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Original Research

Assessment of Factors Affecting Parasite Prevalence and Condition Factor in Farmed Fish of the Western Region of Cameroon

Derrick F. NGUEGUIM[1,4]*, Adoum GAYE[2], Herman V. NGOUMTSOP[1], Jacques NACK[1], Marc K. KOUAM[3], Julius AWAH-NDUKUM[3,5]

[1]: Institute of Fisheries and Aquatic Sciences, University of Douala, Douala, Cameroon
[2]: Livestock Research Institute For Development, BP: 433 Ndjamena - Tchad
[3]: Department of Animal Science, University of Dschang, Dschang, Cameroon
[4]: Laboratory of Applied Hydrobiology and Ichtiology, University of Dschang, Dschang, Cameroon;
[5]: Department of Animal Science, College of Technology, University of Bamenda, Bambili, Cameroon

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***Corresponding author**
Email: derrickngueguim@gmail.com

ABSTRACT

Fish production is an essential livelihood sector in Western Cameroon contributing significantly to food security and employment opportunities. Currently, it faces challenges from parasitic diseases. This study assessed the abiotic drivers of parasitism and their impact on the condition factor of three farmed fish species (*Oreochromis niloticus*, *Cyprinus carpio*, and *Clarias gariepinus*) in the Western Cameroon. Between December 2018 and December 2019, 2,254 fish were sampled monthly from ponds and concrete tanks, and examined using standard parasitological procedures, while water physicochemical parameters were measured simultaneously. Results showed that the overall parasite prevalence was 39.66%, dominated by ectoparasites (34.87%). Only 8.47% of endoparasites were found (*Acanthocephalus* sp. and nematodes). Parasite prevalence was significantly ($p<0.05$) higher during the dry season (46.01%), in non-integrated ponds, on farms managed by less-educated farmers, and with higher feeding frequency. The Principal Component Analysis indicated temperature, turbidity, phosphate, and iron are positively correlated to parasite prevalence, while dissolved oxygen showed a negative association. Although no mortality was recorded, parasitized fish had a significantly ($p<0.05$) lower condition factor (2.53±2.10) compared to non-infected fish (2.90±2.72). It was concluded that, in Western Cameroon fish farms, parasite prevalence is increased during dry-season, high temperature, turbidity, and feeding frequency. Non-integrated pond systems and farms operated by low educated farmers revealed a high parasite prevalence affecting the condition factor in infected fish. To address the issue, efforts should be focused on water quality management, feeding practices, and farmer training.

KEYWORDS: Condition factor; fish farming; Parasite prevalence; water quality, western Cameroon.

INTRODUCTION

Aquaculture represents an essential livelihood sector in Sub-Saharan Africa, particularly in Western Cameroon, where it contributes significantly to food security, income generation, and employment opportunities (**FAO, 2017**). However, the development of this sector is limited by recurring fish diseases, particularly parasite infections, which affect growth performance and profitability in both extensive and semi-intensive production systems (**Bruneaux et al., 2017; Tavares-Dias and Martins, 2017**). In tropical aquaculture environments, abiotic factors, including temperature, dissolved oxygen, pH, turbidity, nutrient loads, and specific ions, have a strong influence on parasite biology, reproduction, and transmission, while management practices such as feeding regimes, culture systems, and farmer education further modulate infection dynamics (**Buchmann et *al.*, 2006; Jerônimo et al., 2020; Jerônimo et al., 2022; Lee et al., 2024**). Although several studies in temperate and other tropical regions have highlighted the impact of these factors, empirical data remain scarce and fragmented for Central African aquaculture, and local information for Western Cameroon is still limited despite reported parasite concerns in cultured fish (**Ngueguim et al., 2020; Tombi et al., 2014**). Therefore, this study aims to identify abiotic causes of parasitism in farmed fish in Cameroon's West Region and propose appropriate health management measures. Specifically, the study assesses the prevalence and intensity of parasite infections across seasons and farming systems,

establishes correlations between water physicochemical parameters and parasite occurrence, and evaluates the impact of these infections on the physiological condition factor of farmed fish.

MATERIALS AND METHODS

Study Area

The study was carried out in the Menoua, Noun, and Hauts-Plateaux divisions of Western Cameroon, which has a Sudano-Guinean climate with a short dry season (mid-November to mid-March) and a lengthy rainy season (mid-March to mid-November) (**IRAD, 2013**). The average annual rainfall is approximately 1,600 mm, and temperatures range from 16 to 27°C (**IRAD, 2013**). However, recent evaluations indicate increasing temperature variability and irregular rainfall (**IPCC, 2022**).

Study Period and Sampling

Between December 2018 and December 2019, 2,254 fish, including *Oreochromis niloticus*, *Cyprinus carpio*, and *Clarias gariepinus*, were randomly sampled from fishponds and concrete tanks. To avoid sampling bias, they were selected regardless of their health status. Individuals from other species or of unknown identity were excluded. Species were separated based on external morphological characters such as body shape, fin configuration, and the presence of barbels for *Clarias gariepinus*, as described in standard regional fish identification guides (**Stiasnney et al., 2007**). Fish were transported alive to the Applied Hydrobiology Laboratory in aerated containers and processed within hours after capture. The fish's size and weight were measured and classified according to **Shehata et al. (2018) and Biu et al. (2014)** respectively.

The sex of the fish specimens was determined by pressing the abdomen of adult fishes to trigger the release of white milk for males and eggs for females; otherwise, the fishes were dissected and the gonads examined using methods described by **Akombo et al. (2013) and Mbakane et al. (2010)**.

Parasitological Analysis

The fish samples were examined externally for ectoparasites using a hand lens for lesions, excess mucus, and visible parasites on the skin, fins, gills, and buccal cavity (**Omeji et al., 2011; Ekanem et al., 2011**). Scrapings from the skin (head to tail), fins, and gills were mixed with 3 mL of 0.9% saline solution and examined under the light microscope (x10, x40; Olympus) for protozoan and monogenean parasite analysis (**Bush et al., 1997; Ngueguim et al., 2020**). Each sample was examined separately as described by **Ekanem et al. (2011)**. The gill arches were dissected and inspected under a stereomicroscope to detect attached crustacean parasites such as *Argulus* sp., *Lernaea* sp., and *Ergasilus* sp. These parasites were identified based on characteristic morphological features (**FAO, 1996; Langdon et al., 2002; Pouder et al., 2011**). For internal examination, the digestive tract, liver, spleen, kidneys, and swim bladder were removed and placed in petri dishes containing physiological solution, which cause a wriggling movement of worms facilitating the counting and identification (using the naked eye). Each part was cut longitudinally and observed under a light microscope using 10X and 30X magnification (**Paperna, 1991**). The internal helminths were identified and counted using procedures described by **Ali (2009), Noga (2010), and Farman et al. (2015**). Parasite prevalence and intensity were calculated using the formula below (**Bush et al., 1997**).

$$\text{Prevalence (\%)} = \frac{\text{Total number of infected fish}}{\text{Number of fish examined}}\ x\ 100$$

$$\text{Intensity} = \frac{\text{Total number of parasites}}{\text{Number of infected fish}}$$

Water Quality Assessment

Immediately after fish collection (6:00 and 8:00 a.m.), water samples were taken from ponds and tanks at 60 cm depth. The physicochemical parameters (temperature, pH, dissolved oxygen, electrical conductivity, turbidity, ammonium, phosphate, iron, calcium, and sulfates) were measured. Temperature, pH, dissolved oxygen, and conductivity were measured in situ using a calibrated multiparameter probe (Proteus), while turbidity was determined with a turbidimeter (TB1 Portable). Ammonium, phosphate, iron, calcium, and sulfates were quantified in the laboratory using colorimetric methods and standard protocols for freshwater analysis (**Rodier et al., 2009**).

Length-Weight Relationship and Condition Factor (K)

The fish's length-weight relationship was obtained by the equation **W=aLb**, where **W** is the weight (g), **L** the total length (cm), **a** the intercept, and **b** the allometric coefficient estimated using linear regression of log-transformed data (**Akombo et al., 2013**). To evaluate the physiological state of parasitized and non-parasitized fish, the method previously used by **Dekić et al. (2016)** was performed. Fulton's condition factor (**K**) was calculated as **K=100×W/L3K=100×W/L3.**

Statistical Analysis

Data were submitted to descriptive statistics and non-parametric tests (Kruskal–Wallis and Mann–Whitney tests) using SPSS version 25.0. Dunn's post hoc comparisons were used to compare prevalence across seasons and culture systems. R software (version 4.4.5) was used to conduct Spearman's rank correlation and Principal Component Analysis (PCA) biplots to visualize the multivariate relationships between water quality parameters and parasite prevalence. Statistical significance was set at $p < 0.05$ for all tests.

RESULTS

Parasite Prevalence and Composition

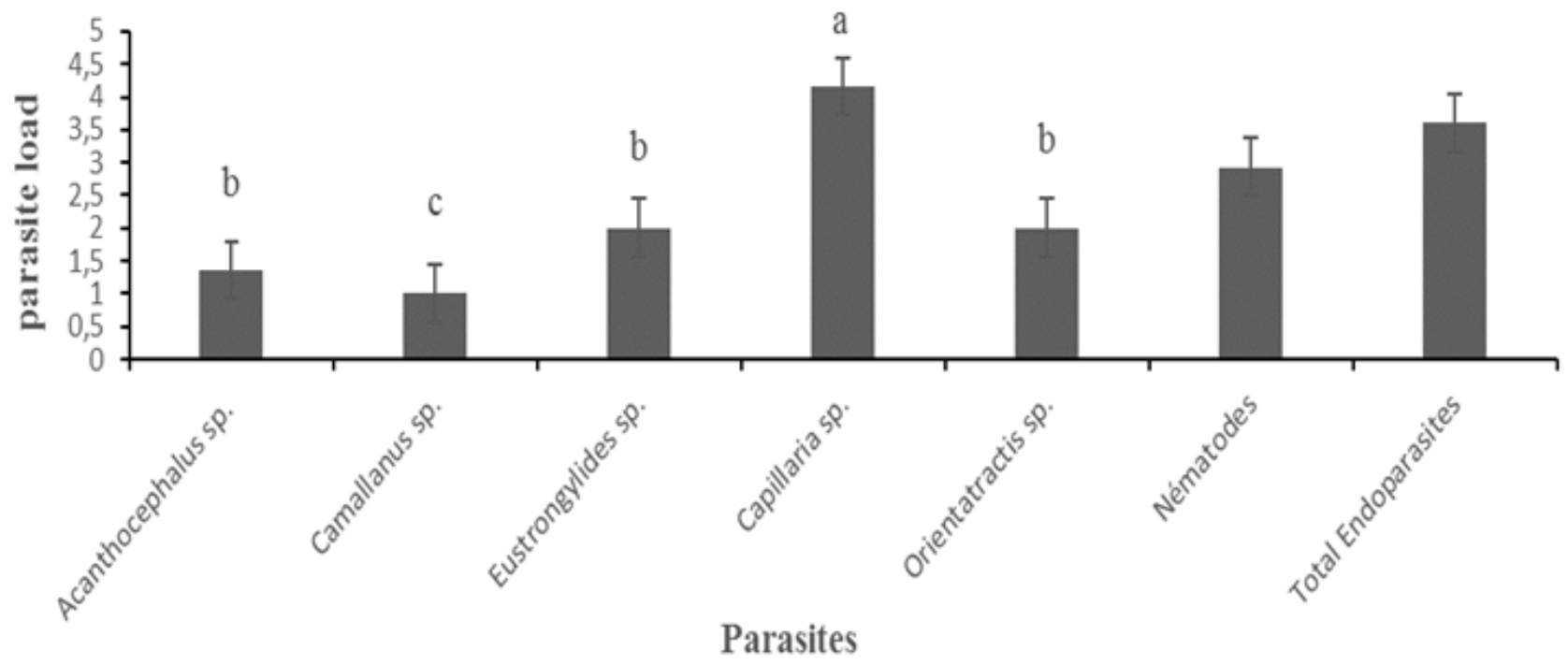
Overall parasite prevalence was 39.66% (37.66-41.70%). Ectoparasites accounted for 34.87%, comprising monogeneans (15.79%), protozoans (15.79%), and crustaceans (12.02%). The most frequent species were *Gyrodactylus* sp. (12.64%), *Myxobolus* sp. (10.29%), and *Argulus* sp. (6.65%). Endoparasites represented only 8.47%, including *Acanthocephalus* sp. (4.84%) and nematodes (**Table1**).

Parasite Intensity

The infection intensity was generally low (<10 parasites per infected fish). However, significant ($p<0.05$) differences were observed among parasite taxa, with *Capillaria* sp. (nematodes) exhibiting the highest intensity and *Camallanus* sp. the lowest (**Figure 1**).

Table 1: Prevalence of parasites in farmed Fish of the Western Region of Cameroon

Parasite group		Species	Prevalence (%) Per species	Prevalence Total (%)	
Ectoparasite	Monogeneans	*Gyrodactylus* sp.	12.64	15.79	34.87
		Dactylogyrus sp.	5.19		
	Protozoans	*Myxobolus* sp.	10.29		
		Trichodina sp	7.05	15.79	
		Chilodonella sp	0.53		
	Crustaceans	*Argulus* sp.	6.65		
		Lernaea sp.	4.21	12.02	
		Ergasilus sp.	2.44		
Endoparasite	Acanthocephalans	*Acanthocephalus* sp.	4.84	4.84	8.47
	Nematodes	*Capillaria* sp.	1.91		
		Camallanus sp.	1.20	4.08	
		Eustrongylides sp.	1.06		
		Orientatractis sp.	0.35		



a, b, c: Bars marked with different letters differ significantly ($p < 0.05$)

Figure 1: Parasite intensity in farmed Fish of the Western Region of Cameroon

Seasonal and spatial variation

The parasite prevalence was significantly ($p < 0.05$) higher during the dry season (46.01%) than rainy season (31.35%). Hauts-Plateaux (35.61%) and Noun (37.41%) recorded the highest ectoparasite prevalence, while endoparasites were more frequent in Menoua (15.32%) (**Table 2**).

Table 2: Effect of season and locality on parasite prevalence

Parameters	Characteristics	Ectoparasite Prevalence (%)	Endoparasite Prevalence (%)	Total Prevalence (%)
Season	Dry (N=1278)	42.80 (40.11-45.53)^{a}	7.98 (6.62-9.60)^{a}	46.01 (43.29-48.75)^{a}
	Rainy (N=976)	24.49 (21.89-27.28)^{b}	9.12 (7.47-11.09)^{a}	31.35 (28.52-34.33)^{b}
Division	Menoua (N=522)	29.12 (25.39-33.16)^{b}	15.32 (12.49-18.67)^{a}	35.63 (31.64-39.83)^{a}
	Hauts-Plateaux (N=775)	35.61 (32.32-39.05)^{a}	7.48 (5.83-9.56)^{b}	40.77 (37.37-44.27)^{a}
	Noun (N=957)	37.41 (34.40-40.52)^{a}	5.54 (4.26-7.17^{b})	40.96 (37.89-44.11)^{a}

Prevalence values bearing different superscript letters (a, b) are significantly different ($p < 0.05$). N = sample size

Level of Farmer's Education, Farming Practices, and Parasitism

Ponds recorded a higher parasite prevalence (43.32%) than tanks (34.8%) (**Table 3**). Feeding frequency and farmer education significantly ($p < 0.05$) influenced parasite prevalence. Fish fed twice daily had higher prevalence than those fed once. Farms with less-educated managers recorded high infection rates (45.41% vs. 37.35% for secondary education).

Table 3: Effects of management factors on parasite prevalence

Factor	Level	Ectoparasite Prevalence (%)	Endoparasite Prevalence (%)	Total Prevalence (%)
Culture System	Pond (N=1984)	35.53 (33.46-37.67)^{a}	8.67 (7.51-9.99) ^{a}	40.32(38.18-41.50)^{a}
	Tank (N=270)	30.00(24.85-35.72)^{b}	7.04(4,56-10.73)^{a}	34.81(29.38-40.67)^{b}
Farmer's Education	None	36.24(30.15-42.81)^{a}	9.17 (7.90-10.62)^{a}	45.41 (38.94-52.04)^{a}
	Primary	37.41(34.40-40.52)^{a}	5.52 (4.05-7.49)^{b}	40.96 (37.89-44.11)^{ab}
	Secondary	32.34 (29.62-35.19)^{b}	5.05(2.84-8.81)^{b}	37.35 (34.51-40.28)^{b}
Feeding frequency	Once daily	29.76(26.59-33.14)^{a}	13.40(11.15-16.04)^{a}	36.46 (33.08-39.98)^{b}
	Twice daily	36.34 (33.40-39.38)^{b}	5.97 (4.66-7.63)^{b}	40.28 (37.27-43.38)^{a}

a, b: prevalence values bearing different superscript letters are significantly different ($p < 0.05$). N = sample size.

Water Quality and Parasitism

Figure 2 showed that the dry season (characterized by higher temperature, turbidity, phosphate, and iron) is strongly associated with higher parasite prevalence, while the rainy season (characterized by higher dissolved oxygen) is associated with lower prevalence. Negative correlations between parasite prevalence and calcium and sulfates were also observed (**Table 4**).

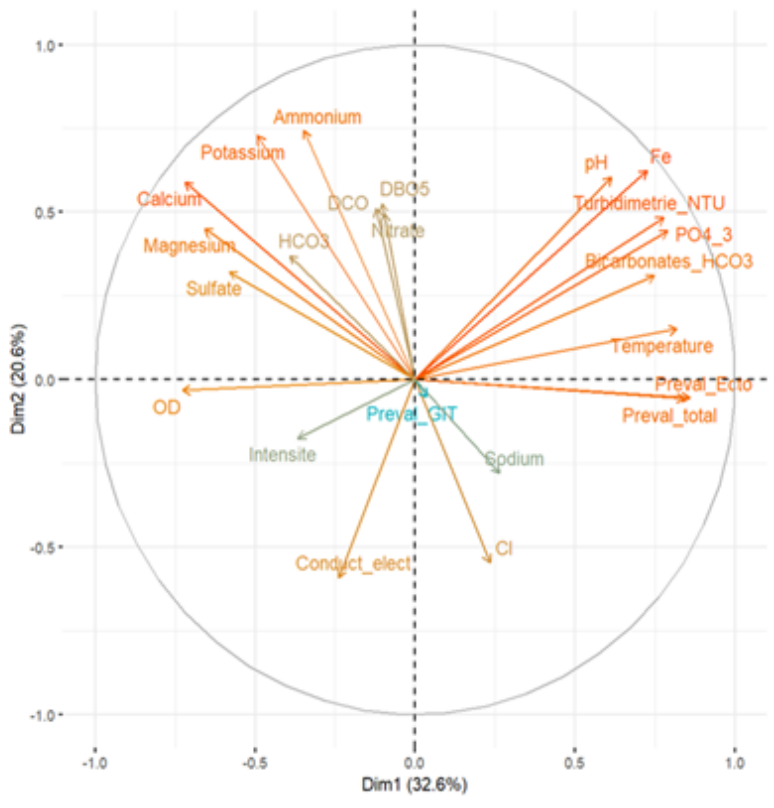


Figure 2: Principal Component Analysis (PCA) biplot of physicochemical water parameters (blue vectors) and total parasite prevalence (red vector).

Table 4: Correlation coefficients between water quality parameters and total parasite prevalence

Parameter	Average ± SD	Correlation coefficients (r)	p-value
Temperature (°C)	20.19 ± 4.83	+0.84	0.008
Dissolved Oxygen (mg/L)	2.91 ± 0.07	-0.75	0.042
Turbidity (NTU)	212.65 ± 154.01	+0.72	0.011
Conductivity (mS/cm)	0.06 ± 0.05	+0.68	0.032
Phosphate (PO_4^{3-}) (mg/L)	49.24 ± 31.61	+0.89	0.004
Iron (Fe) (mg/L)	16.51 ± 14.23	+0.80	0.021
Calcium (Ca^{2+}) (mg/L)	29.74 ± 20.46	-0.65	0.027
Sulfate (SO_4^{2-}) (mg/L)	22.96 ± 20.00	-0.70	0.003

Condition Factor

Infected fish had a significantly ($p < 0.05$) lower Fulton's condition factor (2.53 ± 2.10) compared to non-infected fish (2.90 ± 2.72), indicating negative effects on growth and overall health (**Table 5**).

Table 5: Fulton's condition factor (K) of infected and non-Infected Fish

Parameters	Non-infected Fish (K)	Infected Fish (K)	p-value
Season			
Dry Season	3.24 ± 3.19[a]	2.47 ± 1.94[b]	0.001
Rainy Season	2.87 ± 2.72	2.68 ± 2.39	0.200
Culture System			
Pond	3.36 ± 3.30[a]	2.61 ± 2.17[b]	<0.001
Tank	3.35 ± 2.72[a]	1.92 ± 1.14[b]	0.002
All Fish	2.90 ± 2.72[a]	2.53 ± 2.10[b]	0.002

a, b: Values bearing different superscript letters are significantly different

DISCUSSION

Aquaculture is a vital sector in the West Region, contributing substantially to food security, income generation, and employment opportunities. However, the sector faces persistent challenges, particularly the reemergence of fish diseases that compromise production efficiency and cause economic losses. These disease outbreaks are frequently exacerbated by environmental factors, including water quality and temperature fluctuations, which can compromise fish immune defenses and create favorable conditions for pathogen proliferation (**Bruneaux et al., 2017; Goater et al., 2005).** Climate change models predict increased temperature variability in tropical regions, which may further exacerbate these parasitic challenges in coming decades (**IPCC, 2022**).

This research investigates the impact of abiotic factors on prevalence of parasite and condition factor in three farmed fish species (*Oreochromis niloticus*, *Cyprinus carpio*, and *Clarias gariepinus*). The high parasite prevalence observed highlights significant challenges in Cameroon's aquaculture sector. Ectoparasites were abundant certainly due to direct life cycles and favorable environmental conditions (**Bakke et al., 2007**). This high parasite prevalence is consistent with previous studies, which found that parasite infections have a negative influence on fish production at rate ranging from 30% to 50% (**Jerônimo et al., 2020; Mutungi et al., 2020; Tavares-Dias and Martins, 2017**). It is well documented that dry season promotes parasite transmission and development (**Tombi et al., 2014).** The findings revealed a positive correlation between temperature and parasitism which is consistent with thermodynamic principles in parasite biology stating that high temperatures accelerate parasite metabolic rates, generation times, and transmission windows (**Morley, 2020**). Although the intensity was low, the presence of even small numbers of parasites can have significant subclinical effects on fish performances including, reduced feed conversion efficiency (**Shinn et al., 2015**). Higher parasite loads during the dry season could be due to reduced water volume and elevated temperatures, which promote ectoparasite reproduction. The low prevalence recorded in concrete tanks is likely due to improved water quality control, quicker removal of organic materials, and a potential reduction in intermediate host populations (**Pulkkinen et al., 2018**). The prevalence differences across locations reflect local water quality and management practices (**Maina et al., 2017**). Integrated aquaculture systems can enhance water quality stability, reduce eutrophication, and hence limit parasite proliferation (**Jerônimo et al., 2022**).

Non-integrated ponds have unstable water conditions that promote infestations (**Owili et al., 2013; Roberts and Ellis, 2012**). High turbidity can mechanically damage gill filaments, impairing respiration and increasing vulnerability to ectoparasites such as *Gyrodactylus* sp. Furthermore, the presence of organic pollutants (as indicated by phosphates) provides a substrate for bacterial growth, which might stress fish and reduce their immune response to parasite invasion (**Chidobem et al., 2014; Jeronimo et al., 2022; Vajda et al., 2023**). Negative correlations with dissolved oxygen and calcium underscore the importance of water quality management (**Bruno and Poppe, 1996**).

Poor farming practices increased infection rates (**Ogonna et al., 2017**). Farmer training and improved management are essential to reduce parasitism (**Acosta-Pérez et al., 2022). Smith et al. (2021**) revealed that training programs focusing on biosecurity and early pathogen detection have been shown to significantly reduce parasite prevalence and improve fish health in various tropical aquaculture systems. Fish fed twice daily had a higher parasite prevalence than those fed once daily. This observation might be linked to increased stress levels in fish due to feeding frequency or the possibility of more organic matter accumulation (**Ezeri, 2001**), which can promote parasite proliferation. Therefore, optimizing feeding regimes is more than just promoting growth; it is also a critical biosecurity strategy. Feeding should be adjusted to fish biomass and appetite, minimizing waste and water quality degradation that promotes parasitism (**FAO, 2020**). Moreover, farms managed by farmers with lower educational levels had higher parasite prevalence, emphasizing the importance of knowledge and management skills in disease prevention. Indeed, poorly trained farmers recorded up to 45.41% prevalence, which highlights the importance of sanitary control measures and best management practices in tropical aquaculture to minimize economic losses and promote fish health (**Acosta-Pérez et al., 2022; Jeronimo et al., 2020; Tavares-Dias and Martins, 2017; FAO, 2017**).

Despite the high prevalence, no mortality was recorded, but reduced condition factors indicate subclinical impacts on growth and health, overall farm productivity, and profitability (**Silva et al., 2021**). This finding is consistent with **Thompson and Larsen (2004) and Akoll et al. (2012),** who reported that parasites impair feed conversion, growth performance, and physiological status. Absence of mortality suggests tolerance to moderate infections or adaptation. The significant reduction in condition factor without concomitant mortality indicates a state of subclinical infection. Instead of causing direct mortality, such infections might result in economic losses due to poor feed conversion efficiency (**Shinn et *al.*, 2015**).

CONCLUSION

This study found that parasite prevalence and reduced condition factor in farmed fish of Western Cameroon are mainly influenced by seasonal variation, poor water quality, and inadequate management practices. Infected fish had a decreased Fulton's condition factor, showing that parasitism has deleterious effects on the growth and physiological status of the three considered species. We recommend farmers establish regular water quality monitoring and control measures. Adjust the feeding practices to fish biomass to minimize excessive organic waste, and register for targeted training programs to promote best parasite management and biosecurity measures.

AUTHOR CONTRIBUTIONS

NDF: parasitological analysis, writing; **AG**: analysis, statistics; **HVN:** statistics, review; **JN**: conceptualization, review; **MKK**: conceptualization, writing; **JAN**: conceptualization, review. All authors approved the final manuscript.

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DATA AVAILABILITY

Data is available upon request from the corresponding author.

CONFLICTS OF INTEREST

The authors declared that there is no conflict of interest regarding the publication of this paper.

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