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Incidence of *Lernaea cyprinacea* on Lake Malawi Kampango (*Bagrus meridionalis*)

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Abstract
The incidence of *Lernaea cyprinacea* on Lake Malawi Kampango *Bagrus meridionalis* was assessed. *B. meridionalis* specimens primarily from a research vessel called Ndunduma based at Monkey Bay Fisheries Research Station were used during the study. The study revealed that prevalence was distributed throughout the year with some peaks during cold and rainy season. A significant difference ($P<0.05$) on the preferred places of attack on the fish were noted during the study and the most common part of the fish to find *L. cyprinacea* were in the gills which contributed 77%, followed by an area around pectoral fin (13%) then around ventral fin (10%) and finally other places with negligible contribution. More than half (53%) of the sampled fish population were infected. Prevalence level was noted to increase with an increase in size of the host. There was no any significant effect ($P<0.001$) of the attacks on the *B. meridionalis*'s health as there was a strong correlation between length and weight of the infected fish. The study has reported the incidence of the *L. cyprinacea* on Lake Malawi *B. meridionalis* hence, a great need for further studies on various parameters associated with the infested *B. meridionalis*.

Keywords: *Bagrus meridionalis, Lernaea cyprinacea*, crustacean, ventral fin, length-weight relationship

1. Introduction
The Lake Malawi (09◦ 30' – 14 ◦ 40'S, 33◦50' – 33◦36'E, 472 m above sea level) with an approximate total area of 28, 800km^2 - 30, 800km^2 is the world's eighth largest fresh water body, [15, 21]. The lake which covers a total catchment area of 126, 500km^2 attains a maximum depth of 704-785m with a mean of 290-426m, [15]. Despite the small area, Lake Malawi is one of the water bodies with rich fish diversity and contributes about 14% of the world's fresh water fish and 4% of the total world fish diversity [21]. It is interesting to note that about 95% of Lake Malawi fish species are endemic to Malawi and no any other lake has more fish species than Lake Malawi [21].
Bagrus meridionalis locally known as Kampango is the only member of *Bagridae* family that occurs in Lake Malawi [7]. It is one of the largest fish species and is most commonly distributed, hence its presence in a variety of habitats [7]. *B. meridionalis* is a high value fish and as such it is a commercially important species to both rural and urban communities. Because of its wide spread and presence in a wide depth range, *B. meridionalis* is a target species for both small-scale and commercial fisheries [7, 20, 19]. Banda [1] reported continuous breeding behavior of *B. meridionalis* though a peak was reported to occur in November and December that coincided with the rainy season.
Lernaea cyprinacea (anchorworm) is an ectoparasite that belongs to the family of very small aquatic crustaceans and are very common on freshwater fishes [11]. They get their name from the shape of the head which resembles a ship's anchor. These are parasites that infect fish and one of the main problems with them is that they increase the susceptibility of the fish to other diseases. The worms burrow their heads into the bodies of fish. The most common places to find them are behind the pectoral fin or right behind the dorsal fin. Kabata [9] reported infestation in gill region of *Lernaeocera spp* and *Haemobaphes spp*. If the infestation is heavy, they can be found anywhere on the fish.
The parasite has elongated body which measures approximately 5-25mm long with two egg sacs at the rear end [6, 5]. They usually embed in the muscle of the body wall and often penetrate as far as the internal organs [9, 10]. A raised ulcer usually develops at the point of attachment, and secondary infections often occur at that site. Heavy infestations may cause weight loss and death through bacterial and fungal infections [11].

Male *L. cyprinacea* have a short life span and die after mating; hence, it is female *L. cyprinacea* that is parasitic to fish, [14]. Eggs hatch to produce free-living juvenile parasites, which eventually molt to produce adult stages [9, 10]. The juvenile stages can live without a host for at least five days.

1.1 Host-Pathogen-Environment relationship

Mostly, the relationship between host and parasite (pathogen) is always slanted towards the effects these relationships have on the host. Kabata [8] observed that this attitude is naturally influenced by the man's economic interest on the host and in this case the *B. meridionalis* which is regarded as a high value fish, is favoured. The truth of the matter is that the parasite is also greatly influenced by the host and as such it is not always a one-way traffic kind of arrangement. Shields and Goode [17], Shields and Tidd [18] and Kabata [8] all reported in favour of the parasite and demonstrated how different hosts influence the existence of their respective parasites. Nevertheless, this study has discussed the relationship in favour of the host for the same reason highlighted by Kabata [8].

Figure 1 shows the complex interrelationships of both biotic and abiotic factors that influence the natural mortality of the fish as a component to a total mortality.

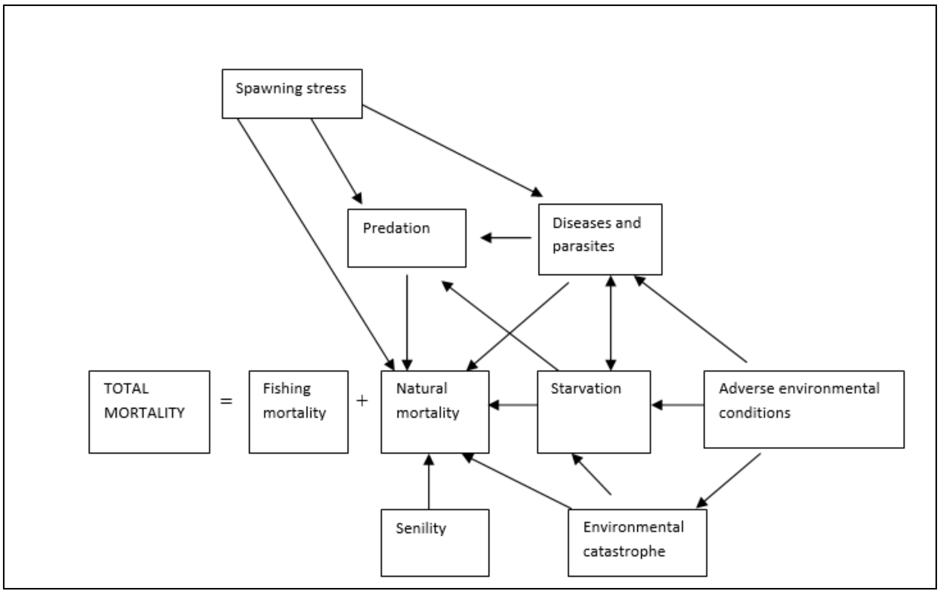

Fig 1: Fish diseases and parasites as contributing factors to mortality in the wild fish population (source: Modified from Moller and Anders,) [13]

The first description of a diseased fish, a deformed sea perch, according to Roberts [16] dates back to as early as 1613, and according to Moller and Anders [13] only a few additional reports were published during the following 250 years. This has been the case because the study of diseases and parasites of marine fish have been regarded mostly as curiosities, attracting only a few specialists. It is therefore of no surprise that little has been done and documented as regards to fish diseases and parasites of lakes and rivers of Malawi.

But considering the seriousness of the ectoparasite infestation coupled with the importance of the host fish species, it was felt that the need to assess the prevalence of the *L. cyprinacea* on *B. meridionalis* cannot be overemphasized. It is therefore the core objective of this study to assess and document the incidence of *L. cyprinacea* on Lake Malawi *B. meridionalis*

1.2 Objectives

Main Objective

Assess the incidence of *Lernaea cyprinacea* infestation on Lake Malawi *B. meridionalis*

Specific Objectives

- Establish the level of prevalence of *L. cyprinacea* on *B. meridionalis*
- Indicate specific areas on the body of the fish where the infestation occurs
- Determine the size range of *B. meridionalis* where the prevalence is the highest
- Determine the effect of the attack on the health status of *B. meridionalis*

2. Materials and Methods

Two types of data sources were used for this study and these included primary sources which involved onboard sampling and secondary sources where previous reports on parasitology of the lake and a grey literature review were used.

2.1 Primary data

A monthly onboard sampling took place in RV Ndunduma based at Monkey Fisheries Research Station. The study was also extended to other fishing vessels belonging to MALDECO Fisheries and other fishing companies and the sampling was being done the moment the vessels reached their respective landing sites. The targeted fish species, *B. meridionalis* was weighed with digital balance and subsequent total length measurements taken with a ruler.

The species were then closely observed for any possible signs of *L. cyprinacea* infestation and a technique recommended by Moller and Anders was applied. A magnifying glass was used to observe presence of *L. cyprinacea* on each individual fish. The presence of *L. cyprinacea* in different places on the body of the fish was followed by counting of a total number per individual fish.

2.2 Search from Literature

Literature from previous studies was used and these were gathered from the Fisheries Research Station library, internet and any other relevant sources.

3. Results

3.1 Distribution of infected *B. meridionalis*

The study which took place from January to December 2015 showed how the infected fish contributed to the total fish sampled. The results in the Figure 2 show that infestations occur throughout the year with a peak during the windy cold season from April to July. The infestation was highest in November but started declining in the subsequent four months.

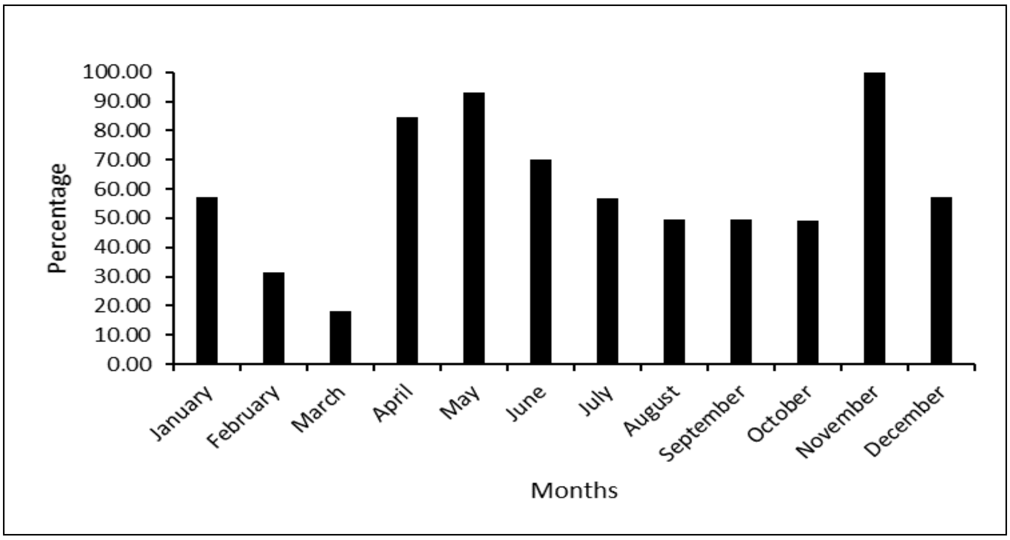

Fig 2: The Percentage distribution of *B. meridionalis* infected by the *L. cyprinacea*

3.2 Prevalence of *L. cyprinacea* in *B. meridionalis* population

Figure 3 shows the prevalence level of *L. cyprinaceas* on *B. meridionalis*. The results reveal that more than half of the sampled population was attacked by *L. cyprinaceas*. Figure 3 shows that 46% of the fish were free from the *L. cyprinacea* attack insinuating that 54% of *B. meridionalis* were infested.

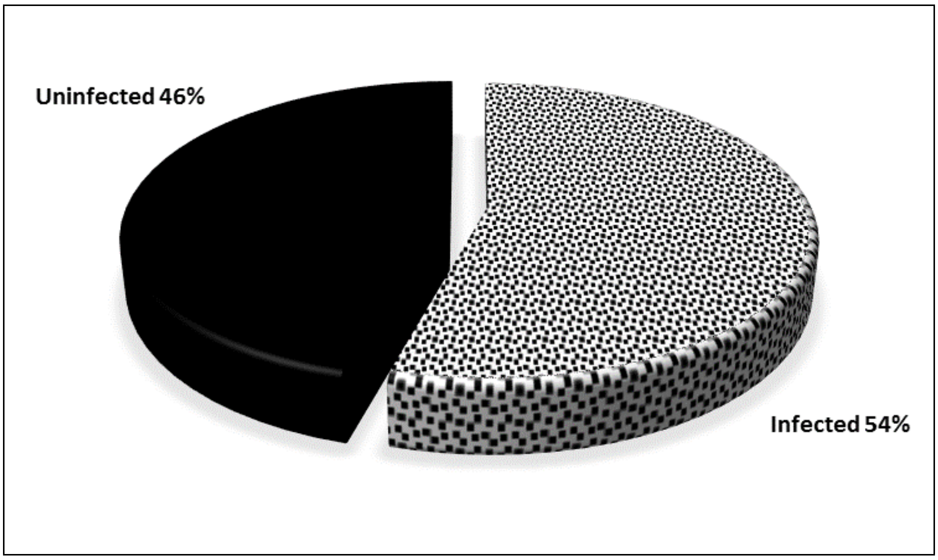

Fig 3: Prevalence of *L. cyprinaceas* in *B. meridionalis* sampled population

3.3 Distribution of *L. cyprinaceas* on the body of *B. meridionalis*

Figure 4 shows the distribution of *L. cyprinaceas* on individual fish. The figure indicates that the most likely place to find *L. cyprinaceas* on the fish is the gill since 77% of all the parasites were recorded in the gills. An area around pectoral fins and ventral fins recorded second and third highest numbers of *L. cyprinaceas* respectively registering 13 and 10%. The study according to Figure 4, revealed that areas other than gills, pectoral and ventral fins registered negligible numbers of *L. cyprinaceas*. The difference in the mean numbers on the body of the fish were however significant ($P<0.001$) for all the four different places and when the other three places were compared to gills using All Pairwise Multiple Comparison Procedures (Dunn's Method), their mean numbers were also statistically different ($P<0.05$).

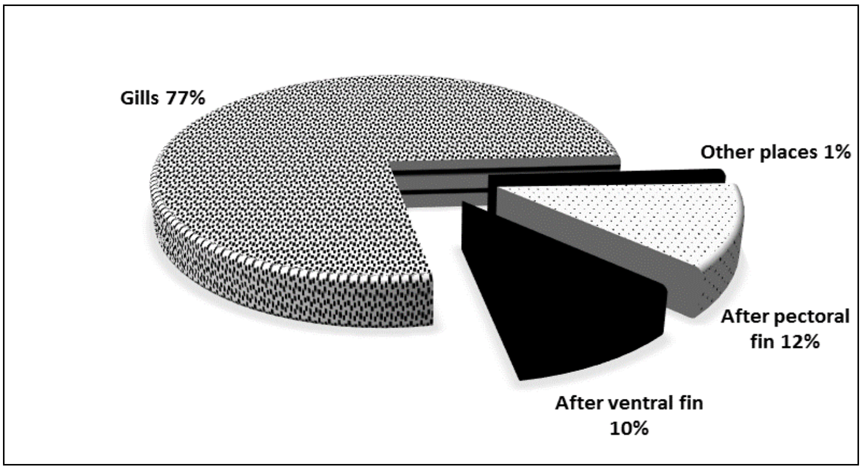

Fig 4: Distribution of *L. cyprinacea* on the body of *B. meridionalis*

3.4 Distribution of fish size against prevalence level

Different parasites prefer different sizes of host and in most cases young host would appear to be most vulnerable. The study looked at the distribution of fish sizes over the availability of *L. cyprinaceas*. Figure 5 shows that the prevalence level increases with an increase in fish size. The small *B. meridionalis* were less prone to attacks than big size *B. meridionalis* (Figure 5). The figure further shows that *B. meridionalis* were in abundance within a size range of 450-500mm but this did not tally with the number of *L. cyprinacea* attacks.

Despite what is shown in Figure 5 on the size distribution, a further analysis of the distribution of the infected fish indicates that the data failed Normality Test (Shapiro-Wilk) at (P<0.001).

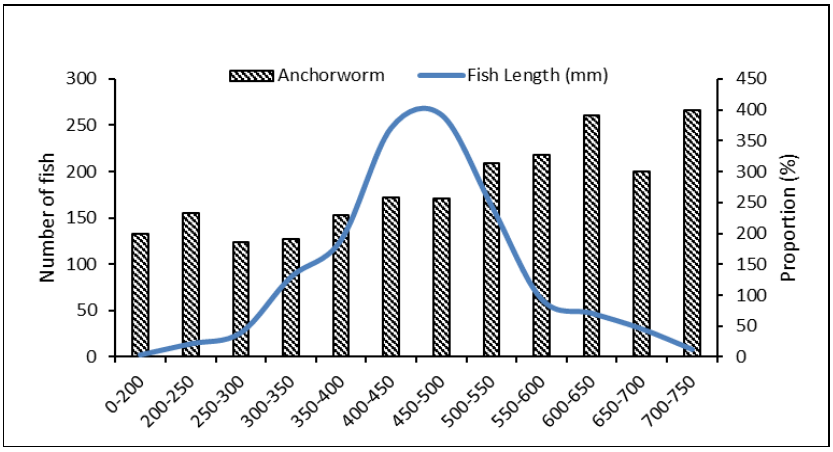

Fig 5: Prevalence level variations based on size differences

3.5 Length-Weight Relationship

The length-weight relationship has been used to measure the condition of the *B. meridionalis* affected by the *L. cyprinacea* and a statistical test was done. Figure 6 shows that there was strong and positive correlation between the length and the weight of the fish (R=0.734) and this correlation was significant (P<0.001).

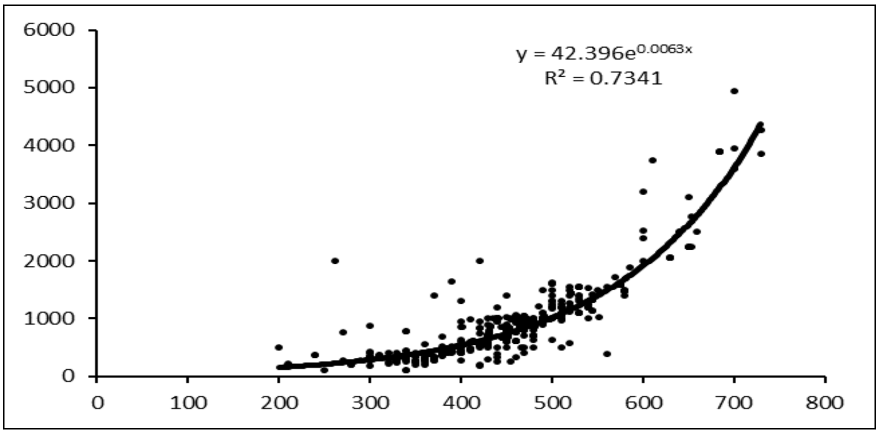

Fig 6: Correlation of length and weight data in infected *B. meridionalis*

4. Discussion

The study has revealed that *L. cyprinacea* attack *B. meridionalis* throughout the year with some peaks in cold months and rainy seasons. The research findings agree to Fryer [4]; Kabala [9] and Mbahinzireki [12]. The parasites are found throughout the year though their life span varies with water temperature. Fryer [4] reported that, *Lernaea* in Japan last about four weeks at 27 ºC and about five weeks at 22 ºC, but last longer during cold winter season as they can live for five to six months.

All parasites derive their energy from their host and therefore to some extent impair its efficiency. The need for the energy required depends on the life cycle of the parasite [4]. Studies have shown that while maintenance requirements of sedentary forms are very low, a copious egg production drains a considerable amount of energy on the host. This could justify the high percentage (53%) in Figure 3 of infested *B. meridionalis* as their efficiency in escaping from the oncoming gears could have been reduced. The results found by Mbahinzireki [12] indicate low occurrence in the cichlids studied that ranged from 5 to 10%. The high infestation rate of *L. cyprinacea* on *B. meridionalis* could also be attributed to the nature of the host skin though its host tolerance is very wide. *B. meridionalis* being scaleless becomes an easier target for parasites to attach or penetrate into their skin.

L. cyprinacea were found almost anywhere on the body of *B. meridionalis* and this is in agreement with what Fryer [4] reported that settlement of *L. cyprinacea* may be almost anywhere on the host. Despite being found anywhere on the body of *B. meridionalis*, Figure 4 indicates that over 75% of the parasites were observed in the gills and this should cause for concern as respiratory system is highly affected. Fryer [2] reported a dense presence of *L. cyprinacea* larvae on the gills of *Bagrus docmac* which served as an intermediate host for the parasite in Lake Victoria. Kabata [9] reported infestation of *Lernaeocera spp* and *Haemobaphes spp* in gill region but further indicated that if the infestation is heavy, they can be found anywhere on the fish. The preference for the gills could be attributed to the fact that the *L. cyprinacea* during free swimming stage are ingested together with water and then resort to attaching themselves to the gills when the host is releasing the water. Another reason for being found in abundance in the gills could be attributed to the shield provided by the gills over other places against some environmental forces e.g. water currents. Probably a more compelling reason is that gills provide an easy access to food circulating with the blood. Although Fryer [2] did not indicate the infection sites on *Haplochromines* spp. he noted that the parasite showed a marked predilection for jaws of tilapines where up to 66 specimens were found on a single host. The parasites were rarely found on the flanks of the hosts and this is in strong agreement with findings of this study where only 27% of the parasites were found in places other than the gills and fewer in the flanks of the host.

The study further determined the size distribution of *B. meridionalis* against the presence of *L. cyprinacea*. Researchers are not very sure whether fish size plays any role in the parasitization process. The study has observed that presence of *L. cyprinacea* increases with size in the *B. meridionalis*. The study has revealed that small size *B. meridionalis* are less vulnerable to *L. cyprinacea* than very big sizes. Similar findings were also reported by Fryer [3]. He anticipated that chances of invading small fish like *Haplochromis* spp. which rarely exceed 150mm were very slim compared to tilapines whose size may reach up to 350mm in length. Most probably the bigger size provides more surface area for invansion. Fryer [2] found that *Lernaea barnimiana* were extremely numerous on *B. altinalis* of 250mm in length in the Victoria Nile but rare on fishes below that size and even when they were infested, the copepods burden was always very low.

It has already been reported that the study data failed Normality Test (Shapiro-Wilk). This indicates that the data varied significantly from the pattern expected if the data was drawn from a population with a normal distribution. The failure is solely attributed to the trawl net's size selectivity to the fish. The bottom trawl net pulled by RV Ndunduma is highly selective with its 38mm cod-end meshsize as such it was very unlikely to find small *B. meridionalis* in the catch hence, the population sampled being not normally distributed.

There was a strong and positive correlation between the length and the weight of the infested fish. This shows that the effect of the *L. cyprinacea* on the fish cannot have immediate effects of the health of the host. The effects can however, negatively affect consumer preference basing on severity of the attack.

5. Conclusion

The study has reported the presence of *L. cyprinacea* in *B. meridionalis* species and further revealed the most likely part of the fish where these parasites are in abundance. It has also highlighted the prevalence level of the parasites to the *B. meridionalis* population where more than half of the population sampled appears to be infected. The study went further to analyse prevalence level in different sizes of the fish and showed that prevalence level increases with an increase in the size of the host. The presence of *L. cyprinacea* has revealed to have little immediate impact on the health of the host, *B. meridionalis.* All in all, the study has updated and increased the knowledge base in as far as pathology of Lake Malawi is concerned.

6. Acknowledgement

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