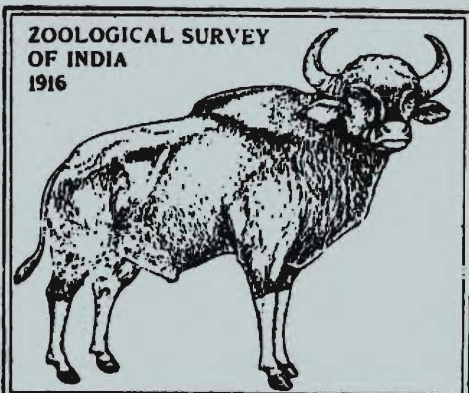


A STUDY ON THE HAEMATOZOA OF
FISHES OF COMMERCIAL
IMPORTANCE FROM INDIA

by
A. K. MANDAL



**ZOOLOGICAL SURVEY
OF INDIA**

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TECHNICAL MONOGRAPH No. 9

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A. K. MANDAL

Zoological Survey of India, Calcutta



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1984

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CONTENTS

	<i>Page</i>
INTRODUCTION	1
MATERIAL AND METHOD	2
OBSERVATION	2
HOST SPECIFICITY AND PATHOLOGY	43
ACKNOWLEDGEMENT	45
SUMMARY	45
REFERENCES	46

A STUDY ON THE HAEMATOZOA OF FISHES OF COMMERCIAL IMPORTANCE FROM INDIA

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INTRODUCTION

Though the fishes are known to host a large number of parasites belonging to different phyla, little attention was given to study the haematozoan parasites of fishes. The Piscine haematozoa emerged with the discovery of a trypanosome by Valentin (1841) and thereafter Laveran and Mesnil (1901) with a haemogregarine. Subsequently a host of other workers carried out a considerable work on these parasites abroad. But a consolidated account came into existence only recently due to the monumental work of Becker (1970, 1977) and Lom (1979).

In India, Lingard (1904) was the first who recorded a haematozoan flagellate from fish. Subsequently, de Mello and Valles (1936 a, b), Qadri (1955, 1962) and a number of workers contributed sporadically on this group. But no comprehensive work on the haematozoa of Indian fishes was published except a detailed account by Mandal (1979) on the genus *Mystus* and by the same author (in press a) on the catfishes. Joshi (1979) also gave an account on the haemoflagellates of fishes from Lucknow.

Uptil now 6 genera viz., *Trypanosoma*, *Trypanoplasma*, *Haemagregarina*, *Babesiosoma*, *Dactylosoma*, *Mesnilium*, and *Haematractidium* have been described from different groups of fishes of which all the genera are represented in India.

The studies on the haematozoan parasites of Indian fishes assumed a special importance due to the vast and varied amount of fish potentialities available in the marine, brackish, estuarine and freshwater sources, and their huge consumption. Hence, the study and observation of these haematozoan parasites by the author and other workers are brought forward in this monograph with a complete taxonomic and pathobiological account to help co-workers and workers in other disciplines.

The taxonomy of the different haematozoan genera occurring in fishes has vividly been discussed by Becker (1970). The same author has felt it difficult to draw the synonymy for the different genera. The present author also could not come to any conclusion about this after consulting the literature in detail. Therefore, instead of repeating the historical resume

of the genera as already given by Becker (1970), the author directly deals the species in each genus recorded from Indian subcontinent while preparing this monograph. The measurements given hereunder are all in microns unless otherwise stated and the stains used are of Romanowsky type.

MATERIAL AND METHODS

The materials are mainly procured from different parts of India particularly from West Bengal, Orissa, Assam, Uttar Pradesh, Bihar, Andhra Pradesh, Tamil Nadu, Kerala and Goa. The potential source is the market at different places or to contact the fishermen at the time of catch. The fish-collecting centres are also equally important for obtaining the host materials. Most cases fishes are brought alive to the laboratory and blood smears are normally taken after puncturing the branchial blood vessels. Wright, Leishman and Giemsa's stains were used for routine staining. Some organ imprints/smears were made and examined particularly in case of positivity in the peripheral blood. While conducting routine examination each slide was observed until all the parasites were located and for measurement at least 40-50 individuals were measured. Camera-lucida drawings were made on graph paper (mm division) which was helpful for area measurements. Regarding other routine haematological data the method as described by Blaxhall and Daisley (1973) were followed wherever necessary.

OBSERVATION

Genus **Trypanosoma** Gruby, 1843

Trypanosoma anabasi Mandal, 1978

(Fig. 1 A, B and Plate I, Fig. 1)

Mandal, 1978a, *Angew. Parasit.*, 19 : 159.

Host : **Anabas testudineus** (Bl.)

Shape : Trypanosomes are elongated and gradually tapering at both ends. Their configuration varies from a 'C' to an 'S' shape but more towards 'C' shape. No polymorphism was noted. No division stages have so far been encountered in blood or any other organ-smear preparations. In one smear the number of individual varies from 5-30.

Cytoplasm : Uniformly granular with number of scattered vacuoles throughout, more abundant in the posterior region of the nucleus. The cytoplasmic granules stain deep blue in Giemsa but they do not form any striation or get localised in any particular place in the body of the parasites.

Nucleus : Nearly oval, situated about the middle and does not occupy the entire width of the body. The chromatin granules are arranged in the form of inverted 'S' and take a dark blue stain with Giemsa.

Kinetoplast : Generally spherical but occasionally oval ; stains very deep blue and always darker than the nucleus. No division stages are found in any preparation.

Flagellum and undulating membrane : From the point of origin, the flagellum trails anteriorly bordering the undulating membrane and extends beyond the body as a free flagellum. It appears very prominent throughout the length and the best result is obtained after treating with Leishman's stain. The conspicuous undulating membrane is having 6-8 large folds. Similar smaller uniform folds are generally observed in the preparation. It stains pinkish in Leishman and light red in Giemsa stain.

The trailing movement of the flagellum is very well marked in the citrate preparation.

The dimensions of the organism are :

Particulars	Range	Mean
Length of the body	26.5-38.5	29.5
Length of the free flagellum	10.5-17.5	15.5
Total length	36.5-56.00	45.00
Length of the nucleus	3.00-4.5	3.3
Width of the nucleus	1.00-2.5	1.3
Width of the undulating membrane	.2-.3	
Diameter of the Kinetoplast	0.5-0.9	.80
Distance from Kinetoplast to posterior tip	1.0-2.3	1.3
Distance from posterior end of the nucleus to Kinetoplast	10.5-13.5	11.6
Distance from anterior end of the nucleus to anterior end of the body	12.5-15.5	13.3

Site of infection : Blood

Locality : Canning, 24 Parganas, West Bengal, India

Vector and life cycle : Unknown

Trypanosoma armeti Mandal, 1975

(Fig. 2 A, B)

Mandal, 1975. *Angew. Parasit.*, 16 : 90.

Host : *Mastocembelus armetus* (Lac.)

Shape : Elongate and fusiform, the anterior end gradually tapering ; whereas the posterior end terminates abruptly. Both broad and slender bodied forms are observed in the preparation.

Cytoplasm : Granular with stray small vacuoles throughout. A thick concentration of granules are observed near the vicinity of the nucleus,

leaving a decided gap around it. They do not form any striation on the body. There is no cytoplasmic difference in broad and slender forms.

Nucleus : Situated almost at the middle of the body. In Leishman's stain it appears pink red in colour and in Giemsa's it becomes reddish. Generally ovoidal or bean shaped but in slender form it is elongated. The chromatin granules are scattered, more towards the periphery and a clear opacity is marked at the central part of the nucleus particularly in broad forms. In slender forms, a thick concentration of nuclear materials are observed at both ends. In most of the specimens it is found that the nucleus is always surrounded by a halo. The clear vacuole around the nucleus though absent in slender forms, is compensated by vacuoles, at both the ends of the nucleus. In any form the nucleus does not cover the entire width of the body.

Kinetoplast : Spherical in most specimens ; sometimes pyramidal-shaped body is also observed and stains darker than the nucleus. It is situated just behind the posterior end. In no specimen the division of kinetoplast is seen in the preparation.

Blepharoplast : It is not observed in any specimens. The axoneme appears to arise directly from the kinetoplast.

Flagellum : It seems to originate from the kinetoplast and moves towards anterior end. It is seen clearly running along the border of the undulating membrane and extending beyond the body as a free flagellum. Amongst all the staining techniques applied, Leishman's stain gives the best results in differentiating flagellum.

Undulating membrane : Conspicuous but narrow and have 8-10 folds. The folds are usually of similar nature throughout, sometimes one or two big folds are observed in addition to the normal smaller folds. It stains pinkish with Leishman and is clearly outlined.

The following are the dimensions of the trypanosome.

<i>Particulars</i>	<i>Stumpy form</i>		<i>Slender form</i>	
	<i>Range</i>	<i>Mean</i>	<i>Range</i>	<i>Mean</i>
Total length of body including the free flagellum	48.0-51.00	49.5	53.0-57.0	54.5
Length of the body proper	38.0-40.0	39.50	42.0-45.0	43.5
Breadth of the body	4.0-5.5	4.8	3.0-4.0	3.5
Length of the free flagellum	10.0-11.0	10.5	11.0-12.0	11.5
Length of the nucleus	4.0-5.0	4.00	5.0-5.5	5.00
Breadth of the nucleus	3.0-3.5	3.2	2.0-2.5	2.2
Length of the Kinetoplast	1.0-1.5	1.00	0.79-1.0	1.00

Site of infection : Blood

Locality : Champahati, 24 Parganas, West Bengal, India

Vector and life-cycle : Unknown

***Trypanosoma batai* Joshi, 1978**

(Fig. 3 A, B)

Joshi, 1978. *J. Anim. Morph. Physiol.*, 45 : 1.

Host : ***Labeo bata*** (Ham.)

Shape : The parasite has long slender body, attenuated at both ends, but the posterior extremity ends more sharply.

Cytoplasm : It is finely granular, taking deep azurophilic stain. Granulation is more in the anterior half than the posterior half and devoid of any vacuole.

Nucleus : It is almost round or oval. In general, the nucleus is almost centrally placed, but in some forms it was clearly present in the anterior half of the body. A centrally placed karyosome stained reddish purple, with a light pinkish area around is present in all the forms.

Kinetoplast : Usually small, round or oval structure, stained dark bluish black with Leishman's stain. But in one of the forms it is conspicuously big, and situated a little away from the posterior extremity.

Blepharoplast : Not distinct.

Flagellum : Fairly long, apparently arising from the kinetoplast and running along the border forming the undulating membrane before becoming free.

Undulating membrane : Narrow, but distinct. No myonemes and granules are present on it.

The dimensions of both the smallest and the largest forms are :

<i>Particulars</i>	<i>Smallest form</i>	<i>Largest form</i>	<i>Mean</i>	<i>Range</i>
Length of free flagellum	10.8	15.0	11.8	9.2-17.0
Length of body	13.2	18.5	17.00	12.6-15.0
Total length	24.0	33.5	28.8	24.0-33.5
Width of the body at the centre of the nucleus	1.0	1.6	1.4	1.0-1.8
Width of the undulating membrane	0.8	0.8	0.9	.08-1.1
Long axis of the nucleus	2.0	1.8	1.6	1.1-2.2
Short axis of the nucleus	0.6	1.0	0.8	0.5-1.2
Distance of the nucleus from posterior end	8.0	9.1	8.2	6.8-9.5
Length of karyosome	0.7	0.8	0.6	0.5-0.9
Width of karyosome	0.6	0.6	0.5	0.4-0.7
Length of kinetoplast	0.6	0.8	0.7	0.5-0.8
Width of kinetoplast	0.5	0.8	0.6	0.5-0.8
Distance of kinetoplast from posterior end	0.8	1.0	0.9	0.7-1.0
Nuclear Index	2.1	1.2	1.5	1.0-2.2

Site of infection : Plasma of the host fish

Locality : Gomati River and Chinhat Lake, Lucknow, Uttar Pradesh, India

Vector and life-cycle : Unknown

Remarks : The description is based on original description of the author.

***Trypanosoma baigulensis* Pandey and Pandey, 1974**

Pandey and Pandey, 1974. *Indian J. Zootm.* 15 : 15.

Hosts : (i) ***Osteobrama cotio* (Ham.)**

(ii) ***Cirrhina reba* (Ham.)** [= *Cirrhinus reba* (Ham.)]

Shape : Irregularly bent, dimorphic viz. large and small, pointed at both ends.

Cytoplasm : Dense, basophilic with numerous large and small granules, concentrated mostly in the middle of the body. Few small vacuoles are also present.

Nucleus : Oval to elongate oval, located nearly in the middle of the body. Stains purplish with basophilic tinge.

Flagellum and undulating membrane : Flagellum long, whip like, distinct ; nearly half the length of the body. In some it remains short. Undulating membrane well developed, distinct, having 3-6 folds.

The dimensions of the organism are :

<i>Particulars</i>	<i>Large form Range</i>	<i>Small form Range</i>
Length of the body (including flagellum)	20.3-22.5	12.1-14.5
Length of cell body	18.1-20.5	10.2-12.3
Length of free flagellum	5.0-5.5	4.0-4.5
Width of the cell body	1.8-2.25	2.0-2.1
Length of nucleus	1.6-2.0	1.2-1.7
Width of the nucleus	1.5-2.0	1.0-1.1
Length from kinetoplast to posterior tip	0.2-0.2	0.2-0.6
Maximum width of the undulating membrane	0.6-1.0	0.8-1.0

Site of infection : Blood

Locality : Baigul Lake, Nainital, Uttar Pradesh, India

Vector and life-cycle : Unknown

Remarks : The description is based on the original description of the species as the present author could not come across any such parasite.

Trypanosoma batrachi Qadri, 1962

(Fig. 4)

Qadri, 1962. *Parasitology*, 52 : 225 ; Mandal (in press a), *Bull zool. Surv. India*.Host : **Clarius batrachus** (Linnaeus)*Shape* : Monomorphic.*Cytoplasm* : Granular with many vacuoles of different sizes. Sometimes the volutine granules form a compact mass and appear very deep in the stained preparation.*Nucleus* : Situated a little towards posterior half of the body, elongated and uniformly compact and occupies almost the whole width of the body where it is situated. The nucleus is always surrounded by a clear halo.*Kinetoplast* : Oval round or bean-shaped ; compact, situated posteriorly, sometimes exceeded the length of width where it is situated.*Flagellum and undulating membrane* : The organism has got a long flagellum and trails along body margin after forming the undulating membrane which can be differentiated from the body. It extends beyond the body as free end and perform a lashing movement in citrate preparations. The undulating membrane stains very deep and has 3-6 folds.

The dimensions of the organism are :

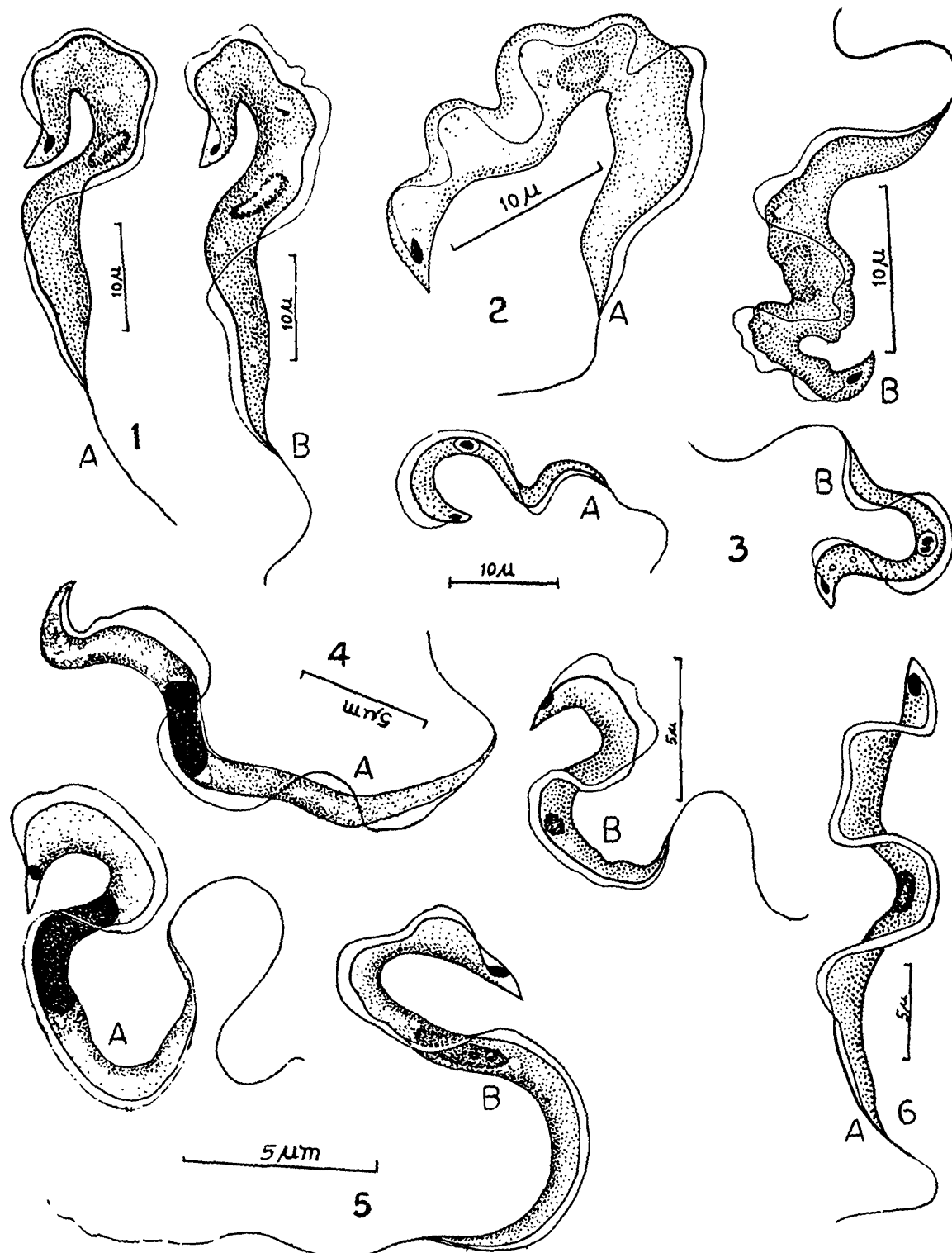
<i>Particulars</i>	<i>Range</i>	<i>Mean</i>
Length of the cell body	22.00-29.00	25.5
Breadth of cell body	1.5-3.5	2.00
Length of the free flagellum	9.00-14.00	12.00
Length of the nucleus	2.00-3.00	2.5
Breadth of nucleus	1.00-1.5	1.25
Length of the kinetoplast	1.00-1.50	1.00

Site of infection : Blood*Locality* : Calcutta market, West Bengal, India*Vector and life-cycle* : Unknown*Remarks* : The species originally described after obtaining the host materials from Hyderabad.**Trypanosoma bengalensis** Mandal, 1979

(Fig. 5, and Plate I, Fig. 3)

Mandal, 1979. *Bull zool. Surv. India*, 2 : 18 (in press a), *Bull. zool. Surv. India*.Host : **Mystus bleekeri** (Day)*Shape* : Monomorphic, elongated and attenuated at both ends.*Cytoplasm* : Granular, the granules are arranged along the border opposite to undulating membrane. Two large vacuoles are found at both extremities of the nucleus.

Nucleus : Bean shaped, centrally placed, in some specimens it is found to shift a little towards the posterior end. It never exceeds the entire width of the body.



Figs. 1-6. 1 A, B. *Trypanosoma anabasi* Mandal, 1978

2 A, B. *T. armeti* Mandal, 1975

3 A, B. *T. batai* Joshi, 1978.

4. *T. batrachi* Qadri, 1962.

5 A, B. *T. bengalensis* Mandal, 1979.

6 A, B. *T. choudhuryi* Mandal, 1977.

Kinetoplast : Round, stains very deep and does not exceed the width where it is situated.

Flagellum and undulating membrane : The flagellum arises from the kinetoplast, trails along the border forming an undulating membrane and extends beyond the body as free portion. The undulating membrane stains light blue having 3-7 folds. The flagellum is weak and appears very faint.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>	<i>Mean</i>
Length of the cell body	14.00-17.5	15.5
Length of the free flagellum	8.5-12.5	10.5
Distance from anterior end of the body to the anterior end of the nucleus	5.5-8.5	7.5
Length of the nucleus	2.00-3.00	2.5
Width of the nucleus	—	0.5
Distance from posterior end of the nucleus to the kinetoplast	4.5-5.5	5.00
Diameter of the kinetoplast	0.5-1.00	0.75
Distance from kinetoplast to the posterior tip	1.00-1.5	1.00
Width of the undulating membrane	—	0.5
Maximum width of the cell body	1.5-2.00	1.75

Site of infection : Blood

Locality : Canning, 24 Parganas, West Bengal, India

Vector and life-cycle : Unknown

***Trypanosoma clariae batrachi* de Mello and Valles, 1936**

de Mello and Valles, 1936a. *Proc. Indian Acad. Sci. (Sec. B)*, 3 : 120.

Host : *Clarias batrachus* (Linnaeus)

Shape : Extremity pointed, posterior end (anterior end mentioned by the authors) rostrum like.

Cytoplasm : Irregularly vacuolated with volutine granules in front of nucleus. The longitudinal striations at the middle are visible.

Nucleus : Oval, long axis is parallel to the long axis of the body with compact chromatin granules situated at the middle or anterior third (posterior as mentioned by the authors).

Kinetoplast : Situated a little behind, with compact granules, stained dark violet by Romanowsky and lodged in stains front by fine oval alveole.

Flagellum and undulating membrane : Undulating membrane distinct ; flagellum arises from the kinetoplast and trails along the body with a free extremity.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>
Length of the cell body	12.5-30.00
Length from posterior and (ant. end referred by the authors) to kinetoplast	1.0-2.5
Length from kinetoplast to posterior end of nucleus	3-30
Length of the nucleus	2-3
Length from ant. border of the nucleus to anterior end (posterior end mentioned by the authors)	2-13
Length of the free flagellum	9-32
Width of the body	1-2.5

Locality : Not mentioned but probably from Goa

Site of infection : Blood

Remarks : The description is based on de Mello and Valles (1936a). It is interesting to note that none of the authors who described trypanosomes from *Clarias batrachus* till date have mentioned anything about this parasite. However, the present author could not come across any parasite from the same host materials after examining the fishes from the type locality (10 examples ; locality-Molem, Goa).

Trypanosoma choudhuryi Mandal, 1977

(Fig. 6A, B and Plate I, Fig. 4)

Mandal, 1977. *Acta Protozool.*, 16 (1) : 2.

Host : **Tilapia mossambica** (Peters)

Shape : Monomorphic, elongated and attenuated at both ends.

Cytoplasm : Stains light blue ; sometimes two large vacuoles are present at both extremities of the nucleus. Numerous granules are present in the cytoplasm, generally localized at the border opposite to the undulating membrane and in most instances these granules are concentrated more towards the portion anterior to the nucleus.

Nucleus : Sausage-shaped, situated almost at the middle of the body, stains deep blue and not occupying the entire width of the body. In most specimens, one dark blue stained karyosomal mass in each was noticed.

Kinetoplast : Generally oval but on many occasions it is found conical ; staining very deep, and sometimes appearing as deep-blue body. It is always large in relation to the width of the posterior end of the body where it is situated.

Flagellum and undulating membrane : The flagellum originates from the kinetoplast and trails anteriorly bordering the undulating membrane and

extending beyond the body as a free flagellum. The undulating membrane stains light blue and is clearly outlined with 4-6 folds.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>	<i>Mean</i>
Length of the cell body	16.5-25.32	20.23
Length of the free flagellum	6.5-12.5	10.79
Total length	—	31.25
Distance from anterior end of the body to anterior end of nucleus	4.5-8.5	6.64
Length of the nucleus	3.5-5.25	4.15
Width of the nucleus	1.0-2.5	1.24
Distance from posterior end of the nucleus to the kinetoplast	5.5-9.5	7.4
Length of the kinetoplast	1.00-1.57	1.2
Width of the kinetoplast	1.1-0.5	0.58
Distance from kinetoplast to the posterior end	0.8-2.5	1.5
Width of undulation of membrane	0.4-0.85	0.5
Width of the cell body	1.5-1.8	0.5

Site of infection : Blood

Locality : Bagmari, Dist. 24 Parganas, West Bengal, India

Vector and life-cycle : Unknown

Trypanosoma channai Narasimhamurti and Saratchandra. 1980
(Fig. 7A, B)

Narasimhamurti and Saratchandra, 1980. *Proc. Indian Acad. Sci.*, 89 : 372.

Host : **Channa punctata** (Bloch) [= *Ophiocephalus* = *Channa punctatus* (Bloch)]

Morphologically three different types viz., slender, medium and stumpy forms were observed in the preparation.

Slender forms :

Shape : Elongated, both anterior and the posterior ends are tapering to fine points.

Cytoplasm : Hyaline and stained pale bluish-pink with Giemsa and did not contain any vacuoles or inclusions.

Nucleus : Situated almost at the middle of the body and elongated in shape. It contained the irregular mass of deeply stained chromation materials.

Kinetoplast : Round or oval and in sub-terminal in position, stained deep pink with Romanowsky type of stain.

Flagellum : It originates from the kinetoplast and moves towards anterior end. It was seen clearly running along the border forming the undulating membrane and extended beyond the body as a free flagellum. It also stained very deeply.

Undulating membrane : Conspicuous with 7 to 10 folds.

Medium-sized forms :

Shape : The medium-sized forms were also pointed at both ends but the body was broadest at the centre.

Cytoplasm : It stained pink and contained vacuoles, distributed at random on the body.

Nucleus : Round or oval situated at the middle of the body.

Stumpy forms :

Shape : The short and stumpy forms were much broader than the medium sized forms.

Cytoplasm : It stained pink and contained numerous vacuoles distributed throughout the cytoplasm.

Nucleus : Round or oval in shape.

The dimensions of three forms of *Trypanosoma channai* are :

Particulars	Slender Range	Medium Range	Stumpy Range
Length of flagellate (including free flagellum)	38.4-51.2	44.8-62.00	42.00-53.00
Length of the cell body	23.2-41.6	36.8-49.00	30.5-44.5
Width of the cell body	1.5-2.5	4.0-5.0	7.2-9.6
Length of free flagellum	8.15-12.00	6.4-16.00	8-13.6
Length of the nucleus	2.4-3.2	2.4-4.8	4.8-7.6
Width of the nucleus	1.6	2.5-5.00	3.2-4.00
Diameter of kinetoplast	0.7	0.7	0.7

Site of infection : Blood

Locality : Visakhapatnam and Srikakulam, Andhra Pradesh, India

Vector and life-cycle : Unknown

Remarks : This description is based on the original description of the species.

Trypanosoma cancili Mandal, 1978

(Fig. 8A, B and Plate I, Fig. 2)

Mandal, 1978a. *Angew. Parasit.*, 19 : 161.

Host : *Xenentodon cancila* (Ham.)

Shape : The trypanosomes are elongated, slender and gradually attenuated at both ends. Their configuration varies from a 'C' to an 'S' shape. No

polymorphism was noted and no division stages were found in the blood or any other organ smear preparation. In one blood smear, the number of individual varies from 3 to 15.

Cytoplasm : Coarsely granular, stains deep blue with Giemsa. There are no striations or any localization of granules on the body. A large number of small vacuoles are scattered within the cytoplasm.

Nucleus : Ovoidal in shape, situated almost at the middle of the body, stains deep blue and not occupying the entire width of the body. The chromatin granules are deeply stained and arranged in irregular manner inside the nucleus.

Kinetoplast : Generally spherical, sometimes oval or even conical form are frequently seen in the preparation. It always takes deep stains.

Flagellum and undulating membrane : The flagellum is very thin, trails anteriorly bordering the undulating membrane and extending beyond the body as free flagellum. In any preparation, the flagellum is hardly visible. The undulating membrane is small, stains very light blue and less clearly outlined. The number of folds varies from 5-7. In living specimens the trailing movement is less conspicuous.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>	<i>Mean</i>
Length of the body	18.5-20.5	20.5
Length of the free flagellum	8.5-11.8	9.5
Total length	27.60-40.3	30.00
Length of the nucleus	2.5-3.5	3.00
Width of the nucleus	1.3-2.8	1.6
Width of undulating membrane	.38-.55	.43
Distance from kinetoplast to posterior tip	1.00-2.5	1.5
Distance from kinetoplast to the posterior end of the nucleus	8.5-10.5	9.00
Distance from anterior end of nucleus to the anterior end of the body	7.5-10.5	8.5

Site of infection : Blood

Locality : Raidighi, 24 Parganas, West Bengal, India

Vector and life-cycle : Unknown

Trypanosome danilewskyi saccobranchi Qadri, 1962

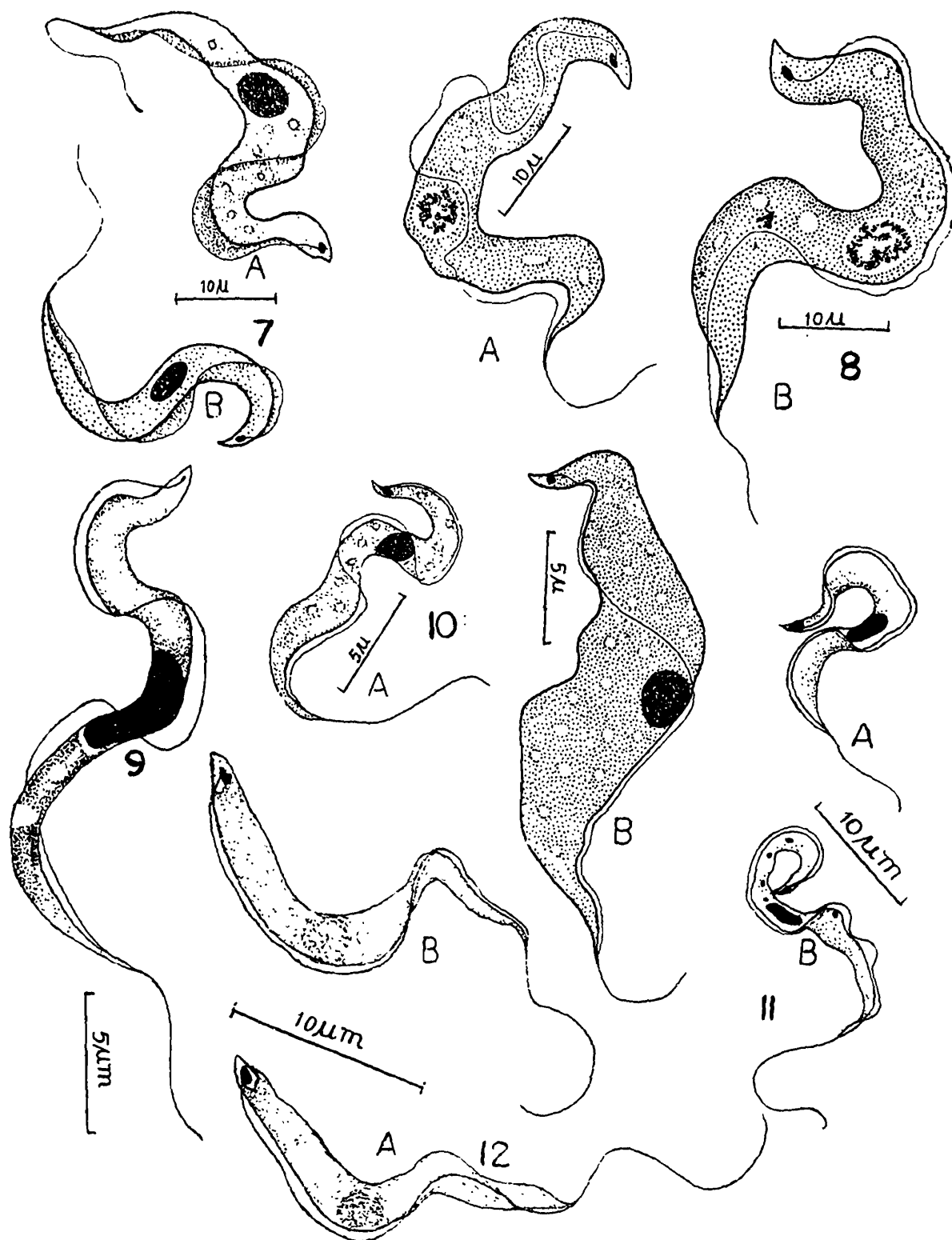
(Fig. 9)

Qadri, 1962. *Parasitology*, 52 : 226 ; Mandal (in press a), *Bull. zool. Surv. India*.

Host : **Heteropneustes fossilis** (Bl.)

Shape : Monomorphic, more pointed at the anterior end.

Cytoplasm : Granular with large vacuoles situated mostly at the anterior region of the body. The granules are uniform but in some species it is found to concentrate more towards the side opposite to undulating membrane.



Figs. 7-12. 7 A, B *T. channai* Narasimhamurti and Saratchandra, 1980.
 8 A, B *T. cancili* Mandal, 1978,
 9 *T. danilewskyi saccobranchi* Qadri, 1962.
 10 A, B *T. gobida* Mandal (in press).
 11 A, B *T. maguri* Tandon and Joshi, 1973
 12 A, B *T. mukundi* Roychaudhury and Misra, 1973.

Nucleus : Compact, elongated and situated at the posterior half of the body not always across the entire width of the body. The vacuoles are always situated at both ends of the nucleus.

Kinetoplast : Very dense, either elongated, round or bar like sometimes covers the entire width of the body.

Flagellum and undulating membrane : Flagellum very thick and prominent, trails along the margin of the body forms a narrow undulating membrane. It extends as free end about half the length of the body. The undulating membrane is provided with 6-9 folds.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>	<i>Mean</i>
Length of the cell body	27.00-33.5	29.5
Breadth of the cell body	1.00-1.5	1.2
Length of the free flagellum	11.00-15.5	13.5
Length of the nucleus	2.00-3.5	3.00
Breadth of nucleus	0.7-1.00	0.5
Length of the kinetoplast	0.75-1.5	0.5

Site of infection : Blood

Locality : Calcutta market, West Bengal, India

Vector and life-cycle : Unknown

Remarks : This species was described by Qadri (1962) after obtaining the host materials from Hyderabad.

***Trypanosoma elongatus* Raychaudhuri and Misra, 1973**

Raychaudhuri and Misra, 1973. Arch. *Protistenk.*, 115 : 13.

Host : ***Ophicephalus punctatus*** Bloch [= *Channa punctatus* (Bloch)]

Shape : Slender and fusiform.

Cytoplasm : Light purple and more granulated in the post-nuclear part of the cell body. The anterior half of the parasite more slender than the posterior half and narrowly pointed.

Nucleus : Appears as a close assemblage of large chromatin dots ; the nuclear membrane not distinct in many cases. It is situated at one-third length before the posterior tip and is closely apposed with one side of the cell wall of the parasite, oval in shape and stains deep red with brown tinge in Giemsa.

Kinetoplast : Triangular in shape and situated at the tip of the posterior region. It stains deep red with brown tinge but refractile in nature. A halo is absent around the kinetoplast.

Flagellum : Arises from the kinetoplast and touches the cell body of the parasite at intervals, finally emerging as a free flagellum. The undulating membrane is distinct and takes a lighter stain than the cytoplasm.

The division stages of this parasite as well as short stumpy form have not observed.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>
Total length of the parasite (including free flagellum)	60.5-62.0
Length of the cell body	43.0-44.5
Breadth of the cell body	3.0-3.5
Length of the free flagellum	17.0-18.5
Length of the nucleus	6.0-6.5
Breadth of the nucleus	3.0
Length of the kinetoplast	0.75
Breadth of the kinetoplast	0.5

Site of infection : Blood

Locality : Lakes and Ponds around Calcutta, West Bengal, India

Vector and life-cycle : Unknown

Remarks : The description is mainly based on Raychaudhuri and Misra (1973). The present author has examined the type slides also.

Trypanosoma gachuii Misra, Chandra and Chaudhury, 1973

Misra, Chandra and Chaudhury, 1973. *Arch. Protistenk.*, 115 : 18.

Host : *Ophicephalus gachua* Ham. [= *Channa gachua* (Ham.)]

Shape : The haemoflagellates were found to occur in two distinct forms, viz., short slender and long slender. Both the forms were slender having a conspicuous free flagellum but their cell body differs in length and width.

Short slender form : Elongated with pointed anterior end but rarely with less pointed posterior end.

Cytoplasm : Stains light pink with few granules at the anterior half which are linearly arranged but scattered at the posterior half of the body. Post nuclear part of the cytoplasm having 3—4 small vacuoles.

Nucleus : Granular stains deep red with Leishman round or elongated in shape. It is situated in the middle but more towards the posterior half of the body.

Kinetoplast : Subterminal and shows the same tinctorial property as the nucleus. It appears to have two parts.

Flagellum : It is found to emerge from the side of the posterior part of the kinetoplast and touches the cell body at regular intervals (3 to 4

attachments) and ultimately leaves as a conspicuous free flagellum forming a definite undulating membrane.

Long slender form : This form resembles the former one only in some morphological features, otherwise they differ mensurally as well as in tinctorial property. The larger form is long with blunt posterior end.

Cytoplasm : Blue to deep blue with Leishman's stain, several striations were found all over the body. No vacuoles but some granules were observed.

Nucleus : Generally round in shape and compact in nature, situated in the middle of the cell body.

Kinetoplast : Single lobed, stains deep red with Leishman stain and is subterminal in position.

Flagellum : Emerges from the side of the kinetoplast having 8 to 10 attachments with the cell body and emerges out as a distinct free flagellum and undulating membrane.

The dimensions of the organism are :

<i>Particulars</i>	<i>Long slender form</i>		<i>Short slender form</i>	
	<i>Range</i>	<i>Mean</i>	<i>Range</i>	<i>Mean</i>
Total length of the body (including free flagellum)	34.4-38.9	36.4	51.1-54.4	53.0
Length of the cell body	23.3-26.4	24.9	38.4-44.4	42.1
Width of the cell body	2.2-2.7	2.3	2.5-5.6	3.9
Length of the free flagellum	10.0-12.5	11.1	10.0-12.2	10.9
Length of the nucleus	2.0-2.8	2.4	2.2-3.3	2.1
Breadth of the nucleus	2.0-2.7	2.2	2.2-3.3	2.1
Post-kinetoplast distance	1.5-2.2	1.7	1.5-2.3	1.7

Site of infection : Blood

Locality : Ponds in and around Calcutta, West Bengal, India

Vector and life-cycle : Unknown

Remarks : The description is mainly based on the original description but the present author has examined the type slides also.

Trypanosoma gobida Mandal (In press b)
(Fig. 10A, B)

Mandal (In press b). *Bull. zool. Surv. India*.

Host : **Glossogobius qiuris** (Ham.)

Two morphologically distinct types namely broad or stumpy and slender forms in the proportion 170 : 30, different in size. No parasite was found in the organ imprints.

Broad or stumpy form :

Shape : Very broad, deeply stained with any Romanowsky stain.

Cytoplasm : It has numerous small vacuoles distributed throughout the body.

Nucleus : Round, densely compact with chromatin materials situated almost at the middle of the body (NI=1.35). It never covers the entire width of the body but sometimes it is shifted towards one edge of the body.

Kinetoplast : Round, deeply stained, situated a little away from the pointed posterior end. It never exceeds the width of the body where it is situated. Sometimes one or two bigger vacuoles are observed close to kinetoplast.

Flagellum and undulating membrane : The undulating membrane forms 6-8 convolutions of the flagellum over the body surface. The flagellum trails freely towards the anterior end, appears very thin with any stain used.

Slender forms :

Cytoplasm : Clear, some scattered volutin granules are found throughout the body, more so close to the nucleus as well as towards the border opposite to undulating membrane.

Nucleus : Very deep, uniformly stained, almost round, covers the entire width of the body. It is situated almost at the middle (NI=1).

Kinetoplast : Round, stains always deeper than the nucleus and does not exceed the width of the body where it is situated.

Flagellum and undulating membrane : The flagellum trails along the border forming a clear undulating membrane and extends beyond the body as free portion which is very thin and long. Undulating membrane is very distinct having 3-5 folds.

The dimensions of diamorphic forms are as follows :

<i>Particulars</i>	<i>Broad form</i>		<i>Slender form</i>	
	<i>Range</i>	<i>Mean</i>	<i>Range</i>	<i>Mean</i>
Length of the free flagellum	8.00-10.5	9.00	14.5-16.5	15.00
Length from anterior end of the body to the anterior end of the nucleus	16.5-19.5	18.10	14.0-16.0	15.5
Length of the nucleus	5.5-6.6	6.00	3.0-4.0	3.5
Length from posterior end of the nucleus to the kinetoplast	21.5-23.0	22.5	11.5-13.0	12.00
Length of the kinetoplast	1.5	—	1.5	—
Length from kinetoplast to the posterior end	1.75	—	1.5	—
Length of the cell body	46.5-51.5	48.5	32.5-38.5	33.5

Site of infection : Blood

Locality : Canning, 24 Parganas, West Bengal, India

Vector and life-cycle : Unknown

Trypanosoma granulorum Laveran and Mesnil, 1902

(Plate I, Fig. 5)

Laveran and Mesnil, 1902. *Arch. Protistenk.*, 1 : 475.

Host : ***Anguilla anguilla*** and ***Amphinopnus*** sp.

Shape : Monomorphic, attenuated at both ends, configuration mainly in the form of a 'C'

Cytoplasm : Highly granulated throughout more so at the anterior half.

Nucleus : Almost bean-shaped, situated more towards the anterior end and does not cover the entire width of the body ; chromatin granules are concentrated at the centre.

Undulating membrane : Conspicuous, can easily be differentiated from the body proper which is devoid of any granules, having numerous folds on the body.

Flagellum : Arises from the kinetoplast, trails anteriorly forming the distinct undulating membrane, and leaves the body as a distinct free portion.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>	<i>Mean</i>
Length of the body	55.00-85.00	65.00
Length of the free flagellum	22.5-32.00	25.00
Total length	85.00-110.0	90.05
Length of nucleus	4.5-6.5	5.20
Width of the nucleus	2.0-3.5	2.5
Distance from kinetoplast to posterior end	3.5-5.5	5.00
Distance from posterior end of nucleus to kinetoplast	18.00-22.5	20.05
Distance from anterior end of the nucleus to anterior end of the body	36.5-43.5	40.05

Site of infection : Blood

Locality : Calcutta market for *Amphinopnus* sp. and for *A. anguilla* not known described by the original author.

Vector and life-cycle : Unknown

Trypanosoma maguri Tandon and Joshi, 1973
(Fig. 11 A, B)

Tandon and Joshi, 1973. *Z. Wiss. Zool.*, 185 : 209 ; Mandal, (In press a) *Bull. zool. Surv. India*.

Host : **Clarias batrachus** (Linnaeus)

Shape : Pleomorphic, attenuated at both ends. The large and small forms have been encountered in the preparation.

Cytoplasm : Granular, arranged throughout the body ; interrupted by stray small vacuoles. The granular disposition is well-marked at the border opposite the undulating membrane.

Nucleus : Oval or reniform, placed almost at the middle of the body or slightly behind the middle. The chromatin granules are densely concentrated and does not form any karyosomal mass.

Kinetoplast : Ovoidal or reniform appears reddish purple. Sometimes a halo was found around the kinetoplast.

Flagellum and undulating membrane : The flagellum is thick and conspicuous but the undulating membrane formed is difficult to differentiate from the body.

The dimensions of the organism are :

<i>Particulars</i>	<i>Large form</i>		<i>Small form</i>	
	<i>Range</i>	<i>Mean</i>	<i>Range</i>	<i>Mean</i>
Length of the cell body	18.00-35.5	25.5	3.00-6.5	5.00
Length of the free flagellum	9.00-21.5	15.00	—	—
Breadth of the cell body	1.5-3.00	2.00	1.00-2.2	1.2
Length of nucleus	2.00-5.00	3.00	1.00-2.00	1.5
Breadth of nucleus	0.7-1.5	1.25	0.5-1.5	1.00
Length of the kinetoplast	0.4-1.5	0.75	0.8-1.00	0.5
Width of the kinetoplast	0.3-1.5	0.5	—	0.3

Site of infection : Blood

Locality : Initially the species was described from Lucknow ; this description is based after obtaining the materials from Calcutta market.

Vector and life-cycle : Unknown

Trypanosoma mrigali Joshi, 1976

Joshi, 1976. *Indian J. Zootm.* 17 : 5.

Host : **Cirrhina mrigala** [= *Cirrhinus mrigala* (Ham.)]

Shape : Generally slender, long or short and rarely stumpy forms are seen. An almost rectangular form is also present. In slender forms the

two ends are sharply attenuated. In stumpy forms the posterior end is beak-shaped, while in the rectangular form the anterior axis is not distinct, but probably the lower half i.e. the part just below the kinetoplast represents the posterior end.

Cytoplasm : In most cases fine granules are noticed, though coarse granules may be present in few forms. It is thin in the rectangular form. The granules take dark azurophilic stain. The cytoplasm often shows vacuoles. No myonemes are seen.

Nucleus : It is oblong to round in shape and quite large in few forms, occupies the maximum breadth of the body. It may be present in the anterior or posterior half of the body in different forms. The nucleus in most cases provided with an inner karyosome, but few forms are devoid of any such thing. The karyosome when present stains deep purplish red and is composed of thick and meshy nuclear chromatin. The rest of the nucleus stains light pinkish and is filled with thin nuclear material. The nucleus of one form appears dividing. The largest nucleus is present in the rectangular form and it is placed in the upper right corner of the body.

Kinetoplast : The kinetoplast is quite distinct in all the forms ; and situated a little away from the posterior extremity. It is usually round or oval, but is almost pear-shaped in the rectangular form and is bigger than in most of the forms. It stains deep black in all the forms.

Blepharoplast : This structure is not distinct in any of the trypanosomes except the rectangular form. In this form the blepharoplast is present towards the upper side of the parabasal body and appeared attached to the latter.

Flagellum : Originates directly from the kinetoplast except in the rectangular form, in which the flagellum arises from a small blepharoplast situated just above the parabasal body. In all the forms, except the rectangular type, the flagellum runs along the outer border of the undulating membrane before being free, whereas in the rectangular form it arises from the blepharoplast and passes through the middle of the body, turns towards the margin of the body, runs along it to be free near the middle of the body, just opposite to its origin.

Undulating membrane : Very distinct, hyaline and without any granules and myonemes. It is not conspicuous in the rectangular form. A well marked polymorphism is evident and three morphologically varied forms with quite characteristic structures are found.

The dimensions of both stumpy and rectangular forms of *T. mrigali* are :

<i>Particulars</i>	<i>Stumpy</i>	<i>Rectangular</i>	<i>Common forms</i>	
	<i>form</i> <i>mean</i>	<i>form</i> <i>mean</i>	<i>Range</i>	<i>Mean</i>
Length of free flagellum	11.8	9.8	9.1-19.0	11.73
Length of body	12.7	14.1	12.0-25.2	18.40
Total length	24.5	23.9	21.4-37.2	30.12
Width of body at the centre of the nucleus	2.0	7.8	1.5-3.5	2.25
Width of the undulating membrane	0.9	1.0	0.7-1.2	0.95
Long axis of nucleus	3.0	4.9	2.0-3.5	2.27
Short axis of nucleus	—	3.0	1.1-2.2	1.50
Distance of nucleus from flagellar end	8.2	—	6.0-14.0	9.32
Length of kinetoplast	0.9	1.9	0.8-1.4	1.2
Width of kinetoplast	0.8	1.5	0.7-1.0	0.8
Distance of kinetoplast from a flagellar end	1.1	—	0.0-2.0	1.1
Nucleus index	1.6	—	0.9-2.0	1.22
Length of karyosome	1.7	2.0	1.0-1.8	1.40
Width of karyosome	1.0	1.5	0.7-1.1	0.92

Site of infection : Plasma of the host fish

Locality : River Gomati, Lucknow, Uttar Pradesh, India

Vector and life-cycle : Unknown

Remarks : The description of this species is based on the description given by the original authors.

***Trypanosoma mukundi* Roychaudhuri and Misra, 1973**

(Fig. 12 A, B)

Roychaudhuri and Misra, 1973. *Arch. Protistenk.*, 115 : 11 ; Mandal (In press a) *Bull. zool. Surv. India*.

Host : ***Heteropneustes fossilis* (Bl.)**

Two forms, viz., a slender form with a free flagellum and a stumpy form with a relatively short flagellum are found.

Slender form :

Shape : The slender form is fusiform in shape with a long free flagellum. The posterior end is abruptly pointed while the anterior tip is pointed narrowly.

Cytoplasm : Stains light blue with Giemsa and granulated in nature. In some, a few small vacuoles were observed in the posterior half of the body.

Volutin granules within the cytoplasm were not found. The narrow cell body is widest in the middle where the nucleus is situated.

Nucleus : Elongate to elongate-oval in shape and placed more or less centrally, slightly towards the posterior half. It stains deep purple with Giemsa. It is rather granulated with distinct nuclear membrane. It usually adheres to the cell wall of the parasite. No distinct karyosome is observed.

Kinetoplast : Kinetoplast is small and round, usually with a halo and stains deep purple. It is located not at the posterior tip but slightly in front of it.

Flagellum and undulating membrane : A distinct flagellum arises from the side of the kinetoplast and forms the undulating membrane with 4-6 attachments with the cell body and leaves as free flagellum at the anterior tip. The undulating membrane takes a light pink stain with Giemsa.

Stumpy form :

This form resembles the slender form in structural morphology but differs in shape, size, number of attachments of undulating membrane and in the length of the free flagellum. The posterior tip of the parasite is narrowly pointed.

The nucleus is round to ovoid and the kinetoplast is nearer the nucleus than in the slender form. The undulating membrane touches the cell-body at 6-9 points. The free flagellum is distinct but short.

No intermediate forms were seen.

Dimensions of the organism are :

<i>Particulars</i>	<i>Slender form</i>		<i>Stumpy form</i>	
	<i>Range</i>	<i>Mean</i>	<i>Range</i>	<i>Mean</i>
Total length of the parasite including (free flagellum)	32.5-43.5	35.5	22.0-28.5	24.5
Length of the cell body	24.0-28.5	26.5	18.0-23.5	19.5
Breadth of the cell body	2.0-2.5	1.75	1.9-2.5	2.00
Length of the free flagellum	9.0-15.5	12.5	4.0-6.5	5.5
Length of the nucleus	2.2-3.7	3.00	2.2-3.7	2.75
Breadth of the Kinetoplast	1.7-2.2	2.00	1.7-2.2	2.00
Diameter of the Kinetoplast	0.75-0	—	0.75-0	—

Site of infection : Blood.

Locality : Calcutta market, West Bengal, India

Vector and life-cycle : Unknown

***Trypanosoma pancali* Mandal, 1975**
(Fig. 13 A, B and Plate I, Fig. 6)

Mandal, 1975. *Angew. Parasit.*, 16 : 92.

Host : ***Mastocembelus pancalus*** (Ham.)

Shape : Elongate, slender and attenuated at both ends. The anterior flagellar end is more gradually tapering than the posterior one. No polymorphism is noticed and no division stages are found in the preparations.

Cytoplasm : Stains light purple with Leishman and light blue with Giemsa. Small vacuoles are present throughout the body. Numerous volutin granules are present in the cytoplasm and located on one side of the body, opposite to undulating membrane in a linear fashion from anterior to posterior ends upto the kinetoplast. But they have not formed any myonemes. A dense accumulation of granules is observed at both ends of the nucleus.

Nucleus : Sausage-shaped, cytoplasm deeply stained and occupies almost the entire width of the body. It lies more towards the posterior half of the body. No karyosome is observed inside the nucleus. In some specimens two clear vacuolated areas are seen at both ends of the nucleus.

Kinetoplast : Conical, stains very deep in most cases ; situated a short distance from posterior elongated end. A clear vacuolated area is observed in most of the specimens surrounding the kinetoplast, particularly opposite the posterior end.

Blepharoplast : No blepharoplast is observed in any of the preparations. The axoneme arises directly from the kinetoplast.

Flagellum : The flagellum originates from the kinetoplast and trails anteriorly along the border of the undulating membrane. It extends beyond the body as a free flagellum.

Undulating membrane : It is hyaline in nature and stains very light pink slender, narrow and clearly outlined, having 5 to 6 folds.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>	<i>Mean</i>
Total length of the body including free flagellum	35.0-40.0	38.5
Length of the body	22.0-26.0	23.5
Breadth of the body	2.0-2.5	2.1
Length of the free flagellum	13.0-14.0	13.5
Length of the nucleus	2.0-3.0	2.5
Breadth of the nucleus	1.0-1.5	1.00
Diameter of the kinetoplasts	0.78-1.0	—

Site of infection : Blood

Locality : Champahati, 24 Parganas, West Bengal, India

Vector and life-cycle : Unknown

***Trypanosoma punctati* Hasan and Qasim, 1962**

Hasan and Qasim, 1962. *Z. f. Parasit.*, 22 : 119.

Host : ***Ophicephalus punctatus*** Bloch [= *Channa punctatus* (Bloch)]

Shape : Spindle shaped, posterior extremity bluntly terminated.

Cytoplasm : Stains faintly ; vacuolated, granular and the granules are concentrated around the vacuoles.

Nucleus : Large, occupies almost the entire width of the body, oblong, located in the anterior half of the body.

Kinetoplast : Large, oval, deeply stained, located terminally, basal granules absent.

Undulating membrane : Narrow, with five to six folds.

Flagellum : Very long, about three-fourths of the body-length.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>
Length of the cell body	30.9-36.2
Length from posterior margin to kinetoplast	6.9-8.9
Length of the nucleus	2.3-3.9
Length from anterior margin of the nucleus to base of the flagellum	6.4-8.5
Length of the free flagellum	12.9-16.4

Site of infection : Plasma of blood

Locality : Ponds around Aligarh, Uttar Pradesh, India

Remarks : The description is based on Hasan and Qasim (1962) and I did not come across this parasite at the time of survey.

***Trypanosoma qadrii* Narasimhamurti and Saratchandra, 1980**

(Fig. 14 A, B)

Narasimhamurti and Saratchandra, 1980. *Proc. Indian Acad. Sci.*, 89 : 374.

Host : ***Clarias batrachus*** (Linnaeus)

Shape : Monomorphic ; elongated, anterior and posterior ends are pointed.

Cytoplasm : Hyaline, without any granules, stained bluish pink with Giemsa and contained a few small vacuoles on either side of the nucleus,

Nucleus : Elongated, stained dark pink with its long axis lying parallel to that of the body. It is situated more towards the kinetoplast. The chromatin is found to form clumps inside the nucleus.

Kinetoplast : Oval or slightly elongated, subterminal in position.

Flagellum : It originates from the kinetoplast and extends towards the anterior end. It is seen clearly lining the border of the undulating membrane and extends beyond the body as free flagellum, and stains deeply with any Romanowsky type of stain.

Undulating membrane : Undulating membrane distinct, found 6-8 convolutions over the body.

The dimensions of the trypanosome are :

<i>Particulars</i>	<i>Range</i>
Length of the body (including free flagellum)	30.00-49.5
Length of the cell body	20.00-31.5
Breadth of the cell body	1.5-2.5
Length of the free flagellum	6.00-14.00
Length of the nucleus	2.5-4.5
Width of the nucleus	0.8-1.5
Length of the kinetoplast	1.0-1.5
Width of the kinetoplast	0.5-0.8

Site of infection : Blood

Locality : Visakhapatnam and Srikakulam, Andhra Pradesh, India

Vector and life-cycle : Unknown

Remarks : The description of the species is based on the description given by Narasimhamurti and Saratchandra (1980) as the present author failed to get this species from *Clarias batrachus*.

Trypanosoma seenghali Joshi, 1976

(Fig. 15 A, B)

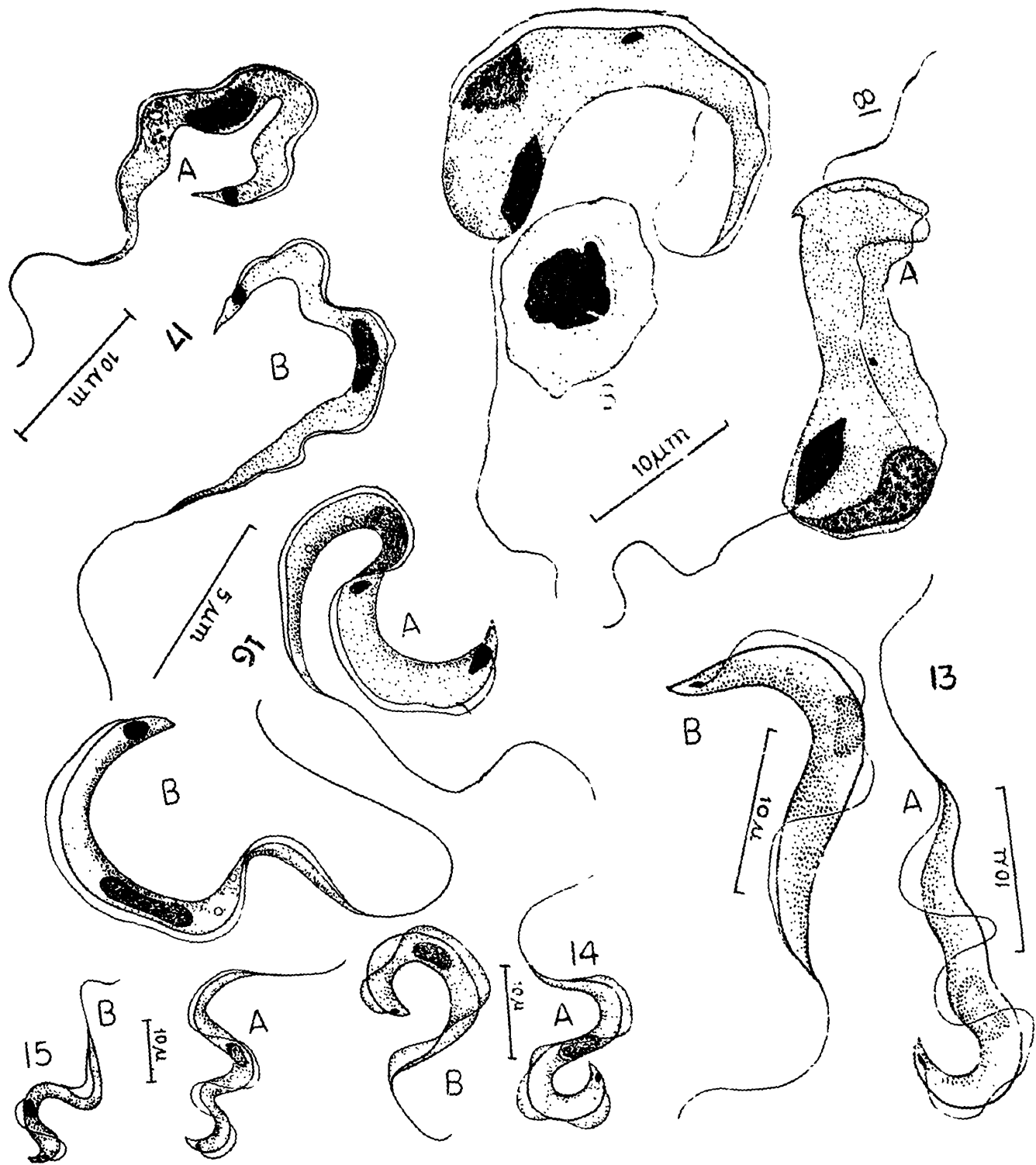
Joshi, 1976. *Indian J. Zool.*, 17 : 7 ; Mandal (In press a) *Bull. zool. Surv. India*.

Host : *Mystus seenghala* [= *Aorichthys seenghala* (Sykes)]

Shape : Body elongated and slender ; tapering at both ends, posterior extremity generally ends sharply, dimorphic.

Cytoplasm : It is finely granulated. The distribution of granules is not even as some forms have fewer granules in the posterior part of the body and are devoid of any vacuoles. It is deeply azurophilic.

Nucleus : Oval or round, occupies most width of the body. It stains pinkish purple. The nuclear chromatin is not very dense and is devoid of a



Figs. 13-18. 13 A, B. *T. pancali* Mandal, 1975.
 14 A, B. *T. qadrii* Narasimhamurti and Saratchandra, 1980.
 15 A, B. *T. seenghali* Joshi, 1976.
 16 A, B. *T. tandoni* Mandal, 1980.
 17 A, B. *T. vittati* Tandon and Joshi, 1973.
 18 A, B. *Trypanoplasma indica* (Mandal, in press).

karyosome. It is generally situated in the anterior half, but in some forms it may be present in the posterior half of the body.

Kinetoplast : Small, round or oval and stains purple bluish, and placed a little away from the posterior end.

Blepharoplast : Not distinct in any form.

Flagellum : It is directly arising from the kinetoplast and runs along the border of the undulating membrane, before becoming free. It may be long or short with marked variation in the free flagellar length.

Undulating membrane : Very distinct and hyaline in appearance. No granules or myonemes are present.

The dimensions of both the smallest and the largest forms are as follows :

<i>Particulars</i>	<i>Smallest forms</i>	<i>Largest forms</i>	<i>Range</i>	<i>Mean</i>
Length of the free flagellum	9.7	10.0	4.5-12.0	8.50
Length of body	17.8	28.0	17.8-28.0	24.50
Total length	27.5	38.0	27.5-38.0	33.0
Width of body at the centre	1.5	2.2	1.2-2.5	1.17
Width of the undulating membrane	1.3	1.8	0.9-2.1	1.40
Long axis of nucleus	2.2	3.0	1.5-3.5	2.76
Short axis of nucleus	1.7	2.0	1.2-2.3	1.0
Distance of nucleus from flagellar end	11.6	12.6	8.5-15.0	11.43
Length of kinetoplast	0.9	1.0	0.3-1.2	0.95
Width of kinetoplast	0.6	0.8	0.3-1.0	0.56
Distance of kinetoplast from aflagellar end	0.8	1.8	0.4-2.0	1.20
Nuclear index	1.7	0.7	0.7-1.8	0.88

Site of infection : Blood.

Locality : Calcutta market. The original description was based on the material obtained from Gomati and Chinhath Lake, Lucknow.

Vector and life-cycle : Unknown.

***Trypanosoma stigmai* Joshi, 1978**

Joshi, 1978. *J. Anim. Morph. Physiol.*, 45 : 4.

Host : ***Barbus stigma*** [= *Puntius sophore* (Ham.)]

Shape : The body is long, stout and does not taper sharply at the ends. On the contrary both the ends are quite broad and appear like the beak of a bird, while a few forms have a spatulated posterior end.

Cytoplasm : Finely granular with frequent vacuoles. The cytoplasmic granules are more or less evenly distributed throughout the body and are deeply azurophilic.

Nucleus : Oval or oblong, mostly placed in the anterior half of the body and occupies a central position in the body-width. It usually has an inner karyosome which occupies nearly half of the inner space. The karyosome is placed marginally within the nucleus of some forms.

Kinetoplast : It is present at the posterior end of the body and is larger in size.

Blepharoplast : Not distinct.

Flagellum : It appears to be originated directly from the kinetoplast and runs along the outer margin forming the undulating membrane, before becoming free anteriorly.

Undulating membrane : Quite conspicuous but thin and hyaline, without any granulation and myonemes.

The dimensions of *T. stigmai*, both the largest and smallest forms are :

<i>Particulars</i>	<i>Smallest forms</i>	<i>Largest forms</i>	<i>Range</i>	<i>Mean</i>
Length of free flagellum	12.8	15.0	9.0-17.8	14.8
Length of body	30.0	49.0	30.0-49.0	35.9
Total length	42.8	64.0	42.8-64.0	50.6
Width of the body at the centre of the nucleus	3.5	4.8	3.5-5.2	4.0
Width of the undulating membrane	1.3	1.0	0.8-1.7	1.4
Long axis of the nucleus	4.3	5.3	3.0-5.7	4.3
Short axis of the nucleus	2.3	3.8	2.2-3.8	2.7
Distance of the nucleus from a flagellar end	16.0	24.0	14.0-24.0	19.8
Length of karyosome	4.0	3.0	2.0-4.3	2.8
Length of kinetoplast	1.6	1.2	1.0-1.7	1.4
Width of kinetoplast	1.2	1.2	0.8-1.7	1.3
Distance of kinetoplast from a flagellar end	0.2	1.8	0.0-1.8	1.0
Nuclear index	1.5	1.1	1.0-1.5	1.2

Site of infection : Blood

Locality : Gomati River and Chinhat lake, Lucknow, Uttar Pradesh, India

Vector and life-cycle : Unknown

Remarks : The description is based on Joshi, 1978.

Trypanosoma striati Qadri, 1955

Qadri, 1955. *Parasitology*, 45 : 80.

Host : **Ophicephalus striatus** [= *Channa striatus* (Bl.)]

Shape : The organisms are polymorphic, consisting of three forms namely, small, intermediate and large, the latter being very broad and stumpy and by far the commonest. Stages of divisions were not observed in living preparations nor in the stained film.

The body is elongated and fusiform. The anterior end is attenuated and pointed while the posterior is less so and terminates rather abruptly in a more or less rounded extremity.

Cytoplasm : In the smaller form it is provided usually with dense granules having very few vacuoles, but in the larger forms it is less granular and contains many vacuoles. The granules are rather irregular in shape and tend to cluster together in a compact mass. In the intermediate form these characters are also intermediate in degree.

Nucleus : Generally lies in the anterior half of the body. It is dark red in small forms and often very difficult to differentiate from the surrounding densely stained cytoplasm. In the large stout forms it is very clearly defined with light staining. Generally the nucleus is spherical or oval, or pear-shaped or bean-shaped. Its chromatin granules vary in size according to the size of the organism, being much larger in stout forms and granules are either scattered or arranged in rows. In some specimens a distinct karyosome, stained deeper red than the rest of the nucleus is present.

Kinetoplast : It is oval or rounded and varies in size according to the size of the parasite. It lies a short distance in front of the posterior extremity. In rare cases distinct large vacuoles are seen surrounding the kinetoplast.

Blepharoplast : Absent and the axoneme appears to arise directly from the kinetoplast.

Flagellum : It seems to originate from the kinetoplast and is seen clearly running along the border of the undulating membrane. There is a distinct free flagellum which is larger in small and intermediate forms, and large in stumpy ones.

Undulating membrane : It is narrow in all the forms and have five to eight small folds. It does not become wider with the increase in size of the body of the parasite. In a few cases the folds are narrow. Sometimes the undulating membrane is narrow, very long, but usually short in all the forms. The membrane is completely hyaline in nature.

The average dimensions of each of three forms of this trypanosome are :

<i>Particulars</i>	<i>Small form mean</i>	<i>Intermediate form mean</i>	<i>Large form mean</i>
Posterior extremity of the body to posterior border of the nucleus	13.00	15.5	26.0
Length of the nucleus	2.5	3.75	5.75
Anterior border of nucleus to anterior extremity of the body	16.5	19.75	23.0
Length of the flagellum	8.0	10.25	11.0
Total length of the body including flagellum	40.0	49.25	65.75
Breadth of the body at its widest part	2.0	3.0	8.0
Breadth of the nucleus	1.5	2.5	7.0
Length of the kinetoplast	0.75	1.0	1.75

Site of infection : Plasma of the host fish

Locality : Hyderabad, Andhra Pradesh and Calcutta market, India

Vector and life-cycle : Unknown

Remarks : The description is mostly based on Qadri (1955) though the material was also collected from the Calcutta market.

Trypanosoma tandoni Mandal, 1980
(Fig. 16 A, B and Plate I, Fig. 7)

Mandal, 1980. *Bull. zool. Surv. India*, 2(2 & 3) : 183 (In press a), *Bull. zool. Surv. India*.

Host : **Wallago attu** (Schneider)

Shape : Monomorphic, elongated and attenuated at both ends. The configuration generally restricted to an 'S'

Cytoplasm : Stains faint blue with Giemsa. Numerous granules are localised in the cytoplasm, deeply concentrated at the border opposite to the undulating membrane in a linear fashion. Sometimes few small vacuoles (2-5 in number) are found in the cytoplasm anterior to the nucleus.

Nucleus : Sausage-shaped, placed almost in the middle of the body. Sometimes shifted a little towards the posterior end. It stains deep blue and does not occupy the entire width of the body. The nuclear material is uniformly distributed and does not form a karyosomal mass.

Kinetoplast : Almost naviculoid in shape, sometimes oval form has also been encountered in the preparations. It stains very deep with any stain used and does not exceed the width of the cytoplasmic mass where it is situated.

Flagellum and undulating membrane : Appears from the base of the kinetoplast and trails anteriorly bordering the undulating membrane. It extends beyond the body as a distinct large free flagellum and performs a clear lashing, movement when the organism is alive in citrate preparation. The undulating membrane stains very faint, having 5-9 folds and can easily be separated from the body cytoplasm by its light colour bordered by thick flagellum.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>	<i>Mean</i>
Length of the cell body	20.5-27.5	23.5
Length of the free flagellum	11.5-18.5	14.4
Distance from anterior end of the body to the anterior end of nucleus	9.00-11.00	10.0
Length of the nucleus	2.25-3.00	2.5
Width of the nucleus	0.5-1.00	0.75
Distance from posterior end of the nucleus to the kinetoplast	6.00-8.5	7.00
Length of the kinetoplast	1.00-1.75	1.5
Width of the kinetoplast	0.5-1.00	0.75
Distance from kinetoplast to the posterior tip	0.5-2.00	1.5
Width of the undulating membrane	0.3-0.95	0.6
Maximum width of the cell body	1.3-1.8	1.5

Site of infection : Blood

Locality : Champahati, 24 Parganas, West Bengal, India

Vector and life-cycle : Unknown

***Trypanosoma trichogasteri* Gupta and Jairajpuri, 1981**

Gupta and Jairajpuri, 1981. *Indian J. Parasit.*, 5 (1), 35.

Host : *Trichogaster fasciata* [= *Colisa fasciatus* (Bloch)]

Shape : Body elongate, slender and attenuated at both ends.

Cytoplasm : It stains faintly, concentration of granules in the cytoplasm is found in the anterior region of the body.

Nucleus : Ovoidal or bean-shaped, lies more towards the posterior half and occupies almost the entire width of the body. Either a single vacuole at one end or two vacuoles at both ends of the nucleus are observed.

Kinetoplast : Well developed, spherical, oval or conical in shape, stained deep purple with Romanowsky stains.

Flagellum : Originates from the kinetoplast and trails anteriorly along the border forming an undulating membrane and extends beyond the body as

a free flagellum. The free flagellum is more than 1/3 of the total body length.

Undulating membrane : Stains lightly and clearly outlined, having 5-6 folds.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>
Total length of the body including free flagellum	35.55-40.35
Length of the cell body	24.05-27.40
Breadth of the cell body	1.25-1.4
Length of free flagellum	11.50-12.95
Length of nucleus	3.00-3.25
Breadth of nucleus	1.0-1.15
Length of kinetoplast	0.70-1.50
Breadth of kinetoplast	0.60-1.00
Width of undulating membrane	0.65-0.78

Locality : Aligarh, Uttar Pradesh, India

Site of infection : Blood plasma

Remarks : A "developmental" form has been described by Gupta and Jairajpuri (1981) in which free flagellum is absent and the undulating membrane is narrow and poorly developed and has only 2-4 folds. Length of the cell body as mentioned by the authors is 13.50-15.25 and breadth of the cell body is 1.20-1.55 ; length of nucleus 2.40-3.50 and breadth of nucleus 0.85-1.30 ; length of kinetoplast 0.45-0.75 and breadth of kinetoplast 0.60-1.10 ; width of undulating membrane 0.50-0.65.

The 'form' described here as "developmental" form does not signify anything because the positions of the kinetoplast and nucleus are those just like those of the adult (trypomastigote ?) form. The free flagellum was not seen probably because of poor staining. Further comments can be made only after examining the slides.

Moreover, the claiming of the first report of Trypanosome from *Trichogaster fasciata* does not hold good because Lingard (1904) came across a trypanosome from the same host material but could not designate the species. The original description is followed here while describing the species with a little modification. The species is distinct and retained as such which is dimorphic showing long and short forms.

Trypanosoma vittati Tandon and Joshi, 1973

(Fig. 17 A, B and Plate I, Fig. 8)

Tandon and Joshi, 1973. *Z. wiss. Zool.* 185 : 212, Mandal (In press a). *Bull. zool. Surv. India.*

Host : **Mystus vittatus** (Bloch)

Shape : Monomorphic, configuration varies from a "C" to an "S".

Cytoplasm : Uniformly granular, a little dense towards the portion anterior to the nucleus. Sometimes a few small vacuoles are seen distributed throughout the body.

Nucleus : Bean-shaped, almost situated at the middle compact with chromatin material ; occasionally a clear area is visible at both extremities of the nucleus. The nucleus does not exceed the width of the body where it is situated.

Kinetoplast : Almost round, very deep with any stain used. It sometimes exceeds the width of the body where it is situated.

Flagellum and undulating membrane : Distinct, clearly outlined, can be differentiated easily from the body cytoplasm. Undulating membrane bordered by the thick flagellum throughout the entire length of the body. The flagellum extends as free portion, very distinct and can be stained with Romonowsky type of stain and shows 5-6 folds.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>	<i>Mean</i>
Length of the cell body	20.00-35.5	25.5
Length of the free flagellum	8.5-14.00	12.5
Distance from anterior end of the body to the anterior end of the nucleus	9.5-12.5	10.5
Length of the nucleus	2.00-4.5	3.00
Width of the nucleus	0.7-1.4	1.2
Distance from posterior end of nucleus to the kinetoplast	8.5-11.5	9.00
Length or width of the kinetoplast	—	1.5
Distance from kinetoplast to the posterior tip	2.00-3.00	2.25
Width of the undulating membrane	0.5-1.5	—

Site of infection : Blood

Locality : Taldi, 24 Parganas, West Bengal, India. This species originally described from Lucknow.

Vector and life-cycle : Unknown

Trypanosoma sp.

Mandal (In press a). *Bull. zool. Surv. India*.

Host : **Aorichthys aor** (Ham.)

Shape : Monomorphic, configuration mostly seen as S.

Cytoplasm : Granular, deeply stained with Romanowsky type of stain. The granules are uniformly distributed throughout the length of the body.

Nucleus : Elongated, homogenous, almost situated at the middle and never occupies the entire width of the body.

Kinetoplast : Oval, deeply stained and appears dark pink does not exceed the maximum width of the body.

Flagellum and undulating membrane : The flagellum arises from the kinetoplast and trails along the body forming an undulating membrane and extends beyond the body as free flagellum. The undulating membrane is having 4-5 folds.

The dimensions of the organism are :

<i>Particulars</i>	<i>Range</i>	<i>Mean</i>
Length of the cell body	30.00-38.5	32.5
Length of the free flagellum	12.00-18.00	18.00
Length of the nucleus	2.00-3.5	2.5

Site of infection : Blood

Locality : Calcutta market, West Bengal, India

Vector and life-cycle : Unknown

Remarks : Further material is needed to designate the species.

Genus **Trypanoplasma** Laveran and Mesnil, 1901

Trypanoplasma indica (Mandal, In press a)

(Fig. 18 A, B and Plate II, Figs. 1, 2)

Cryptobia indica, Mandal, 1979. *Bull. zool. Surv. India*, 2 : 20 (In press a), *Bull. zool. Surv. India*.

Host : **Mystus vittatus** (Bloch)

Shape : Monomorphic, broad and sickle-shaped.

Cytoplasm : Stains faint blue with having fine granules distributed all over the body, less so at the posterior region.

Nucleus : Situated anteriorly, reniform or ovoidal in shape and loosely packed with large irregular chromatin mass.

Kinetoplast : Large, oblong or reniform in shape situated close to the ventral surface towards the anterior end and stained densely pink with Romanoswky type of stain. Most cases it lies opposite to nucleus.

Flagellum and undulating membrane : Anterior flagellum long moves freely when alive. Posterior flagellum trails along the margin of the body forms an undulating membrane and extends as free portion.

The dimensions of the organism are :

Particulars	Range	Mean
Length of the cell body	25.00-30.00	28.5
Width of the cell body	6.00-10.0	8.5
Length of the nucleus	5.00-8.5	7.5
Width of the nucleus	2.5-3.5	3.00
Length of the kinetoplast	5.00-6.00	5.5
Width of the kinetoplast	0.75-2.00	1.5
Length of the anterior flagellum	21.00-30.00	25.00
Width of the undulating membrane	—	0.25
Length of the free end of the trailing flagellum	9.00-12.00	10.5

Site of infection : Blood

Locality : Champahati, 24 Parganas, West Bengal, India

Vector and life-cycle : Unknown

Remarks : *Cryptobia indica* Mandal, 1979 is treated here as *Trypanoplasma indica* which has been discussed vividly by Mandal (In press).

Genus **Haemogregarina** Danilewsky, 1885

Haemogregarina colisa Mandal, Ray, Sarkar and Kahali (In prees)
(Plate II, Figs. 3, 4)

Mandal, Ray, Sarkar and Kahali (In press), *Bull. zool. Surv. India*.

Host : **Colisa fasciatus** (Bloch)

Young gametocytes : The young forms are elongate with one end broader than the other ; measuring 8.0 in length and 2.0 in width with an area of $14.0 \mu\text{m}^2$. It is situated in the half of the erythrocyte facing its concave side towards the convex side of the host cell nucleus.

The cytoplasm is homogeneous, granular and stained faint blue with Leishman and Giemsa stains. The granules are more concentrated towards the poles of the parasite. The nucleus is cylindrical measuring 2.5×1.5 with an area about $4.0 \mu\text{m}^2$; situated at the centre of the gametocyte ; stained deep red. The chromatin granules are loosely arranged within a thin non-visible nuclear membrane.

Mature gametocyte : The mature forms are broad, bean-shaped with both the ends rounded ; occupying almost 50% of the host's erythrocyte either facing its concave border towards the convex side of the host cell nucleus or vice versa. They measure 8.53 in length and 2.36 width with an average area of 14.91 μm^2 . The cytoplasm is homogenous, granulated-more granular towards the poles which stained deep blue with Leishman stain. Sometimes 2 or 3 small vacuoles may be found within the cytoplasm. The rounded or band-shaped nucleus is situated at the middle of the parasite which stained deep red. It is of vesicular type containing large number of chromatin granules within a clear unstained nuclear membrane.

Double infections in an individual blood cell were never found, and there was no indication of schizogony within the cells of the circulating blood.

Site of infection : Blood

Locality : Canning, 24 Parganas, West Bengal, India

Vector and life-cycle : Unknown

Haemogregarina thyrsoidae de Mello and Valles, 1936b

de Mello and Valles, 1936b. *Proc. Indian Acad. Sci.*, (B) 4 : 403.

Host : **Thyrsoidea macrurus** Bleeker

The youngest form is ovoid with a conspicuous nucleus ; having light blue cytoplasm when stained with Romanowsky stain ; irregular vacuoles are seen at the latter stage. Nucleus remains central. Two or more divisions of the nucleus were also noticed.

Site of infection : Erythrocytes

Locality : Nova Goa

Remarks : The description is based on de Mello and Valles (1936b).

Genus Babesiosoma Jakeska and Nigrelli, 1956

Babesiosoma ophicephali Misra, Haldar and Chakravarty, 1969

Misra, Haldar and Chakravarty, 1969. *J. Protozool.*, 16 : 446.

Host : **Ophicephalus punctatus** Bloch [= *Channa punctatus* (Bloch)]

Primary stage : The youngest form stumpy and triangular in shape measuring 3.0 by 2.0, with one end broad and the other end tapering bluntly. It gradually becomes ovoid or spindle-shaped. The nucleus is always at the broader end of the youngest form and remains adhered along with its periphery. The cytoplasm is vacuolated and non-pigmented.

Trophozoites : Ovoid or elongated bodies measuring 3.3-6.0 by 2.0-2.5. The nucleus takes the position along the broader end of the parasite. The

nuclear division occurs at the later stage and the nuclear material elongates along the periphery of the outer wall of the parasite.

Schizogony : It occurs within the erythrocytes and is completed with the formation of four merozoites. The nuclear material elongates along one side of the periphery of the outer wall of the parasite. The nucleus gradually attains maximum length and breaks into two halves. The parasite becomes spindle-shaped and the two nuclei occupy its poles. The first division of the nucleus is longitudinal. The second division occurs along the transverse axis of the parasite. Just prior to second division the parasite becomes dumb-bell shaped. A constriction appears in the middle of each nucleus, ultimately resulting in the formation of four nuclei, two at each pole. The nuclei are arranged in a rosette or cross wise. The nuclei ultimately separate with appropriate amount of cytoplasm and to form merozoites. The merozoites are liberated from the host cell and invade new erythrocytes.

Gametogony : Some of the merozoites which fail to undergo schizogony and develop into gametocytes. The microgametocytes, which are frequently observed, are slender, elongated, spindle-shaped bodies with two nuclei at the middle of the cytoplasm. They lack "dark-bodies" or pigment at this stage. The macrogametocytes are rounded bodies, with a spherical nucleus and a very little cytoplasm.

Pathogenicity : Unknown

Vector and life-cycle : Unknown

Locality : Calcutta and Suburbs, West Bengal, India

Remarks : This description is based on Misra, Haldar and Chakravarty (1969). The present author personally examined the specimen.

Babesiosoma hareni Haldar, Misra and Chakravarty, 1971

Haldar, Misra and Chakravarty, 1971. *Arch. Protistenk.*, 113 : 2.

Host : **Ophicephalus punctatus** Bloch [= *Channa punctatus* (Bloch)]

Primary stage : The youngest form is stumpy and triangular or slightly rounded in shape. This stage is characterised by one end broader and other extremity gradually enlarges in size. Before attaining the trophozoite stage it becomes ovoidal or spindle shaped, measuring 2.0×1.5 . The band-shaped nucleus remains adherent along the periphery of the parasite and occupies a greater portion of the broader end. The cytoplasm is vacuolated without any pigment.

Trophozoite : The full grown trophozoite is ovoid, elongated in shape measuring 2.5×1.5 . The nucleus lies on the broader end of the parasite. The cytoplasm remains vacuolated and non-pigmented.

Schizogony : Schizogony begins within the erythrocytes resulting in four merozoites. The nucleus elongates along one side of the periphery and gradually attains its maximum length breaks up into two nuclei and each of which moves to opposite poles. The division is longitudinal followed by a second division through the transverse axis of the parasite. On the completion of the second division four spindle-shaped nuclei are produced. These are arranged in a cross-wise within the rounded membrane. A fully grown schizont measures 3.5×3.0 . Each mature shizont contains four merozoites. The nuclei gather enough cytoplasm around them, separate from each other. The merozoites are liberated from the host cell and invade new erythrocytes.

Gematogony : Merozoites which do not develop into schizonts undergo gametogony. Two types of gametocytes are noticed. The microgametocytes measuring $5.0-6.5 \times 1.5-2.5$ are long, slender, spindle-shaped with two extremely variable shaped nuclei at the middle. The two nuclei are connected together by a very fine chromatin thread. The cytoplasm is pale blue in colour and is without any pigment. The macrogametocytes are less common in the peripheral blood and are more or less rounded bodies with the spherical nucleus situated at the centre of the non-pigmented cytoplasm. The mature macrogametocyte measures 2.3 in diameter.

Pathogenicity : Unknown

Vector and life-cycle : Unknown

Locality : Calcutta market, West Bengal, India

Remarks : The description is based on Halder, Misra and Chakravarty, 1971.

Babesiosoma sp.

(Plate II, Figs. 5, 6 and 7)

Host : **Muraenesox sp.**

Description : Short, stumpy rounded forms are seen inside the erythrocyte measuring 1.5 in diameter with a distinct nucleus. The trophozoite is ovoid, one end little broad with a prominent nucleus. The cytoplasm is vacuolated. It measures 2.00-2.5 in length and 1.5-2.0 in width. Four distinct nuclei are observed arranged cross-wise inside the erythrocyte which are formed due to schizogony. The full grown schizonts has not been observed.

Site of infection : Erythrocyte

Locality : Canning market, 24 Parganas, West Bengal, India

Vector and life-cycle : Unknown

Remarks : The parasite was detected but could not be designated upto the specific level due to the lack of sufficient material. Out of 20 hosts examined only one was positive.

Genus **Dactylosoma** Labbe, 1894

Dactylosoma sp.

(Plate II, Figs. 8, 9)

Mandal, 1979. *Bull. zool. Surv. India*, 2 : 22, (In press a), *Bull. zool. Surv. India*.

Host : **Mystus vittatus** (Bloch)

Shape : An organism with granular cytoplasm and a clear nucleus was encountered intraerythrocytically and belonging to the genus *Dactylosoma* Labbe, 1894. The merozoites 5 in number and arranged in the form of a fan.

Remarks : Further specimens are needed for specific determination.

Site of infection : R. B. C. of blood

Locality : Taldi, 24 Parganas, West Bengal, India

Vector and life-cycle : Unknown

Genus **Haematractidium** Henry, 1910

Haematractidium sp.

(Plate II, Figs. 10, 11 and 12)

Mandal, Ray, Sarkar and Kahali (In press c), *Bull. zool. Surv. India*.

Host : **Arius sona** (Ham.)

Description : The youngest ring form is a circular minute cytoplasmic body containing a central chromatin granule. It measures 1-2 in diameter. As the parasite enlarges the chromatin granules divide into two or four. The larger forms are elongated or crescent-shaped, situated on one side of the host-cell nucleus. They measure 4.5×1.0 . The cytoplasm is clear, non-granular and stained pale blue. The chromatin dots are very minute and stained deep red with Leishman stain. The host cells has no detectable alteration in structure or staining properties. Binucleate or tetranucleate parasites were invariably larger in number. Double infection in the same erythrocyte was never recorded.

Site of infection : Blood

Locality : Sagar Island, 24 Parganas, West Bengal, India

Vector and life-cycle : Unknown

Genus **Mesnilium** Misra, Haldar and Chakravarty, 1972

Mesnilium malariae Misra, Haldar and Chakravarty, 1972

Misra, Haldar and Chakravarty, 1972. *Arch. Protistenk.*, 114 : 446.

Host : **Ophicephalus punctatus** [= *Channa punctatus* (Bloch)]

Erythrocytic schizogony :

Ring stage : The earlier stage of the parasite in the erythrocyte is represented by a small ring stage having a centrally placed pin-headed chromatin mass. The cytoplasm is represented by a narrow ring enclosed within a vacuole. Amoeboid stages were not found.

Development of schizonts : The ring stage gradually grows into a schizont, increases in size and reaches about half the size of the host erythrocyte. The limiting membrane of the schizont is very thin and can not be observed very distinctly. The nucleus begins to divide and the dividing nuclei are irregularly arranged within the schizont. The position of the schizont within the erythrocyte may be polar, lateral or tangential. Schizogony leads to the formation of 6 to 8 merozoites. Throughout the entire process of schizogony pigment was not formed. The merozoites are liberated from the erythrocytes and the latter now becomes vacuolated. The merozoites may enter new erythrocytes for the continuation of the schizogonic cycle or may develop into gametocytes. It has also been observed that the position of the nucleus of the erythrocyte remains unaltered during the development of the schizonts.

Cycle in Reticulo-endothelial cells : After entering the host body either as sporozoite or as a merozoite, the parasite invades the R. E. cells of liver, spleen or kidney and undergoes schizogony. Its nucleus divides and redivides until many small nuclei are produced. In the resultant schizont, each nucleus is surrounded by a portion of cytoplasm and forms a merozoite. The number of merozoites formed is extremely variable and depends upon the size of the invaded R. E. cell. 16, 22, 48 or even more merozoites have been counted in a single R. E. cell. A full grown merozoite measures 1 in diameter on the average. As the schizont grows larger the nucleus of the host R. E. cell becomes reduced in size, and is left as a residual mass after the completion of schizogony. Ultimately the host cell bursts, liberating the merozoites in the tissue and subsequently the host cell degenerates. The liberated merozoites may invade new R. E. cells and in this way the cycle is continued. The macro and microgametocytes have been observed, although less frequently, in the contact smears of liver only.

It has been found that the parasite invades the R. E. cells of the vertebrate host tissue and undergoes development there ; therefore, this phase of development may be termed as Pre-erythrocytic schizogony. The cycle in R. E. cell may again be repeated after the completion of erythrocytic schizogony and this phase of development is called exo-erythrocytic schizogony.

Cycle in fixed tissue cells : After the completion of one or two erythrocytic schizogony, the merozoites or cryptozoites invade the fixed endothelial cells of the veins and arteries of liver and develop into metacryptozoites. In cases of extreme parasitaemia, all cells encircling the blood vessels of liver are seen to be packed with metacryptozoites, which are later liberated into the blood vessels.

In only a few cases, parenchymatous cells, adjacent to the blood vessels have also been found to be parasitized with these metacryptozoites.

Gametogony : Twenty eight hours after infection, the gametocytes appear in the peripheral circulation. Both macro-and microgametocytes are seen within the erythrocytes of the host fish. The macrogametocyte has a large nucleus and a few coarse pigment granules which are refractile in nature, when fully developed, it covers about three-fourths of the host cell body. The microgametocyte also has single nucleus and is almost of the same size as that of the macrogametocyte. Pigment granules are small, irregularly arranged and large in number. In both macro and microgametocytes, the position of the nucleus is not definite and during their development, the nucleus of the host erythrocyte remains unaltered.

Pathogenicity : Misra *et al* (1972) studied the pathogenicity and noticed that some minute reddish patches appeared at some sites outer the skin tending to enlarge gradually about 22 hours after infection. Later blood oozes from these patches which by now have increased greatly in number and developed almost all over the body. In extreme cases the scales in these regions and the fin rays fall off.

The internal symptoms of the disease include rise in body temperature and changes in respiratory rate. Analysis of body temperature at different hours of infection and respiration rate reveals a close co-relation between them. The body temperature as well as the respiration rate reach the peak at 28 hours after infection which is also the period taken for the completion of one asexual cycle in the R. E. cells. The host fish succumbed to infection after 72 hours.

Locality : Suburbs of Calcutta, West Bengal, India

Remarks : The description is based on Misra, Haldar and Chakravarty (1972). However, the occurrence of this malaria in fish is discussed on many

occasions by different experts, but all of them have the opinion that the presence of malaria in fish is doubtful. The present author also shares a similar view.

HOST SPECIFICITY AND PATHOBIOLOGY

The pathobiological researches on the haematozoan parasites of fishes have not been taken up so far in a wide scale. Mandal (In press a) discussed the host specificity, prevalence and pathogenicity of the haematozoan parasites of cat fishes in detail. Major works on these aspects are due to Tandon and Joshi (1973, 1974), Tandon and Chandra (1977 a b), Tandon (1977) in India and Lom (1973), Khan (1976, 1977 a, b) and Becker (1977) in abroad. Out of the six genera, recorded so far from fishes, major attention, has been given on the trypanosomes.

The host specificity of piscine trypanosomes has not been established so far. The factors, like the vectors and other environmental conditions where the fishes are available, along with the microclimate inside the host as well as the vector have got prime importance.

In fishes, leeches are known to be the vectors of all haematozoan parasites.

The presence of *Mesnilium malariae* in *Channa punctatus* as reported by Misra, Halder and Chakravarty (1972) is questionable to a great extent because the occurrence of malaria in fishes is doubtful as far as vector is concerned. However, further work on this parasite will disclose the truth.

Moreover, the non availability of piscine haematozoa of estuarine fishes of lower Bengal is possibly due to the absence of potential vector in that habitat (Mandal unpublished observations). During the period July 1979 to September 1981 the present author conducted a series of surveys for the haematozoa and their potential vector in the estuaries of Southern Bengal. None of the haematozoan parasites and their vector could be collected. However, the detection of *Haematractidium* sp. in *Arius sona* from Sagar Island and *Babesiosoma* sp. in *Muraenesox* sp. from Canning appears interesting. Because these fishes are likely to contact the infection in the far sea around others where potential leech vectors are available.

Lom (1979) stated that the fishes living near the bottom littoral vegetation were exposed more to the leeches and this, in turn, might influence the transmission and incidence of infection. He further added that factors like temperature, seasonal variation or the age of the fish should be taken into account. Becker (1977) also noted that the slow moving streams provide favourable haunt for the transmission of these parasites. The trypanosome infection is the lowest in carnivorous fishes in comparison to

the omnivorous or herbivorous ones (Mandal, 1978 b). Surface feeding habit and the mucus on the body of the fishes tend to decrease the incidence of infection. On the other hand, bottom dwelling habit with limited motility increase the chances of infection.

In most cases the piscine haematozoan parasites are pathogenic ; however, some of them are nonpathogenic [Kipp (1968) and Smirnova (1970)]. In India, Tandon and Joshi (1973) have studied the pathogenicity of trypanosome infections in fishes. Anaemia and Leucocytopenia were observed by them. They also noted some abnormal cells and macrophages in the circulation of the infected fishes, *Clarias batrachus* and *Mystus vittatus*.

Tandon and Joshi (1974) studied the blood glucose level of healthy fishes and fishes infected with trypanosome in *H. fossilis*, *C. punctatus*, *Clarias batrachus* and *Mystus seenghala* and found that there was a definite fall of glucose level in the infected fishes.

Tandon and Chandra (1977 a, b) studied the serum cholesterol and serum alkaline phosphatase levels in some naturally infected fishes. It was found that the loss of serum cholesterol level was highest (42.39%) in the Spiny eel, *Mastocembelus armatus* and lowest in the carp, *Cirrhina mrigala* (4.56%). In cat fishes, *Heteropneustes fossilis* a loss of 9.83%, *Clarias batrachus* 12.46%, *Mystus seenghala* 11.65% and *Wallago attu* 12.05% was observed. The alkaline phosphatase level of *Clarias batrachus* suffered a loss of 40.68%, in *Cirrhina mrigala* 69.91%, in *M. armatus* 10.94% and in *M. seenghala* 28.82% whereas the minimal level was observed in *W. attu* which was about 3.91%.

The same authors also indicate that the metabolic activity goes down due to trypanosomal infection in fishes.

The trypanosomes are known to utilise a high percentage of sugar from blood, resulting in a complete depletion of the carbohydrate reserve. This causes a serious strain on the liver—a chief centre of cholesterol metabolism. The trypanosome infection disturbs the cholesterol metabolism—leading to hypocholesterolemia in the infected fishes.

The Trypanoplasmosis due to *Trypanoplasma* infection have been indicated by Wales and Wolf (1955), Makeyeva (1956), Britchuk (1969) and Migala (1967, 71) however Nowicki (1940) expressed the doubt. Lom (1979) shares the same view as Nowicki (*loc. cit.*). The present study supports the views of Nowicki (*loc. cit.*) and Lom (*loc. cit.*).

Not much pathogenicity was observed in other haematozoan infection ; however, the dislocation of the erythrocytic nuclei along with hypertrophy were noted in the infections of *Babesiosoma*, *Dactylosoma* and *Haematra-ctidium*. The pathogenicity of the *Mesnilium malariae* has been discussed by the describer and retained as such after the description of the parasite.

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SUMMARY

The haematozoa of Indian fishes are represented by 27 species of *Trypanosoma* with two subspecies, one *Trypanosoma* sp. and six unnamed trypanosomes. One species each of the genera *Trypanoplasma* and *Mesnilium* are also described from piscine hosts along with two species of the genera *Haemogregarina* and *Babesiosoma*. In addition, one *Babesiosoma* sp. one *Dactylosoma* sp. and one *Haematractidium* sp. have also been reported. The host specificity and incidence of infection along with the prevalence of these parasites have been discussed in-detail. An upto date hostparasite list has also been appended.

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Host-parasite list of the Piscine haematozoa described so far
from Indian subregion

Host	Parasite	Author	Year
1. <i>Amphinopnus</i> sp.	<i>Trypanosoma granulosum</i>	Laveran & Mesnil	1902
2. <i>Anabas testudineus</i> (Bl.)	<i>T. anabasi</i>	Mandal	1977
3. <i>Aorichthys aor</i> (Ham.)	<i>Trypanosoma</i> sp.	Mandal	In press a
4. <i>Arius sona</i> (Ham.)	<i>Haematractidium</i> sp.	Mandal, Ray, Sarkar and Kahali	In press
5. <i>Barbus carnaticus</i> [= <i>Puntius carnaticus</i> (Jordan)]	Trypanosome (unnamed)	Lingard	1903*
6. <i>Barbus stigma</i> (= <i>Puntius</i> <i>sophore</i> Ham.)	<i>T. stigmai</i>	Joshi	1978
7. <i>Cirrhina mrigala</i> [= <i>Cirrhinus</i> <i>mrigala</i> (Ham.)]	<i>T. mrigali</i>	Joshi	1976
8. <i>Cirrhina reba</i> [= <i>Cirrhinus</i> <i>reba</i> (Ham.)]	<i>T. baiquensis</i>	Pandey & Pandey	1974
9. <i>Clarias batrachus</i> (Linnaeus)	<i>T. clariae batrachi</i> <i>T. batrachi</i> <i>T. maguri</i> <i>T. qadrii</i>	de Mello & Valles Qadri Tandon & Joshi Narasimhamurti & Saratchandra	1936a 1962 1973 1980
10. <i>Gobius giuris</i> [= <i>Glossogobius</i> <i>giuris</i> (Ham.)]	Trypanosome (unnamed) <i>T. gobida</i>	Patton Mandal	1908** In press b
11. <i>Heteropneustes fossilis</i> (Bl.)	<i>T. danilewski</i> <i>saccobranchi</i> <i>T. mukundi</i> <i>T. danilewskyi</i> <i>saccobranchi</i>	Qadri Roychaudhury & Misra Joshi	1955 1973 1979
12. <i>Labeo bata</i> (Ham.)	<i>T. batai</i>	Joshi	1978
13. <i>Macronis seenghala</i> [= <i>Mystus seenghala</i> <i>Aorichthys seenghala</i> (Sykes)]	Trypanosome (unnamed) <i>T. seenghali</i>	Lingard Joshi	1903* 1976
14. <i>Mastocembelus armetus</i> (Lac.)	<i>T. armeti</i> <i>T. denilewskyi</i> <i>saccobranchi</i>	Mandal Joshi	1975 1979
15. <i>Mastocembelus pancalus</i> (Ham.)	<i>T. pancali</i>	Mandal	1975
16. <i>Muraenesox</i> sp.	<i>Babesiosoma</i> sp.	Mandal	Present communi- cation
17. <i>Mystus bleekeri</i> (Day)	<i>T. bengalensis</i>	Mandal	1978

*Vide de Mello and Valles (1936a)

**Vide Wenyon (1926) and Mandal (In press b)

Host	Parasite	Author	Year
18. <i>Mystus vittatus</i> (Bloch)	<i>T. vittati</i>	Tandon & Joshi	1973
	<i>Dactylosoma</i> sp.	Mandal	1979
	<i>Trypanoplasma indica</i>		In press a
19. <i>Nandus nandus</i> (Ham.)	Trypanosome (unnamed)	Mukherjee & Halder	1979***
20. <i>Notopterus notopterus</i>	<i>T. denilewskyi</i>	Joshi	1979
	<i>saccobranchi</i>		
21. (<i>Ophicephalus gachua</i> [= <i>Channa gachua</i> (Ham.)])	<i>T. gachuui</i>	Misra, Chandra & Choudhury	1973
22. <i>Ophicephalus punctata</i> [= <i>Channa punctatus</i> (Bloch)]	<i>T. punctati</i>	Hassan & Qasim	1967
	<i>T. elongatus</i>	Roychaudhury & Misra	1973
	<i>T. channai</i>	Narasimhamurti & Saratchandra	1980
	<i>Mesnilium malariae</i>	Misra, Halder & Chakravarty	1972
	<i>Babesiosoma hareni</i>	Halder, Misra & Chakravarty	1971
	<i>Babesiosoma ophicephali</i>	Misra, Halder & Chakravarty	1969
23. <i>Ophicephalus striatus</i> [= <i>Channa striatus</i> (Bl.)]	<i>T. striati</i>	Qadri	1955
	Trypanosome (unnamed)	Lingard	1904
24. <i>Osteobrama cotio</i> (Ham.)	<i>T. baiquensis</i>	Pandey & Pandey	1974
25. <i>Telapia mossambica</i> (Peters)	<i>T. choudhuryi</i>	Mandal	1977
26. <i>Thyrosidea macrurus</i> Bleeker	<i>Haemogregarina thyrosoideae</i>	de Mello and Valles	1936b
27. <i>Trichogaster fasciatus</i>	Trypanosoma (unnamed)	Lingard	1904
28. [= <i>Trichogaster fasciatus</i> = <i>Colisa fasciatus</i> (Bloch)]	Haemogregarine (unnamed)	Plimmer	1914
	<i>T. trichogasteri</i>	Gupta and Jairajpuri	1981
	<i>Haemogregarina colisa</i>	Mandal, Ray, Sarkar and Kahali	In press
28. <i>Wallago attu</i> (Schneider)	<i>T. danilewskyi</i>		
	<i>saccobranchi</i>	Joshi	1979
	<i>T. tandoni</i>	Mandal	1980
29. <i>Xenentodon cancila</i> (Ham.)	<i>T. cancili</i>	Mandal	1977

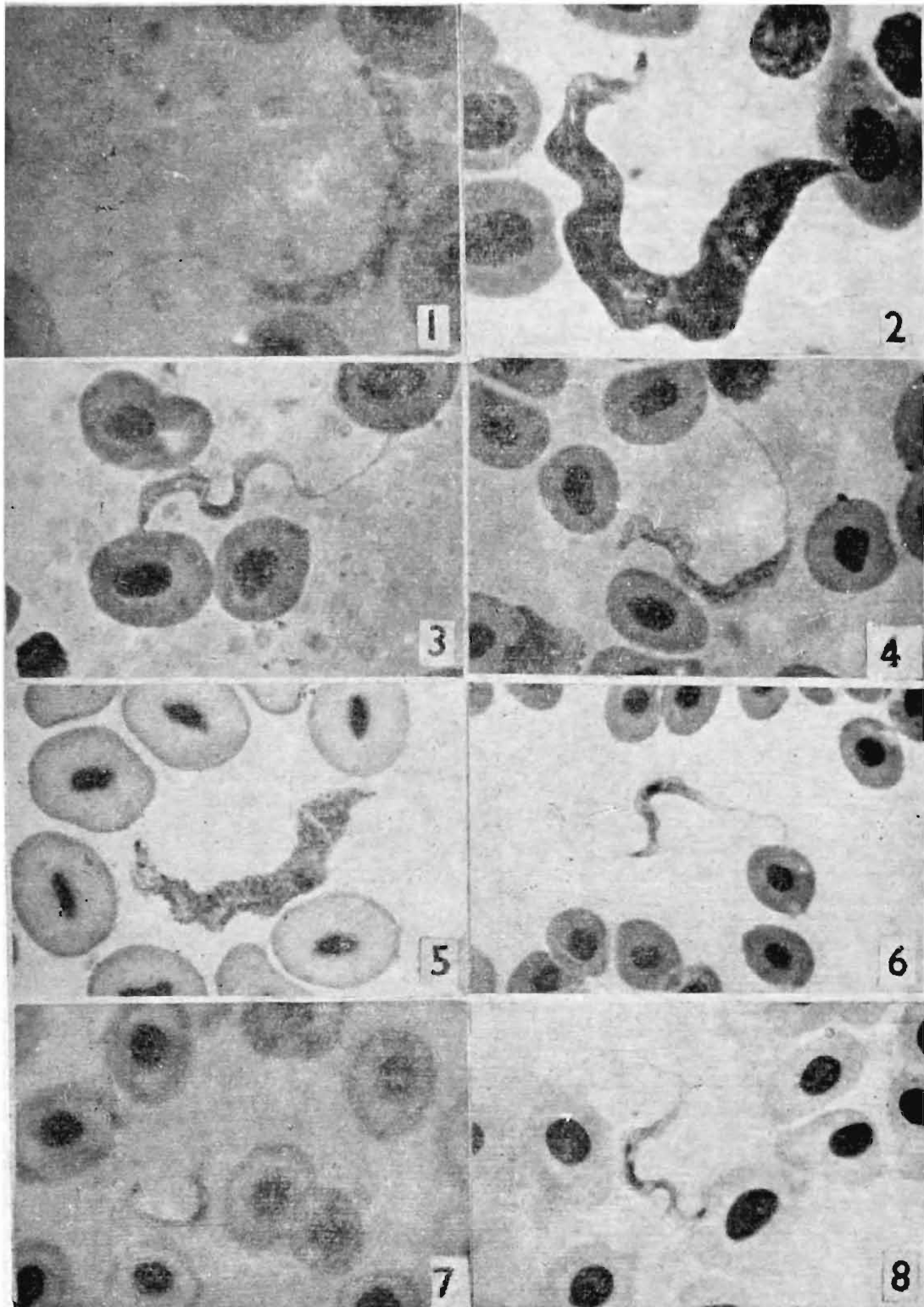
***The authors were personally communicated for the description. Information reached that the species was sent for publication as new in the *Acta Protozoologica*.

PLATES

- Figs. 1-8.
1. Photomicrograph of *T. anabasi* from *Anabas testudineus* (Bl.)
 2. Photomicrograph of *T. cancili* from *Xenentodon cancila* (Ham.)
 3. Photomicrograph of *T. bengalensis* from *Mystus bleekeri* (Day)
 4. Photomicrograph of *T. chaudhuryi* from *Tilapia mossambica* (Peters)
 5. Photomicrograph of *T. granulosum* from *Amphinopnus* sp.
 6. Photomicrograph of *T. pancali* from *Mastocembelus pancalus* (Ham)
 7. Photomicrograph of *T. tandoni* from *Wallago attu* (Schn.)
 8. Photomicrograph of *T. vittati* from *Mystus vittatus* (Bl.)

MANDAL

PLATE I



- Figs. 1-12.
1. & 2. Photomicrographs of *Trypanoplasma indica* from *Mystus vittatus* (Bloch)
 3. Photomicrograph of Female gametocyte of *Haemogregarina colisa* from *Colisa fasciatus* (Bloch)
 4. Photomicrograph of Male gametocyte of *H. colisa* of schizont from *Colisafasciatus* (Bloch)
 5. Photomicrograph of a schizont of *Babesiosoma* sp. from *Muraenesox* sp.
 6. Photomicrograph of Mature schizont of *Babesiosoma* sp. with four nuclei from *Muraenesox* sp.
 7. Photomicrograph of Schizont of *Dactylosoma* sp. from *Mystus vittatus* (Bloch)
 8. Photomicrograph of Mature schizont with 4 merozoites of *Dactylosoma* sp. from *Mystus vittatus* (Bloch)
 9. Photomicrograph of immature form of *Haematractidium* sp. from *Arius sona* (Ham.)
 - 10 & 11. Photomicrographs of binucleated form of *Haematractidium* sp. from *Arius sona* (Ham.).
 12. Photomicrograph of mature elongated form of *Haematractidium* sp. from *Arius sona* (Ham.)

MANDAL

PLATE II

