Determination of Seasonal Occurrence of *Camallanus sp.* and *Ligula intestinalis* on Fresh Usipa, *Engraulicypris sardella* from Selected Mzuzu Markets, Malawi

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Abstract This study assessed the seasonality of two parasites, *Camallanus sp.* and *Ligula intestinalis* on fresh *E. sardella* from selected Mzuzu markets in Malawi. Samples were collected during the cold, dry and rainy seasons and the determination of the parasites was conducted by quantification of prevalence rates and mean intensities of the parasites during the three seasons. These parasites were located in gills and the gastrointestinal cavity respectively. No parasites were observed during the cold season. A total of 46 parasites were observed during the dry season and 28 parasites were observed during the rainy season out of two hundred samples per season. The prevalence rates for the cold, dry and rainy seasons were 0%, 21% and 13% respectively and corresponding mean intensities of 0, 1.1 and 1.08 respectively. The study revealed seasonal variations of prevalence rates and the mean intensities of the parasites. The cold season registered the lowest prevalence rate and mean intensity. These findings indicate a strong interaction of parasite with the environment, the host fish and other fish behavioural factors such as feeding and foraging. The findings suggest that the proliferation of some parasites in *E. sardella* is influenced by ecological dynamics of the habitats as well as the seasonal variations.

Keywords *Ligula intestinalis*; *Camallanus sp.*; Prevalence rates; Mean intensity; Seasonal variations

Background
Parasitism is the relationship between organisms in which the parasite benefits at the expense of the host organism (Roberts and Janovy, 2005) and it is a common phenomenon in most ecological systems (Madanire-Moyo and Barson, 2010). Fish may be final or intermediate hosts of the parasites like cestodes (Sharma, 2016) with intensity of infection varying from one species to another due to physiological and ecological differences (Nimbalkar et al., 2010). The presence of parasites debilitates the fish and affects their quality leading to economic losses on the market (Bhuiyan et al., 2007; Maguza-Tembo and Mfitilodze, 2008; Sumuduni et al., 2015). Khurshid and Ahmad (2012) attribute the severity of the parasite infection to climate of a particular area. The fish under study, *E. sardella* have a fast growing short-life history pattern, endemic to Lake Malawi and spawns throughout the year mainly during the rainy season (Maguza-Tembo et al., 2009). Although some study was conducted on *Ligula intestinalis* infection in *E. sardella* in southern Lake Malawi by (Rusuwa et al., 2014), no work has been done on the parasitic fauna of *E. sardella* that is sold in Mzuzu city from northern Lake Malawi in relation to seasonal population dynamics. Cestodes, *L. intestinalis* cause ligulosis in humans if they are infected when they consume raw or undercooked fish meat (Urdes and Hangang, 2013; Ahmadiara, 2017). Therefore, this study was conducted to determine the parasitic load of fresh *E. sardella* in relation to different seasons of the year with focus on the prevalence rate and the mean intensity of the identified parasite species.

1 Materials and Methods
1.1 Study area and sample collection
The study took place in the city of Mzuzu which has three distinct seasons namely, cold (June and July), dry (October and November) and rainy (January and February). A total of two hundred fish were collected during each season randomly from the selected markets shown in Figure 1. They were taken fresh to the laboratory for examination.
1.2 Fish examination and parasite identification

Specimen preparation and examination were done following procedures by Akinsanya et al. (2007), Biu et al. (2014), Sumuduni et al. (2015) and Edeh and Solomon (2016) while parasites identification were done according to Parpena (1996), Klinger and Floyd (2002) and Poudet et al. (2005).

The skin, gills, internal parts, the eye and the gastrointestinal cavity were examined by scraping using a scalpel. Dissecting and compound microscopes up to 400× magnification were used to examine the specimen on the slides. The recovered parasites were preserved in 70% ethanol for further identification.

Skin scrape was put on the slide with water drop added and examined under the compound microscope. The eye and the intestines were dissected and contents mounted on the microscope for observation. Gill and heart tissues were also placed on the slide for examination while bigger parasites were removed using forceps and identified. The parasites species and location in the host species were recorded.

The calculations of prevalence rate and mean intensity were done according to Ezenwanji et al. (2005), as follows:

\[
\text{Prevalence rate} = \frac{\text{Number of fish infected}}{\text{Number of fish examined}} \times 100\%
\]

\[
\text{Mean intensity} = \frac{\text{Total number of parasites}}{\text{Number of fish infested}}
\]
1.3 Data analysis
The data obtained from the parasitic load determination was analyzed by F-test using SPSS statistical package version 16.0 at 5% level of significance. Tukey HSD and Bonferroni Post Hoc multiple comparisons tests were also conducted to verify the significance of the differences.

2 Results
The parasitic loads for the cold, dry and rainy seasons were determined. Seasonal variations on the parasitic load were noted during the study period. Out of the two hundred sampled fish per season, only two classes of parasites were observed. These are presented in the Table 1.

| Parasite Class | Parasite Species | Site Located       |
|---------------|-----------------|--------------------|
| Nematoda      | *Camallanus sp.* | Gills              |
| Cestoda       | *Ligula intestinalis* | Gastrointestinal cavity |

The two classes of parasites identified in *E. sardella* during the three seasons were cestoda and nematoda. The cestoda species identified was *Ligula intestinalis* and the species of nematoda identified was the *Camallanus sp.* *Ligula intestinalis* parasites were observed in the gastrointestinal cavity while the *Camallanus sp.* parasites were observed on the gills. *Ligula intestinalis* parasites are shown in the Figure 2.

![Figure 2 Ligula intestinalis parasites from E. sardella gastrointestinal cavity](image)

The seasonal parasitic loads are shown in the Table 2

| Season       | Cestoda | Nematoda | Total |
|--------------|---------|----------|-------|
| Cold season  | 0       | 0        | 0     |
| Dry season   | 40      | 6        | 46    |
| Rainy season | 25      | 3        | 28    |
| Total        | 65      | 9        | 74    |

Out of the two hundred sampled fish per season, no parasites were observed during the cold season. Instead, parasites were observed during the dry and the rainy seasons. A total of 46 parasites were observed during the dry season and a total of 28 parasites were observed during the rainy season. Out of the 46 parasites observed during the dry season, 40 parasites were cestoda and 6 were nematoda. During the rainy season, 25 parasites were cestoda and 3 were nematoda. This entails that 86.96% and 13.04% of the recovered parasites during the dry season were cestoda and nematoda respectively. During the rainy season, cestoda comprised of 89.21% and nematoda comprised of 10.79% of the total for the season. A total of 65 cestoda and 9 nematoda were recovered during all
the three seasons. Therefore, 74 parasites were observed in total over the study period. The analysis of variance (F test) showed that the effect of seasons on the prevalence of the parasites was significant, $F (2, 597) = 24.04$, ($p<0.05$). The prevalence rates of the observed parasites during the three seasons are shown in the Figure 3.

![Figure 3 The prevalence rates of parasites during the cold, dry and rainy seasons](image)

The lowest prevalence rate was observed during the cold season. The prevalence rate for the cold season was 0% for the parasites targeted by the study. On the other hand, the highest prevalence rate of 21% was noted during the dry season indicating high infection rate during that time of the year. The rainy season registered a prevalence rate of 13%. This indicates that parasites were also observed during the rainy season in fresh *E. sardella* species. The seasonal changes also showed variations in the mean intensity of the parasites in fresh *E. sardella*. Figure 4 shows the mean intensities of the parasites during the study period.

![Figure 4 The mean intensity of parasites during the cold, dry and rainy seasons](image)

The cold season had mean intensity of 0 while the dry season had a mean intensity of 1.1. The rainy season had a mean intensity of 1.08 which is almost the same as the dry season. Finally, multiple comparisons tests using the Tukey’s HSD and Bonferroni criteria for significance indicated that the differences of the parasitic loads among the seasons were statistically significant. The pair-wise comparisons of the parasitic loads were significant ($p<0.05$).
3 Discussion

The study indicated that seasonal variations had an effect on parasitism. Although the sample size was limited, the total number of parasites, prevalence rate and mean intensity varied across the three seasons of the study. The results observed in the study indicated that the cold season registered the lowest number of parasites while the dry season registered the highest number of parasites. The observations agreed with the findings of Ali et al. (2010) and Ahmad and Ahmad (2013). They reported similar results of higher prevalence rate in summer and lowest in winter. Ahmad and Ahmad (2013) reported highest infection levels in summer months and least infection levels in winter months for helminths parasites in Schizothorax species (S. plagiostomus, S. labiatus, S. ecosinus, S. curvifrons) in Shallabugh Wetland. Khurshid and Ahmad (2012) also observed higher prevalence rate of fish parasites in summer and least in winter in some species of Schizothorax from River Sindh in their study. Koyn (2012) supported the trend that some species of helminths parasites had highest prevalence during different seasons of the year. Fish are hosts to different parasites whose diversity, strategy and abundance depends on several factors including seasonality (Violente-Gonzalez et al. 2008; Neves et al. 2013) while parasites also respond to the seasonal changes of the environment (Yufa and Tingbao, 2011). In contrast, Khanum et al. (2011) reported that parasites were more abundant during the rainy season and lowest during the winter season. Sinare et al. (2016), observed a higher prevalence rate in rainy season as compared to the dry season. According to Poulin (2004) biotic factors such as body size of the host, population density, social behaviours, lifespan, biogeography and diet, and abiotic factors such as temperature, size and geographical range are responsible for the changes in the prevalence and mean intensity of the parasites, Iyaji et al. (2009) observed that as much as the chemical and the physical factors affect the cycles of the organisms, the biotic factors were the ones that mainly affected the prevalence and the abundance of the parasites. According to Khanum et al. (2011), the lower rate of parasite infection during the cold season could be due to reduced feeding tendency of the host fish. On the other hand, Ali et al. (2010) observed that during summer and autumn, the higher incidence could be due to the rise in the temperature that resulted in favouring the development of the larvae in the secondary host. This suggests that the seasonal fluctuations of the parasites may be due to temperature changes, availability of the intermediate host and the host feeding behaviours. In the winter, the low prevalence rates were due to low availability consumption of the intermediate hosts (Ali et al., 2010). Additionally, Dash (2015) highlighted that most parasites had seasonal cycles that were definite and were influenced by the seasonal changes that affected the environment and the physiology of the host fish. Observations by Ibiwoye et al. (2004) revealed that during the dry season evaporation led to reduced water volume, which in turn, resulted in the contraction of the habitat thereby increasing the densities of the host and the parasites. Consequently it resulted in more contact between the host and the parasite. Therefore this could result in the higher infection during the dry season. The increase of the parasites during the rainy season was attributed to rainfall, flood and reduced immunity of the hosts and prevalence of the insects that had an impact on the water bodies (Nhiwatiwa et al., 2009; Khanum et al., 2011). Similarly, the exchange of materials between the terrestrial and the aquatic ecosystems affect the quantities of substances and physical chemical aspects of the water bodies (Affonso et al., 2011). Sumuduni et al. (2015) suggested that slow moving fish were more susceptible to parasites than the fast moving fish while Munoz and Cribb (2005) reported that larger hosts had higher parasites load than the smaller hosts. Therefore by taking in more food and having more space, chances of infection were also high.

Koiri and Roy (2016) reported significant differences in the helminths (cestodes, nematodes and trematodes) loads during different seasons of their study. They observed the highest number of cestodes, followed by nematodes and lastly the trematodes. Bhure et al (2016) also observed highest number in cestodes in Channa punctatus species. On the contrary, Khurshid and Ahmad (2012) recorded the highest number of trematodes followed by cestodes with no nematodes. This suggests that different attributes could favour different parasite species proliferation. Maguza-Tembo and Mitilodze (2008) observed the highest number of cestodes in the buccal cavity and coelomic cavity of Clarias gariepinus than in the other species of fish under study. This suggests that some species of fish could be vulnerable to some specific species of parasites. Dash et al. (2015) suggest that this could be due to host specificity nature of the species of parasites while Koiri and Roy (2017) maintain that seasons interfere with the physiology and ecology of the fish and in turn it has influence over the rate of parasitic infections.
The recruitment process of the parasitic fauna of *E. sardella* in the study was dominated by cestodes. According to Rusuwa et al. (2014), the cestodes were identified as *Ligula intestinalis*. The present study indicated that *Ligula intestinalis* (cestodes) and *Camallanus sp.* (nematodes) identified in the fresh *E. sardella* were common during the dry season and the rainy season. The cold season registered no prevalence of the parasites. Barson and Marshall (2003) observed the prevalence of *L. intestinalis* in *Barbus paludinosus* with no clear seasonal variations but suggested that the dry season had an effect on the prevalence. This is in agreement with the results of the present study which show no prevalence of parasites during the cold season and higher prevalence during the dry season. In contrast to the findings of the study, Anarse et al. (2011) reported no prevalence of cestodes during the rainy season but prevalence in the cold season and summer with the highest prevalence rate. Wetzel (2001) attributes the prevalence of *L. Intestinalis* to an increase in number of copepods which are numerous in stagnant than in running water bodies while Anarse et al. (2011) attributes the prevalence to temperatures that facilitate the hatching of the eggs. Copepods are intermediate hosts of *L. intestinalis* (Piasecki et al., 2004) while the larvae of *Camallanus sp.* are secreted into the water with the fish faeces and ingested by copepods or other crustaceans which are eaten by the other fish hosts where the larvae develops into a full adult (Yanong, 2006). On the other hand, Dejen et al. (2006) reported that during the rainy season the infection reduced due to increased turbidity that decreased the feeding efficiency on the zooplankton. They observed that the infection rate in *Barbus humilis* was high in the clear water than in the shallow turbid water. This implies that habitat changes have some significant effect on the infection rate of the fish. This could be the case because the piscivorous birds could predate more efficiently on the fish in shallow and clear waters than in the turbid and deep waters. Sharma (2016) reported the prevalence of three cestodes parasites in the intestines of freshwater fish, *Channa punctatus* with the highest infection in summer season, followed by winter and lowest in monsoon. Rusuwa et al. (2014) reported the infection of *L. intestinalis* throughout the year. This is contrary with the findings of this study where there is no infection observed during the cold season. *E. sardella* is an endemic species in Lake Malawi and breeds (spawns) throughout the year (Morioka and Kaunda, 2004). Therefore the difference between the findings of this study and that of Rusuwa et al. (2014) on the prevalence of *L. intestinalis* during the cold season could emanate from other factors like; feeding, habitat type, presence of the intermediate hosts and other environmental factors, such as temperatures, turbidity and depth of the water body. The study showed that fish were infected with large numbers of parasites in the latter part of the cold season to end of the dry season. Since most helminths parasites utilize the food chain for their transmission (Dejen et al. 2006), the differences in the prevalence rate of the parasites could be due to difference in habitat, food supply for both the intermediate host and aquatic piscivorous birds that play an important role in the completion of the life cycle of the parasites (Ibrahim and Soliman, 2010). According to Piasecki et al. (2004), the main food of *E. sardella* in the lake are zooplankton, which act as intermediate hosts of *L. intestinalis*. Proceroid larvae in copepod develop into plerocercoid in the fish abdominal cavity (Loot et al., 2006). Therefore the fluctuations in the abundance of the zooplankton could also affect the prevalence rate of the *L. intestinalis* during the different seasons of the year among other factors. The fact that the study reveals the presence of *Ligula intestinalis* should be a cause of concern in public health because it may result in the prevalence of ligulosis in humans. There are reports of human infestation with *Ligula intestinalis* (Barson and Marshall, 2003; Urdes and Hangan, 2013). This entails that if *E. sardella* is not handled properly, humans could be affected by the parasite. However, Ljubojevic et al. (2015) emphasized that the most important risk factor for the spread of the fish-borne parasitic zoonoses is the consumption of raw and undercooked fish meat. This suggests that proper preparation of *E. sardella* which host the parasite could help avert the dangers posed by the parasite.

4 Conclusion and Recommendations

The study rejected the null hypothesis on the seasonal parasitic load in *E. sardella*. The results indicated seasonal variations in the prevalence rates of the parasites in the fresh *E. sardella*. The dry season had the highest prevalence rate followed by the rainy season and lastly the cold season. The study indicated a strong interaction of the parasites with the environment, the host fish and other factors that have some bearing on the cycles of the parasites. Finally, the study indicated that water parameters, variations in fish behaviour, seasonal variations and effective parasite stages were some of the contributing factors to the proliferation of the parasites. This study
recommends the need to investigate the specific factors that have a major influence on the occurrence of parasites in *E. sardella* in different locations during different seasons of the year. Therefore, further studies on different ecological aspects in different locations are essential.

**Authors’ contributions**

The authors were involved in the design of the research, analysis and interpretation of the data as well as the critical revision for important intellectual content and final approval of the version to be published. Therefore the authors are accountable for the aspects of the work published. All authors read and approved the final manuscript.

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**References**

Alfonso A.G., Barbose C., and Novo E.M.L.M., 2011, Water quality changes in flood plain lakes due to the Amazonas River flood pulse: Lago Grande de Curuai (Para), Brazilian Journal of Biology, 71:601-610  
https://doi.org/10.1590/S1519-69842011000400004  
PMID: 21881783

Ahmadiara E., 2017, Is *Ligula intestinalis* really a probable threat to public health? Journal of Food Quality and Hazards Control, 4: 36  
http://www.oajg.net/article/2017/169-1498542717.pdf

Akinsanya B., Otubanjo O.A., and Hassan A.A., 2007, Helminth parasites of *Malapterurus electricus* (Malapteruridae) from Lekki Lagoon, Lagos, Nigerian Journal of American Science, 3(3): 1-5  
http://www.jofamericanscience.org/journals/am-sci/0303/02-0268-Akinsanya-MALAPTERURUS-am-0303.pdf

Ali M.N., Nasir S., Gannaie H.A., Muzaffar G., and Chishti M.Z., 2010, Prevalence studies of parasite *Pomphorhynochus kashmirensis* in local fish species *Schizothorax*, European Scientific Journal, 8(30): 197-209  
http://eujournal.org/index.php/esj/article/view/668

Anarse S., Jawale S., and Borde S., 2011, Population dynamics of *c*estode parasites in *Trygon zugei* from Ratnagiri District (*M*.), India, International Multidisciplinary Research Journal, 1(8):24-26  
http://updatepublishing.com/journal/index.php/imrj/article/view/1504

Barson M., and Marshall B.E., 2003, The occurrence of tapeworms, *Ligula intestinalis* (L) in *Barbus Paludinus* from a small dam in Zimbabwe, African Journal of Aquatic Science, 28(2): 1-4  
https://doi.org/10.2989/16085910309503782

Bhuiany A.S., Akthor S., and Musa G.M., 2007, Occurrence of parasites in *Labeo rohita* (Hamilton) from Rajashahi, University Journal of Zoology, Rajashahi University, 26: 31-34  
http://dx.doi.org/10.3329/ujzru.v26i0.694

Bhure D.B., and Nanware S.S., and Jadhav A.N., 2016, Prevalence and diversity of cestode parasites of freshwater fishes of genus *Channa Scopoli*, World Scientific News, WSN 33: 15-26  
http://www.worldscientificnews.com/wp-content/uploads/2015/10/wsn-33-2016-15-26.pdf

Biu A.A., Diyaawere M.Y., Yakaka W., and Rita D.J., 2014, Incidence of parasites of *Apatosomum* (Hamilton) from Rajashahi, University Journal of Zoology, Rajashahi University, 26: 31-34  
http://dx.doi.org/10.3329/ujzru.v26i0.694

Dash G., Majunder D., and Raghu R.K., 2015, Seasonal distribution of parasites in fresh water exotic carps of West Bengal, India, Indian Journal of Animal Research, 49(1): 95-102  
https://doi.org/10.5956/0076-0555.2015.00020.5

Dejen E., Vijverberg J., and Sibbing F.A., 2006, Spatial and temporal variation of cestodes infection and its effects on two small barbs (*Barbus humilis* and *B. tanapelaicus*) in Lake Tana, Ethiopia, Hydrobiologia, 556:109-117  
https://doi.org/10.1007/s10750-005-1187-0

Edede C., and Solomon R.J., 2016, Endoparasites of *Oreochromis niloticus* and *Clarias gariepinus* found in Utako flowing gutter, Direct Research Journal of Agriculture and Food Sciences, 4(12): 361-373  
http://directresearchpublisher.org/wp-content/uploads/2017/01/Edede-and-Solomon.pdf

Ezenwanji N.E., Agunwode J.N., Phillip C.O., and Ezenwanji H.M.G., 2005, Helminths endoparasites of *Mochokids* in a tropical rainforest river system, Animal Research International, 2(2): 346-352  
http://www.researchmate.net/publication/274156257_Helminth

Eziwowe T.I.I., Balogun A.M., Ogunrusi R.A., and Agbontale J.J., 2004, Determination of the infection densities of mudfish *Eustrongylides* in *Clarias gariepinus* and *C. anguillaris* from Bida flood plain of Nigeria, Journal of Applied Science and Environmental Management, 8(2): 39-44  
http://www.bioline.org.br/request?id=04022
Ibrahim M.M., and Soliman M.F.M., 2010, Prevalence and site preferences of heterophyid metacercariae in Tilapia zilli from Ismailia fresh water canal, Egypt Parasite, 17: 233-239

https://doi.org/10.1051/parasite/201017323

PMid: 21073146

Iyaji O.E., Ehim L., and Eyo J.E., 2009, Parasites assemblage in fish hosts, Bio-Research, 7(2): 561-570

http://dx.doi.org/10.4314/br.v7i2.56606

Khunum H., Begum S., and Begum A., 2011, Seasonal prevalence, intensity and organal distribution of Helminth parasites in Macrornathus aculeatus, Dakar-University Journal of Biological Sciences, 20(2): 117-122

https://doi.org/10.3329/djubs.v2002.8971

Kharshid I., and Ahmad F., 2012, Gastro intestinal helminths infection in fish relative to season from Shallobuch Wetland, International Journal of Recent Scientific Research, 3(4): 270-272

http://recentscientific.com/sites/default/files/Download_193.pdf

Klinger R.E., and Floyd R.F., 2002, Introduction to freshwater fish parasites, Institute of Food and Agricultural Sciences Extension, University of Florida, IFAS Extension

http://www.researchgate.net/publication/255682572

Koiti R., and Roy B., 2016, The season incidence of parasitic Helminth infection among the walking catfish, Clarias gariepinus of Tripura, India, Annals of Parasitology, 62(4): 307-314

http://dx.doi.org/10.17420/ap6204.66

PMid: 28170203

Koiti R., and Roy B., 2016, Spectrum of Helminth parasites infecting some edible fishes of Tripura, Imperial Journal of Interdisciplinary Research (UIR), 3(1): 974-978

http://www.onlinejournal.in/IJIRV3I1/172.pdf

Koyun M., 2012, The occurrence of parasitic Helminth of Capeata umbla in relation to seasons, host size, age and gender of the host in Murat River, Turkey, Journal of Animal and Veterinary Advances, 11(5): 609-614

https://doi.org/10.1017/S0022149X05890496

Ljubojevic D., Novakov N., Djordjevic V., Radosavljevic V., Pelic M., and Cirkovic M., 2015, Potential parasitic hazards for humans in fish meat, Procedia Food Science, 5: 172-175

https://doi.org/10.1016/j.profo.2015.09.049

Loot G., Young-Seuk P., Lek S., and Brosse S., 2006, Encounter rate between local populations shapes host selection in complex parasite life cycle, Biological Journal of the Linnean Society, 89: 99-106

https://doi.org/10.1111/j.1095-2649.2006.00661.x

Madañire-Moyo G., and Barson M., 2010, Diversity of metazoan parasites of the African catfish, Clarias gariepinus (Burchell, 1822) as indicators of pollution in a subtropical African river system, Journal of Helminthology, 84: 216-227

https://doi.org/10.1017/S0017563609990363

PMid: 19761628

Maguza-Tembo F., and Mbitildedzwe M.W., 2008, Occurrence (incidence) of parasites in three fish species (Clarias gariepinus, Oreochromis shiranus and Haplochromis) from Bunda reservoir, Bunda Journal of Agriculture, Environmental Science and Technology, 3:3-7

http://www.academicjournals.org/article137975924_salawu

Maguza-Tembo F., Palsson O.K., and Msiska O.V. 2009, Growth and exploitation of Engraulicypris sardella in the light attraction fishery of Southern Lake Malawi, Malawi Journal of Aquaculture and Fisheries, 1: 6-12

https://www.cabi.org/gara/FullTextPDF/2009/20093200509.pdf

Moriska S., and Kaunda E., 2004, Preliminary examination of the growth of Mpas, Opsaridium microlepis (Gunther, 1864) (Teleostomi: Cyprinidae), younger than one year old, collected from Lake Malawi, African Zoology, 39(1): 13-18

http://hdl.handle.net/10520/EJC17915

Mu-oz G., and Cribb T.H., 2005, Infracommunity structure of parasites of Hemigrammus melapterus (Pisces: Labridae) from Lizard Island, Australia: the importance of habitat and parasites body size, Journal of Parasitology, 91(1): 38-44

https://doi.org/10.1645/GE-3321

PMid: 15858689

Neves L.R., Pereira F.B., Tavares-Dias M., and Lague J.L., 2013, Seasonal influence on the parasites fauna of a wild population of Astromotus ocellatus (Perciformes: Cichlidae) from the Brazilian Amazon, Journal of Parasitology, 99: 718-721

https://doi.org/10.1645/12-84.1

PMid: 23421456

Nishiwatiwa T., Bie T.D., Vervaee B., Barson M., Stevens M., Van-hove M.P.M., and Brendonck L., 2009, Invertebrate communities in dry-seasonal pools of a large sub topical river patterns and processes, Hydrobiologia, 630: 169-186

https://doi.org/10.1007/s10750-009-9790-0
Nimbalkar R.K., Shide S.S., Tawar D.S., and Nale V.B., 2010, A survey on helminths parasites of fishes from Jaikawadi Dam, Maharashtra State of India, Journal of Ecobiotechnology, 2: 38-41
http://updatelpublishing.com/journal/index.php/jebt/article/view/91/90

Parpena I., 1996, Parasites, infections and diseases of fishes in Africa, An update. CIFa Technical paper No. 31, Food and Agriculture Organization, Rome, pp.220
http://www.fao.org/docrep/1008/v9551e/V9551E100.HTM

Piascik W., Goodwin A.E., Eiras J.C., and Nowak B.F., 2004, Importance of Copepoda in freshwater aquaculture, Zoological Studies, 43: 193-205
http://zoolstud.sinica.edu.tw/Journals/43.2/193.pdf

Pouder D.B., Curtis E.W., and Yanong R.P.E., 2005, Common freshwater fish parasites pictorial guide, Institute of Food and Agricultural Sciences, University of Florida
PMid: 16475524

Poulin R., 2004, Macro ecological patterns of species richness in parasite assemblages, Basic and Applied Ecology, 5: 423-434
https://doi.org/10.1016/j.baae.2004.08.003

Roberts C.R., and Janovy J., 2005, Foundation of Parasitology (7th Edition) McGraw-Hill, New York, USA
http://www.searchgate.net/publication/279878660/title/Foundations

Rusuwa B., Ngochera M., and Maruyama A., 2014, Ligula intestinalis (Cestoda: Pseudophyllidea) Infection of Engraulicypris sardella (Pisces: Cyprinidae) in Lake Malawi, Malawi Journal of Science and Technology, 10(1):8014
http://www.aioil.info/index.php/mjst/article/download/10586595868

Sharma B., 2016, Studies on prevalence of cestodes parasite in freshwater fish, Channapunctatus from Meerat (Uttarpradesh) India, Journal of Applied and Natural Science, 8(1): 485-488
https://journals.ansfoundation.org/index.php/jans/article/view/822

Sinarĕ Y., Boungou M., Ouĕda A., Gnĕmĕ A., and Kabrĕ G.B., 2016, Diversity and seasonal distribution of parasites of Oreochromis niloticus in semi-arid reservoirs (West Africa, Burkina Faso), African Journal of Agricultural Research, 11(13): 1164-1170
https://doi.org/10.5897/AJAR2015.10408

Sumuduni B.G.D., Munashaghe D.H.N., Chandrarathna W.P.R., Des S., and Amarasinghe N.J., 2015, Seasonal variation and site specificity of external parasites in gold fish (Carassius auratus L.) and Koi carp (Cyprinus carpio L.) in Rambadagalle Ornamental Fish Breeding Centre, Sri Lanka, Ruhuna Journal of Science, 6:13-20
http://paravi.ruh.ac.lk/rtj/index.php/rtj/article/view/79

Urdes L., and Hangan M., 2013, The epidemiology of Ligula intestinalis (Phylum Platyhelminthes) within the Cyprinidae populations inhabiting the Danubian Delta Area, Animal Science and Biotechnologies, 46(1): 273-276
http://www.spasb.ro/index.php/spasb/article/view/55

Violante-González J., Rojas-Herrera A., and Aguirre-Macedo M.L., 2008, Seasonal patterns in metazoan parasite community of the ‘fat sleeper’ Dorminator Latifrons (Pisces: Electodidae) from Tres Palos Lagoon, Guerrero, Mexico. Revista de Biologia Tropical, 56: 1429-1427
http://www.scielo.sa.cr/pdf/rbt/v56n3/art34v56n3.pdf

Wetzel R.G., 2001, Limnology: Lake and river Ecosystems, 3rd edition, Academic Press, San Diego, USA, pp. 1006
https://books.google.co.uk/edu/Llimnology

Yanong R.P.E., 2006, Nematodes (Roundworms) infections in fish, IFAS Extension University of Florida
http://www.edis.ifas.ufl.edu/pdfs/FA/FA11500.pdf

Yufa L., and Tingbao Y., 2012 Seasonal patterns in the community of gill monogeneans on wild versus cultured orange-spotted grouper, Epinephelus coioides Hamilton, 1822 in Daya Bay, South China Sea, Aquaculture Research, 43(8): 1232-1242
https://doi.org/10.1111/j.1365-2109.2011.02927.x