

# **Blood Values of Some Helminth-Infected Aquacultured Fishes**

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## **Abstract**

*Erythrocytes, thrombocytes, lymphocytes and neutrophils were the principal blood cell types found in the blood of Clarias batrachus, Ophicephalus striatus, Oreochromis mossambicus and Oreochromis niloticus. Eosinophils and basophils were observed in Ophicephalus striatus but were absent in Clarias batrachus. Eosinophils but no basophils were seen in Oreochromis mossambicus and Oreochromis niloticus. Along with mature erythrocytes, immature, dividing, senile, and disintegrated erythrocytes were also observed from the circulating blood of the four fish species.*

*From Clarias batrachus, eight species of helminths were recovered, namely, Cichlidogyrus sclerosus, Actinocleidus sp., Phyllodistomum sp., Opegaster minima, Gauhatiana batrachii, Bovienia serialis, Procammallanus clarius, and Philometra sp. The parasites recovered from Ophicephalus striatus were Diplostomulum sp., Camallanus ophicephali, Arqulus indicus, and Lernaea cyprinacea. Cichlidogyrus sclerosus and Transversotrema laruei were collected from Oreochromis mossambicus and Oreochromis niloticus; from the latter, Gyrodactylus medius was also recovered. The average parasite burden was generally low.*

*Parasitized and unparasitized fishes were active and appeared healthy. Blood values of parasitized fishes showed few significant differences from those of unparasitized fish groups. No parasitized fish group showed significant reduction in mean hematocrit and RBC count or significant increase in mean WBC count and mean % neutrophils in comparison with unparasitized group of the same fish species.*

## **Introduction**

Hematological profiles have been used to assess the health status of fishes. Many factors including diet and stress have been reported to affect the blood parameters (Katz, 1951; Watson et al., 1956; McKnight,

1966; Atkinson and Judd, 1978; Hickey, 1982). The effects of some parasites on the blood values of fishes have also been published (Dogiel et al., 1958; Kawatsu, 1978; Kabata, 1985). Blood values of parasitized fishes raised in the Philippines have not been reported.

Comprehensive works on fish parasites include those of Yamaguti (1958), Hoffman (1967), Lucky (1971), Velasquez (1975) and Kabata (1985). Among the monogenea, *Dactylogyrus* and *Gyrodactylus* were often reported from fish. Paperna (1960) found *Gyrodactylus medius* on *Tilapia nilotica* and other fishes in Israel. In the Philippines, Duncan (1973) reported *Cichlidogyrus sclerosus* from *Tilapia mossambica* and Hanviriyapant (1977), *Actinocleidus* sp. from *Clarias macrocephalus*.

Numerous digenetic trematodes have been found in freshwater and marine fishes as adult parasites or as larvae. *Diplostomulum* larvae had been recorded from the eyes, muscles, or brain of fish; adults develop in birds (Hoffman, 1967). Adult digenea from Philippine fishes include *Transversotrema laruei* from the skin and scales of *Lates calcarifer* and other fishes, and *Opegaster minima* and *Orientocreadium batrachoides* from *Clarias batrachus*, *Ophicephalus striatus* and other fishes (Velasquez, 1975).

*Gauhatiana batrachii*, originally described from the intestine of *Clarias batrachus* in India, has also been found from the same host in Thailand (Kabata, 1985). Lucky (1971) listed species of *Phyllodistomum* from the urinary tract of salmonids, carp and other fishes. Yamaguti (1958) also recorded this genus from various fish species as well as from amphibians.

Reports of cestodes from freshwater fishes include the work of Bovien (1926) who described several *Caryophyllaeus* species from *Clarias batrachus* in Java. Furhmann in 1931 renamed one of Bovien's species as *Bovienia serialis* (Hanviriyapant, 1977).

Of the nematodes, *Procamallanus clarius* from *Clarias batrachus* (master thesis Josef, 1985) and *Camallanus ophicephali* from *Ophicephalus striatus* (Velasquez, 1980; Calhoun, 1981; master thesis Boromthanarat, 1974) are among those reported in the Philippines. In other countries, species of *Philometra* have been recorded from the body tissues of fishes (Hoffman, 1967; Lucky, 1971).

Two groups of crustacea have been frequently reported as fish parasites: Subclasses Branchiura and Copepoda. *Argulus* and *Lernaea* were commonly found in cultured fishes (Hoffman, 1967).

To date, there are no publications on the hematology of helminth-infected fishes in the Philippines. This study reports on the blood values of helminth-infected *Clarias batrachus*, *Ophicephalus striatus*, *Oreochromis mossambicus* and *Oreochromis niloticus*. Unless otherwise stated fish lengths are in mm and weights in grams.

### Materials and Methods

*Clarias batrachus* specimens from Laguna with standard lengths of 120 to 202 and weights of 14.9 to 59.4 were obtained from Nepa Q Mart, Quezon City from February to August, 1983. *Ophicephalus striatus* with standard lengths of 182 to 295 and weights of 68 to 310.8 were bought from Farmers' Market, Quezon City from August to November, 1983. Monthly collections of *Oreochromis mossambicus* were done from fishponds in Malabon in August, September and December, 1982 and January, 1983. Specimens had standard lengths of 55 to 110 and weights of 5.6 to 39.6. *Oreochromis niloticus* were collected from fishpens in Angono, Rizal, in September, 1981 and from January to September, 1983. Specimens had standard lengths of 62 to 150 and weights of 8.3 to 114.2. *Oreochromis mossambicus* and *Oreochromis niloticus* were collected with nets, then placed in aerated plastic bags for transport to the laboratory. *Clarias batrachus* and *Ophicephalus striatus* were transported in plastic pails. In the laboratory, fish were maintained in aerated aquaria until blood sampling. Fish were fed cooked shrimps, fish and shrimp crackers. Physico-chemical data recorded during acclimation of fishes in the laboratory were: temperature, 25°C to 29°C; salinity, 0.05 ppt to 4.5 ppt; dissolved oxygen, 0.1 cc/l to 4.9 cc/l; free CO<sub>2</sub>, 0 ppm to 29.5 ppm; total alkalinity, 4.2 ppm CaCO<sub>3</sub> to 167.8 ppm CaCO<sub>3</sub>.

Blood samples were from live fish acclimatized for at least two weeks in the laboratory. Only apparently healthy, active fishes were sampled. Chemical narcosis was done by applying 40% ethyl alcohol with a cotton tampon under the operculum.

All fish to be sampled were wiped dry with gauze. Standard length in mm and weight in grams were recorded. The caudal peduncle was

severed with a pair of scissors and sufficient quantity of blood was obtained directly for erythrocyte counts, hematocrit determinations and smears for leucocyte counts.

### ***Hematocrit***

The microhematocrit method was used to determine the volume of packed red cells. Blood was allowed to run into one end of a heparinized capillary tube (70 mm long, 0.5-0.9 mm ID). About three fourths of the tube was filled then sealed with plastic clay; duplicate tubes were prepared. The tubes were spun for 35 minutes at 3000 rpm in a clinical model centrifuge and micrometer readings were recorded. Hematocrit values were expressed as the percentage of packed red cell volume in 100 % of whole blood.

### ***Erythrocyte Count***

Blood was drawn from the severed caudal peduncle into a standard Thoma red cell diluting pipette up to the 0.5 mark, then Yokoyama's fluid (1947 in Katz, 1951) was drawn up to the 101 mark. After mixing for 1 to 2 minutes, diluted blood was flooded into an improved Neubauer counting chamber. A Petri dish containing damp filter paper was placed over the chamber to prevent drying. The dilution was allowed to settle several minutes before counting. The number of cells in five secondary squares of the counting chamber was determined and multiplied by 10,000. This represented the number of erythrocytes per cubic millimeter of blood.

### ***Leucocyte Count***

The indirect method (McKnight, 1966) was used to determine the number of leucocytes. The counts were made from blood smears stained panoptically (Lucky, 1977). Jenner's solution was used as fixative. The stained smears were examined under the oil immersion objective of a compound light microscope.

Relative leucocyte counts were made from the same slides as the total counts. Twenty-five to fifty leucocytes were counted in each of four separate fields as in Lucky (1971). The counts for each type of leucocyte were converted to percentages.

### ***Blood Cell Sizes***

Blood cells in panoptically stained smears were measured with a calibrated ocular micrometer under the oil immersion objective of a compound light microscope. From a varying number of slides per fish species, lengths and widths of 30 erythrocytes taken at random on one slide per fish species were obtained.

### ***Recovery of Parasites***

Fish sampled for blood were later examined for helminth parasites. Mucus, skin and mouth cavity scrapings were examined under the stereomicroscope. Gills, gonads, heart, kidneys, esophagus, stomach, intestine, liver, swim bladder, brain, muscle strips and eyes were placed in separate dishes, teased, then placed in bottles for washing and decanting. Magnesium sulfate was added to the bottle with the gills to dislodge monogenea (Velasquez, 1975). The concentrates were examined and the species and number of parasites were recorded.

Parasites collected were fixed in formalin acetic acid solution and kept in vials containing 70% ethyl alcohol. Trematodes and cestodes were stained in borax carmine and mounted in Canada balsam. Nematodes and arthropods were preserved in 70% glycerine alcohol, then mounted in glycerine.

### ***Analysis of Data***

Fish were grouped according to the parasite species recovered. The average parasite burden for each group was computed as follows:

$$\begin{aligned} \text{average parasite burden} &= n/n_1 \\ \text{where } n &= \text{number of parasites} \\ n_1 &= \text{number of fish infected} \end{aligned}$$

Ranges, means and standard error of the means of the blood values for the different fish groups were determined. Difference between the means of uninfected and helminth-infected fish groups were determined by the Student's t-test. Probability of 0.05 or less was considered significant.

Mounted specimens of the different parasites were studied for specific identification. Measurements were done with a calibrated ocular micrometer.

## Results and Discussion

The principal cellular components of the peripheral blood of the four fish species studied were erythrocytes, thrombocytes, lymphocytes and neutrophils. Eosinophils and basophils were also present in *Ophicephalus striatus*. Eosinophils but no basophils were seen in *Oreochromis mossambicus* and *Oreochromis niloticus*. Along with mature erythrocytes, immature, dividing, senile and disintegrated erythrocytes were observed from the blood of the four fish species. The blood cell types observed in the present study confirm those found in other fishes by Andrew (1961), Watson et al. (1963), McKnight (1966) and Boomker (1980, 1981).

Basically, similar blood cell types occur in Class Pisces.

Table 1 shows the parasites recovered from the different fish species. Eight species of helminths were recovered from *Clarias batrachus*. *Cichlidogyrus sclerosus* is probably an accidental parasite of this fish. Two species of crustacea, a larval digenea and a nematode were collected from *Ophicephalus striatus*. Monogenea and a digenea were recovered from the tilapias. Descriptions of these parasites with measurements in micra unless otherwise stated are as follows:

*Cichlidogyrus sclerosus* Paperna and Thurston, 1969  
(Trematoda: Dactylogyridae)  
Plate I, Fig. 6

Diagnosis (Based on 4 specimens): Body 662.5–727.5 long, maximum width 80–125. Prohaptor with four lobes containing head organs. Eyespots two pairs. Copulatory organ of two parts, ejaculator and accessory piece. Ejaculator an oval-mouthed funnel with a basal plate attached on one side, gradually narrowing as a sickle-shaped tube with a sharp tip; ejaculator measured on a straight line from basal plate to tip 32.5–42.5 long; accessory piece robust, sausage shaped, 40–57.5 long. Marginal hooklets 14. Anchors solid; perforated base, one pair dorsal and one pair ventral; wings present on shafts; anchor tips directed outward in relation to body, giving appearance of grappling hook; dorsal and ventral anchors equal, 32.5 long, 20–22.5 wide. Dorsal bar compound, consisting of shallow, V-shaped basal piece and two loop-shaped appendages dividing basal piece into three nearly equal

parts; basal piece 40–50 long, appendages 15–17.5 long. Ventral bar V-shaped, heavy, thin shelf or ledge along inner edge, length taken as shortest distance between tips 52.5.

Host: *Oreochromis mossambicus*

*O. niloticus*

*Clarias batrachus*

Location: gills

Host locality: fishponds in Malabon; fishpens in Laguna Lake, Angono; Laguna Lake, Laguna Province

*Actinocleidus* sp. Mueller, 1937

(Trematoda: Dactylogyridae)

Plate I, Fig. 1

Diagnosis (Based on 4 specimens): Body elongate, 325.0–437.5 by 97.5–112.5. Opisthaptor disc-shaped with two pairs of anchors and 14 marginal hooks. Two dissimilar connecting bars between anchors more or less V-shaped, articulating with each other. One bar consisting of two pieces. Eye spots present.

Host: *Clarias batrachus*

Location: gills

Host locality: Laguna Lake, Laguna Province

*Gyrodactylus medius* Kathariner, 1894

(Trematoda: Gyrodactylidae)

Plate I, Fig. 2

Diagnosis (Based on one specimen): Total body length 297.5, maximum width 52.5. Anterior extremity of prohaptor with two well-defined lobes. Cirrus complex with 9 small and one large hook arranged in a single circle. Central anchors 70 long, roots 22.5 long, shaft 47.5 long and spike 30 long. Root of anchor bent inward or outward. Viviparous; anchor hooks of embryo about midway in parent worm.

Host: *Oreochromis niloticus*

Location: gills

Host locality: fishpens in Laguna Lake, Angono

*Transversotrema laruei* Velasquez, 1958

(Trematoda: Transversotrematidae)

Plate I, Fig. 4

Diagnosis (Based on 10 specimens): Leaf-like, broader than long, 324–402.6 long, 628.5–864 wide. Eyespots present present. Acetabulum diameter 78.6–88.4. Oral sucker absent. Mouth opening directly into pharynx, 39.3–58.9 in diameter. Esophagus narrow, bifurcating just anterior to midbody; branches uniting posteriorly forming cycloid intestine. Testes dendroid, one on each side of acetabulum. Ovary with indented margin, sinistral, anterior to testis but smaller. Uterus well-formed with transverse and ascending parts, discharging into common genital atrium. Vitellaria follicular, heavily developed, extra-intestinal. Egg large 49–117.8 long by 78.4–88.2 wide.

Host: *Oreochromis mossambicus**O. niloticus*

Location: skin (under scales)

Host locality: fishponds in Malabon; fishpens in Laguna Lake, Angono

*Phyllodistomum* sp. Braun, 1899

(Trematoda: Gorgoderidae)

Plate I, Fig. 3

Diagnosis (Based on 3 specimens): Forebody tapered anteriorly, hindbody foliate, with more or less crenulated margin, 3253.6–4851 by 1244.6–1705.2. Oral sucker terminal, diameter 254.8–323.4. Mouth ventroterminal; pharynx absent. Acetabulum pre-equatorial, 372.4–392 across. Testes lobed, intercecal, symmetrical or diagonal, in broadest part of hindbody, more than twice as large as ovary which is compact, dextral, 205.8–245 by 166.6–196. Vitellaria lobed, paired, behind ventral sucker. Uterus occupies most of hindbody intruding into extracecal fields. Eggs yellowish, 22.5–27.5 by 17.5–20.

Host: *Clarias batrachus*

Location: intestine and gonads

Host locality: Laguna Lake, Laguna Province



*Opogaster minima* (Tubangui, 1928) Yamaguti, 1934  
(Trematoda: Opecoelidae)  
Plate I, Fig. 7

Diagnosis (Based on 9 specimens): Body 735–1146.6 long by 127.4–245 maximum width across acetabulum. Tegument smooth. Oral sucker subterminal, moderately developed, circular, 78.4–137.2 transverse diameter. Acetabulum 88.2–127.4 across, in anterior or middle third of body. Prepharynx present, 24.5–29.4 long; pharynx well-developed 58.8–68.6 across; esophagus 147 long bifurcating midway between pharynx and acetabulum. Intestinal ceca uniting at level midway between posterior testis and posterior end of body, forming a narrow common canal leading to outside. Genital pore to one side of median line at level of esophageal bifurcation. Testes intercecal, globular or slightly oval 68.6–107.8 across, one immediately posterior to the other. Cirrus pouch thin-walled, elongated, dilated at both extremities, 176.4–225.4 long by 29.4–68.6 maximum width; located at one side of median line anterior to acetabulum. Ovary elliptical 78.4 across, median, pretesticular; uterus with numerous eggs; vitellaria in distinct follicles on both sides of body, extending from anterior to or level of acetabulum to posterior end of body. Eggs oval, operculate, yellowish to yellowish-brown, 32.5–35 by 17.5–20.

Host: *Clarias batrachus*

Location: intestine

Host locality: Laguna Lake, Laguna Province

*Gauhatiana batrachii* (Dayal and Gupta, 1954)  
(Trematoda: Macroderoididae)  
Plate I, Fig. 5

Diagnosis (Based on 7 specimens): Body elongate, tapering at both ends, with rounded extremities, 539–656.6 by 156.8–235.2. Tegument spinous. Oral sucker large, subterminal, diameter 49–98. Pharynx well-developed, 29.4–49 across. Acetabulum about same size as oral sucker, 49–88.2 across, anterior to midlength of body. Genital pore median, in front of acetabulum. Cirrus sac extending posteriorly past acetabulum 88.2–98 by 29.4–39.2. Testes diagonal or tandem, located between intestinal ceca in posterior of body; anterior testis 49–78.4 by

39.2–58.8. Ovary nearly median, in middle third of body, about half distance between acetabulum and testes, 49–58.8 by 29.4–39.2. Vitelline follicles on each side of intestine at level of bifurcation and along ceca at level between acetabulum and posterior testis. Uterus extending to posterior of body. Eggs numerous, operculate, 20–25 by 12.5–15.

Host: *Clarias batrachus*

Location: intestine, stomach

Host locality: Laguna Lake, Laguna Province

*Diplostomulum* sp. Hughes, 1929

(Trematoda: Diplostomatidae)

Plate II, Fig. 1

Diagnosis (Based on 4 specimens): Total body length 686–784 by 147–284. Forebody foliaceous, concave ventrally; hindbody distinct, conical, 150–180 long on posterodorsal part of forebody. Oral sucker 25–40 across, ventral sucker 25–37.5 across. Holdfast organ prominent, 87.5–100 by 50–57.5.

Host: *Ophicephalus striatus*

Location: muscles, intestine, brain

Host locality: Laguna Lake, Laguna Province

*Bovienia serialis* (Bovien, 1926) Fuhrmann, 1931

(Cotyloda: Lytocestidae)

Plate II, Figs. 9, 12, 13

Diagnosis (Based on 4 specimens): Total body length 5.83 mm to 23.03 mm by 0.3 mm to 0.78 mm. Holdfast not differentiated from the body. Parenchymal muscles surrounding testes, ejaculatory duct not enclosed within parenchymal bulb. No yolk glands posterior to ovary; ovarian lobes in cortex. Uterine coils posterior to testes; uterus without thick coat of accompanying cells. Eggs 49–59 by 29–39.

Host: *Clarias batrachus*

Location: intestine

Host locality: Laguna Lake, Laguna Province

*Procamallanus clarius* Ali, 1956

(Nematoda: Camallanidae)

Plate II, Figs. 10, 11, 14

Diagnosis (Based on 6 specimens): Live nematodes reddish. Body cylindrical. Cuticle finely striated at intervals of 7.5 to 12.5. Mouth enclosed in a sclerotized, barrel-shaped buccal capsule with collar. Esophagus with muscular and glandular parts. Intestine long, from posterior end of glandular esophagus to the short cuticular rectum or cloaca in the male. Nerve ring surrounds muscular part of the esophagus at mid-anterior level. Excretory pore posterior to nerve ring.

Male: Body 2.99 mm to 4.02 mm long, 0.08 mm to 0.09 mm maximum width. Buccal capsule 45–50 by 32.5–35. Muscular esophagus 247.5–287.5 by 32.5–50; glandular esophagus 435–555 by 35–45. Nerve ring 127.5–132.5 and excretory pore 190–232.5 from anterior end of body. Testis single, slightly sinuous, extends to level of anterior intestine, connects posteriorly with the vas deferens. Seminal vesicle opens into cloaca by a short ejaculatory duct. Tail 0.03–0.04 long, curved ventrally upwards; 14 pairs of caudal papillae, 10 preanal and 3 postanal and 1 button. Right spicule 87.5–117.5 long, left spicule 37.5–45.

Female: Body 6.29 mm to 8.16 mm long, 0.12 mm to 0.15 mm maximum width. Buccal capsule 77.5–87.5 by 55–57.5. Muscular esophagus 345–395 by 72.5–82.5; glandular esophagus 612.5–650 by 50–75. Nerve ring 125–135 and excretory pore 265–267.5 from anterior tip of body. Vulva 3.26 mm to 2.58 mm from posterior end of body, with slightly protruded lips. Posterior end of body narrowing posteriorly to anal opening. Tail conical 115–130 long, pointed at tip. Immature worms with two spikes or mucrons at tip of tail.

Host: *Clarias batrachus*

Location: stomach and intestine

Host locality: Laguna Lake, Laguna Province

*Camallanus ophicephali* in part Pearse, 1933

(Nematoda: Camallanidae)

Plate II, Figs. 15, 16, 17

Diagnosis (Based on 6 specimens): Body of both sexes striated throughout. Length of body: male, 4.21 mm to 5.19 mm by 0.1 mm to 0.14 mm; female, 7.27 mm to 11.42 mm by 0.14 mm to 0.2 mm. Length of chitinous buccal apparatus of female 0.04 mm to 0.05 mm; muscular esophagus 0.27 mm to 0.34 mm; glandular esophagus 0.59 mm to 0.67 mm. Chitinous jaws with 18 to 26 ridges. Chitinous pharynx

hemispherical and half as long as wide. Tail of female 0.22 mm to 0.34 mm long, straight, tapering, obtusely rounded at tip; vulva a little in front of middle of body. Viviparous. Tail of male 0.08 mm long, acute, tapering, curved ventrally; four pairs of post-anal papillae and a pair of discoidal elevations near tip of tail; 2 pairs of papillae immediately in front of the anus and six pairs some distance in front of these. Right spicule 0.14 mm, left 0.07 mm. Tridents absent in male and female.

Host: *Ophicephalus striatus*

Location: stomach and intestine

Host locality: Laguna Lake, Laguna Province

*Philometra* sp. Costa, 1845

(Nematoda: Philometridae)

Plate III, Figs. 18, 19, 20

Diagnosis: (Based on 2 specimens): Body filiform, anterior and posterior extremities rounded, 29.7 mm to 30.1 mm long, 0.62 mm to 0.64 mm wide. Anus and vulva atrophied. Uterus occupying entire length of body. Viviparous.

Host: *Clarias batrachus*

Location: palate

Host locality: Laguna Lake, Laguna Province

*Argulus indicus* Weber, 1892

(Crustacea: Argulidae)

Plate III, Fig. 21

Diagnosis (Based on 5 specimens): Carapace ovate, considerably narrowed anteriorly with broad lateral lobes which fall slightly short of the abdomen, just reaching it or slightly overlapping it. Body of males, 3.68 mm to 5.36 mm by 2.76 mm to 4.35 mm; females 4.44 mm to 5.54 mm by 3.77 mm to 4.15 mm. Cephalic area broadly triangular, distinctly separated from the rest of the carapace and projecting a little anteriorly. Anterior respiratory area minute, posterior one very large and oblong. Knob or hook lacking on anterior surface of first antennae. Basal plate of second maxillae not lobed, tips of maxillary teeth blunt. Ribs of suction cup composed of three rods. Swimming lobe of fourth appendage boot-shaped, heel pressed against end of thorax, toe extending to or

beyond edge of abdomen. Whole animal golden yellow flecked with black.

Host: *Ophicephalus striatus*

Location: skin

Host locality: Laguna Lake, Laguna Province

*Lernaea cyprinacea* Linnaeus, 1761

(Crustacea: Lernaeidae)

Plate III, Fig. 22

Diagnosis (Based on one specimen): Cephalothorax very small, in center of holdfast system. Holdfast of two pairs of arms, dorsal pair much longer than ventral, dividing into two branches some distance from their bases; ventral pair simple. Neck soft, slender, cylindrical, enlarged gradually into cylindrical trunk; trunk with bilobed progenital prominence in front of vulvae; abdomen short, bluntly rounded, terminating in pair of small segmented caudal rami. Body length from head to tip of abdomen 9.42 mm. Egg strings elongate, each 1.14 mm long. Eggs multiseriate.

Host: *Ophicephalus striatus*

Location: base of dorsal fin

Host locality: Laguna Lake, Laguna Province

Parasites have been reported to influence the blood values of fish hosts (Bauer in Dogiel et al., 1970; Romestand and Trilles, 1977; Natarajan and Balakrishnan, 1977; Wao, 1979; Kabata, 1985). Bauer (in Dogiel et al., 1970) noted that in all investigated cases, parasites caused decreased hemoglobin content and erythrocyte count, and changes in the leucocyte formula mainly towards some reduction in the number of lymphocytes and corresponding increase of the phagocytic elements. Wao (1979) reported that hematocrit and red cell count of fish infested with a protozoan parasite declined as the infection progressed. In the present study, parasitized compared to unparasitized *Clarias batrachus*, *Oreochromis mossambicus* and *O. niloticus* showed few significant changes in blood values previously associated with parasitism by other authors (Bauer in Dogiel et al., 1970).

In *Clarias batrachus* none of the parasitized groups showed a significant reduction in mean hematocrit, and most groups had

insignificant changes in mean values of erythrocyte size and counts as well as WBC and relative WBC counts (Table 2). The parasites were varied but generally of low intensities aside from being small-sized. Comparison of pooled values of all infected fish with those of uninfected fish showed significant difference only in mean red cell length which was higher in the infected group. This may indicate host reaction to irritation or increased energy needs due to parasitism. Monogenea in the gills of fish can cause copious mucus secretion which may interfere with the respiratory function of the gills. Cestodes and other intestinal helminths when present in great numbers divert to their use a considerable part of the host food (Bauer in Dogiel et al., 1970). *Procamallanus* feed on the blood of the host (Master thesis Josef, 1984).

Table 3 shows the RBC measurements and blood values of *Ophicephalus striatus*. Since all fish were infected, mean blood values of the different parasitized groups were compared with those of fish with lower intensity of infection with *Camallanus ophicephali* (PB=5.4). Few significant differences were observed. Comparison of mean blood values of fish group with lower *Camallanus* infection versus pooled values of all other fish showed no significant differences. This may be due to the generally low intensities of infection with the different parasites.

Table 4 shows the RBC measurements and blood values of *Oreochromis mossambicus*. The insignificant changes in mean blood values of parasitized fish compared to those of unparasitized fish indicate minimal influence of the parasites which occurred at low intensities.

The mean blood values of *Oreochromis niloticus* infested by gill monogenea did not differ significantly from those of unparasitized fish except for the lower mean red cell length in parasitized fish (Table 5). The smaller red cells in parasitized fish may be physiological reaction to provide greater efficiency in gas exchange (Hartman and Lester, 1964 in Srivastava and Griffith, 1974).

In *Transversotrema*-infested *Oreochromis niloticus*, the greater mean red cell width, lower mean hematocrit and leucocyte count in parasitized fish as compared to those of unparasitized fish may be an indication of stress. According to Hattingh and Van Pletzen (1975) these blood values may decrease in stressed fish. There is an apparent need

for the study of the host-parasite relationship between *Transversotrema laruei* and *Oreochromis niloticus*.

The blood picture has been used to indicate the state of health of humans just as it is now recognized as useful in assessing fish health. A striking feature that has emerged from the present work is that for as long as the parasite burden is at a low intensity level the blood picture is not significantly affected, indicating that adaptive mechanisms between parasite and host are a means of survival for both.

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### Plate I

- Fig. 1. *Actinocleidus* sp.\*
- Fig. 2. *Gyrodactylus medius*, opisthaptor
- Fig. 3. *Phyllodistomum* sp.\*
- Fig. 4. *Transversotrema* laruei.\*
- Fig. 5. *Gauhatiiana batrachii*.\*
- Fig. 6. *Cichlidogyrus sclerosus*, opisthaptor
- Fig. 7. *Opegaster minima*\*

### Plate II

- Fig. 8. *Diplostomulum* sp., larva\*
- Fig. 9. *Bovienia serialis*, anterior region
- Fig. 10. Female *Procamallanus clarius*, anterior end
- Fig. 11. Male, posterior end
- Fig. 12. *Bovienia serialis*, middle region
- Fig. 13. Posterior end
- Fig. 14. Female *Procamallanus clarius*, posterior end
- Fig. 15. Female *Camallanus ophicephali*, anterior end
- Fig. 16. Posterior end
- Fig. 17. Male, posterior end

### Plate III

- Fig. 18. Female *Philometra* sp., anterior end
- Fig. 19. Posterior end
- Fig. 20. Middle region
- Fig. 21. *Argulus indicus*, dorsal view\*
- Fig. 22. Female *Lernaea cyprinacea*\*

\*Whole mount

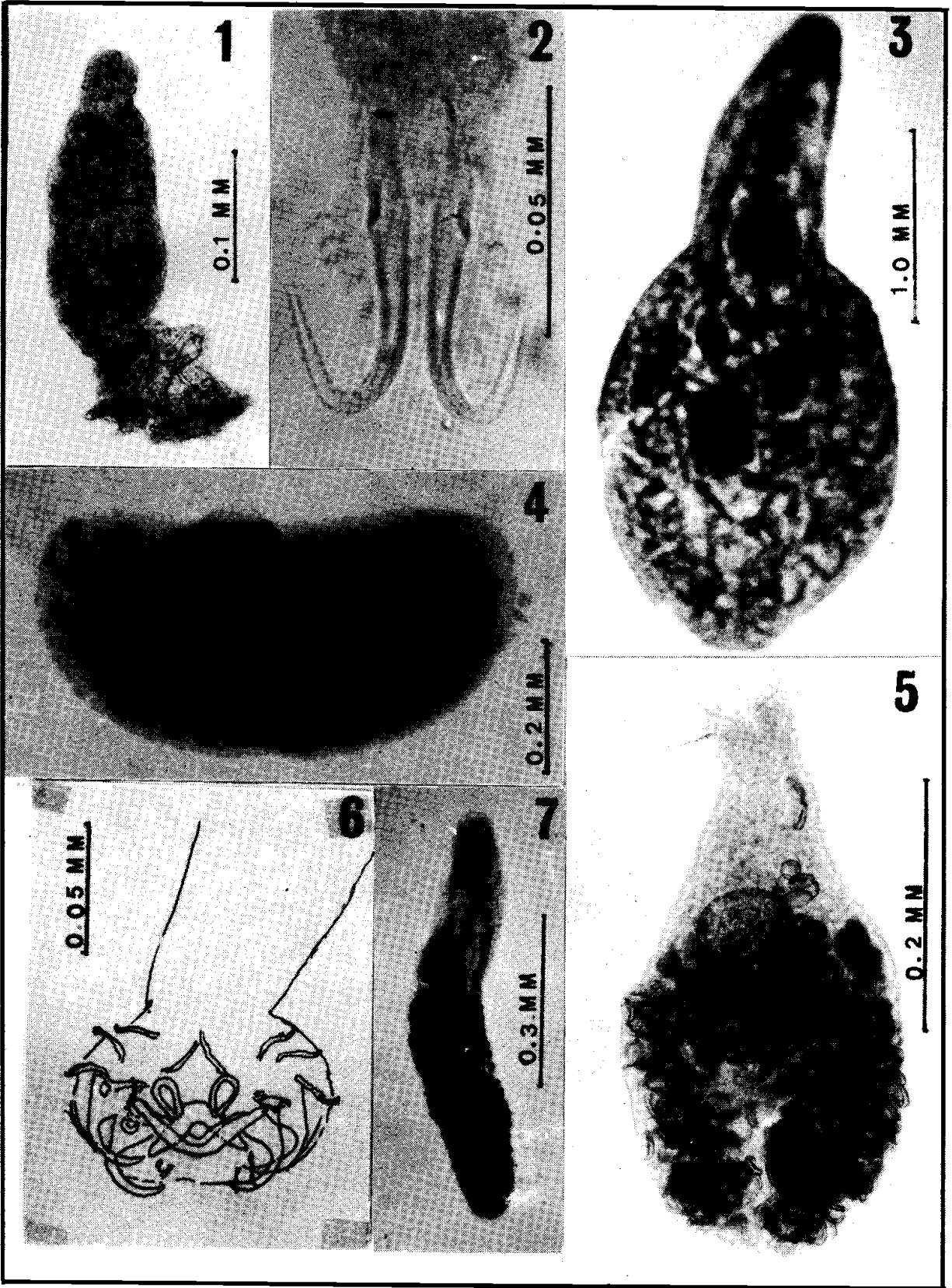


Plate I

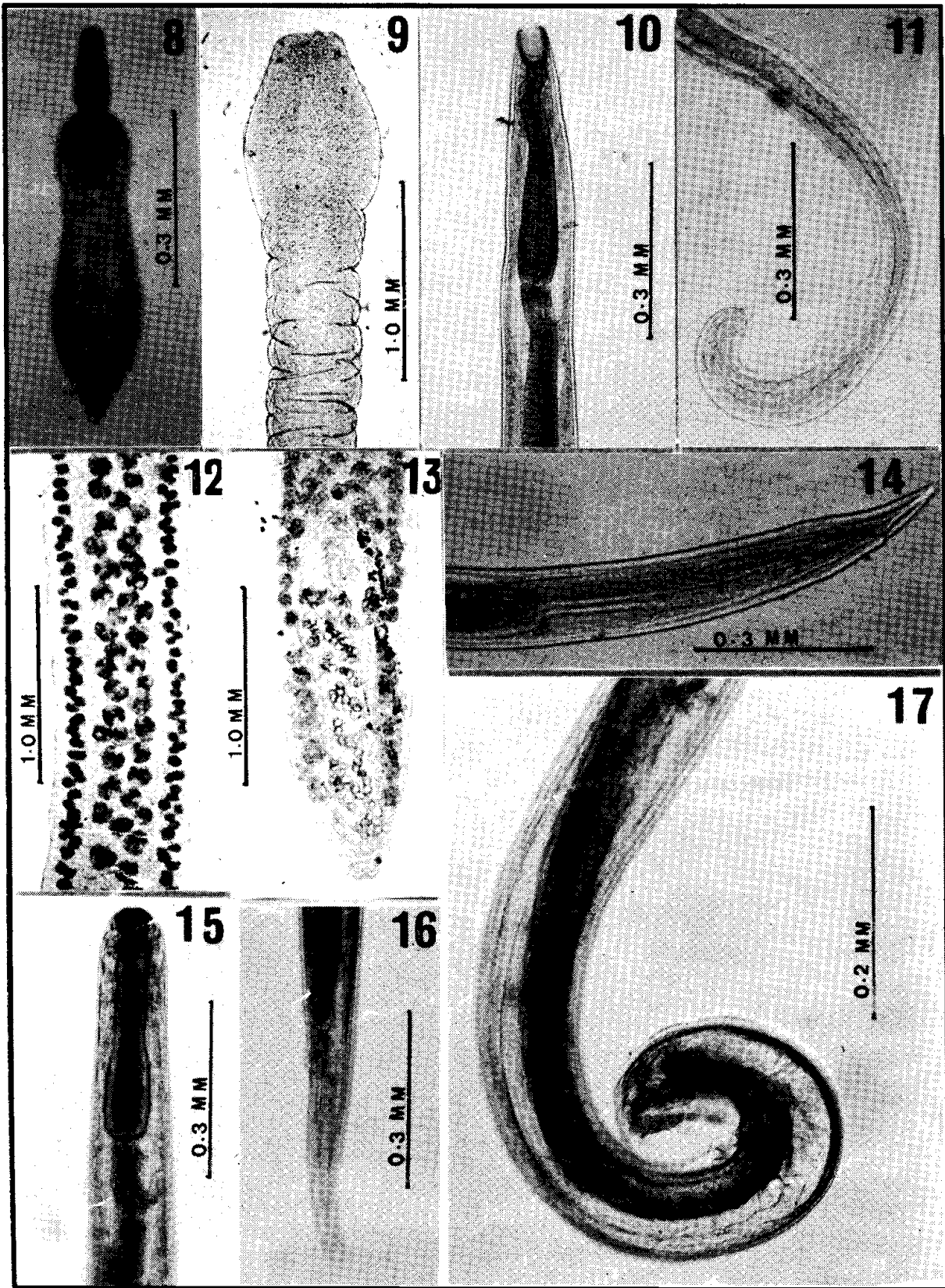


Plate II

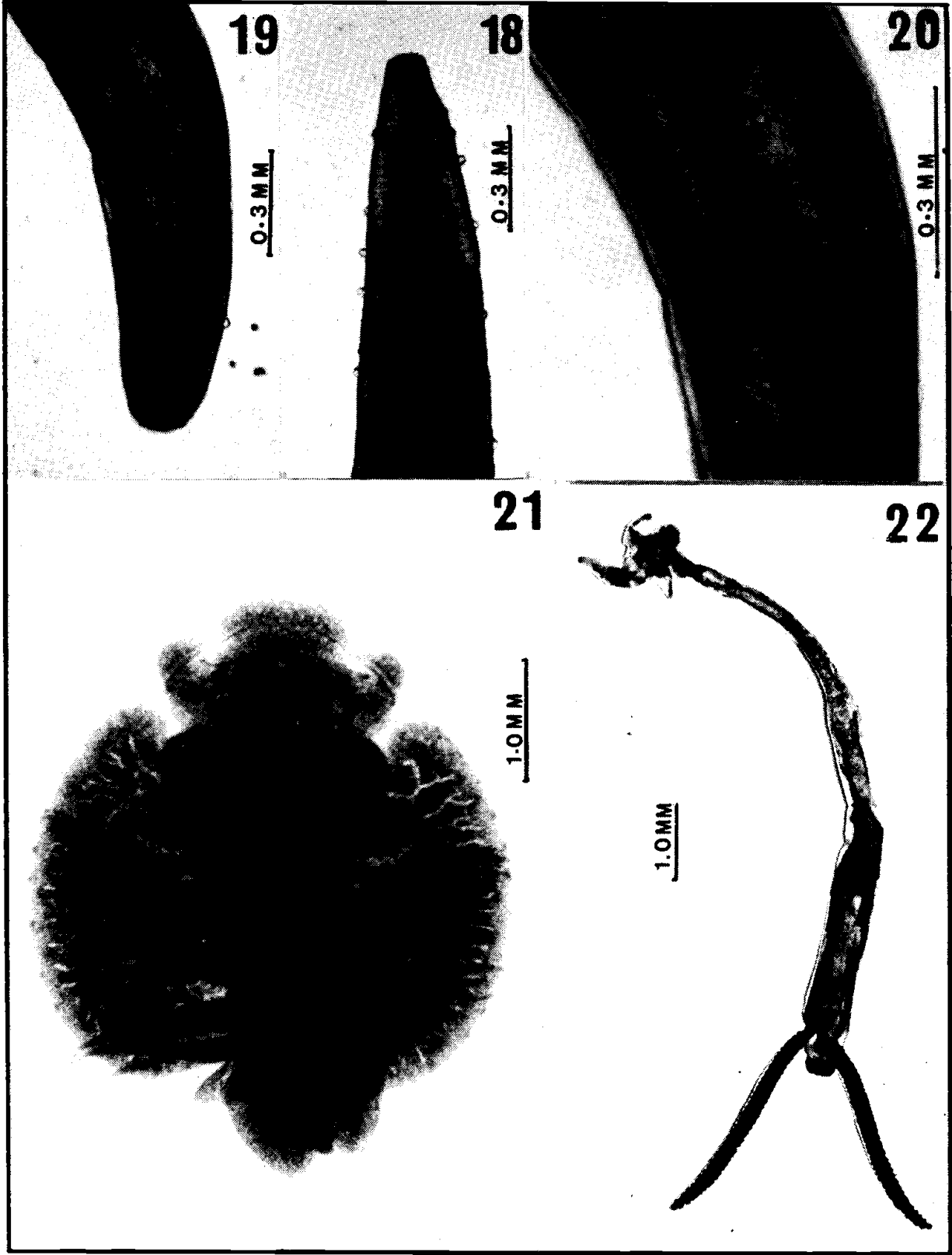


Plate III

Table 1. Sites of Parasitic Infection in Different Species of Fish.

Organ examined	<i>Clarias batrachus</i> (65)*		<i>Ophicephalus striatus</i> (23)		<i>Oreochromis mossambicus</i> (84)		<i>O. niloticus</i> (83)	
	Parasites recovered	Parasite burden	Parasites recovered	Parasite burden	Parasites recovered	Parasite burden	Parasites recovered	Parasite burden
Skin & scales	-		<i>A. indicus</i>	1.0	<i>T. laruei</i>	2.2	<i>T. laruei</i>	1.9
Gills	<i>Monogenea</i>	14.5	<i>L. cyprinacea</i>	1.0	<i>C. sclerosus</i>	9.4	<i>Monogenea</i>	2.5
Mouth cavity	<i>P. clarius</i> <i>Phlometra</i> sp.	1.0 1.0	<i>Diplostomulum</i> sp. <i>C. ophicephali</i>	1.0 1.0	-	-	-	-
Esophagus	-		<i>C. ophicephali</i>	1.5	-	-	-	-
Stomach	<i>Phyllodistomum</i> sp. <i>G. batrachii</i> <i>B. serialis</i> <i>P. clarius</i>	1.0 3.1 2.0 4.4	-		-	-	-	-
Intestine	<i>Phyllodistomum</i> sp. <i>O. minima</i> <i>G. batrachii</i> <i>B. serialis</i> <i>P. clarius</i>	2.0 1.0 10.3 5.6 3.0	<i>C. ophicephali</i>	11.3	-	-	-	-
Liver	<i>P. clarius</i>	1.0	-		-	-	-	-
Heart	-		-		-	-	-	-
Kidneys	-		-		-	-	-	-
Urinary bladder	<i>Phyllodistomum</i> sp. <i>Phyllodistomum</i> sp.	1.0 1.0	-		-	-	-	-
Gonads	-		-		-	-	-	-
Swim bladder	-		-		-	-	-	-
Muscle strips	-		-		-	-	-	-
Brain	-		-		-	-	-	-
Eyes	-		-		-	-	-	-

\* Number of fish examined is found in parentheses

**Table 2. Comparison of Blood Values of Uninfected and Helminth-Infected *Clarias batrachus*.**

Parasite species*	PB	Amplitude	SL (mm)	Wt. (g)	RCL (µm)	RCW (µm)	Ht (%)	RBC (x10 <sup>6</sup> /mm <sup>3</sup> )	WBC (x10 <sup>3</sup> /mm <sup>3</sup> )	Lymp (%)	Neut (%)
Uninfected (14)	0	Mean	158	34.6	10.0	8.8	34.8	2.68	66.0	35.1	64.9
		SE	5.6	3.03	0.11	0.11	1.14	0.08	10.74	5.22	5.23
		Range	120-187	14.9-47.8	9.4-10.6	8.2-9.4	27.3-40.5	2.08-3.16	20.8-153.2	3.4-63.9	36.1-96.6
6 (16)	2.8	Mean	150	30.4	10.3	9.0	34.1	2.50	48.5	32.7	67.3
		SE	3.0	1.44	0.13	0.10	1.35	0.10	5.91	4.22	4.22
		Range	131-173	21.8-41.8	9.4-11.3	8.5-10.1	27.4-44.1	1.94-3.55	18.8-113.8	10.6-66.7	33.3-89.4
		t-test	NS	NS	NS	NS	NS	NS	NS	NS	NS
4,6 (11)	12.0	Mean	155	35.1	10.3	8.9	36.4	2.56	67.0	33.5	66.5
		SE	6.0	3.54	0.12	0.11	1.38	0.15	10.55	6.93	6.93
		Range	129-202	17.5-59.4	9.5-10.9	8.2-9.5	30.4-42.8	1.67-3.25	20.3-150.8	2.5-73.7	26.3-97.5
		t-test	NS	NS	NS	NS	NS	NS	NS	NS	NS
1,4,6 (9)	31.4	Mean	143	29.1	10.2	9.1	34.9	2.65	76.3	38.1	61.9
		SE	3.5	2.50	0.11	0.13	2.00	0.12	19.55	9.24	9.24
		Range	127-156	19.2-38.9	9.7-10.7	8.4-9.6	27.3-46.5	2.203-3.24	2.7-169.	6.0-98.4	1.6-94.0
		t-test	P=0.05	NS	NS	NS	NS	NS	NS	NS	NS
4,5,6 (7)	24.9	Mean	162	42.1	10.3	9.0	40.7	2.81	125.7	54.2	45.8
		SE	8.3	5.49	0.11	0.17	2.36	0.21	33.83	5.08	5.08
		Range	127-185	19.3-54.4	10.0-10.8	8.2-9.6	29.9-49.1	2.04-3.48	33.5-245.8	41.7-79.5	20.5-58.3
		t-test	NS	NS	NS	NS	P=0.05	NS	NS	P=0.05	P=0.05

2,5,6 (4)	9.0	Mean	152	28.2	10.3	9.1	32.9	2.44	38.3	33.1	66.9
		SE	8.1	3.55	0.18	0.15	0.58	0.20	6.61	11.30	11.30
		Range	133-	20.2-	9.8-	8.9-	31.5-	1.84-	26.1-	10.5-	46.7-
		t-test	168	36.8	10.6	9.5	33.9	2.72	53.9	54.3	80.5
			NS	NS	NS	NS	NS	NS	P=0.05	NS	NS
1,3,4,5,6 (3)	39.0	Mean	148	29.8	10.3	9.0	33.2	2.53	63.9	35.2	64.8
		SE	11.4	7.27	0	0.17	2.96	0.46	25.27	8.32	8.32
		Range	126-	15.3-	10.3	8.7-	27.4-	1.93-	32.3-	18.6-	55.6-
		t-test	164	37.9		9.3	37.0	3.44	113.9	44.4	81.4
			NS	NS	P=0.05	NS	NS	NS	NS	NS	NS
7 (1)	1.0	Value	142	29.1	9.8	9.0	33.7	2.22	48.2	37.0	63.0
Total	15.4	Mean	151	33.5	10.3	9.0	35.5	2.57	68.1	37.0	63.0
Infected**		SE	2.3	1.41	0.05	0.05	0.77	0.06	7.26	2.89	2.89
(51)		Range	126-	15.3-	9.4-	8.2-	27.3-	1.67-	18.8-	2.5-	1.6-
		t-test	202	59.4	11.3	10.1	49.1	3.55	245.8	98.4	97.5
			NS	NS	P=0.05	NS	NS	NS	NS	NS	NS

\* 1 - *Monogenea*

2 - *Opogaster minima*

3 - *Phyllostomum* sp.

4 - *Gaulastiana batrachii*

5 - *Boviana serialis*

6 - *Procammallanus clarius*

7 - *Philometra* sp.

NS = not significant

P = probability

SE = standard error of the mean

\*\* number of fish examined

in parentheses

PB = parasite burden

SL = fish standard length

Wt = fish weight

RCL = red cell length

RCW = red cell width

Ht = hematocrit

Lymph = lymphocytes

Neut = neutrophils

**Table 3. Blood Values in Different Groups of Parasitized *Ophicephalus striatus***  
(t-test between group with *Camallanus ophicephali* PB=5.4 and each of the other groups)

Parasite species	PB	Amplitude	SL (mm)	Wt (g)	RCL (um)	RCW (um)	Ht (%)	RBC (x10 <sup>6</sup> /mm <sup>3</sup> )	WBC (x10 <sup>3</sup> /mm <sup>3</sup> )	Lymph (%)	Neut (%)	
<i>Camallanus ophicephali</i> (10)	5.4	Mean	229	154.0	10.2	7.2	41.0	3.88	101.9	37.6	62.4	
		SE	9.0	19.95	0.10	0.07	1.14	0.10	23.16	6.22	6.22	
		Range	182-295	68.0-310.8	9.8-10.7	7.6	35.7-45.8	3.31-4.34	25.2-279.9	4.2-69.9	4.2-69.9	30.1-95.8
<i>Camallanus ophicephali</i> (6)	23.7	Mean	213	155	10.2	7.3	44.3	4.27	54.4	53.9	46.1	
		SE	4.9	32.24	0.07	0.14	1.44	0.21	11.61	7.54	7.54	
		Range	198-228	85.1-142.5	9.9-10.4	7.9	40.6-49.6	3.64-4.90	23.8-106.3	26.0-82.6	26.0-82.6	17.4-74.0
		t-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
<i>Camallanus ophicephali</i> , <i>Argulus indicus</i> (4)	11.0	Mean	217	131.4	10.2	7.1	42.0	3.96	53.3	70.3	29.7	
		SE	10.1	15.59	0.21	0.11	3.59	0.32	19.55	7.83	7.83	
		Range	191-238	94.8-161.0	9.8-10.6	6.9-7.4	33.8-51.1	3.32-4.63	18.1-88.3	54.0-91.6	54.0-91.6	8.4-46.0
		t-test	NS	NS	NS	NS	NS	NS	NS	NS	P=0.01	P=0.01
<i>Camallanus ophicephali</i> , <i>Diplostomulum</i> (2)	12.5	Mean	234	164.4	10.1	7.4	39.8	4.36	91.8	43.3	56.7	
		SE	4.5	5.75	0	0	1.65	0.20	16.85	18.48	18.48	
		Range	230-239	158.7-170.2	10.1	7.4	38.2-41.5	4.16-4.56	75.0-108.7	24.8-61.8	24.8-61.8	38.2-75.2
		t-test	NS	NS	NS	P=0.05	NS	NS	NS	NS	NS	NS
<i>Camallanus ophicephali</i> , <i>Lernaea cyprinacea</i> (1)	11.0	Mean	226	151.8	10.8	6.9	43.3	4.37	50.6	85.7	14.3	
		SE										
		Range										
		t-test										
Total infected*	16.2	Mean	220	133.8	10.2	7.2	42.8	4.15	79.2	56.5	43.5	
		SE	4.4	8.01	0.08	0.08	1.27	0.46	18.59	7.06	7.06	
		Range	191-239	85.1-170.2	9.8-10.8	6.9-7.9	33.8-51.1	3.32-4.90	18.1-106.3	24.8-91.6	24.8-91.6	8.4-75.2
		t-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

\*All infected fish except fish with less than 10 *C. ophicephali* (PB=5.4)





Table 5. Comparison of Blood Values of Uninfected and Helminth-Infected *Oreochromis niloticus*

Parasite species*	PB	Amplitude	SL (mm)	Wt (g)	RCL (um)	RCW (um)	Ht (um)	RBC (x10 <sup>6</sup> /mm <sup>3</sup> )	WBC (x10 <sup>3</sup> /mm <sup>3</sup> )	Lymp (%)	Neut (%)	
Uninfected (58)	0	Mean	110	47.7	11.5	7.9	32.7	2.51	18.0	72.0	28.0	
		SE	2.6	3.16	0.07	0.07	0.60	0.03	1.37	2.65	2.65	
		Range	62-150	8.3-114.2	10.4-13.0	6.6-9.2	21.9-43.3	1.89-3.09	4.1-49.4	4.1-85.3	14.7-96.0	4.0-85.3
T.laruei (14)	1.9	Mean	108	40.9	11.3	8.2	29.9	2.60	10.9	79.0*	21.0	
		SE	3.5	3.92	0.12	0.13	0.82	0.11	1.13	3.96	3.97	
		Range	85-136	24.1-84.0	10.6-12.0	7.3-9.1	24.9-34.9	1.74-3.22	6.2-19.7	6.2-46.9	53.1-99.1	0.93-46.9
		t-test	NS	NS	NS	P=0.05	P=0.01	NS	P=0.001	NS	NS	NS
Monogenea (11)	2.5	Mean	107	43.0	11.0	7.8	33.0	2.47	16.9	74.4	25.6	
		SE	4.5	4.93	0.14	0.21	1.37	0.10	2.59	4.88	4.88	
		Range	83-132	24.8-75.5	10.5-11.7	6.9-8.8	21.9-37.2	2.05-3.01	6.0-34.1	6.0-56.8	43.2-93.2	6.8-56.8
		t-test	NS	NS	P=0.01	NS	NS	NS	NS	NS	NS	NS
Total infected (25)	2.2	Mean	108	41.8	11.2	8.0	31.2	2.54	13.5	76.9	23.0	
		SE	2.7	3.03	0.09	0.12	0.80	0.07	1.41	4.88	3.06	
		Range	83-136	24.1-84.0	10.5-12.0	6.9-9.1	21.9-37.2	1.74-3.22	6.0-34.1	6.0-56.8	43.2-99.1	0.90-56.8
		t-test	NS	NS	P=0.05	NS	NS	NS	P=0.05	NS	NS	NS