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THE MORPHOLOGY AND LIFE HISTORY OF *ECHINOCHASMUS BAGULAI* VERMA, 1935 (TREMATODA: ECHINOSTOMATIDAE) WITH ECOLOGICAL OBSERVATIONS ON ITS LARVAL FORMS*

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INTRODUCTION

PRELIMINARY and fairly detailed examination of the predominant molluscs of the mudflat at Pamban for metacercariae (cysts) and cercariae revealed the occurrence of an echinostome cercaria in *Natica marochiensis* Gmelin, which bore striking resemblances, chiefly in the number, arrangement of the collar spines and in the nature of the excretory vesicle to the metacercarial cysts which I have come across in the bivalve *Katelysia opima* Gmelin. This casual discovery led to the study of its life history by undertaking feeding experiments. A similar method was employed by Beaver (1941) and Yamaguti (1951) in tracing the life histories of *Echinochasmus donaldsoni* and *Echinochasmus japonicus* respectively.

The partially and completely known life history studies on the different species of the genus *Echinochasmus* Dietz [Beaver (1941), Ciurea (1920, 1933), Johnston & Simpson (1944), Miki (1925), Muto (1921), Ujiie (1936) and Yamaguti (1933, 1951)] reveal that the larval stages of these trematodes occur in freshwater hosts except that described by Ciurea (1933). He recorded metacercarial cysts of *E. lliputanus* from the gills of a marine fish and on feeding these cysts to dog he obtained the adult forms. Thus our knowledge of the life history of the members of the genus having their larval stages occurring in marine hosts is very meagre. It is with the object of supplementing further data on these marine echinostome larvae as well as their life history that this work is attempted.

Even though the work on freshwater forms of this genus has been more extensive than on the marine forms, it is only with reference to one species, *E. rugosus* that the miracidial stage has been successfully recorded (Yamaguti, 1933). This, incidentally, is also the only available record of the miracidium of this genus.

MATERIAL AND METHODS

The snail *Natica marochiensis* and the bivalve *Katelysia opima* were used as the source of the echinostome cercaria and metacercaria (cysts) respectively. Collections of these snails and bivalves were made from the tidal mudflat at Pamban twice during a month for a period of two years namely 1954 and 1955. The above hosts

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were brought to the laboratory and were reared in the laboratory to make observations on the emergence and behaviour of the cercariae. Snails measuring on an average of 15 mm. and above were only used in the studies for determining the infection. Smaller ones were not studied as it was difficult to establish beyond doubt the cercarial infection in these even though they might have been infected. The method adopted by Stunkard (1943) was followed in determining the percentage of infection.

A total of 3074 specimens of *Natica marochiensis* and a total of 611 specimens of *Katelysia opima* were examined in this study. For the examination of the snail (*Natica*) and the bivalve (*Katelysia*) populations the following procedure was adopted. The general area in which *Natica* occurred on the mudflat was divided into 15 equal segments (30 yards square) and a random sampling from these segments was made. The average count per month per unit area was made and from this the total population estimate was obtained and is presented in Table 1 (vide p. 43). This procedure was not adopted in the case of the bivalve *Katelysia* because of its relative scarcity and so the entire area was surveyed every time when collection was made.

The infected bivalves were fed to the following birds: the gull-billed tern (*Gelochelidon nilotica*), the black-headed gull (*Larus ridibundus*), the curlew (*Numenius arquata*), the common or fan-tail snipe (*Capella gallinago*), the little egret (*Egretta garzetta*) and the pond heron (*Ardeola grayi*) which were observed to frequent the above mudflat. Besides these birds, the infected bivalves were fed to the domestic duck (*Anser domesticus*) also. Side by side with the feeding experiments, the birds of the above species, used as controls, were also examined. A thorough examination of the faeces of the artifically infected birds was made for the parasites and its eggs. As I had to depend on the bird catchers for the supply of birds, I had to confine myself to the examination of the above hosts for determining the definitive natural hosts.

Adult worms, obtained from the autopsied experimental birds, were studied alive and they were fixed in formalin (7 %) as well as in alcoholic Bouin's fluid. They were stained in alcoholic borax carmine, alum carmine and Ehrlich's haematoxylin and blued in alcoholic-ammonia mixture.

The details of the excretory system were made out from a number of immature cercariae got by teasing out the digestive gland of infected *Natica marochiensis*. The cercariae were studied alive. Ceracriae used for making mounts were fixed with hot 7 % formalin under cover slip pressure with least contraction and undue expansion. They were stained with the above stains.

Description of the area studied

The mudflat at Pamban is nearly a mile long with a maximum width of five to six furlongs. The longer axis of the flat is in a North-westerly direction and the sea is on the western side. There is no other mudflat area present in the near vicinity. Pamban channel (four fathoms deep) runs in the North-south direction about 20 feet away from the low tide mark and is parallel to the mudflat. Since this deep channel separates the mudflat from the nearby islands there is no possibility of mingling of populations between the mudflat and the islands nearby. Thus the first and the second intermediate hosts occur along with the other molluscan fauna as an isolated population.

Morphological description of :

Cercaria (Figs. 1 and 2.)

Echinostome cercariae described from marine snails are very few as compared with those described from freshwater hosts, and chiefly relate to the works of Lebour (1911), Martin (1955) and Cable (1956). There is no record of an echinostome cercaria from the snail *Natica marochiensis* and this is the first record of a marine cercaria from India.

It was observed that cercariae emerged from *Natica* in greater numbers during day time than during nights. A single *Natica* kept under observation liberated during day time on three consecutive days 295, 193 and 147 cercariae and the numbers during the corresponding nights were 10, 7 and 4 thus exhibiting a diurnal periodicity. Diurnal periodicity was also observed by Cort (1922) and Rees (1948). The cercariae held in a finger bowl were found to accumulate on the side facing the source of light thus exhibiting photo-positive orientation and a similar observation was made by Rees (1948) in *C. purpurae*.

Live cercariae ranged from 0.91 mm. to 1.10 mm. in length and in contracted condition it ranged from 0.25 mm. to 0.28 mm. In moderately extended, fixed specimens length ranges from 0.58 mm. to 0.88 mm. and the width is from 0.16 mm. to 0.26 mm. Its shape is elongately oval. Tail is approximately equal to one-third the length of the body in normally extended specimens. At the posterior extremity of the tail is present a pair of glands which open into the vesicle. Acetabulum is situated in the posterior region of the middle third of the body and its diameter ranges from 82μ to 119μ. The future collar region is seen as a distinct thickening but is not well developed. The collar spines are seen as small refractile bodies when stained with vital stain methylene blue. Their arrangement (Fig. 2) is exactly similar to the type met with in the metacercaria (described below) and the adult. They are interrupted dorsally, with 12 spines on each half of the collar and the dorsal innermost overlaps the oral sucker. The inner row of spines measure 7μ in length and the outer row 9μ in length except the 8th and 10th spines on either corner of the collar which measure 11μ in length.

Four pairs of penetration glands are present on either side of the median line embracing the anterior border of the acetabulum and they open by four pairs of ducts at the anterior end. Unicellular glands are abundant throughout the body. Four pairs of glands are present along the posterior wall of the oral sucker and they open by fine ducts at the anterior end.

Oral sucker diameter is from 45μ to 62μ. Pre-pharynx is short and measure from 22μ to 49μ in length and 27μ to 38μ in width. Oesophagus is from 0.18 mm. to 0.27 mm. in length and it bifurcates in front of the acetabulum and the caeca extend to the posterior end of the body where they terminate blindly.

The excretory system.—The excretory vesicle is chambered and the posterior chamber is larger than the anterior. The vesicle opens to the outside posteriorly on the dorsal surface of the body at the point of attachment of the tail. From the anterior chamber at its antero-lateral border the two main collecting trunks arise. The trunks upto the posterior level of the acetabulum are broad and full of excretory granules. From about the middle of the acetabulum they are narrow and proceed forward to the level of the pharynx, taking approximately a parallel course all along.

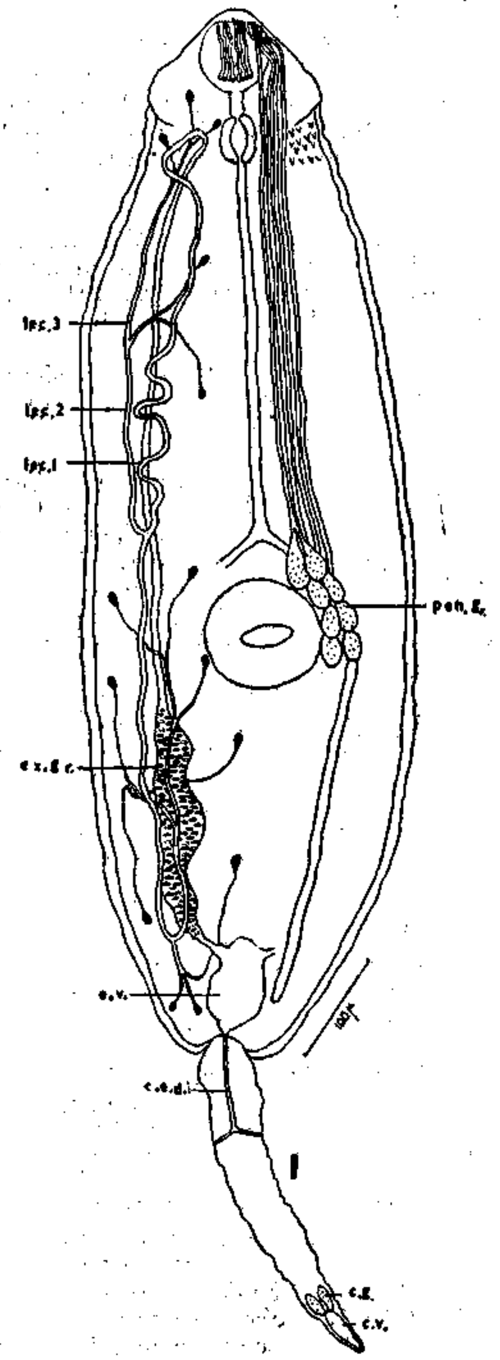


FIG. 1. Cercaria of *Echinochasmus bagulai* showing the excretory system, glands and their ducts.

The two ducts (l.e.c.1) converge a little posterior to the pharynx. The main canals beyond this level are narrow. They make a triangular loop (characteristic of echinostome cercariae) and pass backward on to the inner side of the main ascending canal and bifurcate in front of the acetabulum into the anterior and posterior secondary collecting tubules (l.e.c.2). The anterior collecting tubule divides into two branches the tertiary tubules (l.e.c.3) whereas the posterior collecting tubule divides into three branches. The flame cell arrangement in this cercaria can be represented by the following formula $2\ [(3+2)+(3+3+3)]=28$. A longitudinal canal starts from the posterior part of the vesicle and extends into the tail to one-fourth of its length and at that level it bifurcates into two lateral ducts which reach the sides of the tail.

Redia (Figs. 3 and 4.)

Heavily infected specimens of *Natica marochiensis* harbour rediae in all stages of development.

Well developed rediae measure from 0.90 mm. to 1.25 mm. in length and from 0.26 mm. to 0.29 mm. in breadth. The collar in younger specimens is conspicuous. It encircles the body in the region immediately posterior to the pharynx. Birth pore is dorsal and is on the left side just posterior to the collar, 0.15 mm. to 0.18 mm. from the anterior end. At about the middle are seen a pair of ventro-lateral appendages, the procruscula. In younger specimens they are quite pronounced long and vermiform. But in older specimens they appear as gentle curves.

Digestive system.—Mouth leads to a small vestibule just in front of the pharynx. A little posterior to the mouth opening and on either side is seen a small mass of gland cells which open into the vestibule. The pharynx is well developed and its diameter is 44μ to 56μ. The pharynx leads into a sacculate gut extending as far as the level of the appendages in younger specimens. In older forms having cercariae the sacculate gut is pushed to one side.

Cercariae in various stages of development occur in older rediae, numbering from four to eight and besides a few cercarial embryos also occur. They lie freely in the body cavity of the redia and move back and forth with the movement of the redia. The body of the fully developed cercaria near the birth pore region measures from 0.48 mm. to 0.52 mm. in length.

Metacercaria (Figs. 5 and 6.)

The earliest record of an echinostome metacercaria in a marine bivalve (*Scorbicularia tenuis*) is that of Villot (1879). Subsequently, various marine bivalves are described as harbouring echinostome cysts [Lebour (1908) and Stunkard (1938)]. This is the first record of echinostome cysts from *Katelysia opima* (and the first to be described from India though two other species of *Katelysia* (*Tapes*) *pullastra* and *K.* (*Tapes*) *decussatus* are known to harbour echinostome cysts [Lebour (1908) and Palombi (1934) respectively].

A maximum of 395 cysts were once recorded from a single infected bivalve. These cysts are found encysted in the foot usually at the junction of the posterior half of the body with the foot, though occasionally a few are found encysted in the gill-lamellae and the mantle.

The metacercarial cyst is spherical, measuring from 0.32 mm. to 0.39 mm. in diameter and is double walled. The outer wall is thick and tough and is formed of the connective tissue of the host. Its thickness ranges from 25μ to 32μ. The inner wall is thin and transparent. The metacercaria occupies the entire space within the cyst.

The metacercariae got from the teased out cysts measure from 0.52 mm. to 0.58 mm. in length and 0.23 mm. to 0.29 mm. in width. The collar is 130μ to 142μ in width and the collar spines are more prominent. The inner row of spines measure 10μ in length; the spines of the outer row measure 12μ in length except the 8th and 10th which measure 14μ in length. Acetabulum measures from 97μ to 102μ in length and 112μ to 126μ in width.

Oral sucker is half the size of the acetabulum and measures from 42μ to 51μ in width and its length is approximately the same as the width. Pharynx measures from 25μ in length by 43μ to 52μ in width. Oesophagus measures from 47μ to 55μ in length and bifurcates immediately anterior to the acetabulum. The cacea extend to the posterior end of the body.

The excretory vesicle is chambered and anteriorly it bifurcates into the two main collecting trunks.

The primordium of the anterior testis measures from 12μ to 16μ in length and 18μ to 22μ in width, while the posterior one measures from 19μ to 23μ in length and 18μ to 21μ in width. The primordium of the ovary is situated in the posterior region of the middle third of the body and its size is from 14μ to 17μ long and 27μ to 32μ broad. The cirrus primordium is seen as a small mass of deeply stained cells behind the intestinal bifurcation. The post-testicular space is approximately one-fifth the total length.

Adult (Figs. 7 to 9.)

Regular examination of the different birds mentioned earlier (vide p. 36) during the different seasons of the year when they were available did not, however, show the presence of adult echinostome in their alimentary canal except on one occasion when nine trematodes belonging to a different genus were found in the intestine of the little egret (*Egretta garzetta*). The experiments of artifically infecting the birds by feeding them with the infected bivalves showed that though the metacercariae excysted in all the different hosts, they reached their adult stage only in the following birds, viz., the black-headed gull, the curlew, the little egret and pond heron. The worms reached their adult stage at different interval of periods. viz., 6 days after feeding in the case of pond heron, 8 days after feeding in the little egret, 10 days after feeding in the gull and 12 days after feeding in the curlew. The development of cysts to the adult worm in such a relatively short period (6 days after feeding) was observed in *E. donaldsoni* by Beaver (1941) and in the case of *E. japonicus* it was even earlier, the cysts developing to the adult in 94 hours after feeding (Yamaguti, 1951). They did not excyst in the domestic duck.

The worms obtained by the indirect method (i.e., from the experimental birds) showed characters that are similar to those present in *Echinochasmus bagulai* described by Verma (1935) from *Ardeola grayi* except in certain characters. These

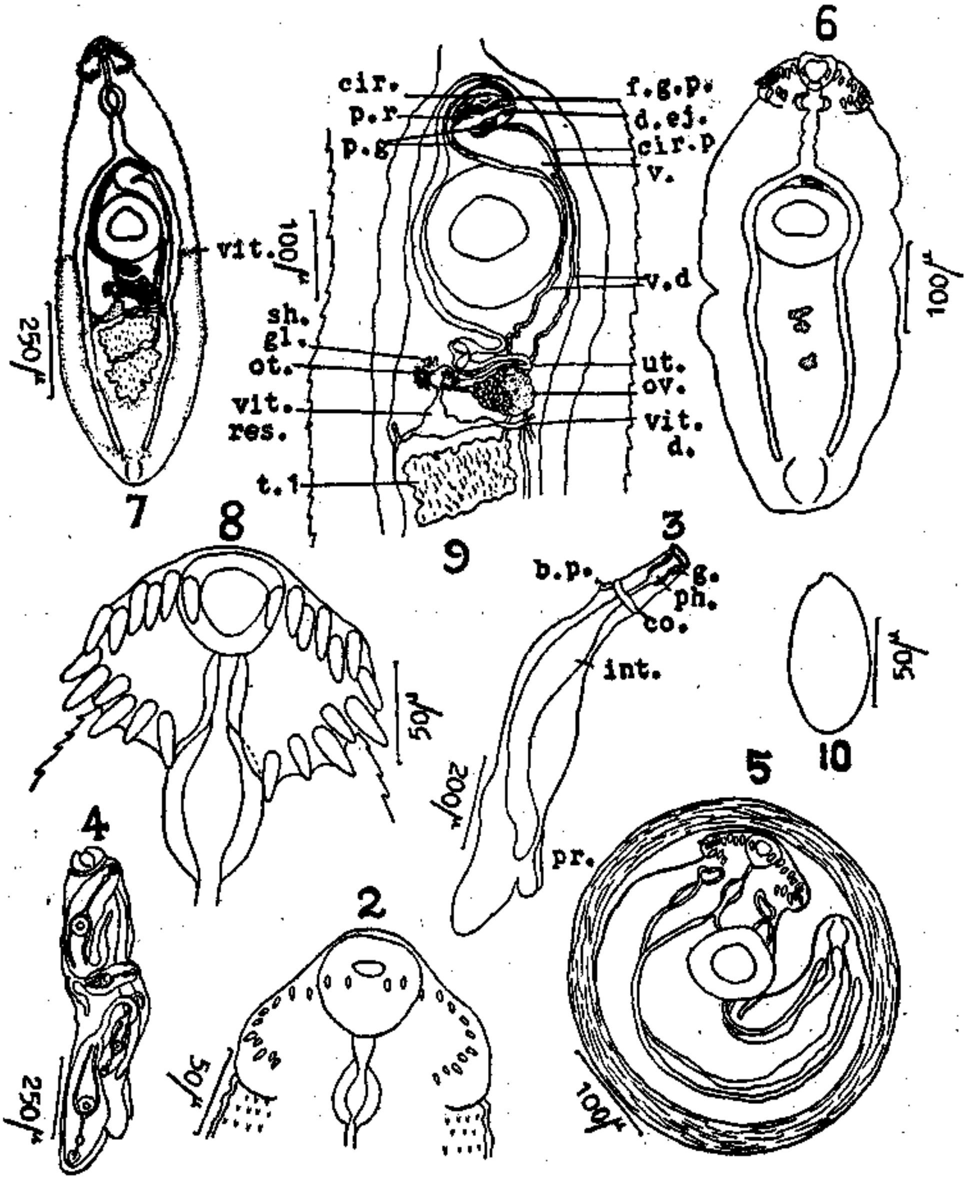


FIG. 2. Arrangement of the collar spines in the cercaria.
FIG. 3. Younger redia of *Echinochasmus bagulai*.
FIG. 4. Older redia of *Echinochasmus bagulai*.
FIG. 5. Metacercarial cyst of *Echinochasmus bagulai*.
FIG. 6. Metacercaria of *Echinochasmus bagulai* teased out from the cyst.
FIG. 7. Adult *Echinochasmus bagulai*.
FIG. 8. Collar of *Echinochasmus bagulai* showing the arrangement of the spines.
FIG. 9. Gonads and their ducts of *Echinochasmus bagulai*.
FIG. 10. Egg of *Echinochasmus bagulai*.

worms are designated as *E. bagulai* and a brief description of it is presented here for a comparison.

Length of the worm 0.8 mm. to 1.46 mm.; maximum width 0.34 mm. to 0.48 mm. Oral sucker 45μ to 64μ in diameter. Collar reniform, 0.10 mm. to 0.15 mm. broad with 24 spines interrupted dorsally and arranged in two rows, alternating with one another; spines of the inner row 21μ to 27μ long; outer row of spines excepting the corner spines (8 and 10) on either side 34μ to 30μ long and the corner spines 33μ long. Pre-pharynx 21μ to 42μ long. Pharynx 61μ to 82μ long and 47μ to 82 μ broad. Oesophagus one to two times the length of the pharynx. Acetabulum 0.16 mm. to 0.21 mm. in diameter. Testes median close behind one another and occupy nearly from one-third to two-fifth of the post-acetabular space; anterior testis 61μ to 121μ long and 134μ to 206μ broad and posterior testis 76μ to 182μ long and 107μ to 200μ broad. Cirrus sac elongate cylindrical, 115μ to 190μ long and 35μ to 55μ broad. It extends from behind the intestinal bifurcation to a maximum of one-seventh of the acetabular length behind the anterior margin of the acetabulum. As the cirrus sac extends around the acetabulum it partly overlaps the latter on the dorsal side. The enclosed vesicula seminalis is an elongate tube, greatly folded upon itself. Its limiting wall is continuous with the wall of the cirrus sac posteriorly at which point the vas deferns enters. In the retracted condition it forms an S-shaped bend. Anteriorly it is continuous through the pars prostatica into the ductus ejaculatorius which opens at the extremity of the cirrus.

Ovary oval in shape 45μ to 75μ broad and 36μ to 61μ long; situated to the right of the median line just behind the beginning of the posterior half of the body. Oviduct arises at the inner narrow side of the ovary and passes to the ootype and the latter is surrounded by shell glands. Vitelline follicles extend from behind the acetabulum and they are lateral to the caeca upto the hinder border of the posterior testis beyond which they are both extracaecal and intracaecal, meeting in the median line. Transverse vitelline ducts are present in between the ovary and the anterior testis. They proceed inwards and at the place of joining they form a large reservoir. It is situated slightly to the left of the median line. By a short common vitelline duct it discharges its contents into the ootype. The uterus is thrown into three coils between the ventral sucker and the ootype. It proceeds forwards to the metraterm which lies dorsal to the acetabulum and is on the left side of the worm. Its anterior end is somewhat ventral to the terminal portion of the cirrus sac and terminates at the shallow genital atrium. A maximum of 16 eggs were present in one of the specimens examined. The eggs measure from 61μ to 90μ in length and 35μ to 38μ in width.

Egg (Fig. 10)

The egg shell is golden yellow in colour. It is oval in shape. The opercular opening measures 18μ in width.

The faeces of the experimental birds did not contain eggs of *E. bagulai* in them even though they harboured mature worms in their intestine. Hence eggs from the uterus of mature *E. bagulai* were taken every time and reared in the laboratory by placing them along with the first intermediate host (the snail *Natica*) and also without them in order to follow the development to the miracidia. In both cases the eggs lived only for a maximum of three days after which period they disintegrated and died. As the supply of eggs was thus limited, the rearing experiment could not be successfully completed to the miracidial stage. So far there is no description of the miracidial phase of a member of the genus *Echinochasmus* except that of *E. rugosus* by Yamaguti (1933) who obtained it by indirect methods and it seems therefore that the miracidium is the most elusive stage of the genus *Echinochasmus*.

Host-parasite relationship

Observations on the seasonal trematode infection in freshwater snails have been reported by Sewell (1922), Rees (1932), Cort *et al.* (1941); on estuarine snail by Rothschild (1941); on marine snails by Miller and Northup (1926) and Martin (1955). The latter two authors have not extended their investigations to the second intermediate host. It is with the object of supplementing their data on the seasonal infection in the marine hosts by the cercaria of *Echinochasmus bagulai* that the following observations are presented.

Among the snails and the bivalves of the mudflat at Pamban examined for infection, it was observed that the snail *Natica marochiensis* and the bivalve *Katelysia opima* harboured the cercaria and metacercaria respectively of the echinostome trematode *E. bagulai*.

The percentage of cercarial infection varied during the different months of the year and they are presented in the Table below.

TABLE I

Percentage of cercarial infection of *Natica* for the years 1954 and 1955

Months	1954			1955		
	Total No. examined per unit area	No. infected	%	Total No. examined per unit area	No. infected	%
January ..	120	15	12	130	14	11
February ..	220	33	15	270	46	17
March ..	275	28	10	300	36	12
April ..	85	8	9	95	8	8
May ..	82	12	14	76	12	16
June ..	74	9	12	84	9	11
July ..	88	7	8	94	7	7
August ..	83	6	7	82	5	6
September ..	90	5	6	96	6	6
October ..	130	8	6	116	6	5
November ..	120	6	5	105	4	4
December ..	144	3	2	115	4	3

In Graph A the percentage of cercarial infection as well as the estimated population of *Natica* are plotted against the different months of the years 1954 and 1955.

Similarly the percentage of infection in *Katelysia* is presented in the Table below.

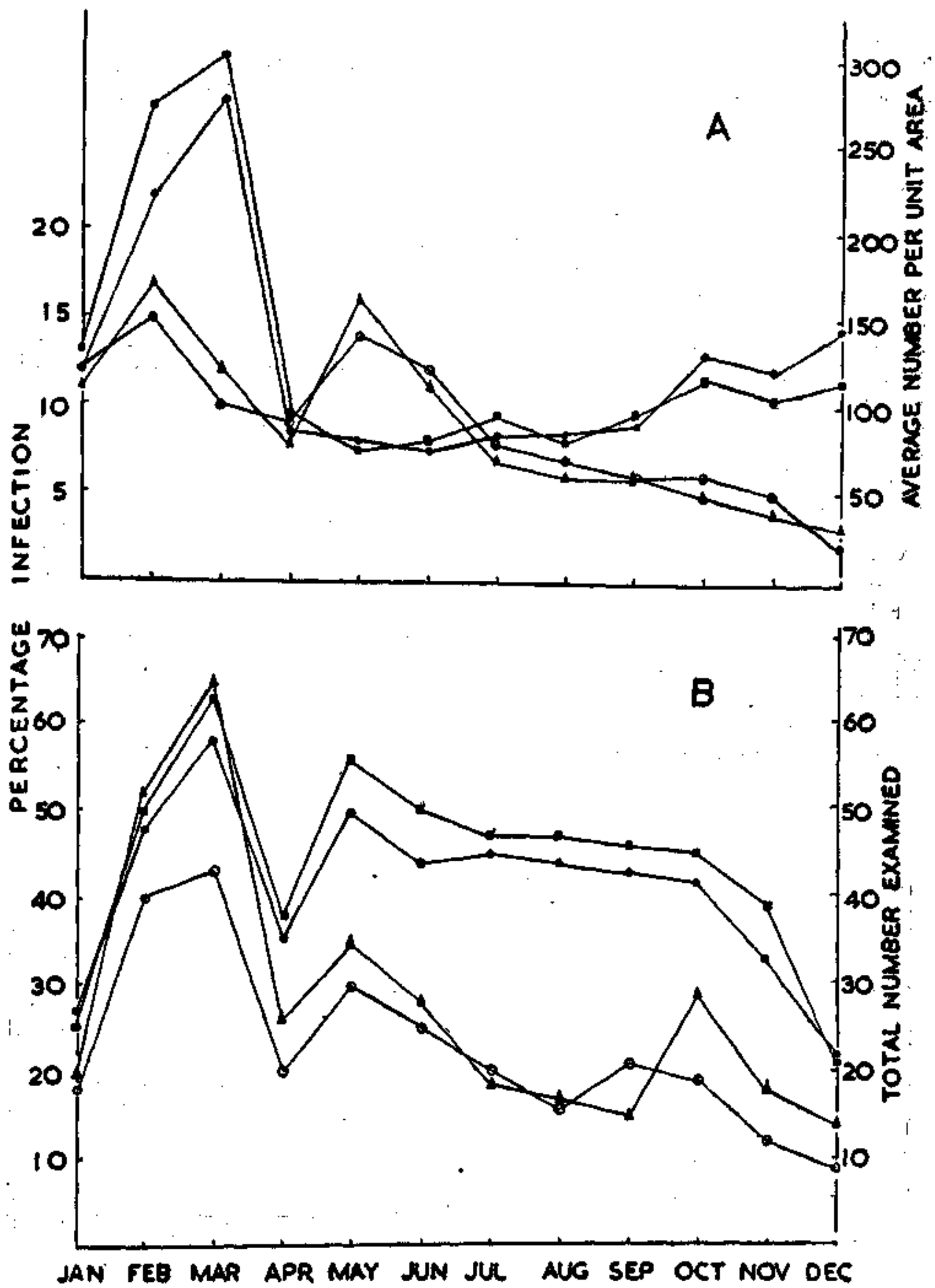
TABLE II

Percentage of metacercarial infection of *Katelysia* for the years 1954 and 1955

Months	1954			1955		
	Total No. of bivalves examined	No. of bivalves infected	%	Total No. of bivalves examined	No. of bivalves infected	%
January ..	18	5	27	20	5	25
February ..	40	19	48	52	26	50
March ..	43	25	58	65	41	63
April ..	20	7	35	26	9	38
May ..	30	15	50	35	19	56
June ..	25	11	44	28	14	50
July ..	20	9	45	19	9	47
August ..	16	7	44	17	7	47
September ..	21	9	43	15	7	46
October ..	19	8	42	29	13	45
November ..	12	4	33	18	7	39
December ..	9	2	22	14	3	21

In Graph B the percentage of metacercarial infection as well as the total population of this host, plotted against the different months of the years 1954 and 1955, are shown.

The population trend in *Natica* in the years 1954 and 1955 is more or less the same. The population is maximum in the months February and March in both the years after which there is a fall. The same is true also of the percentage of infection for the two-year period which reaches to a maximum first in February and again in May. These peaks are well understood when related to the life history of the parasite studied here. The first peak of the cercarial population occurs in February. Naturally, therefore, the miracidial phase must have occupied the period immediately preceding the first cercarial peak, which incidentally coincides with the occurrence of predominantly juvenile forms of *Natica* in the mudflat. That the juvenile stage is the most susceptible period in the life of the host for miracidial infection has been established by Krull (1931, 1934), Ameel (1934) and Cort *et al.* (1941). Therefore it is presumed that the miracidia of this species grow in with the juvenile *Natica* and become cercaria in the host by February. The miracidia themselves must have been developed from the eggs liberated along with the faecal matter of some final host harbouring the mature parasite. Life history studies on the different species of the genus *Echinochasmus* reveal that the final host to be vertebrates and in this case it seems to be birds—an inference drawn from the feeding experiments conducted. The appearance almost simultaneously at this period, of the birds which have been found experimentally susceptible to infection by cysts of this parasite affords more or less an ideal coincidence and condition for the completion of the missing portions of the life cycle of the parasite, namely, the egg and the miracidial phase. The birds referred to appear in the mudflat in November and stay on to the end of April



A. Host-parasite relationship of *Natica marochiensis* and cercaria of *Echinochasmus bagulai* for the years 1954 and 1955.

⊙—⊙ Percentage infection of *Natica* for the year 1954.
▲—▲ Percentage infection of *Natica* for the year 1955.
●—● Population data of *Natica* for the year 1954.
■—■ Population data of *Natica* for the year 1955.

B. Host-parasite relationship of *Katelysia opima* and metacercaria of *Echinochasmus bagula* for the years 1954 and 1955.

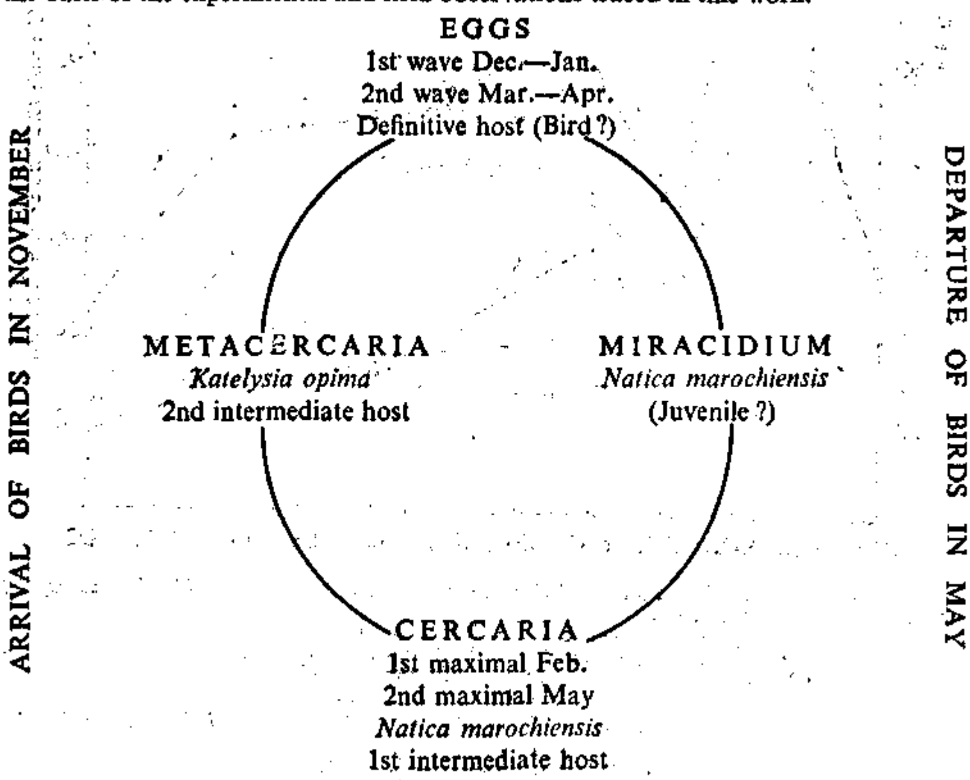
●—● Percentage infection of *Katelysia* for the year 1954.
■—■ Percentage infection of *Katelysia* for the year 1955.
⊙—⊙ Population data of *Katelysia* for the year 1954.
▲—▲ Population data of *Katelysia* for the year 1955.

the following year. It is again tentatively suggested here on the basis of circumstantial evidence that the birds are final hosts for this parasite. Such an evidence of the final host appearing at a time immediately preceding the cercarial peak was also given by Rankin (1939) and Rothschild (1941). Apart from this consideration it is very clearly shown in the Figure that there is almost an identical rise and fall in the host and parasite populations throughout the two-year period.

Bimodality.—In Graph A two cercarial peaks are seen one in February and the other in May. As was demonstrated in the experiments conducted in the laboratory, the cercaria need only about nine days to complete their larval development to the cyst stage as well as to the egg producing adult. From the frequency with which the eggs of the adult worms are cast off along with the faeces of the bird-hosts, one would expect that the casting of eggs would continue at the same rate at which they are liberated by the parasite itself. But from the Graph A which shows two distinct cercarial peaks, it can be inferred that the rate of production of eggs might not be regular as is reflected in the bimodal cercarial peaks which are produced at almost equal intervals. It can further be inferred that the development of the egg into the cercaria would normally take about two months approximately (which is not abnormal as can be verified from the works of Beaver, 1937). The possible interplay of various unknown factors causing the cercarial peaks is, however, not precluded from this observation.

In Graph B it is seen that the second intermediate host which becomes infected with the metacercarial cysts, also displays more or less the same host-parasite relationship that was seen for the first intermediate host and the cercaria.

The following chart summarizes the relationship of the parasite to its hosts, on the basis of the experimental and field observations traced in this work.



Effects of parasitism

The observations presented under this title are restricted to the effects of the parasitism on the first and the second intermediate hosts only. The lethal effect of the larval trematodes more especially on their snail hosts have been recognized by Faust (1917), Rees (1936), Rothschild (1938, 1941) and Rankin (1939) but only a few reports present a definite evidence indicating that they are an important factor in depleting the host populations under natural conditions. In this connection mention may be made of the works of Johnson (1920), Wesenberg-Lund (1934) and Cort *et al.* (1941) who have stressed the importance of the larval trematodes in the reduction of the snail populations. In the course of the observations here it was found that *Natica* with warty shell invariably had a higher percentage of infection, as much as 25%, whereas those having normal shell had only 7% infection. Therefore it seems plausible that one superficial effect of parasitism is at least seen in the wartiness of the shell.

Regarding the pathological effects of the metacercarial cysts on their second intermediate host, there seems to be a general belief that they do not appear to harm the hosts even when present in large numbers (Lebour, 1911 ; Sewell, 1922 ; Harper, 1929 and Rothschild, 1941). On the contrary the present investigations on the host-parasite population (as depicted in Graph B) seems to suggest that the fall in the strength of the host population is related to the harmful effects of the metacercaria. Lal and Baugh (1955) have shown that the development and growth of the metacercaria affected the normal functioning of the organs of *Vivipara bengalensis.* In the mantle, the infection retarded its normal elastic function.

Cercaria and metacercarial cysts of the species *Echinochasmus* affect two distinct hosts—a snail and a bivalve respectively, both of which occupy a common mudflat. In Graph A it can be seen that the population of the host and the cercarial population continue to rise, the former reaching a maximum between February and March. However, at the conclusion of the first cercarial peak in February-March, the rise of *Natica* population is drastically checked and there is a steep fall of nearly 67% in the population of this host, which is prevented from making a further recovery by a second cercarial peak falling in May. The host population from now onwards continues in this low ebb for nearly five or six months after the initial fall. From July onwards when the cercarial population also falls, a gradual recovery of the host population can be seen which continues to rise and repeat the process in the following year. A similar trend in the population of *Physa parkeri* due to the trematode larval infection was observed by Cort *et al.* (1941).

In Graph B, with reference to the second intermediate host the interpretation of the data will follow more or less on the same lines. The general trend shown in the host population curve is that it forms a peak between February and March and after which there is a sudden fall of over 60% and an increase in the population is seen being built up by May. But subsequently there is a steady fall both in the percentage of infection as well as in the population. The fall of the host population begins when the population of the parasite reaches the maximum and the recovery of this host population takes place with fall of the population of the parasites. But what is most striking in both these figures is the near identity of the intensity of percentage of infection. This really indicates that the population of the parasites are of the same order since one gives support to the other. If the depletion of the host population is due to any extraneous environmental factor operating in the mudflat, it should affect the parasites together with their hosts.

SUMMARY

1. Morphological descriptions of cercaria, redia, metacercaria and adult *Echinochasmus bagulai* are presented.

2. The development of the marine cercaria and metacercaria to the adult *E. bagulai* is described. Incidentally this is the first record of a marine cercaria and a metacercaria from India.

3. The two-year data on the ecological studies of the larval trematodes of *E. bagulai* have been analysed with reference to the host-parasite relationship and the effect of parasitism on the population.

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ABBREVIATIONS

b.p.	birth pore	ot.	ootype.
cir.	cirrus	ov.	ovary.
co.	collar	pen. g.	penetration glands.
c.g.	caudal gland	ph.	pharynx.
cir. p.	cirrus pouch	p.g.	prostate glands.
c.e.d.	caudal excretory duct	p.r.	prostate reservoir.
d.ej.	ductus ejaculatorius	pr.	procruscula.
e.v.	excretory vesicle	sh.gl.	shell glands.
ex.gr.	excretory granule	t.I	anterior testis.
f.g.p.	female genital pore	ut.	uterus.
g.	gland	v.d.	vas deferens
int.	intestinal limb	v.s.	vesicula seminalis.
l.e.c.1	lateral excretory canal (main canal)	vit.	vitellaria.
l.e.c.2	lateral excretory canal (seconday canal)	vit.d.	vitelline duct.
l.e.c.3	lateral excretory canal (tertiary canal).	vit.res.	vitelline reservoir.