ECOBIOLOGY OF HELMINTH PARASITES OF FINFISHES AND SHELLFISHES OF COCHIN WATERS WITH SPECIAL REFERENCE TO DIGENETIC TREMATODES

THESIS
SUBMITTED TO
THE COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

UNDER THE
FACULTY OF MARINE SCIENCES

BY
SYED ISMAIL KOYA, M. S.

DIVISION OF
MARINE BIOLOGY, MICROBIOLOGY & BIOCHEMISTRY
SCHOOL OF MARINE SCIENCES
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
COCHIN-682 016

DECEMBER 1987

CERTIFICATE

This is to certify that this thesis is an authentic record of the work carried out by Shri M.S. Syed Ismail Koya, M.Sc., under my supervision and guidance at the School of Marine Sciences, Division of Marine Biology, Microbiology and Biochemistry, Cochin University of Science and Technology, Cochin in partial fulfilment of the requirements for the degree of Doctor of Philosophy and that no part there of has been presented before for any other degree, diploma, associateship, fellowship, or other similar titles of any university.

10/12/87

School of Environmental Studies,
Cochin University of
Science and Technology,
Fine Arts Avenue, Cochin-682 016.

Dr.A. Mohandas
Reader
Supervising Teacher

DECLARATION

I, Shri M.S. Syed Ismail Koya, do hereby declare that the thesis entitled "Ecobiology of Helminth Parasites of Finfishes and Shellfishes of Cochin Waters with special reference to Digenetic Trematodes" is a genuine record of the research work done by me under the scientific supervision of Dr.A. Mohandas, Reader, School of Environmental Studies, Cochin University of Science and Technology in the Faculty of Marine Sciences, and has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles or recognition of any university.

14/11/97

Cochin - 682 016

M.S. Syed Ismail Koya

ACKNOWLEDGEMENTS

I wish to express my deep sense of gratitude to Dr.A. Mohandas, Reader, School of Environmental Studies, Cochin University of Science and Technology for suggesting the research problem, for his guidance and constant encouragement throughout the period, for critically going through the manuscript, and for suggesting improvements.

I am indebted to Dr.C.V. Kurian, former Head of the Department of Marine Sciences for his keen interest in my work and for helpful suggestions, and to Dr.Antony M.Nadakal, Emeritus Professor of Zoology, Mar Ivanios College, Trivandrum, for his valuable suggestions at various stages of this investigation.

I am thankful to Dr.G.S. Sharma, former Director of the School of Marine Sciences, Dr.Y.L. Dora, the present Director, and Dr.N.R. Menon, Head, Division of Marine Biology, Microbiology and Biochemistry, School of Marine Sciences for providing me the necessary laboratory and library facilities. My thanks are due to my senior colleagues, Dr.C.J. Cherian, Dr.M.V. Mohan, Dr.I.S. Bright Singh and Mr.C.G. Rajendran of the College of Fisheries, Kerala Agricultural University, and my several friends who have been helpful to me in one way or the other.

I am grateful to Rev.Fr. Antony Mookkath for his help in coining the latin names for the new species

described in this thesis. I would like to express my thanks to the University Grants Commission, New Delhi, and to the Council of Scientific and Industrial Research, New Delhi for awarding me fellowships during the tenure of which the work was carried out.

I am also grateful to the authorities of the Cochin University of Science and Technology for giving me registration to work as a candidate for the Ph.D. Degree of the University, and for permitting me to use the facilities at the School of Marine Sciences.

Finally, I wish to thank my parents, wife, brothers and sisters for their constant encouragement throughout the period.

CONTENTS

Page No.

CHAPTER I

CHAPTER II

CHAPTER III

......

PREFACE

Marine fishes provide one of the important food resources for the evergrowing world population. In a developing country like India with a coastline of about 6,100 km (George, 1980) and three seas around it, the economy of the coastal population is directly depended on marine fishery. Moreover, resources from the land being limited, our main concern to feed the millions is to explore the living resources from the sea, the important among them being fishes. The people of our country are facing the problem of protein deficiency in diet. Only a meagre percentage of the population is 'privileged' to have protein-rich food but this does not mean that the rest is denied of this facility. On the contrary, our annual production of animal protein for consumption is far from satisfactory to meet the ever increasing demand from a good percentage of the population. Besides, the cost of the common animal protein sources like the livestock, milk, egg, etc. is beyond the reach of common man who is the real victim of protein deficiency.

Fish is perhaps the cheapest but the best animal protein available to man. However, the annual landings of fish in India are not sufficient to meet even the minimum requirement. As a result of planned efforts to develop fisheries, the fish production has gone up from 0.75 million tonnes in 1950-51 to 2.54 million tonnes in 1977-78 (George, 1980), and to 2.84 million tonnes in 1984 (MPEDA, 1984); however, the per capita consumption of fish by an Indian is a staggering low figure of 3 Kg/person/yr (RAPA, 1985). The present exploitation of these resources, in spite of this achievement, is still fractional. The resources, both on the marine and inland sides, are very vast, capable of enabling production to several million tonnes. To meet the challenge, intensive fish culture is now being pursued on an increasing scale throughout the world. The success of the implementation of various fishery development programmes depends to a certain extent, on the intensification of research on fish parasitology because the improvement on fish yield can mainly be achieved from healthy fish stock. However, as other organisms, fishes are also prone to infection by a variety of parasites.

Among the parasites that infect fishes, helminths harm the fishes in a variety of ways. They cause mechanical injury, introduce toxic metabolic by-products, deprive the fish of food, act as carriers of other pathogens, and provide a point of entry for other pathogens through mechanical damage (Williams, 1967;

Rohde, 1982). The important mechanical effects include the damage of tissues caused by the rupture of protective layers, complete or partial atrophy of the internal organs, obstruction of the alimentary canal and damage to its walls. Serious damage to the reproductive organs of fish might cause their partial or complete castration. Damage to the surface of the body and internal organs leads to the formation of wounds through which fungi, bacteria, protozoa,and virus can make their entry into the organism. Other economic effects of infection include reduction in the number of food fishes available to fishery, stunted growth, weight loss, decrease in the yield of fish products and rejection of abnormal or diseased fish by consumers leading to subsequent loss of interest in fishery products (Sindermann, 1970; Srivastava, 1975). Further, helminth zoonoses also play an important role in fish eating populations. Fish transmitted helminth parasites, acquired by man through eating raw or inadequately treated fish products containing infective larvae or juveniles, are well known in parasitology and medicine (Rohde, 1982).

A study of larval trematodes parasitizing marine and brackishwater molluscs and crustaceans is justified on several accoun[illegible]s a prelude to an understanding of the complex life-cycles of trematodes which parasitize, as adults, marine vertebrates, notably fishes. A knowledge of life cycle is important with respect to the systematics and zoogeography not only of the parasites but also of their hosts, and the habits and trophic relationships of all the hosts involved in the cycles. Although one can judge the general pattern of a considerable number of the unknown metazoan life cycles from what is known about the same or similar parasites in other geographical regions or in other fishes, there are some parasites for which information is totally lacking or for which the life cycle pattern is atypical. Further more, such studies may contribute to a better understanding of the ecological impact of parasitism on host organisms and populations. There is no reason to believe that marine and brackishwater parasites are ecologically less important than terrestrial and freshwater parasites, and in recent years it has become more and more evident that they are indeed of great ecological, economic, and hygienic significance (Cheng, 1967; Sindermann, 1970; Rohde, 1982).

The great number of parasitic species of marine and brackishwater animals that have been described indicates that parasites play an important part in the ecology of the oceans and brackishwaters. Inspite of their importance, marine and brackishwater parasites are probably the least known group of organisms. Considering the large number of marine and brackishwater hosts, especially in the tropics, it is no exaggeration to say that the description of marine and brackishwater parasites has hardly begun (Rohde, 1982). With this view in mind, an attempt has been made to study the ecobiology of the helminth parasites of finfishes and shellfishes of Cochin waters with special reference to digenetic trematodes.

The work is broadly divided into three chapters, Chapter I consists of a description of the study area, prevalence of infection and concurrent infections with helminth parasites, seasonal variation, host specificity, and zoogeography of digenetic trematodes; Chapter II deals with the systematics of digenetic trematodes; and Chapter III deals with studies on larval trematodes from molluscs and crustacea, adult from a molluscan host, life-cycle, biology and histopathology.

CHAPTER I

INTRODUCTION

Any comprehensive understanding of marine biology must include knowledge of parasites because they outnumber their hosts and play a profound role in the biological economy of the sea. Marine parasitology may also contribute to studies on evolution, host-specificity and geographical distribution of parasites, and the use of parasites as biological tags may give clues to the distribution pattern of hosts and their activities. They also provide a means for population or stock identification, a matter of paramount importance in international and domestic management of fisheries resources. The parasite fauna of fishes, in general, represents the outcome of interrelationship between the parasites at different developmental stages and the many interdependent influences of the environment. For fishery biologists and management, the analysis of the parasite fauna of fishes provides knowledge of the biology and movements of their hosts (Olson and Pratt, 1973; Arthur and Arai, 1980). The parasites also have been useful in providing information in such diverse areas as the phylogenetic and ecological relationships of their hosts (Svetovidov and Shulman, 1960; Svetovidov, 1961), host diet (Margolis, 1965), the determination of geographic origin of anadromous species (Margolis, 1963, 1982), the study of recruitment of juveniles to adult populations (MacKenzie and Johnston, 1976), and the evaluation of the distinctness of host population (Kabata, 1967). Evidently, marine fishes exhibit an intricate link in the food chain, and hence the study of helminth of marine fishes is of paramount importance. As helminth parasites may lower hosts' resistance to environmental stresses (Cheng, 1964), both natural and man-caused, a knowledge of the presence and abundance of parasites may thus be of importance in considering the environmental impact of proposed engineering projects or the location of potential sources of chemical and thermal pollution.

With about 1,500 species of marine fishes native to Indian waters (Hafeezullah and Siddiqi, 1970) of which about 250 are common to Kerala coast (Eapen and Menon, 1973), a problem of this magnitude can best be solved only by conducting surveys on the helminth fauna of fishes at selected localities. It is encouraging that a beginning on this line in the westcoast of India has already been made by Radhakrishnan and Nair (1979, 1980). It was, therefore, decided to conduct a survey on the occurrence of the helminth parasites in marine fishes and molluscs of the nearshore and offshore waters extending between Alleppey in the south and Ponnani in the north and also of the Cochin backwaters.

It is believed that additional data gained from the present study would allow for more thorough zoogeographic and quantitative ecological analyses than is possible now, and also for a better understanding of seasonal patterns of infection, variations with age, parasite associations or antagonisms, host specificity, and other aspects of host-parasite relationships.

MATERIALS AND METHODS :-

The distribution of parasites may be studied in three different ways (Manter, 1963):- One approach is ecological in which the local precise occurrence of the parasites is considered, the second approach is to select a particular host and study all its parasites in different regions, and the third one is to note the occurrence of the parasites and their nearest relatives over wide areas of the globe. In the present study the problem was approached through the first system. The fishes were collected from near and offshore waters extending between Alleppey and Ponnani, the Cochin backwaters, and also from fish landing centres in and around Cochin. The major fish landing centres of Cochin are Integrated Fisheries Project, Ernakulam Market, Vypeen coast, Fort Cochin and Fishing harbour at Thoppumpady. Collections were made on board the fishing or research vessels. Otter trawls, purse-seines, gill nets and cast nets were the major gears used to catch the fishes. Information regarding the collection site was also obtained. Regular monthly samples of six host species caught from inshore waters for three years (1978, 1979 and 1980) were used to study the variations in the prevalence of infection with digenetic trematodes during premonsoon, monsoon and postmonsoon seasons. The sample size was maintained constant to have uniformity in calculating the prevalence of infection.

The fishes were identified following the taxonomical guidelines given by Munro (1955) and Day (1958). The fishes were, as far as possible, examined the same day or else were deep frozen and examined subsequently. Standard length and sex of the fishes were noted. Details regarding prevalence, intensity and nature of infection, location of the parasites, host species, age and locality were also recorded. The fishes were dissected out and individual organs were examined separately for the parasites. Small digenetic trematodes, cestodes and acanthocephala were flattened under cover slip pressure while big specimens were flattened between glass slides. They were fixed in 10% formalin for 24 hours, washed under running tap water till the fixative was removed and preserved in 70% ethyl alcohol. Digenetic trematodes for whole mounts were stained in acetic alum carmine, Semichon's carmine or haematoxylin; cleared in methyl benzoate and mounted in canada balsam. Nematodes were fixed in hot 10% formalin and preserved in 70% ethyl alcohol glycerine mixture (95 parts of 70% alcohol plus 5 parts of glycerine).

DESCRIPTION OF THE STUDY AREA :-

The study area includes the inshore and offshore waters of Cochin. The northern limit of the study area is Ponnani and southern limit, Alleppey (Fig. 1). The western boundary is 60 kms off the main land. Fishermen engaged in traditional fishing carry out a day's fishing in the inshore waters extending to 10-15 km from the shore, and in the present study this distance is considered as the inshore region and the remaining as offshore region. In the present study, the Cochin backwater system (Vembanad Estuary) is also included in the inshore region (Fig. 2) because this estuary interacts at the margin between the land and the sea (Perkins, 1974). Generally, the area of shallow seas within the 200 m (100 fm) contour is known as the continental shelf (Perkins, 1974), and it forms about 3% of the earth's surface and is the site of major commercial fisheries.

The coastal waters of Cochin, especially the inshore waters, are subjected to constant fluctuations in hydrographic parameters mainly due to the reversing monsoons. The sediments of the first 1 km are sandy and

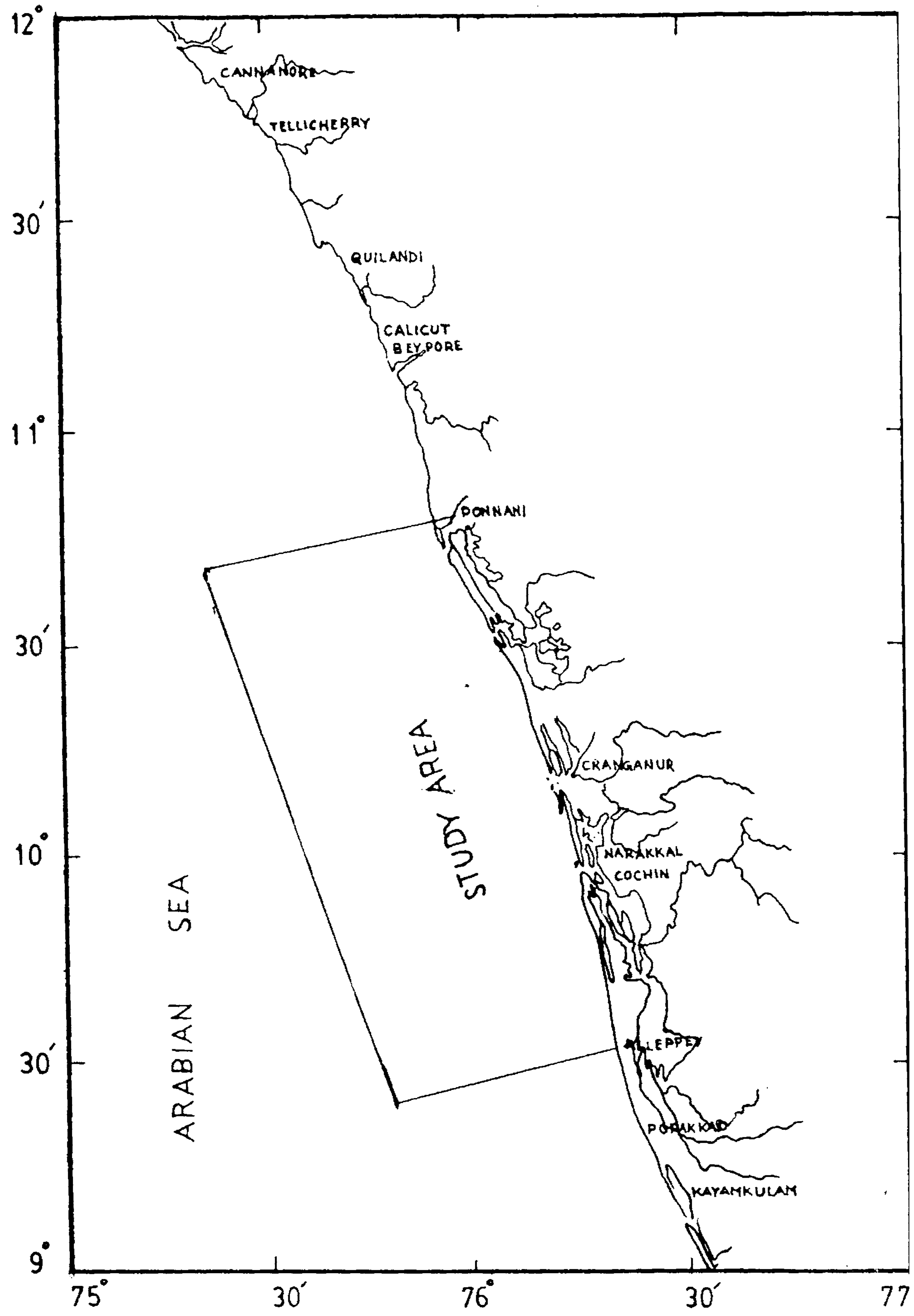
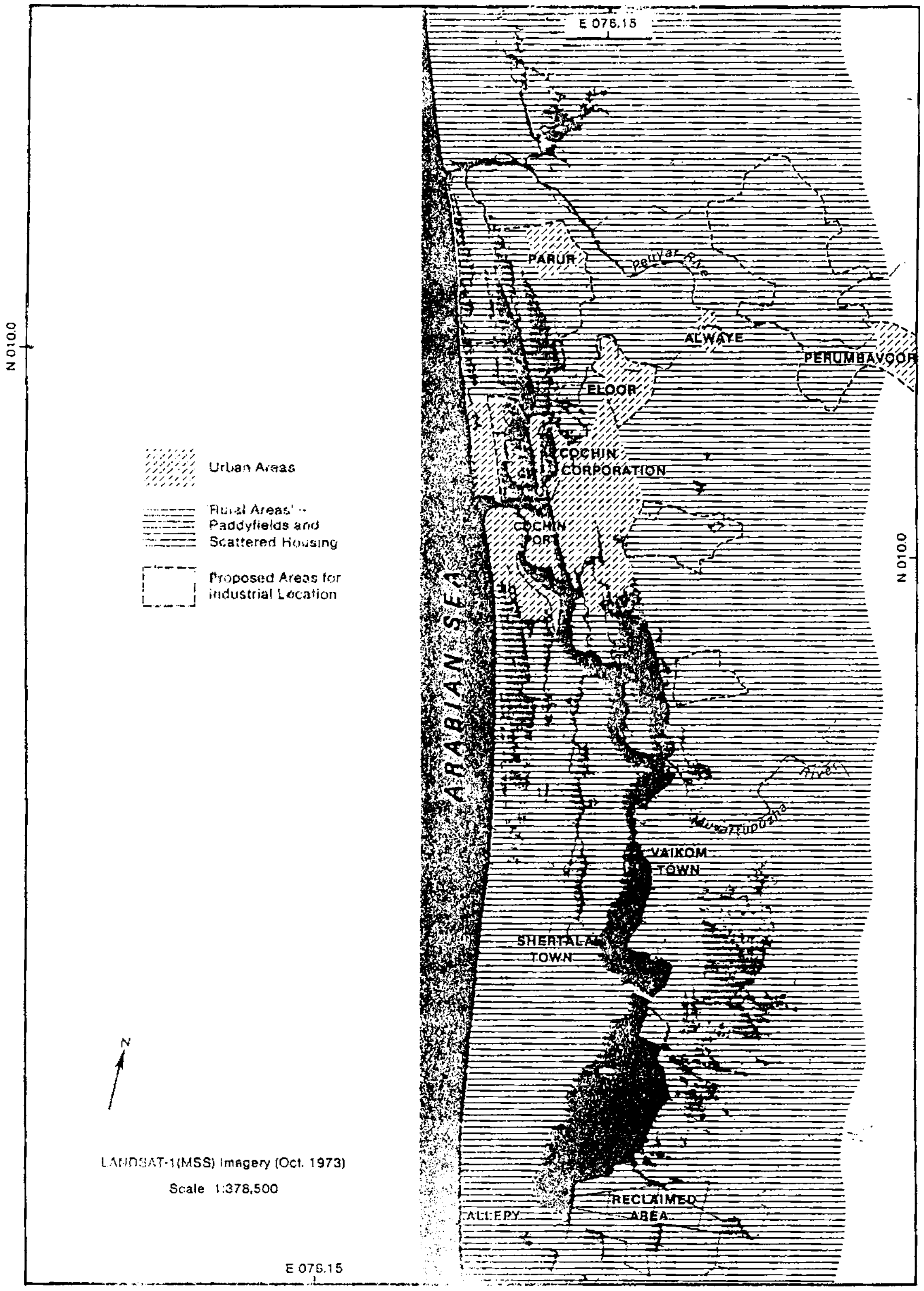


FIG.1.MAP OF KERALA COAST SHOWING THE STUDY AREA.



FIG·2· COCHIN BACKWATER SYSTEM – DARK SHADED AREA thereafter muddy. The coastline is an emergent type, formed of a number of long narrow sand banks running parallel to the original shore line (Darbyshire, 1967).

The maximum surface temperature occurs before the onset of the southwest monsoon season, whereas during the southwest monsoon season the temperature is generally low (Banse, 1959, 1968). The maximum surface temperature of the inshore waters recorded in April-May is about 30°C and the minimum, in July-August, is about 26°C (Banse, 1959, 1968; Damodaran and Hridayanathan, 1966). The bottom water temperature varies between 28°C in May and 23°C in August (Damodaran and Hridayanathan, 1966). The The maximum offshore surface water temperature is 30-31°C in April, and the minimum 28°C in December; and the maximum bottom water temperature is 28-29°C in April and the minimum, 23.5-26.5°C in August (Hridayanathan, 1981).

The maximum surface salinity of $34^{\circ}/_{oo}$ of inshore waters recorded during May dropped to $17.64^{\circ}/_{oo}$ in August (Damodaran and Hridayanathan, 1966). The southwest monsoon, extending from June to September, is a season of heavy rainfall, strong winds and rough sea (Darbyshire, 1967). After the commencement of the monsoon season, the most striking feature near the shore is the increase in discharge of freshwater from the rivers through the Cochin backwater system. This results in a marked drop in the salinity of the surface waters near the shore during certain periods. Kurup and Samuel (1987) reported the lowest salinity of $0.1^{\circ}/_{oo}$ during July-August,'78-80. Darbyshire (1967) observed the maximum offshore water salinity in summer months ($35.5^{\circ}/_{oo}$) and the minimum in January ($30^{\circ}/_{oo}$).

An important feature of Kerala is the influence of the southwest monsoon which affects the hydrographic conditions of the area in a remarkable manner. The effects of the northeast monsoon is rather indirect. Based on the influence of the monsoon and the associated environmental conditions, the year can be conveniently split into three well defined periods having characteristic hydrographic features. The pre-monsoon period (February-May) is comparatively with very little rain fall and characterised by fairly uniform high salinity and high temperature, the monsoon period (June-September) is characterised by heavy rainfall and high inflow of freshwater resulting in considerable drop in salinity, and the post-monsoon (October-January) period shows an increase in salinity and temperature than in the monsoon period (George and Kartha, 1963; Jos Anto, 1975).

These changing patterns in the hydrographic conditions are sequential to the changing pattern in the climatic conditions. The main circulation in the Arabian Sea results in the establishment of a surface current along this coast which reverses itself in the course of the year. The flow is southerly when the circulation in the open sea is clock-wise during southwest monsoon season, and northerly during northeast monsoon season when the circulation is counter-clock-wise (Ramamirtham and Jayaraman, 1960; Varadachari and Sharma, 1967; Sharma et al., 1982). Associated with these drifts are the upwelling and sinking along this coast (Ramamirtham and Jayaraman, 1960; Sastry and D'Souza, 1972). A strong upwelling is regularly observed during the whole period of southwest monsoon (Banse, 1959; Darbyshire 1967). It is believed that the prevailing current system, and not the wind, is mainly responsible for this upwelling (Banse, 1959).

In certain localities of the Kerala coast, the inshore area has got a special property of damping the wave action to produce areas of calm water during the rough monsoon seasons due to the dissipation of wave energy in the large quantity of colloidal suspension in the regions. This strange occurrence of smooth water patches is known as Mudbanks, and locally as "Chakara". Two such mudbanks, one at Narakkal and the other at Fort Cochin are noticed in Cochin area almost regularly during the southwest monsoon season. The phenomenon of appearance of the mudbanks is unique in its formation and function and makes a good contribution to the fishery potential of the state and economic condition of the coastal fishermen. The mudbanks besides affording protection to the coastal areas from severe sea erosion, have proven to be fertile grounds for the exploitation of large quantities of fish and prawns for local fishermen when other regions in the sea will be turbulent and unsafe for fishing operations. The seaward extension of the mudbanks is usually the 6 fathom line, at a distance of about 5 km from the shore line and the alongshore stretch varies from 3 to 6 km (Kurup, 1977).

The Cochin backwater system (Vembanad Estuary), which is also included in the inshore area is a tidal estuary. According to Pritchard (1960) an 'estuary is a semi-enclosed coastal body of water connected freely with the open sea and within which measurable dilution of seawater occurs'. The Vembanad Estuary has two permanent openings to the sea, one at Cochin and the other at Azheecode. At Cochin, the connection is about 450 m wide and forms an entrance to the Cochin harbour (Qasim et al., 1969; Qasim and Madhupratap, 1979).

The Cochin backwater system is situated between 9°30' and 10°10'N, and 76°15'-76°25'E. The backwater extends from Alleppey in the south to Azheecode in the north, and has a length of about 90 km (Ram Raju et al., 1979). The estuary is 16 km wide at the widest part and several narrow canals and rivers empty themselves into the backwaters discharging large quantities of freshwater during the monsoon season. As per the sounding data recorded by the Cochin Port Trust (unpublished official data given for personal use), the depth varies from 1.5 to 17 m. The backwater system covers an area of about 250 sq.km. (Qasim and Madhupratap, 1979). Classified as a tropical positive estuary (Pritchard, 1960; Qasim et al., 1969; Jos Anto, 1971), the characteristics of this estuary are influenced by the two major rivers flowing into it, Muvatupuzha river on the south and Periyar river on the north. The nature of bottom is mostly muddy (Qasim and Madhupratap, 1979), with an admixture of fine sand granules in some areas (Kunjukrishna Pillai et al., 1975). The tidal effects reach all along the lake upto the southern end. The average tidal range of the lake is 1 m in the lower part of the estuary, and it diminishes progressively towards the upper region (Antony, 1979).

The hydrological conditions of this backwater system and its influence on the inshore waters off Cochin are discussed in detail by several workers (Ramamirtham and Jayaraman, 1963; Damodaran and Hridayanathan, 1966; Qasim and Reddy, 1967; Jos Anto, 1971; Mohammed Salih, 1973; Lakshmanan et al., 1982). The hydrographical conditions are influenced both by the sea and by the fresh-water influx. The effects of coastal upwelling, monsoon piling and sinking in the Arabian sea are considerable in the backwaters, and help bring about a well defined seasonal pattern in the backwaters (Ramamirtham and Jayaraman, 1963).

The surface water temperature varies from 25.2°C - 25.8°C in August to 33.6°C - 33.8°C in March - April (Lakshmanan et al., 1982; Kurup and Samuel, 1987). Generally, by the onset of southwest monsoon season, an overall decrease in the surface temperature of 1°C to 1.5°C occurs, and this trend continues during June to October. The maximum bottom water temperature of 31°C occurs in April (Mohammed Salih, 1973), and the minimum of 28°C from December to February (Ramamirtham and Patil, 1965).

High surface salinity of more than 30‰ is observed between January and April (Lakshmanan et al., 1982; Kurup and Samuel, 1987). During monsoon period, the surface salinity values are 0-5‰ along the entire estuary but throughout the year the bottom water salinity remains higher than the surface values (Lakshmanan et al., 1982).

Annual rainfall in Cochin region is 328.9 cm, an average for 70 years, with fluctuations noticeable from year to year (Ananthakrishnan et al., 1979).

PREVALENCE OF INFECTION AND CONCURRENT INFECTION :-

I am using the term Prevalence instead of incidence which according to Margolis et al., (1982) is frequently misused for this concept. Prevalence, usually expressed as a percentage, is defined as the number of individuals of a host species infected with a particular parasite species divided by the number of hosts examined (Margolis et al., 1982).

Of the fifty species of fishes examined for digenetic trematodes, thirty species were infected. They are *Rastrelliger kanagurta*, *Trichiurus savala*, *Caranx malabaricus*, *Caranx kalla*, *Megalaspis cordyla*, *Sciaena* sp., *Parastromateus niger*, *Pampus argenteus*, *Sphyraena* sp., *Leiognathus* sp., *Nemipterus japonicus*, *Therapon jarbua*, *Decapterus russelli*, *Lactarius lactarius*, *Platycephalus* sp., *Psettodes erumei*, *Chorinemus* sp., *Glossogobius giuris*, *Lutjanus johni*, *Gerres filamentosus*, *Scomberomorus* sp., *Tachysurus* sp., *Cynoglossus* sp., *Chirocentrus dorab*, *Thynnus* sp., *Triacanthus* sp., *Ambassis* sp., *Drepane punctata*, *Seriola* sp., and *Narcine* sp. But the digenetic trematodes recovered from *Chorinemus* sp., *Triacanthus* sp., and *Ambassis* sp. could not be processed as they showed signs of disintegration. The remaining twenty species of fishes were free of infection with digenetic trematodes. They were *Scoliodon* sp., *Liza* sp., *Sardinella longiceps*, *Lutjanus argentimaculatus*, *Thrissocles* sp., *Saurida* sp., *Opisthopterus tardoore*, *Pomadasys hasta*, *Anchoviella commersonii*, *Belone* sp., *Anodontostoma chacunda*, *Scatophagus argus*, *Dussumieria* sp., *Lutjanus russelli*, *Mene maculata*, *Etroplus suratensis*, *Lutjanus fulviflamma*, *Serranus* sp., *Exocoetus* sp., and *Epinephelus* sp.

Of the 1934 fishes examined for digenetic trematodes, 540 were infected indicating a percentage of 27.92 (Table I), and the remaining 1394 fishes were free of infection (72.08%). From the Table it is clear that some host species were highly favoured by the trematodes while others were not. Depending upon the number of host fishes examined in each species, they were divided into three groups: where the number of fishes examined in each species was one hundred or more, they were put in group A, where the number was between ten and hundred, they were put in group B and where the number was less than ten, they were put in group C. The maximum prevalence of infection in group A (70.90%) was noticed in T.savala and the minimum in P.niger (3.95%). In group B, the maximum was observed in P.filamentosa (76.92%) and the minimum in Sphyraena sp. (7.59%), and in group C, the maximum was noticed in Narcine sp. (100%) and the minimum in Cynoglossus sp. (25%). The maximum number of 63 trematodes from a single specimen was obtained from T.savala.

In general, more young fishes were found infected than old ones but old ones harboured more number of parasites. Sexwise, more female fishes were infected than males.

Of the 1934 fishes, as many as 593 collected during the first year (January 1978 to December, 1978) were examined for other helminths also, namely, cestodes,

Table I

Names of the host fishes, Number examined, Number infected, Prevalence of infection, and the Number of Digenetic trematodes recovered

	Names of host fishes	Number examined			Number infected			Prevalence of infection (in percentage)	No. of digenetic trematodes recovered	Maximum
		Total	Male	Female	Total	Male	Female			
	1	2	3	4	5	6	7	8	9	10
1	*Rastrelliger kanagurta*	195	89	106	91	42	49	46.67	192	18
2	*Trichiurus savala*	189	78	111	134	57	77	70.90	532	63
3	*Caranx malabaricus*	176	97	79	59	34	25	33.52	76	6
4	*Caranx kalla*	174	78	96	63	26	37	36.21	121	21
5	*Megalaspis cordyla*	174	83	91	43	22	21	24.71	113	11
6	*Sciaena* sp.	168	92	76	8	Nil	8	4.76	14	4
7	*Parastromateus niger*	152	79	73	6	3	3	3.95	12	4
8	*Pampus argenteus*	145	71	74	45	21	24	31.03	117	8
9	*Sphyraena* sp.	79	33	46	6	2	4	7.59	9	2
10	*Leiognathus* sp.	51	24	27	5	2	3	9.80	8	2
11	*Nemipterus japonicus*	37	21	16	8	6	2	21.62	11	2
12	*Therapon jarbua*	35	14	21	10	4	6	28.57	12	2
13	*Decapterus russelli*	30	14	16	3	Nil	3	10.00	10	4
14	*Lactarius lactarius*	24	10	14	2	Nil	2	8.33	6	4
15	*Platycephalus sp.*	21	8	13	7	3	4	33.33	12	2
16	*Psettodes erumei*	20	11	9	2	2	Nil	10.00	4	3
17	*Chorinemus* sp.	18	10	8	3	1	2	16.66	5	3
18	*Glossogobius giuris*	16	6	10	5	2	3	31.25	16	5
19	*Lutjanus johni*	16	7	9	7	Nil	7	46.66	9	2
20	*Gerres filamentosus* (=*Pertica filamentosa*)	13	5	8	10	3	7	76.92	21	4

Table I

Names of the host fishes, Number examined, Number infected, Prevalence of infection, and the Number of Digenetic trematodes recovered

	Names of host fishes	Number examined			Number infected			Prevalence of infection (in percentage)	No. of digenetic trematodes recovered	Maximum	Minimum
		Total	Male	Female	Total	Male	Female				
	1	2	3	4	5	6	7	8	9	10	11
21	*Scomberomorus* sp.	12	5	7	2	Nil	2	16.66	2	1	1
22	*Tachysurus* sp.	11	3	8	1	Nil	1	9.09	2	2	-
23	*Cynoglossus* sp.	8	3	5	2	Nil	2	25.00	6	4	2
24	*Chirocentrus dorab*	7	6	1	3	2	1	42.85	7	3	2
25	*Thynnus* sp.	7	2	5	6	2	4	85.71	42	11	1
26	*Triacanthus* sp.	7	4	3	2	Nil	2	28.57	2	1	1
27	*Ambassis* sp.	6	2	4	2	Nil	2	33.33	2	1	1
28	*Drepane punctata*	4	Nil	4	3	Nil	3	75.00	32	16	7
29	*Seriola* sp.	2	Nil	2	1	Nil	1	50.00	44	44	-
30	*Narcine* sp.	1	Nil	1	1	Nil	1	100.00	2	2	-
31	*Scoliodon* sp.	17	11	6	Nil	Nil	Nil	Nil	Nil		
32	*Liza* sp.	15	7	8	Nil	Nil	Nil	Nil	Nil		
33	*Sardinella longiceps*	11	4	7	Nil	Nil	Nil	Nil	Nil		
34	*Lutjanus argentimaculatus*	10	2	8	Nil	Nil	Nil	Nil	Nil		
35	*Thrissocles* sp.	10	3	7	Nil	Nil	Nil	Nil	Nil		
36	*Saurida* sp.	10	4	6	Nil	Nil	Nil	Nil	Nil		
37	*Opisthopterus tardoore*	9	6	3	Nil	Nil	Nil	Nil	Nil		
38	*Pomadasys hasta*	8	6	2	Nil	Nil	Nil	Nil	Nil		
39	*Anchoviella commersonii*	7	Nil	7	Nil	Nil	Nil	Nil	Nil		
40	*Belone* sp.	6	3	3	Nil	Nil	Nil	Nil	Nil		
41	*Anodontostoma chacunda*	5	2	3	Nil	Nil	Nil	Nil	Nil		
42	*Scatophagus argus*	5	Nil	5	Nil	Nil	Nil	Nil	Nil		
43	*Dussumieria* sp.	4	1	3	Nil	Nil	Nil	Nil	Nil		
44	*Lutjanus russelli*	4	4	Nil	Nil	Nil	Nil	Nil	Nil		
45	*Mene maculata*	4	Nil	4	Nil	Nil	Nil	Nil	Nil		
46	*Etroplus suratensis*	4	3	1	Nil	Nil	Nil	Nil	Nil		
47	*Lutjanus fulviflamma*	2	1	1	Nil	Nil	Nil	Nil	Nil		
48	*Serranus* sp.	2	Nil	2	Nil	Nil	Nil	Nil	Nil		
49	*Exocoetus* sp.	2	2	Nil	Nil	Nil	Nil	Nil	Nil		
50	*Epinephelus* sp.	1	1	Nil	Nil	Nil	Nil	Nil	Nil		
	Total	1934	915	1019	540	234	306	27.92	1441		

nematodes and acanthocephala. This aspect was not considered for the subsequent years as I was concentrating more on digenetic trematodes and other aspects. Although comparasions and conclusions drawn on infection with helminth parasites are limited by such factors as non-random sampling, small sample size, and variation in age and sex composition of fish samples, useful data could be obtained regarding prevalence of single and concurrent infections with helminth parasites. The results are summarised in Table II; and briefly reported already (Syed Ismail Koya and Mohandas, 1982).

Of 593 fishes belonging to 27 species, 396 individuals (66.78%) from 21 species (77.78%) were infected with helminth parasites. Of these, single infection with digenetic trematodes, cestodes, nematodes, and acanthocephalans was found in 341 individuals, and the remaining had multiple infection in different combinations. One hundred and ninety seven individuals (33.22%) were completely free of infection including 51 individuals exclusively from six host species. Taking into consideration of single to multiple infections, trematodes were found in 15 host species, cestodes in 11, nematodes in 12, and acanthocephala in 11 species. The total number of parasites recovered was 2,013; 1,790 from single infections and the remaining from other combinations.

Table II

Percentage of Single, Double, Triple and Multiple infections and Non-infection with Metazoan parasites in various fish hosts

Name of the Host	Number Examined	Digenea	Cestoda	Nematoda	Acantho-cephala	Non-infection	Double infection	Triple infection	Multipl infectio
Caranx kalla	42	40.48	42.86	4.76	nil	nil	7.14	2.38	2.38
Rastrelliger kanagurta	74	29.73	28.38	2.70	nil	22.97	9.46	6.76	nil
Lactarius lactarius	5	nil	nil	nil	nil	100.00	nil	nil	nil
Sciaena sp.	47	14.89	nil	2.13	nil	78.72	4.26	nil	nil
Trichiurus savala	74	43.25	39.19	2.70	nil	nil	14.86	nil	nil
Platycephalus sp.	8	nil	nil	nil	62.50	37.50	nil	nil	nil
Sphyraena sp.	67	nil	88.06	2.99	nil	4.48	1.49	1.49	1.49
Nemipterus japonicus	18	nil	nil	61.11	5.56	27.77	5.56	nil	nil
Leiognathus sp.	26	3.85	nil	nil	nil	92.30	3.85	nil	nil
Megalaspis cordyla	61	19.67	22.96	29.51	nil	14.76	8.18	3.28	1.64
Scoliodon sp.	17	nil	nil	nil	nil	100.00	nil	nil	nil
Pampus argenteus	36	16.67	30.56	nil	5.56	41.67	2.77	nil	2.77
Saurida sp.	5	nil	nil	nil	nil	100.00	nil	nil	nil
Scomberomorus sp.	2	nil	50.00	nil	nil	50.00	nil	nil	nil
Sardinella longiceps	11	nil	nil	nil	nil	100.00	nil	nil	nil
Chirocentrus dorab	1	100.00	nil	nil	nil	nil	nil	nil	nil
Cynoglossus sp.	8	nil	nil	nil	nil	87.50	nil	12.50	nil
Psettodes erumei	16	6.25	nil	nil	37.50	50.00	6.25	nil	nil
Therapon jarbua	21	42.86	4.76	nil	nil	52.38	nil	nil	nil
Opisthopterus tardoore	6	nil	nil	nil	nil	100.00	nil	nil	nil
Anchoviella commersonii	7	nil	nil	nil	nil	100.00	nil	nil	nil
Tachysurus sp.	9	nil	nil	nil	100.00	nil	nil	nil	nil
Decapterus russelli	12	8.33	nil	41.67	nil	50.00	nil	nil	nil
Pomadasys hasta	8	nil	nil	nil	100.00	nil	nil	nil	nil
Pertica filamentosa	4	nil	nil	nil	nil	nil	100.00	nil	nil
Dussumieria sp.	4	nil	nil	100.00	nil	nil	nil	nil	nil
Thynnus sp.	4	nil	nil	nil	nil	nil	75.00	25.00	nil
TOTAL	593	18.38	25.97	7.93	5.23	33.22	6.75	1.85	0.67

One hundred and nine individuals (18.38%) belonging to 11 species harboured a total of 725 digenetic trematodes, and the mean intensity was 6.65. The maximum number of 63 trematodes was obtained from a single specimen of *T.savala*, and *Caranx kalla* coming next harboured 21 trematodes. The highest percentage of infection, barring *C.dorab* (only one specimen and 100% infection), was noticed in *T.savala*. The total number of cestodes recovered from 154 individuals (25.97%) comprising of eight species was 625 and the mean intensity was 4.06. A single specimen of *Sphyraena* sp. harboured the maximum of 20 cestodes, and *T.savala* and *M.cordyla* coming next harboured 12 cestodes each. The highest percentage of infection was found in *Sphyraena* sp. (88.06%), and the lowest in *Therapon jarbua* (4.76%). Nematodes were found in 47 individuals (7.93%) belonging to nine species. The total number of worms recovered was 275 and the mean intensity was 5.85. In a single specimen of *M.cordyla*, a maximum of 40 nematodes were found, and *R.kanagurta* coming next harboured 13 parasites. The highest percentage of infection was noticed in *Dussumieria* sp. (100%), and the lowest in *Sciaena* sp. (2.13%). Thirty one individuals (5.23%) belonging to six host species harboured 165 acanthocephalan parasites. The mean intensity was 5.32. The maximum number recovered from a single host, *P.hasta*, was 16 followed by *Tachysurus* sp.

which harboured 12 parasites. The highest percentage of infection was noticed in P.hasta and Tachysurus sp. (100%), and the lowest in N.japonicus and Pampus sp. (5.56%).

Concurrent infections in different combinations were observed in 55 individuals (9.27%) belonging to 13 host species. Instances of double infection were noted in 40 individuals of 12 host species, triple infection in 11 of 6 host species, and a combination of all the four groups of parasites in 4 individuals of 4 host species (Table II). In double infection, the combinations of trematodes with cestodes, acanthocephalans and nematodes were 26, 5, and 3, respectively and, of nematodes with cestodes and acanthocephalans were 5 and 1, respectively. In triple infection, trematodes with cestodes and nematodes were found in 10 instances, and trematodes with nematodes and acanthocephalans only once. The total number of parasites recovered from multiple infections in different combinations was 223- trematodes 112, cestodes 49, nematodes 38, and acanthocephalans 24. The total number of trematodes recovered from single and multiple infections was 837, cestodes 674, nematodes 313, and acanthocephalans 189.

In double infection, the combination of trematodes and cestodes involved eight host species, namely, *C.kalla* (3 occasions), *R.kanagurta* (7 occasions), *Sciaena* sp. (1 occasion), *T.savala* (11 occasions), *Sphyraena* sp. (1 occasion), *Leiognathus* sp. (1 occasion), *M.cordyla* (1 occasion), and *Thynnus* sp. (1 occasion); of trematodes and acanthocephalans involved two host species, *P.erumei* (1 occasion), and *G.filamentosus* (4 occasions), and of trematodes and nematodes involved two host species, *Sciaena* sp. (1 occasion), and *Thynnus* sp. (2 occasions). In the combination of nematodes and cestodes, the hosts involved were *M.cordyla* (3 occasions), and *Pampus* sp. (2 occasions), and in nematodes and acanthocephalans, the host was *N.japonicus* (1 occasion). In triple infection, the combination of trematodes, cestodes and nematodes was observed in five host species: *C.kalla* (1 occasion), *R.kanagurta* (5 occasions), *Sphyraena* sp. (1 occasion), *M.cordyla* (2 occasions), and *Thynnus* sp. (1 occasion), and the combination of trematodes, nematodes and acanthocephalans was found only in *Cynoglossus* sp. (1 occasion). Combination involving all the four groups of helminths was observed in *C.kalla*, *Sphyraena* sp., *M.cordyla*, and *Pampus* sp. (1 occasion each).

Regarding the sites of occupation, in single infection, trematodes were found in stomach and intestine, cestodes, as larvae in encysted condition, were found attached to liver, heart, kidney, gonads, peritonial cavity and outer wall of the digestive tract, and in free condition were found in the intestine. Nematodes, both as larvae and as adults, were found attached to body musculature and outer wall of the digestive tract and also in liver, heart, kidneys and gonads. When within the digestive tract, adults were found in stomach and larvae in intestine. Acanthocephalans were always found in intestine except in one instance where the specimen was found attached to the outer wall of the intestine of the host fish.

In concurrent infection, the picture was different. Trematodes and cestodes were found in the same individuals of eight host species. In *T.savala*, trematodes were confined to stomach whereas cestodes were found in caeca. In the remaining seven host species, trematodes were recovered from stomach and intestine but cestodes were not found in these sites. They, in encysted condition, were found attached to the peritonial cavity and outer wall of the digestive tract and also in liver, kidney and gonads. In trematode-acanthocephala combination, trematodes were found in the anterior part of the intestine and acanthocephalans in the posterior part of the intestine in *G.filamentosus* whereas in *P.erumei*, trematodes were collected from stomach and acanthocephalans from the posterior part of intestine. In the case of the combination between trematodes and nematodes, trematodes were obtained from stomach and nematodes from intestine in *Sciaena* sp.

but in *Thynnus* sp. both were obtained from intestine; trematodes from the anterior part and nematodes from the posterior part of the intestine. In *M.cordyla* and *Pampus* sp., nematodes were confined to intestine whereas cestodes, as cysts, were found in stomach and also in liver and heart. In *N.japonicus*, acanthocephalans were located in the posterior part of intestine but nematodes were found throughout the intestine. In triple infection involving trematodes, cestodes and nematodes and the five host species, trematodes were recovered from the anterior part of the intestine, nematodes from the posterior part and cestodes from the stomach. Cestodes were collected from the liver and nematodes from the gonads also. In the combination of trematodes, nematodes and acanthocephalans in *Cynoglossus* sp., trematodes were obtained from the stomach, nematodes from the anterior part of the intestine, and acanthocephalans from the posterior part. Interestingly, when all the four groups of helminths were found in *C.kalla*, *Sphyraena* sp., *M.cordyla* and *Pampus* sp. they were located in the intestine without overlapping.

In the present study, the prevalence of infection with helminth parasites in marine fishes was found to be fairly high. This high prevalence of infection cannot be attributed to any particular factor. The parasite fauna of any body of water, according to

Wisniewski (1958), consists of two groups of parasites, typical and less typical of its biocoenosis. The typical parasites are at the same time more numerous and represented by more specimens while the less typical are less numerous and represented by fewer helminths. According to Evans (1978), the level of infection of definitive hosts with intestinal helminths is the result of a balance between immigration and loss, the fluctuations in either or both of these processes will result in the establishment of periodicity in occurrence of such parasites. Dogiel (1964) and Rohde (1982) summarising the studies indicated that a variety of factors can determine or influence the parasite fauna of any species or groups of hosts. It is well established that age, sex, food, mode of life, seasonal and geographic distribution of the host and other biotic and abiotic factors, among others, do modify or alter the helminth fauna of a host population with reference to time and space. As regards the composition of parasite fauna of marine fishes as well as the prevalence and intensity of infection produced by each species of parasite, the factors responsible for are the nature of habitat, the mode of life, feeding and metabolism of the host, composition of the diet, life span, links with other members of its biocoenosis, migration and the phylogenetic factors (Polyanski, 1961; Vernberg and Vernberg, 1974; Paperna and Overstreet, 1981). The abiotic factors which significantly affect all marine parasites in some or all life stages may act directly on the parasite or indirectly on a host, and these factors include temperature, salinity alone or in conjunction with temperature, oxygen concentration, tides, currents, period of light or dark and depth (Vernberg and Vernberg, 1974; Paperna and Overstreet, 1981; Overstreet, 1982). It is generally accepted that temperature is the most important single factor determining the distribution of marine organisms (Hedgpeth, 1957). Temperature affects parasite fauna in two ways, (i) species numbers are greatly increased in warm seas, and (ii) species are different in cold and warm seas. That temperature is the decisive factor responsible for differences in species numbers is indicated by the observation that habitats at different localities which do not differ significantly in any other parameters beside temperature nevertheless differ in species numbers (Rohde, 1982). Moreover, while looking at some surveys, by the distribution of some cosmopolitan species and also by comparison of shallow and deep water parasites in a particular region, it becomes clear that temperature critically affects the parasite fauna. Yet another factor that influences the parasite fauna is the regional variation (Paperna and Overstreet, 1981). The zonation in the distribution of marine fishes into littoral, sublittoral, pelagic and bathypelagic also influences the parasite fauna (Polyanski, 1961). The chemical composition of seawater also exerts influence on the host fish to which the parasite fauna is also subjected (Polyanski, 1961; Overstreet, 1968).

A preliminary survey of larval trematodes in molluscs and crustaceans of the nearshore and offshore waters of Cochin revealed that infection is negligible. Since fishes collected from the inshore waters were also found infected with digenetic trematodes, it is apparent that most of these fishes might have caught infection from other regions and subsequently migrated to this region. Some of the fishes like *R.kanagurta*, *M.cordyla*, *Scomberomorus* sp., *A.commersonii*, *D.russelli*, *Thynnus* sp. etc., are pelagic in habitat, and therefore they might have acquired infection by eating intermediate hosts from elsewhere. Large and fast moving oceanic fishes enhance the distribution of parasites (Rees, 1970). In my collection also many fishes like *R.kanagurta*, *Sphyraena* sp., *M.cordyla*, *Thynnus* sp., *L.johni* etc. were fast moving and migratory in nature and hence they may represent the parasite fauna of other regions also.

The biotic and abiotic factors of the environment are in a state of close interdependence. This is best reflected in the nearshore waters of Cochin and also the Cochin backwater system (Vembanad Estuary). The hydrological conditions of this backwater system and its influence on the inshore waters of Cochin are well documented. The hydrological conditions are influenced both by the sea and by the freshwater influx as discussed in detail under 'study area'. The changes in the hydrological conditions in the nearshore waters of Cochin and in the estuary and the high primary productivity in this area have significantly affected the marine helminth fauna. This is quite evident from the seasonal pattern shown in the prevalence of infection with digenetic trematodes in six species of commercially important fishes collected by me for three consecutive years. Although salinity and temperature fluctuations act directly on attachment, survival, reproduction and movement of adult helminths of marine fishes (Polyanski, 1961; Solonchenko, 1978; Overstreet, 1982), it is difficult at this stage to point out the exact role(s) played by these factors in the prevalence of infection in marine fishes with the helminths. Walkey (1967) stated that since fish are poikilothermic animals, temperature changes in the external environment are transmitted to the parasite fauna also.

It is obvious from the present study that the metazoan parasite fauna of marine fishes of the nearshore and offshore waters of Cochin is quite diversified and the prevalence of infection is fairly high. Radhakrishnan and Nair (1980) reported that of the teleosts 83.65% and of the elasmorbranchs 93.75%, collected from Trivandrum waters, were infected with different metazoan parasites. But they have not mentioned specifically whether these figures are of single infection alone or a combination of single and multiple infections. One thing, however, becomes very clear from the present investigation as well as from the report of Radhakrishnan and Nair (1980) that the south-west coast of India provides a very congenial habitat for the ichthyoparasite fauna.

In the present study, it was found that more young fishes were infected than old ones but the old fishes harboured more number of parasites. With age, significant changes take place in many aspects in the biology of fishes, such as the type of feeding, composition and quantity of diet and physiological conditions. It is well established that the parasite fauna is dependent on the age of the host (Polyanski, 1961; Kagei, 1969; Reimer and Jessen, 1972), though a few parasites are independent of the age of the host (Gorbunova, 1936; Kennedy, 1968). As a broad generalization but with many exceptions, older animals have larger number of parasites than do younger animals of the same species (Noble and Noble, 1976). Studies by Polyanski (1961) and Dogiel (1964) on fishes of Russian waters confirmed that with increase in age there is increase in the incidence and intensity of infection. Studies by Overstreet (1968), Collard (1970), Sasaki (1973), Hughes and Alton (1974), Evans (1977, 1978), and Grabda (1977) also revealed that more older fishes were infected than younger ones. But Rakova (1953), Freeman (1964), Elkins and Corkum (1976), and Solonchenko (1978) reported the other way. James and Srivastava (1967) noticed a general increase in the incidence and intensity of infection with parasites with increase in age in certain fish groups and the reverse condition in a **few** other groups. Lawrence (1970), and Amin (1974) reported considerable decrease in the worm burden in aged **white** sucker and Amin (1974) opined that this might indicate changes in host feeding habits, a host-age resistance mechanism, short term residual infections or, a combination of any of these factors. But Muzzall (1980) observed no such difference. As seen in the present study, the number of parasites was more in older fish, and Polyanski (1961), Dogiel (1964), Elkins and Corkum (1970), Collard (1970), Evans (1977), Muzzall (1980 a), Rohde (1982) and Arthur et al., (1982) also reported that older fishes harboured more number of parasites. Although it was observed in the current investigation that the number of older fishes infected with parasites was less, it cannot be attributed to age resistance or immune response because fish lack an effective immune response against endohelminths (Burn, 1980). Sindermann (1966) and Kennedy (1977) have also noted that very few fishes are capable of mounting effective immune response against their parasites, particularly against helminths. On the contrary, it can be related to changes in host feeding habits, changes in behaviour of fish, volume of intermediate hosts ingested, physiological status,and other biotic and abiotic factors. Rohde (1982) has indicated that older hosts being larger, present more and larger microhabitats to parasites, and they consume larger quantities of food resulting in a greater probability of becoming infected with orally acquired parasites.

It is generally found that female vertebrates are less heavily infected with parasites than males, probably due to the presence of oestrogen. But in the present study it was found that more female fish were infected than males. Thomas (1964 a), Kennedy (1968), Collard (1970), Madhavi (1979) and Sathyanarayana (1982) also reported their findings on the same lines. This difference may be attributed to sex-related difference in host growth rates or may be related to interference with the hormone balance of female fish as a result of parasitic infection. It may also be due to differences in physiological resistance (Thomas, 1964 a) or in attractiveness to the parasites (Paling, 1965).

Pennycuick (1971) suggested that the female fish provided a more favourable environment as the resources which normally go to the production of eggs would, perhaps, be available to the parasites. Rohde (1982) has suggested that the difference in the prevalence of infection in male and female fishes may be due to the differences in the feeding habits.

In the present study more carnivores and omnivores were found infected than herbivores. This is not surprising because these feed on herbivores and invertebrates including molluscs and crustaceans which act as intermediate hosts for various helminths. The main source of infection of plankton feeders with parasites of complex life histories are planktonic animals. Skinner (1974) found in mullets parasites which had planktonic animals as intermediate hosts. Since many plankton feeding fishes lead gregarious lives, good conditions arise for their infestation by parasites with simple life cycles. Dogiel (1961), Polyanski (1961), and Noble (1973) have opined that the plankton feeders are characterised, mainly, by the paucity of their parasite fauna, both in respect of the number of species and the level of infestation they attain. Because the primary productivity in the area under study is very high (Nair et al., 1973), plankton feeders are naturally attracted to this area in large numbers which in turn attract carnivores and omnivores.

There is a principle in ecology known as Gause's rule, which states that two species having essentially the same niche cannot coexist in the same habitat. In the present study, in single infection, trematodes were found in the stomach and the intestine, cestodes in the intestine, nematodes in the stomach and the intestine, and acanthocephalans in the intestine. Crompton (1973), in his review, pointed out that in fish digestive tract, acanthocephalans and cestodes were confined to the lumen and paramucosal lumen of the small intestine, nematodes could be found in most regions of the alimentary tract, and digenetic trematodes in the stomach and the intestine. My own observations are almost in line with the conclusions made by Crompton (1973). *R.kanagurta* harboured six species, *Platycephalus* sp. and *C.malabaricus* harboured three species each, and *C.kalla*, *M.cordyla*, *I.savala*, *Cynoglossus* sp. and *Thynnus* sp. harboured two species each of digenetic trematodes and they were found in the stomach and/or intestine. No explanation is obvious, as remarked by Crompton (1973) also, in cases where two or more species of the same helminth group have different sites in the digestive tract of a host, but have not been observed to occur concurrently.

The distribution and survival of helminths in the alimentary tract of vertebrates may be related to phases of digestive activity or inactivity (Crompton, 1973). One effect of digestion, together with the nature of the diet, is the production of different conditions in different parts of the tract. Some evidence, indicating that conditions vary along the tract, has been discussed at length with a parasitological interest, among others, by Read (1950, 1971), Smyth (1969), Williams et al., (1970), Crompton (1973), and Befus and Oodesta (1976). In poikilotherms, digestion is usually a slower process because it is dependent on ambient temperature (Barrington, 1942). Food reaches the stomach or equivalent part relatively quickly. After periods of mixing, the food is propelled from the stomach through the pylorus into the intestine. The conditions in one part of the tract merge gradually with those in the next rather than differing sharply (Crompton, 1973). Further, digestion, which is under nervous and hormonal control, is affected by factors like the nature of the diet, feeding routine, and the emotional state.

Thomas (1964) suggested that some species may provoke a strong host mucosal reaction thus rendering that area of the intestine unsuitable for attachment by other parasites. Pepsin was found by Smit (1968) in the mucosal extracts and gastric juices of elasmobranchs and teleosts, being secreted only in the cardiac stomach. In teleosts, the acidity of the stomach increases after feeding and falls during fasting (Williams et al., 1970). Highly acid food passing from the stomach into the anterior part of the intestine will exert considerable influence on that region. But Cordier et al., (1957) indicated that fish intestine has strong buffering powers. This flow of acid material into the anterior part of the intestine may influence the distribution of helminths. Williams et al., (1970) remarked that interaction with pancreatic, hepatic and intestinal secretions ultimately results in an approximately neutral pH. Seasonal variations in the activities of digestive enzymes, pepsin, trypsin and amylase could influence the physiological pattern of the fish intestine to such an extent that the parasite distribution or even the composition of the parasite fauna in the gut could be drastically changed (Ananichev, 1959).

In general, the distribution of helminth parasites of the fish intestine depends on the presence of absorbable food materials in the lumen of the gut. The availability of certain classes of nutrients and their different sites of digestion and absorption will play a definite role in determining the parasites and their distribution in the digestive tract.

In infection with more than one group of helminths in the same host, the distribution of each group was slightly different from the distribution when each group occurred alone. The combined population of organisms, both flora and fauna, that live together in a host organ, in the entire host or in a host population are known as the parasite-mix (Noble, 1960) for which a more technical appellation is parasitocoenosis (Noble and Noble, 1976). It seems the parasites appear to abide by a basic ecological rule which was stated by Gause (1934) as "It is admitted that, as a result of competition, two similar species scarcely ever occupy similar niches, but displace each other in such a manner that each takes possession of certain peculiar kinds of food and modes of life in which it has an advantage over its competitor". According to Overstreet (1968), the presence of a species of parasite may increase or decrease the possibility of the presence of other parasite species. One species might be beneficial to the other for it produces a metabolic essential for the second species, or because the reactions of the host against the parasitic species provide essential substances for the second species. Interestingly, in the present study, the helminths in concurrent infection were never seen in the same habitat except when all the four groups of helminths were involved, When all the four groups of helminths were involved, they were found in the intestine without overlapping. They do occupy the same habitat but not the same ecological niche which depends on the habitat and on what the parasites do. This situation is possible, according to Noble and Noble (1976), because of the absence of enemies and the presence of an abundance of food. Muzzall (1982) did not observe in white sucker, displacement (movement) of a species into an intestinal area where it was usually not found when a large number of individuals of another species occurred in the preferred habitat of the former parasite species. Kennedy (1977) did not find any interaction between Pamphorhynchus laevis and other species in fish.

There is evidence that the behaviour of a parasite within its host is influenced by the presence of another species of parasite (Noble and Noble, 1976), and one species of helminth may cause another to extend its site and, interaction between two species may result in a change of site for one or both of them (interactive site segregation)(Crompton, 1973), or this interaction may affect negatively the other organism (Halvorsen, 1976). In the present study it was not looked into critically whether the species of helminths involved in single infection were involved in concurrent infection also, and hence it cannot be said precisely whether the species involved in concurrent infection had actually a change of site.

In concurrent infection, there is apparent restriction of species of helminths to precise regions in the digestive tract (Crompton, 1973; Halvörsen, 1976; Kennedy, 1977; Rohde, 1979), or even expansion of niche (Pianka, 1974; Colwell and Fuentes, 1975). The basic mechanism thought to be most responsible for niche restriction is competition (Holmes, 1973; Pianka, 1974; Colwell and Fuentes, 1975; Rohde, 1979, 1982) but only in relatively few cases, however, that this has been demonstrated experimentally (Rohde, 1979). Other factors considered to be significant are the internal morphology, age, sex and physiological status of the host (Crompton, 1976), morphological adaptations (Rohde, 1982), interference and exploitation (Halvorsen, 1976), predation, parasitism (Connell, 1971; May, 1974; Colwell and Fuentes, 1975), reinforcement of reproductive barriers (Brown and Wilson, 1956; Hardin, 1960; Rohde, 1982))and intrinsic (intraspecific) factors (Rohde, 1979). An important intrinsic factor considered by Rohde (1979, 1982) as responsible for niche restriction in parasites is selection to increase intraspecific contact and thus mating, Although complex behavioural mechanisms regulating population growth (Coulson, 1971; Way and Cammell, 1971), and abnormally high population density have also been considered as intrinsic factors, Rohde (1977, 1982) suggests that in parasites enhancement of the chances of mating is the only intrinsic factor responsible for niche restriction.

Rohde (1979, 1982) cited certain extrinsic (interspecific) factors also, such as, micro and macrohabitats, host age and season in which the infection occurs, negative interspecific effects, such as, interactive site segregation, and resource partitioning as indicated by slightly different mouth parts and differences in other morphological structures, as responsible for niche restriction in concurrent infection. Holmes (1973) presented evidence to support the hypothesis that continued competitive interaction between parasite species in evolutionary time leads to niçhe diversification, largely through site segregation, and consequently results in narrow site specificity. He noted that interactive site segregation, in which the microhabitat of one or several species is reduced in the presence of other species (ie; fundamental niche becomes realized niche), appears to be considerably less common than competitive exclusion. Most common, according to him (Holmes, 1973), is selective site segregation in which a species of parasite occupies a restricted, distinct microhabitat which does not change in the presence or absence of other species of parasites (ie; fundamental niche is equal to realized niche). He further argues that because selective site segregation is much more common than interactive site segregation, parasite faunas are mature communities whose diversity has been established to an important extent through competitive interaction. Rohde (1979), on the other hand, while admitting the role of extrinsic factors in niche restriction opined that even in the absence of competitive interactions niche restriction takes place and added that intrinsic factors are largely responsible for niche restriction. According to him, selective site segregation is not due to competitive interaction but due to the presence of many empty niches which enhance noncompetitive mechanisms. He (Rohde, 1982) concluded that mating hypothesis can explain many cases of niche restriction at least partly; enhancement of the chances of contacting a mating partner may be an important biological function of niche restriction in parasites. However, it is to be noted that parasites often may have restricted microhabitats simply because in an environment composed of many topographically different sites, organisms have to be very specialized in order to survive (Price, 1980), and special adaptations to one site may exclude colonization of another site.

In the present study, it appears that site selection by parasites, and niche restriction are not due to any particular factor but due to combined action of several factors. Different parasitic species may opt different habitats by pure natural selection which is, to a certain extent, related to its mode of life. Certain species may be restricted to particular site in the host's digestive tract because the establishment of infection is dependent on the digestive physiology of the host's alimentary canal, and also because of the changed physiology of the host as a result of infection by another parasite species. Recent evidences, however, suggest that host genetics may also play an important role in the distribution of parasite populations (Wassom et al., 1986).

SEASONAL VARIATION IN THE PREVALENCE OF INFECTION :-

Six species of host fish collected from the nearshore waters of Cochin in 1978, 1979 and 1980 were regularly examined to study the prevalence of infection with digenetic trematodes. The fish species examined were *C.kalla*, *R.kanagurta*, *C.malabaricus*, *T.savala*, *M.cordyla* and *P.argenteus*. The twelve months of the year were divided into three seasons, Premonsoon (February-May), Monsoon (June-September), and Postmonsoon (October-January) as done by Qasim et al., (1969).

A total of 1052 fishes were examined to study the prevalence of infection with digenetic trematodes in different seasons. Of these, 435 fishes (41.35%) were infected. The prevalence of infection with trematodes in the six species of fish examined seasonwise for three years (1978-1980) is given in Table III. From the table it is clear that the prevalence of infection varied from season to season. In 1978, *R.kanagurta*, *C.malabaricus* and *M.cordyla* had the maximum prevalence of infection during the premonsoon season, *C.kalla* during the monsoon season and *T.savala* and *P.argenteus* during the postmonsoon seasons. In 1979, the maximum observed in *R.kanagurta*, *C.malabaricus* and *P.argenteus* was during the premonsoon, in *C.kalla* and *M.cordyla* during the monsoon and in *T.savala* during the postmonsoon seasons.

Table III

Seasonal variation in the prevalence of infection (in percentage) with digenetic trematodes in six species of host fish during the years 1978-1980

Host species	Year	Premonsoon season	Monsoon season	Postmonsoon season
C. kalla	1978	50.00	58.82^{+}	30.00^{-}
	1979	33.33	52.38^{+}	25.00^{-}
	1980	15.79^{-}	42.14^{+}	21.05
R. kanagurta	1978	53.17^{+}	46.34	38.10^{-}
	1979	47.37^{+}	15.79^{-}	42.11
	1980	73.33^{+}	60.00	52.94^{-}
C. malabaricus	1978	68.18^{+}	21.74^{-}	45.00
	1979	41.18^{+}	40.18	36.84^{-}
	1980	5.88^{-}	14.29	25.00^{+}
T. savala	1978	46.86^{-}	56.52	78.95^{+}
	1979	75.00	73.00^{-}	95.24^{+}
	1980	88.89^{+}	50.00^{-}	78.95
M. cordyla	1978	42.86+	14.29^{-}	16.67
	1979	25.00	47.00^{+}	0.00^{-}
	1980	37.50	9.52^{-}	40.00^{+}
P. argenteus	1978	16.67	11.76^{-}	55.00^{+}
	1979	71.43^{+}	0.00^{-}	10.53
	1980	53.33^{+}	6.67^{-}	51.33
Whole sample	1978	47.01^{+}	35.57^{-}	44.07
	1979	49.13^{+}	41.82	35.89^{-}
	1980	45.00^{+}	29.63^{-}	43.00

\+ Maximum prevalence

\- Minimum prevalence

In 1980, R.kanagurta, I.savala and P.argenteus showed the maximum prevalence of infection in the premonsoon, C.kalla in the monsoon, and C.malabaricus and M.cordyla in the postmonsoon seasons. When the samble was considered as whole, the maximum prevalence was found in the premonsoon season in all the three years. Since the study was conducted in six host species for three years, and each year divided into three seasons, based on the 18 data available regarding the prevalence of infection for each season, it could be concluded that the maximum prevalence of infection occurred nine times in the premonsoon season, five times in the postmonsoon season and four times in the monsoon season, and the minimum prevalence occurred nine times in the monsoon season, six times in the postmonsoon season but only three times in the premonsoon season. Interestingly, R.kanagurta and C.kalla always had the maximum prevalence of infection during premonsoon and monsoon seasons, respectively, and P.argenteus, the minimum prevalence during the monsoon season.

The level of infection of definitive hosts with intestinal helminths is the result of a balance between immigration (= input, recruit) and loss (= output, mortality) and fluctuations in either or both of these processes will result in the establishment of periodicity on the occurrence of such parasites (Kennedy, 1970;

Evans, 1978). Immigration will be influenced by factors like fluctuations in feeding intensity and feeding habits of the host (Chubb, 1964; Kennedy, 1968, 1970; Pennycuick, 1971a; Anderson, 1974; Evans, 1978; Muzzall, 1980), seasonal availability in large numbers or non-availability of infective larvae and intermediate hosts (Chubb, 1964; Kennedy, 1968, 1970; MacKenzie and Gibson, 1970; Pennycuick, 1971a; Evans, 1978; Madhavi, 1979; Muzzall, 1980; Overstreet, 1982), hosts' endocrine levels (Kennedy, 1968, 1969), hosts' breeding biology (Kennedy, 1970), overcrowding, and presence of other parasites in the same host species (Kennedy, 1970). Loss may be influenced by rejection of established parasites, and natural death of the parasites themselves (Kennedy, 1970). Immigration itself may be seasonal or non-seasonal. Among the abiotic factors, temperature (Walkey, 1967; Kennedy, 1969, 1971; Evans, 1978; Chubb, 1979), and salinity (Polyanski, 1961; Overstreet, 1968, 1982; Solenchenko, 1978) play dominant roles. Since biotic and abiotic factors are in a state of close interdependence, it is reflected in the seasonal variation in the prevalence of infection also.

A preliminary study revealed that larval trematode infection in the nearshore and offshore waters of Cochin is negligible. The hydrological conditions of the Vembanad Estuary, and their influence on the nearshore waters of Cochin are well documented. Available evidence, in the present study, indicates that seasonal variation in the prevalence of infection with digenetic trematodes in fishes of the nearshore and offshore waters of Cochin is due, a great extent, to the influence of salinity and temperature, a combination of both, and the subsequent effect on feeding. From the data, it can be seen that the maximum prevlance of infection in six host species occurred during the premonsoon season, and the minimum during the monsoon season. In the nearshore and offshore waters, the maximum surface and bottom temperature and salinity were recorded during the premonsoon season and the minimum during the monsoon seasons (Banse, 1959; Damodaran and Hridayanathan, 1966). After the commencement of the south-west monsoon season, there is a marked drop in salinity and temperature consequent on the influx of freshwater from the rivers through the estuary into the sea. These two factors, salinity and temperature, their decrease during the monsoon season, and slow rise during the postmonsoon season reaching the maximum during the premonsoon season, have considerably affected the prevalence of infection with digenetic trematodes in fishes during the three seasons, and it is inferred that marine digenetic trematodes, as a group, are susceptible to changes in salinity and temperature. That fishes lose their parasites of marine origin when they enter freshwater, was well documented, among others, by

Dogiel (1961), and Markov (1961). Similarly, low temperature was also found to be a limiting factor (Markov, 1961). But Overstreet (1968) observed decrease in intensity of parasites with increase in salinity and vice-versa.

One major factor associated with changes in salinity and temperature is the change in the feeding habits by fish. Keast (1968) found that white sucker in Canadian waters intensified their feeding as temperature goes up in spring. Anderson (1974) believed that changes in the bream's (Abramis brama) feeding habits accounted for the seasonal population changes of the cestode Caryophyllaeus laticeps. Muzzall (1980a) observed that increased host feeding may affect the seasonality of parasite infection because recruitment was found to be high in spring months when water temperature rises. In the present study, as indicated earlier, the maximum prevalence of infection in six fish host species occurred during the premonsoon period (nine times) when salinity and temperature increase. In general, the premonsoon period is considered to be a period when gonadial activity and also the feeding activity increase in fishes. So, obviously, there is a link between high salinity, high temperature and increased feeding activity and high prevalence of infection in the premonsoon season.

Yet another factor which may play some role is upwelling. With the onset of southwest monsoon, the process of welling starts in the west coast. The oxygen deficient cold surface water replaces the water of shelf area and this brings about a radical change in the environment.

HOST SPECIFICITY :-

One of the most interesting questions in parasitology is that of host-specificity, i.e. the adaptation and restriction of parasites to one particular taxon of hosts (Arai, 1967; Rohde, 1982). Becker (1933) regarded host specificity as 'the particular adaptation of one species (the parasite in the broad sense) to the milieu within or another species (host or hosts)', and by specificity of parasites he meant its quality of distinctiveness from all others. The degree of dependence of the parasite on the host is directly proportional to the degree of loss of the physiological independence of the parasite. Parasites, like their hosts, have been subjected to evolutionary process and during specialization many of them have lost their ability to adapt themselves to any but the accustomed host or closely related ones. Sandground (1929) opines that the development of strict host specificity is the inevitable consequence of parasitism and 'with increasing adaptation to one species of host, the potentiality of thriving in a multiplicity of divergent hosts is reduced. The final consummation of this process is attained when the parasite has become so delicately adjusted that it can live only in a single species of host'. As Cameron (1956) puts it 'host specificity' appears to be a function of evolutionary age and specialization and that the more host specific a parasite is, the more divergent it appears to be from its original phylogenetic stem.

diverge only within its host which itself may be more or less simultaneously diverging from its own original stem. Examination of these host specific parasites should accordingly be of value in tracing the relationship of the host and in supplementing the palaeontological evidence (Cameron, 1956).

The idea of host specificity as a simple unilateral adaptation belongs to the past. The majority of investigators (Dubinin,1950; Dubinina, 1953; Shulman, 1950 & 1954; Shultz and Davtyan, 1954; Gusev, 1955; Polyanski, 1955; Bykhovski, 1957) are inclined to regard host specificity as an association involving both the parasite and the host or a group of hosts. Though host specificity is one of the fundamental characteristics of parasitization, it is seldom absolute, but to a variable degree relative. It is progressive and with the mutual development and evolution of the host and parasite, becomes more and more strict.

Specificity, as with all adaptations to a definite mode of life, does not appear suddenly, but is formed over a long time, during which accumulation and stabilisation of adaptive characters elaborated by the parasite take place. Specificity is again a genetically fixed manifestation of a definite stage of specialisation in the evolution of the parasite. This is particularly well illustrated by the existence of specificity not only to species or taxonomic groups of hosts but to a heterogeneous but historically united faunistic complex. Schad (1963) is of the opinion that a long association between the parasite and the host will often result in the evolution of a series of very similar species in essentially the same or closely similar habitats.

It is difficult to see specificity in its true light particularly because, in nature, it is frequently manifested as a close adaptation of parasite to host. When such adaptation was sufficiently close to prevent the parasite from associating with any other host species, many authors regarded it as an absolute and unchangeable condition. When no such close adaptation existed it was considered as the absence of specificity. In many cases, however, our knowledge of the host range of parasites is insufficient, and parasites originally thought to exhibit a strict host specificity are later found to be less specific. Interestingly, in many cases, even parasites found on or in many host species usually infect one or a few species more heavily than others.

Broadly speaking the parasites having a direct life cycle (monogenea) are much more host-specific than those with indirect life-cycle (digenea) (Baylis, 1924; Rohde, 1982). But worms which have an indirect life cycle, show more rigid specificity to their intermediate hosts rather than to their final hosts, and this is obvious in the life cycle of digenetic trematodes. The host specificity among digenetic trematodes is of ecological or physiological nature or a combination of both. Parasites which infect a single host taxon or related taxa, are said to exhibit a phylogenetic host specificity. Even parasites with a wide host range always show certain host preferences but these preferences are usually determined by the ecological requirements of the host, and such parasites are said to exhibit ecological host specificity. Groups consisting of members with strict phylogenetic host specificity may also contain some species which have secondarily widened their host range, and have acquired an ecological host specificity (Rohde, 1982). The basis for ecological host specificity need not always be spatial, i.e; the accessibility of the infective form of the parasite to the host. It could have food selection as a basis (Cheng, 1986).

Manter (1965) opined that parasites of fishes, particularly such an abundant and diversified group as the Trematoda, furnish information about present day habits and ecology of their individual hosts. These same parasites also hold promise of telling something about host and geographical connections of long ago. They are simultaneously the product of an immediate environment, and of a long ancestry reflecting associations of millions of years. The message they carry are thus always bilingual and usually garbled.

Eichler (1948), partly on the basis of earlier observations of certain regularities in the distribution of parasites in various hosts, made several conclusions governing evolution of parasites with respect to their hosts. These conclusions led to the formulation of several rules (See Inglis, 1971); they are Fahrenholz's Rule, Szidat's Rule, Manter's Rules, and Eichler's Rule. The first rule states that the classification of some groups of parasites parallels that of their hosts, i.e; the evolution of host and parasites must have been parallel. The second rule states that "primitive" hosts are parasitized by "primitive" parasites, and specialized hosts by specialized parasites, the third rule states that parasites evolve more slowly than their hosts, the longer the association with the host group, the more pronounced the specificity exhibited by the parasites, and a host species harbours the largest number of parasite species in the area where it has resided the longest, and the fourth rule states that large host groups have more genera of parasites than small groups. These rules, however, are not equally valid for all groups of parasites.

Generally, the lower the host specificity, and particularly the phylogenetic specificity, the smaller the applicability of the rules (Rohde, 1982). Obviously, non-specific parasites infect hosts irrespective of their phylogenetic status.

The almost close correspondence of host and parasite evolution (Fahrenholz' rule) permits the use of parasites in the study of host phylogeny (Eichler, 1948). The seemingly "retarded" evolution of parasites, due to the fact that the simpler structure of parasites often prevents evolutionary changes as great as those of their hosts, may result in greater similarity of related parasites than of equally related hosts, and thus facilitate tracing of host phylogeny.

The application of knowledge of host specificity also finds its use to trace the place of origin and dispersal of hosts, and to trace the ancient land connections between land masses (Metcalf, 1929). This method was first employed by von Ihering (1891, 1902), and is often referred to as the "von Ihering method". One assumption on which this method is based is that groups of animals usually have a greater diversity in areas where they have been for a long time, normally where they have originated. With regard to parasites, the reasoning is that hosts are likely to have acquired the greatest variety of parasites in the region where they have lived the longest, and that parasites in such regions had, in turn, much time to become more and more specialized and host specific. If a host moves into a new area, it will lose many of its parasites, especially those with indirect life cycles (Manter, 1967). The'von Ihering method' was also employed by Baer (1947), Dougherty (1949), Manter (1955, 1967), and Gambino and Heyneman (1960) to solve many of the phylogenetic and zoogeography questions.

Contributions on host-specificity of fish digenetic trematodes are rather meagre. However, Manter (1957, 1965) has made comprehensive studies on host-specificity in digenetic trematodes of marine fishes. The trematodes exhibit host specificity in varying degrees. While monogenetic trematodes are highly host specific, in digenetic trematodes, it is pronounced in larval stages (Srivastava and Chauhan, 1976). However, the fact that some genera of digenetic trematodes have not been recorded inhabiting the same ecological niche as others harbouring these parasites suggests incipient host specificity in adult digenetic trematodes also. To account for frequency and intensity of infection in various hosts in addition to the host range, Rohde (1980) developed host specificity indices. One such index uses the number of parasite individuals found in each host species (the "parasite density"). A different index of host specificity was proposed by Price (1980) which he defined as "per cent specificity", the percentage of species in a family that utilizes only one host.

In the present study, a strict host specificity was noticed in the majority of trematodes. Thus, twenty four species of digenetic trematodes were strictly host specific, seven species of digenetic trematodes had two hosts each, and one species had three host species. At the same time, eight out of thirty host species harboured more than one species of digenetic trematodes (Tables IV and V).

The fact that twenty four species of digenetic trematodes were strictly host specific, and that twenty two out of thirty host species harboured only one species of digenetic trematode each, clearly indicates the significance of host specificity. The parasites, in question, seem to be quite adjusted to the conditions within the host and the specificity is remarkably and strongly expressed in the present context. In the hosts where more than one parasite species were recorded, it is a different story. It is believed that the predatory fises, because of their mode of life, harbour other than its specific parasites (Shulman, 1954). In the present study, all the eight host species which harboured more than one species of digenetic trematodes each were either predators or their food consisted of a variety of marine invertebrates and plankton.

The degree of specificity of a parasite may differ at various stages of its developmental cycle.

Table IV

List of trematode species, Family, Host species, Incidence of infection and the Number of digenetic trematodes recovered

Digenetic Trematode species	Family	Host species	Incidence	No. of digenetic trematodes recovered
1. *Mesocoelium cynoglossi* sp. nov.	Brachycoeliidae	*Cynoglossus* sp.	1/8	1
2. *Lepocreadioides indicum*	Lepocreadiidae	*Cynoglossus* sp. *Narcine* sp.	1/8 1/1	5 2
3. *Crassicutis karwarensis*	Homalometridae	*Gerres filamentosus*	10/13	21
4. *Podocotyloides parupenei*	Opecoelidae	*Therapon jarbua*	10/35	12
5. *Coitocaecum glossogobii* sp. nov.	,,	*Glossogobius giuris*	5/16	16
6. *Pseudopecoelina elongata*	,,	*Lutjanus johni*	7/16	9
7. *Tormopsolus rastrelligeri* sp.nov.	Acanthocolpidae	*Rastrelliger kanagurta*	1/195	1
8. *Acanthocolpus liodorus*	,,	*Chirocentrus dorab*	3/7	7
9. *Stephomostomum orientalis*	,,	*Sciaena* sp. *Platycephalus* sp.	8/168 1/21	14 3
10. Monascus typicus	Monascidae	*Megalaspis cordyla* *Caranx kalla* *Decapterus russelli*	23/174 23/174 3/30	62 32 10
11. *Pseudopentagramma nemipteri* sp. nov.	Fellodistomidae	*Nemipterus japonicus*	8/37	11
12. *Odontocotyle arabi*	,,	*Drepane punctata*	3/4	32
13. *Lecithocladium excisum*	Hemiuridae	*Rastrelliger kanagurta* *Pampus argenteus*	83/195 45/145	179 117
14. *Lecithocladium harpodontis*	,,	*Parastromateus niger*	6/152	12
15. *Lecithocladium aegyptensis*	,,	*Rastrelliger kanagurta*	2/195	2
16. *Elytrophalloides rastrelligeri* sp.nov.	,,	*Rastrelliger kanagurta*	1/195	1
17. *Lecithochirium polynemi*	,,	*Trichiurus savala* *Tachysurus* sp.	61/189 1/11	216 2
18. *Lecithochirium acutum*		*Trichiurus savala* *Platycephalus* sp.	73/189 1/21	316 1
19. *Ectenurus lepidus*	,,	*Caranx kalla*	40/174	89
20. *Ectenurus rastrelligeri* sp. nov.	,,	*Rastrelliger kanagurta*	2/195	5
21. *Indostomachicola thynni* sp. nov.	,,	*Thynnus* sp.	3/7	24
22. *Tubulovesicula magnacetabulum*	,,	*Megalaspis cordyla*	20/174	51
23. *Daniella rastrelligeri* sp. nov.	,,	*Rastrelliger kanagurta*	2/195	4
24. *Bucephalus varicus*	Bucephalidae	*Caranx malabaricus* *Thynnus* sp.	20/176 3/7	22 18
25. *Alcicornis multidactylus*	,,	*Caranx malabaricus* *Sphyraena* sp.	22/176 6/79	23 9
26. *Alcicornis thapari*	,,	*Seriola* sp.	1/2	44
27. *Rhipidocotyle karthai*	,,	*Psettodus erumei*	2/20	4
28. *Bucephalopsis longicirrus*	,,	*Caranx malabaricus*	17/176	31
29. *Prosorhynchus tsengi*	,,	*Scomberomorus* sp.	2/12	2
30. *Prosorhynchus manteri*	,,	*Lactarius lactarius*	2/24	6
31. *Neoprosorhynchus purius*	,,	*Platycephalus* sp.	5/21	8
32. *Neoprosorhynchus leiognathi* sp. nov.	,,	*Leiognathus* sp.	5/51	8
33. Not identified		*Chorinemus* sp.	3/18	5
34. Not identified		*Triacanthus* sp.	2/7	2
35. Not identified		*Ambassis*	2/6	2

Table V

List of Host species, Digenetic trematodes species, Incidence of Infection and the Number of digenetic trematodes recovered

Host species	Digenetic trematode species	Incidence	No. of digenetic trematodes recovered
1. *Caranx malabaricus*	1. *Alcicornis multidactylus*	22/176	23
	2. *Bucephalopsis longicirrus*	17/176	31
	3. *Bucephalus varicus*	20/176	22
2. *Caranx kalla*	1. *Ectenurus lepidus*	40/174	89
	2. *Monascus typicus*	23/174	32
3. *Megalaspis cordyla*	1. *Tubulovesicula magnacetabulum*	20/174	51
	2. *Monascus typicus*	23/174	62
4. *Sciaena* sp.	*Stephanostomum orientalis*	8/168	14
5. *Rastrelliger kanagurta*	1. *Ectenurus rastrelligeri* sp. nov.	2/195	5
	2. *Lecithocladium excisum*	83/195	179
	3. *L. aegyptensis*	2/195	2
	4. *Elytrophalloides rastrelligeri* sp. nov.	1/195	1
	5. *Daniella rastrelligeri* sp. nov.	2/195	4
	6. *Tormopsolus rastrelligeri* sp. nov.	1/195	1
6. *Trichiurus savala*	1. *Lecithochirium polynemi*	61/189	216
	2. *L. acutum*	73/189	316
7. *Parastromateus niger*	1. *Lecithocladium harpodontis*	6/152	12
8. *Pampus argenteus*	1. *L. excisum*	45/145	117
9. *Sphyraena* sp.	1. *Alcicornis multidactylus*	6/79	9
10. *Leiognathus* sp.	1. *Neoprosorhynchus leiognathi* sp.nov.	5/51	8
11. *Nemipterus japonicus*	*Pseudopentagramma nemipteri* sp. nov.	8/37	11
12. *Therapon jarbua*	*Podocotyloides parupenei*	10/35	12

Table V

List of Host species, Digenetic trematodes species, Incidence of Infection and the Number of digenetic trematodes recovered

Host species	Digenetic trematode species	Incidence	No. of digenetic trematodes recovered
13. *Decapterus russelli*	*Monascus typicus*	3/30	10
14. *Lactarius lactarius*	*Prosorhynchus manteri*	2/24	6
15. *Platycephalus* sp.	1. *Neoprosorhynchus purius*	5/21	8
	2. *Lecithochirium acutum*	1/21	1
	3. *Stephanostomum orientalis*	1/21	3
16. *Psettodus erumei*	*Rhipidocotyle karthai*	2/20	4
17. *Chorinemus* sp.	Not identified	3/18	5
18. *Glossogobius giuris*	*Coitocaecum glossogobii* sp. nov.	5/16	16
19. *Lutjanus johni*	*Pseudopecoelina elongata*	7/16	9
20. *Gerres filamentosus*	*Crassicutis karwarensis*	10/13	21
21. *Scomberomorus* sp.	*Prosorhynchus tsengi*	2/12	2
22. *Tachysurus*	*Lecithochirium polynemi*	1/11	2
23. *Cynoglossus* sp.	1. *Mesocoelium cynoglossi* sp. nov.	1/8	1
	2. *Lepocreadioides indicum*	1/8	5
24. *Chirocentrus dorab*	*Acanthocolpus liodorus*	3/7	7
25. *Thynnus* sp.	1. *Indostomachicola thynni* sp. nov.	3/7	24
	2. *Bucephalus varicus*	3/7	18
26. *Triacanthus* sp.	Not identified	2/7	2
27. *Ambassis* sp.	Not identified	2/6	2
28. *Drepane punctata*	*Odontocotyle arabi*	3/4	32
29. *Seriola* sp.	*Alcicornis thapari*	1/2	44
30. *Narcine* sp.	*Lepocreadioides indicum*	1/1	2

Shulman (1961) is of opinion that, at the stage of metacercaria, during which relatively little or no development takes place, digenetic trematodes as a rule are loosely specific and have a wide range of hosts. The number of the first intermediate hosts, in which the miracidia metamorphose into sporocysts and development of the redia and cercaria takes place, is considerably smaller. Also, smaller is the number of final hosts, within the gut of which the gonads of the parasite develop and the processes of mating and fertilization of eggs take place.

Bykhovski (1957) believing that the presence of a parasite in a host cannot always be attributed to specificity alone, introduced the concept of 'occurrence' as distinct from 'specificity'. His definition of occurrence lays stress on its great difference from specificity. Occurrence can be viewed as a static phenomenon, the final result of the interrelationship of the parasites' specificity with various environmental factors. Specificity, on the other hand must be viewed as an essentially dynamic phenomenon, the function of which is only to endow the parasite with a broad propensity to infest a particular host. The range of occurrence in nature might, on occations, be narrower than the range of potential specificity. Dogiel (1948) stated that the formation of the intestinal parasites is a result of action of two forces namely phylogenetic (relationship between the host species) and ecological (similarity of diet, etc.).

One of the basic factors indispensable for the development of specificity is the close contact between the parasite and its host. Another important factor is the physiology and the morphology of the parasite. Knorre (1937) opines that since specificity might be regarded as a form of reaction of the body to the environment - in this case to the condition of life within the host - this is also dependent on the degree of stability of the parasite and or on the degree of its morphological and physiological adaptation to a particular host. The higher degree of morphological adaptation of the parasite, the more restricted is its range of specificity. These morphological adaptation or factors are well marked in cestodes (Williams 1961, 1966) and monogenetic trematodes (Rohde, 1982). The same, if not more important, role is played by physiological adaptation. In addition to the necessity of being adapted to the living conditions within a particular host, the parasite might develop, as a result of immunological reactions of the host, what might be termed 'responsive adaptation'. Since the main response of the parasite is the neutralization of the protective substances of the host, a high degree of specialization in this direction will make it impossible or difficult for it to exist in a different host, with a different set of defensive reactions. Another factor leading to host specificity in many cases is differential mortality, after infection (Rohde, 1982). Non-specific infection followed by differential mortality in the wrong hosts is also probable for certain trematodes (James, 1971). Although concrete evidences are lacking the hosts' internal defense mechanisms, including immunity, are known to play an important role in governing host specificity. The manifestation of a minimal amount of host response in the form of cellular response and/or production of antibodies is an important mechanism governing host specificity (Cheng, 1986).

Another factor strongly favouring specificity is the stability of the environment and diet of parasites. Parasites infesting the gut are usually less strictly specific than the mature parasites of other organs (Shulman, 1961). They are rarely confined to one host species. Their specificity is fairly unstable, enabling them under the influence of various factors especially the feeding habits of the host, to infest other species relatively easily. This instability is due to the variability of the chemical conditions of the gut content, which constitutes the environment and provides the source of food for the parasite. The specificity of the parasites of the liver and gall bladder is stricter than the gut parasites (Shulman 1961). Considerably more rigidly specific are the parasites of blood, kidney and urinary bladder. According to Shulman (1961), irrespective of their taxonomic position most of the parasites of these organs are fairly strictly specific. The majority of the trematode genus Phyllodistomum, infesting urinary bladder and ducts, are typically specific to their particular species or families of fishes.

In Bykhovski's (1957) opinion the parasites which penetrate their hosts actively are more strictly specific than those which enter their hosts passively. This relationship between specificity and mode of infestation is probably related to the fact that for the parasites passively entering the host the specialization to a very restricted number of hosts cannot always be advantageous. In the absence of active search, the chances of such parasites finding a suitable host are considerably smaller.

Although the genetic basis of host specificity is far from completely understood, the geographically linked specificity exhibited by Schistosoma spp. has a genetic basis (Cheng, 1986).

As our knowledge of host specificity increases, it is now generally agreed that the number of currently recognized species will be reduced because species reported from different hosts and established on that basis may be found to be infective to additional hosts and thus shown to be identical. Also, morphologic differences that presently constitute the criteria for the definition of new species have been proved in some instances, to be the result of the influence of particular host and hence merely intraspecific variations.

ZOOGEOGRAPHY OF DIGENETIC TREMATODES :-

The geographical distribution of parasites is influenced by the same general rules which affect the distribution of free-living animals, but it is complicated by the requirements of suitable hosts being present in sufficient numbers, as well as the need for favourable external conditions. For various reasons, a host may or may not harbour the same parasites in different parts of its range. These reasons may be due to existing ecological conditions or may be partly based on conditions of the ancient past. Consequently, a detailed and complete understanding of the present distribution of certain parasites may reveal information of the immediate and the distant past of both the hosts and the parasites (Manter, 1967).

Parasites, including those of fish, have so far been almost left out of the studies devoted to marine zoogeography. This, to some extent, is due to the scanty knowledge of the parasites of marine fishes as well, which in many seas have not been studied at all to any significant extent. Even in investigations specificially devoted to parasites of fishes, no broad zoogeographical appraisal has been made, although some authors have produced isolated papers of zoogeographical character. But in recent years its importance seems to have been realized, and papers on this aspect are piling up from many parts of the world (Polyanski, 1961a).

Von Ihering (1891) was the first to recognize the significance of parasites in zoogeography. In 1902 while studying the parasites of mammals he stated: "the worms prove a valuable aid in the analytical study of zoogeography and paleogeography". In the last few decades, studies on the zoogeographical aspects of fish parasites are also coming up. A number of publications which have appeared in recent years, however, allow an attempt at reviewing them from the zoogeographical point of view (Shulman, 1949; Shulman and Shulman-Albova, 1953; Polyanski, 1955; Zhukov, 1953, and Strelkov, 1956). Importance of such reviews can be justified since the parasitological data can give considerable help in solving several zoogeographical problems (Manter, 1963; Rohde, 1982).

Digenetic trematodes of marine fishes, although still incompletely known, tend to show consistent patterns of global distribution (Manter, 1963). The publications of Manter (1955, 1963, 1965, 1967), who studied the zoogeography of trematodes of various seas, are of considerable interest. He dealt with the fish trematodes of the Atlantic coast of Europe, Mediterranean, the Red sea, the Atlantic coast of USA, the coast of Florida, the coastal waters of New Zealand, Australia, Ceylon and Bay of Bengal. The author has pointed out the existence of considerable differences in the composition of the fauna of the fish trematodes in various areas, differences which allow one to speak of definite zoogeographical distinctions existing in this large group of endohelminths. Szidat (1961), Lebedev (1969), and Fischthal (1972, 1977, 1980) are the other workers who have studied in great detail the zoogeographical aspects of marine fishes of the world oceans. Margolis (1963, 1965, 1982) has indicated the importance of parasites as indicators of geographical origin and biology.

In the present study thirty-two species of digenetic trematodes were recorded from thirty host species. Of these, nine species, namely, *Mesocoelium cynoglossi*, *Coitocaecum glossogobii*, *Tormopsolus rastrelligeri*, *Pseudopentagramma nemipteri*, *Elytrophalloides rastrelligeri*, *Ectenurus rastrelligiri*, *Indostomachicola thynni*, *Daniella rastrelligeri*, and *Neoprosorhynchus leiognathus* are treated as new. Of the remaining twenty-three species twelve species, namely, *Lepocreadioides indicum*, *Crassicutis karwarensis*, *Pseudopecoelina elongata*, *Stephanostomum orientalis*, *Odontocotyle arabi*, *Lecithocladium harpodontis*, *Lecithochirium acutum*, *Alcicornis multidactylus*, *Alcicornis thapari*, *Rhipidocotyle karthai*, *Prosorhynchus manteri* and *Neoprosorhynchus purius* are recorded from Indian waters (including Pakistan), and the remaining eleven species are recorded from other waters as well. Thus, *Podocotyloides parupenei* was recorded from Fiji (Manter, 1963), *Acanthocolpus liodorus* from North Vietnam Bay (Mamaev and Oshmarin, 1966), *Monascus typicus* from Mediterranean, Adriatic, Black and Red Seas (Fischthal, 1972), *Lecithocladium excisum* from Mediterranean, Adriatic, Black Sea, Atlantic, Baltic, Pacific, Sea of Japan, Putiatin Island, North Sea, Wood Hole, Gulf of Mexico, South China Sea, New Zealand, and Australia (Fischthal, 1972, 1980), *Lecithocladium aegyptensis* from Red Sea, Australia, New Caledonia and Mediterranean (Fischthal, 1980), *Lecithochirium polynemi* from New Caledonia, (Yamaguti, 1971), *Ectenurus lepidus* from Mediterranean, Tyrrhenian, Adriatic, Aegean and Black Seas, Ghana, Nigeria, Puerto Rico, Brazil, Southwest Africa, Scotland, Hawaii, New Zealand, Gulf of Aden, Arabian Sea and Israel (Fischthal, 1980), *Tubulovesicula magnacetabulum* from Inland Sea of Japan, (Yamaguti, 1939, 1971), *Bucephalus varicus* from Red Sea, Baja California, Mexican and Panama Pacific, Philippines, South China Sea, Fiji, Okinawa, Indian Ocean, Arabian Sea, Southwest Africa, Gulf of Mexico, Florida, Atlantic, Bimini, Jamaica, Curacao, Belize, and Israel (Fischthal, 1980), *Bucephalopsis longicirrus* from the Red Sea (Nagaty, 1937), and *Prosorhynchus tsengi* from China Sea, Toyama Bay of Japan and Arabian Sea (Hafeezullah et Siddiqi, 1970; Yamaguti, 1971).

It is interesting to note that the genera

Stephanostomum, Prosorhynchus, Rhipidocotyle, Monascus, Ectenurus, Lecithocladium, Lecithochirium and Tubulovesicula have world-wide distribution.

It is seen that majority of the trematode fauna of this region differs from the fauna of other regions. Of the thirty-two species, only eleven are recorded from other waters. Manter (1965) has indicated that although some genera and few species of digenetic trematodes are almost world-wide in one host or another, most genera and species found in shore fishes are more or less restricted in distribution. Further, the trematode fauna of fishes may differ markedly north to south along a coast, or shallow to deep water in warm seas. Evaluation of many surveys shows that many species of Indo-Pacific differs from those from the Atlantic (Rohde, 1982). It was also observed that endemicity of species is much greater than that of the genera. Although, temperature is considered to be a factor for differences in species diversity and composition of parasites, the differences in species diversity between Pacific and Atlantic have been attributed to the older age of the Pacific Ocean. According to the generally accepted Theory of Continental Drift, the Pacific was in existence for much of the geological time, whereas the Atlantic began to form only approximately one hundred and fifty million years ago when the continent began to drift apart, and obviously there was more time for the species to originate and accumulate in the Pacific. Evolution in the two oceans has been largely separate and this is supported by facts. There has been a considerable exchange of parasitic species between cold Northern Pacific and Atlantic during the warm interglacials, and there was also some exchange between tropical Eastern Pacific and Western Atlantic across a narrow trans-oceanic connection which was closed several million years ago, and between the Indian ocean and Eastern Atlantic via the Tethys Sea, existing until the Tertiary (Ekman, 1953). According to him (Ekman, 1953), the West African tropical marine Fauna, in general, is poorer than any other tropical coastal fauna. Fischthal (1972), has indicated that, of the one hundred and seven species of trematodes found in West African marine fishes, hundred were allocated to sixty-four genera (seven immature), many of these genera are located in most of the world's Seas with the exception of the polar Seas. He has indicated that historical and present day events concern physical and biological environmental factors and their effects on the actual and potential hosts as well as on life-cycle stages of the trematodes have resulted in the geographical distribution.

Briggs (1967) summarized the information concerning tropical marine fishes and invertebrates as follows: "There is no doubt that the Indo-West Pacific Region has served as the evolutionary and distributional centre for the entire marine tropics. Its fauna is almost unbelievably rich with, for example, more than 3,000 species of shore fishes. It seems clear that the unusually stable ecosystems and high level of competition provide the proper environment for the evolution of dominant species that can successfully invade the other regions. From the Indo-West Pacific, dominant species migrate eastward across the open ocean to America, westward around the Cape of Good Hope into the Atlantic, and northward through the Suez Canal into the Mediterranean. Successful reciprocal migrations are, at least, very rare and may be completely lacking. Furthermore, judging from the general indications of relationship among the four great tropical faunas, this process has been going on for many millions of years. Some of the dominant species are so successful that they have been able to establish and maintain circumtropical distributions (indicating more or less regular migrations across the East Pacific, Old World land, and the mid-Atlantic barriers). The Western Atlantic tropics may be considered a secondary centre of evolutionary radiation. Many species produced in this area have proved capable of migrating eastward to colonize the Eastern Atlantic region. However, species originating in the Eastern Atlantic are apparently incapable of successfully invading the Western side. Again, the advantage seems to lie with the area that possesses the richer fauna and higher level of competition."

Regarding the zoogeographical distribution of trematodes of marine fishes, Manter (1963) reported that about 40% of the species of trematodes of the Canadian Pacific occur in the North Atlantic and about 20% of the species of the trematodes of the Caribbean occur along the Pacific coast of tropical America. Manter (1967) observed great differences in endemicity of marine fishes by digenetic trematodes in oceanic islands in different oceans, and the trematode fauna of marine fishes of tropical (northern) Australia was found to show great affinities with the digenetic trematodes of New Caledonia, Japan, Red Sea and the Caribbean. Digenetic trematodes of marine fishes from the barrier reef and reef lagoon of Belize (Central America) were found to show strong zoogeographical affinities with the fauna of the tropical western Atlantic, although some were found to occur in the eastern Atlantic, Mediterranean and Indo-Pacific regions (Fischthal, 1977). In another study on digenetic trematodes of marine fishes from Israel's Mediterranean coast, Fischthal (1980) has observed that the zoogeographical affinities of these trematodes are strong with other parts of the Mediterranean and adjacent Seas as well as with the European and African Atlantic, although some were also found to occur in many other regions.

The reasons for the meagre level of similarities existing between the digenetic trematode fauna of marine fishes of Indian waters and of elsewhere is difficult to explain. But as indicated by Manter (1965), the fauna of fishes differs markedly from waters to waters for various reasons and factors due to existing ecological conditions, and also due to the conditions of the ancient past. It is interesting to note that even in small localities separated by a few miles, endemic forms are seen. Siddiqi and Cable (1960) found that the trematodes of fishes of Mona Island, only 45 miles from Puerto Rico but separated by a channel, included a large percentage of species different from those of the Puerto Rico proper. Thus, of 24 species from Mona Island, only six were collected from Puerto Rico. To cite another example is the work of Manter (1967). New Caledonia is an oceanic Island 600 miles east of northern Australia and another 600 miles to the east lie the islands of Fiji. Interestingly, only four of the thirty-five species of digenea known from Fiji occurred in New Caledonia, and only four of them in Australia, and of some thirty-three species from New Caledonia, one-third occurred also in Australia. Obviously, New Caledonian trematodes exhibit more affinities towards Australian fauna.

Several factors are being attributed for the zoogeographical distribution of trematodes, the most important being temperature. Temperature affects parasitefauna in two ways. Firstly, species numbers are greatly increased in warm seas. That the temperature is the decisive factor responsible for differences in species numbers is indicated by (1) the observations that habitats at different latitudes which do not differ significantly in any other parameters beside temperature neverthless differ in species numbers, (2) by a critical look at some surveys, (3) by the distribution of some cosmopolitan species, and (4) by the comparison of shallow and deep water parasites (Rohde, 1982). Rohde (1978) has postulated that higher temperatures accelerate the speed of evolution, probably by shortening the generation times and increasing speed of selection. Greater evolutionary speed has led to the accumulation of more species in the tropical seas and warm surface waters.

Other factors responsible for the distribution of parasites are ocean currents and depths (Manter, 1967), and age of the oceans (Rohde, 1982). In the west coast of India, where the present study was conducted, a true tropical charactor in the temperature is always evident. The ocean current is peculiar, flowing towards south for half of the year, and reversing itself in the remaining period (Ramamirtham and Jayaraman, 1960; Varadachari and Sharma, 1967; Sharma et al., 1982). Associated with this is the phenomenon of upwelling and sinking along the coast (Sastry and D'Souza, 1972).

In general, there is richer parasite fauna in the Indo-Pacific than in the Atlantic, a largely different composition of the parasitefauna in the two oceans, a greater endemicity of parasite taxa in the Indo-Pacific, gradients of increasing species diversity from cold to warm waters, and decreased diversity in the deep sea.

In conclusion, it can be said that "Parasites of fishes particularly such an abundant and diverse group as the Trematoda, furnish information about present-day habits and ecology of their individual hosts. These same parasites also hold promise of telling us something about host and geographical connections of long ago. They are simultaneously the product of an immediate environment and of a long ancestry reflecting associations of millions of years. The messages they carry are thus always bilingual and usually garbled. Today, we know only a few selected pieces of the code. As our knowledge grows, studies based on adequate collections, correctly classified and correlated with knowledge of the host and life cycles involved should lead to a deciphering of the messages now so obscure. Eventually, there may be enough pieces to form a meaningful language which could be called Parascript - the language of parasites which tells of themselves and their hosts both today and yesteryear" (Manter, 1965).

SUMMARY

Importance of the study of helminth parasites, especially that of digenetic trematodes of marine fishes, has been discussed. A detailed description of the study area - inshore and offshore waters of Cochin including the Cochin Backwater system - is given. The hydrological parameters, and their impact on the occurrence of trematode parasites in fishes are discussed at length.

Prevalence of infection in marine fishes with helminth parasites, and concurrent infections in different combinations have been discussed. Of the fifty species of fishes examined for digenetic trematodes, thirty species were infected. They are *Rastrelliger kanagurta*, *Trichiurus savala*, *Caranx malabaricus*, *Caranx kalla*, *Megalaspis cordyla*, *Sciaena* sp., *Parastromateus niger*, *Pampus argenteus*, *Sphyraena* sp., *Leiognathus* sp., *Nemipterus japonicus*, *Therapon jarbua*, *Decapterus russelli*, *Lactarius lactarius*, *Platycephalus* sp., *Psettodes erumei*, *Chorinemus* sp., *Glossogobius giuris*, *Lutjanus johni*, *Gerres filamentosus*, *Scomberomorus* sp., *Tachysurus* sp., *Cynoglossus* sp., *Chirocentrus dorab*, *Thynnus* sp., *Triacanthus* sp., *Ambassis* sp., *Drepane punctata*, *Seriola* sp., and *Narcine* sp. The remaining twenty species of fishes have been found to be free of infection with digenetic trematodes. They were *Scoliodon* sp., *Liza* sp., *Sardinella longiceps*, *Lutjanus* argentimaculatus, Thrissocles sp., Saurida sp., Opisthopterus tardoore, Pomadasys hasta, Anchoviella commersonii, Belone sp., Anodontostoma chacunda, Scatophagus argus, Dussumieria sp., Lutjanus russelli, Mene maculata, Etroplus suratensis, Lutjanus fulviflamma, Serranus sp., Exocoetus sp., and Epinephelus sp.

Of the 1934 fishes examined for digenetic trematodes, 540 were infected indicating a percentage of 27.92, and the remaining 1394 fishes were free of infection (72.08%). From a total of 1934 fishes, as many as 593 belonging to 27 species were examined for other helminths.also, namely, cestodes, nematodes, and acanthocephala. Among these 593 fishes, 396 individuals (66.78%) from 21 species (77.78%) were infected with helminth parasites. Of these, single infection with digenetic trematodes, cestodes, nematodes and acanthocephalans was found in 341 individuals and the remaining had multiple infections in different combinations. Taking into consideration of single and multiple infections in different combinations, trematodes were found in 15 host species, cestodes in 11, nematodes in 12, and acanthocephalans in 11 species.

In the present study, it was found that more young fishes were infected than old ones but the old fishes harboured more number of parasites. The various possible reasons for this have been discussed. Sex wise, more female fishes were found infected than males. Also, more carnivores and omnivores were infected than herbivores. This aspect has also been discussed in detail.

Seasonal variations in the prevalence of infection in six fish species were studied for three years. The twelve months of the year were devided into three seasons - Premonsoon, Monsoon, and Postmonsoon as done by Quasim et al. (1969). Mostly, the maximum prevalence of infection occurred during "premonsoon" season, and the minimum in the "monsoon" season. The link between and among high salinity, high temperature, and increased feeding activity is thought to be responsible for the high prevalence in the "premonsoon" season, and these aspects have been discussed in great detail.

A detailed study on host-specificity and zoogeographical relationships were also carried out. A strict host-specificity was noticed in 24 species of a total of 32 species of digenetic trematodes, and twenty-two out of thirty host species harboured only one species of digenetic trematodes each. Of the thirty-two species of digenetic trematodes collected in the present study, nine were treated as new. Of the remaining twenty-three species, twelve species, namely, Lepocreadioides indicum, Crassicutis karwarensis, Pseudopecoelina elongata, Stephanostomum orientalis, Odontocotyle arabi, Lecithocladium harpodontis, Lecithochirium acutum, Alcicornis *multidactylus*, *Alcicornis thapari*, *Rhipidocotyle karthai*, *Prosorhynchus manteri*, and *Neoprosorhynchus purius* were found only in the Indian waters (including Pakistan). Only eleven species of digenetic trematodes were found to have a wider zoogeographical distribution, indicating a high rate of endemism in this region. The various aspects related to host-specificity and zoogeographical distribution of digenetic trematodes in various seas have also been discussed in this chapter in support of the conclusions.

REFERENCES

Amin, O.M. 1974. Intestinal helminths of the white sucker, Catostomus commersoni (Lacepede), in SE Wisconsin. Proc. Helminth. Soc. Wash. 41 : 81-88.

Ananichev, A.V. 1959. Digestive enzymes of fish and seasonal changes in their activity. Biokhimiya. 24 : 952

Ananthakrishnan, R., B. Parthasarathy, and J.M. Pathan 1979. Meteorology of Kerala. In: Contributions to Marine Sciences. 60-125.

Anderson, R.M. 1974. Population dynamics of the cestode Caryophyllaeus laticeps (Pallas, 1781) in the bream Abramis brama L. J.Anim. Ecol. 43: 305-322.

Antony, A. 1979. Studies on the Foraminifera of the South West Coast of India. Ph.D. Thesis submitted to the University of Cochin(Unpublished).

Arai, H.P. 1967. Preliminary report on the parasites of certain marine fishes of British Columbia. J. Fish.Res. Board Canada. 26: 2319-2337.

Arthur, J.R., and H.P.Arai. 1980. Studies on the parasites of Pacific herring (Clupea harengus pallasi Valenciennes) : a preliminary evaluation of parasites as a geographical origin for spawning herring. Can.J.Zool. 58: 521-527.

Arthur, J.R., L.Margolis, D.J.Whitaker, and T.E.Mc Donald. 1982. A quantitative study of economically important parasites of walleye pollock (Theragra chalcogramma) from British Columbia waters and effects of postmortem handling on their abundance in the musculature. Can.J.Fish.Aqua. Sci.39: 710-726.

Baer, J.G. 1947. Les helminthes parasites des vertebres. Relations phylogeniques entre leur evolution et celle de leurs hotes. Consequences biologiques et medicales. Ann.Soc.Franche-Comte Univ. Besa on. 2 : 99-113.

Banse, K. 1959. On upwelling and bottom trawling off the southwest coast of India. J. Mar. Biol. Assoc. India. 1 : 33-49.

Banse, K. 1968. Hydrography of the Arabian Sea shelf of India and Pakistan and effects on demersal fishes. Deep-Sea Res. 15 : 45-79.

Barrington, E.J.W. 1942. Gastric digestion in the lower vertebrates. Biol. Rev. 17 : 1-27.

Baylis, H.A., 1924. Some consideration on the host distribution of parasitic nematodes. J. Linn. Soc. Zool. 36 : 13-23.

Becker, E.R. 1933. Host specificity and specificity of animal parasites. Amer. J. Trop. Med. 13 : 505-523.

Befus, A.D., and R.B. Oodesta, 1976. Intestine. In : "Ecological aspects of parasitology. (Ed. C.R.Kennedy) ; Amsterdam, Oxford : North Holland Pub. Co. 303-325.

Briggs, J.C., 1967. Relationship of the tropical shelf regions. Stud. Trop. Oceanogr. Miami. 5 : 569-578.

Brown, W.L., Jr., and E.O. Wilson, 1956. Character displacement. Syst. Zool. 5 : 49-64.

Burn, P.R. 1980. Density dependent regulation of a fish trematode population. J. Parasit. 66 : 173-174.

Bykhovski, B.E. 1957. Monogenoidea, their taxonomy and phylogeny. Publ: AN S.S.S.R., Leningr.

Cameron, T.W.M. 1956. Parasites and parasitism. The English language Book Society and Methuen & Co. Ltd., London.

Cheng, T.C. 1964. The biology of animal parasites. W.B. Saunders, Philadelphia.

* Not seen in original

Cheng, T.C. 1967. Marine molluscs as hosts for symbioses with a review of known parasites of commercially important species. Adv. Mar. Biol. 5 : 1-424.

Cheng, T.C. 1986. General Parasitology, Second Edition, Academic Press College Division, Orlando, Florida, U.S.A.

Chubb, J.C. 1964. Occurrence of Echinorhynchus clavula (Dujardin, 1845) nec Hamann, 1892 (Acanthocephala) in the fish of Llyn Tegid (Bala lake), Merionethshire. J. Parasit. 50 : 52-59.

Chubb, J.C. 1979. Seasonal occurrence of Helminths in freshwater fishes. Adv. Parasit. 17 : 141-313.

Collard, S.B. 1970. Some aspects of host-parasite relationships in Mesopelagic fishes. In : A symposium on Diseases of fishes and shellfishes. Special Publn. No. 5, American Fisheries Society, Washington, D.C.

Colwell, R.K., and E.R. Fuentes, 1975. Experimental studies of the Niche. Ann. Rev. Ecol. Syst. 6 : 281-310.

Connell, J.H. 1971. On the role of natural enemies in preventing competitive exclusion in some marine animals and in rain forest trees. In : Dynamics of Population. (Ed. P.J. den Boer and G.R. Gradwell). Centre for Agricultural Publ. Docum., Wageningen.

Cordier, D., A. Maurice, and J.R. Worbe. 1957. Influence du pH du milieu intestinal sur 1' absorption du glucose Chez les poecilothermes. C.r. Seanc. Soc. Biol. : 151:1200.

Coulson, J.C. 1971. Competition for breeding sites causing segregation and reduced young production in colonial animals. In : Dynamics of Populations. (Ed. P.J. den Boer and Gradwell). Centre for Agricultural Publ. Docum. Wageningen : 257-268.

Crompton, D.W.T. 1973. The sites occupied by some parasitic helminths in the alimentary tract of vertebrates. Biol. Rev. 48 : 27-83.

Crompton, D.W.T. 1976. Entry into the host and site selection. In : Ecological Aspects of Parasitology. (Ed. C.R. Kennedy); Amsterdam, Oxford : North Holland Pub. Co. 41-73.

Damodaran, R., and C. Hridayanathan, 1966. Studies on the mudbanks of the Kerala coast. Bull. Dept. Mar. Biol. Oceano. 2 : 61-68.

Darbyshire, M. 1967. The surface waters off the coast of Kerala, South-west India. Deep-Sea Res. 14 : 295-320.

Dougherty, E.C. 1949. The phylogeny of the nematode family Metastrongilidae Leiper, 1909 : a correlation of host and symbiote evolution. Parasitology. 39 : 222-234.

Day, F. 1958. The fishes of India. William Dowson and Sons Ltd., London.

*Dogiel, V.A. 1948. Achievements and prospects of parasitological studies in Leningrad University. Vestn. Leningrad St. Univ. 3 :

Dogiel, V.A. 1961. Ecology of the parasites of freshwater fishes. In : Parasitology of Fishes. (Ed. V.A. Dogiel, G.K. Petrushevski and Yu. I. Polyanski). Oliver and Boyd, Edinburgh and London. 1-47.

Dogiel, V.A. 1964. General Parasitology. Oliver and Boyd, Edinburgh and London.

*Dubinin, V.B. 1950 . On specificity of ticks and its relation to the evolution of their hosts. Adv. Med. Biol. Moscow. 29 : 3.

*Dubinina, M.N. 1953 . Specificity of ligulids at various stages of their life-cycle. Mag. Parasit. Moscow. 15:

*Not seen in original

Eapen, P.K., and K.K.P. Menon, 1973. Common marine and freshwater fishes of Kerala. Seafood Export J. *5* : 25-38.

Eichler, W. 1948. Some rules in ectoparasitism. Ann. Mag. Nat. Hist. *1* : 588-598.

Ekman, S. 1953. Zoogeography of the Sea. Sidgwick and Jackson, London.

Elkins, C.A., and K.C. Corkum, 1976. Growth dynamics and seasonal prevalence of *Crepidostomum isostomum* and *Phyllodistomum pearsei* in *Aphredoderus sayanus*. J. Wildlife Dis. *12* : 208-214.

Evans, N.A. 1977. The occurrence of *Sphaerostoma bramae* (Digenea : Allocreadiidae) in the roach from the Worcester-Birmingham Canal. J. Helminth. *51* : 189-196.

Evans, N.A. 1978. The occurrence and life history of *Asymphylodora kubanicum* (Platyhelminthes : Digenea : Monorchidae) in the Worcester-Birmingham Canal, with special reference to the feeding habits of the definitive host; *Rutilus rutilus*. J. Zool. Lond. 184 : 143-153.

Fischthal, J.H. 1972. Zoogeography of Digenetic Trematodes from West African Marine Fishes. Proc. Helminth. Soc. Wash. *39* : 192-203.

Fischthal, J.H. 1977. Some Digenetic Trematodes of Marine Fishes from the Barrier Reef and Reef Lagoon of Belize. Zool. Scripta. *6* : 81-88.

Fischthal, J.H. 1980. Some Digenetic Trematodes of Marine Fishes from Israel's Mediterranean Coast and their Zoogeography, especially those from Red Sea Immigrant Fishes. Zool. Scripta. *9* : 11-23.

Freeman, R.S. 1964. Flat worm problems in fish. Can. Fish. Cult. *32* : 11-18.

Gambino, J.J., and D. Heyneman, 1960. Specificity and speciation in the genus Cyrtosomum (Nematoda: Atractidae). Amer. Midland Naturalist. 63 : 365-382

Gause, G.F. 1934. The struggel for existence. Baltimore, Williams & Williams.

George, M.J. 1980. Status of Coastal Aquaculture in India. In : Present Status of Coastal Aquaculture in Countries boardering the Indian Ocean; Issued by the Marine Biological Association of India, Cochin. 28-53.

George, M.J., and K.N.Kartha, 1963. Surface salinity of Cochin backwater with reference to tide. J.Mar. Biol. Assoc. India. 14 : 568-577.

*Gorbunova, M.N. 1936. Changes in the parasite fauna of pike and roach with the age of the host. Ann. Leningr. Univ. 7 : 3.

Grabda, J. 1977. Studies on parasitisation and consumability of Alaska pollock, Theregra chalcogramma (Pall). Acta. Ichthyol. Piscat. 7 : 15-34.

*Gusev, A.V. 1955. Fish Monogenoidea of the Amur river system. Trav. Inst. Zool. Acad. Sci. USSR. 19.

Hafeezullah, M., and A.H.Siddiqi, 1970. Digenetic trematodes of marine fishes of India. Part 1. Bucephalidae and Cryptogonimidae. Indian J. Helminth. 22 : 1-22.

Halvörsen, O. 1976. Negatice interaction amongst parasites. In: Ecological aspects of Parasitology. (Ed.C.R.Kennedy). North Holland Publishing Company, Amsterdam. 99-114.

Hardin, G. 1960. The Competitive exclusion principle. Science. 131 : 1292-1297.

Hedgpeth, J.W. 1957. Marine biogeography. In: Treatise on Marine Ecology and Paleoecology. Vol.1 (Ed.J.W. Hedgpeth). Geol. Soc. America: 359-382.

*Not seen in original

Holmes, J.C. 1973. Site selection by parasitic helminth: Interspecific interactions, site segregation and their importance to the development of helminth communities. Can.J. Zool. 51 : 333-347.

Hridayanathan, C. 1981. Studies on the macrobenthos of mudbanks of Southwest Coast of India. Ph.D. Thesis submitted to the University of Cochin (Unpublished).

Hughes, S.E., and M.S.Alton, 1974. Trawl surveys of ground fish resources near Kodiak Island, Alaska, 1973. Natl. Oceanic Atmos. Adm.Natl. Mar. Fish. Serv. Northwest Fish. Cent. Proc. Rep. 37 pp.

*Ihering, H.von. 1891. On the ancient relations between New Zealand and South America. Trans. Proc. New Zealand Inst. 24 : 431-445.

*Ihering, H.von. 1902. Die Helminthen als Hilfsmittel der zoogeographischen Forchung. Zool. Anz. 26 : 242-251.

Inglis, W.G. 1971. Speciation in parasitic nematodes. Adv. Parasit. 9 : 185-223

James, B.L. 1971. Host selection and ecology of marine digenean larvae. In : Fourth European Marine Biology Symposium (Ed. D.J.Crisp). Cambridge : Univ. Press : 179-196.

James, B.L., and L.P.Srivastava, 1967. The occurrence of Podocotyle atomon (Rud., 1802)(Digenea), Bothriocephalus scorpii (Muller, 1776)(Cestoda), Contracaecum clavatum (Rud., 1809)(Nematoda), and Echinorhynchus gadi Zoega, in Muller, 1776 (Acanthocephala) in the five bearded rockling, Onos mustelus (L). J.Nat. Hist. 1 : 363-372.

Jos Anto, V. 1971. The bottom salinity characteristics and the factors that influence salt water penetration in the Vembanad Lake. Bull. Dept. Mar. Biol. Oceanogr. Univ. Cochin. 5 : 1-16.

*Not seen in original

Jos Anto, V. 1975. Bottom salinity charactoristics of Cochin Backwaters. In : Recent Researches in Esturine Biology. (Ed: R.Natrajan): Hindustan Pub. Corp. New Delhi : 233-243.

Kabata, Z. 1967. Whiting stocks and their gall-bladder parasites in British waters. Dept. Agric. Fish. Scotland. Mar. Res. 2 : 1-11.

Kagei, N. 1969. Life history of nemotodes of the genus Anisakis. Fish. Res. Board. Can. Transl. Ser. No.1324.

Keast, A. 1968. Feeding of some Great Lakes fishes at low temperatures. J. Fish. Res. Board Canada. 25 : 1199-1218.

Kennedy, C.R. 1968. Population biology of the cestode Caryophyllaeus laticeps (Pallas, 1781) in dace, Leucuscus leuciscus L. of the river Aron. J. Parasit. 54 : 538-543.

Kennedy, C.R. 1969. Seasonal incidence and development of the cestode Caryophyllaeus laticeps (Pallas) in the river Aron. Parasitology. 59 : 783-794.

Kennedy, C.R. 1970. The population biology of helminths of British freshwater fish. Symp. Br. Soc. Parasit. 8 : 145-159.

Kennedy, C.R. 1971. The effect of temperature upon the establishment and survival of the Cestode Caryophyllaeus laticeps in orfe, Leuciscus idus. Parasitology. 63 : 59-66.

Kennedy, C.R. 1977. The regulation of fish parasite populations. In : Regulation of Parasite populations (Ed.G.W.Esch) Academic Press, Inc. New York, London, San Francisco, pp. 63-109.

*Knorre, A.G. 1937. The distribution of parasites in their hosts and the problem of specificity. Ann. Leningrad Univ. 13, Ser. biol. 3 : 4.

Kunjukrishna Pillai, V., K.J.Joseph, and A.K.Kesavan Nair, 1975. The plankton production in the Vembanad Lake and adjacent waters in relation to the

*Not seen in original

environmental parameters. Bull. Dep. Mar. Sci. Univ. Cochin. *7* : 137-150.

Kurup, B.M., and C.T.Samuel. 1987. Ecology and fish distribution pattern of a tropical estuary. *In* : Abstracts - National Seminar on Esturine Management. No. EB. 13. 2pp.

Kurup, P.G. 1977. Studies on the physical aspects of the mudbanks along the Kerala coast with special reference to the Purakad mudbank. Bull. Dept. Mar. Sci. *8* : 1-72.

Lakshmanan, P.T., C.S.Shynamma, A.N.Balchand, P.G.Kurup, and P.N.K.Nambisan, 1982. Distribution and Seasonal variation of temperature and salinity in Cochin backwaters. Indian J. Mar. Sci. *11*: 170-172.

Lawrence, J.L. 1970. Effects of Season, host age, andd Sex on endohelminths of *Catostomus commersoni*. J.Parasit. *56* : 567-571.

Lebedev, B.I. 1969. Basic regularities in distribution of monogeneans and trematodes of marine fishes in the world oceans. Zool. Zh. *48* : 41-50.

Mac Kenzie, K., and D.J.Gibson, 1970. Ecological studies of some parasites of plaice *Pleuronectes platessa* L. and flounder *Platichthys flesus* (L). Symp. Br. Soc. Parasit. *8* : 1-42.

Mac Kenzie, K., and C.Johnston, 1976. Recruitment to the Minch herring population, as determined by the use of parasites as biological tags and a new parasitic charactor. Int. Counc. Explor. Sea C.M. 1976/H. *34* Pelagic Fish. Comm.

Madhavi, R. 1979. Observations on the occurrence of *Allocreadium fasciatusi* in *Aplocheilus melastigma*. J. Fish. Biol. *14* : 47-58.

Mamaev, I.L., and P.G.Oshmarin, 1966. Trematodes of the family Acanthocolpidae Luhe, 1901 in herrings of the family Acanthocolpidae Luhe, 1901 in herrings of the North-Vietnam Bay. Helminthologia. *7* : 155-164.

Manter, H.W.. 1955. The Zoogeography of trematodes of marine Fishes. Exptl. Parasitol. 4 : 62-86.

Manter, H.W. 1957 [illegible] specificity and other host relationships among the digenetic trematodes of marine fishes. First symp. Host specificity Among Par. Certebr. Neuchatel; Paul Attinger. 185-198.

Manter, H.W. 1963. The zoogeographical affinities of trematodes of South American freshwater fishes. Syst. Zool. 12 : 45-70.

Manter, H.W. 1965. Parasites of fishes as biological indicators of recent and ancient conditions. In : Host-Parasite Relationships. Proc. 26th Annual biology Colloquium. (Ed. James E.Mc Cauley). 59-71.

Manter, H.W. 1967. Some aspects of the geographical distribution of parasites. J.Parasit. 53 : 1-9.

Margolis, L. 1963. Parasites as indicators of the geographical origin of sockeye salmon, Onchorhynchys nerka (Walbaum), occurring in the North Pacific Ocean and adjacent Seas. Int. North Pac. Fish. Comm. Bull. 11 : 101-156.

Margolis, L. 1965. Parasites as an auxiliary source of information about the biology of Pacific salmons (Genus Oncorhynchus). J.Fish.Res. Board Can. 22: 1387-1395.

Margolis, L. 1982. Parasitology of Pacific salmon-an overview. In : Aspects of Parasitology. (Ed.E. Meerovitch) Mc Gill University, Montreal, Canada. 135-226.

Margolis, L., G.W.Esch, J.C.Holmes, A.M.Kuris, and A.M.Schad, 1982. The use of ecological terms in parasitology (Report of an Ad hoc Committee of American Society of Parasitologists). J. Parasit. 68 : 131-133.

Markov, G.S. 1961. Physiology of fish parasites. In : Parasitology of fishes (Ed.V.A.Dogiel., G.K. Petrushevski and Yu.I. Polyanski). Oliver and Boyed., Edinburgh and London. 117-139.

May, R.M. 1974. Stability and Complexity in model ecosystems. (2nd Ed.). Princeton University Press., Princeton, N.J.

Metcalf, M. 1929. Parasites and the aid they give in problems of taxonomy, geographical distribution, and paleography. Smithson. Misc. Collect.81: 1-36.

Mohammed Salih, K.Y. 1973. On the growth of the back-water clam Meretrix casta (Chemnitz) in the clam beds off Cochin Barmouth. J. Mar. Biol. Assoc. India. 15 : 345-353.

MPEDA, 1984. Statistics of Marine Products Exports No.16. Pub. The Marine Products Export development Authority, Cochin, India.

Munro, I.R.S. 1955. The marine and freshwater fishes of Ceylon. Dept. of External Affairs, Canberra.

Muzzall, P.M. 1980. Population biology and host-parasite relationships of Triganodistomum attenuatum (Trematoda : Lissorchiidae) infecting the white Sucker, Catostomus commersoni (Lacepede). J. Parasit. 66 : 293-298.

Muzzall, P.M. 1980 a. Seasonal distribution and ecology of three Caryophyllaeid cestode species infecting white suckers in SE New Hampshire. J. Parasit. 66 : 542-550.

Muzzall, P.M. 1982. Comparison of the parasite communities of the white sucker (Catostomus commersoni) from two rivers in New Hampshire. J. Parasit. 68 : 300-305.

Nagaty, H.F. 1937. Trematodes of fishes from the Red Sea. Part 1. Studies on the family Bucephalidae Poche, 1907. Publ: Fac.Med. Egypt Univ. 12: 1-172.

Nair, P.V.R., Sydney Samuel, K.J.Joseph, and V.K.Balachandran, 1973. Primary production and potential fishery resources in the Seas around India. In : Proceedings of the Symposium on living resources of the Seas around India. CMFRI Special publication. 184-198.

Noble, E.R. 1960. Fishes and their parasite-mix as objects for ecological studies. Ecology. 41: 593-596.

Noble, E.R. 1973. Parasites and fishes in a deep-sea environment. Adv.Mar.Biol. 11: 121-195.

Noble, E.R., and G.A.Noble, 1976. Parasitology : The biology of animal parasites. 4th Edn. Lea & Febiger, Philadelphia.

Olson, R.E., and L.Pratt, 1973. Parasites as indicators of English sole (Parophrys vetulus) Nursery grounds. Trans. Amer. Fish. Soc. 102 : 405-411.

Overstreet, R.M. 1968. Parasites of the inshore lizard fish, Synodus foetens, from South Florida, including a description of a new genus of cestoda. Bull. Mar. Sci. 18 : 444-470.

Overstreet, R.M. 1982. Abiotic factors affecting marine parasitism. In: Parasites-Their World and Ours (Ed. D.F.Mettrick and S.S.Desser). Proc. Fifth International Congr. Parasitol. 2: 36-39.

Paling, J.E. 1965. The population dynamics of the monogenean gill parasite Discocotyle sagittata Leuckart on Windermere trout Salmo trutta L. Parasitology. 55, : 667-694.

Paperna, I., and R.M.Overstreet, 1981. Parasites and diseases of mullets (Mugilidae). In : Aquaculture of Grey Mullets. (Ed.O.H.Oren), Cambridge University Press. 411-493.

Pennycuick, L. 1971. Differences in the parasite infections in three-spined Sticklebacks (Gasterosteus aculeatus L.) of different sex, age, and size. Parasitology. 63 : 407-418.

Pennycuick, L. 1971 a. Seasonal variations in the parasite infections in a population ofthree-spined sticklebacks, Gasterosteus aculeatus L. Parasitology. 63 : 373-388.

Perkins, E.J. 1974. The biology of Esturine and Coastal waters. Academic Press., London.

Pianka, E.R. 1974. Evolutionary ecology. Harper and Row, New York.

*Polyanski, Yu.I. 1955. Contribution to parasitology of fishes of the northern seas of the USSR. Fish parasites in the Barents Sea. Trav. Inst. Zool. Acad. Sci. USSR. 19.

Polyanski, Yu.I. 1961. Ecology of Parasites of Marine fishes. In : Parasitology of Fishes. (Ed. V.A. Dogiel, G.K. Petrushevski and Yu.I. Polyanski). Oliver and Boyd; Edinburgh and London. 48-83.

Polyanski, Yu.I. 1961 a. Zoogeography of the parasites of USSR Marine fishes. In : Parasitology of Fishes. (Ed. V.A. Dogiel, G.K. Petrushevski and Yu.I. Polyanski). Oliver and Boyd; Edinburgh and London. 230-245.

Price, P.W. 1980. Evolutionary Biology of Parasites. Princeton, New Jersey : Princeton University Press.

Pritchard, D.W. 1960. In : Encyclopedia of Science and Technology. Mc Graw-Hill, New York and London.

Qasim, S.Z., and M.Madhupratap, 1979. Changing ecology of Cochin backwaters. In : Contributions to Marine Sciences Dedicated to Dr.C.V.Kurian. (Ed.G.S.Sharma, A. Mohandas and A.Antony) 137-142.

Qasim, S.Z., and C.V.G.Reddy, 1967. The estimation of plant pigments of Cochin backwater during monsoon months. Bul. Mar. Sci. 17 : 95-110.

Qasim, S.Z., S.Wellershalus, P.M.A.Bhattathiri, and S.A.H.Abidi, 1969. Organic production in a tropical estuary. Proc. Indian Acad. Sci. B 69 : 51-94.

Radhakrishnan, S., and N.B.Nair, 1979. Digenetic trematodes from the fishes of South West Coast of India. Bull. Dept. Aqua. Biol. & Fish. Univ. Kerala. 4 : 95-107.

Radhakrishnan, S., and M.B.Nair. 1980. On the metazoan parasites associated with fishes along the South West Coast of India. Symp. Coastal Aquaculture (Abst) : 148-149.

Rakova, V.M. 1953. Invasion dynamics in Ide fish according to age. In : Contributions to helminthology published to commemorate the 75th birthday of K.I.Skrjabin, Academy of Sciences of the U.S.S.R. (English translation, 1966), Israel Program for Scientific Translations, Jerusalem. (Ed. A.M.Petrov et al.,). 575-582.

Ramamirtham, C.P., and R. Jayaraman, 1960. Hydrographical features on the Continental shelf waters off Cochin during the years 1958 and 1959. J. Mar. Biol. Assoc. India. 2 : 199-207.

Ramamirtham, C.P., and R. Jayaraman. 1963. Some aspects of the hydrographical conditions of the backwaters around Willingdon Island (Cochin). J. Mar. Biol. Assoc. India 7 : 150-168.

Ramamirtham, C.P., and M.R.Patil. 1965. Hydrography of the West Coast of India during the pre-monsoon period of the year 1962 - Part 2. In and offshore waters of the Konkan and Malabar coasts. J. Mar. Biol. Assoc. India. 7 : 150-168.

RAPA, 1985. Agriculture in Asia-Pacific Region - A pictorial profile. RAPA Monogr. 133 pp.

Ram Raju, V.S., P. Udayavarma, and Abraham Pylee, 1979. Hydrographic characteristics and Tidal prism at the Cochin Harbour mouth. Indian J. Mar. Sci. 8 : 78-84.

Read, C.P. 1950. The vertebrate small intestine as an environment for parasitic helminths. Rice Inst. Pamph. 37 : 1-94.

Read, C.P. 1971. The microcosm of intestinal helminths. In : Ecology and Physiology of Parasites. (Ed.A.M.Fallis). University of Toronto Press. 188-200.

Rees, G. 1970. Some helminth parasites of fishes of Bermuda, and an account of the attachment organ of Alcicornis carangis Mac Callum, 1917 (Digenea : Bucephalidae). Parasitology. 60 : 195-221.

Reimer, L., and O.Jessen. 1972. Parasitenbefall der Nordseeherringe. Angew. Parasitol. 13 : 65-71.

Rohde, K. 1977. A non-competitive mechanism responsible for restricting niches. Zool. Anz. 199 : 164-172.

Rohde, K. 1978. Latitudinal gradients in species diversity and their causes. 1. A review of the hypotheses explaining the gradients. Biol. Zentralbl. 97 : 393-403.

Rohde, K. 1979. A critical evaluation of intrinsic and extrinc factors responsible for niche restriction in parasites. Amer. Nat. 114: 648-671.

Rohde, K. 1980. Host specificity indices of parasites and their application. Experientia. 36: 1369-1371.

Rohde, K. 1982. Ecology of marine parasites. Univ. Queensland Press, St. Lucia-London-New York.

Sandground, J.H. 1929. A consideration of the relation of host specificity of helminths and other metazoan parasites to the phenomenon of age resistence and immunity. Parasitology. 21 : 227-255.

Sasaki, M. 1973. Survey of parasites of the Alaska pollock, Theragra chalcogramma Hokkaido Suisan Shikenjo Geppo (Hokusuishi Geppo). Fish. Mar. Ser. Transl. Ser. No. 3944 : 1977.

Sastry, J.S., and R.S.D'Souza, 1972. Upwelling and upward mixing in the Arabian Sea. Indian J. Mar. Sci. 2 : 17-27.

Sathyanarayana, M.C. 1982. Incidence of trematode parasite, Paraplerurus sauridae, in relation to season, sex and length of the marine fish, Saurida undosquamis. Indian J. Mar. Sci. 11 : 188-189.

Schad, G.A. 1963. Niche diversification in a parasitic species of flock. Nature. 198 : 404-406.

Sharma, G.S., R. Narendran Nair, and Basil Mathew, 1982. Current structure in the Intertropical Indian Ocean during the Northeast Monsoon. Indian J. Mar. Sci. 11 : 7-14.

*Shulman, S.S. 1949. Parasites of fishes in the aquatories of the Latvian Republic. Report on thesis, Inst. Freshw. Fish. Leningr.

*Shulman, S.S. 1950. Parasites of fishes in the aquatories of the Latvian Republic (Abstract of thesis). Trud. gel'mint. Lab. 4.

*Shulman, S.S. 1954. On the specificity of fish parasites. Zool. Zh. 33 : 1.

Shulman, S.S. 1961. Specificity of fishes. In : Parasitology of fishes. (Ed. V.A. Dogiel; G.K. Petrushevski; and Yu. I. Polyanski). Oliver and Boyd, Edinburgh and London. 104-116.

* Not seen in original

*Shulman, S.S., and R.E. Shulman-Albova, 1953. Parasites of fishes of White Sea. Publ : AN S.S.S.R.

*Shultz, R.S., and E.A. Davtyan, 1954. On the types of the host-parasite relation in helminthology. Zool. Zh. 33.6.

Siddiqi, A.H., and R.M. Cable, 1960. Digenetic trematodes of marine fishes of Puerto Rico. Sci. Surv. Porto Rico and Virgin Isls. 17 : 257-369.

Sindermann, C.J. '1966. Diseases in marine fishes. In :Advances in Marine Biology. (Ed. F.S. Russal). Academic Press, Inc., London-United Kingdon. 4 : 1-89.

Sindermann, C.J., 1970. Principal Diseases of Marine Fish and Shell-fish. Academic Press. New York and London.

*Skinner, R. 1974. Parasites of the striped mullet, Mugil cephalus, from Biscayne Bay, Florida with descriptions of a new genus and three new species of trematodes. Thesis, University of Miami, Coral Gables.

Smit, H. 1968. Gastric Secretion in the lower Vertebrates and birds. In : Handbook of Physiology. American Physiological Society, Washington, D.C.

Smyth, J.D. 1969. The Physiology of Cestodes. Oliver and Boyd Ltd. : Edinburgh and London.

Solonchenko, A.I. 1978. Effect of salinity of the helminth fauna of fishes from the Sea of Azov. In : Parasitofauna of the Animals of the Southern Seas. Naukova Dumka, Kiev, U.S.S.R.

Srivastava, C.B. 1975. Fish pathological studies in India - A brief review. In : Dr. B.S. Chauhan Comm. Vol. 349-358.

Srivastava, C.B., and B.S. Chauhan, 1976. Distribution of the genus Cyclocoelum Brandes, 1892 on host orders and its bearing on their interrelationships. Rec. Zool. Surv. India. 69 : 295-303.

* Not seen in original.

*Strelkov, Yu. A. 1956. Endoparasitic helminths of marine fishes in eastern Kamchatka. Report Zool. Inst. Acad. Sci. U.S.S.R.

*Svetovidov, A.N. 1961. On the origin of certain amphiboreal gadoid and clupeoid fishes in the light of species composition of their parasites. Zool. Zh. 40 : 1335-1344.

Svetovidov, A.N., and S.S.Shulman, 1960. An association between the species composition of the parasites of certain groups of fishes and parallels in their ecology and distribution. Zool. Zh. 39: 1866-1870..

Syed Ismail Koya, M.S., and A. Mohandas, 1982. Helminth parasites of marine fishes of Cochin. Indian J. Parasit. 6 : 103-105.

Szidat, L. 1961. Versuch einer Zoogeographic des Sud-Atlantic mit Hilfe von Leitparasiten der Meeresfische. Parasitol. Schrift. 13 : 1-98.

Thomas, J.D. 1964. Studies on the populations of helminth parasites in brown trout (Salmo trutta L.) J, Anim. Ecol. 33 : 83-95.

Thomas, J.D. 1964a. A comparison between the helminth burdens of male and female brown trout Salmo trutta L. from a natural population in the river Teify, West Wales. Parasitology. 54 : 263-272.

Varadachari, V.V.R., and G.S.Sharma, 1967. Circulation of the surface waters in the North Indian Ocean. J. Indian Geophys. Union. 4 : 61-73.

Vernberg, W.B., and F.J.Vernberg, 1974. Metabolic pattern of a trematode and its host : a study in the evolution of physiological responses. In : Symbiosis in the Sea (Ed. W.B.Vernberg). University of South Carolina Press, Columbia, South Carolina. 161-172.

Walkey, M. 1967. The ecology of Neoechinorhynchus rutili (Muller). J. Parasit. 53 : 795-804.

* Not seen in original

Wassom, D.L., T.A.Dick, N.Arnason, D.Strickland, and A.W.Grundmann, 1986. Host Genetics : A key factor in regulating the distribution of parasites in natural host populations. J. Parasit. 72 : 334-337.

Way, M.J., and M.E.Cammell, 1971. Self regulation in aphid populations. In : Dynamics of Populations. (Eds. P.J.Den Boer and G.R.Gradwell). Proc. Adv. Study Inst. on Dynamics of Numbers in populations, Oosterbeck, 1970. Centre for Agricultural Publ. Docum. Wageningen. 232-242

Williams, H.H. 1961. Observations on Echeneibothrium maculatum (Cestoda : Tetraphyllidea). J. Mar. Biol. Assoc. U.K. 41 : 631-652.

Williams, H.H. 1966. The ecology, functional morphology and taxonomy of Echeneibothrium Beneden, 1849 (Cestoda: Tetraphyllidea), a revision of the genus and comments on Discobothrium Beneden, 1870, Pseudanthobothrium Baer, 1956, and Phormobothrium Alexander, 1963. Parasitology. 56 : 227-285.

Williams, H.H. 1967. Helminth diseases of fish. Helm. Abst. 36 : 261-295.

Williams, H.H., A.H.Mc Vicar, and R.Ralph. 1970. The alimentary canal of fish as an environment for helminth parasites. Symp. Br. Soc. Parasit. 8 : 43-77.

Wisniewski, W.L. 1958. Characterization of the parasitofauna of an eutrophic lake. Acta. Parasit. Pol. 6 : 1-64.

Yamaguti, S. 1939. Studies on the helminth fauna of Japan. Part. 26. Trematodes of Fishes VI. Jap. J. Zool. 8 : 211-230.

Yamaguti, S. 1971. Synopsis of digenetic trematodes of vertebrates. Vol.I. Keigaku Publ.Co.Tokyo.

*Zhukov, E.V. 1953. Endoparasitic helminths of fishes of the sea of Japan and of the Kuril shallows. Report, Zool. Inst. Acad. Sci. U.S.S.R.

* Not seen in original.

CHAPTER II

INTRODUCTION

The earliest record of our knowledge on trematode fauna dates back to 1379, when Jehan de Brie referred to the liver fluke of sheep. But Zeder (1800) was the first to have made a definite attempt to classify the parasitic worms. Of the five families he created, the trematodes were included in the "sucking worms". But Rudolphi (1808), for the first time, used the term "Trematoda" for Zeder's "sucking worms" with a taxonomic rank of an order.

The digenetic trematodes of marine fishes of Indian waters are not sufficiently known. H.D.Srivastava, in a series of papers published between 1933 and 1948 reported a large number of genera and species of digenetic trematodes of Indian marine fishes. In spite of the fact that he has been one of the major contributors in this field, some papers presented at various meetings in abstract form with insufficient descriptions and without diagrams did not serve any meaningful purpose. Chauhan in the early 40's and mid 50's published a series of papers on marine trematodes, and although his main work was a compilation of the Trematode fauna of India, in general, his specific work on Gasterostomata and Prosostomata published in 1954 actually stimulated further research in this field. Other notable contributions of this century from India on trematodes in general, have come from Bhalerao, Dayal, Lal, Mehra, Moghe, Sinha, Soparkar, Thaper, Verma, Job, A.N.Gupta, N.K.Gupta, P.C.Gupta, V.C.Gupta, Anantharaman, Hanumantha Rao, Karyakarte, Baugh, C.B.Srivastava, Hafeezullah, Jamil Ahamed, P.N.Sharma, Pande, Khar, Siddiqi, Radhakrishnan, Madhavi, Mehrotra, Sehgal, Deepa Sahai, and others. According to Hafeezullah and Siddiqi (1970) upto that period a total of 69 valid species of digenetic trematodes belonging to 47 genera from about 61 species of fishes of the Bay of Bengal and Arabian Sea have been reported.

Most of the work on trematodes of marine fishes has come from only a few places on the coastline which is about 6000 km long, and the variety of marine fishes of these waters is also large. With about 1500 species of fishes native to Indian waters (Hafeezullah and Siddiqi, 1970), of which about 250 are common to Kerala coast (Eapen and Menon, 1973), the problem of studying the digenetic trematode fauna of marine fishes can best be solved only by conducting surveys at selected localities by several investigators. In the west coast of India, such an attempt has already been made by Radhakrishnan and Nair (1979, 1980). The fact that only a small number of digenetic trematodes has been reported from a fraction of the fish species available in the coastal waters necessitates the need and urgency for extensive study of this group of parasites. A knowledge of the digenetic trematodes of marine fishes is important, as mentioned earlier, on several accounts. In the present study, fishes were collected from the nearshore and offshore waters of Cochin extending between Alleppey and Ponnani, and also from the backwaters. The digenetic trematodes recovered from these fishes are described in this chapter.

MATERIALS AND METHODS

Fishes for the present study were collected from near and offshore waters extending from Alleppey to Ponnani, the Cochin backwaters, and also from the fish landing centres in and around Cochin. Almost all the fishes were examined, as far as possible, the same day or else were deep frozen and were examined subsequently. The fishes were dissected out and individual organs were examined separately for digenetic trematodes. Examination included the entire alimentary system and coelomic cavity of all fishes, the gills, heart, swim bladder, urinary bladder and other tissues. Small trematodes were flattened under coverslip pressure while bigger ones were flattened between glass slides. They were fixed in hot alcohol-formalin-acetic acid (AFA), or in 10% formalin. They were subsequently washed under running tap water until all the fixative was removed. The specimens were stained in acetic alum carmine, Semichon's carmine or haematoxylin; cleared in methylbenzoate and mounted in Canada balsam. All measurements are in millimeters unless otherwise indicated. Measurements were taken on fully-formed eggs unless the text indicates otherwise. A camara-lucida was used for all illustrations. Except for new species the discussion is limited to aspects that supplement the available literature.

BRACHYCOELIIDAE Johnston, 1912

Brachycoeliidae Johnston, 1912

The family Brachycoeliidae was erected by Johnston (1912). Cheng (1958) referred to this family of flukes as members of the subfamily Brachycoeliinae Looss, 1899 in agreement with the opinion of Fuhrmann (1928)"...in retaining Brachycoeliinae as a subfamily under Dicrocoeliidae until additional evidences can indicate differently". In a later paper Cheng (1959) stated that the subfamily Brachycoeliinae should be elevated to familial rank as suggested by Johnston (1912) since such an arrangement seems to be the natural one as based on the life history patterns of *Glypthelmins quieta* as reported by Rankin (1944), and Leigh (1946), and *Mesocoelium brevicaecum* as reported by Ochi (1930). Subsequently, the life history of *Brachycoelium obesum* was also worked out (Cheng, 1960a). In all these three cases the parasites utilize only one intermediate host. In asmuch as the members of the genus *Brachycoelium* are different from those of *Glypthelmins* and *Mesocoelium*, Cheng (1959) has chosen to retain the subfamily Brachycoeliinae Looss, 1899 under Brachycoeliidae to include *Brachycoelium*, and erected the Glypthelminae n.subfam., also under Brachycoeliidae to include *Glypthelmins* and other genera. Although the affinities between *Brachycoelium* and *Mesocoelium* are well established, in the opinion of Cheng (1960b), the differences in the relationships of testes to ovary and the comparative length of the intestinal caeca, justify the assignment of the genus Mesocoelium to the subfamily Mesocoeliinae, an arrangement that Yamaguti (1958, 1971) has accepted. Yamaguti (1971), however, changed the nomenclature of the subfamily Glypthelminae, as subfamily Glypthehelminthinae and assigned it to the family Macroderoididae. As such, the family Brachycoeliidae Johnston, 1912 includes only two subfamilies, Brachycoeliinae and Mesocoeliinae.

The genus Mesocoelium Odhner, 1911 was originally assigned to the subfamily Mesocoeliinae Looss, 1899 by Odhner (1911). Dollfus (1929) erected the subfamily Mesocoeliinae with Mesocoelium as the type genus, and later (Dollfus, 1933) erected Mesocoeliidae to include this subfamily. Dollfus' system has not been widely accepted, and Cheng (1960 b) opined that in recognizing the family Brachycoeliidae Johnston, 1912, Mesocoeliinae is of some systematic value as a subordinate group only.

Family diagnosis:- Body spinous, elongate to oval; Oral sucker subterminal, pharynx small, oesophagus long or short, intestinal caeca short or half long. Acetabulum small, more or less preequatorial. Testes symmetrical or oblique, situated in middle third of body or a little more anteriorly or posteriorly. Cirrus sac present. Genital pore median, anterior to ventral sucker. Ovary submedian, either anterior or posterior to testes.

Uterus mainly posttesticular. Vitellaria follicular restricted to anterior part of the body. Excretory vesicle tubular, may be divided anteriorly into two short arms. Intestinal parasites of amphibians and reptiles, exceptionally of fishes.

Mesocoeliinae Dollfus, 1929

Subfamily diagnosis :- Body elliptical to lanceolate, spinose. Oral sucker subterminal, well developed; pharynx small, or moderately large. Oesophagus short; caeca short or half-long. Acetabulum usually smaller than oral sucker, in the anterior third or half of the body. Testes symmetrical or not, intercaecal, in acetabular or postacetabular zone. Cirrus pouch between acetabulum and intestinal bifurcation. Genital pore at or near intestinal bifurcation. Ovary submedian, posterior to right or left testis. Vitellaria extracaecal, chiefly in anterior half of the body. Uterine coils occupying most of hindbody, rarely extending into forebody. Excretory vesicle tubular, divided anteriorly into two short arms. Intestinal parasites of amphibians and reptiles, exceptionally of fishes.

Mesocoelium Odhner, 1911

Generic diagnosis :- Genital pore either anterior or posterior to intestinal bifurcation, on or lateral to midline. Testes anterior to or same level as, or posterior to acetabulum. Ovary posterior to testes. Uterus with much folded ascending and descending limbs, folds limited to post-ovarian area. Intestinal parasites of amphibians and reptiles, exceptionally of fishes (Cheng, 1960 b; Schell, 1970).

Mesocoelium cynoglossi sp.nov. (Fig. 1)

Host	:	Cynoglossus sp
Site	:	Stomach
Incidence	:	1/8
No. of parasites	:	1
Locality	:	Off Cochin

Species diagnosis (based on single specimen) :- Body oval, anterior end broader than the posterior end; 2.583 long and 1.281 wide. Cuticle spinous, sparse posteriorly. Oral sucker 0.252 by 0.315; acetabulum round 0.210 in diameter; prepharynx not seen, pharynx 0.084, oesophagus inconspicuous, if any; intestinal caeca extending posterior to midlength of the body; testes round, right testis 0.252 and left testis 0.231 in diameter, on each side of acetabulum and partially overlapping it. Cirrus pouch 0.231 by 0.063; genital pore close to right of intestinal bifurcation; ovary 0.168 x 0.189, situated posterior to right testis; vitellaria consisting of individual follicles, lateral in position, extending upto the middle of the body. Excretory vesicle obscured by eggs. Uterus filling hindbody, ventral to gonads, ascending on left.

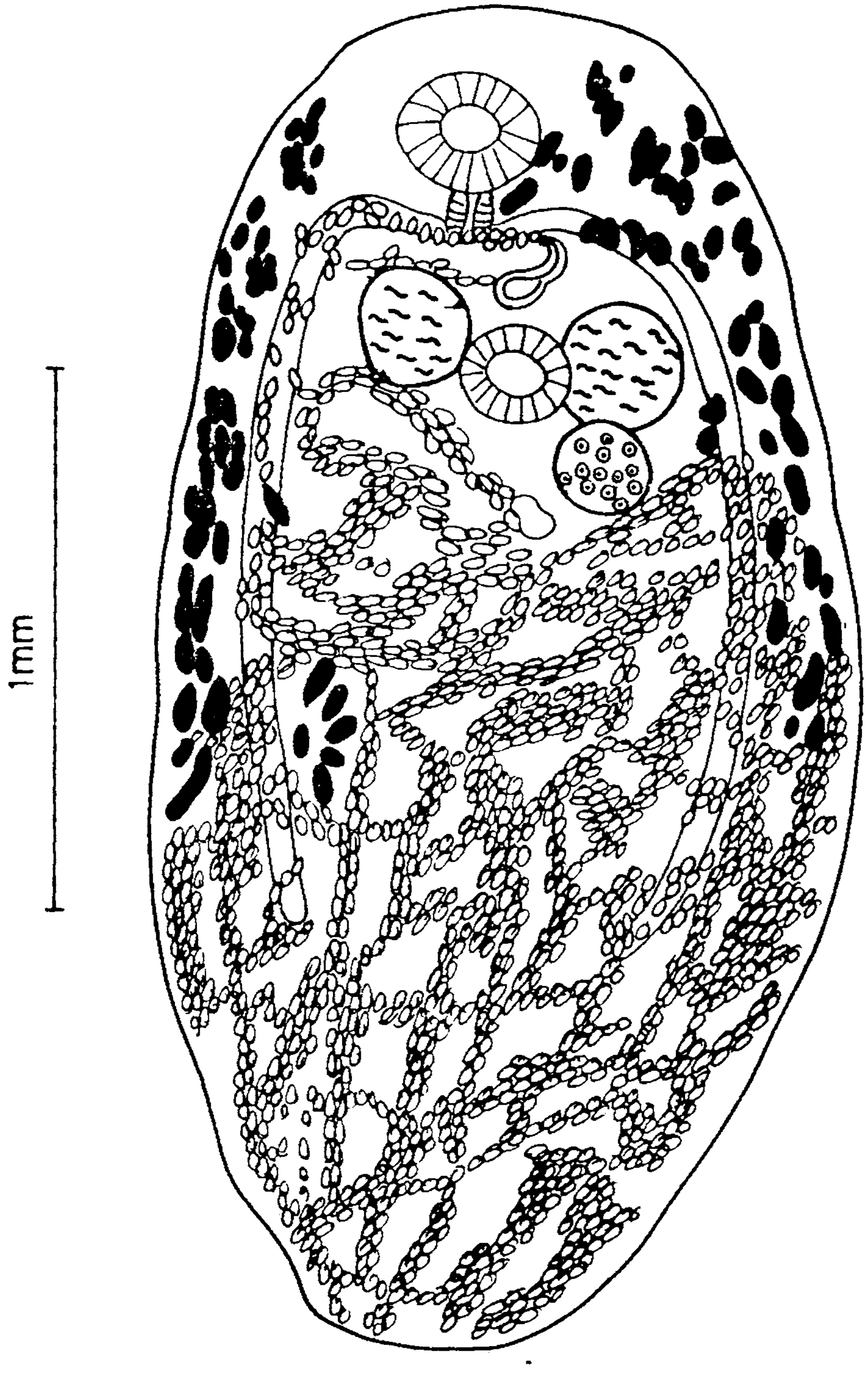


FIG.1. *MESOCOELIUM CYNOGLOSSI* SP. NOV.

Eggs numerous, operculate, measuring 0.025 x 0.018 - 0.032 x 0.021.

Discussion :

In the genus Mesocoelium, three distinct groups of species can be recognized by the location of testes (Cheng 1960 b). In the first group, the testes are symmetrically placed on each side of the acetabulum; in the second group, the testes are anterior to the level of the acetabulum; and in the third group, the testes are posterior to the level of that sucker. The first group can be divided into two subgroups based on the length of the intestinal caeca. In the first subgroup the caeca extend past the midlevel of the body while the caeca terminate before reaching that level, and usually are confined to the anterior one third of the body in the second subgroup. Hence, the present specimen belongs to the first subgroup of the first group.

The only other record of Mesocoelium from a fish is M.scatophagi reported by Fischthal and Kuntz (1965). The present specimen differs from M. scatophagi, in the following aspects: M. scatophagi is charecterised by a preoral hood which is lacking in the present form. M. scatophagi is smaller than the present form. In the present form caecal shoulders are not inflated whereas in M. scatophagi they are inflated. Whereas in M. scatophagi the genital pore opens slightly posterior to the sucker opening, in the present form it opens near the intestinal bifurcation. In the present form, the ovary is smaller than the testes, whereas in M. scatophagi ovary is larger than the testes. In M. scatophagi cirrus overlaps acetabulum, whereas in the present specimen there is no such overlapping. Hence, the present form is designated as a new species, Mesocoelium cynoglossi. It is noted that these are the only two records of Mesocoelium from fishes, while most of the forms are recorded from amphibia and reptiles.

LEPOCREADIIDAE (Odhner, 1905) Nicoll, 1935

Lepocreadiidae (Odhner, 1905) Nicoll, 1935

The family Leprocreadiidae comprises an enormous number of digenetic trematodes almost exclusively parasites of the digestive tract of marine fishes (Stunkard, 1979). Yamaguti (1971) listed 24 subfamilies, and the subfamily Lepocreadiinae contained 15 genera. Although life history studies of some Lepocreadiid trematodes have been worked out the discrepancies in morphology and life-cycle of species included in the family Lepocreadiidae are quite unresolved (Stunkard, 1979).

Lepocreadiidae (Odhner, 1905) Nicoll, 1935

Family diagnosis :- Digenea, almost exclusively parasitic in digestive tract of marine teleosts. Body usually spinose, often occulate, elongate, exceptionally with wing-like lateral expansions, exceptionally divided into two regions. Oral sucker usually without appendages but may be provided with sphincter, or two or more lobes or processes; prepharynx usually present, rarely very long; pharynx always present; oesophagus variable in length, caeca usually reaching posterior extremity where they mostly terminate blindly, sometimes forming cloaca or ani (opens through separate ani in Bianium and Diploproctodaeum) or united. Acetabulum simple, in anterior half of the body. Testes two, tandem, diagonally or symmetrically situated in hindbody, sometimes divided into a number of follicles. Cirrus pouch present; external seminal vesicle present or absent; pars prostatica and prostatic cells in-or outside cirrus pouch. Genital pore median, submedian or marginal, exceptionally dorsal, usually anterior to acetabulum (posterior to ventral sucker in <u>Postporus</u>), marginal or dorsal near acetabulum. Ovary median or submedian, pretesticular. Seminal receptacle and Laurer's canal usually present. Uterine coils confined to hindbody. Vitellaria consisting of large numbers of follicles and surrounding caeca to variable extent in hindbody, may extend into forebody. Excretory vesicle usually tubular, long or short, occasionally elongate saccular or 'Y'-shaped, pore usually terminal.

Lepocreadiinae Odhner, 1905

Subfamily diagnosis :- Body oval pyriform or more elongate, spined, usually occulate. Prepharynx usually distinct, oesophagus short, caeca reaching posterior extremity. Acetabulum in anterior or middle third of the body. Testes tandem, diagonal or symmetrical, exceptionally single in posterior half of the body. Cirrus pouch well developed, anterior, dorsal or posterior to acetabulum, Vesicular seminalis externa usually present. Prostatic cells in-or outside cirrus pouch. Genital pore median or submedian, at varying levels. Ovary median or submedian, at pretesticular, occasionally opposite anterior testis. Receptaculum seminis and Laurer's canal usually present. Vitellaria follicular, extending along caeca for their entire length sometimes leaving their anterior portion free, may or may not be confluent in posttesticular region. Uterus confined to region anterior to ovary or testes, occasionally extending into space between testes. Eggs large, excretory vesicle short often long and reaching to acetabulum or further forward. Intestinal parasites of marine, exceptionally freshwater, teleosts.

Genus :- Lepocreadioides Yumaguti, 1936

Generic diagnosis :- Body foliate, with median emargination at posterior end, spinulate, Oral sucker subterminal; prepharynx very short; pharynx large; oesophagus very short or practically absent; caeca wide, reaching to posterior end. Acetabulum larger than oral sucker in anterior half. Testes diagonal at about middle of hindbody. External seminal vesicle preacetabular. Cirrus pouch enclosing seminal vesicle, distinct prostatic complex and protrusible cirrus. Genital pore marginal, close to oral sucker. Ovary low submedian, between acetabulum and posterior testis, Receptaculum seminis and Laurer's canal present. Vitellaria circumcaecal extending into forebody. Uterine coil intercaecal, posterior and dorsal to acetabulum.

Eggs large. Excretory vesicle tubular, long, curved, and reaching beyond acetabulum. Parasitic in digestive tract of marine teleosts.

Lepocreadioides indicum Srivastava, 1941

Host	: Cynoglossus sp. and Narcine sp.
Site	: Stomach/intestine
Incidence	: 1/8 and 1/1
No. of parasite	: 5 and 2
Locality	: Off Cochin

The specimens recorded here have body range between 0.75 - 1.050 x 0.40 - 0.50 which is slightly less than the measurements given for the original specimens. However, in all other characteristics, such as, the position of testes, ovary, position of seminal vesicle, opening of the genital pore, extent of vitellaria and intestinal caeca etc., the present specimens show similarities with Lepocreadioides indicum Srivastava, 1941.

This species was originally described by Srivastava (1941) from Platycephalus insidiater collected from Puri and Karachi. This species was collected again from the Bay of Bengal and Arabian sea from a variety of hosts, Cynoglossus bilineatus, C. dubius, C. lida, C. lingua, C. macrolepidotus, C. puncticeps and C. sindensis (Hafeezullah, 1970). Bilqees (1981) recorded this species from Karachi coast from the fish Platycephalus scabar and

Cynoglossus sindenis. Gupta and Govind (1984) reported the occurrence of this species in *Platycephalus insidiater* collected from off Puri coast, Bay of Bengal. In the present study it was reported from *Cynoglossus* sp. It appears *L. indicum* is a common trematode inhabiting the intestine and stomach of various species of *Cynoglossus* and *Platycephalus* occurring along the east and west coasts of India, and west coast of Pakistan. *Narcine* sp. is a new host record.

HOMALOMETRIDAE (Cable et Hunninen, 1942) Yamaguti, 1971

Homalometridae (Cable et Hunninen, 1942) Yamaguti, 1971

Family diagnosis :- These digenetic trematodes are related to Lepocreadiidae in life-history and adult morphology except the cirrus pouch being completely absent. Body oval, fusiform or more elongate, spined or not. Oral sucker subterminal, simple or may be provided laterally with papillae or processes. Prepharynx may be distinct or not; oesophagus short or practically absent; caeca terminating at or near posterior extremity. Acetabulum in anterior half of the body, sucker-like as usual, or may form a thin-walled sac and reinforced by lips or lobes at its aperture. Testes tandem, diagonal, exceptionally symmetrical, in posterior half of the body. No cirrus pouch. Seminal vesicle free in paranchyma; prostatic complex sometimes well developed, sometimes indistinct. Hermaphroditic duct or genital sinus may be developed. Genital pore usually immediately preacetabular, may be postbifurcal or even postacetabular. Ovary submedian, pretesticular. Seminal receptacle and Laurer's canal present. Vitellaria follicular, in lateral fields of hindbody, but may often extend into forebody, confluent in posttesticular area, sometimes in preacetabular area, too. Uterus winding between testes or ovary and acetabulum. Excretory vesicle tubular, usually reaching to testes or ovary, may be unusually long. Parasites of marine fishes.

Homalometrinae Cable et Hunninen, 1942

Subfamily diagnosis :- Body oval, fusiform or elongate, spinose. Oral sucker simple or may be provided laterally with papillae or processes. Prepharynx distinct, oesophagus short; caeca terminating at or near posterior extremity. Acetabulum in anterior half of body. Testes tandem or diagonal, postequatorial. Seminal vesicle free in parenchyma. Pars prostatica and prostatic cells present. No cirrus pouch. Genital pore median, immediately preacetabular or postbifurcal. Ovary submedian, pretesticular. Receptaculum seminis and Laurer's canal present. Vitellaria in lateral fields of hindbody, may extend into forebody, confluent in posttesticular, sometimes preacetabular area. Uterus winding between anterior testis and acetabulum. Excretory vesicle reaching to posterior testis or ovary.

Genus - Crassicutis Manter, 1936

Generic diagnosis :- Body medium-sized, flattened oval. Cuticle very thick, smooth except for rudimentary spines which are embedded in the cuticle of the ventral surface. Oral sucker large, terminal or subterminal; prepharynx present. Pharynx well developed; oesophagus short; caeca more or less apart from lateral margins of the body, reaching to near posterior extremity. Acetabulum not very large, pre-equatorial. Testes tandem or diagonal, between two caeca, postequatorial. Seminal vesicle saccular, free in parenchyma, extending a short distance posterior to acetabulum. No cirrus pouch. Genital pore median, just preacetabular. Ovary submedian, between acetabulum and right testis medial to right caecum. Receptaculum seminis and Laurer's canal present. Uterus winding between testes and genital atrium, containing few large eggs. Vitellaria occupying most of body, posterior to pharynx except for region of gonads and peripheral area. Excretory vesicle reaching to testes, with dorsal opening. Parasitic in digestive tract of marine teleosts.

Crassicutis karwarensis Hafeezullah, 1970

Host	:	*Gerres filamentosus*
Site	:	Intestine
Incidence	:	10/13
No. of parasites	:	21
Locality	:	Cochin

Yamaguti (1971) has listed seven species under *Crassicutis*. Subsequently two more species were recorded, viz., *C. karwarensis* Hafeezullah, 1970, and *C. caranxi* Bilqees, 1976 (cited from Bilqees, 1981). The largest specimen collected in the present study measures 1.575 x 0.735 and in all other characteristics also it resembles *C. karwarensis*, and is considered the same. For both, the host species is also same, and both are reported from the west coast of India.

OPECOELIDAE (Ozaki, 1925) Yamaguti, 1971

Opecoelidae (Ozaki, 1925) Yamaguti, 1971

Family diagnosis :- Digenea resembling Allocreadiidae and Lepocreadiidae in adult morphology, but different in life history, especially in the cercaria usually being cotylocercous xiphidiocercaria. Body small, more or less elongate, flattened, usually aspinose, nonocculate. Anus or ani may be present or absent. Acetabulum with or without papilliform or tentacular appendages. Testes postovarian, two, tandem or diagonal. External seminal vesicle present or absent. Cirrus pouch rudimentary or absent, or more or less well developed. Genital pore preacetabular, pre-or postbifurcal, median or submedian, exceptionally submarginal. Accessory suckers may be present. Ovary pretesticular, median or submedian. Seminal receptacle present or absent. Laurer's canal present. Uterus usually entirely preovarian; eggs usually large. Vitelline follicles usually large, variable in extent. Excretory vesicle tubular or saccular. Parasitic in digestive tract of marine and freshwater fishes.

Plagioporinae Manter, 1947

Subfamily diagnosis :- Body elongate, more or less fusiform or subcylindrical, unarmed. Oral sucker subterminal, prepharynx present; pharynx moderately developed, oesophagus short; caeca terminating at or near posterior extremity, exceptionally united posteriorly. Acetabulum larger than oral sucker, usually in anterior half of the body. Testes tandem or diagonal, toward middle of hindbody or posterior to it. Cirrus pouch more or less developed; external seminal vesicle absent. Prostatic cells inside cirrus pouch. Genital pore usually submedian or sublateral, rarely median. Ovary submedian, pretesticular. Receptaculum seminis and Laurer's canal present. Uterus confined to space between testes or ovary and genital pore, overreaching caeca laterally or not. Vitelline follicles large or small, variable in extent, usually along caeca between level of oesophagus and posterior extremity, but may be confined to hindbody. Excretory vesicle tubular, reaching to level of testes or ovary, occasionally to intestinal bifurcation, with terminal pore. Intestinal parasites of marine, exceptionally freshwater fishes.

Genus - Podocotyloides Yamaguti, 1934 emended Prichard, 1966

Generic diagnosis :- Body elongate with stalked (not merely protuberant) acetabulum. Cuticle smooth. Acetabulum in anterior third of body, smaller, subequal, or larger than the oral sucker. Prepharynx short, pharynx small to moderaterly large, oesophagus as long or longer than pharynx, caeca terminating near posterior end of the body. Testes tandem, in posterior half of body, smooth, rounded or ovoid. Cirrus sac elongate, more or less sinuous, extending posterior to acetabular stalk. Seminal vesicle tubular, straight or somewhat coiled. Prostate cells well-developed. Cirrus protrusible. Ovary pretesticular, rounded, unlobed. Seminal receptacle and Laurer's canal present. Vitelline follicles extending from posterior end of cirrus sac to posterior end of body, intruding or not between testes and ovary, more or less filling posttesticular space. Uterus preovarian. Metraterm well differentiated, with distal sphincter or not. Genital atrium distinct or not. Gential pore in forebody, submedian. Execretory vesicle tubular, extending to level of ovary or more anteriorly. Intestinal parasites of warm-water marine fishes.

Podocotyloides parupenei (Manter, 1963) Pritchard, 1966

Host : *Therapon jarbua*
Site : Intestine
Incidence : 10/35
No. of parasites: 12
Locality : Off Cochin

Manter (1963) described this species as *Podocotyle parupenei* from *Paruoeneus indicus*. Pritchard (1966) reviewed the species of *Podocotyle*, modified the generic diagnosis of *Podocotyloides* **as given** by Yamaguti (1954), and *Podocotyle parupenei* was transferred to the genus *Podocotyloides* on the basis of its unlobed ovary and pedunculate acetabulum. Yamaguti (1971), however, listed this species under *Podocotyle*. But this species continues to be included under *Podocotyloides* (Hafeezullah, 1971; Madhavi, 1975)

Specimens of *P. parupenei* collected in the present study measure slightly less than those described originally by Manter (1963). The acetabulum appears slightly protruded but the stalk is withdrawn. The largest specimen measures 1.113 x 0.357. In considering the unlobed nature of the ovary, position of the ovary away from the anterior testis, presence of vitellaria between the ovary and the anterior testis, and in the characteristic nature of the egg (6-11 in number) with papilla-like knob at one end, the specimens of the present study show similarities with *P. parupenei* and is treated as the same species.

P. Parupenei, is also reported from the east coast of India (Hafeezullah, 1971; Madhavi, 1975). Hafeezullah (1971) collected the specimens from *Therapon puta*, *T. theraps*, and *Nemipterus japonicus*, and he noticed that the paiilla-like knob at one end of the eggs is indistinct and in some specimens the genital pore was slightly posterior to the base of the pharynx. Madhavi (1975) noticed over 30 eggs in the uterus without the knob-like protrusion at one end, and a distinct metraterm with a thick wall of circular muscles lying parallel to the anterior part of the cirrus sac. These specimens were collected from *T. jarbua*, as in the present study.

Family Opecoelidae

Opecoelinae Stunkard, 1931

Subfamily diagnosis :- Oral sucker without muscular processes anteriorly. Acetabulum often papillate, pedunculate or not, usually near anterior extremity. Caeca sometimes ending blindly, but usually either united posteriorly or opening outside by a single or double anus, or through uroproct. Genital pore ventral, preacetabular, occasionally with accessory sucker in its vicinity. Ovary lobed or not, median or submedian, pretesticular seminal receptacle present or absent.

Genus - Coitocaecum Nicoll, 1915

Generic diagnosis :- Body plump or elongate, unspined. Oral sucker subterminal; prepharynx distinct; pharynx well developed; oesophagus usually short; caeca united near posterior extremity. Acetabulum moderately large, at junction of anterior with middle third of body or in middle third, rarely with papilliform marginal protuberances. Testes tandem, sometimes diagonal, in posterior half of body. Cirrus pouch retort-shaped, containing elongate saccular or tubular seminal vesicle, prostatic complex and ejaculatory duct, entirely or mostly preacetabular. Genital pore situated to left of pharynx or oesophagus, or a little more posteriorly. Ovary median or a little to right of median line just in front of anterior testis. No receptaculum seminis, Laurer's canal present. Vitellaria circumcaecal, usually confined to hindbody, may extend into forebody. Uterus coiled between ovary and acetabulum. Excretory vesicle tubular, reaching to ovarain level. Parasitic in intestine or gall bladder of freshwater and marine teleosts.

Note-Nicoll (1915) created the genus *Coitocaecum*. Wiśniewski (1933) divided the genus *Coitocaecum* into three generic groups, viz; *Coitocaecum*, *Nicolla*,and *Ozakia*. Crowcroft (1951) restudied Nicoll's type specimens and treated *Ozakia* as synonym of *Coitocaecum*. Yamaguti (1958) considered *Ozakia* and *Nicolla* as synonyms of *Coitocaecum*. Ślusarski (1958), Skrjabin and Koval (1956) (in Skrajabin and Koval, 1958), Dollfus (1959 a, b, 1960), and Ahamed (1980) considered *Ozakia* as a synonym of *Coitocaecum*. Later, Yamaguti (1971), however, considered *Coitocaecum* and *Ozakia* as distinct genera. Considering all aspects of the two genera *Ozakia* and *Coitocaecum*, I prefer to treat the specimens collected in the present study as belonging to the genus *Coitocaecum*.

Coitocaecum glossogobii sp. nov. (Fig. 2).

Host : *Glossogobius giuris*
Site : Intestine/stomach
Incidence : 5/16
No. of Parasites : 16
Locality : Cochin backwaters

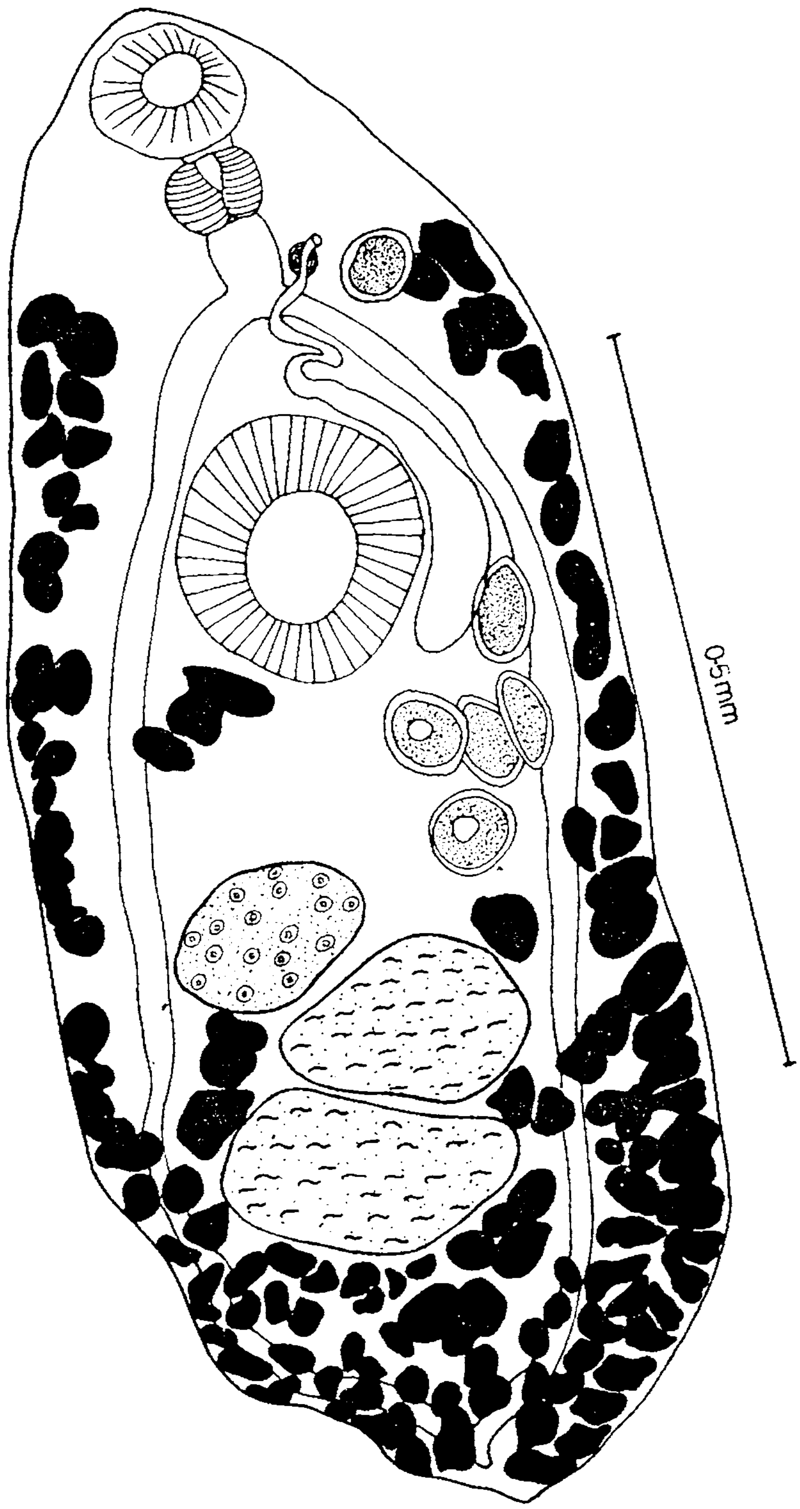


FIG 2. COITOCAECUM GLOSSOGOBII SP. NOV.

Body short, aspinose with rounded extremities, 0.982 - 1.029 long x 0.414 - 0.448 wide. Oral sucker almost spherical, subterminal 0.069 - 0.099 long x 0.092 - 0.110 wide. Prepharynx short, Pharynx slightly ovoid 0.046 - 0.07 x 0.055 - 0.09. Oesophagus 0.046 long. Intestinal caeca united at the posterior end of the body. Acetabulum almost spherical, 0.151 - 0.183 x 0.161 - 0.183, much larger than the oral sucker. Testes entire, tandem, transversely elongated, in the posterior half of the body. Anterior testis 0.101 - 0.138 x 0.152 - 0.193, Posterior testis 0.099 - 0.115 x 0.184 - 0.221. Vesicula seminalis saccular, extending upto the posterior margin of the acetabulum. Cirrus sac thin-walled, enclosing indistinct pars prostatica and cirrus.

Genital pore at level of oesophagus. Ovary transversely elongated, pretesticular, 0.083 - 0.996 x 0.113 - 0.115. Vitellaria follicular, extending from oesophagial level upto the hind end of the body, more confluent in the posterior region of the body. Uterus extending between ovary and acetabulum. Eggs few in number, operculate, 0.046 - 0.066 x 0.033 - 0.050. Excretory bladder tubular.

Discussion :

Of all the species coming under the genus Coitocaecum Nicoll, 1915, the new form closely resembles C. manteri Ahamed, 1980 in the position of testes, ovary, extent of vitellaria and nature of intestinal caeca. But it differs from this species in having a small oral sucker, and fewer number of eggs which are small sized. Further, the genital pore opens at the level of oesophagus behind pharynx. In this respect, the present form shows resemblence with *C. thaperi* Ahamed, 1980. However, in *C. thaperi*, the vitellaria extend from the hind margin of acetabulum, testes are separated from each other, ovary is triangular, and vesicula seminalis extends only one-third length of acetabulum. Hence, the present form is considered as a new species under the genus *Coitocoecum*, and named *Coitocaecum glossogobii* sp. nov.

Family Opecoelidae

Subfamily Opecoelinae

Genus Pseudopecoelina Yamaguti, 1942

Generic diagnosis :- Body elongate, unspined. Oral sucker ventroterminal, prepharynx present, pharynx well developed, oblong; oesophagus short, caeca forming cloaca at posterior extremity. Acetabulum prominent, but not pedunculate, near anterior extremity. Testes diagnol or tandem, in posterior half of body. No external seminal vesicle. Cirrus pouch long, extending far posterior to acetabulum, enclosing seminal vesicle, pars prostatica and long ejaculatory duct. Genital pore to left of oesophagus. Ovary median or submedian, pretesticular. No seminal receptacle. Laurer's canal present. Uterus coiled between ovary and acetabulum. Vitellaria occupying dorsal and lateral areas between acetabulum and anterior testis; but extending all round the body further behind. Excretory vesicle tubular. Intestinal parasites of marine teleosts.

Pseudopecoelina elongata Hafeezullah, 1971

Host : Lutianus johni

Site : Intestine

Incidence : 7/16

No. of parasites : 9

Locality : Off Cochin

Hafeezullah (1971) described this species from

Upeneus bensasi and *U. taeniopterus* from Mandapam and Madras, respectively (east coast of India). Measurements overlap fairly well with those given by Hafeezullah (1971). In other characteristics also there is agreement, and the specimens collected in the present study are treated as *P. elongata*. It is noted that the present specimens were collected from the west coast of India from a different host species.

ACANTHOCOLPIDAE Lühe, 1909

Acanthocolpidae Lühe, 1909

Family diagnosis :- Digenea with certain affinities to Lepocreadiidae on the one hand and to Echinostomatidae on the other, in life cycle pattern. Body with or without circumoral spines. Neck region enlarged or not, may be armed with spines or cuticular projections. Oral sucker usually small; prepharynx variable in length, occasionally absent. Pharynx present. Caeca terminating at or near posterior extremity, may open into excretory vesicle. Acetabulum comparatively small, near anterior extremity, sometimes closer to midbody than to anterior extremity. Testes tandem or diagonal, in posterior half of body. No external seminal vesicle. Cirrus pouch present. Ejaculatory duct usually developed, variable in length. Genital pore preacetabular. Ovary pretesticular. Vitellaria follicular, in hindbody, occasionally extending into forebody. Seminal receptacle usually absent. Uterus intercaecal, winding forward from ovary or descending as far as anterior or posterior testis. Excretory vescile Y-shaped. Parasites in fishes, occasionally in reptiles.

Acanthocolpinae Lühe, 1906

Subfamily diagnosis :- Body more or less elongated, sometimes slender, spinose or not. Eye spots present or not. Caeca opening into excretory vesicle or directly outside by ani, or ending blindly. Acetabulum prominent, may be subsessile, near anterior extremity. Testes tandem near posterior extremity. Cirrus pouch long, extending far posterior to acetabulum. Hermaphroditic duct long or short. Ovary immediately or some distance anterior to fore-testis. Seminal receptacle absent, exceptionally present; Laurer's canal present. Vitellaria in greater posterior part of body. Uterus confined to preovarian region.

Genus - *Tormopsolus* Poche, 1926

Generic diagnosis :- Body slender, eyespotted, spined. Oral sucker small, subterminal, without circumoral spines. Prepharynx long; pharynx well developed in relation to oral sucker; oesophagus short; caeca narrow, opening into excretory vesicle at posterior extremity. Acetabulum prominent, near anterior extremity. Testes median, tandem, in posterior part of the body, separated one from the other by vitellaria. Cirrus pouch long, extending far posterior to acetabulum, enclosing tubular winding seminal vesicle, prostate complex and spined ejaculatory duct. Hermaphroditic duct rather short, opening just in front of anterior testis, with vitellaria in between. No seminal receptacle. Laurer's canal present. Uterine coils preovarian; metraterm spined; eggs comparatively large. Vitellaria extending in lateral fields from behind cirrus pouch to posterior extremity, confluent in median field. Excretory vesicle Y-shaped; stem reaching to ovary. Intestinal parasites of marine teleos

Tormopsolus rastrelligeri sp. nov. (Fig. 3)

Host	: *Rastrelliger kanagurta*
Site	: Intestine
Incidence	: 1/195
No. of parasites	: 1
Locality	: Off Cochin

Body long, delicate, tapering towards anterior extremity and almost rounded in the posterior end, eye-spots not clear; spinose, spines confined to anterior quarter of the body. Body measures 2.95 x 0.437. Oral sucker terminal 0.075 x 0.087; acetabulum in anterior one third of the body, 0.087 x 0.100; sucker with ratio 1 : 1.3. Prepharynx long - 0.087, pharynx 0.037 x 0.035. Oesophagus very long, delicate almost three times longer than prepharynx, bifurcating far anterior to acetabulum. Genital pore median, immediately preacetabuluar. Testes two, close to each other, intercaecal, tandem, in the posterior one third of the body, anterior testis 0.250 x 0.188, posterior one 0.250 x 0.174, Cirrus sac long, intercaecal, extending from slightly in front of the midlevel of the body to the anterior margin of acetabulum. Cirrus sac contains a long seminal vesicle and a cirrus. Genital pore slightly anterior to the anterior margin of acetabulum. Ovary median, lying immediately anterior to the anterior testis - 0.087 x 0.120. Vitellaria follicular, extending from the anterior one quarter of the body to the

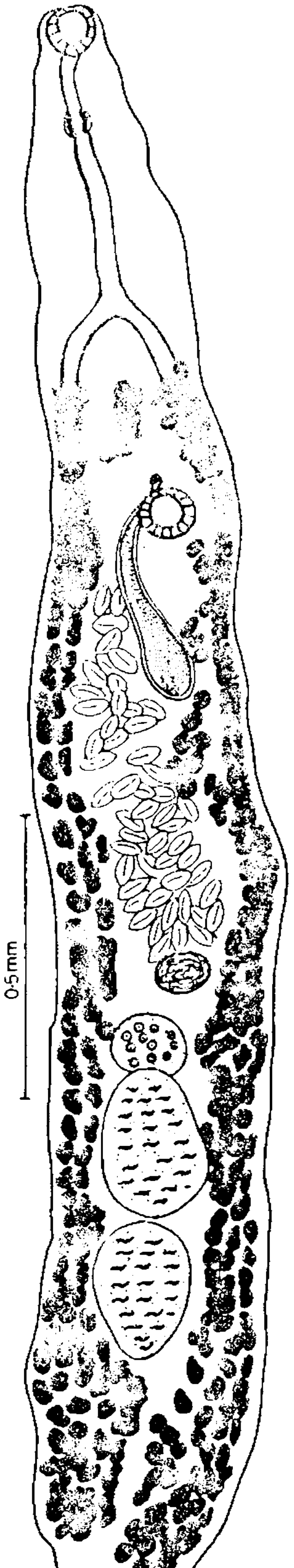


FIG 3 TORMOPSOLUS RASTRELLIGERI SP NOV

posterior end. They are largely extracaecal and circumcaecal but at certain places protrude into the intercaecal spaces, confluent with one another in the posttesticular area. Uterus extending intercaecally from ovary to almost the acetabular level. Eggs numerous, operculate, and measure 0.048 - 0.060 x 0.012 - 0.024.

Discussion :-

Yamaguti (1971) has listed six species under Tormopsolus. Parukhin (1965) described T. rhachicentri from the South China sea. Bilqees added two more forms, T. spatulatum Bilqees, 1972, and T. longisaccus Bhutta and Khan, 1975 (Cited from Bilqees, 1981). Madhavi (1976a), however, synonymized T. spatulatum with T. rhachicentri. The present form is smaller than all the forms described. Other major characteristic features of the present species different from the rest are (1) intestinal bifurcation far in front of acetabulum (2) long oesophagus, and (3) closely situated testis. Although T. spatulatum (= T. rhachicentri too has a long oesophagus, it is different from the present species, in having an unspined tegument, longer prepharynx, and widely situated testes and ovary. Moreover, the bifurcation of oesophagus is just anterior to acetabulum. Hence the present specimen is considered new and named Tormopsolus rastrelligeri sp. nov. It is noted that the host is also a new record.

Family-Acanthocolpidae

Subfamily-Acanthocolpinae

Acanthocolpus Lühe, 1906

Generic diagnosis :- Body cylindrical, more or less slender, unspined. Oral sucker subterminal, small, without circumoral spines. Prepharynx long; oesophagus short, caeca ending blindly near posterior extremity. Acetabulum subsessile, near anterior extremity. Testes median, directly tandem near posterior extremity. Cirrus pouch long, extending far posterior to acetabulum, enclosing seminal vesicle, prostatic complex and spined ejaculatory duct. Hermaphroditic duct long; its posterior half bearing spines similar to those of ejaculatory duct and metraterm. Genital pore just in front of short acetabular peduncle. Ovary just in front of anterior testis. Vitellaria extending sides of body from behind cirrus pouch to posterior extremity, confluent in post-testicular area. Uterus coiled in preovarian, intercaecal field; metraterm spined like cirrus. Parasitic in the intestine of marine teleosts.

Acanthocolpus liodorus Lühe, 1906

Host	:	Chirocentrus dorab
Site	:	Intestine
Incidence	:	3/7
No. of parasites	:	7
Locality	:	Off Cochin

The present specimens agree in all details with the original description. Yamaguti (1953) considered *A. luhei* Srivastava, 1939 as synonym of *A. liodorus*, and Caballero (1952), Manter (1963), and Madhavi (1976) also agree to this. However, a careful study of these specimens by Hafeezullah (1971a) has revealed that *A. luhei* does not agree with *A. liodorus* atleast in the anterior extent of vitellaria, larger sucker ratio and in the absence of acetabular peduncle. It was, therefore, considered by him as a valid species. Gupta and Jahan (1975), and Radhakrishnan and Nair (1979) also share this view. Gupta and Sharma (1972) also do not agree with the synonymy and uphold the validity of *A. luhei* in view of the extension of vitelline follicles which extend more anteriorly than in any of the species described under this genus. The specimens collected by Hafeezullah (1971a), Madhavi (1976), Radhakrishnan and Nair (1979), and in the present study were from the same host *Chirocentrus dorab*. It is noted that this tematode is found in *C. dorab* collected from the east and west coasts of India.

Family - Acanthocolpidae

Stephanostominae Yamaguti, 1958

Subfamily diagnosis:- Body elongate, sometimes slender, spinose, circumoral crown of spines present; prepharynx long; pharynx well developed, oesophagus short; caeca ending blindly at posterior extremity or opening into excretory vesicle. Acetabulum prominent, in anterior- or middle-third of the body. Testes tandem, in posterior part of body. Cirrus pouch elongate, reaching far posterior to acetabulum. Hermaphroditic duct long or short. Ovary median or submedian, pretesticular. Seminal receptacle usually absent; Laurer's canal present. Vitellaria in hindbody, commencing at varying levels. Uterus confined to region anterior to ovary. Excretory vesicle Y-shaped, with comparatively long stem.

Genus - Stephanostomum Looss, 1899

Generic diagnosis :- Body elongate or rather slender, sometimes filiform, occulate or not, spinose. Oral sucker terminal with circumoral spines in two complete alternating rows. Prepharynx long, pharynx longer than wide; caeca terminating blindly at posterior extremity, where they may open into the excretory vesicle. Acetabulum prominent, rather small, in anterior or middle third of body. Testes tandem in posterior part of body. Cirrus pouch elongate, reaching far posterior to acetabulum. Hermaphroditic duct reduced, or may be long. Genital pore preacetabular.

Ovary pretesticular, median, or submedian. No seminal receptacle. Uterus winding between ovary and acetabulum; eggs large. Vitellaria circumcaecal, commencing at level of acetabulum or more posteriorly. Excretory vesicle Y-shaped, bifurcating between ovary and anterior testis. Parasitic in intestine or stomach of marine teleosts.

Stephanostomum orientalis (Srivastava, 1939a) Madhavi, 1976

Host : *Sciaena* sp. and *Platycephalus* sp.
Site : Intestine
Incidence : 8/168 and 1/21
No. of parasites: 14 and 3
Locality : Cochin

Srivastava (1969a) described specimens collected from *Caranx kalla* from Puri, Bay of Bengal as *Acanthocolpus orientalis*. Madhavi (1976) collected the same species from Carangids of Bay of Bengal, and considered them as identical to those collected by Srivastava (1939a). Judging from the close similarities, it was presumed by Madhavi (1976) that the spines surrounding the oral sucker were lost in Srivastava's specimen due to maceration. Hence, these specimens were transferred to the genus *Stephanostomum* and designated as *S. orientalis* (Srivastava, 1939a) Madhavi, 1976. The specimens collected in the present study are quite identical to *S. orientalis*. The measurements overlap fairly well with the descriptions. The present specimens were collected from the west coast of India, but the hosts are new records.

MONASCIDAE (Dollfus, 1952) emended Yamaguti, 1971

Monascidae (Dollfus, 1952) emended Yamaguti, 1971

Family diagnosis :- Digenea with unknown family relationships; life history unknown. Body slender nearly cylindrical. Oral sucker subterminal, with longitudinally elongated opening; pharynx longer than wide; caeca single; running on the right of median line, opening into excretory vesicle at extreme posterior end of body. Acetabulum comparatively small, in anterior third of body. Testes tandem in posterior half of body. Cirrus pouch preacetabular, containing bipartite seminal vesicle and muscular pars prostatica. Genital pore submedian, preacetabular. Ovary in anterior half of body. Vitellaria extending along each side of body between acetabulum and anterior or posterior testis. Uterus filling up entire hindbody. Excretory vesicle V-shaped; arms reaching to oral sucker. Intestinal parasites of marine teleosts.

Genus - Monascus Looss, 1907

Generic diagnosis :- Body much elongated, nearly cylindrical. Oral sucker subterminal. Prepharynx extremely small; pharynx elongated oval; intestinal caecum single to right side of median line, usually opening into excretory vesicle. Genital pore submedian, preacetabular. Testes tandem, postequatorial. Cirrus sac small, preacetabular or partly to one side of acetabulum. Vesicula seminalis bipartite; pars prostatica followed by small ductus ejaculatorius. Ovary pretesticular, preequatorial.

Vitellaria of small follicles, lateral, from behind acetabulum to anterior or posterior testis. Uterus large, much coiled, filling up almost entire postacetabular body. Excretory vesicle Y-shaped, arms long reaching oral sucker. Parasitic in marine fishes.

Monascus typicus (Odhner, 1911) Yamaguti, 1954

Host : *Megalaspis cordyla*, *Caranx kalla*,and *Decapterus russelli*
Site : Stomach and Intestine
Incidence : 23/174, 23/174,and 3/30
No. of parasites : 62, 32,and 10
Locality : Off Cochin

Occurence of this species from Indian region has been reported by Hafeezullah and Siddiqi (1970) from the intestine of *Decapterus russelli* caught at Cochin. This species has further been recorded by Madhavi (1975 a) from *Pampus argentius*, from the east coast of India, and by Karyakarte and Yadav (1976) from *Platycephalus macrocanthus*, collected from Ratnagiri, west coast of India. In the present study this species was recorded from yet another host, *Megalaspis cordyla* from the west coast of India.

Srivastava (1941 a) described *Monascus orientalis* (= *Haplocladus orientalis*) and has stated that *M. orientalis* differed from *M. typicus* in "..... the extent of vitellaria which reach the level of the posterior testis in the Indian species, while in *M. typicus* they stop in front of the anterior testis". Srivastava (1982) has indicated that in *M. typicus* the vitellaria extend upto the anterior level of posterior testis whereas in *M. orientalis* they extend upto the posterior level of posterior testis or beyond. Although the figure of *M. typicus* by Odhner (1911) shows the vitellaria terminating at the level of the anterior portion of the anterior testis, in the discription he has stated that the vitellaria reach posteriorly to the posterior testis. Fischthal and Kuntz (1963 a) observed that the vitellaria terminate at the anterior margin of the anterior testis or it may terminate at the level of approximately 47 to 70% of distance between testes. Karyakarte and Yadav (1976) have indicated that the extension of vitellaria varies from specimen to specimen in the species. In the present study also such variation was observed. Karyakarte and Yadav (1976) concluded that these two species, *M. typicus* and *M. orientalis*, are one and the same. In the light of this conclusion, the specimens recovered from *Caranx kalla* (23/174; No. of parasites - 32), and *Decapterus russelli* (3/30; No. of parasites - 10), although small sized, are also treated as *M. typicus*. Køie (1979) has remarked that a redescription is necessary to see whether *M. orientalis* is a valid species. Although *M. typicus* has been recorded from various localities in the world (KØie, 1979), she feels that *M. minor* and *M. typicus* are synomyms of *M. filiformis*. Fischthal and Thomas (1968) have recorded "The redescription of *M. filiformis* by Dollfus (1947) indicates characteristics which overlap those of *M. typicus*. The latter may be a synonyms of the former, but final decision must await life cycle studies" Nahhas and Powell (1971) have opined that "If there are any differences between *M. filiformis* and *M. typicus* they have to be sought in features other than gonad topography and egg size. It is quite possible that *M. typicus* is not a valid species, but the authors hesitate to reduce it to synonying on the basis of a single specimen".

FELLODISTOMIDAE Nicoll, 1913

Fellodistomidae Nicoll, 1913

Family diagnosis :- Body plump or elongate, rather stout. Oral sucker and pharynx present. Oesophagus usually short, sometimes long. Caeca moderately long, sometimes short or long, occasionally united anteriorly. Acetabulum large or medium-sized usually well apart from oral sucker. Testes usually in hindbody, symmetrical oblique or tandem, exceptionally single. Cirrus pouch usually not extending posterior to acetabulum. Pars prostatica enclosed in cirrus pouch, usually well developed. Genital pore median, submedian, sublateral or posttesticular; seminal receptacle present or absent. Laurer's canal present. Vitellaria lateral, usually rather limited in extent, divided into follicular or tubular acini, or forming bunch-like groups, eceptionally compact. Uterus variable in extent. Excretory vesicle V, U or Y-shaped, occasionally tubulo-saccular, with arms not united anteriorly. Parasites of marine, freshwater or brackishwater fishes.

Baccigerinae Yamaguti, 1958

Subfamily diagnosis :- Body oval, round to elongate, very small with cephalic gland cells strongly developed in neck or shoulder region. Oral sucker subterminal or practically terminal; pharynx small or rather well developed; oesophagus moderately long; caeca short, half-long or longer. Acetabulum usually larger than oral sucker, in anterior half of body. Testes symmetrical or subsymmetrical, postacetabular, in middle third of body, just medial to caeca. Cirrus pouch variable in development, occassionally very weekly developed or practically absent, anterior or dorsal to acetabulum, may extend further posteriorly than acetabulum; containing bipartite seminal vesicle, distinct or indistinct prostatic complex and short cirrus. Genital pore close to intestinal bifurcation or just preacetabular. Ovary lobed or not, median or submedian, postequatorial, posttesticular. Vitellaria compact, more or less closely massed together in extracaecal fields in acetabular, acetabulotesticular or bifurcovarian zone. Uterus occupying entire or almost entire hindbody. Excretory vesicle V-shaped. Intestinal parasites of marine and brackishwater fishes.

Genus - Pseudopentagramma Yamaguti, 1971, emended

Syn. Pentagramma Chulkova, 1939, preoccupied

Generic diagnosis :- Body elongate or ovoid, small non-spinous with dermal gland-cells strongly developed along each side of forebody. Oral sucker subterminal; pharynx small, oesophagus short, or moderately long. Caeca narrow or broad, ending some distance short of posterior extremity. Acetabulum a little larger than oral sucker or very large. Testes symmetrical or subsymmetrical, post acetabular. Cirrus pouch anterodorsal to acetabulum, indistinct, adhearing close to seminal vesicle. Genital pore immediately postbifurcal. Ovary median, posttesticular, lobed or unlobed. Vitellaria compact or consisting of large follicles massed together, between acetabulum and testes, sometimes between testes and ovary or postovarian, intercaecal or extracaecal. Uterus occupying entire hindbody; eggs small. Excretory vesicle present. Parasites of marine teleosts.

Pseudopentagramma nemipteri sp. nov. (fig. 4).

Host : *Nemipterus japonicus*
Site : Stomach/Intestine
Incidence : 8/37
No. of parasites : 11
Locality : Off Cochin

Specific diagnosis (based on 4 specimens)

Body ovoid 0.651 - 0.816 x 0.360 - 0.420

Cuticle non-spinose. Oral sucker subterminal, round, 0.084 to 0.120 in diameter. Ventral sucker very large, wider than long, 0.156 - 0.180 x 0.216 - 0.228, in the anterior half of the body. Prepharynx not seen. Pharynx 0.026 - 0.032 x 0.031 - 0.042. Caecal bifurcation preacetabular, caeca broad, extend almost to the posterior end. Testes entire, symmetrical and postacetabular 0.036 - 0.060 x 0.060 - 0.096. Cirrus pouch anterodorsal to acetabulum, indistinct, adhearing close to seminal vesicle. Genital pore preacetabular and postbifurcal.

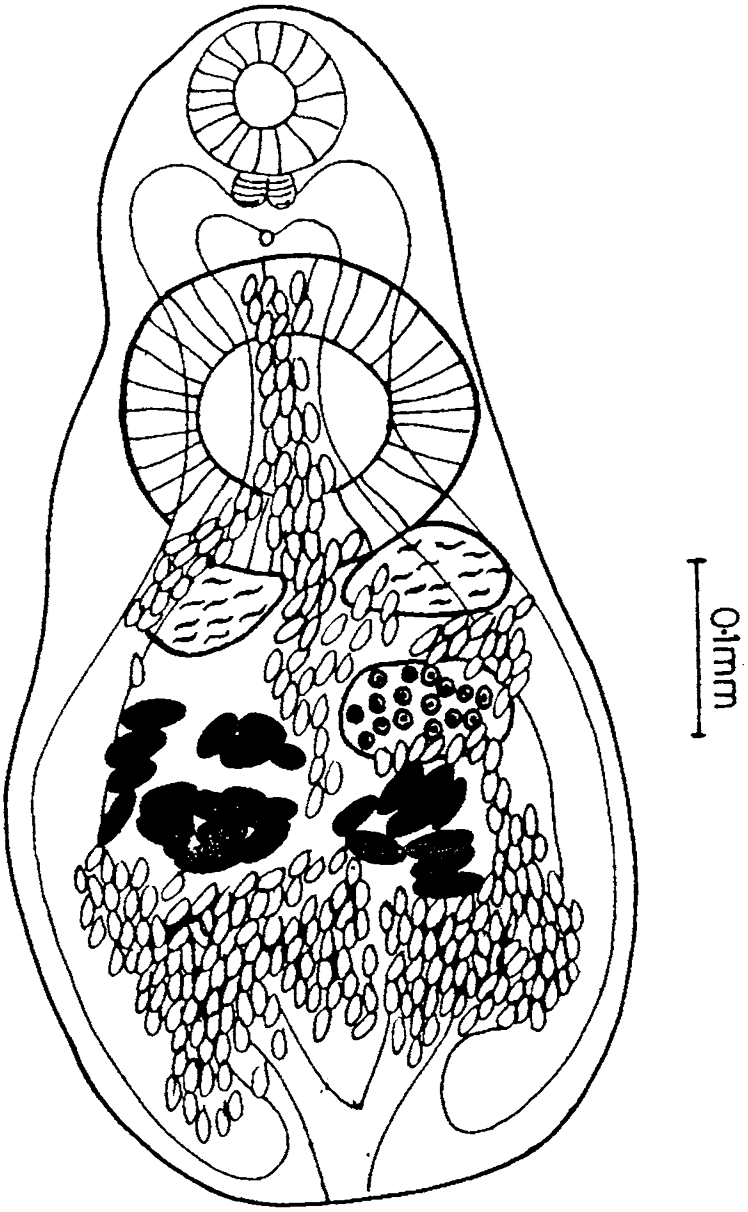


FIG.4. PSEUDOPENTAGRAMMA NEMIPTERI SP. NOV.

Ovary 0.048 - 0.060 x 0.108 - 0.216, entire, median and posttesticular. Vitellaria consisting of large follicles massed together, at ovarian or postovarian levels. Uterus filling the posterior half of the body. Eggs numerous 0.024 - 0.033 x 0.012 - 0.018. Excretory vesicle Y-shaped with short stem, arms reaching to almost oral sucker.

Discussion :- Chulkova (1939) proposed *Pentagramma* for three specimens of a trematode from the pyloric caeca of *Alosa kessleri pontica* from the Black sea, which she named *P. symmertricum*. Further records of this trematode from the type and other hosts were published (See, Margolis and Ching, 1965). On the basis of Chulkovas' somewhat incomplete account of *P. symmetricum*, Yamaguti (1958) created the subfamily Pentagramminae, containing only *Pentagramma*, within the Fellodistomatidae. Margolis and Ching (1965) reviewed the trematode genera *Bacciger* and *Pentagramma*. They gave additional details of morphology for *P. symmetricum*, and *Monorcheides* (?) *petrowi* (Layman, 1930) was transferred to the genus *Pentagramma*. Accordingly, *Pentagramma* consisted of 2 species; *P. symmerticum* Chulkova, 1939 as the type species, and *P. petrowi* (Layman, 1930) n. comb. Yamaguti (1971) created the genus *Pseudopentagramma* and transferred these two species of *Pentagramma* under the new genus. He transferred *Orientophorus caspialosa* (Kurochkin, 1964) also under this new genus. As such, the three species listed under Pseudopentogramma are P. symmetricum, P. petrowi, and P. caspialosae. P. symmetricum was recorded from the Black Sea, P. petrowi from the Sea of Japan, Bering Sea, and the Pacific Ocean (Margolis and Ching, 1965), and P. caspialosae from the Caspian Sea (Kurochkin, 1964).

In having a large acetabulum which is almost two and half times larger than the oral sucker and the extent of intestinal caeca to almost the posterior end of the body, and in having an unlobed ovary, the present species differs from the other three species of Pseudopentagramma, and hence it is considered as a new species. This is the first record of this genus from Indian waters. The species is designated as Pseudopentagramma nemipteri sp. nov.

Family - Fellodistomidae

Discogasteroidinae Srivastava, 1939

Subfamily diagnosis :- Body oval to pyriform, spined or not. Oral sucker may be unusually large and provided with lip-like margin. Caeca short not surpassing acetabulum. Acetabulum very large, discoid and weakly muscular or sucker-like and muscular, often emarginate in median line, somewhat nearer to posterior extremity than to anterior. Testes symmetrical or subsymmetrical, in acetabular or postacetabular zone. Cirrus pouch well developed, anterior or anterodorsal to acetabulum. Ovary median, submedian or lateral immediately pretesticular or between and anterior to testes, occasionally placed more anteriorly and level with anterior end of acetabulum. Seminal receptacle present or absent. Vitellaria in two lateral clusters anterior to testes or acetabulum, surrounding caeca or lateral to them. Uterine coils largely in hindbody, may extend into forebody. Excretory vesicle Y, V or U-shaped. Parasites of fishes.

Odontocotyle (Hafeezullah et Siddiqi, 1970) Hafeezullah et Siddiqi, 1971 (cited from Srivastava, 1982)

Generic diagnosis :- Body elongate, pyriform, spinose. Acetabulum discoid, emarginate. Oral sucker ovate with a pair of tusk-shaped cuticular structurers projecting into oral cavity from anterior end of body. Mouth longitudinally slit-like. Prepharynx and pharynx present, oesophagus comparatively long; caeca short, saccular to claviform. Testes symmetrical or subsymmetrical, posterior or posterodorsal to acetabulum. Cirrus sac elongate, usually oblique, between acetabulum and caecal arch, containing bipartite seminal vesicle, tubular pars prostatica surrounded by well developed prostate cells and large protrusible cirrus beset with spines. Genital pore submedian, postbifurcal. Ovary spherical, dorsal or posterior to acetabulum, pretesticular. Seminal receptacle and Laurer's canal present. Vitellaria follicular, in two lateral clusters, preacetabular. Uterus in hindbody. Excretory vesicle undetermined.

Odontocotyle arabi (Hafeezullah et Siddiqi, 1970)
Hafeezullah et Siddiqi, 1971

Host : *Drepane punctata*
Site : Intestine
Incidence : 3/4
No. of parasites : 32
Locality : Off Cochin

The present specimens agree closely with the original description of Hafeezullah et Siddiqi (1970). The host is also the same. The two tusk-like structurers associated with the oral sucker are clearly seen. Madhavi (1975 a) also reported this species from the same host species.

HEMIURIDAE Looss, 1899

Family Hemiuridae Looss, 1899

In the present study, for identification of the members of this family, the classification of Gibson and Bray (1979) has been followed.

Family diagnosis :- Body usually small but elongate. Ecsoma present, occasionally reduced or vestigial. Body-surface smooth or with annular plications; the latter occasionally being serrate giving a scaley appearence. Presomatic pit or ventro-cervical groove occasionally present. Oral and ventral suckers well developed; usually close together. Pharynx well developed. Oesophagus usually short. 'Drüsenmagen' normally present. Gut-caeca terminate blindly; usually within ecsoma. Testes two; tandem, oblique or symmetrical; preovarian; in hindbody. Seminal vesicle tubular, saccular or constricted into portions, muscular or thin-walled, in fore-or hindbody. Pars prostatica of variable length; usually tubular, but ocasionally vesicular, may be linked to seminal vesicle by aglandular duct. Ejaculatory duct, if present, usually short. Sinus-sac usually well developed, occasionally reduced or absent. Prostatic or ejaculatory vesicle occasionally present within sinus-sac. Hermaphroditic duct usually enclosed within sinus-sac.

Permanent sinus-organ and genital atrium well developed, small or absent; temporary sinus-organ may form hermaphroditic duct in some cases. Genital pore mid-ventral at level of oral sucker or pharynx. Ovary oval, usually entire, posttesticular. Mehlis' gland postovarian. Laurer's canal, and canalicular or blind seminal receptacle absent. Juel's organ and uterine seminal receptacle present. Uterus coiled mainly in pre- and/or postovarian region of hindbody; few or no coils present in forebody; initially decending into or towards ecsoma and then ascending towards forebody. Eggs numerous; small embryonated; rarely with a polar filament. Vitallarium varies between forms with seven tubular branches (three on one side of body, four on the other) and forms with two distinct, oval masses; mainly postovarian. Excretory vesicle Y-shaped; arms united in forebody or not. Parasitic mainly in the gut, especially stomach, of marine teleosts, occasionally present in gut of freshwater teleosts and lung of sea-snakes.

Elytrophallinae Skrjabin and Guschanskaja, 1954

Subfamily diagnosis :- Ecsoma well developed. Body surface smooth or plicated. Pre-somatic pit absent, but ventrocervical groove often present. Testes tandem to symmetrical, usually oblique. Seminal vesicle with exceptionally thick muscular wall; oval, not constricted into portions; present in forebody, dorsal to ventral sucker or in hindbody. Pars prostastica tubular; long or short; usually linked to seminal vesicle by short aglandular duct. Sinus-sac present; commonly tubular, long; not enclosing ejaculatory or prostatic vesicle. Sinus-organ usually well developed, but delicate and amuscular. Genital atrium usually deep (depending upon contraction). Ovary oval. Eggs rarely filamented. Vitellarium seven tubular to tear-shaped lobes, three on one side, four on the other, which may form rosette. Excretory arms united in forebody. Parasitic mainly in stomach of marine teleosts.

Genus - *Lecithocladium* Lühe, 1901

Generic diagnosis :- Body-surface with plications. Oral sucker often funnel-shaped. Pharynx elongate. Seminal vesicle large; in hindbody. Pars prostatica long and sinus; mainly or entirely in hindbody. Sinus-sac tubular; narrow; not reaching level of seminal vesicle and usually entirely or mainly in forebody. Vitelline lobes long and tubular. Parasitic in stomach of marine teleosts.

Lecithocladium excisum (Rud., 1819) Lühe, 1901

Host : *Rastrelliger kanagurta* and *Pampus argenteus*

Site : Intestine

Incidence : 83/195 and 45/145

No. of parasites : 179 and 117

Locality : Off Cochin

Dawes (1946) has declared L. excisiforme as synonym of L. excisum. Manter (1954), Fischthal and Kuntz (1963), Nahhas and Short (1965), and Yamaguti (1971) have concurred with this view. But Radhakrishnan and Nair (1979) observed that there are some major differences between the two and the synonimity drawn by the above authors has to be further checked.

Gupta and Sehgal (1970) described L. excisiforme from Stromateus niger and Trygon sp. from Bombay, and Radhakrishnan and Nair (1979) from Parastromateus niger from Trivandrum. My observation also tally with the original description of the species. The hosts are new records from Indian waters.

Family - Hemiuridae

Subfamily - Elytrophallinae

Lecithocladium harpodontis (Srivastava, 1937) Chauhan, 1954

Host	:	*Parastromateus niger*
Site	:	Stomach/intestine
Incidence	:	6/152
No. of parasites	:	12
Locality	:	Off Cochin

This species was originally described by Srivastava (1937) as *L. harpodoni*. Chauhan (1954) recorded this species from *Chrysophrys datnia* from Puri, east coast of India. The specimens collected in the present study are similar to *L. harpodontis* and is considered as same. The host is a new record.

Family - Hemiuridae

Subfamily - Elytrophallinae.

Lecithocladium aegyptensis Fischthal and Kuntz, 1963

Host	:	Rastrelliger kanagurta
Site	:	Intestine
Incidence	:	2/195
No. of parasites	:	2
Locality	:	Off Cochin

Fischthal and Kuntz (1963) recorded this species from Pomadasys olivaceus collected from Egypt. Except for slight increase in measurements, the specimens collected in the present study look exactly like L. aegyptensis, and hence it is considered the same. The host is a new record and L. aegyptensis is a new record from Indian waters.

L. aegyptensis appears to be more similar to L. excisum. It is distinguishable from the latter, being much smaller in all respects. Additionally, it differs in lacking a neck-hump, in the more posterior position of the seminal vesicle, and in the deep lateral incisions of the ventral lip rather than just notches (Fischthal and Kuntz, 1963).

Family - Hemiuridae

Subfamily - Elytrophallinae

Genus - Elytrophalloides Szidat, 1955 emended

Generic diagnosis :- Body surface with plications. Seminal vesicle large, reaching back to level of testes. Pars prostatica sinuous, in the hind region. Sinus-sac long, narmally reaching back level of seminal vesicle. Vitelline lobes tearshaped or long and tubular. Parasitic in stomach of marine teleosts.

Elytrophalloides rastrelligeri sp. nov. (Fig. 5)

Host	:	Rastrelliger kanagurta
Site	:	Stomach
Incidence	:	1/195
No. of parasites	:	1
Locality	:	Off Cochin

Specific diagnosis : (description based on one specimen)

Body elongate with tail protruded, total length 2.075, maximum width being at level of vitellaria, 0.714. Cuticle with plications; conspicuous in the anterior half of the soma. Oral sucker, spherical, subterminal, 0.083 x 0.116. Pre-pharynx absent. Parynx very small. Oesophagus short. Caeca reaching the posterior end of the tail. Acetabulum fairly large 0.216 x 0.249. Sucker ratio 1 : 2.12.

Testes ovoid, 0.099 x 0.199, nearly symmetrical in anterior half of the body. Seminal vesicle very large,

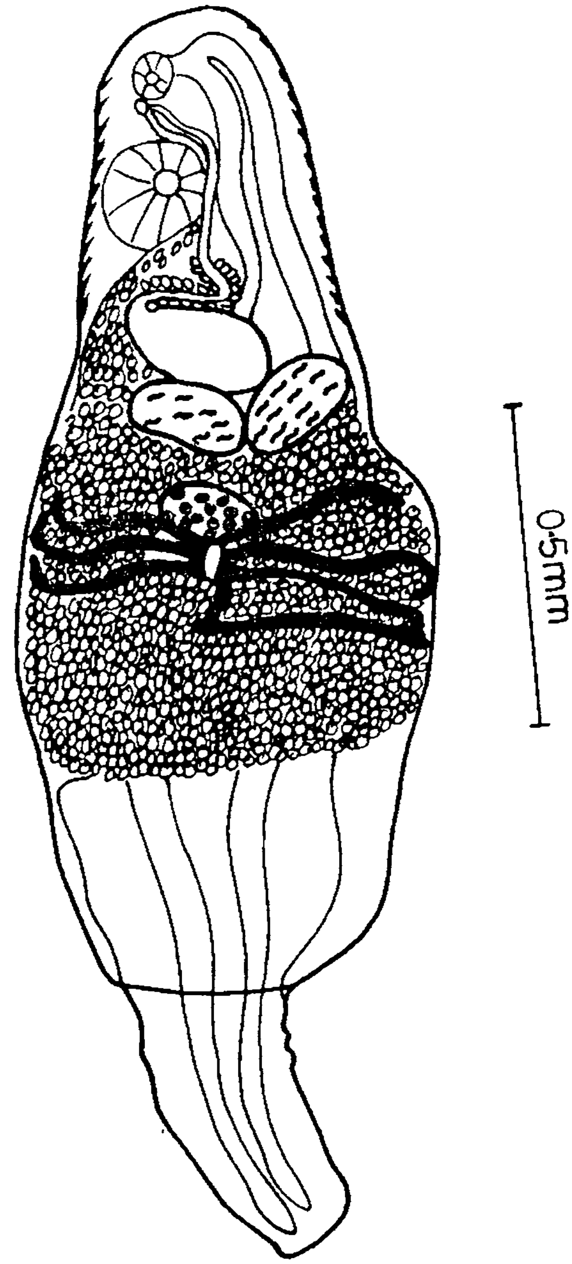


FIG. 5. ELYTROPHALLOIDES RASTRELLIGERI SP. NOV.

thickwalled, oblique to body axis and anterodorsal to testes, measures 0.166 x 0.282. Pars Prostatica narrow, tubular giving a sinuous appearance to pars prostatica at the seminal vesicle region, winding anterolateral to seminal vesicle surrounded by dense layer of prostatic cells. Sinus sac long, tubular, thick-walled and enclosing the hermaphroditic duct, reaching back to the level of seminal vesicle, genital pore opening ventral to oral sucker. Ovary ovoid, posttesticular 0.099 x 0.199. Vitellaria devided into seven long digitiform tubes, 0.693 - 0.735 long. Uterus convoluted, anterior and posterior to vitellaria. Eggs very small, numerous and thin-walled, 0.01 - 0.015 x 0.015 - 0.020.

Discussion :- The only other species under this genus is *E. merlucci* Szidat, 1955. In *E. merlucci*, the intestinal caeca terminate at the posterior end of the soma, testes are oblique, seminal vesicle saccular and vitellaria are short, digitiform. The present species differs from *E. merlucci* in all these characters, and hence it is considered as new species,and designated as *Elytrophalloides rastrelligeri* sp. nov. This genus is recorded for the first time from the Indian waters, and the host is a new record.

Family - Hemiuridae

Subfamily - Lecithochiriinae Lühe, 1901

Subfamily diagnosis :- Ecosoma usually well developed, occasionally reduced. Bodysurface usually smooth, but occasionally plicated or rugate. Muscular 'shoulder pads' present or absent. Presomatic pit and ventrocervical groove present or absent. Testes tandem to symmetrical, usually oblique. Seminal vesicle elongate; constricted into two portions, which are occasionally separated by a duct or tubular and convoluted, in bipartite forms anterior half may have thicker wall; normally in forebody, but forms with halves separated by duct may extend into hindbody. Pars prostatica short, vesicular or tubular; may extend slightly into base of sinus-sac; linked to seminal vesicle by short, aglandular duct. Sinus-sac present; rarely of 'open' type; enclosing distinct ejaculatory or prostatic vesicle and metraterm. Permanent sinus-organ absent. Genital atrium usually small or absent, occasionally well developed. Ovary oval. Uterus mainly pre-ovarian or roughly equally distributed in pre-and post-ovarian fields. Eggs without filaments. Vitellaria seven, digitiform to oval lobes in lateral groups of three and four, or with tendency to become two distinct lateral masses which often exhibit three and four lobes. Excretory arms united in forebody. Normally parasitic in gut of marine teleosts.

Genus - Lecithochirium Lühe, 1901

Generic diagnosis :- Ecsoma well or poorly developed. Body-surface smooth. Pre-oral lobe rarely with two lateral knobs. Presomatic pit and/or ventrocervical groove often present. Seminal vesicle bipartite, tripartite or occasionally coiled; in forebody. Pars prostatica tubular, with wide lumen, vesicular. Short narrow extension of pars prostatica and/or ejaculatory duct may be present within sinus-sac. Ejaculatory (or prostatic) vesicle linked posteriorly to antero-dorsally with pars prostatica or ejaculatory duct. Temporary sinus-organ may form. Vitellarium two lateral masses; usually divided into three and four oval to digitiform lobes. Parasitic in gut (mainly stomach) of marine teleosts.

Lecithochirium polynemi Chauhan, 1954

Host	:	Trichiurus savala and Tachysurus sp.
Site	:	Stomach
Incidence	:	61/189 and i/11
No. of parasites	:	216 and 2
Locality	:	Off Cochin

This species was first described by Chauhan (1945) as Lecithochirium polynemus, and subsequently renamed by him as L. polynemi (Chauhan, 1954). The same species was again recorded from Indian waters by Gupta and

Mehrotra (1970), and Gupta and Sehgal (1970) from *Trichiurus haumela*, and by Radhakrishnan and Nair (1979), and by me from *Trichiurus savala*. *Tachysurus* sp. is a new host record for this species, all hosts from the west coast of India. My observations with regard to this species tally well with the description of the species by Chauhan (1954).

Family - Heminuridae

Subfamily - Lecithochiriinae Lühe, 1901

Lecithochirium acutum

Host : *Trichiurus savala* and *Platycephalus* sp.

Site : Stomach

Incidence : 73/189 and 1/21

No. of parasites : 316 and 1

Locality : Off Cochin

This species was originally described by Chauhan (1945) as *Lecithochirium acutus*, and later renamed as *L. acutum* by him (Chauhan, 1954). This species was recorded again from Indian waters by Gupta and Mehrotra (1970) and by Gupta and Sehgal (1970) from *Trichiurus haumela*. In the present study this species was collected from *Trichiurus savala* and *Platycephalus* sp. all from the west coast of India. The measurements overlap well with those given by the other workers. The hosts are new records.

Family - Hemiuridae

Dinurinae Looss, 1907

Subfamily diagnosis :- Ecsoma well developed; occasionally large. Body surface plicated or smooth (apparently occasionally striated). Presomatic pit absent. Testes symmetrical to tandem, usually oblique. Seminal vesicle thin-walled; oval to tubular; may be constricted into two or four portions; in forebody, dorsal to ventral sucker or in hindbody. Pars prostatica tubular or vesicular; short or long may be linked to seminal vesicle by aglandular duct. Sinus-sac present; small or large; usually oval not enclosing a prostatic vesicle. Permanent sinus-organ large and muscular, reduced to small papilla or apparently absent. Genital atrium usually well developed; deep or shallow (often depending upon contraction). Ovary usually oval; occasionally reniform or lobed. Terminal portion of uterus may or may not form distinct vesicle just outside sinus-sac. Vitellaria normally seven tubular lobes; three on one side, four on the other. Excretory arms united or not, united in forebody. Normally parasitic in stomach of marine teleosts.

Genus - Ectenurus Looss, 1907

Generic diagnosis :- Body-surface with plications. Seminal vesicle saccular, tubular, or divided into two or three sections; postero-dorsal to ventral sucker or in anterior hindbody. Pars prostatica short (? or missing); connected to seminal vesicle by long, aglandular duct. Sinus-sac and permanent sinus-organ present; small. Ovary oval. Excretory arms not united in forebody.

Ectenurus lepidus Looss, 1907

Host	:	*Caranx kalla*
Site	:	Stomach and intestine
Incidence	:	40/174
No. of parasites	:	89
Locality	:	Off Cochin

This species differs from the most closely similar *E. americanus* (Manter, 1947, Manter and Pritchard, 1960) in sucker ratio and egg size. In these respects it is intermediate between *E. trichuri* (Yamaguti 1934; Manter and Pritchard 1960) and *E. leiognathi* (Yamaguti, 1953; Manter and Pritchard, 1960) on one hand, and *E. americanus* on the other.

This species occurs in a variety of hosts (Manter, 1954; Manter and Pritchard 1960; Yamaguti 1971). The measurements fall within the range given for the species (Yamaguti, 1970, 1971). The sucker ratio is 1 : 2.7 - 3.2, which is almost the ratio given by Manter (1954). Although many members of Carangidae act as definitive hosts for this species, the host recorded in the present study is new. This trematode is recorded for the first time in India.

Family - Hemiuridae

Subfamily - Dinurinae

Ectenurus rastrelligeri sp. nov. (Fig. 6)

Host	:	Rastrelliger kanagurta
Site	:	Stomach
Incidence	:	2/195
No. of parasites	:	5
Locality	:	Off Cochin

Specific diagnosis: (description based on two specimens)

Body elongate with plications, tapering at both the ends, 2.52 - 2.74 x 0.448 - 0.498, the maximum width being at the posterior end of the soma. Tail distinct with its proximal part invaginated into the body. Oral sucker subterminal, with inconspicuous preoral lobe, 0.083 - 0.099 in diameter. Prepharynx absent, pharynx 0.055 - 0.05. Oesophagus bulbus and caeca extend into the tail and terminate at midlevel of the tail. Acetabulum very large, round in outline, 0.40 x 0.415 and situated in the anterior third of the body. Sucker ratio 1:4.2 - 4.8.

Testes contiguous, almost oval, obliquely tandem, in the anterior two third of the body, 0.133 x 0.083 - 0.166 x 0.133. Seminal vesicle saccular but divided into two sections, reaching to near the anterior testis. Pars prostatica short, connected to seminal vesicle by long aglandular duct. Sinus sac present,

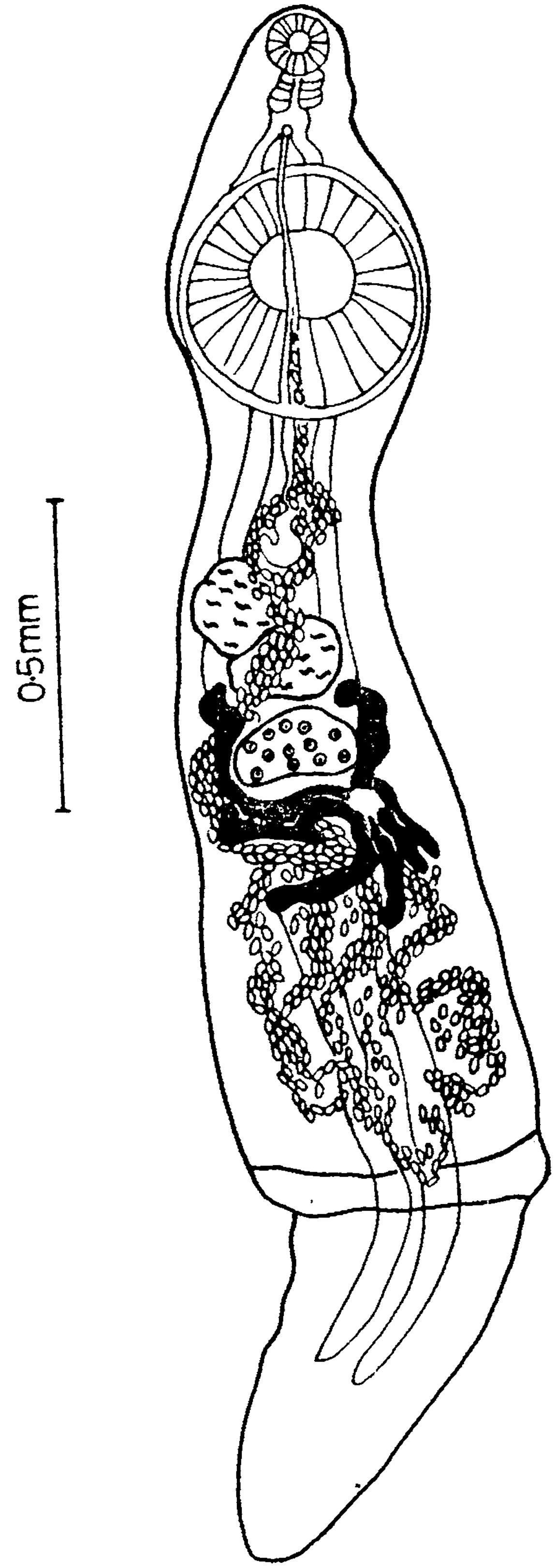


FIG. 6. *ECTENURUS RASTRELLIGERI* SP. NOV.

sinous organ inconspicuous. Hermaphroditic duct narrow, straight, and genital atrium open ventral to oral sucker. Ovary beanshaped, with entire margin 0.099 x 0.232 - 0.099 x 0.244, ventral, in posterior half of the body, separated from the testes. Vitellaria consisting of seven tubular lobes, two anteriorly directed lobes almost embracing the ovary. Main bulk of uterus consisting of ascending and descending coils immediately behind vitellaria, not extending into tail., distant ascending uterus passes between ovary and the dorsal side of the posterior testes. Eggs elliptical.

Discussion :- Yamaguti (1971) has listed eleven species including the type species E. lepidus, and Bilqees (1981) has recorded two more. Of all the forms, the present species shows some similarity with E. virgula Linton, 1910, E. trachuri, (Yamaguti, 1934) Manter et Pritchard, 1960, E. labeonis (Fischthal et Kuntz, 1963) Yamaguti, 1971; and E. minutes Zaidi and Khan, 1977 (cited from Bilqees, 1981). E. virgula is small sized, and in this species the uterus extends into ecsoma, sucker ratio is less and testes and ovary are round and very close to the ventral sucker. In E. trachuri the sucker ratio is small, testes are small sized, and testes and seminal vesicle are at acetabular level. E. labeonis is small sized, the sucker ratio is 1:3.05, seminal vesicle is tripartite, and pars prostatica very long. Fischthal and Kuntz (1963) have indicated that the uterine coil may enter ecsoma in extended specimens. *E. minutus* is also small sized, and caeca extend to almost the posterior end of the tail. Testes are somewhat triangular-shaped and seminal vesicle is situated at acetabular level.

Since the present species is distinctly different from other species, it is considered as a new species and named *Ectenurus rastrelligeri* sp. nov.

Family - Hemiuridae

Subfamily - Dinurinae

Genus - Indostomachicola Gupta et Sharma, 1973, emended

Generic diagnosis :- Body very long, subcylindrical and muscular, tail longer than body proper or slightly smaller. Anterior extremity not curved ventrad. Body paranchyma not refractive throughout. Oral sucker surmounted by prominent preoral lobe. Prepharynx absent. Pharynx present. Oesophagus short. Caeca prominently shouldered, immediately after bifurcation. Caeca more or less sinuous and extending to posterior extremity. Postbifurcal pit present. Acetabulum large, close to anterior extremity. Testes oblique or tandem, postacetabular. Seminal vesicle large, saccular, postacetabular and pretesticular. Pars prostatica winding, dorsal to acetabulum. Hermaphroditic duct present, not enclosed in a pouch. Genital atrium tumbler-shaped, genital pore posterior or ventral to pharynx. Ovary bigger than testes or smaller, posttesticular. Receptaculum seminis absent. Vitelline tubules consist of seven tubules running through uterine coils, may not extend into tail. Uterine coils extend into tail, and circumcaecal or not. Eggs small, numerous, unfilamented. Excretory vesicle Y-shaped. Intestinal and stomach parasites of fishes.

Indostomachicola thynni sp. nov. (Fig. 7)

Host : Thynnus sp.
Site : Stomach/intestine
Incidence : 3/7
No. of parasites : 24
Locality : Off Cochin

Specific diagnosis: (Description based on 6 specimens)

Body surface plicated, long, subcylindrical and slightly dilated at the posterior end, 2.324 - 5.146, tail almost as long as the body, narrows posteriorly, 2.573 - 4.731. Oral sucker roughly spherical, subterminal, surmounted by preoral lobe and two muscular pad-like bulges on either side, 0.365 - 0.647 x 0.415 - 0.714. Acetabulum large, well developed, round and lies in the anterior part of the body, 0.415 - 0.664 x 0.448 - 0.647. Sucker ratio about 1:1, Prepharynx absent. Pharynx well developed. Oesophagus short and stumpy. Caeca with shoulders at the pharyngeal level, sinous and extend upto the posterior end of the tail. Testes almost round, tandem postacetaular; anterior testes 0.232 - 0.415 x 0.282 - 0.647, posterior testis 0.249 x 0.465 -0.265 x 0.431. Seminal vesicle saccular, postacetabular, 0.230 x 0.105 - 0.36 x 0.126. Pars prostatica long, uninterrupted, serpentine like and dorsal to acetabulum. Hermaphroditic duct present, not enclosed in a sheath. Genital atrium

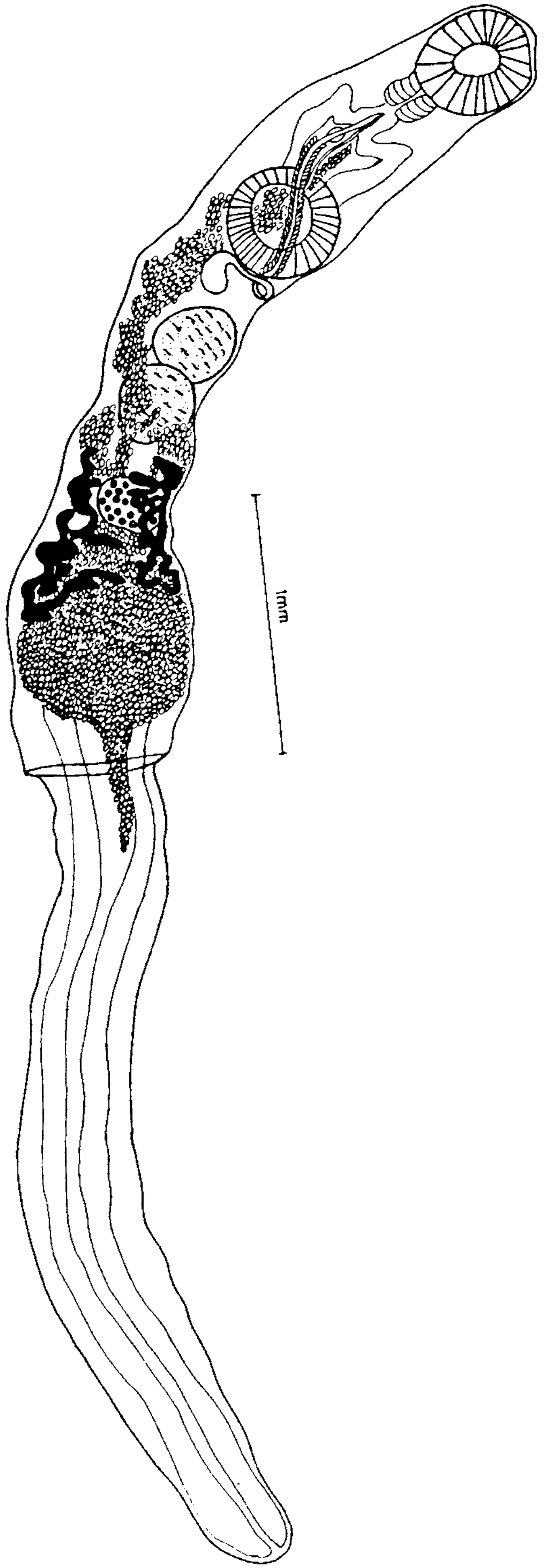


FIG 7 *INDOSTUMACHICOLA* *THYNNI* SP NOV

tumbler-shaped and genital pore lies just below posterior and ventral to pharynx. Ovary transversely elongated, median and posttesticular, 0.166 x 0.348 - 0.232 x 0.398. Receptaculum seminis absent. Uterus winding, more at the posterior end, extend into ecsoma, in some specimens circumcaecal. Vitellaria consisted of seven tubules, interceacal and extraceacal. Eggs small, numerous and unfilamented, completely filling uterine loops; 0.006 x 0.012 - 0.008 x 0.016. Excretory opening ventral and terminal, and excretory vesicle Y-shaped.

Discussion :- The new genus *Indostomachicola* was erected by Gupta and Sharma (1973). When a comparison of genera *Stomachicola* Yamaguti, 1934 and *Indostomachicola* Gupta et Sharma, 1973 was made, the specimens collected in the present study were found to fit in more in the genus *Indostomachicola*. Gupta and Sharma (1973) have already compared this genus with *Stomachicola* and *Allostomachicola*, and have clearly mentioned the differentiating characters of the genus *Indostomachicola*.

Yamaguti (1958, 1971) synonymized *Pseudostomachicola* with *stomachicola* and created at the same time a new genus *Allostomachicola*. He further insists that even this genus is synonymus to *Pseudostomachicola*. Gupta and Sharma (1973) doubt that if *Pseudostomachicola* is synonymus to both, how the distinctness between *Stomachicola* and *Allostomachicola* could be retained. They feel that both these genera are distinct and valid units. Verma (1973) is in agreement with Yamaguti in considering the genus *Pseudostomachicola* as synonym of *Stomachicola* but does not agree with him for creating *Allostomachicola*. Gupta and Ahamed (1978) are in agreement with Verma (1973) in considering *Pseudostomachicola* and *Allostomachicola* as synonymus of *Stomachicola*.

The present specimens, though show similarities with members of the species *Indostomachicola kinneie* Gupta and Sharma, 1973, differ from them in the following characters. In the present species, the sucker ratio is about 1:1 while in *I.kinnie* it is 1 : 4.2. Whereas in *I. kennie*, the seminal vesicle is larger than testes, in the present species, it is smaller. In *I. kinnei*, the testes are oblique and ovary is very close to testes while in the present species testes are tandem and ovary is away from the testes. In *I. kinnei*, the ovary is larger than testes whereas in the present species it is smaller. In *I. kinnei*, vitelline tubules enter into tail but in the present species they do not.

For these major reasons, the specimens collected in the present study are considered to belong to a new species of *Indostomachicola*, viz. *Indostomachicola thynni* sp. nov.

Family - Hemiuridae

Subfamily - Dinurinae

Genus - Tubulovesicula Yamaguti, 1934

Generic diagnosis :- Body rather fusiform, with more or less long tail. Oral sucker subterminal, with preoral lobe. Oesophagus very short, caeca terminating at posterior extremity. Acetabulum larger than oral sucker, near anterior extremity. Testes more or less diagonally juxtaposed behind acetabulum. Vesicula seminalis tubular, more or less winding, pretesticular. Pars prostatica long. Hermaphroditic duct expanded at base, enclosed in muscular pouch. Genital atrium usually opening at level of pharynx. Ovary submedian, usually in middle third of the body. Receptaculum seminis present. No Laurer's canal. Vitellaria consisting of seven tubular lobes. Uterus extending into tail; eggs thick-shelled, embryonated. Excretory arms uniting dorsal to pharynx. Stomach parasites of marine fishes.

Tubulovesicula magnacetabulum Yamaguti, 1939

Host	:	Megalaspis cordyla
Site	:	Intestine
Incidence	:	20/174
No. of parasites	:	51
Locality	:	Off Cochin

This species was originally described by

Yamaguti (1939) from *Epenephelus akaara*, from the Inland sea of Japan. The specimens collected in the present study look exactly like *T. magnacetabulum*, and is considered to belong to the same species. Although the measurements overlap fairly well with those given for *T. magnacetabulum*, the sucker ratio is 1:3.7 as against 1:3, given by Yamaguti. Manter (1947, 1954), and Sogandares-Bernal (1959) discussed at some length the status of the species of the genus *Tubulovesicula*. Subsequently, Stunkard (1973, 1980) discussed in detail, the systematics of the hemiurid trematodes. While Manter (1954) considered *T. lindbergi*, *T. pinguis*, *T. angusticauda*, *T. magnacetabulum*, *T. anguillae*, and *T. spari* as valid species, Sogandares-Bernal (1959) considered only the first four species as valid species. Although the systematic relations of the genera *Stomachicola* and *Tubulovesicula* were called in question by the report of Sinclair et al. (1972), the life-cycle studies of *T. pinguis* carried out by Stunkard (1973, 1980) have shown the morphological and bionomical differences between *S. rubea* and *T. pinguis* and clearly demonstrated generic distinctions. The prediction by Sinclair et al. (1972) that *T. pinguis* is a stage in the life-cycle of *S. rubea* has thus been rejected by Stunkard (1980). Yamaguti (1971) has listed 15 species of Tubulovesicula, however, the validity of *T. californica*, *T. diacopae* and

T. hebrae is still doubtful.

This is the first record of this species from Indian waters and the host is a new record.

Family - Hemiuridae

Subfamily - Hemiurinae Looss, 1899

Subfamily diagnosis :- Ecsoma well developed. Body surface plicated or scaley (i.e. with crenulate plications). Presomatic pit absent. Testes tandem to oblique. Seminal vesicle thinwalled, or partially or slightly muscular, bipartite or oval, in hindbody. Pars prostatica tubular, long, gland-cells occasionally delimited by membrane. Sinus-sac present, often tubular, not enclosing prostatic vesicle. Permanent sinus-organ absent, but hermaphroditic duct may be protruded to form temporary sinus-organ. Genital atrium usually small, but variable in length. Ovary oval. Vitellarium composed of two distinct oval masses, but these may show slight tendency toward location in three and four style. Excretory arms united in forebody. Parasitic in stomach of marine teleosts.

Genus - Daniella Sahai and Srivastava, 1977 emended

Generic diagnosis :- Body with scales and moderately long tail. Oral sucker subterminal. Acetabulum almost equal to oral sucker and situated near it. Prepharynx absent, pharynx globular. Oesophagus short, intestinal caeca long, narrow, straight, reaching almost the posterior extrimity of tail. Testes tandem, closely postequatorial, and separated. Seminal vesicle pear-shaped, thin-walled and undivided, almost at middle of body length; pars prostatica very long, straight and surrounded by prostate cells all along its course or in part. Hermaphroditic duct enclosed in small tubular muscular pouch. Genital pore submedian, at level with pharynx or slightly below. Ovary posttesticular nearly half way between posterior testis and body end, and separated from the former by uterus. Vitellaria as two compact diagonally placed masses or as two masses distinctly three - and four - lobed, and postovarian. Seminal receptacle present. Uterus well developed, extending into tail. Eggs small and numerous. Excretory vesicle Y-shaped, arms united anteriorly. Parasitic in the stomach and intestine of marine teleosts.

Daniella rastrelligeri sp. nov. (Fig. 8)

Host : *Rastrelliger kanagurta*
Site : Stomach/intestine
Incidence : 2/195
No. of parasites : 4
Locality : Cochin
Specific diagnosis:- (Description based on 4 specimens)

Body poorly muscular, closely set minute scales

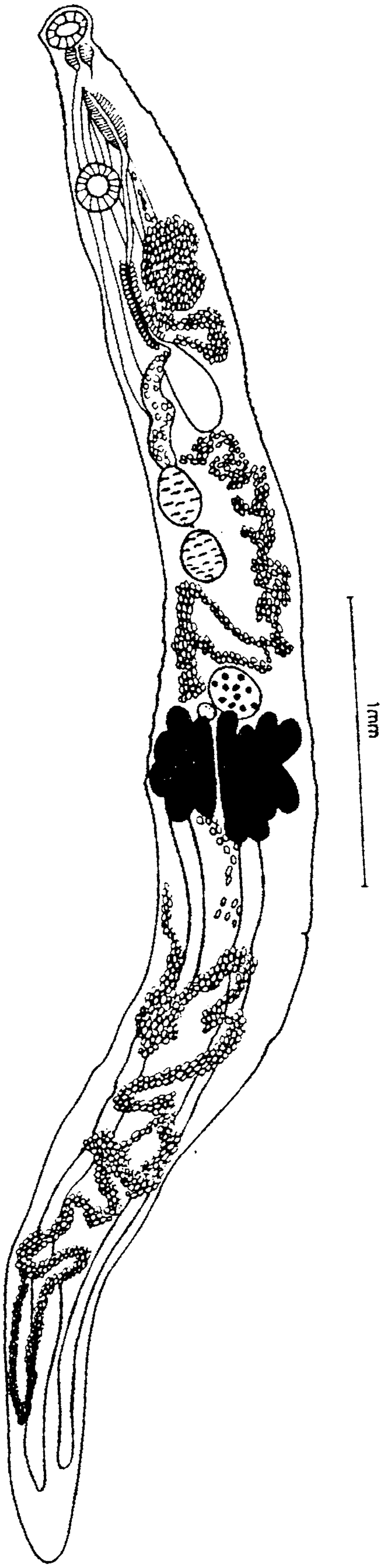


FIG 8 *DANIELLA RASTRELLIGERI* SP NOV

present on body but absent on ecsoma. Body measures 2.100 - 3.455 x 0.378 - 0.597. Ecsoma long, narrower than body, tapers towards posterior end and measures 1.470 - 2.310 in length. Oral sucker subterminal, 0.084 - 0.133 x 0.126 - 0.182. Acetabulum close to oral sucker, larger than it and measures, 0.168 - 0.199 x 0.189 - 0.199. Prepharynx absent. Pharynx globular, measures, 0.063 - 0.116 in diameter. Oesophagus short, intestinal caeca narrow, straight and extend to a position a little in front of the posterior extremity of the tail.

Testes two, almost round, tandem, postequatorial and intercaecal. Anterior testis measures, 0.158 - 0.232 x 0.158 - 0.249. Posterior testis, 0.147 - 0.232 x 0.137 - 0.216. Seminal vesicle pear-shaped, undivided, thin-walled, far behind acetabulum and reaching posteriorly a little in front of anterior testis. Pars prostatica intercaecal, long, tubular, and surrounded by prostate gland cells in the posterior half. In some specimens gland cells extend to the posterior level of acetabulum. Pars prostica joins metraterm at level with the anterior margin of acetabulum to form hermaphroditic duct enclosed in an elongated, muscular pouch. Genital pore submedian, at intestinal bifurcation level. Ovary almost round, lying nearly half-way between posterior testis and body end, separated from the former by uterine coils, measures 0.105 - 0.182 x 0.147 - 0.216. Seminal present on body but absent on ecsoma. Body measures 2.100 - 3.455 x 0.378 - 0.597. Ecsoma long, narrower than body, tapers towards posterior end and measures 1.470 - 2.310 in length. Oral sucker subterminal, 0.084 - 0.133 x 0.126 - 0.182. Acetabulum close to oral sucker, larger than it and measures, 0.168 - 0.199 x 0.189 - 0.199. Prepharynx absent. Pharynx globular, measures, 0.063 - 0.116 in diameter. Oesophagus short, intestinal caeca narrow, straight and extend to a position a little in front of the posterior extremity of the tail.

Testes two, almost round, tandem, postequatorial and intercaecal. Anterior testis measures, 0.158 - 0.232 x 0.158 - 0.249. Posterior testis, 0.147 - 0.232 x 0.137 - 0.216. Seminal vesicle pear-shaped, undivided, thin-walled, far behind acetabulum and reaching posteriorly a little in front of anterior testis. Pars prostatica intercaecal, long, tubular, and surrounded by prostate gland cells in the posterior half. In some specimens gland cells extend to the posterior level of acetabulum. Pars prostica joins metraterm at level with the anterior margin of acetabulum to form hermaphroditic duct enclosed in an elongated, muscular pouch. Genital pore submedian, at intestinal bifurcation level. Ovary almost round, lying nearly half-way between posterior testis and body end, separated from the former by uterine coils, measures 0.105 - 0.182 x 0.147 - 0.216. Seminal receptacle not clear. Mehli's gland lateral to the posterior extremity of the ovary. Vitellaria as two postovarian masses distincily three - and four - lobed. Uterus well developed and extends into ecsoma. Eggs, numerous, measure, 0.023 - 0.027 x 0.013 - 0.016. Excretory vesicle Y-shaped.

Discussion :- While creating the genus *Daniella*, Sahai and Srivastava (1977), have taken into consideration the similarities and differences with the two closely related genera, *Dinosoma* and *Anahemiurus*. In my opinion the genus *Daniella* is valid and the characters of the specimens collected by me come closer to the generic features of *Daniella* than any other genus. The present specimens are considered to belong to a new species of *Daniella*. This species is compared with the only other species of *Daniella*, *D. madrasensis* and the differences shown by the present species justify the creation of a new species.

The present species is slightly larger than *D. madrasensis*. In the present species, the vitellaria are in the form of two postovarian masses distinctly three - and four - lobed, whereas in *D. madrasensis*, they are in the form of two compact diagonally placed postovarian masses. Further, in the present species, the pars prostatica is not surrounded by prostatic gland all along its length, whereas in *D. madrasensis*, it is surrounded by the glands all along its length. In the present species the genital pore is at intestinal bifurcation level but in D. madrasensis, it is at level with the posterior margin of pharynx. In D. madrasensis, the uterus extends only some distance into ecsoma whereas in the present species it extends almost to the posterior end of the ecsoma.

Because of these differences, the present specimens are considered to belong to a new species, and designated as Daniella rastrelligeri sp. nov.

BUCEPHALIDAE Poche, 1907

Bucephalidae Poche, 1907

Family diagnosis :- Digenea without oral sucker. Rhynchus as adhesive organ, at anterior extremity. Pharynx and oesophagus present. Intestine simple, saccular or tubular. No acetabulum. Testes two, usually in middle or posterior, exceptionally anterior region of body. Cirrus pouch in posterior part of body, containing seminal vesicle and prostatic complex; cirrus projecting into genital atrium usually in the form of crooked lobe, occasionally in a simple lobe; exceptionally no genital lobe. Genital pore ventral, terminal or subterminal. Ovary variable in position in relation to testes, usually in middle third of body. Seminal receptacle present or absent. Laurer's canal present. Vitellaria follicular, usually in anterior part of the body. Uterus strongly winding, with numerous small eggs. Excretory vesicle tubular, long or short, giving rise to a collecting vessel on each side. Parasitic in fish, exceptionally in amphibians.

Bucephalinae Nicoll, 1914

Subfamily diagnosis :- Body elongate spined. Rhynchus wedge-, or crown-shaped with or without tentacular appendages or caplike expansion anteriorly. Mouth postequatorial. Instine short. Cirrus pouch mostly or entirely postetesticular. Ovary immediately pretesticular.

Vitellaria preovarian. Excretory vesicle tubular. Parasitic as adult in freshwater or marine teleosts.

Genus - Bucephalus Baer, 1827

Generic diagnosis :- Body more or less elongate. Rhynchus suckerlike, usually with seven tentacular appendages, each base of which is connected with gland cells by a large duct. Mouth opening in middle third of the body. Intestine short. Testes tandem or diagonal, equatorial or postequatorial. Ovary pretesticular. Vitelline follicles divided in front of ovary into two distinct groups. Cirrus sac at the posterior half towards the left side of the body. Excretory vesicle variable in length. Parasitic in freshwater or marine fishes.

Bucephalus varicus Manter, 1940

Host	:	Caranx malabaricus and Thynnus sp.
Site	:	Intestine/stomach
Incidence	:	20/176 and 3/7
No. of parasites	:	22 and 18
Locality	:	Off Cochin

Manter (1940) named Bucephalus varicus for specimens from Caranx sp. at Bahia Honda, Panama. He considered the B. polymorphus Baer, 1827 of Nagaty (1937) to be a synonym of B. varicus. Reasons for considering B. varicus, distinct from B. polymorphus Baer, 1827 were: (1) longer cirrus sac, (2) pretesticular ovary, and

(3) *B. varicus* is from marine hosts. Manter (1963 a) redefined *B. varicus*, and *B. polymorphus* Baer, 1827 of Caballero, Bravo and Grocott (1953) and *B. pseudovaricus* Valasquez (1959) were considered synonyms of *B. varicus*. Although Gupta and Mehrotra (1970) described *B. polymorphus* Baer, 1827 from *Therapon jarbua* and *Pomadasys hasta* from Bay of Bengal, Madhavi (1974) regarded it as identical to *B. varicus* Manter, 1940. Madhavi (1974) recorded this species from the Bay of Bengal from Carangids, Therapondis and Polynemids. Bilqees (1981) also recorded this species from Karachi coast from a Sphyrind.

Considering the valid characteristics of *B. varicus* given by Manter (1963 a), the specimens collected in the present study are treated identical to *B. varicus*. Besides *Caranx malabaricus*, this species was collected from *Thynnus* sp. also. Manter (1955) has indicated that *B. varicus* occurs in Carangids of the regions of Japan, Red Sea, Gulf of Mexico, and the tropical Pacific. It is noted that this species also occurs in Carangids of Arabian Sea and Bay of Bengal.

Family - Bucephalidae

Subfamily - Bucephalinae

Genus - *Alcicornis* Mac Callum, 1917

Generic diagnosis :- Body elongated, anterior half flattened, the posterior cylindrical. Cuticle spiny.

Anterior end with a funnel-shaped rhynchus and seven tentacles. Oral aperture simple, not guarded by an oral sucker and opens on the ventral surface. Muscular pharynx present. Intestinal caecum simple and sac-shaped with its blind end either directed anteriorly or posteriorly. Testes two in the posterior half of the body. Cirrus sac elongated at the posterior end. Vesicula seminalis present inside the cirrus-sac. Ovary anterior to testes. Receptaculum seminis absent. Vitelline glands composed of two lateral sets. Uterine coils fill the posterior two thirds of the body in mature specimens. Male and female genital ducts open in a common genital atrium subterminally at the posterior end on the ventral surface. Excretory vesicle simple tubular sac opening independantly terminally at the posterior end.

Alcicornis multidactylus Madhavi, 1974

Host : *Caranx malabaricus* and *Sphyraena* sp.
Site : Intestine/stomach
Incidence : 22/176 and 6/79
No. of parasites : 23 and 9
Locality : Off Cochin

Yamaguti (1971) listed four species under this genus; *A. carangis* Mac Callum, 1917; *A. baylisi* Nagaty, 1937; *A. cirrudiscoides* Valasquez, 1959, and *A. siddiqii* Nahhas and Cable, 1964. Hafeezullah and Siddiqi (1970 a) described *A. thapari*, and Gupta and Sharma (1972) added one more species A. indicus to the list. Although Manter (1954) described A. longicornutus, Howell (1966) worked out the life history of this species and transferred it to the genus Bucephalus and designated as B. longicornutus (Manter, 1954).

Of all the species of Alcicornis, the specimens collected in the present study come close to A. multidactylus Madhavi, 1974, and are considered as the same, although some variations were noticed. Madhavi (1974) has observed fifteen tentacles on the rhynchus, as against the usual seven. In most of the specimens I collected, the tentacles could not be observed but in one more than ten could be noticed. It is presumed that the tentacles were lost during the process of staining. In body measurements, position of testes, cirrus-sac, extent of vitellaria and uterus, position of mouth opening, etc. there are similarities. In the original description, the ovary is close to the anterior testis but in my specimens, it is slightly away from the testis. This is considered as intraspecific variation only, and does not warrant creation of a new species.

Madhavi (1974) has not compared this species with A. indicus Gupta and Sharma, 1972. A. indicus too has only seven tentacles as in other species, and moreover it is larger than A. multidactylus. Further, in A. indicus the ovary is too close to the anterior testis and the cirrus-sac extends only upto the posterior testis. The hosts are new records from Indian waters.

Family - Bucephalidae

Subfamily - Bucephalinae

Genus - Alcicornis

Alcicornis thapari Hafeezullah and Siddiqi, 1970

Host : Seriola sp.
Site : Intestine
Incidence : 1/2
No. of parasites : 44
Locality : Off Cochin

The measurements of the present specimens and my observations tally well with the original description given by Hafeezullah and Siddiqi (1970 a), and hence they are considered to belong to the same species, A. thapari. In a few specimens, the uterus extends a little more anteriorly, but this is considered only as an intraspecific variation. Seriola sp. is a new host record for this species.

Family - Bucephalidae

Subfamily - Bucephalinae

Genus - Rhipidocotyle Diesing, 1858

Generic diagnosis :- Body elongate, more or less slender. Rhynchus with pentagonal cap - or hood-like expansion and suctorial pit ventroposteriorly. Mouth opening usually in middle third. Intestine short. Testes tandem or oblique, in posterior half of the body. Cirrus pouch at the posterior half towards the left side of the body. Ovary pretesticular. Vitellaria usually divided into paired preovarian groups. Uterus not extending so far forward as it does in *Bucephalus* and *Bucephalopsis*. Excretory vesicle very long, may well reach the rhynchus. Parasitic in marine and freshwater fishes.

Rhipidocotyle karthai Hafeezullah and Siddiqi, 1970

Host : *Psettodes erumei*
Site : Stomach
Incidence : 2/20
No. of parasites : 4
Locality : Cochin

This species was originally described by Hafeezullah et Siddiqi (1970) as *Phipidocotyle karthai*, but has to be corrected as *Rhipidocotyle karthai*. The specimens in the present study are smaller. However, in the nature of the rhynchus with one median, two pairs of anterolateral and one pair of posterolateral papillae, position of genital organs, extend of uterus and vitelline follicles, and in the position of pharynx, the present specimens tally well with the description given for *R. karthai*, and hence are considered as belonging to the same species.

The difference in size does not warrant the creation of a new species. As in the present study, Hafeezullah and Siddiqi (1970), also collected this species from P. erumei, but from the east coast of India.

Family - Bucephalidae

Prosorhynchinae Nicoll, 1914

Subfamily diagnosis :- Body plump to elongate, spinose. Rhynchus sucker-like or somewhat plug-shaped, with or without marginal lobes. Pharynx variable in levels. Testes diagonal, near middle of body, occasionally symmetrical, anterior. Cirrus pouch comparatively larger. Ovary pretesticular, occasionally intertesticular. Vitellaria largely or entirely preovarian or in testicular zone. Excretory vesicle tubular, long or short. Parasites of marine and freshwater fishes.

Genus - Bucephalopsis (Dies, 1855)

Generic diagnosis :- Body fusiform to subcylindrical. Rhynchus sucker-like, without tentacular appendages, usually provided with circular rows of spines slightly larger than body spines, but not as large as in Dollfustrema. Mouth usually in middle third of body, occasionally in anterior or posterior third. Intestine short. Testes tandem or oblique, usually postequatorial. Cirrus pouch and its contents, as well as genital lobe, as in Bucephalus. Ovary anterior or opposite to testes.

Receptaculum seminis absent. Vitelline follicles divided into paired preovarian groups. Uterus may ascend as far as, or to near, rhynchus. Excretory vesicle variable in length. Parasitic in intestine of marine and freshwater fishes, exceptionally in batrachians.

Bucephalopsis longicirrus Nagaty, 1937

Host	:	*Caranx malabaricus*
Site	:	Stomach
Incidence	:	17/176
No. of parasites	:	31
Locality	:	Off Cochin

This species was originally described by Nagaty (1937) from *Sphyraena agam* from the Red Sea. Yamaguti (1971) synonymized *Bucephalcides arcuatus* (Linton) of Manter (1940), and of Siddiqi and Cable (1960) with *B. longicirrus*. Nagaty (1937) has given a detailed description of this species, and the observations and measurements of the specimens I collected tally well with the original description. However, there is slight variation in the egg size. In the present specimens, the eggs measure 0.018 - 0.026 x 0.012 - 0.014, whereas Nagaty (1937) has given the egg size 0.017 - 0.021 x 0.013. The characteristic feature of this species is the extreme length of the cirrus sac.

In this respect, this species comes closer to

(1) B. karvei originally described by Bhalerao (1937), and subsequently by Chauhan (1954 a), and Gupta (1956); and (2) B. belonea Srivastava, 1938. However, Gupta (1956) considered B. belonea as a synonym of B. karvei. In B. karvei, the oral sucker is four times bigger than the pharynx but in B. longicirrus, they are of the same size. Moreover, in B. karvei, the intestine is globular whereas in B. longicirrus it is a short thick-walled single caecum. In B. longicirrus, the vitelline follicles are concentrated around pharynx but in B. karvei, they are away from the pharynx, and situated closer and anterolateral to oral sucker. This parasite is reported from Indian waters for the first time and the host is also a new record.

Family - Bucephalidae

Subfamily - Prosorhynchinae

Genus - Prosorhynchus Odhner, 1905

Generic diagnosis :- Body plump to elongate, spined. Rhynchus plug - or funnel-shaped, without tentacular appendages. Mouth opening usually in middle third of body. Intestine short. Testes tandem or oblique, in middle third of body or further behind. Cirrus pouch containing tubular seminal vesicle and well developed prostastic complex. Genital pore ventroposterior or terminal. Ovary in front of anterior or posterior testis. Vitellaria anterior to ovary and testes, may or may not be divided into paired groups. Uterus ascending as far forward as vitellarian zone or behind it. Excretory vesicle short or moderately long. Parasites of marine and freshwater fishes.

The genus *Prosorhynchus* is further classified into two subgenera, viz, *Skrjabiniella* and *Prosorhynchus*.

Prosorhynchus tsengi Chin, 1933

Host : *Scomberomorus* sp.
Site : Intestine
Incidence : 2/12
No. of parasites : 2
Locality : Off Cochin

This species was originally described from *Platycephalus indicus* from China. *P. platycephali* described by Yamaguti (1934) from the same host species from Toyma Bay, Japan was considered a synonym of *P. tsengi*. From Indian waters, this species was reported by Hafeezullah and Siddiqi (1970) from *Platycephalus scaber* collected from Cochin. In the present study this species is collected from a new host. Although my observations tally well with the original description, the specimens collected in the present study are much larger (3.843 - 4.977 x 0.567). This size difference may be due to its occurrence in a new host.

Family - Bucephalidae

Subfamily - Prosorhynchinae

Prosorhynchus manteri Srivastva, 1938

Host	: *Lactarius lactarius*
Site	: Stomach/Intestine
Incidence	: 2/24
No. of parasites	: 6
Locality	: Cochin

This species was originally described by Srivastava (1938). Chauhan (1954 a) redescribed this species collected from *Tetradon oblongus*, from the Bay of Bengal. Madhavi (1974) reported the occurrence of this species from *Trichiurus haumela*, also from the Bay of Bengal. In measurements and observations, the specimens collected in the present study agree well with the description given for *P. manteri*, and hence are considered as same. *L. lactarius*, however is a new host record.

Family - Bucephalidae

Neoprosorhynchinae Yamaguti, 1958 emended

Subfamily diagnosis :- Body subcylindrical, spinose. Rhynchus inverted conical. Pharynx preequatorial or postequatorial; intestine short. Testes pharyngiointestinal region. Cirrus pouch comparatively long. Ovary posttesticular. Vitellaria in testicular zone and extending anteriorly. Excretory vesicle present.

Genus - *Neoprosorhynchus* Dayal, 1948 emended

Generic diagnosis :- Body small, subcylindrical, spinose. Rhynchus inverted conical. Mouth pre-or post-equatorial. Intestine saccular, directed foreward from pharynx. Testes tandem, to left of pharynx and oesophagus, or symmetrical to oblique. Cirrus pouch not reaching to pharynx. Genital pore ventroterminal. Ovary opposite and posterior to testes, behind oral aperture, giving rise to germiduct at its anterior end; shell gland complex immediately anterior to ovary. Vitelline follicles small, scattered irregularly on either side of intestine and partly covering it, and sometimes extending anteriorly. Uterus filling up entire space between vitellaria and genital atrium; eggs very small. Excretory vesicle Y-shaped, arms reaching the intestine. Intestinal parasites of marine fishes.

Neoprosorhynchus purius Dayal, 1948

Host : *Platycephalus* sp.
Site : Intestine
Incidence : 5/21
No. of parasites : 8
Locality : Cochin

Dayal (1948) created this genus, to accommodate his new species, *Neoprosorhynchus purius* on the ground that this species differs from all the known genera in the relative position of ovary to testes and in having a Y-shaped excretory bladder.

This is the second report on the occurrence of this species but the host is a new record. Although Dayal (1948) has not specifically mentioned the anterior extend of the uterus, in the figure he gave, the uterus extends only upto midlevel of the intestine. But in all the specimens of this species from my collection, the uterus extended anteriorly to the midlevel between the anterior end of the body and the intestine. In body measurements and in all the other charectoristics there is resemblence with *N. purius*, and the specimens I collected are considered as the same. *Platycephalus* sp. is a new host record.

Family - Bucephalidae

Subfamily - Neoprosorhynchinae

Neoprosorhynchus leiognathi sp. nov. (Fig. 9)

Host : *Leiognathus* sp.

Site : Stomach/Intestine

Incidence : 5/51

No. of parasites : 8

Locality : Cochin

Specific diagnosis:- (Description based on four specimens)

Body small, cylindrical, slightly tapering

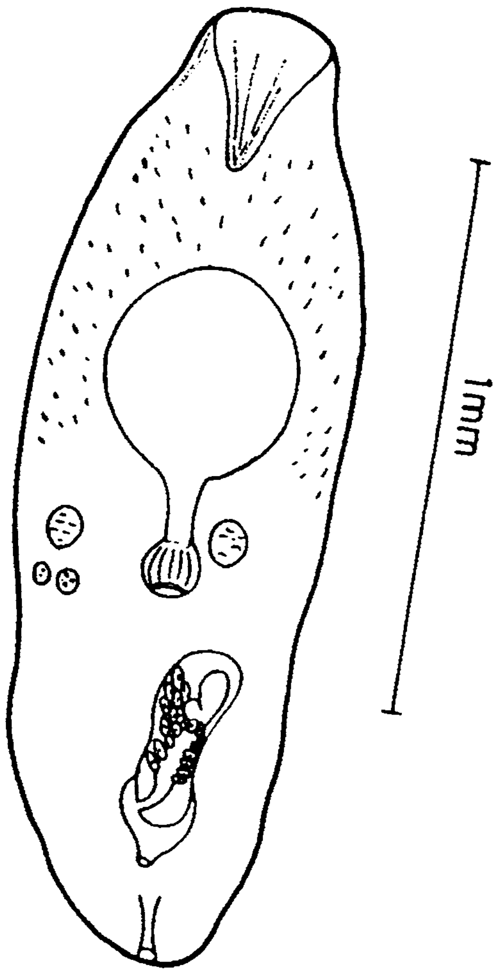


FIG. 9. NEOPROSORHYNCHUS LEIOGNATHI SP. NOV.

anteriorly and with backwardly directed spines, measures 1.26 - 1.68 x 0.46 - 0.55. The rhynchus measures 0.21 - 0.27 x 0.19 - 0.21, having a shape of an inverted cone. Mouth opening in the posterior half of the body, opens into forwardly directed alimentary canal. Pharynx well developed and measures 0.063 - 0.084 in diameter. Oesophagus long, 0.084 - 0.095, and opens into a sac-like intestine measuring 0.189 - 0.357 x 0.201 - 0.315. Excretory pore terminal in the posterior side of the body. Testes slightly oval, symmetrical, or oblique. When symmetrical, they are situated on either side of the pharynx, when oblique left testis is posterior to pharynx. Left testis measures 0.084 - 0.105 x 0.084 - 0.095. Right testis 0.084 - 0.105 x 0.095 - 0.105. Cirrus sac measures 0.273 - 0.315 x 0.084 - 0.126, and opens a little away from the posterior end of the body. Within the cirrus sac seminal vesicle, pars prostatica, prostatic gland cells, genital lobe, and ejaculatory duct conspicuous. The seminal vesicle is saccular, and the genital lobe is muscular and bulbus. Ovary is posterior to right testis, oval shape, and measures 0.032 - 0.042 x 0.040 - 0.042. The shell glands form a compact mass and lie closer to the ovary or a little in front of it. The vitelline glands consists of small follicles scattered irregularly on either side of the intestine extending anteriorly to the posterior end of the rhynchus.

Discussion :- All the specimens collected in the present study are immature because no eggs could be seen. Although the reproductive organs have not attained maturity, the location of the ovary posterior to the testes can be clearly noticed. The genus was created to accommodate the only species *Neoprosorhynchus purius*. The present specimens though immature, also belong to the same genus, showing differences with *N. purius*, and hence have been considered to belong to a new species. Since the specimens are immature, the categorization of the specimens to a new species of *Neoprosorhynchus* is tentative.

The present species differs from *N. purius* in having the mouth opening situated postequatorially. In *N. purius* it is preequatorial. Whereas in *N. purius* the testes are tandem on left side, in the present specimens they are opposite or slightly oblique. In *N. purius* the vitelline follicles are scattered irregularly on either side of the intestine and partially covering it but in the present species they extend anteriorly to the posterior margin of the rhynchus.

Since the generic diagnosis of *Neoprosorhynchus* was based on a single species, *N. purius*, and since the present species also belongs to the same genus, the chatectoristic features of the genus have been emended accordingly.

CHAPTER II

SUMMARY

A brief review of literature on the adult digenetic trematodes of marine fishes of Indian waters has been made. Thirty two species of digenetic trematodes were collected in the present study from thirty host species. The trematodes belonged to nine families, namely, Brachycoeliidae Johnston, 1912 ; Lepocreadiidae (Odhner, 1905) Nicoll, 1935, Homalometridae (Cable et Hunninen, 1942) Yamaguti, 1971; Opecoelidae (Ozaki, 1925) Yamaguti, 1971; Acanthocolpidae Lühe, 1909; Monascidae (Dollfus, 1952) Yamaguti, 1971; Fellodistomidae Nicoll, 1913; Hemiuridae Looss, 1899; and Bucephalidae Poche, 1907. Of the thirty two species, nine species have been treated as new, namely, *Mesocoelium cynoglossi*, *Coitocaecum glossogobii*, *Tormopsolus rastrelligeri*, *Pseudopentagramma nemipteri*, *Elytrophalloides rastrelligeri*, *Ectenurus rastrelligeri*, *Indostomachicola thynni*, *Daniella rastrelligeri*, and *Neoprosorhynchus leiognathi*. Four genera, namely, *Mesocoelium* Odhner, 1911, *Tormopsolus* Poche, 1926, *Pseudopentagramma* Yamaguti, 1971, *Elytrophalloides* Szidat, 1955, and their hosts are new records from Indian waters. Also, the genus *Indostomachicola* Gupta et Sharma, 1973 has been recorded from a new host species. Eighteen species of digenetic trematodes collected in the present study are from new host species. The trematodes are;

Lapocreadioides indicum, *Pseudopecoelina elongata*, *Stephanostomum orientalis*, *Monascus typicus*, *Lecithocladium excisum*, *L. harpodontis*, *L. aegyptensis*, *Lecithochirium polynemi*, *L. acutum*, *Ectenurus lepidus*, *Tubulovesicula magnacetabulam*, *Bucephalus varicus*, *Alcicornis multidactylus*, *A. thapari*, *Bucephalopsis longicirrus*, *Prosorhynchus tsengi*, *P. manteri*, and *Neoprosorhynchus purius*. The remaining five species, namely *Crassicutis karwarensis*, *Podocotyloides parupenei*, *Acanthocolpus liodorus*, *Odontocotyle arabi*, and *Rhipidocotyle karthai* are found in hosts already recorded from India. New species are described and discussed in detail, and in other cases the discussions are limited to aspects that supplement the available information.

REFERENCES

Ahamed, J. 1980. On four new trematodes of the genus Coitocaecum Nicoll, 1915 (Trematoda, Opecoelidae) from marine fishes of Bay of Bengal. Acta. Parasit. 27: 423-429.

*Baer, K.E.von. 1827. Beitrage zur kenntnis der niedern Thiere. Nova Acta Leop. Carol. 13: 523-762.

Bhalerao, G.D. 1937. Studies on the helminths of India. Trematoda-IV. J. Helminth. 15: 97-124.

Bhutta, M.S., and D.Khan, 1975. Digenetic trematodes of vertebrates from Pakistan. Bull. Dept. Zool. Univ. Punjab Article 8: 1-175.

Bilqees, F.M. 1972. Marine fish trematodes of W.Pakistan. X. Tormopsolus spatulatum sp.n. (Acanthocolpidae: Acanthocolpinae) from a fish of Karachi coast. Proc. Helminth. Soc. Wash. 39: 138-140.

Bilqees, F.M. 1976. Two new Lepocreadiid trematodes from fishes of Karachi coast. Norw. J. Zool. 24: 195-199.

Bilqees, F.M. 1981. Digenetic trematodes of the fishes of Karachi coast. Kifayat Acadamy, Karachi.

*Caballero,yC.E. 1952. Revisión de los genéros y especies que integran la familia Acanthocolpidae Lühe, 1909. Revta. Med. Vet. Parasit. Caracas. 11: 1-231.

*Caballero,yC.E., M.Bravo, and R.G.Grocott. 1953. Helmintos de la Republica de Panama. VII. Descipcion de algunos trematodos de peces marinos. An. Inst. Biol. 24: 97-136.

Cable, R.M., and A.V.Hunninen. 1942. Studies on Deropristis inflata (Molin), its life history and affinities to the trematodes of the family Acanthocolpidae. Biol. Bull. 82: 292-312.

---

* Not seen in original.

Chauhan, B.S. 1945. Trematodes from Indian marine fishes. Pt.IV. On some trematodes of the family Hemiuridae Lühe, 1901 with description of six new forms. Proc. Indian Acad. Sci. B. 21: 160-173.

Chauhan, B.S. 1954. Studies on the Trematode fauna of India. Part-IV. Subclass Digenea (Prosostomata) (A revision Hemiuroidea from the Indian region). Rec. Indian Mus. 51: 289-393.

Chauhan, B.S. 1954a. Studies on the trematode fauna of India. Part III. Subclass Digenea (Gasterostomata). Rec. Indian Mus. 51: 231-287.

Cheng, T.C. 1958. Studies on the Trematode Family Dicrocoeliidae. I.The genera Brachycoelium (Dujardin, 1845) and Leptophallus Lühe, 1909 (Brachycoeliinae). Amer. Midl. Nat. 59: 67-81.

Cheng, T.C. 1959. Studies on the trematode family Brachycoeliidae. II. Revision of the genera Glypthelmins (Stafford, 1900) Stafford, 1905, and Margeana Cort, 1919; and the description of Reynoldstrema n. gen. (Glypthelminae n.subfam). Amer. Midl. Nat. 61: 68-88.

Cheng, T.C. 1960a. The life history of Brachycoelium obesum Nicoll, 1914; with a discussion of the systematic status of the trematode family Brachycoeliidae Johnston, 1912. J. Parasit. 46: 464-474.

Cheng, T.C. 1960b. Studies on the trematode Family Brachycoeliidae. IV. A revision of the Genus Mesocoelium Odhner, 1911; and the status of Pintnaria Poche, 1907. Amer. Midl. Nat. 63: 439-469.

Chin (Tsin), S.M. 1933. A new trematode parasitic in the stomach of Snake fish. J.Sc.Nat.Univ. Shantung, Tsingtao, China. I: 104-116.

*Chulkova, V.N. 1939. Parasite fauna of fishes in the vicinity of Batumi (In Russian with English summary). Uch. Zap. Leningr. Gos. Univ. No.43 Ser. Biol. Nauk, No.11 : 21-32.

---

* Not seen in original.

Crowcroft, P.W. 1951. Notes on the taxonomy of the genus *Coitocaecum* Nicoll, 1915 (Digenea:Opecoelidae). J. Parasit. *37*: 251-256.

Dawes, B. 1946. The trematoda with special reference to British and other European forms. Cambridge Univ. Press.

Dayal, J. 1948. Trematode parasites of Indian fishes. Part I. New trematodes of the family Bucephalidae Poche, 1907. Indian J. Helminth. *I* : 47-62.

*Diesing, K.M. 1855. Revision der Cercarieen. Sitz. Kais. Akad. Wiss. math—nature. Kl. *15*

*Diesing, K.M. 1858. Revision der Myzhelminthen. Abteilung: Trematoden. Sitz-ber. K. Acad. Wiss. Wien math-nature. Kl. *32*: 307-390.

Dollfus, R.P. 1929. Helmintha. I. Trematoda et Acanthocephala. (Contribution à l'étude de la faune du Cameroun. II.). Faune Colonies Francaises. *3*: 73-114.

Dollfus, R.P. 1933. Sur quelques parasites de Poissons recoltes a Catiglione (Algerie). Bull. Sta. Aquicult. Alger. Fasc. *2* : 199-273.

Dollfus, R.P. 1947. Sur *Monascus filiformis* (Rudolphi, 1819) A. Looss,1907, trématode de l'intestine de *Cepola rubescens* (L.) en Mediterranée. Ann. Parasit. Hum. Comp. *22*: 319-329.

Dollfus, R.P. 1952. Affinités naturelles de *Pseudochetosoma salmonicola* Dollfus, 1951 (Steganodermatidae n. fam.) - Emendation de la superfamille Haploporoidea Nicoll, 1935. Arch. Inst. Pasteur Maroc. *4* : 369-386.

Dollfus, R.P. 1959 a. Sur un distome de la famille des Coitocaecidae pourvu d'um receptaculum seminis. Bull. Soc. Zool. France. *83*: 370-376.

Dollfus, R.P. 1959 b. Recherches experimentales sur *Nicolla gallica* (R.Ph.Dollfus, 1941) R.Ph.Dollfus, 1958; sa cercaire cotylicerque et sa métacercaire progénétique. Observations sur la famille des

---

* Not seen in original.

Coitocaecidae Y. Ozaki, 1928; s.f. Coitocaecinae F. Poche, 1926; Trematoda Podocotyloidea et sur les cercaires cotylicerques d'eau douce et marines. Ann. Parasit. Hum.comp. 34 : 595-622.

Dollfus, R.P. 1960. Recherches experimentales sur Nicolla gallica (R-Ph.Dollfus 1941) R-Ph. Dollfus, 1958, sa cercaire cotylicerque et sa metacercaire progénétique. Observations sur famille des Coitocaecidae Y. Ozaki, 1928, s.f. Coitocaecinae F. Poche, 1926, Trematoda Podocotyloidea et sur les cercaires cotylicerques d'eau douce et marines. Ann. Parasit. Hum. comp. 35: 65-117.

Eapen, P.K., and K.K.P.Menon. 1973. Common Marine and freshwater fishes of Kerala. Seafood Export J. 5: 25-38.

Fischthal, J.H., and R.E.Kuntz. 1963. Trematode parasites of fishes from Egypt. Part III. Six new Hemiurida Proc. Helminth. Soc. Wash. 30: 78-91.

Fischthal, J.H., and R.E.Kuntz, 1963 a. Trematode parasite of fishes from Egypt. Part IV. A redescription of Monascus typicus (Odhner, 1911) (Fellodistomidae). Proc. Helminth. Soc. Wash. 30: 177-182.

Fischthal, J.H., and R.E.Kuntz. 1965. Digenetic trematodes of fishes from North Borneo (Malaysia). Proc. Helminth. Soc. Wash. 32: 63-71.

Fischthal, J.H., and J.D.Thomas. 1968. Digenetic trematodes of some freshwater and marine fishes from Ghana. Proc. Helminth. Soc. Wash. 35: 126-140.

*Fuhrmann, O. 1928. Trematoda. Kukenthal's Handb. Zool. 2: 171 pp.

Gibson, D.I., and R.A.Bray. 1979. The Hemiuroidea: terminology, systematics and evolution. Bull. British Mus. 36: 35-146.

Gupta, A.N., and P.N.Sharma. 1972. Studies on digenetic trematodes from Marine fishes of Indian waters. Part III. An. Inst. Biol. Univ. Nal. Auton. Mexico 43, Ser. Vievic. Del. Mar.Y.Limnol. 1: 93-102.

* Not seen in original

Gupta, A.N., and P.N. Sharma. 1973. Studies on the Family Hemiuridae (Trematoda:Digenea), with a description of a new Genus from Marine Fish of Indian waters. Mar. Biol. 19 : 89-91.

Gupta, N.K. 1956. Studies on the digenetic trematodes of marine fishes from the Gulf of Mannar, India. Res. Bull. Punjab Univ. 89 : 61-83.

Gupta, N.K., and V. Mehrotra. 1970. Observations on some already known digenetic trematodes of marin fishes of Ernakulam (South India). Res. Bull. Punjab Univ. 21 : 87-99.

Gupta, N.K., and S.K. Sehgal. 1970. Studies on some hemiurid trematodes from marine food fishes in India. Res. Bull. Punjab Univ. 21 : 227-229.

Gupta, P.C., and H. Govind. 1984. Digenetic trematodes of marine fishes of Bay of Bengal, Puri coast, Orissa. Indian J. Parasit. 8 : 41-48.

Gupta, V., and J. Ahamed. 1978. Digenetic trematodes of marine fishes. IX. On two new species of the genus Stomachicola Yamaguti, 1934 (Trematoda, Hemiuridae) from marine fishes of Puri, Orissa. Acta Parasit. 25 : 211-215.

Gupta, V., and A. Jahan. 1975. On some trematodes of marine fishes of Puri. Indian J. Helminth. 27 : 45-61.

Hafeezullah, M. 1970. Lepocreadiid trematodes of marine fishes of India. Parasitology. 61 : 345-356.

Hafeezullah, M. 1971. Opecoelid trematodes of marine fishes of India. Parasitology. 62 : 321-329.

Hafeezullah, M. 1971 a. On some new and known digenetic trematodes from marine fishes of India. J. Helminth. 45 : 73-88.

Hafeezullah, M., and A.H. Siddiqi. 1970. Digenetic trematodes of marine fishes of India. Part II. Fellodistomatidae. J. Parasit. 56 : 932-940.

Hafeezullah, M., and A.H. Siddiqi. 1970 a. Digenetic trematodes of marine fishes of India. Part I. Bucephalidae and Cryptogonimidae. Indian J. Helminth. 22 : 1-22.

Howell, M.J. 1966. A contribution to the life history of Bucephalus longicornutus (Manter, 1954). Zoo. Pubs.V.U.W. 40: 1-42.

*Jehan de Brie, 1379. Le bon Berger (original not discovered but, extracts published in Bon Berger by Paul Lacrocx : Isid Liseux, Paris, 1879).

Johnston, S.J. 1912. On some trematode parasites of Australian frogs. Proc. Linn. Soc. New S. Wales. 37: 285-362.

Karyakarte, P.P., and B.B.Yadav. 1976. On a new known species of the genus Monascus Looss, 1907 (Trematoda:Monascidae) from fishes from the west coast of India. Nat. Sci. Marathwada Univ. Aurangabad. 15: 169-175.

Køie, M. 1979. On the morphology and life-history of Monascus(=Haplocladus) filiformis (Rudolphi, 1819) Looss, 1907 and Steringophorus furciger (Olsson, 1868) Odhner, 1905 (Trematoda, Fellodistomidae). Ophelia. 18: 113-132.

Kurochkin, Y.V. 1964. Helminth fauna of Clupeid fish in the Caspian Sea. Trudy Astrakh. Gos. Zapovedom. 9: 164-181.

Layman, E.M. 1930. Parasitic worms from the fishes of Peter the Great Bay. (In Russian, German summary). Izv. Tikhookean. Nauch. Prom. Skantsii. 3: 1-20.

Leigh, W.H. 1946. Experimental studies on the life-cycle of Glypthelmins quieta (Stafford, 1900), a trematode of frogs. Amer. Midl. Nat. 35: 460-483.

Linton, E. 1910. Helminth fauna of the Dry Tortugas. II. Trematodes. Carneg. Inst. Wash. Publ. No. 133: 1-98.

*Looss, A. 1899. Weitere Beitrage zur Kenntnis der Trematoden fauna Aegyptens, zugleich Versuch einer naturlichen Glicederung des Genus Distomum Retzius. Zool. Jahrb. Syst. 12: 521-784.

---

* Not seen in original

*Looss, A. 1907. Zur' Kenntnis der distomen familie Hemiuridae. Zool. Anz. 31: 585-620.

Lühe, M. 1901. Uber Hemiuriden. Zool. Anz. 24: 394-403.

Lühe, M. 1906. Trematode parasites from marine fishes of Ceylon. Ceyl. Pearl Oyster Fish. Rep. 5: 97-108.

*Lühe, M. 1909. Parasitische Plattwurmer. I. Trematoden. Süsswasserfauna Deutschl. Heft. 17: 1-215.

Mac Callum, G.A. 1917. Some new forms of parasitic worms. Zoopathologica. 1: 43-75.

Madhavi, R. 1974. Digenetic trematodes from marine fishes of Waltair coast, Bay of Bengal. Family-Bucephalidae. Riv. Parassit. 35: 189-199.

Madhavi, R. 1975. Digenetic trematodes from marine fishes of Waltair coast, Bay of Bengal. Family Opecoelidae. Riv. Parassit. 36: 153-164.

Madhavi, R. 1975 a. Digenetic trematodes from marine fishes of Waltair coast, Bay of Bengal. Family Fellodistomidae. Riv . Parassit. 36: 267-278.

Madhavi, R. 1976. Digenetic trematodes from marine fishes of Waltair coast, Bay of Bengal. Family Acanthocolpidae. Riv. Parassit. 37: 115-128.

Manter, H.W. 1936. Some trematodes of cenote fish from Yucatan. Carnegie Inst. Wash. Pub. No.457: 33-38.

Manter, H.W. 1940. Digenetic trematodes of fishes from the Galapagos Islands and neighboring Pacific. Allan Hancock Pacific Exped. 2: 325-497.

Manter, H.W. 1947. The Digenetic Trematodes of Marine Fishes of Tortugas, Florida. Amer. Midl. Nat. 38: 257-416.

Manter, H.W. 1954. Some digenetic trematodes from fishes of New Zealand. Trans. R. Soc. N.Z. 82: 475-568.

* Not seen in original.

Manter, H.W. 1955. The zoogeography of trematodes of marine fishes. Exp. Parasitol. 4: 62-86.

Manter, H.W. 1963. Studies on digenetic trematodes of fishes of Fiji. II. Families Lepocreadiidae, Opistholebetidae, and Opecoelidae. J. parasit. 49: 99-113.

Manter, H.W. 1963 a. Studies on digenetic trematodes of fishes of Fiji. IV. Families Haploporidae, Angiodictyidae, Monorchiidae, and Bucephalidae. Proc. Helminth. Soc. Wash. 30: 222-232.

Manter, H.W., and M.H.Pritchard. 1960. Additional hemiurid trematodes from Hawaiian fishes. Proc. Helminth. Soc. Wash. 27: 165-180.

Margolis, L; and H.L. Ching. 1965. Review of the trematode genera Bacciger and Pentagramma (Fellodistomatidae) and description of P. Petrowi (Layman, 1930) n. comb. from marine fishes from the Pacific coast of Canada. Can. J. Zool. 43: 381-405.

Nagaty, H.F. 1937. Trematodes of fishes from the Red Sea. Part.I. Studies on the family Bucephalidae Poche, 1907. Publ. Fac. Med. Egypt Univ. 12: 1-172.

Nahhas, F.M., and R.M.Cable. 1964. Digenetic and aspidogastrid trematodes from marine fishes of Curacao and Jamaica. Tulane Stud. Zool. 115: 167-228.

Nahhas, F.M., and E.C.Powell. 1971. Digenetic trematodes of marine fishes from the Floridan northern Gulf of Mexico. Tulane Stud. Zool. 17: 1-9.

Nahhas, F.M., and R.B.Short, 1965. Digenetic trematodes ofmarine fishes from Apalachee Bay, Gulf of Mexico. Tulane Stud. Zool. 12: 39-50.

Nicoll, W. 1913. New trematode parasites from fishes of the English Channel. Parasitology. 5: 238-246.

Nicoll, W. 1914. The trematode parasites of fishes from the English Channel. J. Mar. Biol. Assoc. U.K. 10: 466-505.

Nicoll, W. 1915. A list of the trematode parasites of British marine fishes. Parasitology. 8: 339-378.

*Nicoll, W. 1934-'35. Verms records. Zool. Rec.

*Ochi, S. 1930. Über die entwickelungeschiste von "Mesocoelium brevicaecum n. sp.". Okay. Igakk. Zasshi Jg. 42: 388-402.

*Odhner, T. 1905. Die Trematoden des Arktischen Gebietes. Fauna Arctica. 4: 291-372.

*Odhner, T. 1911. Zum natürlichen system der digenen trematoden. Zool. Anz. 37: 181-191.

Ozaki, Y. 1925. Preliminary notes on a trematode with anus. J. Parasit. 12 : 51-53. Zool. Mag. 37: 416-423.

Parukhin, A.M. 1965. A new trematode species from the marine fish Rachycentron canadus of the South China Sea. Uch. Zap. Gork. Gos. Pegagog. Inst. 56 : 17-19.

Poche, F. 1907. Über die Kennzeichnung in ihrem Verhaltniss zur Gultigkeit eines Namens. Zool. Anz. 32: 99-106.

*Poche, F. 1925-1926. Das System der Platodaria. Arch. Naturg. A. 91: 1-458.

Pritchard, M.H. 1966. A revision of the Genus Podocotyle (Trematoda:Opecoelidae). Zool. Jb. Syst. Bd. 93: 158-172.

Radhakrishnan, S., and N.B. Nair. 1979. Digenetic trematodes from fishes of the South-West Coast of India. Aquatic Biol. 4: 95-107.

Radhakrishnan, S., and N.B. Nair. 1980. On the metazoan parasites associated with fishes along the South West Coast of India. Symp. Coastal Aquaculture. (Abst): 148-149.

* Not seen in original

Rankin, J.S.Jr. 1944. A review of the trematode genus Glypthelmins Stafford, 1905, with an account of the life cycle of G. quieta (Stafford, 1900) Stafford, 1905. Trans. Amer. Microsc. Soc. 63: 30-43.

*Rudholphi, C.A. 1808. Entozoorum sive vermium intestinalium historia naturalis. Vol. I. Amstelead. 1-527.

*Rudholphi, C.A. 1819. Entozoorum synopsis cui accedunt mantissa duplex et indices locupletissimi. Berolini : 1-811.

Sahai, D., and H.D.Srivastava. 1977. Trematodes of Indian fishes. Part-I. Two new genera of hemiurids (Subfamily-Hemiurinae Looss, 1899). Proc. Nat. Acad. Sci. India. Sect. B. 47: 7-12.

Schell, S.C. 1970. The Trematodes. W.M.C. Brown Company.

Siddiqi, A.H., and R.M.Cable, 1960. Digenetic trematodes of marine fishes of Puerto Rico. N.Y.Acad. Sci. 17: 257-369.

Sinclair, N.R., F.G.Smith, and J.J.Sullivan. 1972. The Stomachicola rubea : Tubulovesicula pinguis enigma. Proc. Helminth. Soc. Wash. 39: 253-258.

Skrjabin, K.I., and L.K.Guschanskaja. 1954. In: Trematodes of animals and man. Principles of Trematodology, Moscow.(Ed. K.I.Skrjabin) 9: 225-623.

Skrjabin, K.I., and V.P.Koval. 1958. Podsemeistvo Coitoçaecinae Poche, 1925. In: Trematody žívotnyh i čeloveka. 15. Izd. Akad. Nauk SSSR, Moskva. 329-434.

Ślusarski, W. 1958. Formy ostateczne Digenea Z ryb lososiowatych (Salmonidae) dorzecza Wisly; poludniowego Baltyku. Acta Parasit. Pol. 6: 249-528.

Sogandares-Bernal, F. 1959. Digenetic trematodes of marine fishes from the Gulf of Panama and Bimini, British West Indies. Tulane Stud. Zool. 7: 69-117.

Srivastava, C.B. 1982. The fauna of India and the adjacent countries. Director, Zool. Survey of India(Ed): 166 pp.

* Not seen in original.

Srivastava, H.D. 1937. New hemiurids from the Indian marine food fishes. III. Two new parasites of the genus *Lecithocladium* Looss from Indian fishes with a revision of the genus. Proc. Indian Sci. Cong. 295-296.

Srivastava, H.D. 1938. Studies on the gasterostomatous parasites of Indian food fishes. Indian J. Vet. Sci. 8: 317-340.

Srivastava, H.D. 1939. New Fellodistomids from Indian hosts. II. Three new parasites of the subfamily Discogasteroidinae from Indian marine food fishes. Indian J. Vet. Sci. & Anim. Husb. 9: 209

Srivastava, H.D. 1939 a. Three new parasites of the genus *Acanthocolpus* Lühe, 1906 (Family-Acanthocolpidae Indian J. Vet. Sci. & Anim. Husb. 9: 213-216.

Srivastava, H.D. 1941. New Allocreadiids (Trematoda) from Indian marine food fishes. Part V. A new parasite of the genus *Lepocreadioides* Yamaguti, 1936 Indian J. Vet.Sci. & Anim. Husb. 11: 52-54.

Srivastava, H.D. 1941 a. New Fellodistomids (Trematoda) from Indian fishes. Part III. A new parasite of the genus *Haplocladus* Odhner, 1911 from an India marine fish. Indian J. Vet.Sci. & Anim. Husb. 11: 42-44.

Stunkard, H.W. 1931. Further observation on the occurrenc of anal openings in digenetic trematodes. Z. Parasitenkde. 3: 713-725.

Stunkard, H.W. 1973. Observàtions on *Tubulovesicula pinguis* (Linton, 1910) Manter, 1947 and on the systematics of the hemiurid trematodes. Biol. Bull. 145: 607-626.

Stunkard, H.W. 1979. Observations on the life-history of Lepocreadiid trematodes. Riv. Parassit. 39: 493-

Stunkard, H.W. 1980. The morphology, life-history, and systematic relations of *Tubulovesicula pinguis* (Linton, 1910) Manter, 1947 (Trematoda: Hemiurid Biol. Bull. 159: 737-751.

Szidat, L. 1955. La fauna de parasitos de *Merluccius hubbsi*. Comun. Inst. Nac. Invest. Cienc. Nat. B. Aires, Ser. Cienc. Zool. **3**: 1-54.

Valasquez, C.C. 1959. Studies on the family Bucephalidae Poche, 1907 (Trematoda) from Philippine food fishes. J. Parasit. **45**: 135-147.

Verma, S.L. 1973. Helminth parasites of freshwater fishes. Part IX. On a new trematode *Stomachicola mastacembeli* sp. n. from the intestine of a freshwater fish, *Mastacembelus armatus*. Zool. Anz. **190**: 167-170.

Yamaguti, S. 1934. Studies on the helminth fauna of Japan. 2. Trematodes of fishes. Jap. J. Zool. **5**: 249-541.

Yamaguti, S. 1936. Studies on the helminth fauna of Japan. Part 16. Trematodes of fishes, III. Published by author. 1-6.

Yamaguti, S. 1939. Studies on the helminth fauna of Japan Part 26. Trematodes of fishes, VI. Jap. J. Zool. **8**: 211-230.

Yamaguti, S. 1942. Studies on the helminth fauna of Japan. Part-39. Trematodes of fishes mainly from Naha. Trans. Biogeogra. Soc. Jap. **3**: 329-398.

Yamaguti, S. 1953. Parasitic worms mainly from Celebes. 3. Digenetic trematodes of fishes, II. Acta Med. Okayama. **8**: 257-295.

Yamaguti, S. 1954. Systema Helminthum. Part I. Digenetic Trematodes of fishes. Published by author, Tokyo. 1-405.

Yamaguti, S. 1958. Systema Helminthum. Vol.I. Parts I and II. The digenetic trematodes of vertebrates. Interscience, New York.

Yamaguti, S. 1970. Digenetic trematodes of Hawaiian fishes. Keigaku Publishing Co., Tokyo, Japan.

Yamaguti, S. 1971. Synopsis of digenetic trematodes of vertebrates. Vol.I., and II. Keigaku Publishing Co., Tokyo, Japan.

*Wiśniewski, L.W. 1933. Remarques sur la systématique de la famillede Coitocaecidae-_Nicolla_ n.g., _Ozakia_ n.g. _Coitocaecum proavitum_ n. sp. C.r.mens. Séanc. Cl.Sci. math. nat. Acad. Pol. Sci. Lett. _1_:6.

*Zeder, F.G.H. 1800. Erster Nachtrag zur Naturgeschichte der Eingeweidewürmer von F.A.C Goeze (Leipzig).

*Not seen in original.

CHAPTER III

INTRODUCTION

Although the role of molluscs as hosts of zooparasites has been known for over two centuries, it has only been in recent years that host-parasite relationships between molluscs and their parasites have been studied in any detail and a great deal remains to be elucidated. Parasites of marine molluscs are of significant importance to fishery biologists because, many of them, particularly the digenetic trematodes, develop to their infective larval forms in molluscs and later as adults become parasitic in various fishes including the commercially important species. The need for life cycle research on marine digenetic trematodes is apparent, and similarly a survey of larval trematodes developing in marine molluscs and other invertebrates and vertebrates is essential. Unfortunately, the marine larval trematode fauna of India with a coast line of about 6,100 Km is imperfectly known and obviously has received no attention whatever in this part of the country. Parasitism in marine molluscs, especially the commercially important species, has far reaching economic implications. They inflict injuries to their hosts in many ways. The hosts' physiology is disturbed, growth halted, reproductive organs destroyed and reproduction inhibited,and massive invasion might bring mass mortality especially in clams and oysters etc. (Sindermann, 1970). Tissue damages caused by larval trematodes in molluscs range from slight to rather severe changes involving mechanical destruction of cells coupled with autolysis and parasite induced lysis (Mohandas, 1974 a, 1977). Lesser damage is caused to other invertebrate hosts by the quiescent metacercarial stage, but fishes infested by that stage are seriously affected or killed. The larval trematodes can, as pointed out earlier, deplete the population of invertebrate hosts which might be of economic importance since it might reduce the food supply to fish. All these clearly point out the vital role the larval trematodes play in the hostparasite relatioship involving them and the molluscs.

This study is only a beginning so far as the marine larval trematodes of Kerala waters are concerned. Because of the limitations of time, the study has never been an exhaustive one. My collection was confined mostly to Cochin backwater system and nearshore waters of Cochin, and although 800 specimens each of <u>Perna viridis</u> (Linné), <u>Sunetta scripta</u> (Linné), <u>Villorita cyprinoides</u> (Gray), and <u>Turritella attenuata</u> Reeve were collected from the nearshore waters, and 700 specimens of <u>Melania tuberculata</u> (Müller) and 100 specimens of <u>M. scabra</u> (Müller) from backwaters, infection rate was negligible. Interestingly fishes taken from these regions harboured many species of adult trematodes. Infact the number of adult species collected by me has certainly exceeded, by several folds, the number of cercarial species reported in this chapter. Marine cercariae are rarely found in high percentage in mollus in which they develop (Cable, 1956), thus a large numbe of any one such host species must be collected and examined to disclose the types of larval trematodes tha may develop in it. Collecting large number of specimen called for more time than was available at my command. Same is the case with the survey of metacercariae in other invertebrates as more time was spent on the collection of adult trematodes from marine fishes. It seems certain that a more extensive coverage of the region would have yielded many additional larval forms from molluscs and other invertebrates and the neglible number of cercarial species recorded here is no indication of the adult trematode fauna in marine vertebrates of this region.

In this chapter, apart from the redescription of the cercariae already reported and the description o an adult obtained from a molluscan host, other aspects like ecobiology, histopathology and life history have also been included. This chapter is divided into five parts: PART A gives a redescription of <u>Cercaria</u> sp.II Kerala Mohandas, 1979, other larval stages and a description of the adult obtained through experimental study; PART B deals with Cercaria chackai Nadakal et al., 1969, its redia and the survival characteristics of the cercaria in different media; PART C covers a description of Cercaria melanocrucifera Reimer et Sita Anantaraman, 1968, its redia and histopathological studies on the molluscan tissue; PART D is on a Carneophallid metacercaria obtained from the prawn Metapenaeus monoceros Fabricius and PART E gives a description of an adult fluke recovered from an unusual host, a marine mollusc, Perna viridis Linné.

PART A. Philophthalmus (Philophthalmus) cochinensis sp. nov., adult of Cercaria sp.II Kerala Mohandas, 1979 - Life cycle study (Digenea : Philophthalmidae)

Members of the genus Philophthalmus occur usually as parasites in the conjunctival sac and occasionally in the digestive tract of vertebrates, mostly birds. During the course of the present investigation, one species of freshwater gastropod, Melania tuberculata, collected from a brackish water habitat having connections with the Cochin backwater system, liberated cercariae of the "Megalura type" which encysted readily on a glass slide. When these cysts were administered to the conjunctival sac of chickens, they developed to maturity and were found to belong to the genus Philophthalmus. As only one adult with eggs and two immature worms could be attained, early part of the life cycle could not be worked out. This section deals with the descriptions of the cercaria, redia, metacercaria and the adult which is considered as a new species.

Materials and Methods :- 500 specimens of Melania tuberculata (Müller) collected on three occasions from a brackishwater fish farm, Vyttila, Cochin belonging to the Kerala Agricultural University (in the month of June, 1979) were brought to the laboratory in live condition and kept in groups of 5-10 in beakers, the mouths of which were covered with cheeze-cloth to provide good aeration and also to prevent the escape of snails. Those which shed cercariae were isolated individually and kept in separate beakers. Water in the containers was changed daily and the snails were fed with water plants. The snails which shed cercariae were later crushed and examined for other larval stages once the study of the cercaria was completed. Morphological studies of the cercariae, either without staining or by staining with vital stains such as neutral red and methylene blue (0.01% concentration), were based on those which came out spontaneously from the snails. Invertebrate physiological saline and refrigeration of the cercariae (10-15°C) facilitated the study of excretory system. With one or two drops of the medium, the cercariae were transferred to a glass slide, a No.1 cover slip was placed over, excess medium blotted off by a strip of blotting paper and examined under a binocular research microscope. The preparation was sealed with vaseline around the cover slip to prevent evaporation of the medium. The genital system was studied using acetocarmine. Rediae were studied alive using vital stains, and metacercariae also alive but without using vital stains. Measurements were made of atleast 20 larval forms each, fixed in hot 5% formalin and expressed in millimeters but of metacercariae were based on 10 live specimens.

To study the life cycle, metacercariae encysted on glass slides were used. Ten cysts were administered, five each to the right and left orbital cavities of one 5 day-old chicken and nine cysts, five to the right orbital cavity and four to the left orbital cavity of one 10 day-old chicken. The first bird was autopsied 9 days and the second 13 days postinfection and the orbital cavities and digestive tracts were examined for the adults. The recovered flukes were washed in saline, studied alive and then pressed in between two slides and immediately fixed in 10% formalin. They were stained in Semichon's carmine, processed in the routine manner and mounted in canada balsam. Measurements were in millimeters and drawing was made with the aid of a camera-lucida.

Observation :

A.1. Cercaria, Redia and Metacercaria

Cercaria sp. II Kerala Mohandas, 1979

Host : *Melania tuberculata* (Müller)

Prevalence : 2.4% (12/500)

Locality : Brackishwater farm in Vyttila, Cochin

Location : Digestive gland

Measurements : Body - 0.384-0.608 by 0.120-0.208;
Tail - 0.336-0.448 by 0.048-0.072;
Oral sucker - 0.056-0.072;
Ventral sucker - 0.072-0.088;
Pharynx - 0.024-0.040.

This cercaria is an active swimmer like many other cercariae of this group and moves about swiftly in water by a series of rhythmic movements of the body and tail. A characteristic feature of the cercariae of this group is a constriction at level of the acetabulum. They are usually shed in the morning hours or whenever the water in the container in which the infected snails are kept, is changed. It has a peculiar habit of hanging down from the surface film of water supported by the infolded tail tip and also by secretions from the associated glands and making serpentine movements, swaying from side to side. Usually the cercariae are seen in groups on the surface film of water and they readily encyst on hard objects.

Body is oval to spindle-shaped, slightly constricted at level of the acetabulum and pale-brown coloured by the presence of coloured granular cystogenous materials in the cystogenous cells which in young forms are arranged in four linear rows. In mature cercariae, however, the pattern is lost and the cells lie scattered. Body cuticle is beset with backwardly directed spines throughout its length. There are two pairs of papillae with sensory hairs in the posterior half of the body. Spineless tail is composed of parenchymatous cells and tip is infolded into a flask-shaped structure with two gland cells on either side, positioned one above the other. The cells are nucleated and with clear granular cytoplasm. Oral sucker is slightly smaller than the postequatorially situated ventral sucker. Mouth is subterminal, prepharynx short, pharynx oval-shaped, and the short and stumpy oesophagus bifurcates immediately into long intestinal caeca which extend to near the posterior extremity. The eight pairs of penetration gland cells situated at level of the pharynx contain well developed nuclei and granular protoplasm.

The excretory bladder is non-epithelial and situated at the posterior end of the body. From the anterior end of the bladder arises the two main excretory ducts. Each duct runs anteriorly taking a wavy course and at level of pharynx, the duct bends on itself and descends. At the acetabular level it divides into two, as anterior and posterior collecting tubes. Excretory concretions or ciliated patches are absent in the ducts or tubes. The flame cell formula is 2(3+3+3+3+3+3) = 36. The nervous system is represented by two masses situated on either side of the prepharynx and connected by transverse nerve fibres. From each mass arise one nerve cord antero-laterally and two posterolaterally. The genital anlage consists of two masses of cells, one situated at the triangular space formed by the caeca and the anterior margin of the acetabulum and the other posterior to the acetabulum. These two masses are connected by a strand of cells.

Redia :

Measurements : Daughter Redia : 1.360-2.400 by 0.240-0.400
Mother Redia : 1.200-1.312 by 0.192-0.224

Development of the cercariae takes place in rediae found in the digestive gland. There are two redial generations. Mother rediae are pale-white coloured but mature daughter rediae appear slightly pigmented because of the presence of growing cercariae containing coloured cystogenous materials. Pharynx is well developed in both. In mother redia, gut extends to half the body length. Lumen of the gut is filled with orange-yellow granules. In young daughter redia, the gut reaches far below the level of lateral appendages but in older ones it reaches only half of the body length. Inside the mother redia are seen daughter rediae and germ balls. Older mother rediae which no longer produce daughter rediae have shrivelled bodies with gut occupying greater portion of the body. Birth pore is situated ventrolaterally, posterior to the collar. Body wall is faintly wrinkled but papillae are totally absent. Excretory system is fairly well developed with a minimum of 10 flame cells scattered throughout the body. Development of the cercariae is completed inside the rediae.

Metacercaria :

Measurements : 0.320-0.384 by 0.144-0.192.

Before encysting, the cercaria creeps a short distance on the hard surface, fixes itself to the surface by the acetabulum and oral sucker, the body flattens, cystogenous materials slowly ooze out of the body, spread uniformly and form a cyst using the body as a mould. After some time, the body shrinks gradually leaving behind a space between it and the cyst wall. Tail drops out almost immediately the cyst formation commences, leaving behind a dome-shaped elevation at the narrow end. The metacercaria rotates in the space for some time but gradually becomes quiescent. The flask-shaped cyst consists of two layers, an inner cyst wall proper and the outer flared layer cementing the cyst to the substrate.

Discussion :- When Cercaria sp.II Kerala is compared with other forms of the 'Megalura type', it becomes clear that it shows many differences from others. Cercaria megalura (Cort, 1914) and its redia are comparatively smaller. Body is aspinose and salivary glands are absent. Cystgenous cells are with cytoplasmic rodlets and caudal gland cells are 15-20 in number. Cable and Hayes (1963) claimed that Philophthalmus gralli as described by West (1961) from the USA and by Alicata (1962) from Hawaii is probably distinct from P. gralli Mathis and Léger, 1910 and they renamed the North American species as P. megalurus Cort, 1914 because of the specific name of its larva, Cercaria megalura. In this connection it is interesting to note that Alicate and Noda (1960) had given a preliminary account of the adult belonging to the genus *Philophthalmus* and its life cycle stages. This parasite was identified later by Ching (1961) as *P. gralli* Mathis and Léger, 1910, and subsequently Alicata (1962) gave a detailed account of all developmental stages of *P. gralli* with some information on the early migration of the parasite in the final host. When a comparison is made of *P. gralli* and its larval stages as described by Alicata and Noda (1960), Ching (1961) and Alicata (1962) with *P. megalurus* and its larval stages as given by West (1961), it becomes very clear that these two forms are distinct, and I believe that Alicata and Noda, Ching and Alicata were dealing with *P. gralli* Mathis and Léger and not with *P. megalurus* as commented by Cable and Hayes (1963). Cercaria *P. megalurus* (West, 1961) has a very long tail with less than 10 unicellular adhesive glands and mouth is surrounded by a narrow band of spines and sensory papillae. Cephalic glands are approximately 20 pairs mostly lateral to oesophagus and two additional pairs of similar glands are found in the hind body. There are only 15 pairs of flame cells and the recurrent arm of each primary duct has about 5 ciliated patches. In *Cercariae indicae* IV (Sewell, 1922), lip of the mouth is provided with a series of papillae and pharynx is surrounded by a cluster of pharyngeal gland cells. There are 10-12 pairs of salivary gland cells, only 14 pairs of flame cells, and oesophagus is narrow and long. Although *Cercariae indicae* IV also has four caudal gland cells, they are positioned one above the other. A philophthalmid cercaria, as described by Murty (1966) showing close resemblance to *Cercariae indicae* IV has 18 pairs of flame cells. *Cercaria nicobarica* III (Sewell, 1931) lacks in body spination and salivary gland cells. Pharynx is with separate muscular and glandular regions. There are 10 pairs of caudal gland cells but only 15 pairs of flame cells. Although the present species and *Cercaria ratnagiriensis* (Peter, 1954) show similarities in the number and disposition of salivary gland cells, the latter is characteristic in having eight caudal cells, 12 pairs of flame cells and a clump of 10 rod-shaped structures anterior to the caudal cells. *Cercaria caudiglandula* as described by Premvati (1954) has spines on the tail, 9 pairs of penetration gland cells, 12-14 pear-shaped caudal gland cells and only 13 pairs of flame cells. In having sensory papillae and a row of about 14 pores at the anterior end, long oesophagus, droplets in excretory ducts, rodlets in cystgenous cells and redia without lateral appendages, the marine form *Cercaria caribbea* V (Cable, 1956) differs from *Cercaria* sp. II Kerala. Although in general body measurements and in flame cell formula the present form shows similarities with cercaria P. gralli as described by Alicata and Noda (1960), Ching (1961) and Alicata (1962); in the latter the two suckers are of the same size and sensory papillae are absent. Rediae are comparatively smaller and characterised by cuticular papillae, and metacercaria in having two lateral winglike expansions. The two marine forms, cercaria P. burrili and cercaria Cloacitrema narrabeenensis (Howell and Bearup, 1967) are fairly large with caudal excretory ducts, small papillae at the anterior end of the body and four to six caudal gland cells. While the former has five pairs of papillae, long oesophagus and only 12 pairs of flame cells, the latter is characterised in having cystogenous cells with either rods or granules and typically oval shaped cysts. Cercaria Cloacitrema philippinum (Velasquez, 1969) has smooth cuticle, sensory papillae at the anterior end and a row of 12 pores at the anterior edge of oral sucker, rodlets in cystogenous cells, three pairs of cephalic glands, long oesophagus and oval cyst. The two marine forms, cercaria P. hegeneri and cercaria P. larsoni (Penner and Trimble, 1971) are large with fairly long oesophagus. The excretory system of the former consists of a caudal branch. Redial gut extends only one-fifth of the body length and the cyst wall consists of many concentric layers of materials. The excysted form has approximately 20 pairs of cephalic glands (Haas and Fried, 1974) but only 15 pairs of flame cells with three ciliary patches in each primary duct (Fried and Grigo, 1976). The redia of *P. larsoni* is very small, and during cyst formation the tail of the cercaria is found attached to the posterior end of the cyst wall. Cercaria *P. andersoni*, another marine form, described by Dronen and Penner (1975), has a smooth cuticle, 10 papillae at the edge of the oral sucker, long oesophagus and only 15 pairs of flame cells. Although Wardle (1974) described two philophthalmid cercariae of the "Megalura type", *Cercaria* sp. XVII and *Cercaria* sp. XVIII, they are not taken into consideration for they possess collar spines and apparently do not belong to the genus *Philophthalmus*.

A.2. *Philophthalmus* (*Philophthalmus*) *cochinensis* sp. nov.

Experimental host : Chicken (*Gallus gallus domesticus*)

No. of parasites recovered : One adult from the right eye of a chicken 13 days postinfection and two immature forms, one from each eye of a chicken nine days postinfection.

Location : Under the nictitating membrane

Measurements : (of holotype material)
Body - 1.900 by 0.625;
Oral sucker - 0.212 by 0.230;
Pharynx - 0.207 by 0.212;
Ventral sucker - 0.378 by 0.330;

Ovary - 0.153 by 0.258;
Anterior testis - 0.236 by 0.366;
Posterior testis - 0.153 by 0.270;
Egg - 0.030-0.059 by 0.018-0.035;
Sucker ratio - 1:1.43;
Ovary-anterior testis ratio - 1:1.42 and Ovary-posterior testis ratio - 1:1.05.

Measurements : (of two immature specimens)
Body - 0.862 and 1.068 by 0.300 and 0.354;
Oral sucker - 0.106 and 0.118 by 0.118 and 0.147;
Pharynx - 0.094 and 0.129 by 0.094 and 0.129;
Ventral sucker - 0.177 and 0.248 by 0.183 and 0.236;
Ovary - 0.047 and 0.071 by 0.070 and 0.106;
Anterior testis - 0.059 and 0.094 by 0.094 and 0.153;
Posterior testis - 0.070 and 0.118 by 0.094 and 0.142;
Sucker ratio - 1:1.55 and 1:1.6

Philophthalmus Looss, 1899

Generic diagnosis :- (as given by Yamaguti, 1971) Philophthalmidae, Philophthalminae, *Philophthalmus*. Body elongate fusiform or pyriform. Acetabulum at about one third of body length from the anterior end. Oral sucker followed by short prepharynx; pharynx usually large; oesophagus very short; caeca terminating at posterior extremity. Cirrus pouch long, usually extending posterior to acetabulum, enclosing elliptical seminal vesicle, prostatic complex and eversible ejaculatory duct. Testes tandem, near posterior extremity. Genital pore median, at or behind intestinal bifurcation. Ovary usually in the posterior third of the body. Uterus winding between testes and acetabulum sometimes overreaching caeca laterally. Vitellaria arranged in symmetrical longitudinal series outside caeca anterior to testes. Excretory vesicle strongly constricted just before dividing into two lateral arms. Parasitic in conjunctival sac of birds.

Philophthalmus (Philophthalmus) cochinensis sp. nov.(Fig. 1). Specific diagnosis :- (based on holotype material) Body is lacking in spines, elongate, attenuated anteriorly and rounded posteriorly, and slightly constricted at acetabular level. Greatest width is at level of vitellaria. Oral sucker is subterminal and wider than long and the ventral sucker, larger than the oral sucker, is situated in the anterior half. Mouth leads into a pharynx which is strongly muscular. A prepharynx is absent. Oesophagus is short, slightly thicker and immediately divides into two well developed caeca which extend to the posterior end of the body. The testes, situated in the posterior region, are unequal in size and tandem in position. The anterior testis is larger, the anterior margin of which

Fig. 1. *Philophthalmus* *(Philophthalmus)* cochinensis sp. nov.

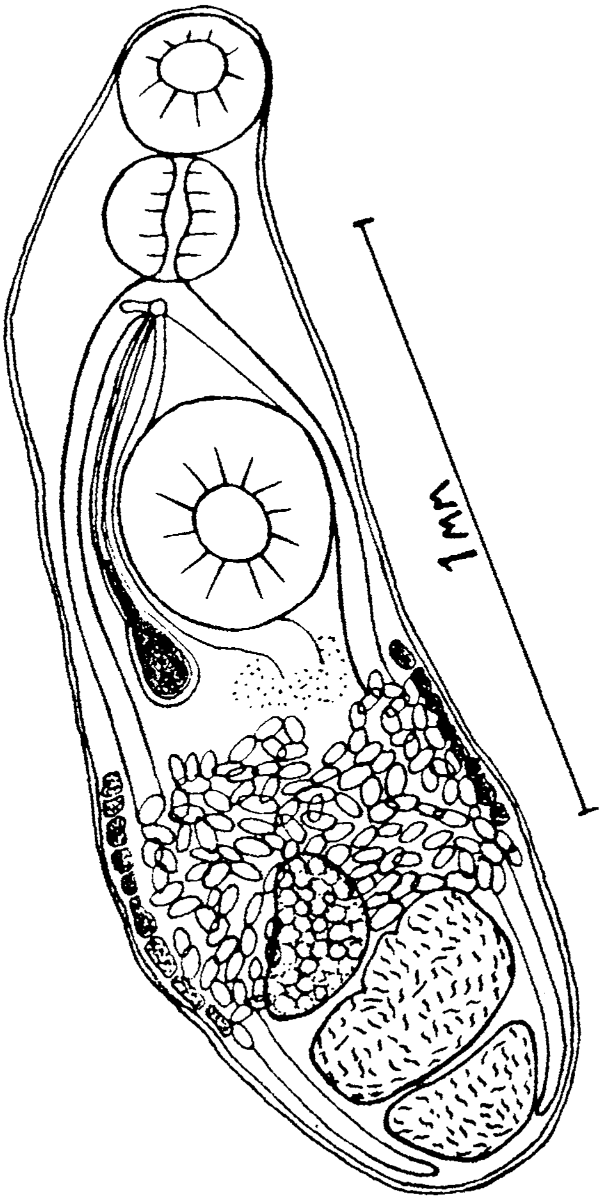


FIG. 1.

is indistinctly lobed. The cirrus sac is a long club shaped structure, placed on the right side of the ventral sucker and extending posteriorly from the level of intestinal bifurcation to a distance slightly beyond the posterior margin of the ventral sucker. The vesicula seminalis occupies the broad basal part of the cirrus sac. The ejaculatory duct is long and traverses the whole narrow part of the cirrus sac and ultimately terminates in a short, eversible and unarmed cirrus. The genital pore is median, at level of intestinal bifurcation. There is no pars prostatica. Ovary is oval shaped, situated anterior to anterior testis. The metraterm is wide near the posterior end but distally it narrows down and runs alongside the cirrus sac and opens at the genital pore. Vitellaria are extracaecal, follicular, nine on the right side and eight on the left side, and extend laterally from a short distance behind the ventral sucker to the level of the posterior margin of ovary. Eggs are numerous, non-operculate and occupy the space between the ventral sucker and the anterior testis. Excretory vesicle is not visible in stained specimen but in live condition it appeared as a 'T' shaped non-chambered structure.

Discussion :- Yamaguti (1958, 1971) divided the family Philophthalmidae into five subfamilies, namely, Philophthalminae, Parorchiinae, Echinostephillinae, Cloacitrematinae and Skrjabinoverminae. Baugh (1962), however, recognized only two subfamilies, Philophthalminae and Cloacitrematinae (spelled by Baugh Cloacitreminae). The subfamily Parorchiinae was elevated to the family rank while the other two subfamilies were dropped. While Yamaguti (1971) considered three genera, *Ophthalmotrema*, *Pygorchis* and *Philophthalmus* under the subfamily Philophthalminae, Baugh (1962) treated *Echinostephilla* also under this subfamily. It is not my intention, at this level, to critically discuss the classification of the family Philophthalmidae, on the contrary I am focussing attention on the genus *Philophthalmus*.

The genus *Philophthalmus* was created by Looss (1899) for *P. palpebrarum*, which had been found under the eyelids of the avian hosts, *Corvus cornix* and *Milvus parasiticus*, at Cairo, Egypt. Looss (1899) transferred *Distomum lucipetus* Rudolphi, 1819 also to this new genus. Later Braun (1901) redescribed *P. lucipetus* and also described another species, *P. lacrymosus*, from Brazil. Looss (1907) subsequently added one more species, *P. nocturnus*, from Egypt, and Mathis and Léger (1910) described *P. gralli* from Tonkin. Sugimoto (1928) while recording *P. gralli* from Formosa, also described *P. anatinus*. *P. problematicus* and *P. rizalensis* were reported from the Philippines (Tubangui, 1932), *P. nyrocae* from Japan (Yamaguti, 1934), *P. skrjabini* from Moscow (Efimov, 1937), *P. occularae* (Wu, 1938), and *P. sinensis*

(Hsü and Chow, 1938), both from China. Tretiakowa (1948) described *P. muraschkinzewi* and Gvozdev (1953) described *P. coturnicola*, both from Russia. From Yugoslavia, Richter et al., (1953) reported *P. posaviniensis* and *P. cupensis*. Jaiswal and Singh (1954) described *P. mirzai* and *P. indicus*, and Jaiswal (1955) recorded *P.aquillai*, all the three from India. While Timon-David (1955) reported *Philophthalmus* sp. from France, Buša (1956) described *P. hovorkai* from Czechoslovakia. Shigin (1957) described *P. oschmarini* from Rybinsk reservoir; Dissanaike and Bilimoria (1958) reported *Philophthalmus* sp. from Ceylon, and Mamaev (1959)* described *P. offlexorius* from East Siberia. From India, two more forms, *P. lucknowensis* and *P. halcyoni*, were reported by Baugh (1962), Vassilev (1962; cited from Index-Catalogue of Medical and Veterinary Zoology, suppl., 22, part 3, 1980) described *Philophthalmus* sp. from Yugoslavia and Oshmarin (1963) recorded *P. capellae* and *P. proboscidus* from Primorskii Krai. *P. elongatus* and *P. enterobius* were reported by Belopol'skaia (1963) from Amur Basin. Cable and Hayes (1963) claimed that *P. gralli*, as described by West (1961) from the USA and by Alicata (1962) from Hawaii, is distinct from *P. gralli* Mathis and Léger, 1910 and they renamed the North American species *P. megalurus* Cort, 1914 because of the specific name of its larva, *Cercaria megalura*. Penner and Fried (1963) described *P. hegeneri* from Florida. *Philophthalmus*

---

* cited from Yamaguti (1971)

(*Mixophthalmus*) *chrysommae* was reported by Karyakarte (1966), *Philophthalmus* sp. by Murty (1966), *P. peteri* by Sreekumaran (1966), and another *Philophthalmus* sp. by Karyakarte (1967); all the four from India. Howell and Bearup (1967) recorded *P. burrili* from Australia, and Karyakarte (1968) described *Philophthalmus* (*Philophthalmus*) *columbae* and *Philophthalmus* (*Philophthalmus*) *acridotheres* (Karyakarte, 1969), both from India. *P. larsoni* was reported by Penner and Trimble (1970) from Florida, USA; *Philophthalmus* (*Tubolecithalmus*) *alii* by Karyakarte (1971) and *Philophthalmus* sp. by Venkat Reddy and Subramanyam (1971), both from India, and *P. andersoni* by Dronen and Penner (1975) from Florida and California, USA. George Varghese and Kalyana Sundaram (1975) tentatively identified the specimens they collected from fowls in Kerala, India as *P. gralli*. *P. rhionica* was recored by Tikhomirov (1976) from western Gruziia, and Brooks and Palmieri (1978) reported *P. pulchrus* from Malaysia. By reducing the genus *Ophthalmotrema* to synonomy with *Philophthalmus*, Penner and Fried (1963) added another species, *P. numenii*, but Yamaguti (1971) did not accept this view. So there are atleast 46 species of *Philophthalmus* recorded so far from throughout the world.

Alicata and Noda (1960) listed 19 species of *Philophthalmus*, and Ching (1961) listed 23 but recognized only nine as valid species which were *P. gralli*, *P. lacrymosus*, *P. lucipetus*, *P. muraschkinzewi*, *P. nocturnus*, *P. offlexorius*, *P. palpebrarum*, *P. rizalensis* and *P. sinensis*. *P. anatinus* Sugimoto, 1928 and *P. nyrocae* Yamaguti, 1934 were regarded as synonyms of *P. gralli*. This consideration was based mainly on studies of reared materials of *P. gralli* in mammals and birds. The identification of species of *Philophthalmus* is complicated by the fact that several characters which many workers consider as of taxonomic importance were not considered as fairly constant by Ching (1961). While Ram Prakash and Pande (1968) considered *P. indicus*, *P. aquillai*, *P. lucknowensis* and *P. halcyoni* as synonyms of *P. mirzai* attributing the variations mostly to fixation and/or to age and host differences, Saxena (1979) redescribed *P. lucknowensis* and retained the species status. Yamaguti (1971) listed 29 species but he also considered *P. anatinus* and *P. nyrocae* as synonyms of *P. gralli*. Srivastava and Pande (1971) considered *P. mirzai* also as a synonym of *P. gralli* besides those species which were earlier assigned by Ram Prakash and Pande (1968) as synonyms of *P. mirzai*. Nasir and Diaz (1972) suppressed the subgenus *Philophthalmus* and considered *P. (P.) columbae* as a synonym of *P. offlexorius*. According to them the cercaria of *P. gralli* of West (1961) is a distinct species from *Cercaria megalura* and the combination proposed by Cable and Hayes (1963) should be discarded. Vassilev (1973) and Vassilev and Ossikovski (1974) treated *P. posaviniensis*, *P. cupensis*, *P. hovorkai* and *Philophthalmus* sp. Vassilev, 1962 as probable synonyms. Mehra (1980) considered *P. mirzai*, *P. indicus*, *P. aquillai*, *P. lucknowensis*, *P. halcyoni* and *P.* (*M.*) *chrysommae* as synonyms of *P. gralli*, and Srivastava (1982) added *P.* (*T.*) *problematicus*, *P.* (*T.*) *columbae*, *P.* (*P.*) *acridotheres* and *P.* (*T.*) *alii* also to the list of synonyms of *P. gralli*.

On the basis of difference in the type of vitellaria in the genus *Philophthalmus*, Skrjabin (1947) divided the genus into two subgenera, *Philophthalmus* with follicular vitellaria and *Tubolecithalmus* with tubular vitellaria. Karyakarte (1966) added the third subgenus *Mixophthalmus* in which he included the forms with a mixed vitellaria considering the condition as intermediate between the tubular and follicular types of vitellaria. Although Yamaguti (1971), and Nasir and Diaz (1972) are not inclined to accept this division of the genus *Philophthalmus* into three subgenera and Ching (1961) of Skrjabin's (1947) classification of the genus into two subgenera, I feel that there is ample justification for division of the genus *Philophthalmus* into subgenera.

After a study of over 50 specimens of mature *P. gralli* obtained from four different hosts, Ching (1961) concluded that location of the genital pore, ratio of transverse diameters of suckers, ratio of diameters of ovary to testes, type of vitellaria, extent of vitellaria, extent of seminal vesicle and egg size were the characters which remained fairly constant. The variations observed due to age were the size of the seminal vesicle, extent of uterine loops, condition of the testes and spination of the body. On these grounds, of the 23 species described till then, Ching (1961) considered only nine as valid species. Beaver (1937), Berrie (1960), Arora et al., (1962), and Lie (1963) also observed intra-specific variations in the characters of the trematodes reared in different hosts. The criteria used to differentiate a digenetic trematode at species level should include, as far as possible, the distinctive morphological features of the cercariae as well and the diagnosis of closely related forms based on adult morphology alone will often be confusing and misleading (Mohandas, 1973 a). Different hosts, as mentioned earlier, bring about conspicuous variations in the adult morphology and these become so marked that the same species occurring in different hosts may be mistaken for separate species. It is well established that gene expression is modified by environment and it is possible, as Smyth (1966) remarked, that in the case of a parasite also the different environments provided by different hosts may affect its gene expression resulting in phenotypic variations.

In the case of *Philophthalmus*, cercarial stages of only six species were described so far, viz., of *P. gralli*, *P. megalurus*, *P. hegeneri*, *P. burrili*, *P. larsoni* and *P. andersoni*. Besides these, desc on a few more cercariae (discussed under part III A.1), the adults of which are yet to be described, are also available. In these circumstances, identification of the different species of *Philophthalmus* based on life cycle studies alone, keeping the others whose life cycles are yet to be reported as *species inquirenda*, does not sound to be a reasonable proposition. On the contrary, a reclassification of the species under the genus *Philophthalmus* based on the types of vitellaria would cover all the species which can be included in the three subgenera : *Philophthalmus*, *Tubolecithalmus* and *Mixophthalmus*; the first two created by Skrjabin (1947), and the third by Karyakarte (1966). The type of vitellaria has been considered as a fairly constant character by Ching (1961) herself although she believed that yolk glands in the genus *Philophthalmus* are either tubular or follicular, a view endorsed also by Yamaguti (1971). However, Skrjabin (1947), Penner and Fried (1963), Penner and Trimble (1970) and Dronen and Penner (1975) considered the follicular nature of vitellaria different from the tubular nature. Going through the descriptions of the different species of *Philophthalmus*, it becomes evident that certain species have vitellaria of the tubular type, on one side and the follicular type on the other side or a mixture of these two on both sides and, such species could be included in the subgenus *Mixophthalmus*, established by Karyakarte (1966). Although Karyakarte (1966) considered only three species under this subgenus- *Philophthalmus occularae* Wu, 1938, *P. halcyoni* Baugh, 1962 and *P. chrysommae* Karyakarte, 1966 - other species such as *P. gralli* Mathis et Léger, 1910, *P. megalurus* (Cort, 1914) Cable et Hayes, 1963, *P. peteri* Sreekumaran, 1966, *P. burrili* Howell et Bearup, 1967, and *Philophthalmus* sp. Karyakarte, 1967 can also be included in the subgenus *Mixophthalmus*.

The forms with follicular type of vitellaria, including the new species, come under the subgenus *Philophthalmus*. These include *P. lucipetus* (Rud) Looss, 1899, *P. lacrymosus* Braun, 1901, *P. skrjabini* Efimov, 1937, *P. indicus* Jaiswal et Singh, 1954, *P. mirzai* Jaiswal et Singh, 1954, *P. offlexorius* Mamaev, 1959, *P. lucknowensis* Baugh, 1962, *P. hegeneri* Penner et Fried, 1963, *P. columbae* Karyakarte, 1968, *P. acridotheres* Karyakarte, 1969, *P. larsoni* Penner et Trimble, 1970, and *P. andersoni* Dronen et Penner, 1975. Including the new species there are 13 species coming under the subgenus *Philophthalmus*.

The criteria used to differentiate a digenetic trematode at species level, as mentioned earlier, should include as far as possible the distinctive morphological features of the cercariae as well. In the subgenus Philophthalmus, the cercarial forms of only three species, viz., P. hegeneri, P. larsoni and P. andersoni are known, and the cercaria of Philophthalmus (Philophthalmus) cochinensis shows marked differences from these cercariae, as discussed already. In adult morphology also the new species differs from the remaining species in the subgenus Philophthalmus (Table I). The characters which Ching (1961) considered as constant were the location of the genital pore, ratio of transverse diameters of suckers, ratio of diameters of ovary to testes, type and extent of vitellaria, extent of seminal vesicle and egg sizes. Besides these, I am including the position of vitellaria, type of cirrus and the number of yolk glands (vitelline follicles) also as constant characters. In the new species the location of the genital pore is median, at level of intestinal bifurcation. The condition is the same in the remaining forms except in P. indicus, P. mirzai, P. acridotheres, P. larsoni and P. andersoni. No other species has the sucker ratio of 1:1.43 as seen in Philophthalmus (Philophthalmus) cochinensis. Same is the case in respect of the ratio of diameters of ovary to testes. Regarding the position of vitellaria, there is not much difference among the various species. In all

TABLE I

Comparison of constant characteristics among *Philophthalmus* (*Philophthalmus*) species

	P.lucipetus	*P.lacrymosus*	*P.skrjabini*	*P.offlexorius*	*P.indicus*	*P.mirzai*	*P.lucknowensis*	*P.hegeneri*	*P.columbae*	*P.acridotheres*	*P.larsoni*	*P.andersoni*	*P.cochinensis* n. sp.
Location of the genital pore	Median at intestinal bifurcation	At or near intestinal bifurcation	At or near intestinal bifurcation	At or near intestinal bifurcation	Anterior to intestinal bifurcation	Rightside in front of intestinal bifurcation	Median at level of intestinal bifurcation or slightly aside	Median at level of intestinal bifurcation	Median at level of intestinal bifurcation	Right side of oesophagus or at level of pharynx	Above and to the side of intestinal bifurcation	Median above intestinal bifurcation	Median at level of intestinal bifurcation
Sucker ratio	1:2 to 1:2.2	1:1.5	1:1.3	1:1.3 to 1.8	1:1.3	1:1.08	1:1.2 to 1.3	1:2	1:1.2	1: 1.6	1: 1.5	1:1.8	1:1.43
Ratio of Ovary:Testis	1:3	1:1.1	1:2 and 1:2.4	1:2	1:0.72 and 1:0.53	1: 2.53 and 1: 2.5	1:2.6 and 1:2.5	1:2.11 and 1:2.29	1:1.06 and 1:1.2	1:1.2 and 1:1.08	1:1.32 to 1:2.41	1:2.3 and 1:2.1	1: 1.42 and 1: 1.05
Position of Vitellaria	Third quarter of the body	Third quarter of the body	Third quarter of the body		From the posterior margin of acetabulum downwards	Middle of the body to posteriorward	Middle of the body to posteriorward	Anterior half of the posterior half	Second third of the body	Third quarter of the body	Middle of the posterior half	Anterior half of the posterior half	Anterior half of the posterior half
Extent of seminal vesicle	Posterior to acetabulum	Rarely extends beyond posterior margin of acetabulum	Posterior to acetabulum	Posterior to acetabulum	Does not extend beyond the posterior margin of acetabulum	Extends beyond the posterior margin of acetabulum	Extends beyond the posterior margin of acetabulum	Does not extend beyond the posterior margin of acetabulum	Extends beyond the posterior margin of acetabulum	Extends slightly beyond the posterior margin of acetabulum	Extends beyond the posterior margin of acetabulum	Extends beyond the posterior margin of acetabulum	Extends beyond the posterior margin of acetabulum
Type of cirrus	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Non-spinose (inferred)	Non-spinose (inferred)	Spinose	Spinose	Spinose	Not given	Spinose	Spinose	Non-spinose
Egg size (length) in µm	83 - 104	67	Not available	77 - 80	77 - 79	75 - 82	66 - 87/ 105-122(Live)	50 - 75	83 - 84	60 - 84	56 - 70	72.5-77.5	30 - 59
Extent of vitellaria from anterior testis to acetabulum	35 to 45%	55 to 60%	55 to 60%	35 to 45%	90 to 95%	Appx. 65%	80 to 92.5%	35 to 60%	Not given	Appx. 75%	Apox. 45%	35 to 40%	75 to 85%
Number of yolk glands	6-7 follicles on each side	5-6 follicles on each side	5 follicles on one side & 6 on the other side	5-6 follicles on each side	Not given	6 or 7	9 to 15 and 9 to 16	6 and 5 or 5 and 4	6 and 4	3 or 4	4 to 9 and 2 to 11	6 or 7	9 and 8

the species in the subgenus *Philophthalmus*, except in *P. lacrymosus*, *P. indicus* and *P. hegeneri*, the seminal vesicle extends beyond the posterior margin of the acetabulum. In the present species, the type of cirrus is non-spinose and it is inferred that the same condition prevails in *P. indicus* and *P. mirzai* also. In *P. lucipetus*, *P. lacrymosus*, *P. skrjabini* and *P. offlexorius*, the type of cirrus was not mentioned. Egg size is the lowest in the new species and the extent of vitellaria from anterior testis to acetabulum is 75-85%. In other species the figures are different. While the present form has nine and eight vitelline follicles, no other species has the same numbers.

So, the differences in larval characters, sucker ratio, ratio between the diameters of ovary and testes, type of cirrus, egg size, extent of vitellaria, and the number of vitelline follicles are the strong points which justify the creation of the new species under the subgenus *Philophthalmus*. The new species, *Philophthalmus* (*Philophthalmus*) *cochinensis*, has been named after the city, Cochin.

In the new species, the eggs did not show any sign of development, apparently being unfertilized. It appears that cross fertilization is a prerequisite to egg embryonation in this species. This is not surprising because Fried (1962) found that isolated adults of

P. hegeneri stopped growing after 20 days in chick's eye and never produced fertile eggs. Similarly, Howell and Bearup (1967) also noticed that singleworm infections of *P. burrili* were infertile. However, Nollen (1971 a) was successful in getting one cycle completed with no evidence of deterioration in the case of single-worm infection with *P. megalurus*. Saxena (1979) observed both normal and infertile eggs in the same individuals of *P. lucknowensis*. At this stage it is difficult to say for certain about the type of fertilization in the genus *Philophthalmus*, and as Nollen (1971 b) put it "In the genus *Philophthalmus* the situation seems to vary among different species".

When all is said and done, the species identification of members in the genus *Philophthalmus* is becoming more and more difficult mainly for want of descriptions on larval stages, particularly on cercariae. It is to be hoped that eventually more descriptions on larval forms and detailed morphological studies on adults might reveal differences that have escaped attention so far, paving way for easy identification of the different species coming under the genus *Philophthalmus*.

PART B. Cercaria chackai Nadakal, Mohandas et Sunderaraman, 1969, its redia, and survival characteristics of the cercaria in different media (Digenea : Transversotrematidae)

The Transversotrematidae is believed to be the smallest family of marine trematodes and is restricted to the Indo-Pacific region (Cable, 1974). The members of this family occupy an ectoparasitic niche, inhabiting the recesses beneath the scales of fresh water, brackish water and marine fishes. Of the seven species comprising the genus Transversotrema Witenberg, 1944, the cercariae of T. patialense (Soparkar, 1924) Yamaguti, 1958, T. laruei Velasquez, 1958, T. soparkari Pande and Shukla, 1972, and T. chackai Mohandas, 1973 are already known. The larval form of the type species T. haasi Witenberg, 1944, of T. licinum Manter, 1970 and of T. chauhani Agarwal and Singh, 1981, and the adult of Cercaria koliensis Olivier, 1947 are yet to be discovered. The known cercariae develop in gastropod molluscs of the genera Melania or Thiara. An interesting feature with this group is the report of natural infections of T. haasi and T. licinum from marine fishes. As the adults are found in marine, brackish and fresh water fishes but none of the cercariae recorded from typical marine molluscs, it was thought worthwhile to study the effects of salinity, pH and O_2 on survival of the larval form of T. chackai, namely Cercaria chackai, found in

Melania tuberculata and *M. scabra* living in fresh water and brackish water conditions.

Materials and Methods :- 200 specimens of *Melania tuberculata* (Müller) and 100 specimens of *Melania scabra* (Müller), collected from a brackish water fish pond, Vyttila, Cochin belonging to the Kerala Agricultural University were brought to the laboratory alive and kept in groups of 5-10 in beakers the mouths of which were covered with cheeze-cloth to provide good aeration and also to prevent the escape of snails. Those which shed cercariae were isolated individually and kept in separate beakers. Water in the containers was changed daily and the snails were fed with water plants. Methods of studying the cercaria and redia were the same as described in detail under Part A - Materials and methods. Survival of the cercariae in sea water, sea water diluted with deionized water in different proportions, deionized water, pond water, and tap water was observed. To each medium in a 15 ml petri dish, five freshly emerged cercariae (within **five** minutes of emergence) were transferred with minimum pond water and the time of transfer was recorded. To obtain fresh cercariae, once the process of emergence started, pond water in which the molluscs were kept was changed periodically and the cercariae continued to emerge in large numbers within a few minutes. The experiment was conducted at room temperature (33°C) and the temperature of the media was also recorded. The dishes were examined constantly under a binocular microscope and the activity of the cercariae was observed. Dead cercariae, those which displayed no movement spontaneously or even after some manipulation, were counted and the time of death recorded. The experiment was repeated six times, and in each medium a total of 30 cercariae was used. Just before the start of the experiment, the pH of the media was checked by a pH Meter, salinity estimated by Grasshoff's method (Grasshoff, 1976), and oxygen concentration by Winkler method (as outlined in Strickland and Parsons, 1965). Light intensity was measured using a Lux Meter.

Observation:

B.1. Cercaria and Redia

Cercaria chackai Nadakal, Mohandas et Sunderaraman, 1969

Host : *Melania tuberculata* (Müller) and *M. scabra* (Müller)

Prevalence : 5% and 3% respectively (10/200 and 3/100)

Locality : Brackish water fish pond in Vyttila, Cochin

Location : Digestive gland

Measurements : Body - 0.420-0.600 by 0.700-1.050;
Tail stem - 0.520-0.630 by 0.105-0.165;
Tail furca - 0.290-0.365 by 0.080-0.120;
Appendage - 0.220-0.290 by 0.050-0.100;
Diameter of Eye spot - 0.015-0.030;
Diameter of Pharynx - 0.040-0.085;
Diameter of Ventral sucker - 0.110-0.160

This cercaria is large enough to be seen easily with naked eyes. Sometimes it suspends itself in water with the head pointed downwards and tail upwards, the furcae acting as float and the adhesive organs characteristically flexed. In this position it sinks to the bottom, lie there for a while and resumes the swimming locomotion again. This consists of alternating bouts of passive vertical dropping and active tail-first swimming. Each bout of swimming results in the upward displacement of the larvae in the water column. This displacement of the larvae is usually curved or tortuous. The free lateral margins of the body also help in swimming and their undulations resemble the beatings of wings of a bat. On a thin film of water, the cercaria performs looping movements. While floating freely in water, the tail is held under the ventral side of the body and the lateral edges of the body turned inwards.

The cercaria is biocellate, furcocercous and transparent with the general appearance of a tiny ray-fish. The body is covered with triangular, scale-like spines. Eye spots are pigmented and spherical. Oral sucker is absent and acetabulum is situated at about midlevel of the body; discoid and pedunculate. Tail is reticulate in appearance, non-spinose, and the base of the tail is flanked by a pair of appendages, each tipped with an adhesive pad. Mouth is ventral, pharynx is well developed and the oesophagus is narrow, nonmuscular and bifurcating at acetabular level to form cyclocoel intestine with slightly lobulated wall composed of large cells. The paired testes are lobed, symmetrically placed within intestinal ring and contain spermatozoa. The S-shaped seminal vesicle is situated just anterior to right testis, half within and half outside the intestinal loop. The anterior end narrows down to form the ejaculatory duct extending to genital atrium with subventral pore, well anterior to the mouth. Ovary is small, situated anterior to the left testis within the intestinal loop. The distinct but empty uterus extend transversely to right from ovary, crosses the intestine and accompanies the ejaculatory duct to the genital atrium. A seminal receptacle is absent.

The excretory vesicle, situated just posterior to the intestine, is saccate to bilobed depending on the state of contraction. From the vesicle the caudal excretory duct extends through the tail stem, bifurcates at the far end and opens at a pore on each furca. The main excretory ducts, one on each side of the vesicle, arise from the anterolateral margins of the vesicle. Each main duct extends anteriorly to form a wide loop, part of which is ciliated, at acetabular level and then descends. This ciliated descending duct, at midlevel of the excretory vesicle, divides into two; one branch running anteriorly and the other posteriorly. The anterior branch which is also ciliated divides into two secondary ducts at acetabular level. To one of the secondary ducts most of the flame cells of the anterior half empty and the other secondary duct extends towards the acetabulum to form a commissure with the corresponding secondary duct of the other side, just anterior to intestine and posterior to pharynx. The posterior branch before it enters into the tail gives off one secondary duct to which are connected two tertiary ducts. Flame cells of the middle and posterior regions empty into these tertiary ducts. A commissure crosses the excretory vesicle to unite the secondary ducts of the posterior branches. The posterior branch, after giving off the secondary duct, enters into the tail where three flame cells get connected to the branch. In addition to the three pairs of flame cells in the tail stem, 42 pairs were observed in the body.

Redia :

Measurements of mother redia - 1·175-1·900 by 0.470-0.600;
diameter of Pharynx - 0.120-0.210.

Body is simple, oval to pear-shaped, with an attenuated tail and orange coloured. Pharynx is prominent and spherical. The saccular intestine, not reaching mid-level of the body, contains small brownish-yellow materials.

Mother redia contains daughter rediae and 10-40 germ balls. There are three flame cells on each side, and the excretory ducts open laterally at about midlevel of the body. Heavy pigmentation and stumpy appearance distinguished mother from daughter rediae. Development of the cercariae is completed in the digestive gland of the snail.

Discussion :- *Cercaria chackai* differs from the previously described transversotrematid cercariae in size and features of the excretory system. In size and morphology, the species is most like *C. patialensis* in which Anantaraman (1948) and Brien (1954) reported both ascending and descending limbs of the main excretory ducts to be ciliated. In *C. chackai*, however, cilia are limited to the descending limbs of the main ducts, anterior branches of the descending ducts and part of the loop. Besides being decidedly larger than *C. koliensis* and the cercaria *Transversotrema laruei*, *C. chackai* has a commissure crossing the excretory vesicle where as in *C. koliensis* it is anterior to the vesicle, and the cercaria *T. laruei* has two anterior commissures. The last species has four pairs of flame cells in the tail stem whereas others have only three pairs. *Cercaria soparkari* differs from all the known transversotrematid cercariae in the shape of the eye and by the presence of bristles on the caudal furcae. In this form, the anterior collecting canal was observed to be ciliated, there were only five flame cells in the tail stem and ovary was located near the right testis.

As to the snail hosts, *C. patialensis* was reported from *M. tuberculata* (Soparkar, 1924; Anantaraman, 1948; Crusz, 1956; Crusz, Ratnayake and Sathananthan,1964; Hanumantha Rao and Ganapati, 1967; Murty and Hanumantha Rao, 1968) and *M. anomala* (Brien, 1954); *C. koliensis* from *M. terebra* (?) (Oliver, 1947); cercaria *T. laruei* from *Thiara riquettii* (Velasquez, 1961); *C. chackai* from *M. tuberculata* and *M. scabra* (Nadakal, Mohandas and Sunderaraman, 1969), and *C. soparkari* from *M. tuberculata* (Pandey, 1971). The rediae of various species in these hosts also differ in size, number of embryos and in the number of flame cells.

B.2. Survival characteristics of the Cercaria

Results:- In laboratory conditions the cercariae emerged in large numbers around noon when light intensity was about 700 Lux and continued to emerge till late in the evening with dim light of 50 Lux. No cercariae emerged after dusk. Naturally shed cercariae had the maximum life span of 20h. 40 min. in pond water under experimental conditions when salinity of water was 17.8 ppt, pH 6.45, O_2 5.76 ml/l, and temperature 31.5°C. Fifty percent survival period was more than 16h 30min. survival pattern of *C. chackai* in different media with varying salinity, pH and O_2 values is given in Table II. From the data it is clear that cercariae can tolerate salinity fluctuations to a great extent. With increase in salinity beyond 17.8 ppt, survival period was considerably reduced and

Table II. Survival Pattern of Cercaria chackai in different media

	Sea water	Approximate proportion of sea water : deionized water									Deionized water	Pond water	Tap water
		90 : 10	80 : 20	70 : 30	60 : 40	50 : 50	40 : 60	30 : 70	20 : 80	10 : 90			
Salinity ‰	38·3	34·42	30·35	27·64	23·58	18·97	14·10	11·40	8·67	4·60	0·0	17·8	0·0
Survival time (means ± SD)	min s 4 26± 1 06	min s 4 48± 1 10	min s 5 20± 1 07	min s 6 18± 1 36	h min 7 22± 1 13	h min 12 43± 2 03	h min 13 35± 4 10	h min 14 34± 3 29	h min 15 24± 2 19	h min 15 11± 1 32	h min 1 45± 2 24	h min 16 9± 2 43	h min 13 25± 2 56
Range	min min 3 8	min min 3 8	min min 3 9	min min 2 11	h min h min 6 05–11 30	h min h min 9 30–16 30	h min h min 11 08–17 40	h min h min 11 30–18 05	h min h min 11 45–18 50	h min h min 12 30–19 10	h min h min 0 25–3 15	h min h min 11 15–20 40	h min h min 9 45–19 50
50% Survival period (more than)	min 4	min 5	min 5	min 6	h min 7 00	h min 13 20	h min 13 55	h min 15 17	h min 16 10	h min 15 40	h min 2 12	h min 16 30	h min 14 00
pH	8·15	8·15	8·15	8·15	8·05	7·95	7·80	7·80	7·70	7·50	7·00	6·45	7·70
O_2 Concentration in ml/l	2·61	3·51	3·74	3·97	4·68	4·88	4·99	5·10	5·44	5·97	4·65	5·76	5·21
Temperature °C	31·5	31·5	31·5	31·5	31·5	31·5	31·5	31·5	31·5	31·5	31·5	31·5	31·5

h-hour(s), min-minute(s), s-second(s).

beyond 23.58 ppt, the period was restricted to a few minutes. Below the salinity of 17.8 ppt, although the period of survival was shorter, the difference was not very appealing and even in tap water with no salinity, the cercariae survived upto 19h 50min. Interestingly, in deionized water the maximum period of survival was only 3h 15min. As the maximum survival took place in pond water at pH 6.45 it is assumed that the cercariae preferred a slightly acidic medium. At higher pH beyond 8.05 coupled with increased salinity, survival time was drastically reduced to a few minutes. At salinities beyond 23.58 ppt, although the O_2 values were comparatively less, it is not presumed, for reasons explained below, that shortage of available oxygen was the reason for early death.. Temperature, obviously, has not played any role in the survival characteristics of the cercariae because the temperature of all the media was the same throughout the experiment.

Discussion :- A wide range of biological and physico-chemical factors exert their influence on the emergence of cercariae. It was already reported that *C. chackai* emerged around noon and a mere change of water was sufficient to stimulate the process of cercarial emergence as well as to increase the activity of the molluscan host, and this does not appear to be correlated with any degree of significance to any particular factor (Mohandas, 1974).

The time of emergence of two other closely related cercariae, cercaria *T. patialense* and *Cercaria soparkari*, however, is quite different. Thus, cercaria *T. patialense* was reported to emerge only at dusk continuing to do so throughout the night (Hanumantha Rao and Ganapati, 1967), and *C. soparkari* from dusk to nightfall (Pandey, 1971).

There are only a very few studies dealing with salinity tolerence of fresh water cercariae or the tolerance of dilution by marine cercariae. Porter (1938) reported that cercaria *Schistosoma haematobium* whose normal life span was about 30h died in 16h in 0.85% salt solution, in 10h 35min in 1% salt solution, and in less than one hour in 1.5% salt solution. Ingalls (1946) stated that cercaria *S. japonicum* survived a little over 9h in 1% sodium chloride solution, 5 to 20 min. in 1.5% salt solution and 3 to 15 min in 2% salt solution. *Cercariae indicae* VIII was found to survive a maximum of 48h in tap water at 10°C but only 38h in invertebrate physiological saline at the same temperature (Mohandas, 1974). While *C. chackai* survived for about 21h in natural pond water, cercaria *T. patialense* was reported to have normal activity, presumably in stream water. for a little over six hours only (Hanumantha Rao and Ganapati, 1967; Murty and Hanumantha Rao, 1975). Quite interestingly, cercaria *T. patialense* was shown to survive a maximum of 44h in tap water at 24°C when light intensity was 150 Lux and 50% survived longer than 26h (Anderson and Whitfield, 1975).

The reason for this abnormally contrasting results is difficult to explain. Murty and Hanumantha Rao (1975) reported that cercaria *T. patialense* behaved in normal manner in saline media of 18 ppt or 19 ppt but could not survive when salinity was raised above 21 ppt. *C. chackai* was found to survive several hours when salinity was raised upto 23.58 ppt but at salinities 27.64 ppt and above, survival time decreased with increase in salinity and was restricted to a few minutes. Hence, the upper incipient lethal level of *C. chackai* falls between the salinity range of 23.58 ppt and 38.3 ppt. The ability of this cercaria to survive longer time in freshwater conditions and in a wide range of salinity from 0 ppt to 23.58 ppt shows that it is a fresh water form adapted to brackish water conditions also. Although the family Transversotrematidae is considered to have marine origin (Cable, 1974), the occurrence of *T. patialense*, *T. soparkari*, *T. chackai* and *T. chauhani* beneath the scales of fresh water fishes (Crusz et al., 1964; Murty and Hanumantha Rao, 1968; Pande and Shukla, 1972; Mohandas, 1973; Agarwal and Singh, 1981) indicates that at least these four species had their origin in fresh water. *C. patialensis*, *C. soparkari* and *C. chackai* might have undergone physiological and/or morphological preadaptation. That, the family Transversotrematidae has both marine and fresh water species, is not surprising because there are several families and even genera having representations in both marine and fresh water habitats (Stunkard and Shaw, 1931; Cable, 1974).

Behaviour of cercariae transferred from marine to diluted conditions was also studied by Stunkard and Shaw (1931), Rees (1947), and Kuntz (1957). These authors stated that a decrease in salinity generally affected the longevity and activity of cercariae. Stunkard and Shaw (1931) showed that the marine cercariae they studied had the ability to withstand dilutions containing only one-eighth to one-fourth sea water. Kuntz (1957) reported cercaria of *Heterophyes aequalis* to survive within the range 6-19 ppt, but not in freshwater. Based on circumstantial evidence, Paperna and Lahav (1971) suggested that this larva could survive hypersaline conditions. Lee and Cheng (1970) showed graphically that about 20% of the cercariae of *Stellantchasmus falcatus* tested in Hawaii survived 20h in 4.5 and 9.0 ppt, but none lasted over 10h in 1.2 or 18.0 ppt. Vernberg and Vernberg (1974) quoting Kasschau's observations reported that cercariae of *Himasthla quissetensis* and *Lepocreadium setiferoides* were also able to tolerate low salinities, the former even down to 3ppt. The ability of these cercariae to survive long periods in transitional media shows their adaptation to new hosts as well as to new environments. As stated by Stunkard and Shaw (1931) "Due to the well-

-known and constantly appearing variations which occur among animals, certain fresh water species may have become adapted to life in brackish and eventually sea-water, while similarly, marine species may have entered fresh-water habitats". The average survival time of C. chackai in deionized water was only 1h 45 min with a range of 25 min to 3h 15 min. The low survival time in deionized water and in higher concentrations of sea water is due to the failure or poor functioning of the osmoregulatory mechanisms of the cercariae.

In the case of C. chackai it is assumed that death rate is density independent at the densities of cercariae per unit volume of water used in the experimental study. The two important factors likely to invalidate this assumption are shortage of available oxygen in water and accumulation of waste products. Even in sea water at 38.3 ppt salinity, O_2 content was 2.61 ml/l and since the volume of water used was relatively large with a considerable area exposed to air, it is reasonable to conclude that these processes are unlikely to be limiting factors. Although cercariae cannot survive prolonged periods under anaerobic conditions (Smyth, 1966; Vernberg, 1963; Erasmus, 1972), complete anaerobiosis does not take place in the present experiment. As observed in the present study, mortality within a population of freshly emerged cercariae varied considerably between individuals even under optimum conditions indicating that death rate is age or time dependent. This is particularly significant in the case of non-feeding cercarial stage since death rate may often increase in time due to the progressive utilization of the non-replaceable food reserves, generally in the form of glycogen and lipids (Ginetsinskaja and Dobrovolskii, 1962; Erasmus, 1972).

Maximum survival of C. chackai took place at pH 6.45 and this appears to be the optimum pH for the larva. With increase in pH there is decrease in survival time but pH does not appear to be the single factor responsible for this. It is interesting to note that in tap water the maximum survival period was 19h 50 min at pH 7.70 against the maximum of 20h 40min in pond water at pH 6.45. Similarly at pH 8.05 the maximum survival was for 11h 30 min while it was only for 11min at pH 8.15, both in the mixture media of sea water and deionized water at different proportions. In this experiment, hence, it appears that the role of pH, if any, becomes significant only at higher salinities.

Since temperature of all the media was maintained constant at 31.5°C, this factor in no way has affected the survival pattern of C. chackai.

That a connection exists between the sea and the water bodies from where the molluscs were collected is known in the present instance as well as in the case of cercariae _T. patialense_ (Murty and Hanumantha Rao, 1975), and _T. laruei_ (Velasquez, 1961). It is possible that marine fishes may migrate to estuaries and contact infection as has been suggested by Velasquez (1961), and while describing a closely related genus _Prototransversotrema_, Angel (1969) reported that infection with _P. steeri_ was found in marine fish common in brackish waters and also venturing into fresh waters. Considering the ability of the cercariae to tolerate salinity fluctuations, it is also possible that the cercariae themselves may be carried down stream into marine environments where they may survive a sufficiently long time to infect marine fishes. If such a fresh water influx exists in the vicinity from where Witenberg and Manter recorded the adult forms, it becomes easier to solve the problem of representation of the family Transversotrematidae in dual habitats: natural infection of two adult species in marine fishes and the occurrence of larval forms of the other species in fresh water and brackish water molluscs alone.

PART C. *Cercaria melanocrucifera* Reimer et Sita Anantaraman, 1968 and histopathological studies on the molluscan digestive gland.

Whereas studies on larval trematodes of fresh-water and terrestrial molluscs have received considerable impetus from the need to know about flukes of medical and veterinary importance, studies on larval trematodes of marine molluscs have seldom had economic justification (Cheng, 1967). As a result, a knowledge of marine cercariae has lagged behind even that of their adults. Holliman (1961) in an investigation of cercarial fauna in marine molluscs of the Gulf of Mexico, summarized work to that date, most of it from the North Atlantic. Subsequently, contributions were made from Europe by Rebecq (1964), Chubrik (1966), James (1968), and Reimer (1970). In the Pacific, Miller (1925) at Puget Sound, Martin (1955, 1972) in California, and Ito (1980) in Japan studied marine cercariae. Angel (1954), Bearup (1955, 1956, 1960, 1961), Ewers (1964, 1965), Pearson (1968), and Cannon (1978) described cercariae from marine molluscs of Australian waters. Cable (1956, 1963) studied marine cercariae of Puerto Rico and, Curacao and Jamica, and Epstein (1972), and Wardle (1974) made surveys on the cercarial fauna of marine and estuarine molluscs of Galveston, Texas. A survey of the marine cercariae of the Woods Hole, Massachusetts region was made by Stunkard

(1970) who subsequently (Stunkard, 1983) reviewed and revised the marine cercariae of the same region. In India, very little work has been done on marine cercariae and perhaps the only report is by Reimer and Sita Anantaraman (1968).

In this section, an account of Cercaria melanocrucifera which was briefly described by Reimer and Sita Anantaraman (1968), and the pathology caused by the larval stages in the digestive gland of the marine mollusc, Turritella attenuata, is given.

Materials and Methods :- Marine molluscs of the species, Sunetta scripta (Linné), Villorita cyprinoides (Gray) and Turritella attenuata Reeve collected from the nearshore waters of Cochin in the months of February, March and April in 1980 and 1981 were brought to the laboratory alive. In the laboratory the molluscs were isolated into several groups in a small quantity of seawater at room temperature, just sufficient to fully immerse the mollusc, permit limited mobility and adequate oxygen for 48 hr period. The water was examined periodically for the presence of emerged cercariae. Isolation of molluscs was terminated after 48 hours if no cercariae emerged and the molluscs were generally considered negative for cercarial infections and was discarded. When a large number of molluscs from a single collection appeared negative, after the examination some of the individuals were crushed and examined.

Emerged cercariae were transferred to a watch glass for further study. For microscopical study, they were transferred in a few drops of seawater to a slide and a No.1 cover glass was placed over the drops of water. Coverslip pressure was controlled by absorption of excess water with a blotting paper. Neutral red and methylene blue in concentration of 0.01% were used as vital stains. Infected molluscs were retained till the study of cercaria was over and eventually sacrificed to study other larval stages. To study the pathology, hepatopancreas of infected and uninfected molluscs of the same sex and age was fixed in Bouin's fluid, embedded in paraffin and sections cut at 6 µm. Sections were stained with Heidenhein's haematoxylin and eosin. Measurements of larval stages were made of 20 individuals fixed in 10% formalin under coverslip pressure and expressed in mm. Drawings were made with the aid of a camera-lucida.

Observations :

Eight hundred specimens each of *S. scripta*, *V. cyprinoides* and *T. attenuata* were examined. Of these only two specimens of *T. attenuata* were infected with *Cercaria melanocrucifera*.

Host : *Turritella attenuata*
Prevalence : 0.25% (2/800, both females)
Locality : Nearshore waters of Cochin
Location : Hepatopancreas and Gonad
Measurements : *Cercaria* : Body length - 0.137-0.205;
Body width - 0.050-0.085;
Tail length - 0.5-1.875;
Tail width - 0.050-0.175;
Oral sucker (diameter) - 0.025-0.037;
Pharynx - 0.0065-0.0090 x 0.0075-0.0110;
Excretory vesicle - 0.020-0.045.
Redia : 0.575-1.170 x 0.120-0.195.

Cercaria melanocrucifera is an ocellate magnacercous cercaria possessing an enormously enlarged tail, distinctly pigmented, and devoid of finfolds. The cercarial body is comparatively smaller (Fig. 2). The proximal portion of the tail is inflated a little, middle portion is enlarged considerably and distal portion is slender and tapering to a point (Fig. 3). The body spination is confined to the anterior half and the first 4-5 rows of spines are slightly larger. Cystogenous cells are found throughout the body, concentrated mainly in the area behind the level of eye spots and they contain granular materials. Refractile globules are very few or even absent. Eye spots are dark. A delicate narrow finfold is present on each side of the anterior third of the body, extending upto the level of pigmented eye spots. Oral sucker is well developed and acts as a penetrating organ

Fig. 2. Cercaria melanocrucifera - Body showing the general organization

Fig. 3. Inflated tail showing the cruciform marking

Fig. 4. Diagram showing the oral sucker with dorsal and ventral lips bearing

Fig. 5. Cercarial body showing excretory system

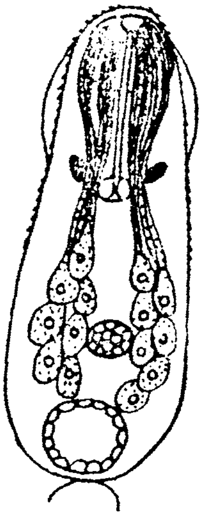


FIG. 2

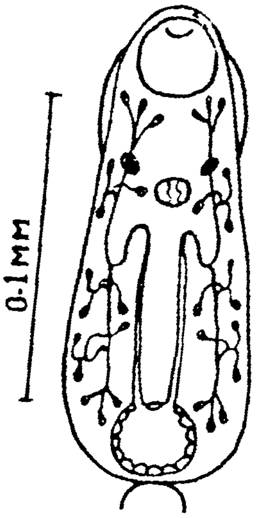


FIG. 5

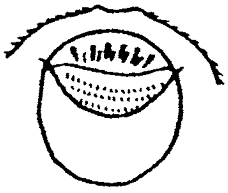


FIG. 4

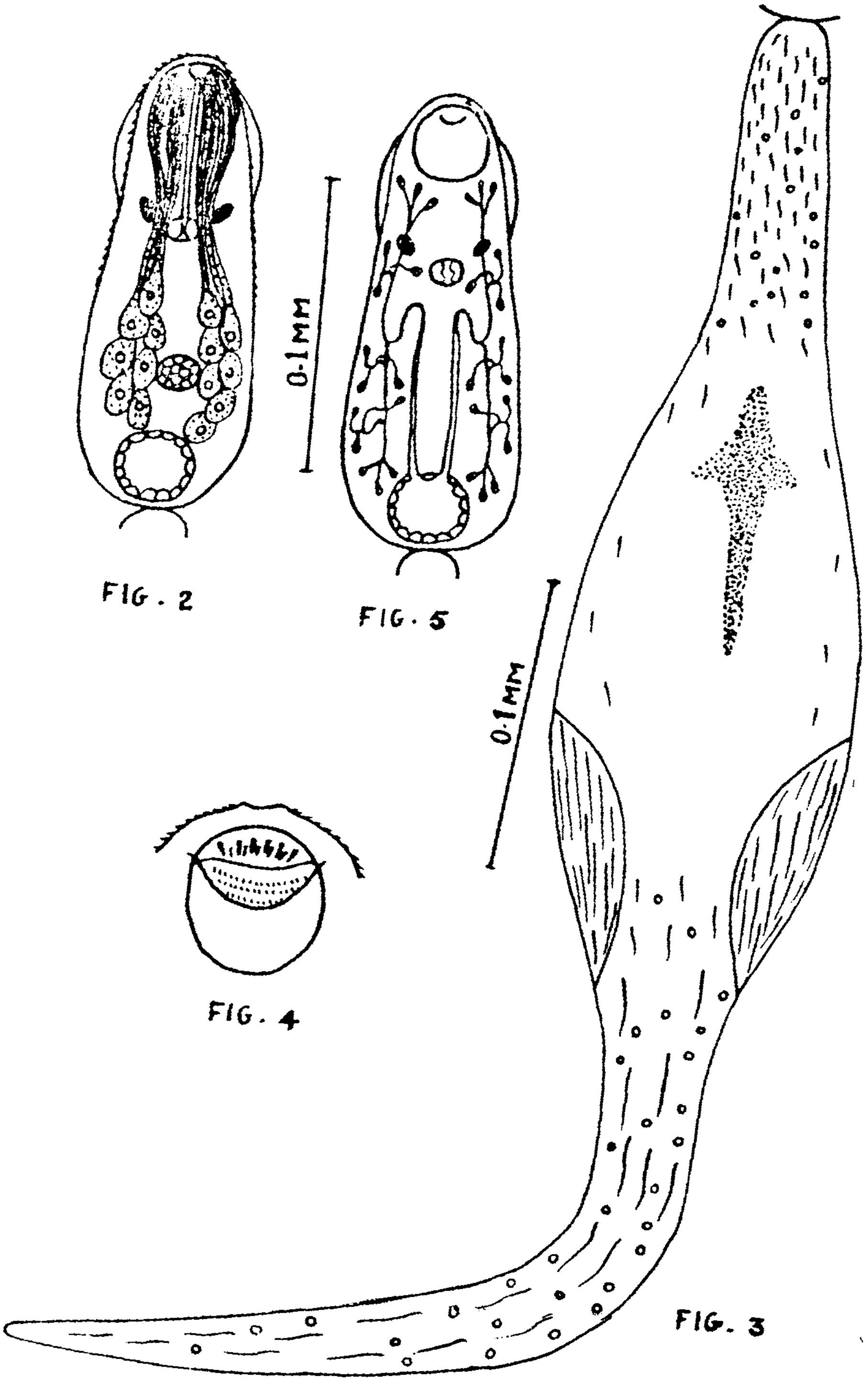


FIG. 3

and can be extended and contracted. The dorsal lip of the oral sucker has eleven spines arranged in a double row and the ventral lip has three rows of short spines (Fig. 4). Mouth is subterminal, prepharynx is narrow and straight and pharynx is small and almost globular. Rest of the digestive system and a ventral sucker are absent. Penetration glands, seven on each side, posterior to the pharynx, contain coarsely granular protoplasm and well developed nuclei. The duct arising from each cell runs anteriorly. The ducts are grouped in 4 bundles of 3-4-4-3 pattern. The grouping of ducts into bundles takes place at level of or slightly above the level of eye spots. The ducts open near the mouth. The penetration glands do not encircle the excretory vesicle.

The excretory vesicle is almost spherical in outline and is thick walled. From the anterolateral margins of the vesicle arise the two main excretory ducts. Each main duct runs anteriorly to a point slightly below the level of pharynx, curves on itself and the retrograde duct after running for a short distance divides into two, one branch running anteriorly and the other posteriorly. Associated with the anterior duct are seen 6 flame cells and with the posterior duct are seen 9 flame cells. The flame cell formula is 2(3+3+3+3+3) = 30 (Fig. 5). No trace of a caudal excretory duct or flame cells in the tail was observed. The genital rudiments are represented by a mass of cells situated between the pharynx and the excretory vesicle (Fig. 2).

The non-spinose tail is with reddish-brown longitudinal pigmented streaks at the base and a black cruciform marking is seen in the dilated region. The postero-lateral corners of the dilated region are equipped with muscle fibres in hemispherical patches. Longitudinal muscle fibres are well developed particularly in the posterior half of the body (Fig. 3).

Development of the cercariae takes place in sausage shaped rediae which are reddish-brown coloured. Mouth is situated at the anterior end. Pharynx is well developed but the intestine is small.

The brown-green coloured digestive gland of _T. attenuata_ was found to occupy almost the whole of the visceral spire. The gonad was attached to the posterior part of the digestive gland. The gland consisted of numerous dilated, blind ending tubules bound together by a meshwork of connective tissue containing the visceral haemocoelic space. The whole gland was enclosed in an epithelial sac, the _tunica propria_. The tubules separated from the haemocoel by thin layers of fibrous connective tissue were lined with glandular epithelium. The epithelial lining consisted of two distinct cell types. The more frequently observed cells were the tall, columnar,

PLATE 1. Explanation of Figures

Fig. 1. Uninfected digestive gland of T. attenuata. x 100
A-Absorptive cell, G-Glandular epithelium,
L-Lumen of the tubule, S-Secretory cell,
T-Tunica propria

Fig. 2. Tubular damage caused by parthenitae. x 100
Arrow marks indicating remnants of tubules

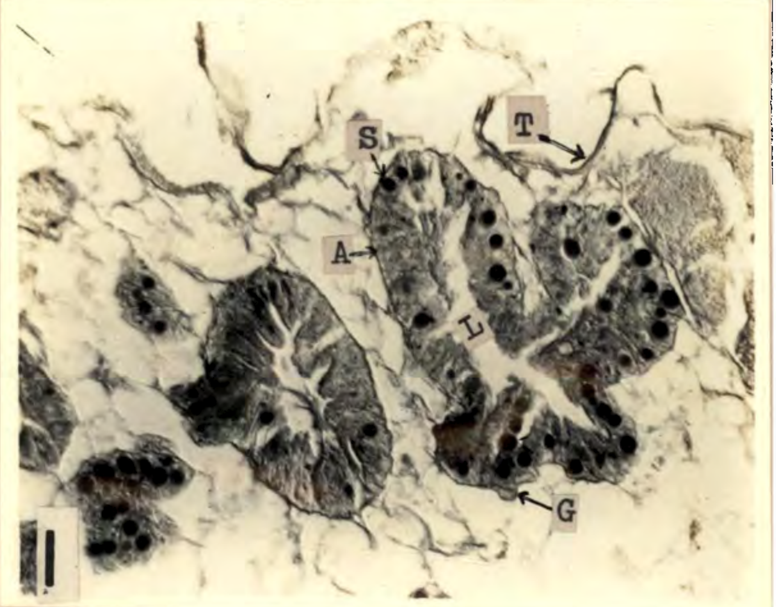
Fig. 3. Fibrous nature of digestive gland cells. x 100

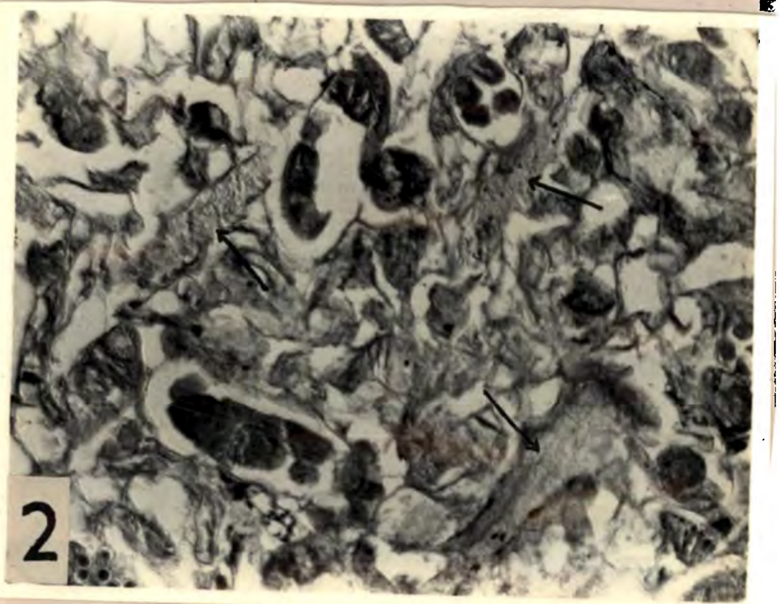
Fig. 4. Completely disorganised tubules. x 100

Fig. 5. Arrow marks indicating the movement of dense granules towards the lumen. Also note the sloughing of epithelium (thick arrow). x 100

Fig. 6. Arrow indicating complete necrosis of the epithelium. x 100

PLATE 1





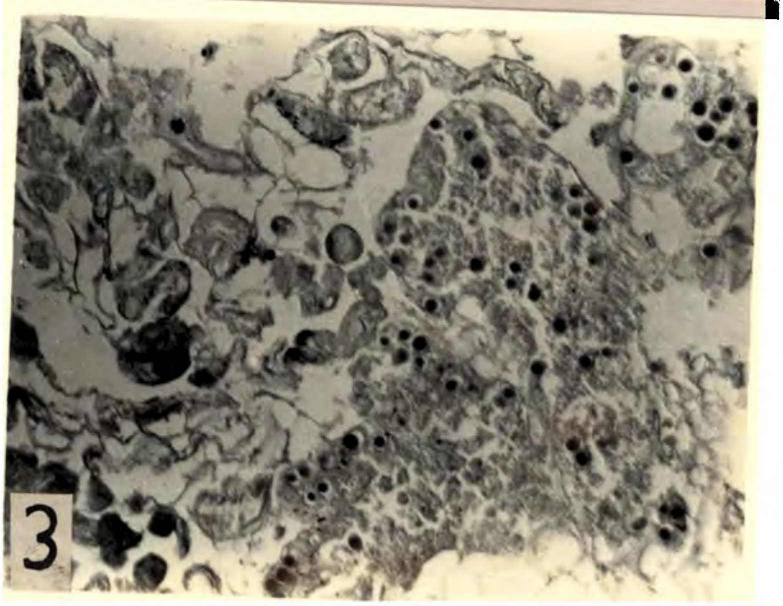
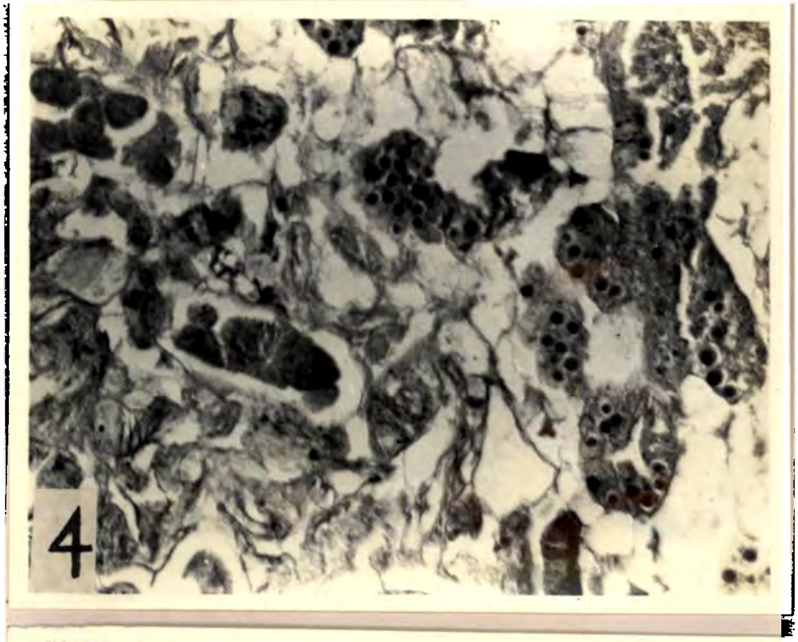
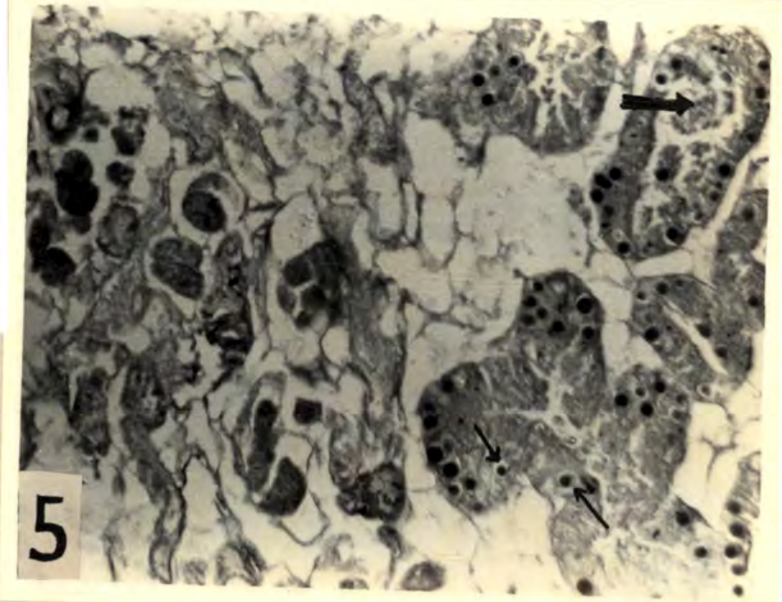
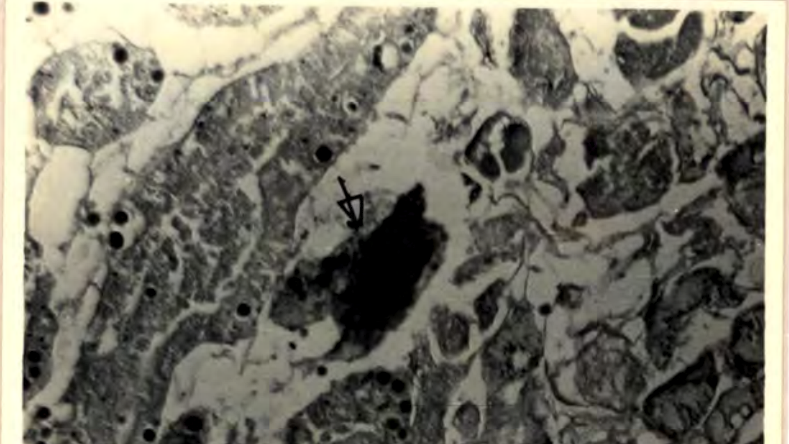


PLATE 1







absorptive cells with basal nuclei, a few vacuoles and some globules. These absorptive cells were thickly packed. The second type of cells, clearly distinguishable from the absorptive cells were the triangular shaped secretory cells; less in number with the base abutting the basement membrane and the apex pointed towards the lumen. These cells too had basal nuclei and each cell possessed atleast one large vacuole containing a dense granule and a few small vacuoles. The relative proportion of these two types of cell varied between tubules (Plate 1, Fig. 1).

The digestive gland infected with *C. melanocrucifera* and its rediae was swollen considerably. The *tunica propria* was under considerable pressure. The larval stages occurred within the intertubular space of the digestive gland and also in the space between the tubules and the *tunica propria*. Large areas of the digestive gland were replaced by rediae and cercariae and consequently there was significant reduction in the number of tubules. The diameter of the tubules became smaller. The cercariae were lying free in the intertubular space intermingled with rediae. The typical response to the presence of larval stages in the digestive gland consisted of tubular damage and separation of tubules by the masses of parthenitae, which by their migration, feeding and reproduction induced progressive focal tubular degenerative changes (Plate 1, Fig. 2). Tubules in direct contact with rediae showed histolysis. As a result of increased vacuolation, the cells appeared fibrous (Plate 1, Fig. 3). The lateral walls of adjacent epithelial cells degenerated and consequently adjacent vacuoles became confluent. This was followed by a breakdown of the distal walls resulting in the complete loss of organization of the cytoplasm, nuclei and globules, and finally in the cell contents being shed into the tubule lumen (Plate 1, Fig. 4). In those cells which were not completely destroyed, their nuclei began to migrate towards the lumen. The secretory cells also showed signs of breakdown although the process was slow. The nuclei of these cells also showed signs of migration towards the lumen. The large vacuoles of adjoining cells containing dense granules sometimes fused and these granules also began to move towards the lumen (Plate 1, Fig. 5). Tubules which had been subjected to ingestion showed a disruption of their basal epithelium. In some tubules, not attacked by larval stages, sloughing of the epithelium occurred. In certain areas, there was complete necrosis of the epithelium and only an agglomerate of cellular debris remained in the vicinity of the rediae (Plate 1, Fig. 6). The pathogenicity caused by the larval stages was so severe that 80-90% of the total tubules were destroyed completely, and the remaining showed all signs of destruction.

Discussion :- Species of Turritella have been known to harbour larval trematodes belonging to the Rhodometopa (Rothschild, 1935; Hutton, 1955), and the Opisthorchioid groups (Cable, 1956). In the checklist of known marine cercariae, thirteen species of magnacercous cercariae were mentioned as belonging to the family Heterophyidae, and three species of magnacercous cercariae of unknown affinity as belonging to the Opisthorchioid group (Holliman, 1961). Cercaria caribbea LXXI (Cable, 1963), Cercaria sp. XX (Wardle, 1974), and Cercaria queenslandae IX (Cannon, 1978) were also included under the group of magnacercous cercariae. On a comparison with all the known magnacercous cercariae, Cercaria melanocrucifera is found to resemble C. caribbea XVII Cable, 1956 to some extent. But in the presence of finfolds on the body, a black cruciform marking in the dilated region of the tail and in the extend of penetration glands only upto the level of excretory vesicle, C. melanocrucifera differs from C. caribbea XVII.

Cable (1956, 1963) has suggested, on ecological grounds, that members of the magnacercous group belong to species of the genus Galactosomum of the subfamily Haplorchinae (Fam: Heterophyidae). Although Pearson (1973) made a tentative sorting of haplorchine genera and cercarial types, studies by Ito (1956) and Holliman (1961) indicate that there may be forms intermediate among the four groups tentatively made by Pearson (1973).

Encysted metacercariae of Galactosomum spinetum were obtained from the visceral adipose tissue of the fish Hyporhampus unifasciatus in Florida, following exposure to magnacercous cercariae (Sogandares-Bernal and Hutton, 1960). Although metacercariae of several species of Galactosomum have been reported from marine and brackish-water fishes (Madhavi and Hanumantha Rao, 1968; Pearson, 1973; Rekharani and Madhavi, 1983), and adults from fish-eating birds and ichthyophagous mammals (Sita Anantaraman, 1961, 1963; Anantaraman, 1972; Pearson, 1973), a knowledge of the life cycle is limited to only one species, G. timondavidi, elucidated by Prévot (1973). Based on the morphological and experimental evidences, Cable (1963) suggested that adults of magnacercous cercariae could probably belong to the genus Galactosomum but Pearson (1973) was a little more cautious when he stated that "The relationships between cercarial types and genera may be further complicated, if it is found, as seems likely, that not all cercariae in Galactosomum are magnacercous". Reimer and Sita Anantaraman (1968) believed that Cercaria melanocrucifera may be the larva of any of the four species of Galactosomum, two of them found in Larus argentatus, one in Sterna fuliginosa and the remaining one as juvenile in the crab, Mututa victor (Sita Anantaraman, 1961, 1963), or a related one.

The literature relating to the pathological effects of larval digenetic trematodes on the digestive gland of their molluscan hosts has been reviewed by Cheng and Snyder (1962), James (1965), Wright (1966), Reader (1971), Mohandas (1974 a), Sommerville (1978) and Huffman & Fried (1985). Such studies have been made on a variety of molluscs but this appears to be the first investigation on the effects of parasitism on the digestive gland of *T. attenuata*.

In the past two main types of cells have been reported as comprising the epithelium of the digestive gland of molluscs, although the terminology used to designate these cells has been different. Thus 'absorptive cell' has been called liver, ferment, digestive, glandular, palisade, hepatic, vacuolar, excretory or secretory cells while the 'secretory cell' has been called calcium, lime, calciferous, crypt, basiphil or excretory cells. Besides these two, a third type of undifferentiated cells has also been reported, among others, by Walker (1970), Reader (1971, 1976), Meuleman (1972) and Sommerville (1978). The vacuolated absorptive cells are believed to be primarily responsible for the digestion of food materials absorbed from the tubule lumen (Reader, 1976; Sommerville, 1978) and also in the absorption of soluble food materials (Meuleman, 1972; Reader, 1974, 1976). The secretary cells appear to be mainly concerned with the production of digestive enzymes (Pal, 1971; Reader, 1976) and with the formation of calcareous concretions (Reader, 1976). This calcium could be used for cell growth and repair (Abolins-Krogis, 1970; Walker, 1970; Reader, 1976), in the production of mucus (Walker, 1970) and also could act as a buffer against changes in pH (Reader, 1976).

The variety of pathological effects which are noticed in the digestive gland of T. attenuata infected with rediae and C. melanocrucifera can be summarized as follows:

i. Reduction in the number and size of tubules
ii. Complete destruction of individual tubules
iii. Necrosis of the gland in certain areas
iv. Fragmentation of cells
v. Migration of nuclei and dense granules
vi. Sloughing of parts of the tubular epithelium
vii. Separation of tubules

The primary method of cell destruction and removal by rediae appeared to be through direct ingestion. This observation was borne out by the presence of cellular debris in the redial gut and by the appearance of some tubules which had pieces obviously eaten away. Similar changes were observed by Cheng (1963), Reader (1971), Mohandas (1974 a), Sommerville (1978), and Crewsf and Esch (1987). Physical damage resulted also from the compression of the host tissue by the growth, reproduction and movement of parthenitae; a view also shared by Cheng and Snyder (1962), Cheng (1963), James (1965), Porter et al., (1967), Mohandas (1974 a, 1977), and Sommerville (1978). Physiological damage was thought to be due to lysis of host cells by parasite enzymes. These enzymes would be released into the host tissue surrounding the parasites as a result of their feeding activity and egestion of waste material from the redial intestine (Cheng, 1963; Sommerville, 1978). The toxic action of waste materials from parasitic excretion must also be considered to be a cumulative factor. Strong evidence for this has been suggested by Cheng and Snyder (1962), Mohandas (1974 a) and Sommerville (1978). The mechanical damage could also be due to starvation, occuring as a result of competition for nutrients among the parasite, the gonad and the digestive gland (James, 1965; Sommerville, 1978). Depletion of glycogen from the tissue is thought to be another reason for the lysis of cells (Cheng and Snyder, 1962, 1963; Cheng, 1963). Cheng and Snyder (1963) postulated that the parasite secretes a glycogen digesting enzyme which hydrolyses the host glycogen, absorbing the simple sugars. Another suggestion given for the lysis of cells is the presence of aminopeptidase along the body wall of rediae and cercariae and it is thought that lysis might be due to the action of this enzyme (Cheng and Yie, 1968; Porter, 1970). Moore and Halton (1973) correlated the damage caused in the digestive gland of *Lymnaea truncatus* by infection with larval stages of *F. hepatica* with incréased intracellular digestion, including autolysis, to maintain the nutritional requirements of the host while under parasite stress. Chemically mediated castration can be caused by secretions from larval trematodes, and results in the lysis of gonadal and hepatopancreatic tubules (Cheng et al., 1973; Crews and Esch, 1987).

In spite of the best explanations given for the damage caused to the digestive gland of molluscs infected with larval stages of digenetic trematodes, although some of them in the form of suggestions and postulations based on cicumstantial evidences, a true picture based on biochemical studies is still wanting.

PART D. Incidence and intensity of infection in *Metapenaeus monoceros* Fabricius with Carneophallid Metacercariae

Prawns form an important item of food and are available in large quantities from the coastal waters of Kerala. Export of prawns to foreign countries is on the increase and to cope up with the demand, numerous culture ponds are established in various parts of the country. This intensive culture leads to crowding, and can be influenced adversely by diseases and other stress contributed by a number of biological and abiological factors. Prawns of all ages and stages harbour parasites and they occur in many sites. The majority of parasites and disease conditions affecting prawns, unlike those affecting other marine organisms, have not been investigated thoroughly in our country. Infact, people rearing prawns and encountering heavy mortalities rarely know the causes. Personnel involved with such operations, especially the commercial large scale ones, seldom mention or publicly discuss those problems. Most operators take a certain amount of loss for granted. Estimated mortality values used for calculations of expected optimal production by many operators is as high as 20 to 50% loss of larvae and 20% loss of postlarvae (Overstreet, 1986). Although blamed for many prawn-kills, the abiological factors may not always be the culprits. Microbial, protozoan and helminth infections are not uncommon in prawns. Helminth diseases of crustaceans seem less abundant and less severe in their effects than those of microbial or protozoan etiology. Prawns usually play the role of intermediate host for some helminths which may be transmitted through the foodweb to higher vertebrate hosts. In the life cycle of some members of the digenean trematode families such as Microphallidae, Opecoelidae etc., penaeid prawns act as the second intermediate host (Yamaguti, 1975). While surveying various crustaceans in the nearshore and offshore waters of Cochin for larval trematodes, _Metapenaeus monoceros_, a common prawn species of this region, was found to be infected with metacercariae which were identified as belonging to a species of the genus _Carneophallus_ (Microphallidae),Considering the public health importance of this genus, it was thought worthwhile to study the incidence and intensity of infection of this metacercaria in the prawn, _M. monoceros_. Simultaneously attempts were also made to find out its natural definitive host(s) and probable experimental host(s).

Materials and Methods :- Prawns of the species _Metapenaeus monoceros_ Fabricius were collected from tributaries of the Vembanad Lake, seven kilometers northwest of Cochin during January to June, 1981. They were collected with dip nets from a small boat and transported in buckets to the laboratory for observation and study. They were fed with powdered biscuits, and water was changed daily. The samples were examined fractionally for cysts, and to locate their sites in the host several specimens were dissected individually with needles. Excystment of metacercariae in the laboratory was easily done by pricking the cyst with a needle and teasing the worm out. Keeping the cysts in saline (0.75%) at room temperature for 6-10 hrs. facilitated excystment through manipulation with fine needles, and keeping the cysts overnight in saline, excystment took place without mechanical assistance. Measurements of cysts (30 nos) were from unfixed specimens but of excysted ones (30 nos) were from specimens fixed in 5% formalin under cover slip pressure and expressed in mm. The cysts were studied alive and excysted forms, either alive or from stained preparations. They were stained in Semichon's carmine, passed through grades of alcohol, cleared in methyl benzoate and mounted in Canada balsam. Drawings were made with the aid of a cameralucida. To find out the natural definitive host, a few species of fishes were collected from the endemic area and examined. While field collection was underway, laboratory experiments were conducted to determine which of several animals could serve as possible definitive hôst(s), as tabulated below. The cysts (with connective tissue) were administered orally in a few drops of saline and the animals were sacrificied 1 day to 10 days post-infection (see Table III) and the digestive tract was examined thoroughly for adult worms.

TABLE III

Data showing details about the experimental hosts, age, number of cysts administered, number of hosts used and autopsy day

Experimental host	age	No. of cysts administered	No. of hosts used	Autopsy day
White rat (*Rattus norvegicus*)	2 months	25	2	2 days and 10 days post-infection
		50	2	5 days post-infection
		100	2	6 days post-infection
,,	5 months	20	2	2 days post-infection
		40	2	3 days post-infection
		100	2	4 days post-infection
Chicken (*Gallus gallus domesticus*)	3-day old	10	2	1 day and 7 days post-infection
		20	2	3 days and 7 days post-infection
		50	2	3 days and 10 days post-infection
Duckling (*Anas boschas domesticus*)	3-day old	25	3	3 days and 8 days (2 nos.) post-infection
		50	1	8 days post-infection
	5-day old	25	4	7 days post-infection
Pigeon (*Columba livia*)	3 months	50	2	5 days post-infection
		50	1	1 day post-infection
Frog (*Rana hexadactyla*	unknown	15	6	7 days post-infection
Fish (*Glossogobius giuris*)	unknown	10	1	3 days post-infection
		15	1	4 days post-infection
		25	3	5 days post-infection
		50	5	6 days post-infection
		75	1	7 days post-infection
		100	2	7 days post-infection

Results :-

Metacercaria (Fig. 6) :- Of the 551 prawns examined 151 (27.4%) were infected with metacercariae. Ninety six of the infected prawns were females and 55 males. As many as 150-220 cysts were recovered from individual specimens. Fully grown metacercariae (those with vitelline follicles and seminal vesicle filled with motile sperms) were found attached to muscle tissues by strands of connective tissue, usually in the abdominal segments and occasionally on uropods, telson and cephalothorax. The cysts were large, visible to naked eyes and opaque. Ovoid cysts measured 0.442-0.650 x 0.390-0.468. Cyst wall consisted of two layers, an outer fibrous, radially and circularly striated layer of 0.025-0.143 thickness, and an inner hyaline thin wall of 0.006-0.019 thickness. Excretory vesicle, vitelline follicles and suckers were conspicuous and other structures poorly visible.

Preadult (Excysted metacercaria) (Fig. 7) :- Excysted flukes were almost fully grown except for the absence of eggs in the uterus. Body is pyriform under coverslip pressure, and measures 0.546-0.806 x 0.377-0.559. Tegumentary spines are very conspicuous and extend posteriorly upto the level of the excretory vesicle. Oral and ventral suckers are almost of the same size, and measure 0.052-0.090 in diameter. Ventral sucker is situated postequatorially. Prepharynx is

Fig. 6. Metacercaria with fibrous outer wall and inner hyaline wall.

Fig. 7. Preadult of *Carneophallus* sp.

Fig. 8. Excretory and female reproductive systems of *Carneophallus* s (preadults).

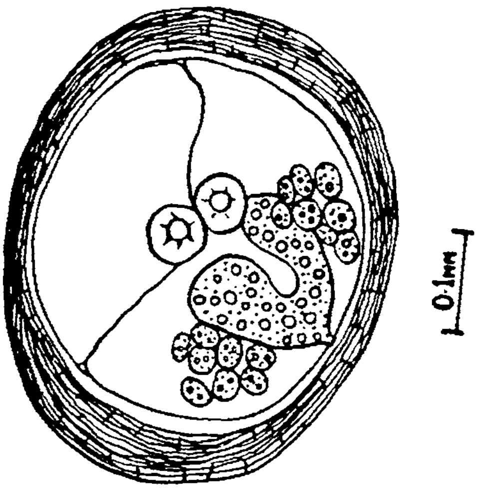


FIG. 6

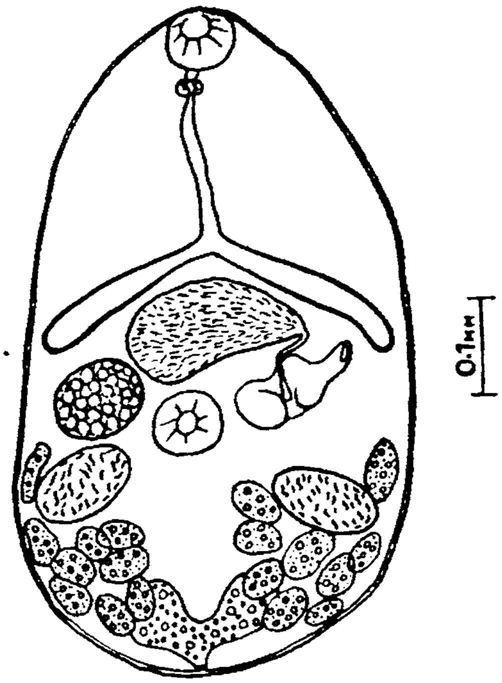


FIG. 7

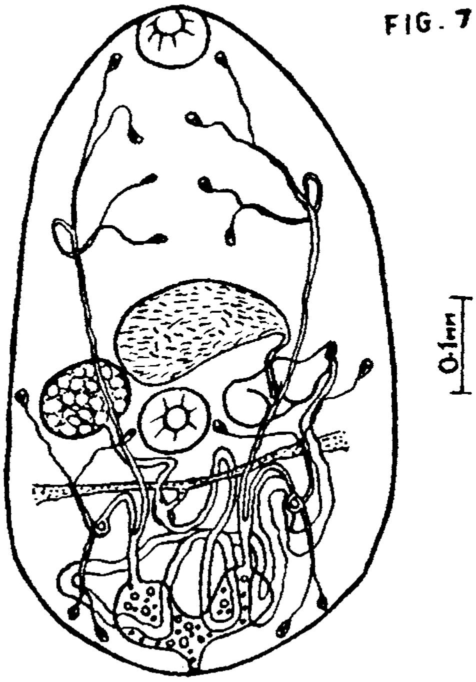


FIG. 8

short and pharynx well developed, 0.013-0.020 x 0.013-0.039. Oesophagus is narrow and long, 0.078-0.195, and divides just infront of seminal vesicle into long and thickwalled caeca. Caeca are as long as or longer than oesophagus and extend to anterior level of ovary on one side and male papilla on the other side. Testes are postequatorial, symmetrical and sometimes partially covered by vitelline follicles. Right testis measures 0.065-0.091 x 0.097-0.130 and left testis 0.065-0.078 x 0.104-0.117. Opening of the sperm ducts into the seminal vesicle is not clear. Seminal vesicle is very conspicuous, anterior to testes, 0.065-0.117 x 0.130-0.260 and mesial. Pars prostatica is short. Genital atrium is thin walled and almost filled with trilobed male papilla, two lobes ventral and one lobe dorsal. Ejaculatory duct pierces one of the lobes and bears two to three rows of very small papillae. Ovary is dextral, ovoid, 0.070-0.117 x 0.091-0.123, and anterior to testis. Ootype complex is present. The uterus in preadult is coiled, restricted to the posterior half of the body and the terminal uncomplicated metraterm empties into the genital pore at tip of the lobe (Fig. 8). There are 8-9 vitelline follicles on each side, situated at level of testes and extending posteriorly. Vitelline ducts unite midventrally, just below the ventral sucker. Excretory bladder is large and bicornuate, and the flame cell formula is 2(2+2+2+2) = 16 (Fig. 8). The presence of a lobed male papilla one of which is penetrated by the ejaculatory duct and an unmodified metraterm gives strong reason to believe that these preadults belong to a species of the genus Carneophallus Cable and Kuns, 1951 of the family Microphallidae.

From the endemic area, 15 specimens of Eleotrix fusca (Schneider), 16 specimens of Megalops cyprinoides (Broussonet), and 33 specimens of Glossogobius giuris Buchanan-Hamilton were collected and examined for the adult. Of these, only one specimen of G. giuris was positive to infection but that too yielded only eight immature and non-ovigerous specimens of Carneophallus sp. None of the experimental hosts, white rat, chicken, duckling, pigeon, frog and fish was susceptible to infection with carneophallid metacercariae.

Discussion :- A large number of helminths can infect crustaceans, and many of these can affect cultured products in extensive and semi-intensive systems. They can retard growth, alter behaviour, kill hosts, hamper marketability, and create public health problems (Overstreet, 1983, 1986). Shrimps act as second intermediate hosts for a few digeneans. Wu (1937) observed metacercariae of Ozakia plagiorchis in Palaemon asperulus and P. nipponensis, and Yamaguti (1942) noticed them in

Leander paucidens. Metacercarial cysts of *Microphallus minus* were found in *Macrobrachium nipponense* (Ochi, 1928; Kanemitsu et al., 1953), *Leander serrifer* (Yeh and Wu, 1951; Kanemitsu et al., 1953), *Palaemon nipponensis* and *P. asperulus* (Yeh and Wu, 1951), and of *M. minus* var. *asadai* in *P. nipponensis* (Kaji, 1957). Metacercariae of *Opecoeloides fimbriatus* were found encapsulated in the tissues surrounding all vital organs of penaeid shrimps (Hutton et al., 1959 a; Overstreet, 1973), and those of *Microphallus* sp. in the body musculature of *Penaeus duorarum* (Hutton et al., 1959 a, b; Sogandares-Bernal and Hutton, 1959), in the tail region of penaeid shrimps (Overstreet, 1978), and in the abdominal musculature of *Palaemonetes pugio* (Overstreet, 1979). Bridgman (1969) noticed metacercarial cysts of *Carneophallus choanophallus* in the muscle tissues of abdominal segments, cephalothorax and appendages of *Macrobrachium ohione* and *Palaemonetus pugio*, and Velasquez (1975) reported metacercarial cysts of *C. brevicaeca* from *Macrobrachium* sp. This report, on the occurrence of metacercarial cysts of *Carneophallus* sp. in *Metapenaeus monoceros*, appears to be the first from Indian waters revealing the role of shrimps as second intermediate host in the life cycle of a digenetic trematode. In the present study it was also found that the overall infection rate was 27.4%. Kanemitsu et al. (1953) reported 40-80%

infection in *Leander serrifer* with metacercarial cysts of *Microphallus minus* but Sogandares-Bernal and Hutton (1959) observed that in *Penaeus duorarum* infection with metacercariae was not at all heavy. In *Macrobrachium ohione*, the percentage of infection with metacercaria of *Carneophallus choanophallus* was 27.4 (Bridgman, 1969).

This discovery of prawns acting as second intermediate host in the life cycle of a microphallid is of significant public health importance. Kaji (1957), and Otagaki (1958) showed experimentally that *Microphallus minus* var. *asadai* and *M. asadai*, respectively, can infect human beings. Africa and Garcia (1935) found *Heterophyes brevicaeca* (syn: *Carneophallus brevicaeca*, Velasquez, 1975) during autopsies in Philippines and reported cardiac involvement and other complications associated with this infection in human beings. Continuous consumption of raw, naturally infected shrimps or semi-cooked ones favours the adverse involvement of the heart, spinal cord and other vital organs (Velasquez, 1975). Considering these aspects, the cysts obtained from *M. monoceros* are of great public health importance because they also belong to a species of *Carneophallus*.

Ward (1901) defined the new genus *Microphallus* and proposed a new subfamily Microphallinae to contain it and *Levinseniella*. Although this subfamily was included in the family Heterophyidae by several subsequent workers, Travassos (1921) removed this subfamily from the Heterophyidae and elevated it to family status. Baer (1943) divided the family Microphallidae Travassos, 1921 into two families; Microphallidae and Maritrematidae, distinguished by the absence of a cirrus sac in the former and the presence of this organ in the latter. In the family Microphallidae, he included the genera *Microphallus*, *Levinseniella*, *Spelotrema*, *Monocaecum* and *Spelophallus*. But in the same paper he (Baer, 1943) suppressed *Spelotrema* and *Monocaecum* as identical with *Microphallus*, and Stunkard (1951) added *Spelophallus* also to the list of synonyms. The proposal of Baer (1943) to divide the family Microphallidae was analysed by Cable and Kuns (1951) and accepting the synonymy, they created a new genus *Carneophallus* and recognized a series of genera from *Microphalloides* and *Pseudospelotrema* to *Levinseniella* and *Carneophallus*, showing gradual reduction of the cirrus sac correlated with increased complexity in structure of the copulatory organs. Accordingly, they rejected the proposal of Baer, retained the genera with a cirrus sac in the family Microphallidae, and presented a scheme to illustrate the probable evolution in the family. Agreeing to the arguments of Cable and Kuns (1951), Stunkard (1951) remarked that there was no basis for recognition of the family Maritrematidae.

The discussion here is concerned with the genus Carneophallus Cable and Kuns, 1951 and the species included in the genus within the subfamily Microphallinae Ward, 1901. Although Capron et al. (1957), Biguet et al. (1958), and Deblock (1971) considered the genus redundant, Yamaguti (1958, 1971), Cable et al. (1960), Bridgman (1969), Velasquez (1975), and Heard and Overstreet (1983) consider the genus valid. Biguet et al. (1958) argued that lobation of the male copulatory organ was not significant to warrant a separate genus. Cable et al. (1960) objected to lumping of heterogeneous groups into the single genus Microphallus contending that the adult morphology alone was not a satisfactory basis to decide the taxonomic relationships of Carneophallus with other genera. Bridgman (1969) supporting the view of Cable et al. (1960) considered the identification of species based upon the shape and form of phallus as appropriate instead of identifying the species based upon the comparative dimensions of the phallus as followed by Biguet et al. (1958). Bridgman (1969) found justification in separating out those species having a large fleshy-lobed male papilla under the genus Carneophallus when Biguet et al. (1958) could find ample reason for the maintenance of the genus Levinseniella on the development of a thickened ornamental wall of the genital atrium. The lobation of the male papilla and an unmodified metraterm are strikingly obvious features, and I too feel that *Carneophallus* should be treated as a valid genus.

Cable and Kuns (1951) distinguished the genus *Carneophallus* as microphallids with a large unornamented thin-walled genital atrium which is almost filled with a lobed fleshy male papilla, one of the lobes being penetrated by the ejaculatory duct. This genus was erected to include the species *Carneophallus trilobatus*. Cable and Kuns (1951) transferred *Spelotrema pseudogonotyla* (Chen, 1944) also to the genus *Carneophallus*. Coil (1956) described *C. muellhaupti*, Caballero (1958) described *C. skrjabini*,and Leigh (1958) described *C. turgidus*. *C. bilobatus* was added by Cable et al. (1960). Siddiqi and Cable (1960) described *C. lactophrysi*, and later Bridgman (1969) added two more species, *C. choanophallus* and *C. basodactylophallus*, under the genus *Carneophallus*.

C. trilobatus (Cable and Kuns, 1951) was transferred later to *Spelotrema* by Belopolskaia (1954) and to *Microphallus* by Capron et al., (1957). But Cable et al. (1960), in addition to the species previously assigned to the genus *Carneophallus*, brought *Microphallus chabaudi* (Capron et al., 1957), *M.tringae* (Capron et al., 1957),and also *M. canchei* (Biguet et al.,

1958) under *Carneophallus*. Bridgman (1969) listed all the 12 species including the two described by him under *Carneophallus*. But Yamaguti (1971) transferred *C. skrjabini*, which was earlier transferred to the genus *Microphallus* by Belopolskaia (1963 a), to *Spelotrema* and *C. canchei* to *Spelophallus*. *Carneophallus lactophrysi* Siddiqi et Cable, 1960 was transferred to another genus *Pseudocarneophallus* by Yamaguti (1971). In this genus the cirrus is bipartite and the ejaculatory duct perforating the distal lobe of the cirrus opens at the tip of this lobe instead of sideways as in *Carneophallus*. This only difference was considered to be of significance at genus level by Yamaguti (1971) in view of different host relationships. Deblock (1971) considered *C. basodactylophallus* as *Microphallus basodactylophallus*,and *C. choanophallus* as a junior synonym of *M. turgidus* (Leigh, 1958). Although Heard and Overstreet (1983) considered the genus *Carneophallus* valid for atleast the type species, *C. trilobatus* Cable and Kuns, 1951, remarked that "Perhaps some or all of the several remaining species that have been placed in *Carneophallus* should be transferred to *Spelotrema* Jägerskiöld, 1901, with *Spelophallus* Jägerskiöld, 1908 as a junior synonym, rather than to *Microphallus* which, in fact, may be monotypic for *M. opacus* (Ward, 1894)".

Yet another species that deserves attention is

Carneophallus brevicaeca (Africa and Garcia, 1935) Velasquez, 1975. Originally identified as a heterophyid by Africa and Garcia (1935), it was assigned later to the genus *Spelotrema* under the family Microphallidae by Tubangui and Africa (1938). Baer (1943) suppressed *Spelotrema* and transferred all the known species of *Spelotrema* to *Microphallus*. Morozov (1952), and Yamaguti (1958, 1971) returned *Microphallus brevicaeca* to the genus *Spelotrema*. But Velasquez (1975) was successful in tracing the life cycle, though partially, and in proving convincingly the taxonomic status of the species while transferring it to the genus *Carneophallus*. So, besides the nine species listed by Yamaguti (1971), *C. brevicaeca* can also be included under the genus *Carneophallus*.

Inspite of the best efforts made by me to find the natural definitive host(s) and probable experimental host(s), it was not possible to get the adults in either way. From the fact that metacercarial cysts failed to develop into adults in a mammal, birds, amphibia and fish, it is almost certain that this species has a very narrow host-specificity. Six of the ten carneophallids listed are parasitic in birds, three in mammals and one in fish and a mammal. *C. brevicaeca* was recorded from the fish, *Glossogobius giuris* and the experimental host, *Rattus rattus* (Velasquez, 1975). In the present study also excysted but immature flukes were recovered from the intestine of G. giuris. However, only one of the thirty three fish examined was infected. On another occasion, sixteen fish of the same species were examined but none was infected with this trematode. Oral infection of thirteen fish of the same species with metacercariae of this fluke also did not yield positive results. All these show that the natural definitive host of this fluke may not be G. giuris. Rather than other vertebrates being the primary definitive hosts, aquatic birds, such as sea gulls and herons, may be more important, a view also shared by Yamaguti (1975),and Heard and Overstreet (1983). Since I was unable to get any gravid fluke either from natural definitive host or from experimental definitive host, it is proposed, for the time being, to treat the preadults as members of a species of Carneophallus. However, these preadults are compared with other members of the species of Carneophallus and the taxonomic status is assessed.

The preadults of this species are comparatively larger, and in the number of vitelline follicles also they differ from the rest. In C. trilobatus, the caeca reach the level of acetabulum, pars prostatica is surrounded by gland cells and ejaculatory duct bears only one row of papillae. C. pseudogonotyla is characterised by the presence of a special muscular structure, the pseudogonotyl, and the male papilla has only two lobes. In *C. muellhaupti* the oral sucker is with papillae and the male papilla is lobed only slightly. *C. turgidus* lacks in a prepharynx but has a seminal receptacle. In both *C. chabaudi* and *C. tringae*, the male papilla has a large lobe pierced by the male duct and a small accessory lobe. The male papilla of *C. bilobatus* is bilobed and pars prostatica is well developed surrounded by prostate gland cells. In *C. choanophallus*, the male papilla is collard, and the vitelline follicles extend from the tip of the caeca to the posterior region. *C. basodactylophallus* has a small posterior flap at the base of the male papilla. In *C. brevicaeca*, the pars prostatica is surrounded by numerous glands, the male papilla is crowned anteriorly by a circlet of fine spines, and ejaculatory duct bears only one row of papillae. These differences exhibited by other species of *Carneophallus* but absent in the present form are strong enough to consider the preadults as members of a different species. Since discussion is based on preadults but not on ovigerous adults, I prefer to treat these preadults as members of a *species inquirenda* of the genus *Carneophallus.*

PART E. Rare occurrence of a sexually matured adult digenetic trematode in the green mussel, Perna viridis Linné

Among the marine resources, molluscs come next in importance to fishes and crustaceans. Mussels form one of the favourite items of food, and supplies are fairly ample offering good opportunities for further expansion and utilization. In recent years, with the realization of their importance, improved techniques have been introduced for mussel culture. However, as other organisms, molluscs are also prone to infection by a variety of parasites including larval, progenetic, and sexually mature adult trematodes. Instances of infection with sexually matured adult trematodes in molluscan tissues will throw new light on the process of evolution of life-cycles in digenetic trematodes. In this section the occurrence of a sexually matured adult digenetic trematode in the green mussel, Perna viridis, is reported in detail. A brief report on this was published earlier by Syed Ismail Koya and Mohandas (1982).

Materials and Methods :- Eight hundred specimens of P. viridis were collected, on two occasions, from Narakkal approximately 10 km north-west of Cochin, and examined for larval trematode infection. Although they were free of infection with larval trematodes, an adult digenetic trematode recovered from one of the mussels was fixed in 5% formalin, measured, stained with Semichon's carmine, and mounted in Canada balsam.

Result :-

Host : *Perna viridis* Linné
Prevalence : 0.125% (1/800)
Locality : Narakkal, Cochin
Location : Gonad of a female specimen
Measurements : (in mm) Length - 2.94; width - 0.24;
Oral sucker - 0.071 x 0.156;
Ventral sucker - 0.184 x 0.141;
Anterior testis - 0.113 x 0.141;
Posterior testis - 0.099 x 0.127;
Ovary - 0.141 x 0.156;
Egg - 0.0085 - 0.023 x 0.0057 - 0.011.

Body is smooth, non-spinose, elongate, fusiform, and tapering gradually towards the posterior end. Oral sucker is well developed and the subterminal mouth leads into a prepharynx. A pharynx is absent. Caecal bifurcation starts just anterior to the level of ventral sucker and the simple caeca extend to the posterior end. The prominent ventral sucker is situated in the anterior third of the body. Testes are tandem, two in number, and intercaecal. Ovary is post-acetabular and pre-testicular in position and situated in the anterior third of the body. Testes are almost oval but ovary is round. Vitellaria are not clear, and the long uterus

Fig.9 . Gorgoderina sp.

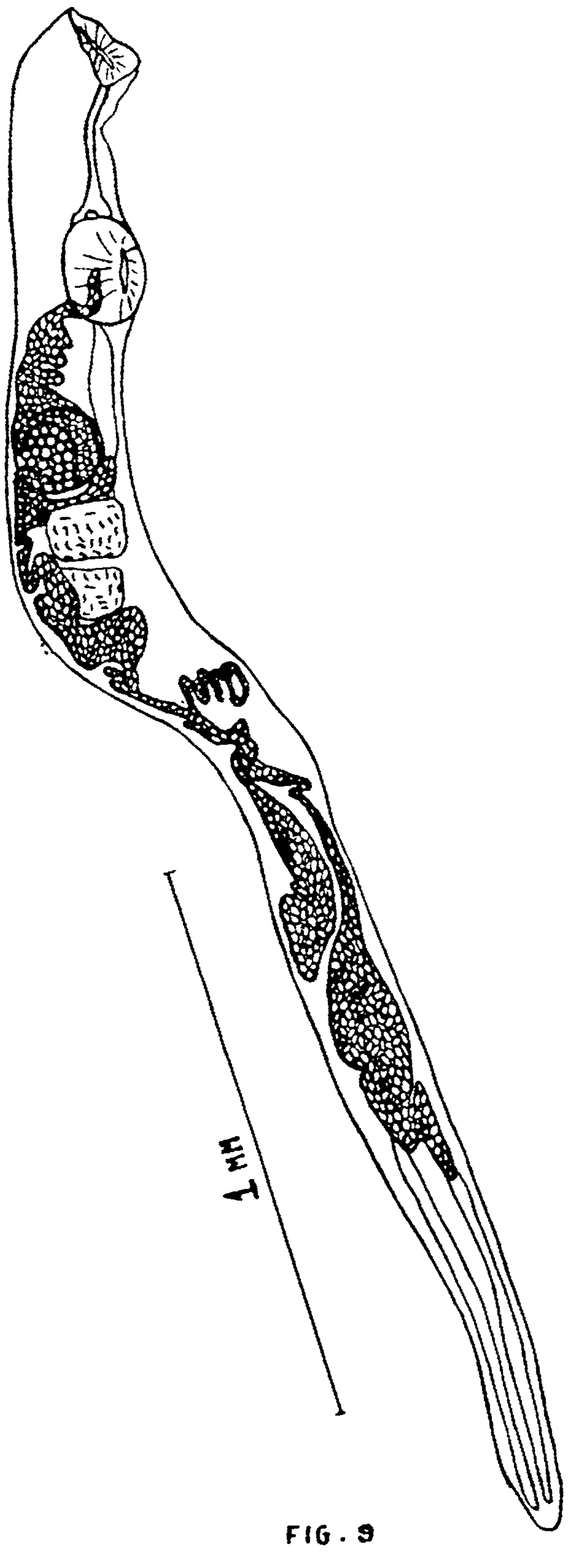


FIG. 9

with ascending and descending limbs contains numerous eggs. Based on the above characters, the specimen has been identified as a species of the genus Gorgoderina, normally found in the urinary bladder of amphibians and teleost fishes (Fig. 9).

Discussion :- This is the first report from India on the occurrence of a sexually mature adult digenetic trematode in the marine lamellibranch, *P. viridis*. Maturation of trematodes in freshwater and marine gastropods (Szidat, 1956; Honer, 1961; Dollfus, 1964; Dolgikh, 1965; Ichihara, 1965; Looss-Frank, 1969; Murty, 1970; Pandey, 1973; Goodman and Panesar, 1976; Shimura, 1980), and in other invertebrates (Myers, 1956; Peters, 1957; Schmidt and Chaloupka, 1969; Sullivan and Heard, 1969; Beckerdite and Corkum, 1974; Font and Corkum, 1975) is well known. This phenomenon is also reported in lamellibranchs (Freeman and Llewellyn, 1958; Stunkard and Uzmann, 1959; Wardle, 1980; Winstead and Couch, 1981). Freeman and Llewellyn (1958) described an adult fellodistomid, *Proctoeces subtenuis* (syn. of *P. maculatus* according to Stunkard and Uzmann, 1959), from the kidney of the mud-burrowing lamellibranch, *Scrobicularia plana* in Essex, and Stunkard and Uzmann (1959) reported sexually matured and gravid flukes, *P. maculatus*, from the mussel, *Mytilus edulis*. Frank (1969) described two sexually matured trematodes *P. buccini* and *P. scrobiculariae* from *Buccinum undulatum* and *Scrobicularia plana*, respectively. The trematode reported herein is without a cyst and has attained complete sexual maturity with fully developed testes and ovary and has numerous eggs and hence it does not seem to be progenetic. The progenetic forms are often encysted, and can usually only contribute to the further life-history of the species; in many cases they can only attain the definitive form of the adult after transfer to a vertebrate host (Freeman and Llewellyn, 1958). Many examples of progenetic trematodes are listed by Wu (1938), Dawes (1946), Stunkard (1959), Erasmus (1972), and Pearson (1972). It cannot be said with certainty whether the occurrence of a sexually matured adult trematode in *P. viridis* is purely accidental or yet another example of abbreviated life-cycle. Several instances of abbreviated life cycles have been listed, among others, by Freeman and Llewellyn (1958), Stunkard (1959), and Pearson (1972).

SUMMARY

Part A : A preliminary survey on larval trematodes infecting marine and brackishwater molluscs in the area under investigation revealed that prevalence of infection was neglibible. The life cycle of *Philophthalmus* (*Philophthalmus*) *cochinensis* sp. nov., adult of *Cercaria* sp.II Kerala, Mohandas, 1979 was worked out in the laboratory using domestic chicken as the experimental definitive host. The cercariae were collected from the gastropod, *Melania tuberculata*, and the cercariae readily encysted on glass slides. The cysts were administered to the conjunctival sac of chickens, and adults recovered. A thorough review of literature on *Philophthalmus* has been made. The creation of the new species is justified, and the significance of the study of larval trematodes in the correct identification of adult trematodes is stressed.

Part B : The survival characteristics of *Cercaria chackai*, the larval form of the curious ectoparasitic digenetic trematode *Transversotrema chackai*, in sea water, sea water diluted with deionized water in different proportions, deionized water, pond water, and tap water were studied. Naturally shed, fresh cercariae had the maximum life span of 20h 40min in pond water at salinity 17.8‰, pH 6.45, O_2, 5.76ml/l and temperature 31.5°C. With increase

in salinities beyond 17.8$^{\circ}/_{oo}$ survival time was drastically reduced, and beyond 23.58$^{\circ}/_{oo}$ it was restricted to a few minutes. In sea water of 38.3$^{\circ}/_{oo}$ salinity, the maximum survival time was only 8min. Below 17.8$^{\circ}/_{oo}$ salinity, although the survival time was less, the difference was not very marked, and even in tap water with no salinity, the cercariae lived upto 19h 50min. In deionized water, the maximum survival was only 3h 15min. It was concluded that this cercarial species preferred a slightly acidic medium, and neither temperature nor oxygen affected the survival pattern. *Cercaria chackai* is a typical fresh water form showing considerable tolerance to salinity fluctuations, although the family Transversotrematidae is considered to have a marine origin.

Part C : *Cercaria melanocrucifera* has been described in detail, and the pathological changes induced by this cercaria and its redia in the digestive gland of *Turritella attenuata* discussed. Of the eight hundred specimens each of *Sunetta scripta*, *Villorita cyprinoides* and *Turritella attenuata*, only two specimens of *T. attenuata* were infected. The variety of pathological effects caused by the cercariae and rediae in the digestive gland of *T. attenuata* included (i) reduction in the number and size of tubules, (ii) complete destruction of individual tubules, (iii) necrosis of the gland in certain areas, (iv) fragmentation of cells, (v) migration of nuclei and dense granules, (vi) sloughing of parts of the tubular epithelium, and (vii) separation of tubules.

Part D : Specimens of *Metapenaeus monoceros*, a common prawn species of this region, were found to be infected with metacercaria of *Carneophallus* sp. The prevalence of infection was 27.4%. Inspite of the best efforts made to find out the natural definitive host(s) or probable experimental host(s), it was never possible to get the adults. The preadults were compared with other species of *Carneophallus*, and the present specimens have been tentatively considered as belonging to a new species of the genus *Carneophallus*.

Part E : An adult digenetic trematode recovered from the gonad of a female green mussel, *Perna viridis* has been identified as a new species of the genus *Gorgoderina*, and described in detail. Species of this genus are normally found in the urinary bladder of amphibian and teleost fishes. This is the first report from India on the occurrence of a sexually mature adult digenetic trematode in a marine lamellibranch, and for that matter in an invertebrate. The trematode is without a cyst, has attained complete sexual maturity with fully developed testes, ovary, and numerous eggs, and hence does not seem to be progenetic.

REFERENCES

Abolins-Krogis, A. 1970. Electronmicroscopic studies of the intracellular origin and formation of calcifying granules and calcium Spherites in the hepatopancreas of the Snail, Helix pomatia. Z. Zeliforsch. 108: 501-515.

Africa, C., and E.Garcia. 1935. Hetrophyid trematodes of man and dog in the Philippines with descriptions of three new species. Philipp.J.Sci.57: 253-267.

Agarwal, N., and H.S.Singh. 1981. On a rare trematode Transversotrema chauhani n.sp. from a freshwater fish Nandus nandus (Ham). Curr. Sci. 50: 426-427.

Alicata, J.E. 1962. Life cycle and developmental stages of Philophthalmus gralli in the intermediate and final hosts. J. Parasit. 48: 47-54.

Alicata, J.E., and K.Noda. 1960. Observations on the life history of Philophthalmus, a species of eye-fluke of birds in Hawaii. In : Libro Homenaji al Dr.Eduardo Cabellero Y Cabellero. 67-73.

Anantaraman, M. 1948. Observations on Cercaria patialensis Soparkar, 1924, and its relationships. Indian J. Helminth. 1: 11-22.

Anantaraman, M. 1972. The ecology of parasitism in the intertidal zone. Proc. Indian Nat. Sci. Acad. 38: 150-155.

Anderson, R.M., and P.J.Whitfield. 1975. Survival characteristics of the free-living cercaria population of the ectoparasitic digenean Transversotrema patialensis (Soparkar, 1924). Parasitology. 70: 295-310.

Angel, L.M. 1954. Parorchis acanthus var. australis n. var., with an account of the life cycle in South Australia. Trans. Roy.Soc.Aust. 77: 164-174.

Angel, L.M. 1969. Prototransversotrema steeri gen. nov., sp. nov. (Digenea: Transversotrematidae) from a South Australian fish. Parasitology. 59:719-724.

Arora, S., M.M.Agarwal, and S.M.Agarwal. 1962. Studies on some intra-specific variations in *Paradistomum orientalis* Narain and Das, collected from the liver and intestine of *Calotes versicolor* Daud, Part II. (Dicrocoelidae-Trematoda). Indian J. Helminth. *14*: 5-15.

*Baer, T.G. 1943. Les trématodes parasites de la musaraigne d'eau *Neomys fodiens* (Schreb). Bull. Soc. Neuchât. Sci. Nat. *68*: 34-84.

Baugh, S.C. 1962. Contributions to our knowledge of digenetic trematodes. Part V. On two new species of *Philophthalmus* Looss, 1899, and a discussion on the family Philophthalmidae. J. Helminth. *36*: 243-258.

Bearup, A.J. 1955. A schistosome larva from the marine snail *Pyrazus australis* as a cause of cercarial dermititis in man. Med. J. Aust. 955-960.

Bearup, A.J. 1956. The life cycle of *Austrobilharzia terrigalensis* Johnston, 1917. Parasitology. *46*: 470-479.

Bearup, A.J. 1960. The life cycle of *Acanthoparyphium spinulosm* Johnston, 1917 (Trematoda:Echinostomatidae). Aust. J. Zool. *8*: 217-225.

Bearup, A.J. 1961. Observations on the life cycle of *Stictodora lari* (Trematoda:Hetrophyidae). Proc. Linn. Soc. N.S.W. *86*: 251-257.

Beaver, P.C. 1937. Experimental studies on *Echinostoma revolutum* (Froelich), a fluke from birds and mammals Illinois. Biol. Monogr. *15*: 1-96.

Beckerdite, F.W., and K.C.Corkum. 1974. *Alloglossidium macrobdellensis* sp.n. (Trematoda:Macroderoididae) from the leech, *Macrobdella ditetra* Moore, 1953. J. Parasit. *60*: 434-436.

*Belopolškaia, M.M. 1954. Helminth fauna of tetraonid birds of SSSR. Rabot. Gelm. 75-Let Skrjabin. 47-65.

* Not seen in original.

*Belopol'skaia, M.M. 1963. Helminth fauna of Sandpipers in the lower region of the Amur in the period of flight and nidification. I. Trematoda. Trudy Gelm. Lab. Akad. Nauk SSSR. *13*: 164-195.

Belopol'skaia, M.M. 1963 a. Family Microphallidae Travassos, 1920. In: Skrjabin, K.I. Trematodes of animals and man. Principles of trematodology. Moskva. *11*: 259-502.

Berrie, A.D. 1960. The influence of various definitive hosts on the development of *Diplostomum phoxini* (Faust) (Strigeida, Trematoda). J. Helminth. *34*: 205-210.

Biguet, J., S.Deblock, and A.Capron. 1958. Contribution a'la connaissance des Microphallidae Travassos, 1920. (Trematoda) II. Ann. Parasit. *33*: 396-444.

*Braun, M. 1901. Zur Revision der Trematoden der vögel. II. Zbl. Bakt. *29*: 941-948.

Bridgman, J.F. 1969. Life cycles of *Carneophallus choanophallus* n. sp., and *C. basodactylophallus* n. sp. (Trematoda: Microphallidae). Tulane Stud. Zool. Bot. *15*: 81-105.

Brien, P. 1954. Deux formes larvaires de trématodes Congolais. Le parthénogoniele cycle des cellules germinales. Ann.K.Mus.Belg. Congo Tervuren, n.r. Zool. Wetensch. *1*: 153-162.

Brooks, D.R., and J.R.Palmieri. 1978. *Philophthalmus pulchrus* sp. n. (Digenea: Philophthalmidae) from the intestinal caeca of a Malaysian moorhen. Proc. Helminth. Soc. Wash. *45*: 166-168.

Buša, V. 1956. Novy trematod *Philophthalmus* (*Tubolecithalmus*) *hovorkai* n. sp. husi domacej (*Anser anser domesticus*). (Russian and German summaries). Biologia Bratislava. *11*: 751-754.

Caballero,y C.E. 1958. Helmintos de la Republica de Costa Rica. III. Descriptión de una nueva especie de tremátodo digéneo *Carneophallus skrjabini* n. sp. Ann. Esc. Nac. Cien. Biol. *9*: 77-83.

Cable, R.M. 1956. Marine cercariae of Puerto Rico. Scientific Survey of Porto Rico and the Virgin Islands. New York Acad. Sci. 16: 491-577.

Cable, R.M. 1963. Marine cercariae from Curacao and Jamaica. Z. Parasitenkde. 23: 429-469.

Cable, R.M. 1974. Phylogeny and taxonomy of trematodes with reference to marine species. In: Symbiosis in the Sea. (Ed.W.B.Vernberg), University of South Carolina Press, Columbia, South Carolina. 173-194.

Cable, R.M., and K.L.Hayes. 1963. North American and Hawaiian Freshwater species of the genus *Philophthalmus* (Trematoda:Digenea). J. Parasit. 49: 41 (Abst).

Cable, R.M., and M.L.Kuns. 1951. The trematode family Microphallidae with the description of *Carneophallus trilobatus* gen. et sp. nov., from Mexico. J. Parasit. 37: 507-514.

Cable, R.M., R.S.Connor, and J.W.Balling. 1960. Digenetic trematodes of Puerto Rican Shore birds. Scientific Survey of Porto Rico and the Virgin Islands. New York Acad. Sci. 17: 187-255.

Cannon, L.R.G. 1978. Marine cercariae from the gastropod *Cerithium moniliferum* Kiener at Heron Island, Great Barrier Reef. Proc.R.Soc. Qd. 89: 45-57.

Capron, A., S.Deblock, and J.Biguet. 1957. Première contribution a la connaissance des Microphallidae Travassos, 1920 (Trematoda). Description de deux nouveaux Microphallidés de charadriiformes: *Microphallus chabaudi* et *Microphallus tringae*. Non-validité du genre *Carneophallus* Cable et Kuns, 1951. Bull. Soc. Zool. France. 82: 378-392.

Chen, H.T. 1944. *Spelotrema pseudogonotyla* n.sp. (Trematoda: Microphallidae) from Hongkong. J. Parasit. 30: 159-161.

Cheng, T.C. 1963. The effects of *Echinoparyphium* larvae on the structure of and the glycogen deposition in the hepatopancreas of *Helisoma trivolvis* and glycogenesis in the parasite larvae. Malacologia. 1: 291-303.

Cheng, T.C. 1967. Marine molluscs as hosts for Symbiosis; with a review of known parasites of commercially important species. Adv. Mar. Biol. 5: 1-424.

Cheng, T.C., and R.W.Snyder. 1962. Studies on host-parasite relationships between larval trematodes and their hosts. I. A review. II. The utilization of the hosts glycogen by the intramolluscan larvae of *Glypthelmins pennsylvaniensis* Cheng, and associated phenomena. Trans. Amer. Micros. Soc. 81: 209-228.

Cheng, T.C., and R.W.Snyder. 1963. Studies on host-parasite relationships between larval trematodes and their hosts. IV. A histochemical determination of glucose and its role in the metabolism of molluscan host and parasite. Trans. Amer. Micros, Soc. 82: 343-346.

Cheng, T.C., and H.W.F.Yie. 1968. Histochemical demonstration of aminopeptidase activity associated with the molluscan stages of *Philophthalmus gralli* Mathis and Léger. Parasitology. 58: 473-480.

Cheng, T.C., J.T.Sullivan, and K.R.Harris. 1973. Parasitic castration of the marine prosobranch gastropod *Nassarius obsoletus* by sporocysts of *Zoogonus rubellus* (Trematoda): Histopathology. J. Invertebr. Pathol. 21: 183-190.

Ching, H.L. 1961. The development and morphological variation of *Philophthalmus gralli* Mathis and Legér, 1910 with a comparison of species of *Philophthalmus* Looss, 1899. Proc. Helminth. Soc. Wash. 28: 130-138.

Chubrik, G.K. 1966. Fauna and ecology of trematode larvae from molluscs in the Barents and White Seas. Trudy. Murmansk. Biol. Inst. 10: 78-166.

Coil, W.H. 1956. *Carneophallus muellhaupti* n. sp., a Microphallid trematode from the Sanderling from Southern Mexico. Proc. Helminth.Soc.Wash.23: 138-140.

Cort, W.W. 1914. Larval trematodes from North American fresh-water snails.J.Parasit. 1: 65-84.

Crews, A.E., and G.E.Esch. 1987. Histopathology of larval trematode infections in the freshwater pulmonate snail, *Helisoma anceps*. J.Invertebr. Pathol. 49: 76-82.

Crusz, H. 1956. The progenetic trematode *Cercaria patialensis* Soparkar in Ceylon. J. Parasit.42: 245.

Crusz, H., [illegible].E.Ratnayake, and A.H.Sathananantham. 1964. Observations on the structure and life cycle of the digenetic fish-trematode *Transversotrema patialense* (Soparkar). Ceylon J.Sci. Biol. Sci. 5: 8-17.

Dawes, B. 1946. The Trematoda. Cambridge at the University Press.

Deblock, S. 1971. Contribution à l'étude des Microphallidae Travassos, 1920, XXIV. Tentative de phylogénie ét de taxonomie. Bull.Mus.Natl.Hist. Nat. Paris, 3e Ser., Zool. 7: 353-468.

Dissanaike, A.S., and D.P.Bilimoria. 1958. On an infection of a human eye with *Philophthalmus* sp. in Ceylon. J. Helminth. 32: 115-118.

*Dolgikh, A.V. 1965. Progenetic metacercariae of *Proctoeces* in Black Sea molluscs. Mater. Nauch. Konf. Veses. Obshch. Gelmint., part II. 89-94 (in Russian).

Dollfus, P. 1964. Metacercaria : *Proctoeces progeneticus* n.sp. (Trematoda, Digenea) Chez une *Gibbula* (Gastropoda-Prosobranchiata) de la côte atlantique du Maroc. Observations sur la famille des Fellodistomatidae. Ann. Parasit.Hum.Comp. 39: 755-774.

Dronen, N.O.Jr, and L.R. Penner. 1975. Concerning *Philophthalmus andersoni* sp.n. (Trematoda:Philophthalmidae), another occular helminth from birds which develops in a marine gastropod. Univ. Connecticut Occasional papers (Biol. Sci. ser.). 2: 217-224.

Efimov, A.S. 1937. A new trematode, *Philophthalmus skrjabini*, parasite in *Larus ridibundus*. K.I. Skrjabin Jub. Vol. Moscow. 149-154.

Epstein, R.A. 1972. Larval trematodes of marine gastropods of Galveston Island, Texas. M.S.Thesis, Biology Dept., Texas A&M Univ.

Erasmus, D.A. 1972. The biology of Trematodes. Edward Arnold Limited, London.

Ewers, W.H. 1964. The influence of the density of snails on the incidence of larval trematodes. Parasitology. 54: 579-583.

Ewers, W.H. 1965. The influence of larval trematodes in adults of *Velacumantus australis* (Quoy and Gaimard) Gastropoda: Potamididae). J.Helminth. 39 : 1-10.

Font, W.F., and K.C.Corkum. 1975. *Alloglossidium renale* n.sp. (Digenea:Macroderoididae) from a freshwater shrimp and *A.progeneticum* n.comb.Trans. Amer.Microsc.Soc. 94: 421-424.

Freeman, R.F.H., and J.Llewellyn. 1958. An adult digenetic trematode from an invertebrate host: *Proctoeces subtenuis* (Linton) from the lamellibranch *Scrobicularia plana* (Da Costa).J.Mar.Biol.Assoc.U.K. 37: 435-457.

Fried, B. 1962. Growth of *Philophthalmus* sp. (Trematoda) in the eyes of Chicks. J.Parasit. 48: 395-399.

Fried, B., and K.L.Grigo. 1976. Observations on the cercaria and metacercaria of *Philophthalmus hegeneri* (Trematoda). Trans. Amer. Micros, Soc. 95: 86-91.

George Varghese, C., and R.Kalyana Sundaram. 1975. On the incidence of *Philophthalmus gralli* from domestic fowl (*Gallus gallus domesticus*). Kerala J. Vet. Sci. 6: 101-107.

Ginetsinskaja, T.A., and A.A.Dobrovolskii. 1962. Glycogen and fat in the various phases of the life cycle of trematodes. Vestnik.Leningrad.Univ. Ser. Biol. 9: 67-81.

Goodman, J.D., and T.S.Panesar. 1976. *Parasymphylodora manteri* n.sp. an adult trematode from a freshwater pulmonate Snail, *Biomphalaria choanomphala choanomphala*, from lake Victoria Uganda. Trans. Amer. Microsc. Soc. 95: 204-209.

Grasshoff, K. 1976. Determination of the salinity. In : Methods of Sea Water Analysis. (Ed. K.Grasshoff) Verlag Chemic, Weinheim, New York. 31-58.

*Grozdev, E.V. 1953. New trematodes of gallinaceous birds in Kazakhstan. Trudi. Instituta Zoologii, Akademiya Nauk Kazakhskoi SSR. 1 : 175-181.

Haas, M.R., and B. Fried. 1974. Observation on cephalic glands in *Philophthalmus hegeneri*. J. Parasit. 60 : 1041-1043.

Hanumantha Rao, K., and P.N. Ganapati. 1967. Observations on *Transversotrema patialensis* (Soparker, 1924) (Trematoda) from Waltair, Andhra Pradesh (India). Parasitology. 57 : 661-664.

Heard, R.W., and R.M. Overstreet. 1983. Taxonomy and life histories of two North American species of "*Carneophallus*"(*Microphallus*) (Digenea : Microphallidae). Proc. Helminth. Soc. Wash. 50 : 170-174.

Holliman, R.B. 1961. Larval trematodes from the Apalachee Bay area, Florida, with a checklist of known marine cercariae arranged in a key to their superfamilies. Tulane Stud. Zool. 9 : 2-74.

Honer, M.R. 1961. *Diplodiscus subclavatus* (Goeze, 1782) var. *paludinae* var. nov., from *Paludina vivipara* Lin. in the Netherlands. Z. Parasitenkde. 20 : 489-494.

Howell, M.J., and A.J. Bearup. 1967. The life histories of two bird trematodes of the family Philophthalmidae. Proc. Linn. Soc. New South Wales. 92 : 182-194.

*Hsü, H.F., and C.Y. Chow. 1938. Studies on helminths of fowls. II. Some trematodes of fowls in Tsingkiangpu Kiangsu, China. China Med. J. Suppl. No. 2 : 441-450.

Huffman, J.E., and B. Fried. 1985. Histopathological and histochemical effects of larval trematodes in *Goniobasis virginica* (Gastropoda : Pleuroceridae). Veliger. 27 : 273-281.

Hutton, R.F. 1955. *Cercaria turritella* n. sp., a"huge-tailed" monostome larva from *Turritella communis* Risso. J. Mar. Biol. Assn. U.K. 34 : 249-255.

Hutton, R.F., F. Sogandares-Bernal, B. Eldred, R.M. Ingle, and K.D. Woodburn. 1959a. Investigations on the parasites and diseases of Salt-water shrimps (Penaeidae) of Sports and Commercial importance to Florida (Preliminary Report). Florida State Board Conserv. Tech. Ser. 26 : 1-38.

Hutton, R.F., F. Sogandares-Bernal, and B. Eldred. 1959b. Another species of *Microphallus* Ward, 1901 from the pink shrimp, *Penaeus duorarum* Burkenroad. J. Parasit. 45 : 490.

Ichihara, A. 1965. On a trematode (*Proctoeces* sp.) of the topshell *Turbo* (*Batillus*) *cornutus*. I. Geographical distribution in Japan and observations on the living fluke. Jap. J. Parasitol. 14 : 426-436.

Index-Catalogue of Medical and Veterinary Zoology. 1980. Parasite-Subject Catalogue, Parasites : Trematoda and Cestoda. Suppl. 22, part 3. Published by U,S. Department of Agriculture.

Ingalls, J.M. Jr. 1946. The control of *Schistosomiasis japonica* III, Studies on the longevity of cercariae of *Schistosoma japonicum* in saline solutions. J. Parasit. 32 : 521-524.

Ito, J. 1956. Studies on the brackishwater cercariae in Japan. II. Two new long-tailed cercariae, *Cercaria komiyai* n. sp., and *Cercaria nigrocaudata* n. sp. in Tokyo Bay (Trematoda). Jap. J.M. Sci. & Biol. 9 : 235-242.

Ito, J. 1980. Studies on cercariae in Japan. Reprint of papers compiled in the commemoration of 25th

Anniversary as a Professor of Shizuoka University, Shizuoka, Japan. 376 pp.

*Jägerskiöld, L.A.K.E. 1901. *Tocotrema expansum* (Crepl.) *Monostomum expansum* (Crepl.), eine genitalnapftragende Distomide. Centralbl. Bakt. 30 : 979-983.

*Jägerskiöld, L.A.K.E. 1908. Kleine Beiträge zur kenntnis der vogel trematoden. Centralbl. Bakt. 48: 302-317.

Jaiswal, G.P. 1955. On a new species of trematode belonging to the genus *Philophthalmus* Looss, 1899 from the eyes of bird in Hydrabad, Deccan. Proc. Indian Sci. Congr. Assoc. 42nd. 4: 10.

Jaiswal, G.P., and B.N.Singh. 1954. On two new trematodes of the genus *Philophthalmus* Looss, 1899 from the eyes of birds in Hydrabad, Deccan. J.Helminth. 28: 135-142.

James, B.L. 1965. The effects of parasitism by larval digenea on the digestive gland of the intertidal prosobranch, *Littorina saxatilis* (Olivi) Subsp. . *tenebrosa* (Montagu). Parasitology. 55: 93-115.

James, B.L. 1968. The occurrence of larval digenea in ten species of intertidal prosobranch molluscs in Cardigan Bay. J.Nat.Hist. 2: 329-343.

Kaji, F. 1957. On a new species of *Microphallus* and its life history. Tokyo Iji Shinshi. 74: 265-271.

Kanemitsu, T., J.Asada, and F.Kaji. 1953. Experimental studies on the first intermediate host of *Microphallus minus* Ochi, and relation to *Leander serrifer* verified recently as its second intermediate host. Hiroshima Igaku. 6 : (Suppl.1) 284-294.

Karyakarte, P.P. 1966. *Philophthalmus* (*Mixophthalmus*) *chrysommae* Subgen. et sp. nov. from the orbital cavity of the yellow eyed babbler, *Chrysomma sinensis*. Indian J. Helminth. 18 : (Seminar Suppl.) 25-28.

Karyakarte,P.P. 1967. *Philophthalmus* sp. (Trematoda: Philophthalmidae) from the eye of vulture in India. Curr. Sci. 36: 381.

Karyakarte, P.P. 1968. A new species of *Philophthalmus* (Trematoda: Philophthalmidae) from the orbital cavity of the pigeon, *Columba livia* (Gmelin) in India. Riv. Parassit. 29: 253-256.

Karyakarte, P.P. 1969. A new species of *Philophthalmus* (Trematoda: Philophthalmidae) from the orbital cavity of the common myna, *Acridotheres tristis* (Linnaeus) in India. Marathwada Univ.J.Sci.8:79-83.

Karyakarte, P.P. 1971. A new species of *Philophthalmus* (Trematoda : Philophthalmidae) from the orbital cavity of the ring dove, *Streptopelia decaocto* in India. Marathwada Univ.J.Sci.10: 71-73.

Kuntz, R.E. 1957. Experimental studies on the biology of *Heterophyes aequalis* Looss, 1902 in Egypt. Proc. helminth. Soc. Wash. 24: 110-116.

Lee, F.O., and T.C.Cheng. 1970. The histochemistry of *Stellantchasmus falcatus* Onji and Nishio, 1915 (Trematoda: Heterophyidae) metacercarial cyst in the mullet *Mugil cephalus* L. and histopathological alterations in the host. J.Fish. Biol. 2: 235-243.

Leigh, W.H. 1958. *Carneophallus turgidus* sp.nov. (Microphalloidae) from the raccoon, *Procyon lotor*, in South Florida. J. Parasit. 44: 100-102.

Lie, K.J. 1963. Studies on Echinostomatidae in Malaya. III. The adult *Echinostoma malayanum* Leiper, 1911 (Trematoda) and probable synonymy of *Artytechinostomum sufrartyfex* Lane, 1915. Z. Parasitenkde. 23: 124-135.

*Looss, A. 1899. Weitere Beiträge zur kenntnis der Trematoden Fauna Aegyptens. Zool. Jbr.S. 12: 521-784.

*Looss, A. 1907. Notizen zur Helminthologie Aegyptens. VII. Über einige neue Trematoden der äegyptischen Fauna. Zbl.Bakt. 43: 479-490.

Looss-Frank, B. 1969. Zwei adults Trematoden aus Nordsee-Mollusken: *Proctoeces buccini* n.sp. and *P. scrobiculariae* n.sp. Z. Parasitenkde. *32*: 324-340.

Madhavi, R., and K.Hanumantha Rao. 1968. Metacercaria of *Galactosomum puffini* Yamaguti, 1941 (Trematoda: Heterophyidae) from marine fishes of Waltair Coast, Bay of Bengal. Curr. Sci. *37*: 702-703.

Manter, H.W. 1970. A new species of *Transversotrema* (Trematoda : Digenea) from Marine fishes of Australia. J. Parasit. *56*: 486-489.

Martin, W.E. 1955. Seasonal infections of the Snail, *Cerithidea californica* Haldeman, with larval trematodes. Essays Nat. Sci. Honor of Captain Allan Hancock. 203-210.

Martin, W.E. 1972. An annotated key to the cercariae that develop in the snail *Cerithidea californica*. Bull. 5th.Calif.Acad.Sci. *71*: 39-43.

* Mathis, C., and M.Léger. 1910. Douve oculavie de la poule. Bull. Soc. Path. Exot. *3*: 245-251.

Mehra, H.R. 1980. The fauna of India and the adjacent countries. Platyhelminthes. Vol.I. Trematoda.

Meuleman, E.A. 1972. Host-parasite interrelationships between the freshwater pulmonate *Biomphalaria pfeifferi* and the trematode *Schistosoma mansoni*. Netherlands J. Zool. *22*: 355-427.

Miller, A.M. 1925. Larval trematodes of certain marine gastropods from Puget Sound, Washington. Publs. Puget Sound. Mar. Biol. Stn.*5* : 75-89.

Mohandas, A. 1973. *Transversotrema chackai* sp.nov., adult of *Cercaria chackai* from fishes (Digenea: Transversotrematidae). Hydrobiologia. 43: 183-188.

Mohandas, A. 1973 a. Studies on the life history of *Echinostoma ivaniosi* n.sp. J. Helminth. *47*: 421-438.

* Not seen in original.

Mohandas, A. 1974. Studies on the freshwater cercariae of Kerala. Biology. II. Emergence, behaviour and viability of cercariae. Proc. Nat. Acad. Sci. India. 44: 139-144.

Mohandas, A. 1974 a. The pathological effect of larval trematodes on the digestive glands of four species of gastropods. Folia Parasit. 21: 219-224.

Mohandas, A. 1977. On two new species of cercariae and the histpathology of the digestive gland of their host, *Digoniostoma pulchella* (Benson). Acta. Parasit. Polon. 25: 17-24.

Mohandas, A. 1979. Studies on the freshwater cercariae of Kerala. VI. Philophthalmid cercaria, *Cercaria sp.II Kerala*, n.sp. Indian J. Parasit. 3: 29-32.

Moore, M.N., and D.W.Halton. 1973. Histochemical changes in the digestive gland of *Lymanea truncatula* infected with *Fasciola hepatica*. Z. Parasitenkde. 43: 1-16.

*Morozov, F.N. 1952. Heterophyidiasis of man, domestic and wild animals. Tr. Lab. Gel'mintol Akad Nauk SSSR. 6: 397-400.

Murty, A.S. 1966. Experimental demonstration of the life cycle of *Philophthalmus* sp. (Trematoda : Philophthalmidae). Curr. Sci. 35 : 366-367.

Murty, A.S. 1970. *Pseudodiplodiscoides pilai* gen. et. sp.nov. (Trematoda : Diplodiscidae) from the apple snail *Pila globosa* (Swainson) in Andhra Pradesh. Zool. Anz. 185: 311-317.

Murty, A.S., and K.Hanumantha Rao. 1968. On a new host record for the fish trematode *Transversotrema patialensis* (Soparkar, 1924) Crusz and Sathananthan, 1960. Curr. Sci. 37 : 652-653.

Murty, A.S., and K.Hanumantha Rao. 1975. Tolerence of *Transversotrema* cercariae (Trematoda: Tranversotrematidae) to increased salinities. In: Recent Researches in Esturine Biology. (Ed.R.Natarajan). Hindustan Publishing Corporation(I),Delhi, India. 70-75.

Myers, B.J. 1956. An adult *Hemiurus* sp. (Trematoda) from *Sagitta elegans* Verrill.Can.J.Zool. 34: 206-207.

Nadakal, A.M., A.Mohandas, and V.Sunderaraman. 1969. *Cercaria chackai* sp.n. (Transversotrematidae) from Kerala, India.J.Parasit. 55: 1187-1190.

Nasir, P., and M.T.Diaz. 1972. Avian flukes of Venezuela. Riv. Parassit. 33: 245-276.

Nollen, P.M. 1971a. Studies on growth and infection of *Philophthalmus megalurus* (Cort, 1914) Trematoda) in chicks. J.Parassit. 57: 261-266.

Nollen, P.M. 1971b. Viability of a self-fertilizing strain of *Philophthalmus megalurus* (Trematoda : Digenea). J. Parassit. 57: 1222-1226.

*Ochi, S. 1928. On a new trematode *Microphallus minus* n.sp. with *Macrobrachium nipponensis* as it's intermediate host. Tokyo Iji Shinshi. No.2578 : 1360-1370.

Oliver, L. 1947. *Cercaria koliensis*, a new fork-tailed cercaria from Guadal canal. J.Parasit. 33: 234-240.

*Oshmarin, .G. 1963. Parasitic worms from mammals and birds of Primorskii Krai. Akad. Nauk. SSSR.

Otagaki, H. 1958. A study on some trematodes whose intermediate hosts are crabs inhabiting mouth of river flowing into Inland Sea of Japan. Jap. J. Parasit. 7: 167-182.

Overstreet, R.M. 1973. Parasites of some penaeid shrimps with emphasis on reared hosts. Aquaculture. 2: 105-140.

Overstreet, R.M. 1978. Marine maladies? Worms, Germs, and other symbionts from the Northern Gulf of Mexico. Mississippi - Alabama Sea Grant Consortium. 1-140.

Overstreet, R.M. 1979. Crustacean health research at the Gulf Coast Research Laboratory. Proc. Second Biennial Crustacean Health Workshop. Texas A & M. Univ., Texas. TAMU-SG. 79: 300-314.

* Not seen in original

Overstreet, R.M. 1983. Metazoan symbionts of crustaceans. In : The Biology of Crustacea. Vol. 6 (Ed. A.J. Provenzano), Academic Press, New York; 155-250.

Overstreet, R.M. 1986. Solving parasite-related problems in cultured crustacea. In : Proc. Sixth International Congr. Parasitology (Ed. M.J. Howell), Australian Academy of Science, Canberra. 309-318.

Pal, S.G. 1971. The fine structure of the digestive tubules of Mya arenaria L. I. Basophil cell. Proc. Malacol. Soc. London. 39 : 303-309.

Pande, B.P., and R.P. Shukla. 1972. On the juvenile and adult of an ectoparasitic fluke in some of our freshwater fishes. Curr. Sci. 41 : 682-684.

Pandey, K.C. 1971. On a rare cercaria, Cercaria sonarkari n. sp. (Transversotrematidae) from Lucknow, India. J. Helminth. 45 : 321-326.

Pandey, K.C. 1973. Diplodiscus mehrai Pande, 1937 from the common apple snail, Pila globosa Swainson, at Lucknow. Indian J. Zoot. 14 : 175-177.

Paperna, I., and M. Lahav. 1971. New records and further data on fish parasites in Israel. Bamidgeh. 23 : 43-52.

Pearson, J.C. 1968. Observations on the morphology and life cycle of Paucivitellosus fragilis Coil, Reid, and Kuntz, 1965 (Trematoda : Bivesiculidae). Parasitology. 58 : 769-788.

Pearson, J.C. 1972. A phylogeny of life - cycle patterns of the Digenea. Adv. Parasit. 10 : 153-189.

Pearson, J.C. 1973. A review of the Subfamily Haplorchinae Looss, 1899 (Trematoda : Heterophyidae) II. Genus Galactosomum. Phil. Trans. Roy. Soc. London. Ser. B. 266 : 341-447.

Penner, L.R., and B. Fried. 1963. *Philophthalmus hegeneri* sp. n., an ocular trematode from birds. J. Parasit. 49 : 974-977.

Penner, L.R., and J.J. Trimble III. 1970. *Philophthalmus larsoni* sp. n., an occular trematode from birds. Univ. Connecticut Occasional Papers (Biol. Sci. Ser.). 1 : 265-273.

Penner, L.R., and J.J. Trimble III. 1971. A comparison of the larval stages of *Philophthalmus hegeneri* and *P. larsoni* (Trematoda : Philophthalmidae). Zool. Anz. 186 : 373-379.

Peter, C.T. 1954. Studies on the biology of certain trematodes parasitic in domestic animals. Ph. D. Thesis., Univ. of Madras.

Peters, L.A. 1957. An analysis of the trematode genus *Allocreadium* Looss with the description of *Allocreadium neotenicum* sp. nov. from water beetles. J. Parasit. 43 : 136-144.

Porter, A. 1938. The larval trematodes found in certain South African mollusca with special reference to Schistosomiasis (Bilharziasis). Publn. South African Inst. Med. Res. 8 : 1-492.

Porter, A. 1970. The effects of parasitism by the trematode *Plagioporus virens* on the digestive gland of its snail host, *Flumenicola virens*. Proc. Helminth. Soc. Wash. 37 : 39-44.

Porter, A., I. Pratt, and A. Owczarzak. 1967. Histopathology and histochemical effects of the trematode, *Nanophyetus salmincola* (Chapin) on the hepatopancreas of its snail host, *Oxytrema siliqua* (Gould). Trans. Amer. Micros. Soc. 86 : 232-239.

Premvati. 1954. Three new species of cercariae from the snail, *Melanoides tuberculatus* (Muller). J. Zool. Soc. India. 6 : 43-50.

Prévot, G. 1973. Cycle evolutif de *Galactosomum timondavidi* Pearson et Prévot, 1971 (Trematoda : Heterophyidae). Parasite de goeland a pieds jaunes *Larus argentatus*. Ann. Parasit. Hum. Comp. 48 : 457-467.

Ram Prakash, and B.P. Pande. 1968. On some of the known and hitherto unknown trematodes parasitic in the common pariah kite, *Milvus migrans* (Boddaert). Indian J. Helminth. 20 : 1-24.

Reader, T.A.J. 1971. The pathological effects of sporocysts, rediae and metacercariae on the digestive gland of *Bithynia tentaculata* (Mollusca : Gastropoda). Parasitology. 63 : 483-489.

Reader, T.A.J. 1974. Autoradiographic studies on the uptake of I^{14} CI-glucose by *Bithnia tentaculata* (Mollusca : Gastropoda) and its larval digeneans. J. Helminth. 48 : 235-240.

Reader, T.A.J. 1976. Studies on the ultrastructure, histochemistry, and cytochemistry of the uninfected digestive gland of *Bithynia tentaculata* (Mollusca : Gastropoda) and on the ultrastructure of this host organ in snails infected with larval digeneans. Z. Parasitenkde. 50 : 11-30.

*Rebecq, J. 1964. Recherches Systématiques biologiques et ècologiques sur les formes larvaires de quelques trematodes de Camargue. Thesis Universite d' Aix-Marseille.

Rees, G. 1974. A study of the effect of light, temperature and salinity on the emergence of *Cercaria purpurae* Lebour from *Nucella lapillus* (L). Parasitology. 38 : 228-242.

Reimer, L.W. 1970. Digene Trematoden und Cestoden der ostseefische als naturliche Fischmarken. Parasit. Shr Reihe. 20 : 1-144.

Reimer, L.W., and Sita Anantaraman. 1968. *Cercaria melanocrucifera*, a new *magnacercous cercaria* (Opisthorchioidea) from the marine gastropod, *Turritella attenuata* Reeve, 1897, from the Bay of Bengal, Madras. Curr. Sci. 37 : 316-318.

Rekharani, Z., and R. Madhavi. 1983. Metacercaria of *Galactosomum ussuriense* Oshmarin, 1963 (Trematoda : Heterophyidae) from brackishwater fishes of Bheemunipatnam (India). J. Helminth. 57 : 91-94.

* Not seen in original.

*Richter, S., O. Vražić, and Z. Aleraj. 1953. Filoftalmoza domaće guske. Veterinarski Archiv. 23 : 193-205.

Rothschild, M. 1935. The trematode parasites of *Turritella communis* Lmk. from Plymouth and Naples. Parasitology. 27 : 152-170.

*Rudolphi, C.A. 1819. Entozoorum synopsis cui accedunt mantissa duplex et indices locupletissimi. Berolini. 1-811.

Saxena, S.K. 1979. Studies on the life-history of *Philophthalmus lucknowensis* Baugh, 1962. I. Morphology of the adult with a discussion on the taxonomic status of the species. Riv. Parassit. 39 : 467-494.

Schmidt, G.D., and K. Chaloupka. 1969. *Alloglossidium hirudicola* sp. nov., a neotenic Trematode (Plagiorchiidae) from leeches, *Haemopis* sp. J. Parasit. 55 : 1185-1187.

Sewell, R.B.S. 1922. Cercariae indicae. Indian J. Med. Res. 10 (Suppl) : 1-370.

Sewell, R.B.S. 1931. Cercariae nicobaricae. Indian J. Med. Res. 19 : 785-806.

*Shigin, A.A. 1957. Parasitic worms of heron and grebe of the Rybinsk reservoir. Trudy Dar. Gos. Zapov. 4 : 245-289.

Shimura, S. 1980. Ecological aspects of *Proctoeces ichiharai* (Trematoda : Digenea). Bull. Mar. Sci. 30 : 145-149.

Siddiqi, A.H., and R.M. Cable. 1960. Digenetic trematodes of Marine fishes of Puerto Rico. N.Y. Acad. Sci. 17 : 257-369.

Sindermann, C.J. 1970. Principal diseases of Marine Fish and Shellfish. Academic Press, New York and London.

Sita Anantaraman. 1961. Studies on helminths of Madras. Ph.D. thesis, University of Madras.

* Not seen in original.

Sita Anantaraman. 1963. On helminth parasites from the Madras coast. J. Mar. Biol. Assn. India. *5* : 1-3.

Skrjabin, K.I. 1947. Trematodes of Animals and Man - Fundamentals of Trematodology. Vol. I. 407 pp. (English transilation) Pub : Gulab Primlani, Amerind Pub. Co., Pvt. Ltd. New Delhi.

Smyth, J.D. 1966. The Physiology of Trematodes. Oliver & Boyd, Edinburgh and London.

Sogandares-Bernal, F., and R.F. Hutton. 1959. The identity of metacercaria B reported from the pink shrimp, *Penaeus duorarum* Burkenroad, by Woodburn et al. in 1957. J. Parasit. *45* : 362 and 378.

Sogandares-Bernal, F., and R.F. Hutton. 1960. Notes on the probable partial life-history of *Galactosomum spinetum* (Braun, 1901) (Trematoda) from the west coast of Florida. Proc. Helminth. Soc. Wash. *27* : 75-77.

Sommerville, C. 1978. The histopathology of *Stephanochasmus baccatus* Nicoll, 1907 in the digestive gland of *Buccinum undatum* (L). J. Fish. Dis. *1* : 219-232.

Soparkar, M.B. 1924. A new cercaria from Northern India, *Cercaria patialensis* nov. sp. Indian J. Med. Res. *11* : 933-942.

Sreekumaran, P. 1966. Studies on the common trematodes of ducks (*Anas boschas domesticus*) in Kerala. M.Sc. thesis (Veterinary Science)., Kerala University.

Srivastava, C.B. 1982. The fauna of India and the adjacent countries. Platyhelminthes Vol I. (Supplement), Trematoda - Digenea.

Srivastava, S.C., and B.P. Pande. 1971. The eye-fluke *Philophthalmus gralli* Mathis & Leger, 1910, in two anatid hosts with remarks on the genus. Indian J. Anim. Sci. *41* : 740-743.

Strickland, J.D.H., and T.R. Parsons. 1965. A manual of Sea Water Analysis. Bulletin No. 125, Fisheries Research Board of Canada., Ottawa.

Stunkard, H.W. 1951. Observations on the morphology and life-history of *Microphallus limuli* n. sp. (Trematoda : Microphallidae). Biol. Bull. 101 : 307-318.

Stunkard, H.W. 1959. The morphology and life history of the digenetic trematode, *Asymphylodora amnicolae* n. sp., the possible significance of progenesis for the phylogeny of the digenea. Biol. Bull. 117 : 562-581.

Stunkard, H.W. 1970. The marine cercariae of the Woods Hole, Massachusetts region. Biol. Bull. 138 : 66-76.

Stunkard, H.W. 1983. The marine cercariae of the Woods Hole, Massachusetts region, a review and a revision. Biol. Bull. 164 : 143-162.

Stunkard, H.W., and R.C. Shaw. 1931. The effect of dilution of Sea water on the activity and longevity of certain marine cercariae, with descriptions of two new species. Biol. Bull. 61 : 242-271.

Stunkard, H.W., and J.R. Uzmann. 1959. The life cycle of the digenetic trematode, *Proctoeces maculatus* (Looss, 1901) Odhner, 1911 (Syn : *P. subtenuis* (Linton, 1907) Hanson, 1950), and description of *Cercaria adranocerca* n. sp. Biol. Bull. 116 : 184-193.

Sugimoto, M. 1928. On the trematode parasites (Genus *Philophthalmus*) found in the eyes of Formosan domestic birds. J. Jap. Soc. Vet. Sci. 7 : 22-34.

Sullivan, J.J., and Heard, R.W. III. 1969. *Macroderoides progeneticus* n. sp., a progenetic trematode (Digenea : Macroderoididae) from the antennary gland of the cray fish, *Procambarus spiculifer* (Leconte). Trans. Amer. Microsc. Soc. 88 : 304-308.

Syed Ismail Koya, M.S., and A. Mohandas. 1982. Rare occurrence of a sexually mature adult digenetic trematode in the green mussel, *Perna viridis* Linne. J. Helminth. *56* : 41-43.

Szidat, L. 1956. Über den Entwicklungszyklus mit progenetischen larvenstadien (Cercariaeen) von *Genarchella genarchella* Travassos, 1928 (Trematoda, Hemiuridae) und die Möglichkeit einer hormonalen Beeinflussung der Parasiten durch ihre Wirtstiere. Z.Tropenmed. Parasit. *7* : 132-153.

Tikhomirov, I.A. 1976. The life cycle of *Philophthalmus rhionica* n. sp. Vestnik Leningrad Univ. *15* : 33-47. (English Summary).

*Timon-David, J. 1955. Trématodes des Goélands de I'Ile de Riou. Ann. Parasit. Hum. comp. *30* : 446-476.

*Travassos, L. 1921. Contribuicão para conhecimento o da fauna helmintolojica brasileira-IX. Sobre as especias da sub-familia Microfallinae Ward, 1901. Arch. Esc. Sup. Agr.Med.Vet. *4*: 84-91.

*Tretiakowa, O.N. 1948. Two new helminths of birds of the Cheliabinsk oblast-*Philophthalmus muracschkinzewi* and *Tatria skriabini* n.sp. Sborn. Rabot Gel'm 40, Nauch, Deiat.Skrj.232-236.

Tubangui, M.A. 1932. Trematode parasites of Philippine Vertebrates. Flukes from birds. Philipp.J.Sci. *47*: 369-404.

Tubangui, M.A., and C.M.Africa. 1938. The systematic position of some trematodes reported from the Philippines. Philipp. J.Sci. *67*: 117-127.

*Vassilev, I. 1973. On the ecology of the parthnogenetic stages of Philophthalmids in Yugoslavia. Izvestiya Tsent. khelmint. Lab. *16*: 25-28.

*Vassilev, I., and E.Ossikovski. 1974. Comparative Electrophoretic studies of water-soluble proteins from *Philophthalmus* collected in Bulgaria and Yugoslavia. Izvestiya Tsent. khelmint. Lab. 17 : 43-50.

* Not seen in original

Velasquez, C.C. 1958. *Transversotrema laruei*, a new trematode of Philippine fish (Digenea : Transversotrematidae). J.Parasit. 44: 449-451.

Velasques, C.C. 1961. Further studies on *Transversotrema laruei* velasquez with observations on the life cycle (Digenea: Transversotrematidae). J. Parasit. 47: 65-70.

Velasquez, C.C. 1969. Life cycle of *Cloacitrema philippinum* sp.n. (Trematoda : Digenea: Philophthalmidae). J. Parasit. 55: 540-543.

Velasquez, C.C. 1975. Observations on the life cycle of *Carneophallus brevicaeca* (Africa et Garcia, 1935) Comb.n. (Digenea : Microphallidae). J. Parasit. 61 : 910-914.

Venkat Reddy, P., and C. Subramanyam. 1971. Some cytological observations in the digenetic trematode *Philophthalmus* sp. from eagle. Curr. Sci. 40 : 578.

Vernberg,W.B. 1963. Respiration of digenetic trematodes. Ann. New York. Acad. Sci. 113: 261-271.

Vernberg, W.B., and F.J.Vernberg. 1974. Metabolic pattern of a trematode and its host : a study in the evolution of physiological responses. In : Symbiosis in the Sea. (Ed.W.B.Vernberg), University of South Carolina Press, Columbia, South Carolina. 161-172.

Walker, G. 1970. The cytology, histochemistry and ultrastructure of the cell types found in the digestive gland of the slug *Agriolimax reticulatus* (Muller). Protoplasma. 71: 91-109.

*Ward, H.B. 1894. On the parasites of the lake fishes. I. Notes on the structure and life-history of *Distoma opacum* n.sp. Trans.Amer.Microsc. Soc. 15: 173-182.

*Ward, H.B. 1901. Notes on the parasites of the lake Fish. 111. On the structure of the copulatory organs in *Microphallus*, nov. gen. Trans. Amer. Micros. Soc. 22: 175-187.

* Not seen in original.

Wardle, W.J. 1974. A survey of the occurrence, distribution and incidence of infection of helminth parasites of marine and estuarine mollusca from Galveston, Texas. Ph.D. Dissertation, Texas A & M. University.

Wardle, W.J. 1980. On the life cycle stages of *Proctoeces maculatus* (Digenea : Fellodistomidae) in mussels and fishes from Galveston Bay, Texas. Bull. Mar. Sci. 30: 737-743.

West, A.F. 1961. Studies on the biology of *Philophthalmus gralli* Mathis and Léger, 1910 (Trematoda: Digenea). Amer. Midl. Nat. 66: 363-383.

Winstead, J.T., and J.A.Couch. 1981. *Proctoeces* sp. (Trematoda: Digenea) in the American oyster, *Crassostrea virginica*. Trans. Amer. Microsc. Soc. 100 : 296-305.

Witenberg, G. 1944. *Transversotrema haasi*, a new fish trematode. J. Parasit. 30 : 179-180.

Wright, C.A. 1966. The pathogenesis of helminths in the mollusca. Helminth. Abstr. 35: 207-224.

*Wu,L.Y. 1937. Two encysted trematodes of freshwater shrimps around Shomghai region. Peking. Nat. Hist. Bull. 11: 199-204.

*Wu, L.Y. 1938. Parasitic trematodes of tree sparrows, *Passer montanus taivanensis* Hartert, from Canton, with a description of three new species. Lingnan Sci.J. 17 : 389-394.

Wu, K. 1938. Progenesis of *Phyllodistomum lesteri* sp. nov. (Trematoda: Gorgoderidae) in freshwater shrimps. Parasitology. 30: 4-19.

Yamaguti, S. 1934. Studies on the Helminth fauna of Japan. pt.3. Avian trematodes. 11. Jap.J.Zool. 5: 543-583.

Yamaguti, S. 1942. Studies on the helminth fauna of Japan. pt.38. Larval trematodes of fishes. Jap. J.Med. Sci.VI. Bacteriol & Parasit.2: 131-160.

* Not seen in original.

Yamaguti, S. 1958. Systema Helminthum. Vol.1. The digenetic trematodes of vertebrates. Parts 1 and 2. Interscience Publishers, New York.

Yamaguti, S. 1971. Synopsis of Digenetic trematodes of Vertebrates. Keigaku Publishing Co., Tokyo, Japan.

Yamaguti, S. 1975. A synoptical review of life histories of digenetic trematodes of vertebrates. Keigaku Publishing Co., Tokyo, Japan.

*Yeh, J., and K. Wu. 1951. Progenesis of *Microphallus minus* Ochi (Trematoda: Microphallidae) in freshwater shrimps. Peking. Nat. Hist. Bull. *19*: 193-208.

* Not seen in original.