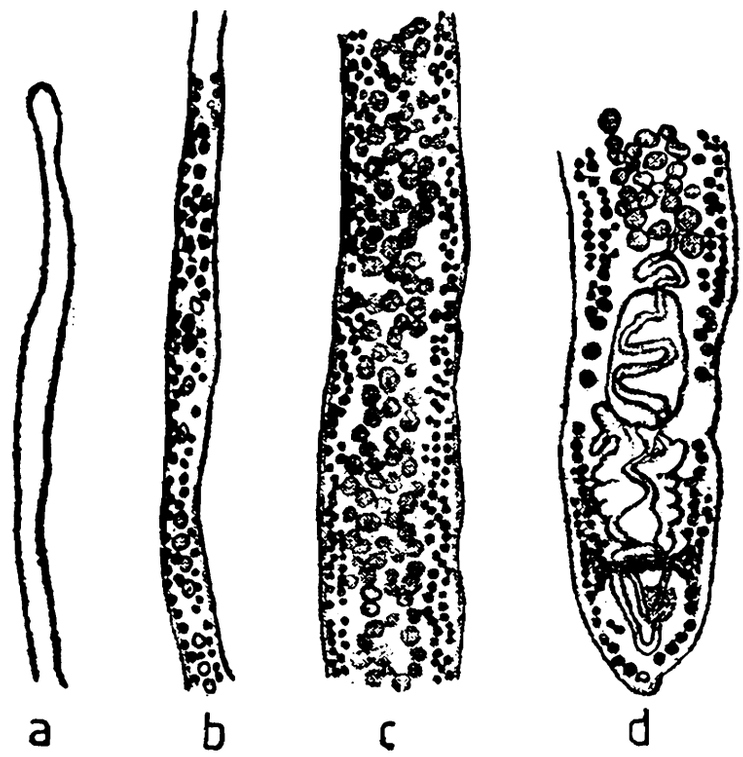

Fig. 48 : ***Lucknowia indica*** **Satpute and Agarwal (After Satpute and Agarwal, 1980a).**
a. Scolex and neck,
b&c. Middle parts af body,
d. Posterior part of body.

batrachus examined at Raipur (Madhya Pradesh). The scolex of this genus has been characterised to be "ovoid globular or pear-shaped with a pair of longitudinal grooves and a terminal introvert". Their Fig. 2 suggests that some of the specimens were partially decomposed and flaccid. As Mackiewicz (1981b) observed in the case of ***Crescentovitus biloculus*** Murhar, 1963 that "the loculi in fact are artifacts on an unspecialised scolex", the same seems to be true with the scolex of ***Introvertus raipurensis*** too. This is corroborated

by the action of Schmidt (1986) in synonymising *Introvertus* Satpute and Agarwal, 1980 with *Lucknowia* Gupta, 1961 (although I do not agree with this synonymy on some different grounds) and characterising scolex as unspecialised for both. Thus, the two longitudinal grooves and terminal introvent on the scolex of *I. raipurensis* appear to be pseudostructures and non-existent being artifacts of fixation. Niyogi, Gupta and Agarwal (1982) described *Lucknowia indica* from the same host *Clarias batrachus* and from the same locality of Raipur. Its scolex in Fig. 1 has been shown slightly swollen as in *Bovienia serialis* from the same host and locality while in Fig. 2 the scolex is stumpy. It means that the shape of scolex in *L. indica* is variable. From the foregoing discussion it becomes fairly clear that the scoleces in *I. raipurensis* and *L. indica* (both from the same host and locality) are unspecialised although swollen. Further, as has been observed by Mackiewicz (1981b) in the case of *Lucknowia fossilis* Gupta, 1961, it seems there are no post-ovarian vitelline follicles in *I. raipurensis* and *L. indica* too. In fact, they are the follicles of the ovary. Post-ovarian follicles of vitellaria are therefore absent in these two species. Once the unspecialised nature of scolex in *I. raipurensis* and absence of post-ovarian vitelline follicles are established, there remains no pronounced morphological differences between these two species and *Bovienia serialis*. Thus, *Introvertus* falls as a synonym of *Bovienia*. Consequently, *I. raipurensis* and *L. indica* also become synonyms of *B. serialis*.

Genus 8. **Lytocestoides** Baylis

1928. *Lytocestoidies* Baylis, *Ann. Mag. nat. Hist.*, series 10, 1 : 552-562.

Diagnosis : Scolex short, roughly conical, not broader than rest of body, unspecialised. Neck absent. Male and female gonopores separate. Common genital atrium present in last fourth of body length. Testes medullary, between scolex and uterus. Vitelline follicles regular in shape, cortical, superficial, forming a continuous layer surrounding testes and continuing laterally to post-ovarian region. Ovary bowtie-shaped, bilobed. Uterus relatively short, not extending anterior to cirrus sac. Excretory canals, at least in posterior region of body, internal to vitellaria. Parasitic in cyprinoid and siluroid fishes. Africa, India.

Type species : *Lytocestoides tanganyikae* Baylis, 1928, in *Alestes* sp. ; Kirando in Tanganyika.

16. **Lytocestoides paithanensis** Shinde and Deshmukh

(Fig. 49)

1975. *Lytocestoide paithanensis* Shinde and Deshmukh, *Marathwada Univ. Nat. Sci. J.*, 14 (7) : 233.
1981b. *L. paithanensis* : Mackiewicz, *Himalayan J. Sci.* 1 (1) : 6.
1985. *L. paithanensis* : Agarwal, *Indian Rev. Life. Sci.*, 5 : 143.

Material examined : Nil.

Host—*Pseudeutropius taakree* (Sykes), (Siluriformes : Schilbeidae) ; location—intestine ; locality—Paithan (river Godavari, Maharashtra) ; no. of specimen—one.

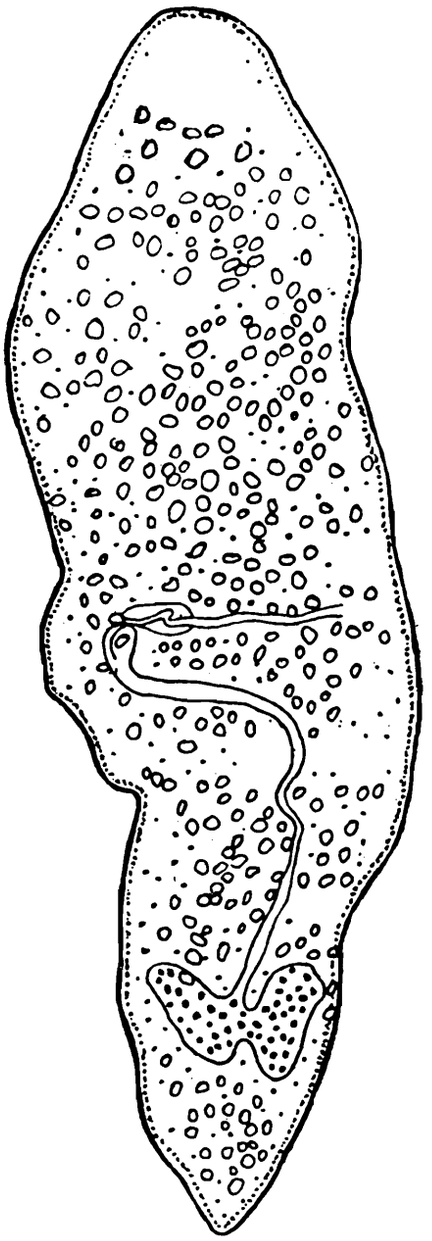

Fig. 49 : *Lytocestoides paithanensis* Shinde and Deshmukh (After Shinde and Deshmukh, 1975).

Description: Body elongated, conical anteriorly, broadened in middle, slightly tapering posteriorly to conical end, measuring 2·5 × 0·79. Scolex conical, not marked off from body, unspecialised. Neck absent. Male and female gonopores separate, opening on ventral surface in middle region. Common genital atrium apparently present.

Testes follicular, medullary, about 400 in number, 0·025-0·061 in diameter, extending from base of scolex to cirrus sac. Vas deferens almost in middle of body, winding. External and internal seminal vesicles apparently absent. Cirrus sac situated in middle region of body, 0·16 × 0·066, opening by male pore ventrally.

Ovary medullary, dumbbell- or butterfly-shaped, bilobed, lobes connected by very short and narrow isthmus, situated in posterior region of body. Uterine extent twice length of post-isthmus space (not shown figure). Vagina thin, narrow, winding tube. No seminal receptacle. Utero-vaginal opening as female pore closely behind male pore. Vitellarium follicular, follicles smaller than testes, cortical, lateral, post-ovarian follicles of vitellarium present. Pre-ovarian and post-ovarian follicles of vitellaria connected by follicles lateral to lobes of ovary.

Remarks: Mackiewicz (1981b) has examined the solitary specimen of the present species. He could not determine its genus because of its bad and decomposed condition. Moreover, the material has been inadequately studied and ill-described since some important characters could not be made known and there are certain self-contradictions in the discription. Attempt should be made to collect some more material from the type host and type locality and the species carefully reappraised since it has been described on the basis of a single specimen which is immature without the development of uterus and eggs. The vitellarium has been presumed to be follicular rather than granular because the post-ovarian vitellarium is follicular. Since the species looks akin to *Lytocestoides tanganyikae* Baylis, 1928 in shape and general details, it is retained in the genus *Lytocestoides* Baylis 1928 tentatively.

Lytocestoides paithanensis differs from the type species *L. tanganyikae* mainly in the position of genital pores being almost in middle of body and longer extent of pre-isthmus uterus (supposed).

SPECIES OF UNCERTAIN SYSTEMATIC POSITION

Caryophyllaeus kashmirensis Mehra *Species inguirenda*

1930. *Caryophyllaeus kashmirensis* Mehra, *Proc. 17th Sci. Congr. Ass.* : 247.
1972. *Caryophyllaeus kashmirensis* : Mackiewicz, *Exptl. Parasit.*, 31 : 486.
1981b. *Caryophyllaeus kashmirensis* : Mackiewicz : *Himalyan J. Sci.*, 1 (1) : 4.
1985. *Caryophyllaeus kashmirensis* : Agarwal, *Indian Rev. Life. Sci.*, 5 : 142.

Material examined : Nil.

Host—*Schizothorax micropogan* Heckel, (Cypriniformes : Cyprinidae) ; location—intestine ; locality—near Srinagar, Kashmir ; no. of specimens—several.

Description : Body elongated, 30·0-60·0 long, 1·0-2·0 wide at level of male gonopore situated in last eight to tenth of body length. Scolex slightly wider than rest of body, smooth, unspecialised. Vas deferens strongly convoluted. Pre-ovarian vitelline follicles cortical, external to inner longitudinal muscles, annularly arranged surrounding testes. Post-ovarian vitelline follicles present, medullary in disposition. Ovary entirely medullary. Uterus much convoluted, with thick coat of uterine glands, not extending anteriorly beyond female gonopore. Vagina a straight tube, joining terminally with uterus to from a short utero-vaginal canal opening ventrally as female gonopore. Genital atrium not known. Seminal receptacule not known.

Eggs 45-55 × 30-30 μm.

Osmoregulatory canals 10-13.

Remarks : The account of *Caryophyllaeus kashmirensis* Mehra, 1930 is available only in the abstract from. Its full description was never published. That is why the necessary illustrations are not available. Mehra (1930) did not mention the outline (whether irregular or smooth) of the vitelline follicles in his abstract and clearly stated that they are cortical in disposition being external to inner longitudinal muscles but placed his species in the genus *Caryophyllaeus* Gmelin, 1790 in the family Caryophyllaeidae. This is a serious self-contradiction. According to the stated cortical position of pre-ovarian vitelline follicles, the species ought to have been placed in the family Lytocestidae. Mehra was apparently misled by medullary disposition of post-ovarian vit. follicles in placing it in the genus *Caryophyllaeus*. Moreover, information on the number and extent of testes, position of cirrus sac, external and internal seminal vesicles, shape and anterior extent of ovary, seminal receptacle and genital atrium is not at all available. Knowledge on these characters is necessary to formulate a definite

diagnosis of *Caryophyllaeus kashmirensis*. Non-availability of information on these important characters made Mackiewicz (1972) declare it as *species inquirenda*. He (1981) further suggested that fresh material should be collected from the type host and type locality, carefully studied and compared with *Adenoscolex oreini* Fotedar, 1958 which is reported from the fish *Orienus sinuatus* commonly found in the hill streams of Kashmir.

Taking clue from the described distribution of pre-ovarian vitelline follicles to be external to the inner longitudinal muscles, Agarwal (1985) included *Caryophyllaeus kashmirensis* in the family Lytocestidae. Further, presuming the *Adenoscolex oreini* Fotedar, 1958 (also described from a hill stream fish of Kashmir) to be identical to *Caryophyllaeus kashmirensis*, he suggested that *"C. kashmirensis* be considered synonymous to *A. oreini"*. There does not seem to be good justification in this action or suggestion since *Adenoscolex* Fotedar, 1958 (type species *A. oreini*) is a very well established genus in the family Capingentidae, and Agarwal (1985) himself considers *C. Kashmirensis* to belong to the family Lytocestidae. Mackiewicz (1981b) has rightly suggested that fresh material of *C. kashmirensis* should be collected from the type host from Kashmir and its correct and complete description should be furnished first, and only then any action can be taken regarding its systematic position *vis-a-vis A. oreini*. Till then *C. kashmirensis* should best be considered *species inquirenda* or a species of uncertain systematic position. Probably Mackiewicz thinks that Mehra (1930) might have erred in studying the position of vitelline follicles in relation to the inner longitudinal muscles because he has himself observed in the abstract that the species (*C. kashmirensis*) apparently connects the two genera *Caryophyllaeus* and *Lytocestus*. From this discussion at least this much becomes clear that *Caryophyllaeus oreini* Mehra, 1930 does not belong to the genus *Caryophyllaeus*.

DISCUSSION

No concerted efforts have been made to collect and study caryophyllid cestodes in India. They have been reported only from a few places. A vast area still remains to be explored for these worms. Altogether 40 species under 14 genera have been reported from Indian region, including one species each from Nepal and Pakistan. *Lytocestus filiformis* was originally described from Sudan (Africa), but it has been recorded from the north-eastern region of India also. The Indian caryophyllids represent three of four families, namely, Caryophyllaeidae, Capingentidae and Lytocestidae. The family Balanotaeniidae is known from Australian region only.

Prof. J.S. Mackiewicz of the State University of New York at Albany, USA, has personally examined most of the described Indian caryophyllid species. He (1981b) found that some materials are in such a condition that their family and genera are difficult to be determined while others have been inadequately and erroneously studied and described. He further remarks that the taxonomy of described Indian caryophyllids is far from satisfactory and a clear picture of the systematics of the Indian caryophyllid fauna does not emarge.

These observations and remarks of Prof. J.S. Mackiewicz prompted me to revise the taxonomy of described species of Indian caryophyllids and straighten it which is in utter confusion. With this aim in view I tried to seek the co-operation of some of the Indian authors for examining their reported materials, but the same was not extended for reasons best known to them excepting Dr. V. Tandon. So, I had to depend on the existing literature on the group as well as my own collection to study intraspecific variations. As a result, most of the diagrams of species, reliable or not, used in this work have been taken from original sources. Due to inadequacies in the description of species some tentative taxonomic decisions had to be taken.

While going through the literature critically I could understand at least five main reasons for unsound foundation of the taxonomy of Indian caryophyllids. Firstly, the materials perhaps were not processed for collection according to the standard technique due to which overflattening and crushing occured. In many cases probably late fixation caused creeping in of artefacts of fixation. Secondly, barring a few cases, cross-sections and mid-sagittal sections of body were not cut leading to erroneous family and genus determinations. Thirdly, perhaps suitable stain was not chosen to stain the whole specimens and differentiation after overstaining was not dextrously done making it difficult to distinguish follicles of testes, vitellaria and ovary one from the other. Fourthly, use of cytological studies of these organs were not at all employed along with the general morphological and anatomical studies. Fifthly, in many cases even the morphological and anatomical studies were deplorably inadequate and inaccurate leading to repeated descriptions of many species under new names and under different genera. Moreover, there is no dearth of examples in which new species have been described utilising the pseudo-characters which develop due to the state of contraction and relaxation at the time of fixation.

From the study of my own caryophyllid collections from the cat-fishes *Clarias batrachus* and *Heteropneustes fossilis*, I have found it very difficult in the whole mounts to make out number of gonopores, presence or absence of common genital atrium and whether the vitellaria is lateral or annular, medullar, or partly medullary and partly cortical. I have also found variations in scolex shape in the specimens of a single population. In one and the same population it has also been detected that the posterior extent of vitalline follicles may or may not be continuous with those of the anterior horns of the ovary, and the follicles of

posterior ovarian horns may extend up to the posterior end of the body, occasionally intermingling from both sides giving the false impression of post-ovarian vitelline follicles. This intraspecific variation is very common misleading to the investigators.

The biology, specially the development and life-history, has not at all been worked out. Our knowledge on the biology of Indian caryophyllid is rather cipher. The pressing need to have a good and sound understanding of the taxonomy of these cestodes is to make adequate and accurate studies on morphology, anatomy and intraspecific variations employing correct techniques of collection and staining of material well supplemented by cross-sections and mid-sagittal sections.

As a result of the study of 40 species of caryophyllids under 14 genera, the valid species and genera have been found to be 16 and 8 respectively with one species, *Caryophyllaeus kashmirensis*, of uncertain systematic position, Mackiewicz (1972) considered it as *species inquirenda* as its inadequate account is available only in abstract form. However, its resemblances to *Adenoscolex oreini*, also from Kashmir, are unmistakable.

India is a vast country with numerous benthic feeding Siluriformes and Cypriniformes freshwater fishes, and with about 67 species of freshwater oligochacte annelids known so far belonging to the families Tubicidae, Naididae and Aelosomatidae. These facts are indicative that many more caryophyllids are yet to be discovered from India.

HOST—PARASITE LIST

Host	Parasite
Order Clupeiformes	
Family Clupeidae	
Hilsa ilisha (Ham.—Buch.) Syn. *Macrura ilisha* (Ham.)	*Bovienia ilishai* Zaidi and Khan
Order Channiformes	
Family Channidae	*Lytocestus fossilisi* (Gupta)
Channa striatus (Bloch)	
Order Cypriniformes	
Family Cobitidae	*Paracaryophyllaeus lepidocephali* (Kundu)
Lepidocephalus guntea (Ham.)	

Host	Parasite
Family Cyprinidae	
Barbus kolus (Sykes)	*Brevicolus aurangabadensis* Shinde
Cirrhina mrigala (Ham.)	*Breviscolex naldurgensis* Shinde *et al.*
Labeo calbasu (Ham.)	*Breviscolex aurangabadensis* Shinde
Oreinus sinuatus (Heckel)	*Adenoscolex oreini* Fotedar
Ostiobrama cotio (Ham.)	*Paracaryophyllaeus ostiobramensis* (Gupta and Sinha)
Order siluriformes	
Family Bagridae	
Rita rita (Ham.)	*Pseudocaryophyllaeus indica* Gupta
Family Clariidae	
Clarias batrachus (L.)	*Bovienia serialis* (Bovien)
	Djombangia Penetrans Bovien
	Lytocestus birmanicus Lynsdale
	Lytocestus filiformis (Woodland)
	Lytocestus indicus (Moghe)
	Lytocestus longicollis Rama Devi
	Pseudocaryophyllaeus indica Gupta
Family Heteropneustidae	
Heteropneustes fossilis (Bloch)	*Bovienia bilocula* (Murhar)
	Djombangia penetrans Bovien
	Lytocestus fossilisi (Gupta)
	Pseudocaryophyllaeus indica Gupta
Family Schilbeidae	
Pseudeutropius taakree (Sykes)	*Lytocestoides paithanensis* Shinde and Deshmukh

PARASITE—HOST LIST

(Species marked with asterisk are synonyms)

Parasite	Host
Family Caryophyllaeidae Leuckart	
Genus *Paracaryophyllaeus* Kulakovskaya	
P. lepidocephali (Kundu)	*Lepidocephalus guntea* (Ham.)
P ostiobramensis (Gupta & Sinha)	*Ostiobrama cotio* (Ham.)
Genus *Pseudocaryophyllaeus* Gupta	
P. indica Gupta	*Clarias batrachus* (L.)
**Capingentoides batrachii* Gupta	*Clarias batrachus* (L.)
**Pseudocaryophyllaeus lucknowensis* Gupta & Sinha	*Heteropneustes fossilis* (Bloch)
**P. mackiewiczi* Gupta & Parmar	*Heteropneustes fossilis* (Bloch)
**P. ritai* Gupta & Singh	*Rita rita* (Ham.)
Family Capingentidae Hunter	
Genus *Adenoscolex* Fotedar	
A. oreini Fotedar	*Oreinus sinuatus* (Heckel)
Genus *Breviscolex* Kulakovskaya	
B. aurangabadensis (Shinde)	*Barbus kolus* (Sykes) *Labeo calbasu* (Ham.)
B. naldurgensis Shinde *et al.*	*Cirrhinus mrigala* (Ham.)
**Lytocestoides mackiewiczi* Shinde *et al.*	*Cirrhinus mrigala* (Ham.)
Family Lytocestidae Hunter	
Genus *Bovienia* Fuhrmann	
B. bilocula (Murhar)	*Heteropneustes fossilis* (Bloch)
**Capingentoides fotedari* Gupta & Parmar	*Clarias batrachus* (L.)
**C. heteropneusti* Gupta & Sinha	*Heteropneustes fossilis* (Bloch)
**C. singhi* Verma	*Heteropneustes fossilis* (Bloch)

Parasite	Host
**Pseudocapingentoides cameroni* Gupta and Sinha	*Heteropneustes fossilis* (Bloch)
**P. gomatii* Gupta and Parmar	*Heteropneustes fossilis* (Bloch)
**P. indica* Verma	*Heteropneustes fossilis* (Bloch)
Bovienia ilishai Zaidi and Khan	*Hilsa ilisha* (Ham.—Buch.) Syn. *Macrura ilisha* (Ham.)
Bovienia serialis (Bovien)	*Clarias batrachus* (L.)
**Introvertus raipurensis* Satpute and Agarwal	*Clarias batrachus* (L.)
**Lucknowia indica* Niyogi *et al.*	*Clarias batrachus* (L.)
Genus *Djombangia* Bovien	
D. penetrans Bovien	*Clarias batrachus* (L.)
**D. caballeroi* Sahay and Sahay	*Heteropneustes fossilis* (Bloch)
**D. clariae* Kundu *et al.*	*Clarias batrachus* (L.)
**D. Indica* Satpute and Agarwal	*Clarias batrachus* (L.)
Genus *Lytocestoides* Baylis	
L. paithanensis Shinde and Deshmukh	*Pseudeutropius taakree* (Sykes)
Genus *Lytocestus* Cohn	
L. birmanicus Lynsdale	*Clarias batrachus* (L.)
L. filiformis (Woodland)	*Clarias batrachus* (L.)
L. fossilisi (Gupta)	*Heteropneustes fossilis* (Bloch)
**Capingentoides gorakhnathi* Agarwal and Singh	*Clarias batrachus* (L.)
**C. moghei* Pandey	*Channa striatus* (Bloch)
**Lytocestoides fossilis* Kanth *et al.*	*Heteropneustes fossilis* (Bloch)
Lytocestus fossilis Singh	*Heteropneustes fossilis* (Bloch)
Lytocestus indicus (Moghe)	*Clarias batrachus* (L.)
**Introvertus chauhani* Pandey and Tiwari	*Clarias batrachus* (L.)
**Lytocestus marathwadaensis* Shinde & Phad	*Ctarias batrachus* (L.)
**Pseudolytocestus clariae* Gupta	*Clarias batrachus* (L.)
**P thapari* Gupta and Parmar	*Clarias batrachus* (L.)
Lytocestus longicollis Rama Devi	*Clarias batrachus* (L.)

SUMMARY

A comprehensive account of the morphology, anatomy and life cycles of the Caryophyllidea in general and systematic account of Indian caryophyllids in particular have been provided. The taxonomy of the Indian caryophyllid cestodes known so far consisting of 40 species (including one each from Nepal and Pakistan) under 14 genera and 3 families was in utter confusion. This was largely due to inadequate and faulty descriptions of species and mostly without cutting the cross-sections and mid-sagittal sections. The taxonomy of these forms has been revised largely on the basis of literature bringing down the numbers to 16 species under 8 genera with one species of uncertain systematic position. Reasons have been given for the belief that many more species remain undiscovered in Iudia. Host-parasite and parasite-host lists have also been furnished.

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