STUDIES ON THE TREMATODE FAUNA OF INDIA

Part II. Subclass ASPIDOGASTREA.

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CONTENTS.

I. General Account.

The author has elsewhere dealt with the trematode fauna of India, of the suborder *Gasterostomata*. An attempt has been made in this paper to deal briefly with the Aspidogastrid trematode parasites recorded, from the Indian region so far, covering India, Pakistan, Burma, Ceylon, etc.

II. Subclass Aspidogastrea Faust & Tang, 1936.

Syns. *Aspidocotylea* Monticelli, 1892. (unavailable).
Aspidocotylida Lahille, 1918.
Aspidogastrata Faust, 1932.
Aspidogastrea (Order) Faust & Tang, 1936.

Helminth parasites of the class Trematoda have been broadly divided into three groups : *Monogenea*, *Aspidogastrea* and *Digenea*. The Digenea are broadly distinguished by the fact that their life history is not direct, *i.e.* there is alternation of hosts. In contrast to this, the life history of a Monogenea is direct and they are mostly found in different situations as ectoparasites. The representatives of the order Aspidogastrea combine the characters of both the above groups but are disqualified from inclusion into either group because of the equivocal nature of their life history.

Ward and Hopkins (1931) observe that among the trematodes the suborder *Aspidocotylea* attracts particular attention. The number of known forms is small ; they vary considerably from each other as a rule and the group appears, in consequence, as a few short series of widely separated species, each group of which deserves the status of a taxonomic unit. Both in structure and in life cycle, these forms appear to be transitional between the monogenetic trematodes and the other digenetic groups.

Faust and Tang (1936) state that this group of trematodes is one of the most instructive in the phylum Platyhelminthes, yet scant attention has been paid to these species by students of helminthology.

Dawes (1946) distinguishes the Aspidogastrid trematodes from Monogenean and Digenean by the following characterisation:—

"Main adhesive apparatus a single row of suckerlets or alveoli set upon the ventral surface of the body, or three or four longitudinal rows

of alveoli set upon an enormous posterior disc, which lacks hooks or hooklets. Other adhesive organs weakly developed or unrepresented. Excretory and genital pores as in Digenea. Endoparasites of Vertebrata, especially fishes and chelonians, but also in Mollusca and Crustacea."

The parasites of this group penetrate more deeply into the body of the host than do most Monogenea and the adhesive apparatus is again a character of distinction. The anterior organ of attachment is feeble and absent in adult, but the posterior occupies almost the entire ventral surface of the body, consisting of numerous suckerlets or *alveoli*, arranged in one, three or four rows. In some elongate forms a single row of alveoli is developed on the ventral surface but generally three or four rows arise from the surface of a large disc, which is as conspicuous as the 'foot' of a gastropod-mollusc. The maximum number of alveoli in a row are 32 and in four rows 144. There are no hooks or hooklets. I would suggest the use of the term "haptor" widely used, at present, in the study of Monogenea for the ventral (posterior) adhesive apparatus of this group. Alveoli when present in more than one row are usually arranged alternately and when villei or ventral papillae are also present they are generally placed in between these rows—a beautiful example of an economy of space which permits the accommodation of the largest possible number of organs of adhesion. The mouth is situated at the tip of a very mobile anterior conical process. Other external apertures occur in much the same situations as in Digenea. The genital pore is slightly behind the mouth and the excretory pores are posterior. In some, there is a solitary excretory pore. There is no vaginal pore, but Laurer's canal which is closed in some species, may open near the posterior extremity as in Digenea.

The subclass *Aspidogastrea* contains only a solitary family, *Aspidogastridae* Poche, 1907 These are known as parasites of cold blooded, poikilothermous vertebrates and invertebrates of both marine and fresh waters in all the five continents. Notably they occur in gastropod and lamellibranch mollusca, the larger crustaceans, some fishes and chelonians.

According to Stunkard (1917) the family is of special interest to students of trematode morphology. The form of the adhesive apparatus, with its retractile marginal organs, the separation of the body into dorsal and ventral portions by a muscular partition, the sac-like alimentary tract and the details of the genital organs are peculiar to the group. The family contains both ectoparasitic and endoparasitic species ; forms with direct development and at least one species which has an intermediate host, while the hosts infested by the adult parasites include both invertebrates and vertebrates, species having been reported from molluscs, fishes and turtles.

They may inhabit various locations in the host and may be seen through the transparent wall of the pericardium ; sometimes 20-30 individuals being closely packed in the anterior region of the pericardial cavity near the internal opening of the kidney. Juvenile individuals are said to inhabit the intestine and may occasionally be found encysted in the pericardial gland.

The genus *Aspidogaster* is not confined to molluscs, but has been reported both from freshwater and marine fishes. The fact that the same species may occur in both molluscs and fishes, in the opinion of Dawes, indicates that the former may play the part of both the intermediate and final hosts. Parasitized mussels generally present a starved and shrunken appearance.

III. Systematic Account.

A. *Taxonomic Position.*

Since 1827, when von Baer discovered *Aspidogaster conchicola*, the earliest known representative of the group from the fresh water mussels of the genera, *Anodonta* and *Onio* from Prussia, many attempts have been made to find a satisfactory niche in the scheme of classification of the trematode for this interesting group. However, because of its peculiar multiloculate adhesive apparatus which is usually but not invariably a ventral disc bearing a number of suckerlets or alveoli, Burmeister (1856) first called attention to the difference between the genus *Aspidogaster* and the remainder of the trematodes and suggested a division of the trematoda into (1) *Malacobothrii* for the distomes and holostomes, (2) *Pectobothrii* for the polystomes, and (3) *Aspidobothrii* for *Aspidogaster*. Subsequent writers, however, continued to include *Aspidogaster* with the polystomes until Monticelli (1892) revised the classification of Burmeister, but named the three suborders, into which he divided the trematodes, as *Heterocotylea*, *Aspidocotylea* and *Malacocotylea*.

In the classification of Monticelli, the *Aspidocotylea* contained the single family *Aspidobothridae*. Poche (1907) proposed to make the name of the family agree with the rules of Zoological nomenclature according to which " The name of the family is formed by adding the ending—(idae) to the stem of the name of its type genus " Thus the name of the family must become *Aspidogastridae*. Further Poche (1926) placed aspidogastrids in the Digenea, referring them to the suborder Prosostomata and the tribe *Aspidogastroidae*. Faust and Tang (1936) raised objections to the scheme, on the ground that aspidogastrid trematodes combine the characters of both *Monogenea* and *Digenea*. It is disqualified for admission to the *Monogenea* by the nature of its adhesive apparatus, which lacks such accessories as cuticular supports, hooklets or anchors, by the posterior position of the excretory pore or pores and by the simple rhabdocoelan intestine. On the other hand, the absence of an alternation of generations in life-history militates against its inclusion in the *Digenea*. The simplest type of life-history, *e.g.* that of *Aspidogaster conchicola* is one in which the sole host is a gastropod or lamellibranch mollusc. For such reasons, Faust and Tang (1936) proposed the creation of a new subclass, *Aspidogastrea*, equal in rank with Monogenea and Digenea.

In the scheme of classification which I have followed in my studies I have treated the entire group of trematodes as divided into three Subclasses, *viz.* (1) *Monogenea*; (2) *Aspidogastrea*; (3) *Digenea*, the last being further sub-divided into two Orders, *viz.* (*a*) *Gasterostomata*, (*b*) *Prosostomata*. Dawes (1946) mentions the three subclasses as only orders.

Faust and Tang (1936) created a new family, *Stichocotylidae* for the genus, *Stichocotyle*, which has a single row of sucking cups and retained all other forms possessing more than one row of sucking cups under the family *Aspidogastridae*. This arrangement is, however, not accepted by other workers on the group and therefore the family *Stichocotylidae* goes into synonymy to *Aspidogastridae* Poche, 1907.

The important taxonomic characters in the family are, the number of rows and nature of alveoli on the adhesive disc ; presence or absence of papillae on the ventral surface of the disc ; presence or absence of marginal organs ; presence or absence of oral sucker and existence of lips bordering the mouth ; number of testes ; presence or absence of the cirrus pouch, etc.

Dawes (1941) does not consider the presence or absence of an oral sucker to be a factor of generic importance. Stunkard (1917) regards the lack of such a sucker as one of the characters of the genus, *Aspidogaster*, but Eckmann (1932) describes this structure in each of her species, *A. decatis* and *A. enneatis*, and states that it is well developed in the latter species. She (1941) also states that the number of alveoli present on the disc of the adhesive apparatus in different aspidogastrids do not seem to bear any relation to the size of the body or of the disc.

Shipley and Hornell (1904, p. 95) state that the number of alveoli probably increases with age.

B. *Phylogeny.*

Faust and Tang (1936) discussed the systematic position and phylogeny of the group in detail. This subject has been a matter of opinion ever since von Baer discovered the earliest known representative of the group, in 1827. Some workers have considered it as belonging to Monogenea, others to Digenea. Some even classified them with Polystomes. However, majority regards them as belonging to an independent rank, intermediate in position between the Monogenea and Digenea.

As pointed out by Faust and Tang, they are decidedly not members of the Monogenea group. They lack posterior sucking discs or cuticular hooklets or anchors. The excretory pore or pores are posterior in position rather than anterior and their intestinal tract is always rhabdocoelic in type, as in Turbellarians and Gasterostomes (Digenea). On the other hand, there is no evidence that they have an alternation of generations, a characteristic requisite for inclusion in the Digenea. The fully developed embryo within the egg shell, which breaks through the opercular opening to proceed with its development is a larva already possessing the fundamental characteristics of an adult, such as the ventral sucking disc, the excretory system with a posterior opening and the rhabdocoelic gut. This immature adult generally lacks even any suggestion of a ciliated epithelium. Our knowledge of a complete life cycle of an aspidogastrid is lacking, but its development is believed to be fundamentally direct, *i.e.* the young worm develops directly into an adult, either in the same host or in another individual of the same or different species. The mplest type of host relationship is obviously that in

which either a gastropod or a bivalve mollusc is the sole host, as generally in *Aspidogaster conchicola,* when such infected mollusc hosts are ingested by cold blooded vertebrates, such as fishes, frogs and reptiles. These parasites have been recorded to have frequently demonstrated their ability to withstand digestion and to attach themselves to the wall of the stomach or small intestine of the vertebrate, thus indicating initiation of second host association of Digenea. A more complicated condition is present in *Stichocotyle nephropsis,* in which encysted larvae, closely resembling adults superficially, are present in crabs or lobsters while the adults occur in biliary passages of elasmobranchs. Probably a first stage larva of this species develops in some marine molluscs and later reaches passively or actively the malacostracan host and becomes encysted in the abdomen of this second host. Thus there is cumulative evidence in this group of trematodes, indicating how alteration of hosts is in the process of being achieved, apparently without any alternation. By the way, such a situation more closely resembles that in certain nematodes (Spiruroids), than it does a complicated trematode life-cycle and may possibly help in throwing some light on the phylogeny and affinities of parasitic nematode worms. However, as far as aspidogastrid trematodes are concerned, some species of other genera, *e.g. Aspidogaster, Cotylaspis, Cotylogaster,* etc., also occur both in Unionidae and fish, and fresh water turtles and fish. Such a relation indicates the possible transition from the monogenetic type with a single host in the life-history to the digenetic type utilising at least two hosts in life cycle.

C. *Affinities and phylogeny in the Platyhelminthes.*

The original ancestor or ancestors of the various groups of Platyhelminthes appear to have had some common characters such as ciliated epithelium without cuticle, rhabdocoelic gut, life cycle with direct development and free living existence. Evolution in due course may have operated along two lines; one for free living existence as in the case of Turbellarians and the Temnocephalids and the other for parasitic life such as in Trematoda, as will be seen from points of comparative study of the groups. Turbellarians possess eyes and innumerable cilia, covering the epithelium at its surface and lack thick shelled eggs. In Temnocephala, the cilia may occur in patches or localised regions in exceptional instances and eyes occur more frequently than in Trematoda, where they are confined to the larval stages, except in a few Monogenetic flukes. There is no typical external ciliation in Trematoda except in larval stages. Turbellarians generally lead an independent existence, hunting and devouring living prey such as earthworms, snails, woodlice, etc. However, some live in habitual association with molluscs and echinoderms and a few have acquired the habit of penetrating into and living in the bodies of sea urchins, holothurians and other invertebrates thus foreshadowing the parasitic mode of life of trematodes. Temnocephalids attach themselves to the surface of an invertebrate animal, generally a fresh-water crustacean, but they also do not derive nourishment from their host, but capture and devour insect larvae, rotifers and other small creatures, and are thus not parasites in full sense of the term. A trematode habitually nourishes itself at the expense of

another animal, the host. Many trematodes attach themselves to superficial parts of the host, but others penetrate into the body and settle down in one of the internal organs. The former are called ectoparasites (Monogenea) and the latter endoparasites (Digenea). Their life-history provides a more important distinction. Ectoparasitic trematodes develop directly in or on a single type of host whereas endoparasitic trematodes develop through a sequence of young individuals unlike the parent (larvae) with at least one and sometimes more than one change of host. As a rule, digenetic trematodes spend a good part of their larval life in bodies of molluscs and some leave the first host and penetrate into another mollusc or a crustacean or sometimes a fish, before finally settling down in a vertebrate animal to become mature. Aspidogastrids occupy an intermediate position between Monogenea and Digenea as already discussed. Temnocephala seem to occupy an intermediate position in evolution between Turbellarians and Trematoda, particularly Aspidogastrids and Gasterostomes. They further resemble trematodes in having a posterior sucker, a hermaphrodite reproductive system, having a similar general plan, simple and saccular gut, lacking an anus, as in few Turbellarian and Gasterostome trematodes.

The Turbellarians seem to occupy the most primitive and lowest position according to evolution amongst the Platyhelminthes and the Digenea (Prosostomata) probably the most advanced and the highest. The evolution seems to have proceeded along two ecological factors, *viz.* mode of living and feeding. Amongst Trematodes, Monogenea appears to be a primitive group, though it has highly specialised for ectoparasitic life. Aspidogastrids appear to have more resemblance with Gasterostome trematodes than others and seem to have adapted generally for ectoparasitic life by developing ventral adhesive disc or apparatus. Some of them have been recorded from internal situations also. They occupy an intermediate position between the Monogenea and Digenea. The intermediate or probably transitional groups of Aspidogastrids and Gasterostomes, are found to be less common and are comparatively more simple in structure also. This subject of the possible phylogeny of the Platyhelminthes is being dealt with in greater detail in a later paper on Prosostomes (*Hemiuroidea*).

Family ASPIDOGASTRIDAE Poche, 1907.
Sys. *Aspidobothrii* Burmeister, 1856.
Aspidobothridae Monticelli, 1888.
Aspidobothriidae Bresslau, 1912.
Stichocotylidae Faust and Tang, 1936.

Family diagnosis : Subclass *Aspidogastrea* Faust and Tang, 1936; with characters of the Subclass.

Intestine simple; oral sucker very poorly developed or wanting. Ventral sucking organ a powerful conspicuous adhesive disc or apparatus with a series of small suckers. In molluscs and cold blooded vertebrates.

Other diagnostic characters are :—

Adult parasitic on or in the soft parts of molluscs (Gastropods and Lamellibranchs) or in the intestinal canal of cold-blooded vertebrates.

Development probably direct, with ciliated or unciliated larvae; hatching from eggs. Adults hermaphroditic. Oral sucker absent or poorly developed. Ventral sucking organ a powerful adhesive disc or apparatus frequently divided into series of sucking cups; intestine a simple blind sac. Flame-cell pattern of larva: 2 (1+1+1). All known species belong to a single Order *Aspidogastrea* Faust and Tang, 1936 (=Order *Aspidogastrata* Faust, 1932) which has the characteristics of the subclass, *Aspidogastrea* of Faust and Tang (1936).

The family *Aspidogastridae* contains forms of three distinct categories based on the presence of number of rows of alveoli, situated on the adhesive disc which is the most important character for systematic studies in the group. Some forms are with a single row of alveoli; others with three rows and still other forms with four rows. For the sake of convenience in taxonomic studies, the author proposes to divide them in these categories into three systematic units by creating three new subfamilies . *viz.* *Micraspisinae*, for forms with single row of alveoli on the adhesive disc; *Cotylaspisinae* for forms with three rows of alveoli on the sucker or haptor and *Aspidogasterinae* for forms with four rows of suckers or acetabula.

Key to Subfamilies of Family Aspidogastridae Poche, 1907.

1. Single row of alveoli on ventral adhesive apparatus; disc of ventral adhesive apparatus present or lacking	*Micraspisinae*, **subfam. nov.**
2. Several longitudinal rows of alveoli on disc of ventral adhesive apparatus which is invariably present.	3.
3. Three rows of alveoli on disc ..	*Cotylaspisinae*, **subfam. nov.**
4. Four rows of alveoli on disc	*Aspidogasterinae*, subfam nov.

(*a*) Subfamily *Aspidogasterinae*, **subfam. nov.**

(Text-figs. 1, 6 and 8.)

Subfamily diagnosis : *Aspidogasteridae* Poche, 1907 ; **with Family characters.**

Ventral disc of adhesive apparatus invariably present. Four rows of alveoli on the ventral disc. Oral sucker absent. Marginal organs present. Mouth terminal or subterminal. Testis one or two. Cirrus pouch present or absent. Mouth with or without lip like processes. Papillae on the ventral part of the body present or absent.

Type genus—*Aspidogaster* Baer, 1927.

Key to Genera of Subfamily Aspiaogasterinae, subfam. nov.

1. Testis single	2.
Testes two; alveoli numerous ..	*Multicotyle* Dawes, 1940.
2. Papillae on central region of ventral disc, lacking	3.
Papillae on central region of ventral disc present, hollow	*Lophotaspis* Looss, 1902.
3. Mouth with lip-like processes	*Lobatostoma* Eckmann, 1932.
Mouth without lip-like processes	*Aspidogaster* Baer, 1827.

1. Genus **Aspidogaster Baer,** 1827.

This is the type genus of the family and contains the oldest representative of the group, discovered for the first time by von Baer in 1827

Generic diagnosis: *Aspidogasterinae*, subfam. nov.; with Subfamily characters.

Ventral adhesive disc large and oval, with four rows of alveoli. Papillae on central region of ventral disc lacking. Marginal organs present. Mouth subterminal, without liplike processes. Oral sucker absent. Testis single. Cirrus present. Sexual pore median. Ovary small.

Type species—*Aspidogaster conchicola* Baer, 1827; from lamellibranch mollusc, *Anodonta*, Prussia.

So far two species of the genus, *viz. Aspidogaster indicum* Dayal, 1943 and *Aspidogaster piscicola* Rawat, 1948 have been recorded from the Indian region. They can be differentiated as follows :—

Key to Indian Species of Genus Aspidogaster Baer, 1827.

Number of alveoli on the ventral adhesive disc 62. Testis equal in size to ovary	*Aspidogaster indicum* Dayal, 1943.
Number of alveoli on the ventral adhesive disc 58. Testis twice as large as ovary ..	*Aspidogaster piscicola* Rawat, 1948.

(i) **Aspidogaster indicum** Dayal, 1943.

(Text-Figs. 1-5.)

Specific diagnosis: *Aspidogaster* Baer, 1827 : with Generic characters.

Body of the worm leaf-shaped, consisting of two parts, a dorsal containing all the organs and the ventral adhesive disc, measuring 4·52* long×2·20 broad (type). Ventral adhesive disc oval, muscular, multiloculate sucker, with crenate outline, measuring 2·8×2·2 in type specimen. Alveoli 62 in four longitudinal rows; 32 peripheral and 30 in two longitudinal rows of 15 each. Marginal organs present. Excretory pore at the posterior end of body, on dorsal side. Mouth at the anterior end, subterminal. Oral sucker muscular, funnel like. Prepharynx small. Pharynx strong, muscular. Oesophagus small. Intestine long tubular, extending upto the posterior end of testis or even beyond it. Genital opening anterior to adhesive disc, on ventral side, on left side of pharynx. Testis oval or spherical in the posterior half of body, behind ovary. Cirrus sac large, pear-shaped, containing pars prostatica, ejaculatory duct and retractile petaloid cirrus. Vesicula seminalis outside cirrus sac. Ovary situated just anterior to testis, retort shaped. Uterus fills up nearly the whole space between the cirrus sac and posterior end of disc. Female genital opening lies adjacent to male opening, on the anterior side. Vitelline glands consist of a large number of follicles, lateral in disposition, extending from a little posterior to cirrus sac to hinder end of ventral adhesive disc. Laurer's canal, öotype and shell gland present. Eggs oval, with a thick yellowish-brown shell, measuring 0·06-0·09×0·025-0·045.

*All measurements in this paper are given in millimetres.

Host.—Fresh-water fish, *Barbus tor* (Ham.).

Habitat.—Intestine.

Locality.—Lucknow.

The species is characterised by large number of alveoli on the ventral adhesive disc; anterior position of genital pore and petaloid cirrus.

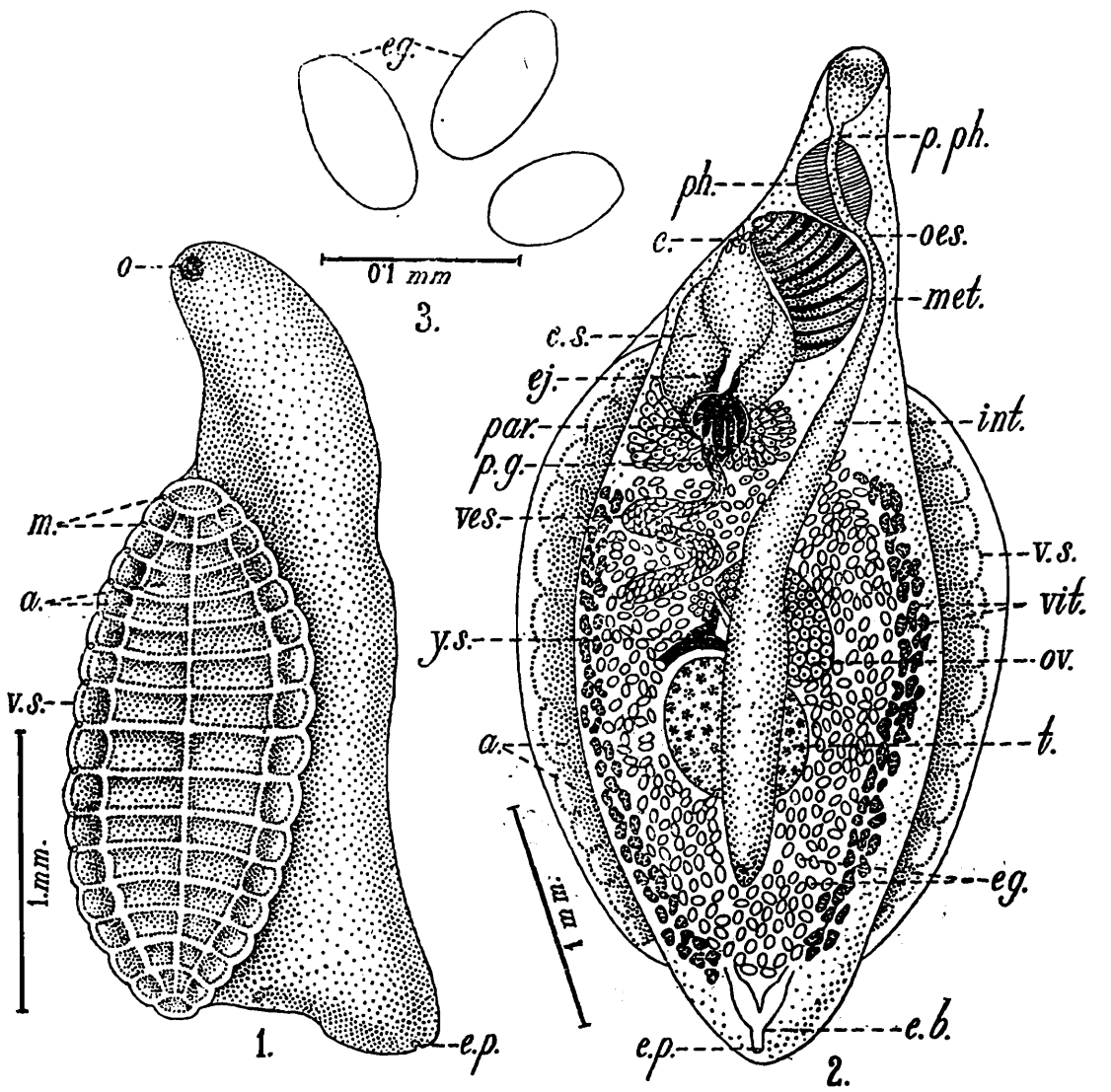

Fig. 1.—*Aspidogaster indicum*, ventro-lateral view of the animal, showing ventral adhesiv e disc or sucker. (Paratype). (After Dayal).

Fig. 2.—*Aspidogaster indicum*, dorsal view of the animal, showing internal organs. (Type specimen). (After Dayal).

Fig. 3.—*Aspidogaster indicum*, eggs highly magnified. (After Dayal).

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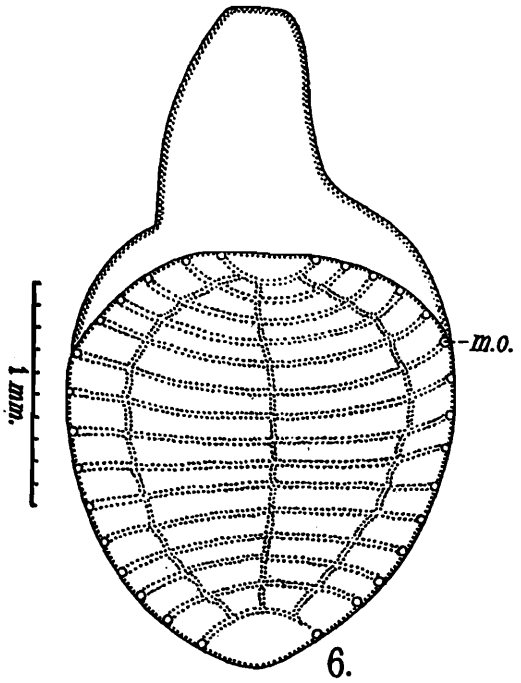
(2) **Aspidogaster piscicola** Rawat, 1948.

(Test-figs. 6, 7.)

Specific diagnosis : *Aspidogaster* Baer, 1827; with Generic characters.

Body divided into anterior narrow and posterior broad portions; the former containing the mouth, pharynx, oesophagus, and male and female genital pores; the latter being further divided into a dorsal part, containing the genital organs, their ducts, vitellaria and intestine and, the ventral, 1·82 long×1·59 broad, being subdivided by muscular ridges, transverse and longitudinal, into small fifty-eight alveoli, in four rows, the marginal containing 2(14)+2 and median 14 each. Marginal

organs very small, spherical in shape, lying in interstices between the peripheral alveoli, very near the edge of the body. Mouth terminal, round



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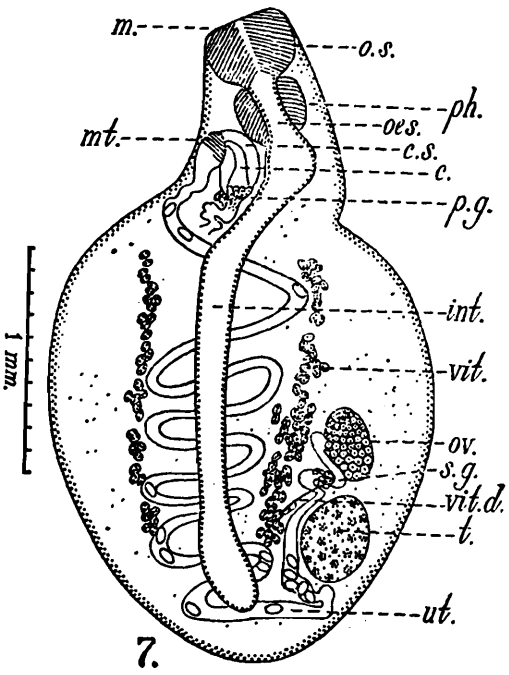

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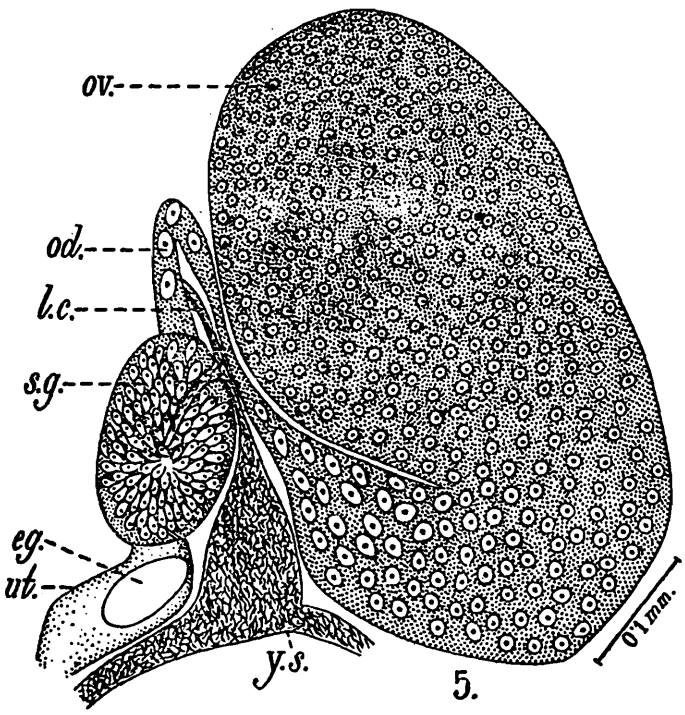

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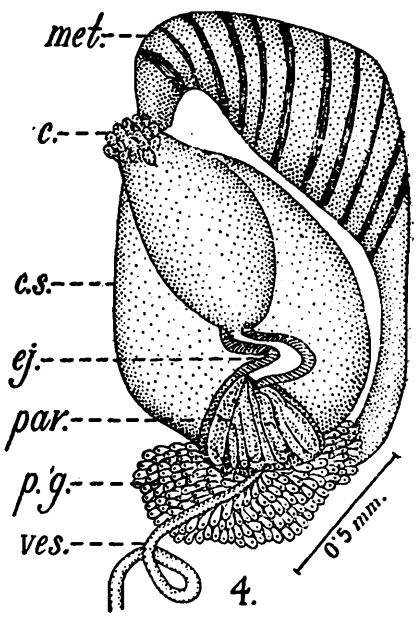


4.

FIG. 4.—*Aspidogaster indicum*, cirrus sac, metraterm, etc. (Sketched from paratype). (After Dayal).

FIG. 5.—*Aspidogaster indicum*, ovary and öotype complex. (Diagrammatic). (After Dayal).

a., alveoli ; *c.*, cirrus ; *c. s.*, cirrus sac ; *e. b.*, excretory bladder ; *eg.*, eggs ; *e. j.*, ejaculatory duct ; *e. p.*, excretory pore ; int., intestine ; *l. c.*, laurer's canal ; *m.*, marginal organs ; *met.*, metraterm ; *m.* mouth opening ; *od.*, oviduct ; *oes.*, oesophagus ; *ov.*, ovary ; *par.*, pars prostatica ; *ph.*, pharynx ; *p. ph.*, prepharynx ; *p g.*, prostate glands ; *s. g.*, shell glands ; *t.*, Testis ; *ut.*, Uterus ; *ves.*, vesicula seminalis ; *vit.*, Vitelline glands ; *v. s.*, ventral adhesive disc or sucker ; *y. s.*, yolk sac.

FIG. 6.—*Aspidogaster piscicola* ventral view, showing the ventral adhesive disc and marginal organs. (After Rawat).

FIG. 7.—*Aspidogaster piscicola* dorsal view, showing internal anatomy. (After Rawat).

c., cirrus ; *c. s.*, cirrus sac ; *int.*, intestine ; *m.*, mouth ; *m. o.*, marginal organ ; *mt.*, metraterm ; *oes.*, oesophagus ; *o. s.*, oral sucker ; *ov.*, ovary ; *p. g.*, prostate glands ; *ph.*, pharynx ; *s. g.*, shell glands ; *t.*, testis ; *ut.*, uterus ; *vit. d.*, vitelline duct ; *vit.*, vitellaria.

opening at the anterior end, leading into oral sucker, a spherical, bulbous, muscular enlargement, measuring 0·23 long—0·4 broad. Prepharynx 0·68 long—0·78 broad, narrow, tube-like. Pharynx 0·31 long—0·27 broad, thick muscular. Intestine, single caecum, median, ending with a little dilatation. Testis single, oval, situated posteriorly, on right side, post ovarian, measuring 0·36 long—0·25 broad. Cirrus sac pear-shaped, sac-like, with muscular walls, situated, anteriorly, on the left side of oesophagus. Cirrus, spherical at the base, containing glandular cells, its gradually narrowing anterior tube opening into the genital pore. Prostate glands, unicellular gland cells, situated around the basal portion of cirrus sac. Vas deferens coiled. Ovary situated a little in front of testis, oval in shape. Shellgland and ootype present. Vitellaria, small, arranged in two lateral longitudinal rows, lying on either side of the intestinal caecum. Uterus very long. Eggs elliptical, with egg case, measuring 0·077—0·087 × 0·038.

Host.—Labeo rohita.

Location.—Intestine.

Locality.—Lucknow.

This species differs from *A. indicum* Dayal, in the number of alveoli, relative size of ovary and testis, size and shape of genital organs.

It will be observed that both these species are recorded from the same locality, although from different hosts but it is a freshwater fish in both the cases. Faust and Tang (1936) pointed out that the same species in this group have been found to occur from two different hosts.

The number of alveoli is a variable character, as stated by Rawat himself, it being 60-74 in *A. conchicola* and 58 in *A. piscicola.*

Shipley and Hornell (1904, p. 95) state that the number of alveoli probably increases with age.

The size of the testis is also a variable character, depending upon the time of its maturation as observed by Sproston (1945), in the case of the genus, *Kuhnia.* Therefore, it probably needs further studies before this species could be finally taken as a distinct, valid species, from *A. indicum* Dayal (1943).

The author had an opportunity to examine a few specimens of *Aspidogaster piscicola* collected from a freshwater fish, *Labeo* sp. at Allahabad. Unfortunately no details could be recorded.

2. Genus **Lophotaspis** Looss, 1902.

Generic dignosis: *Aspidogasterinae,* **subfam. nov.**; with Subfamily characters.

Ventral adhesive organ with four rows of alveoli. Marginal organs present in the form of tentacles, at all the intersections of the ridges of the adhesive disc. Mouth terminal. Oral sucker absent. Intestine median, simple. Papillae on central region of ventral disc present, hollow. A single testis at the posterior end of body, from which a vas deferens extends upto the genital pore. Cirrus absent. Genital pore between the mouth and pharynx.

Type species—*L. vallei* (Stossich, 1899) from the oesophagus and stomach of a marine chelonian, *Thalassochelys caretta* at Corfu, Ceylon.

Syns. *Aspidogaster vallei* Stossich, 1899 : *Lophotaspis adhaerens* Looss, 1902 from *Thalassochelys corticata*.

A representative of this genus has been recorded from Ceylon.

(iii) **Lophotaspis margaritiferae** (Shipley and Hornell, 1904) Ward and Hopkins, 1918.

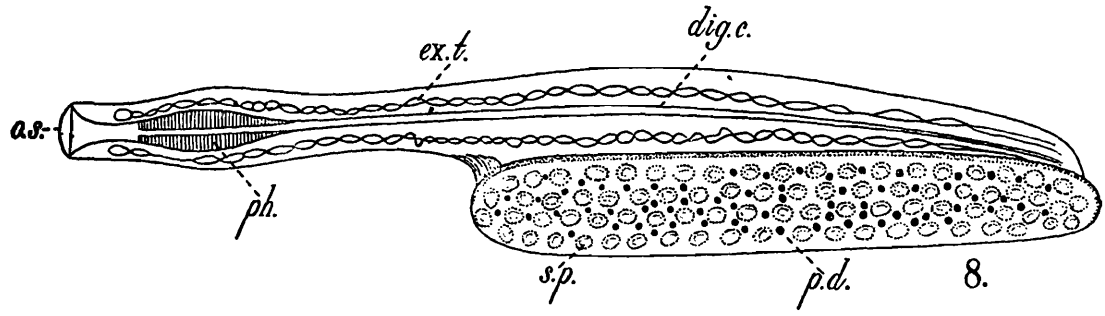
(Text-fig. 8.)

Syn. *Aspidogaster margaritiferae* Shipley and Hornell, 1904.

Specific diagnosis : *Lophotaspis* Looss, 1902 ; with Generic characters.

Specimen immature, length 6·0, colour brown ochre dorsally but the foot has a beautiful rose-red hue. Four rows of alveoli or suckers on the foot arranged alternately—an economy of space which permits the accommodation of the largest possible number of pits. Number of alveoli not precisely known, it probably increases with age but there are something like 20 in the outer rows and 18 in the two median rows. A number of " tube-feet " project from the area between the outer rows and the middle rows and between the two central rows, none on the outside of the outer rows. They are hollow, thin walled, tubular erectile organs of the simplest structure, possessing the power of extension in an extraordinary degree ; capable of great extension and of complete retraction by inversion, in manner similar to the eversion and retraction

9.



8.

FIG. 8.—*Lophotaspis margaritiferae* : adult from the pericardial chamber of a pearl oyster, seen ventrolaterally. The tube feet are retracted. (After Shipley and Hornell.)

dig. c., digestive caecum ; *ex. t.*, double excretory trunks ; *o. s.*, oral sucker ; *p. d.* pedal disc ; *ph.*, pharynx ; *s. p.*, sucker pits.

FIG. 9.—*Macraspis elegans*, Olss. (After Benham).

of proboscides of the cestode, *Tetrarhynchus*. Partially retracted, they exhibit a closely annulated or wrinkled appearance, reminding one of the annulation of an earthworm, the anterior extremity of which they greatly resemble. Body composed of two distinct regions. Dorsum minutely wrinkled or annulated transversely. Oral sucker a transverse slit bounded by thin mobile lips. Alimentary canal median and unbranched, ending blindly near the posterior end of the body. Mouth situated at the base of oral sucker-slit. Prepharynx, a short narrow buccal canal. Pharynx strongly muscular, oblong in optical section. Oesophagus a thin-walled vesicle. Intestine a long, thick-walled digestive caecum. Excretory system more highly specialised than in some

Distomes. Genital pore just between the pharynx and the anterior end of the foot. Penis well-marked. Testis and ovary single. No vitellaria, uterus or Laurer's canal were distinguishable. Movements, leechlike.

Host.—*Margaritifera vulgaris*, Schum.

Habitat.—Pericardial cavity.

Location.—South and south-east areas of the Cheval Paar, Ceylon.

Most allied to *L. macdonaldi* Monticelli, 1891, in the possession of remarkable " tentacles " or " tube-feet " It however differs in colour, size being nearly half; in the absence of " caeca " in the intestine; in the fewer number of tentacles and alveoli location, host and locality.

3. Genus **Lobatostoma** Eckmann, 1932.

Generic diagnosis : Aspidogasterinae, **subfam. nov.,** with Subfamily characters.

Adhesive ventral disc with four rows of alveoli. Papillae on central region of ventral disc lacking. Marginal organs present. Mouth surrounded by lip like processes. Oral sucker absent. Testis single. Cirrus present.

Type species—*Lobatosoma ringens* (Linton, 1907) Eckmann, 1932, from a marine fish, *Micropogon*, U.S.

4. Genus **Multicotyle** Dawes, 1940.

Generic diagnosis : Aspidogasterinae, **subfam. nov.** ; with Subfamily characters.

Ventral adhesive disc bearing four longitudinal rows of suckerlets or alveoli, of which the openings are reduced to mere transverse slits. Marginal organs present, at the periphery of the disc, only in the anterior region of body. Papillae on the ventral surface of the disc or elsewhere lacking. Mouth subterminal and lacks lip-like processes. A concentration of muscular tissue is to be seen in whole mount around the mouth and this may prove to be the rudiments of sucker. Testes two. Cirrus absent.

Type species—*Multicotyle purvisi* Dawes, 1940, from River turtle, *Siebenrockiella crassicollis* (Intestine), Malaya.

(*b*) Subfamily *Macraspisinae*, **subfam. nov.**

(Text-fig. 9.)

Subfamily diagnosis : *Aspidogastridae* Poche, 1907 ; with Family characters.

Disc of ventral adhesive apparatus present or lacking. Ventral adhesive disc or apparatus with a single row of suckerlets or alveoli, confluent or distinct. Testis one or two. Marginal organs present or absent. Mouth terminal or subterminal. Oral sucker present or absent. Cirrus present. Mouth without lip-like processes.

Type genus—*Macraspis* Olsson, 1868.

Key to Genera of Subfamily MACRASPISINAE, **subfam. nov.**

Ventral adhesive disc present. Suckers confluent. Testis single	*Macraspis* Olsson, 1868.
Ventral adhesive disc lacking. Suckers distinct and separate. Testes two	*Stichocotyle* Cunningham, 1889.

5. Genus **Macraspis** Olsson, 1868.

Generic diagnosis : *Macraspisinae*, **subfam. nov.** ; with Subfamily characters.

Ventral adhesive disc with a single row of confluent acetabula. Marginal organs present. Mouth terminal. Testis single. Cirrus present.

Type species—*M. elegans* (Olsson, 1868) Monticelli, 1891—from gallbladder of a fish, *Chimaera monstrosa* from the coast of Europe.

6. Genus **Stichocotyle** Cunningham, 1884, *emed.* Faust and Tang, 1936.

Generic diagnosis : *Macraspisinae*, **subfam. nov.** ; with Subfamily characters.

Ventral adhesive surface with a single row of more or less distinct, acetabular cups which may either be simple or separated from one another or may be subdivided by transverse septa, which may not only divide the original acetabula into several pockets but also similarly divide the intra-acetabular spaces. Marginal organs absent. Mouth subterminal. Oral sucker absent. One or two testes. Cirrus present.

Type species—*S. nephropsis* Cunningham, 1884, from Norwegian Lobster, *Nephrops* ; adult in bile ducts of Rays (Odhner, 1905).

Faust and Tang (1936) divided the genus into two subgenera, *Multicalyx* and *Stichocotyle* and defined them as follows :—

1. Subgenus *Stichocotyle* : with simple acetabula separated by interspaces. Testes two. Represented by *Stichocotyle* (*Stichocotyle*) *nephropsis* Cunningham, 1884.
2. Subgenus *Multicalyx* : with acetabula subdivided by transverse septa which also produce transverse divisions of the intramuscular space on the ventral side of th body. Testis single. Monotypic. Represented by *Stichoctyle* (*Multicalyx*) *cristata* Faust and Tang, 1936.

(*c*) Subfamily *COTYTASPISINAE*, **subfam. nov.**
(Text-figs. 10 & 12.)

Subfamily diagnosis : *Aspidogastridae* Poche, 1907 ; with Family characters.

Disc of ventral adhesive apparatus invariably present. Rows of alveoli on the ventral disc three. Testis one or two. Cirrus sac present or lacking. Marginal organs present. Mouth terminal or subterminal. Oral sucker present or lacking.

Type genus—*Cotylaspis* Leidy, 1857

Key to Genera of Subfamily COTYLASPISINAE, **subfam. nov.**

1. Testes two. Mouth terminal ; oral sucker present	*Cotylogaster* Monticelli, 1892.
Testis single. Mouth subterminal ; oral sucker absent	2.
2. Cirrus sac present	*Cctylaspis* Leidy, 1857.
Cirrus sac lacking	*Lissemysia* Sinha, 1935.

7. Genus **Cotylaspis** Leidy, 1857.

Syn. *Platyaspis* Monticelli, 1892.

Generic diagnosis : *Cotylaspisinae*, **subfam. nov.**; with Subfamily characters.

Disc of ventral adhesive apparatus present, oval. Number of rows of alveoli on the disc three. Marginal sense organs present. Mouth subterminal. Oral sucker absent. Testis single. Cirrus sac present. Ovary dextral, smaller than testis.

Type species—*C. insignis* (Leidy, 1857) Braun, 1893, from mantle cavity of north American Unionidae mollusc.

8. Genus **Cotylogaster** Monticelli, 1892.

Generic diagnosis : *Cotylaspisinae*, **subfam. nov.;** with Subfamily characters.

Disc of ventral adhesive apparatus present, oval. Number of rows of alveoli on the disc three. Marginal organs present. Mouth terminal. Oral sucker present. Testes two. Cirrus sac present.

Type species—*C. michaelis* Monticelli, 1892, from intestines of a European fish, *Cantharus vulgaris*.

9. Genus **Lissemysia** Sinha, 1935 *emend.* Tandon, 1949.

Generic diagnosis : *Cotylaspisinae*, **subfam. nov.**; with Subfamily characters.

Ventral adhesive apparatus with three rows of alveoli. Marginal organs present. Mouth subterminal, without lip-like processes. Oral sucker absent. Testis one. Cirrus sac lacking. Other diagnostic characters are :—

Size small. Body divided into two parts, anterior dorsal, forebody and a posterior ventral adhesive disc. Adhesive disc divided into three rows of 27-29 alveoli ; 19 peripheral, 8-10 median. Prepharynx absent. Pharynx muscular. Oesophagus short. Intestine sac-like. Excretory system typical of the family. Testis one, on the right side of the median line. Vesicula seminalis coiled and voluminous. Cirrus absent. Ovary in the middle, variable in position. Receptaculum seminis absent. Uterus with or without ascending and descending limbs and containing variable number of eggs. Metraterm absent. Parasites of Chelonia and Mollusc.

Type species—*Lissemysia indica* Sinha, 1935, from a fresh-water chelonian, *Lissemys punctata* (intestine), Lucknow.

Key to Indian Species of Genus LISSEMYSIA Sinha, 1935.

Number of alveoli on median row of adhesive disc 10. Uterus without distinct ascending and descending limbs. Common vitelline duct arising from the middle of the reservoir	*L. indica* Sinha, 1935.
Number of alveoli on median row of adhesive disc 8. Uterus with a descending and an ascending limb. Common vitelline duct arising from the right side of the reservoir	*L. ovata* Tandon, 1949

(4) **Lissemysia indica** Sinha, 1935.

(Text-figs. 10, 11.)

Specific diagnosis : *Lissemysia* Sinha, 1935 ; with Generic characters.

Body composed of two parts, anterior dorsal forebody and posterior ventral multiloculate adhesive disc, measuring (average) 0·62-0.65 length ×0·62-0·66 width. Worm measures (average) 0·89 length, 0·62 width. The number of alveoli is 29, nineteen being peripheral and ten median. Marginal organs fine narrow tube like structures, situated at the end of

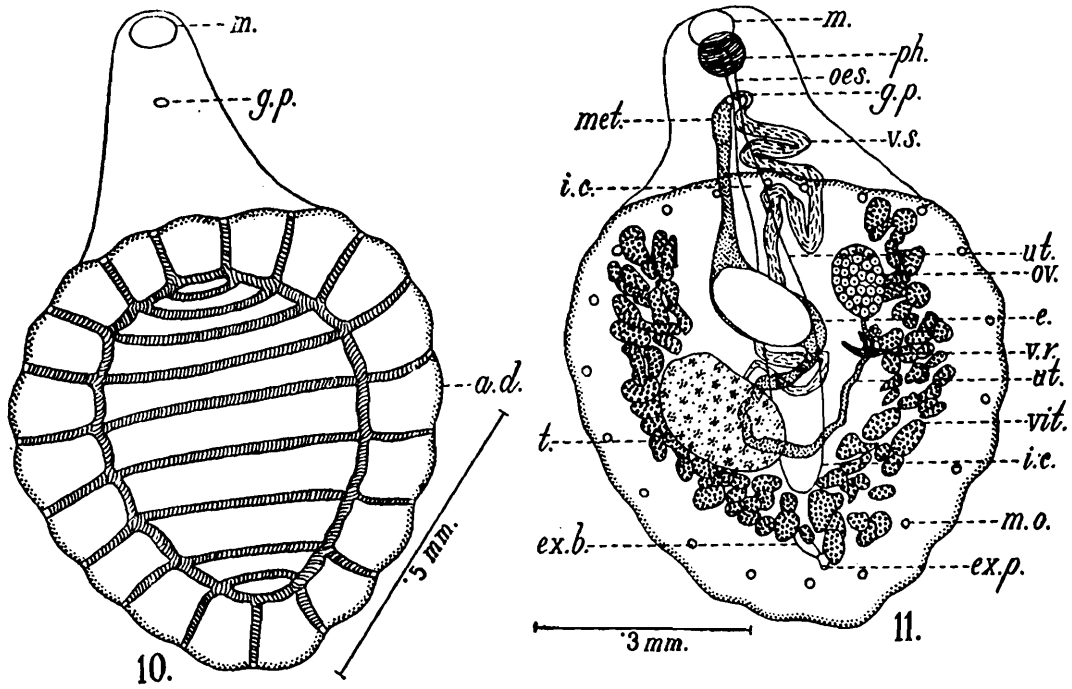


FIG. 10.—*Lissemysia indica*, external characters. (After Sinha).
FIG. 11.—*Lissemysia indica*. general anatomy. (After Sinha).

a. d., adhesive disc ; *e.* egg ; *ex. b.*, excretory bladder ; *ex. p.* excretory pore ; *g. p.*, genital pore ; *i. c.*, intestinal caecum ; *m.*, mouth ; *met.*, metraterm ; *m. o.*, marginal organ ; *oes.*, oesophagus; *ov.*, ovary; *ph.*, pharynx ; *t.*, testis ; *ut.*, uterus; *vit.*, vitellaria ; *v. r.*, vitelline reservoir ; *v. s.*, vesicula seminalis.

cross positions of the adhesive disc, in spaces between muscular edges of adhesive disc and outer wall of body. Mouth like cup-shaped funnel, subterminal, on ventral surface. Oral sucker and prepharynx absent. Pharynx spherical. Oesophagus small. Intestine median, a large sac-like structure. Excretory pore dorsal, near the posterior end of body. Testis single, large, generally on right side, ovoid in shape, measuring 0·20 ×0·13. Vas deferens present. Vesicula seminalis much coiled. Genital pore median, ventral, situated a little behind pharynx. Male and female duct open separately, the latter opening on the right and the former on the left side. Ovary small, ovoid, on the left side, slightly

anterior to the middle of body, measuring 0·075×0·10. Oviduct, common vitelline duct, ŏotype and shell gland observed. Vitelline follicles large, more numerous posteriorly than anteriorly, arranged along sides of the body and are continuous with each other behind intestinal sac. Uterine egg large and oval, observed single in front of testis, measuring 0·156 ×0·09.

Host.—*Lissemys punctata* Bonnaterre.

Location.—Intestine.

Locality.—Lucknow.

The species is characterised by the arrangement of alveoli on the adhesive disc in three rows, nineteen peripheral and ten median ; presence of marginal organs at cross partition of the adhesive disc ; simple, sac-like intestine ; excretory pore on dorsal surface ; one testis, generally on right, absence of cirrus and cirrus sac, receptacula seminis ; arrangement of vitellaria along sides of the body meeting posteriorly ; uterus with discending and ascending coils and presence of a single large egg.

(5) **Lissemysia ovata** Tandon, 1949.

(Text-figs. 12-15.)

Specific diagnosis : *Lissemysia* Sinha, 1935, with Generic charaters.

Body divided into an elongated narrow anterior part and a flattened disc-like posterior part, bearing adhesive disc ; worm measuring 0·96-1·43×0·53-0·63. The adhesive organ is divided into three rows of 27 alveoli, 19 peripheral, surrounding 8 in the median row. Marginal organs present in between the peripheral alveoli, in the interstices between the muscular edges of the disc and peripheral wall ; flask shaped, enclosed in a thin sac-like structure, opening to the exterior by an aperture. Oral sucker absent. Mouth cup shaped funnel, situated subterminally at the antero-ventral end, acting as an adhesive organ, 0·142×0·123. Prepharynx absent. Pharynx, elongated, muscular, 0·085 in diameter. Oesophagus short. Intestine blind sac-like, lined internally with large, elongated and flattened cells. Excretory pore dorsal, median, near the posterior end, surrounded by a small papilla-like structure. Testis single large, oval, on right side, measuring 0·142×0·18. Vas deferens narrow duct. Vesicula seminalis tubular. Cirrus sac slightly swollen tube. Male genital aperture, on left side, posterior to pharynx. Ovary smaller than testis, measuring 0·133-0·104, slightly elongated, situated on the right side, anterior to testis. Oviduct, common vitelline duct, ŏotype, shell gland, & uterine coils observed. Metraterm opens to outside, at the female genital aperture, situated near the male genital pore. Vitellarian follicle arranged on dorsal side of disc, in rows along sides, in the posterior part and continuous at posterior end ; less numerous posteriorly than along the sides and anteriorly ; about 35 on each side. Uterus contains one to three oval and golden yellow operculated eggs, measuring 0·218-0·237×0·114-0·133.

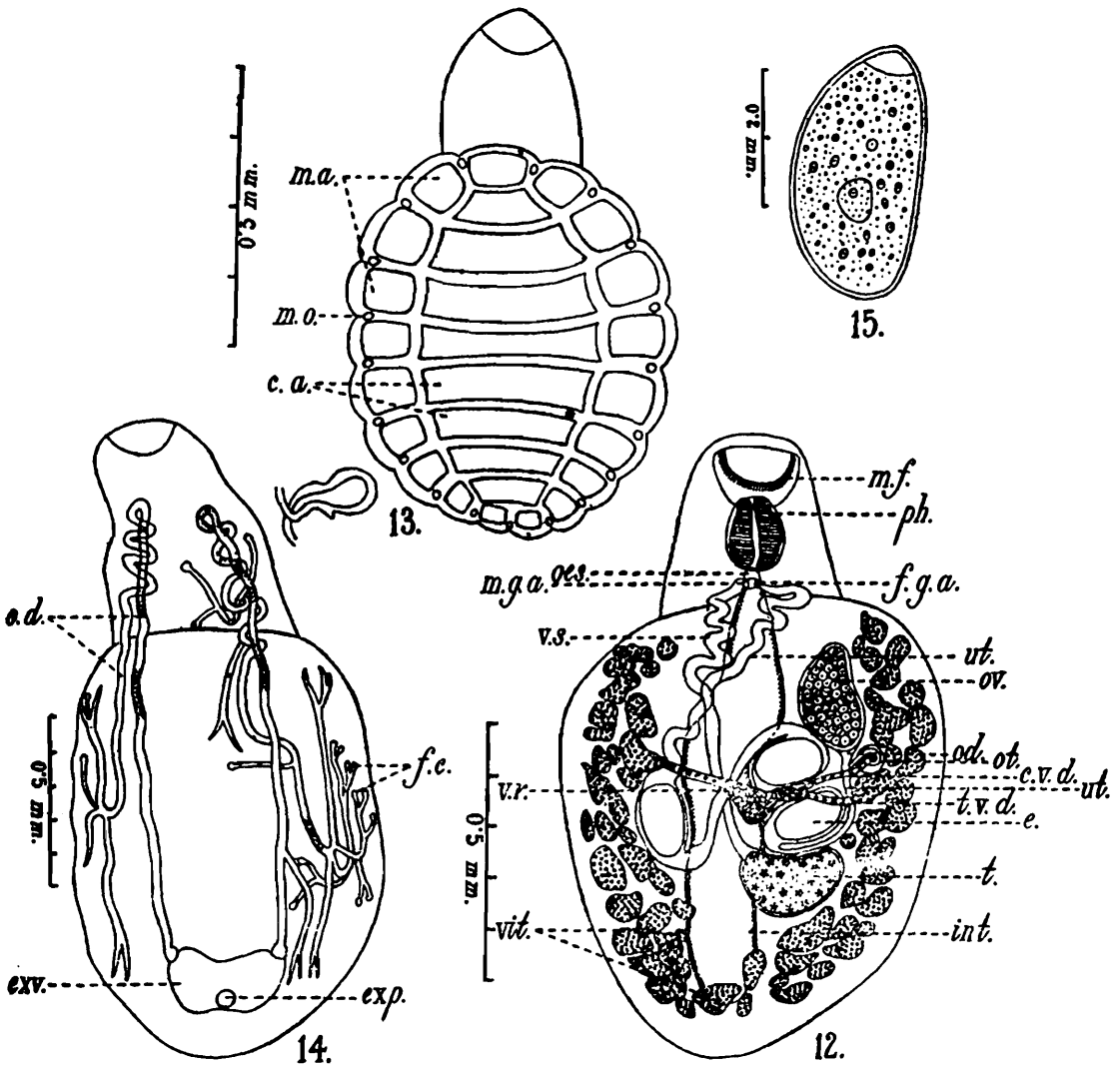


FIG. 12.—*Lissemysia ovata*, ventral view, showing adhesive disc and marginal organs (after Tandon).

FIG. 13.—*Lissemysia ovata*, dorsal view, showing internal anatomy (after Tandon).

FIG. 14.—*Lissemysia ovata*, dorsal view, showing excretory system (after Tandon).

FIG. 15.—*Lissemysia ovata*, egg., freshly taken out of the uterus (after Tandon).

c. a., central alveoli ; *c. v. d.*, common vitelline duct ; *e.*, eggs ; *e.d.*, excretory duct ; *ex. p.*, excretory pore ; *ex. v.*, excretory vesicle ; *f. g. a.*, female genital aperture ; *f.c.*, flame cell ; *int.*, intestine ; *m. f.*, mouth funnel ; *m. g. a.*, male genital aperture ; *m. o.*, marginal organ ; *o. d.*, oviduct ; *oes.*, oesophagus ; *ot.*, shell gland with ôotype ; *ov.*, ovary ; *m. a.*, marginal alveoli ; *ph.*, pharynx ; *t.*, testis ; *t.v.d.*, transverse vitelline duct ; *ut.*, uterus ; *vit.*, vitelline glands ; *v. r.*, vitelline reservoir ; *v. s.*, vesicula seminalis.

Hosts.—*Vivipara bengalensis*, *Lamellidens corrianus* and *Indonaia caerulea*.

Habitat.—Ctenidia.

Locality.—Kukrail stream, Lucknow, India.

This species differs from the other species of the genus, recorded from Lucknow, in its size, shape of pharynx, presence of eight median alveoli instead of ten, disposition of uterine coils, nature of distribution of vitellarian follicles, position of ovary, in the nature of origin of common vitelline duct, large size and number of eggs in the uterus.

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V. Summary.

This paper deals with the Aspidogastrid trematode fauna, known from the Indian region. Brief specific diagnosis and a diagram have been given in the case of each species. General description of the group, with regard to, particularly salient points of general morphology, anatomy, life-histories, taxonomy, ecology, evolution and phylogeny of the group has been brought out and diagnostic definitions and dichotomous keys at every step, *e.g.*, to the family, subfamilies, genera, subgenera and Indian species have been provided. A new record, with regard to host and locality of a parasite of the group has been incorporated and three new subfamilies have been proposed. The author suggests the use of the term 'haptor' widely used, at present, in the study of Monogenea, for the ventral (posterior) adhesive apparatus, of this group.

List of Indian species recorded; with their hosts, location and locality,

Name of parasite.	Host.	Location.	Locality.
Class. *Trematoda* Rudolphi, 1808.			
Subclass. *Aspidogastrea* Faust and Tang, 1936.			
Family. *Aspidogastridae* Poche, 1907.			
1. Subfamily. *Aspidogastrinae*, **subfam. nov.**			
A. Genus.—*Aspidogaster*, Baer, 1927.			
(1) *Aspidogaster indicum* Dayal, 1943.	Fresh water fish, *Barbus tor* (Ham.).	Intestine	Lucknow.
2) *A. piscicola* Rawat, 1948.	(*a*) *Labeo rohita* (*b*) *Labeo* sp.	Intestine Intestine	Lucknow. Allahabad.
B. Genus.—*Lophotaspis* Looss, 1902.			
(3) *Lophotaspis margaritiferae* (Shipley & Hornell, 1904) Ward & Hopkins, 1918. syn.—*Aspidogaster margaritiferae* Shipley & Hornell, 1904.	Pearl oyster, *Margaritifera vulgaris*.	..	Ceylon.
2. Subfamily.—*Cotylaspisinae*, **subfam. nov.**			
C. Genus.—*Lissemysia* Sinha, 1935.			
(4) *Lissemysia indica* Sinha, 1935.	*Lissemys punctata*	Intestine	Lucknow.
(5) *L. Ovata* Tandon, 1949.	Snail, *Vivipara bengalensis* (Lamarck).	Ctenidia	Kukrail. Lucknow.

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