EFFECTS OF FISH PARASITES ON THE RELATIVE CONDITION FACTOR (Kn) OF THE FISHES IN THE RESERVOIRS OF PERAK RIVER, MALAYSIA

*[1]Ibrahim Ado Abdulmalik, [2]Yahaya Zary Shariman and [2]Hashim Zarul Hazrin

[1]Department of Zoology, Federal University Lokoja, Kogi State, Nigeria.
[2]School of Biological Sciences, Universiti Sains Malaysia,11800 Pulau Pinang, Malaysia.

*Corresponding authors' email: ado.ibrahim@fuloja.edu.ng

ABSTRACT

This research presents the effects of fish parasites infection on the relative condition factor (Kn) of fishes sampled from Chenderoh, Bersia and Temengor Reservoirs of Perak River. Fishes were examined for Parasites in the reservoirs, The fishes were infected with parasites belonging to 8 taxonomic groups, Protozoa, Myxozoa, Monogenean, Digenean, Cestoda, Nematoda, Acanthocephala and Crustacean. The mean Kn values of the fishes showed that 78 infected and 38 uninfected fishes have a good condition factor, 30 infected and 35 uninfected fishes have poor condition factor. This showed that the effects of parasites in infected fish Kn depends on the virulence of the parasites and availability of food to the fish hosts.

Keywords: Fish parasites, Relative condition factor, Perak Reservoirs

INTRODUCTION

The health status of freshwater fish can be measure by fish relative condition factor, which is a practical tool for researchers to study the quality of fish habitat, pollution, growth of fish and effect of fish parasites (Criag, *et al.,* 2005). Freshwater fishes are infected by a diverse group of parasites, these parasites can affect fish body condition, behaviour, metabolism, fecundity, and growth (Lafferty, 2008).

The wellness of fish, condition of the body, and fatness are condition factors. Heavier fish at a known length is assumed to be in good condition (Froese, 2006). Condition factor has been used in the Fish Biology study since the early 20th century as a health quantitative indicators (Marinho, *et al.*, 2013; Silva *et al.*, 2013 and Froese, 2006).

According to Mir *et al.*, 2012 and Sarkar *et al.,* 2013, to know the condition factor of individual fish species, measurement of the length and weight of a fish is taken to explain the condition of that fish. Fish relative condition factor is quantifiable, it allows for the comparison of a single fish species condition factor in a population, single fish species from other dissimilar populations (Barnham and Baxter, 1998).

Resources like foods are limited within fish populations which may result in competition and this differs in Individuals (Bengon *et al.,* 1990). Differences in nutritional condition, rates of growth, and size of the body is because of the uneven distribution of food due to competition for a given length (Westerberg *et al.*, 2004).

The fish relative condition factor can be correlated with the mean prevalence of fish parasites positively or negatively (Arnott *et al.*, 2000; Thilakaratte *et al.*, 2007). The fish growth can be affected by parasites, and parasites that infect fish are of many types (Marcogliese, 2004), However, according to Peg *et al.*, 2011, They compared the mean condition factors of infected and uninfected fish, concluded that there was no significant difference between the mean condition factors of infected and uninfected fish.

Parasites prevalence and fish condition factor are usually anticipated to correlate negatively because parasites usually cause diseases in the fish host, Studies have shown that fish can possess' high prevalence of parasites with good condition factors (Gerard *et al*, 2015). According to Pope and Kruse (2007), the fish relative condition factor greater than 100 is assumed to be in good health condition which is the benchmark value parameter.

There were no reports of the effect of fish parasites on fish relative condition factor (Kn) in the reservoirs. Studies conducted on fish condition factor in Perak Reservoirs were focused on length – weight relationship on condition factor, fish population, and diversity (Muzzalifah *et al.*, 2012, 2015). Fish parasites could affect the growth, condition factor, physiology, and reproductive rates of a fish host. When assessing fish health, the fish relative condition factor is a vital factor to evaluate.

This is because the relative condition factor is unaffected by gonads formation or reproduction processes (Le Cren, 1951). The purpose of this paper is to study the effect of parasites on fish relative condition factor (Kn) in the reservoirs.

MATERIALS AND METHODS

This research was conducted in Temengor, Bersia and Chenderoh Reservoirs in Perak River, Malaysia. Temengor Reservoir has an area of 152 km^2 and 80 Km long with a dendritic shape. Located northeast of Grik Town, between latitude 5.55^0 North and longitude 101.34^0 East. Bersia Reservoir has an area of 5.7 Km^2 and located between latitude 5.41^0 North and longitude 101.22^0 East and Chenderoh Reservoir covers approximately 21 Km^2. It is located between latitude 5.02^0 North and longitude 100.97^0 East (Hashim *et al.*, 2012).
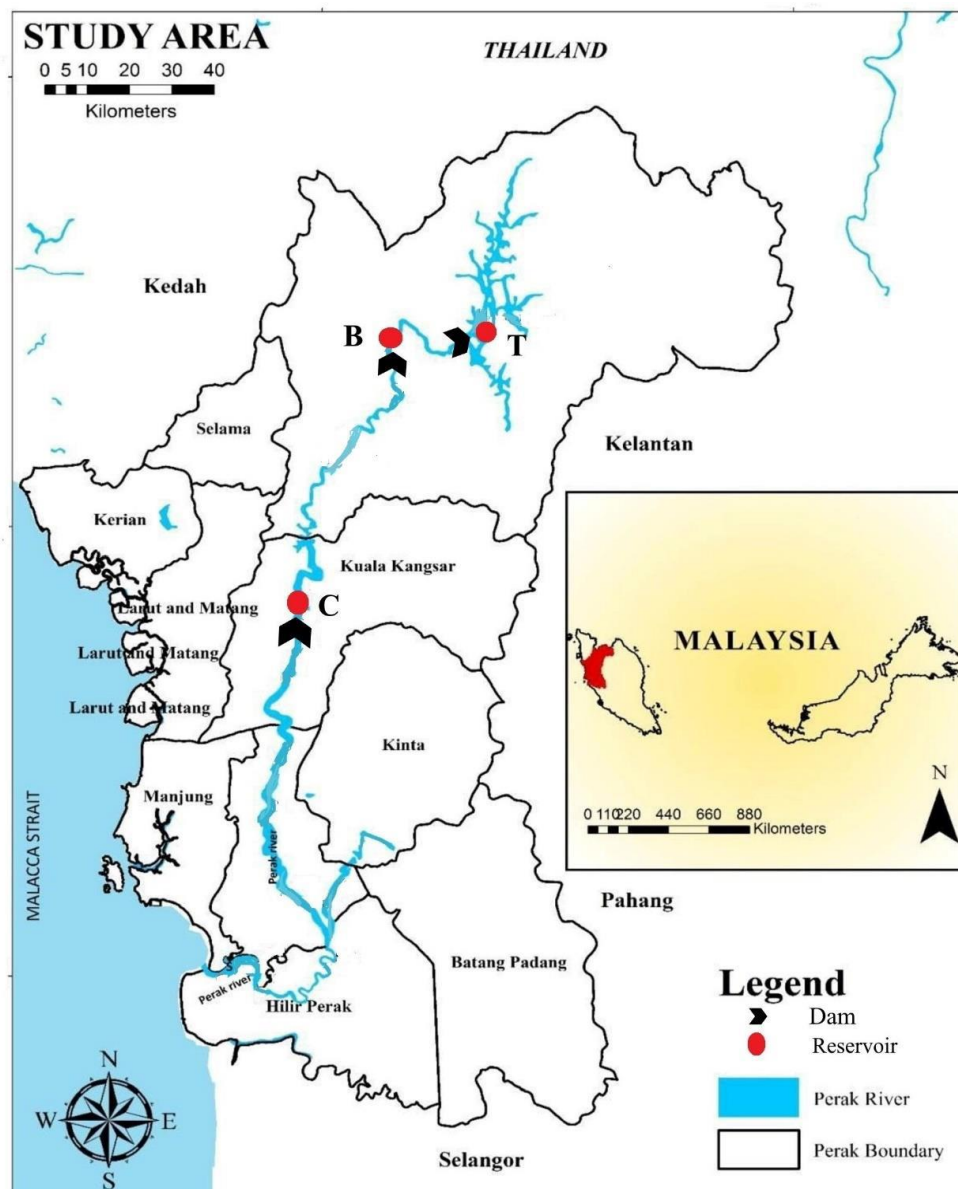
Figure 1: Location of Temengor (T), Bersia (B), Chenderoh (C) Dams and Reservoirs along the Perak River. Adapted from Salam *et al*., (2019)

Live freshwater fish were randomly sampled from fishermen catch at landing sites and from a fish farm in the reservoirs (Table 1) . They were all transported alive in battery power aerated cooler with the reservoir water to Universiti Sains Malaysia Laboratory where they were kept in aquaria for one to two days until euthanatized. The fishes were identified using keys prepared by Froese and Pauly (2019), Rainboth (1996), Hashim *et al*., (2012). The live fishes were killed humanly. This was done by severing the spinal cord of the fish with a sharp knife. The fish total length (cm) was measured by using fish measuring board and the wet weight (gm) by digital weighing scale.

Table 1: List of fish species bought per reservoir, weight range, length range during this study from Temengor (T), Bersia (B), and Chenderoh (C) reservoirs along Perak River

Fish species	Weight (g) min-max	Length (cm) min-max	T	B	C
Osteochilus vittatus	15.0 - 247.0	12.0 - 24.5	37	11	2
Cyclocheilichthys apogon	17.0 - 108.0	11.4 - 17.0	9	11	1
Labiobarbus leptocheilus	14.0 -127.0	12.3 - 25.8	21	13	-
Mystacoleucus obtusirostris	17.0 -29.0	11.3 - 15	6	14	-
Hampala macrolepidota	17.0 -111.0	10.5 - 18	2	20	15
Barbonymus schwanenfeldii	12.0 -244.0	9 - 24	-	9	28
Total number of fish per reservoir			75	78	46

Smeared were made from the skin scrapping and observed under the microscope for ectoparasites. Fish were dissected and examined for internal parasites using standard parasitological techniques. Parasites were identified after Anderson *et al.*,(1980), Gussev (1985), Hoffman (1967), Kabata (1979, 1985) Paperna (1996), and Yamaguti (1958, 1961a, 1961b).

The relative condition factor (Kn) was estimated by Froese (2006) formula, which is expressed as follows:

Kn = W/W^

Where W = The observed weight in gram.

W^ = The calculated weight derived from length-weight relationship.

The length-weight relationship was determined using the equation applied by Froese (2006):

W = a L^b

W = The total weight (g)

L= The total length (cm)

a = Constant

b = Growth exponent

The value of constant a and b were estimated using least-square method to log transformed the data as applied by Froese (2006):

$Log_{10} W = Log_{10} a + b\ Log_{10} L$

The benchmark for relative condition factor (Kn) to determine fish's good health condition is 1 which is good health condition factor (Le Cren, 1951). Mann-Whitney U test was performed to compare the differences between the relative condition factor (Kn) of presence and non-presence of fish parasites using IBM SPSS Statistics software version 24 (New York, USA). Normality tests were done on all data before statistical analysis using the Kolmogornov-Smirnov test performed using IBM SPSS Statistics software version 24 (New York, USA).

RESULTS AND DISCUSSION

The fish parasites isolated belong to 8 phyla (Table 2), Protozoa (2 species), Myxozoa (two species), Monogenean (12 species), Digenean (3 species), Cestoda (1 species), Nematoda(4 species), Acanthocephala (3 species) and Crustacean. (5 species).

Table 2: List of the fish parasites isolated from fish hosts in River Perak Reservoirs

Taxonomy group	Parasites species
Protozoan	*Bolantidium* sp., Unidentified Protozoan cyst
Myxozoa	*Henneguya* sp., *Myxobulus* sp.
Monogenean	Three *Dactylogyrus* spp., *D. tapienensis, D. hamacopulus, D.lampam, D. dolichoirri, Gyrodactylus* sp., *Cornudiscoides sundanensis, Cichlidogyrus sclerosus, Scutogyrus longicornis, Paradiplozoon barbi*
Digeneans	*Osteochilotrema malayea*, unidentified larva trematode, unidentified adult trematode
Cestoda	*Bothriocephalus* sp.
Nematoda	*Camallanus* sp., *Procamallanus* sp., *Cucullanus* sp., unidentified nematode
Acanthocephalans	*Acanthocephalus* sp., *Acanthogyrus* sp., *Acanthosentis* sp.
Crustaceans	Three *Lamproglena* spp. *Ergasilus* sp., unidentified copepod

The mean fish health condition factor of infected fishes in the reservoirs shows that most of the fish samples were infected by parasitic monogeneans (Bu & Leong, 1997; Bellay *et al*., 2015). In this research, each of the fish species population showed variations in the mean relative condition factor (Kn) and can be used only to compare the condition factor of the same fish species

Relative condition factor (Kn) is unaffected by gonads formation, reproduction processes (gonadosomatic index, GSI). The mean fish relative condition factor (Kn) of parasitized and unparasitized fish species in Temengor, Bersia and Chenderoh reservoirs is shown in Table 2.

Parasitized fishes with good fish health condition factor were *O. vittatus* (21 individuals) with a mean Kn of 1.13, *C. apogon* (15 individuals) with a mean Kn of 1.08, *H. macrolepidota* (10 individuals) mean Kn of 1.08 and *B. schwanenfeldii* (32 individuals) with mean Kn of 1.04. These parasitized fishes were in good health condition based on their mean kn that exceed 1, indicating the host condition factor is not affected by the parasites or the virulence of the parasite is low to affect the fish host. Relative condition factor (Kn) is unaffected by reproduction processes and gonads formation (Jisr *et al.,* 2018). According to Gerard *et al.* (2015), the host condition factor is not affected by parasites. This is because the fish parasites' virulence is very low or less pathogenic to affect the host condition (Cressler *et al.,* 2016). This shows that the fish parasites do not cause any harmful effects to the fish as the fish may have adequate food (stomach content) supply which increases the immunity of the fish host against parasites thereby minimizing the harmful effect of the parasites (Lizama *et al.*, 2006).

On the other hand, parasitized fishes with poor health condition factor less than 1 including *L. leptocheilus* (16 individuals) with mean Kn of 0.94 and *M. obtusirostris* (14 individuals) with a mean Kn of 0.97. The poor health condition of these parasitized fish may be because of low nutrient intake caused by the parasite's presence in the host tissues or stomach content. The fish parasitized have poor condition factor compared to healthy fish. The fish parasites' virulence is high which affect the host condition (Cressler *et al., 2016*). This may also be because of low nutrient intake by the fish host caused by these parasites which affect the fish body condition, behaviour, metabolism, and growth by depleting the fish energy reserves (Lafferty, 2008; Sac *et al.*, 2016).

Unparasitized fish with good health condition factor were *C. apogon* (6 individuals) with mean Kn of 1.08, *L. leptocheilus* (18 individuals) mean Kn of 1.09, *H. macrolepidota* (27 individuals) with a mean Kn of 1.03 and *B. schwanenfeldii* (5 individuals) with mean Kn of 1.23 since their mean Kn exceed 1, indicating good health condition.

The unparasitized fish habitat is in good condition due to abundant food sources in the reservoirs. Whereas unparasitized fish with poor health condition factor include *O. vittatus* (29 individuals) with a mean Kn of 0.89 and *M. obtusirostris* (6 individuals) with a mean Kn of 0.48. This may be because of the scarcity of food at a certain period to the fishes in the reservoirs or high competition for food among the fish. According to Batubara *et al.*(2019), the aquatic habitat of the fish is in good condition due to abundant food availability, less competition, and predation. This indicates that the availability of food and competition is in equilibrium

in the fish habitat (Muchlisin *et al.*, 2010). Unparasitized fish with poor relative condition factor (Kn) are, *O. vittatus* and *M. obtusirostris* from the fish family Cyprinidae. According to Gupta *et al.* (2011), the reason for poor condition factor in these fishes may be due to food availability is scanty at a certain period to these fishes in the reservoirs or due to high competition among the fish for food.

Table 3: The mean relative condition factor (Kn) of parasitized fish and unparasitized fish in Temengor, Bersia and Chenderoh reservoirs

Fish species	Status	N	Mean W(g)	Mean W^(g)	Mean Kn
O. vittatus	P	21	65.24	57.54	1.13
	U	29	124.45	138.66	0.89
C. apogon	P	15	33.33	30.64	1.08
	U	6	66.50	61.02	1.08
L. leptocheilus	P	16	31.44	33.19	0.94
	U	18	43.00	39.40	1.09
H. macrolepidota	P	10	43.10	39.85	1.08
	U	27	43.81	42.19	1.03
B. schwanenfeldii	P	32	87.06	83.17	1.04
	U	5	53.40	43.29	1.23
M. obtusirostris	P	14	26.00	26.65	0.97
	U	6	22.40	45.74	0.48

(mean Kn greater than 1 is a good health condition factor)

The relative condition factor (Kn) comparison of parasitized and unparasitized fish in Temengor, Bersia and Chenderoh reservoirs is shown in Table 4. Parasitized *O. vittatus* (mean Kn 1.13) was highly significant than unparasitized *O. vittatus* (mean Kn 0.89). Mann-Whitney U test indicated that this difference was statistically significant p = 0.001. While parasitized *C. apogon* (mean Kn 1.08) was not statistically significant than unparasitized *C. apogon* (mean Kn 1.08) (p = 0.753).

Parasitized *L. leptochelus* (mean Kn 0.94) was highly significant than unparasitized *L. leptochelus* (mean Kn 1.09). A Mann-Whitney U test indicated that this difference was statistically significant p = 0.001. In contrast, parasitized *H. macrolepidota* (mean Kn 1.08) was not significant than unparasitized *H. macrolepidota* (mean Kn 1.03). Mann-Whitney U test indicated that this difference was not statistically significant p = 0.339.

By contrast, parasitized *B. schwanenfeldii* (mean Kn 1.04) was highly significantly different from unparasitized *B. schwanenfeldii* (mean Kn 1.23) (p = 0.001). While parasitized *M. obtusirostris* (mean Kn 0.97) was highly significant different from unparasitized *M. obtusirostris* (mean Kn 0.48) (p= 0.001).

The comparison of relative condition factor (Kn) of parasitized fish is significantly lower than that of unparasitized fish (Muñoz *et al*., 2015). In this research, a similar results were observed as relative condition factor (Kn) of parasitized *O. vittatus, L. leptocheilus, B. schwanenfeldii,* and *M. obtusirostris* are significantly lower from than unparasitized species. This may be because the parasite could have reduced the food intake (stomach content) of the fish host (Sac *et al.*, 2016). According to Cressler *et al.* (2016), the parasitized fish parasites' virulence may be high which might affect the fish host condition.

Conversely, the relative condition factor of unparasitized *C. apogon* and *H. macrolepidota* are not significantly lower from parasitized species. Ergonul & Altinday (2005) reported that the condition factor for parasitized and unparasitized fish did not exhibit a marked difference. According to Cressler *et al.* (2016) the parasitized fish parasites' virulence is very low to affect the fish host wellbeing.

Table 4: Comparison of mean Relative condition factor (Kn) of parasitized fish and unparasitized fish species in Sungai Perak reservoirs

Fish	Parasitized fish mean Kn	Unparasitized fish mean Kn	*P*
O. vittatus	1.13	0.89	0.001*
C. apogon	1.08	1.08	0.753
H. macrolepidota	1.08	1.03	0.399
L. leptocheilus	0.94	1.09	0.001*
B. schwanenfeldii	1.04	1.23	0.001*
M. obtusirostris	0.97	0.48	0.001*

(*P*: values of Mann- Whitney U) * significant at α = 0.01

CONCLUSION

The results of this research showed for the first time the effect of parasites to the relative condition factor of the fishes in the reservoirs. Out of 181 fish individuals, 78 infected and 38 uninfected fish individuals have a good fish health condition. Thirty infected and 35 uninfected fish have a poor fish health condition. The effect of parasites in infected fish health condition depends on the virulence of the parasites and food availability for the fish host.

REFERENCES

Anderson, R. C., Chabaud, A. G., & Willmott, S. (1980). *CIH keys to the nematode parasites of vertebrates. Commonweaith Bureaux*. England: Frnham Royal Books.

Arnott, S. A., Barber, I., & Huntingford, F. A. (2000). Parasite-associated growth enhancement in a fish-cestode system. *Proceedings of the Royal Society of London., 267*, 657-663.

Barnham, P.C. & Baxter, A. (1998). Condition Factor for Salmonid Fish. *Journal of Fisheries Notes*: 1–3.

Batubara A. S, Muchlisin, Z. A. ,Efi zon3, D ,Elvyra ,R., Irham2, M. (2019) Length -weight relationship and condition factors of the Naleh fish, *Barbonymus gonionotus* (Pisces, cyprinidae) harvested from Nagan River. *Vestnik Zoologii*, 53(1): 75–82, https://doi.org/10.2478/vzoo-2019-0008

Bellay S., Oliveira E.F., Almeida-Neto M., Abdallah V.D., Azevedo R.K., Takemoto R. M., Luque J.L. (2015). The patterns of organization and structure of interactions in a fish-parasite network of a Neotropical river. *International Journal for Parasitology*, 45, 549–557. http://dx.doi.org/10.1016/j.ijpara.2015.03.003.

Begon M., Harper J. L. and Townsend C.R. (1990): Ecology: Individuals, Populations and Communities, second edition. Blackwell Scientific, Boston.

Bu, S. S. H., & Leong, T. S. (1997). Fish parasites communitis in tropical reservoirs along the Perak River, Malaysia. *Hydrobiologia, 356*, 175-181.

Craig, J.M., Thomas, M.V., and Nichols, S.J., (2005) Length-weight relationship and a relative condition factor equation for lake sturgeon (*Acipenser fulvescens*) from the St Clair River system (Michigan, USA). *Journal of. Applied Ichthyology*. 21, 81-85.

Ergönül, M.B. & Altındağ, A. (2005). The effects of *Ligula intestinalis* plerocercoids on the growth features of tench, *Tinca tinca* in Mogan Lake (Ankara, Turkey). *Turkish Journal of Veterinary and Animal Science*, 29, 1337-1341.

Froese, R. (2006). Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology, 22*(4), 241-253. https://doi.org/10.1111/j.1439-0426.2006.00805.x

Gérard, C., Hervé, M., Réveillac, E., & Acou, A. (2015). Spatial distribution and impact of the gill-parasitic Mazocraes alosae (Monogenea Polyopisthocotylea) on Alosa alosa and A. fallax (Actinopterygii, Clupeidae). *Hydrobiologia, 763*(1), 371-379. https://doi.org/10.1007/s10750-015-2391-1

Gussev, A. V. (1985). *Key of freshwater fish parasites: Metazoan parasites*. Leningrad: Zoological Institute,USSSR Academy of Sciences.

Gupta, B.K., Sarkar, U.K., Bhardwaj, S.K. & Pal, A. (2011). Condition factor, length-weight and length-weight relationships of an endangered fish *Ompok pabda* (Hamilton 1822) (Silurifomes: Siluridae) from the River Gomti, a tributary of the River Ganga, India. *Journal of Applied Ichthyolog*y 27: 962-964.

Hashim, Z. H., Zainuddin, R. Y., Shah, A. S. R. M., Sah, M. S. A., Mohammad, S., & Mansor, M. (2012). Fish checklist of Perak, Malaysia. *Check list, 8*(3), 408-413.

Hoffman, G. L. (1967). *Parasites of North American freshwater fishes*. London,England: The Regenst of the University of California.

Kabata, Z. (1979). *Parasitic copeda of British fishes* London: Ray Society.

Kabata, Z. (1985). *Parasites and diseases of fish cultured in the tropics*. London: Taylor and Francis Ltd.

Lafferty, K., Allesina, S., Arim, M., Briggs, De Leo, G., & Dobson, A. (2008). Parasites in food webs: The ultimate missing links. *Ecology Letters., 11*(6), 533-546. https://doi.org/10.1111/j.1461-0248.2008.01174.x

LeCren E D.(1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the Perch (*Perca fluviatilis)*. J*ournal Animal Ecology*. 20:201-19

Lizama, M. A. P.; Takemoto, R. M.; Pavavelli, G. C.(2006) Parasitism influence on the hepato, splenossomatic and weight/length relation factor of *Prochilodus lineatus* (Valenciennes, 1836) (Prochilodontidae) of the upper Parana river floodplain, Brazil. *Revista Brasileira de Parasitologia Veterinaria.* 15(3) 116-122.

Marcogliese, D. J. (2004). Parasites: small players with crucial roles in the ecological theater. *EcoHealth* 1:151–164.

Marinho, R.G.B.; Tavares-Dias, M.; Dias-Grigório, M.K.R.; Neves, L.R.; Yoshioka, E.T.O.; Boijink, C.L.& Takemoto, R.M.(2013). Helminthes and protozoan of farmed pirarucu (*Arapaima gigas*) in eastern Amazon and host-parasite relationship. A*rquivo Brasileiro de Medicina Veterinária e Zootecnia,* 65(4): 1192-1202. https://doi.org/10.1590/S0102-09352013000400035.

Mir, J.I., Shabir, R. & Mir, F.A. (2012.) Length-Weight Relationship and Condition Factor of *Schizopyge curvifron*s (Heckel, 1838) from River Jhelum, Kashmir, India. *World Journal of Fish and Marine Sciences* 4(3): 325–329.

Muchlisin, Z. A., Musman, M., Siti-Azizah, M. N. (2010). Length-weight relationships and condition factors of two threatened fishes, *Rasboratawarensis* and *Poropuntius tawarensis*, endemic to Lake Laut Tawar, AcehProvince, Indonesia. *Journal of Applied Ichthyology, 26*, 949–953.

Muzzalifah A. H., Mashhor M. and Siti Azizah M.,(2015) . Length-weight relationship and condition factor of fish populations in Temengor Reservoir, *Sains Malaysiana*, 44, 61-66.

Muzzalifah A. H., Mashhor M., Hashim Z. H, & Mohd. S,M.(2012) A comparative study of fish population in Temengor Reservoir and Bersia Reservoir, Perak, Malaysia. J*ournal of research in Biology* 2(3): 184 –192.

Paperna, I. (1996). *Parasites, infection and disease of fishes in Africa*. Rome: Food and Agricultural Organization.

Pegg, J., Williams, C. F., Cucherousset, J., & Britton, J. R. (2011). What are the consequences of infection by the introduced parasite *Philometroides sanguineus* for threatened crucian carp *Carassius carassius* populations in England? *Ecology of Freshwater Fish, 20*, 598–604.

Poulin, R.(1998). *Evolucionary ecology of parasites: from individuals to communities.* London: Chapman and Hall

Pope, K., & Kruse, C. (2007). Condition. *Analysis and interpretation of freshwater fisheries data. American Fisheries Society, Bethesda, Maryland* , 423-471.

Sac,G.,Serezli,E.E., & Okgerman, H.(2016). Theoccurerence of *Ligula intestinalis* in its fish host *Rutilus rutilus* (L.) and the effects of parasite on the fish growth (Buyukcekmece Reservoir, Turkey). *Journal of Aquaculturen Engineering and Fisheries Research*,2(3):142-150.

Sarkar, U.K., Khan, G.E., Dabas, A., Pathak, A.K., Mir, J.I., Rebello, S.C., Pal, A. and Singh, S. P. (2013). Length weight relationship and condition factor of selected freshwater fish species found in River Ganga,Gomti and Rapti, India. *Journal of Environmental Biology* 34: 951–956.

Silva, R.M.; Tavares-Dias, M.; Dias, M.W.R.; Dias, M.K.R. & Marinho, R.G.B. (2013). Parasitic fauna in hybrid tambacu from fish farms. *Pesquisa Agropecuária Brasileira*, 48(8):

1049-1057.   https://doi.org/10.1590/S0100-204X2013000800034.

Thilakaratne, I. D. S. I. P., McLaughlin, J. D., & Marcogliese, D. J. (2007). Effects of pollution and parasites on biomarkers of fish health in spottail shiners *Notropis hudsonius* (Clinton). *Journal of Fish Biology 71*, 519- 538.

Westerberg, M.; Staffan, F. & Magnhagen, C. (2004). Influence of predation risk on individual competitive ability and growth in Eurasian perch, *Perca fluviatilis*. *Animal Behaviour* 67: 273– 279.

Yamaguti, S. (1958). *Systema Helminthum,Digenetic trematodes of vertebrates* (Vol. 1). New York: Intersciences.

Yamaguti, S. (1961a). *Systema Helminthum. The nematodes of vertebrates* (Vol. 3). New York: Interscience.

Yamaguti, S. (1961b). *Systema Helminthum.Monogenea and Aspidocotylea* (Vol. III). New York John Wiley and Sons Inc.