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Physicochemical parameters of the Lekki Lagoon in relation to abundance of Wenyonia sp Woodland, 1923 (Cestoda: Caryophyllidae) in Synodontis clarias (Linnaeus, 1758)

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ABSTRACT

Parasitic infection of fish is seen worldwide, and they are of particular interest in the tropics. Reports indicate that parasite infections in fishes lead to a disruption in aquaculture production. This study was undertaken to determine the association between physicochemical parameters and the abundance of Wenyonia sp Woodland, 1923 in Synodontis clarias collected from Lekki Lagoon, Lagos, Nigeria. A total of 180 Synodontis clarias were investigated between April 2019 and March 2020. The physicochemical parameters such as temperature, pH, turbidity, electrical conductivity, dissolved oxygen, and total dissolved solids of the surface water at the Lekki Lagoon were assessed in situ using the Horiba U50 multi-water sampler at three (3) Points, 500 metres apart. There was a positive correlation between parasite abundance and all the physicochemical parameters investigated. Water temperature showed a positive correlation with pH and turbidity and a negative correlation with electrical conductivity, dissolved oxygen, and total dissolved solids. The results showed that the statistical T-value (-2.72) of the parasite abundance between the male and the female fish was lower than the critical T-value (1.98), indicating no significant difference in the levels of infections between the male and female fish samples. In conjunction with future data, the data produced in this study can be used in monitoring the aquatic habitat for informed remediation of the lagoon to aid the preservation of the ecological services rendered by the aquatic ecosystem.

1. Introduction

Parasitic diseases of fish are widespread worldwide and are of particular importance in the tropics (Roberts et al., 2000). Parasitic infections in fishes have been reported to enormously disrupt aquaculture production and its economic viability (Abba et al., 2018). Freshwater fish can serve as definitive, intermediate, or paratenic (transport) hosts (Osimen and Anagha, 2020) in the lifecycle of many species of helminth parasites. Parasites usually affect the market value of commercially produced fish, thus raising public health concerns, especially in areas where raw or smoked fish is eaten (Paperna, 1996; Auta et al., 2019). Parasites constitute a significant problem confronting aquaculture with pathological conditions that arise from their infection, with potentially serious consequences, especially in crowded conditions (Van-den Brock, 1979). Mbuthia, 1993 (Mbuthia, 1993) reported that parasites hamper fish reproduction, growth, appearance and, welfare. There is a relationship between parasites, the state of the water body, and fish health. Endoparasitic infections often indicate the quality of the water since fish helminths generally increase in abundance and diversity in polluted waters (Poulin, 1992; Avenant-Oldewage, 2001).

Water quality deals with water's physical, chemical, and biological characteristics (Johnson et al., 1997) together with all other hydrological properties (Ahmad et al., 2016). Various physicochemical and biological factors are used as determinants of water quality, as they may directly or indirectly affect the suitability of the aquatic environment and invariably distribution and production of fish and other aquatic animals (Yerima et al., 2017). The health status of the aquatic ecosystem directly or indirectly influences fish health, thereby affecting the immunity of fish and leading to disease susceptibility (Abba et al., 2018). Fishes in polluted water bodies are more susceptible to diseases (Biswas and Pramanik, 2016).

Aquatic systems are affected by several anthropogenic activities that decrease water quality by introducing organic and inorganic pollu-

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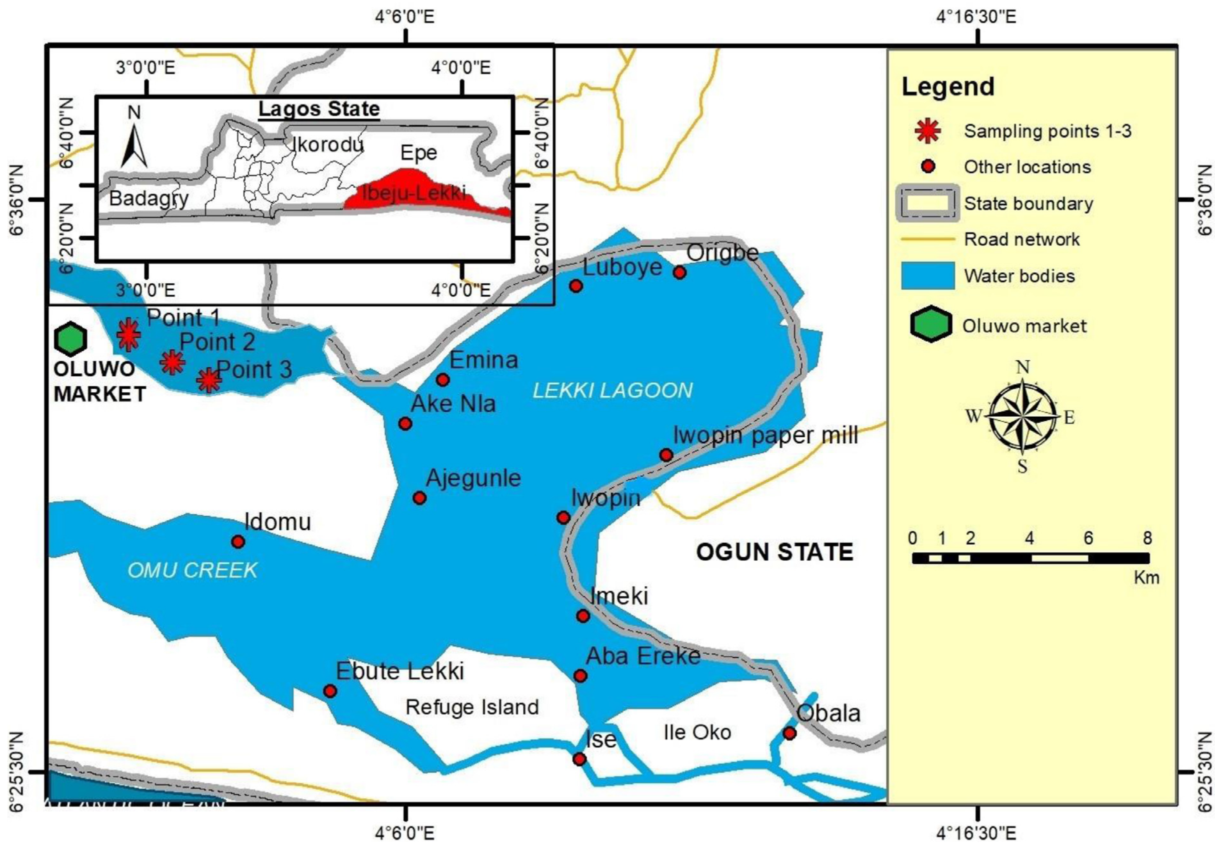


Fig. 1. Map of Lekki Lagoon showing the sampling points (Akinsanya et al., 2020).

tants (Bayoumy et al., 2015). Water quality parameters such as water pH, temperature, dissolved oxygen content, alkalinity, salinity, carbon dioxide, and free carbon and parasitological factors like prevalence, mean intensity, mean abundance of parasite indicate a distinct relationship between water quality and parasitic infection or fish susceptibility to parasitic infection (Biswas and Pramanik, 2016).

Water quality and seasons are the most important factors affecting the prevalence of parasites (Bayoumy et al., 2015). Altered water quality may also improve conditions for parasites if their host's density increases (Lafferty and Kuris, 1999). Therefore, Fish parasite communities may provide crucial information on ecosystem conditions due to their intimate contact with the host and aquatic environments (Singh and Mishra, 2013).

Synodontis clarias (Linnaeus, 1758), the squeaker or upside-down catfish, is a benthopelagic, potamodromous, freshwater fish. It has a strong, bony head capsule, with a grey to green colour on the back and white on the underside. S. clarias, in its natural environment, is a bottom feeder, feeding on insect larvae, plants, and detritus (Awaïss et al., 2010). This fish has been reported to occur in the Lekki Lagoon (kusemiju, 1981).

This study was undertaken to determine the association between water quality parameters and the abundance of gastrointestinal parasites in Synodontis clarias from Lekki Lagoon, Lagos, Nigeria.

2. Material and methods

2.1. Study area

The Lekki Lagoon (Fig. 1) has a surface area of about 247km^2 (Adesalu and Nwankwo, 2009). The lagoon lies within 6°25′- 6°35′N and 4°00′- 4°13′E and is characterized by alternating dry and wet seasons (Adesalu and Nwankwo, 2009). Land in the study area is predominantly used for agriculture, with great use of agrochemicals (Adesalu and Nwankwo, 2012). The vegetations in the catchment area of the lagoon comprise mangrove species identified as Rhizophora racemosa (red mangrove), Avicennia nitida (white mangrove), Acrosticum aureum, Paspalum orbiculare, and Dryopteris (Adesalu and Nwankwo, 2012).

Lekki Lagoon has a maximum depth of 6.4 m, the greater part of the lagoon is shallow than 3.0 m in depth (Akinsanya and Kuton, 2016). The Lekki Lagoon is fed by the River Oni discharging to the north-eastern and River Oshun and Saga flowing into north-western parts of the lagoon (Emmanuel and Chukwu, 2010).

2.2. Sample collection

One hundred and eighty Synodontis clarias were obtained fresh from the Oluwo market between April 2019 and March 2020 at Epe, Lagos, Nigeria.

2.3. Physicochemical parameters

The physicochemical parameters of the surface water at Lekki Lagoon were taken using the Horiba U50 multi-water sampler in situ (Popoola et al., 2015). The physicochemical parameters determined are temperature, pH, turbidity, electrical conductivity, dissolved oxygen, and total dissolved solids. The readings for these water parameters were taken at three sampling points 1, 2, and 3 along the lagoon 500 m apart.

2.4. Determination of fish morphometrics

The fishes' standard lengths and total lengths were measured with a metre rule (Akinsanya et al., 2007). Their weight was also taken with a digital weighing balance (Ohaus CS 5000). A gross examination of the gonads was used to determine the sex of the fishes (Akinsanya and Kuton, 2016).

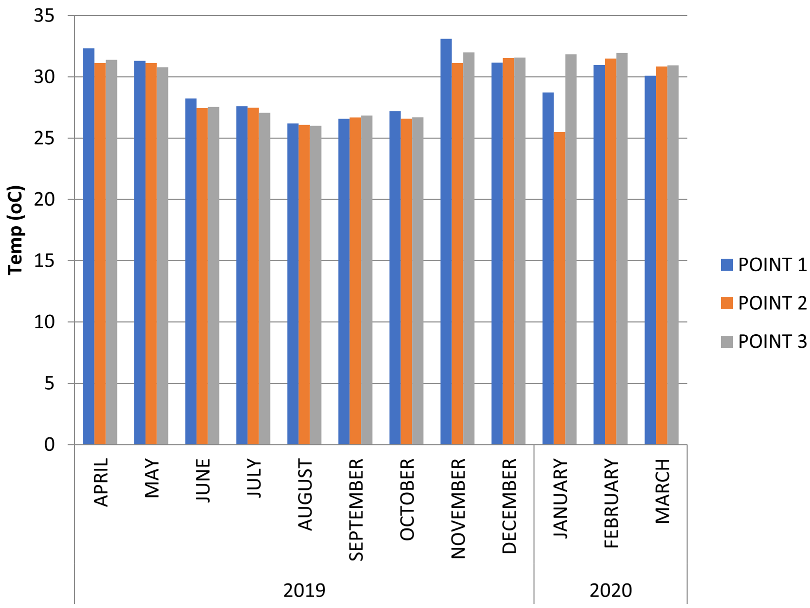


Fig. 2. Spatial and temporal variation in surface water temperature.

2.5. Parasitological examination

The fishes were dissected, and the gastrointestinal part of each fish was removed, placed inside Petri dishes with physiological saline (Akinsanya and Kuton, 2016), slit open, and examined for parasitic helminths (Olurin and Somorin, 2006). The collected helminth parasites were fixed in 70% alcohol (Hassan et al., 2010), counted, and recorded. Identification of the specimens to species level was done using keys provided by (Paperna, 1996; Ukoli, 1972; Yamaguti, 1959).

2.6. Data analysis

Mean parasite abundance was calculated using the formula below:

$$Mean\ parasite\ abundance = \frac{The\ total\ number\ of\ parasites\ recovered}{The\ total\ number\ of\ fish\ hosts\ examined}$$

Pearson's correlation was used to establish the correlation coefficient between the various physicochemical parameters and parasite abundance.

3. Results

The temperature of the surface water samples at point 1 was higher than that of point 2, which was higher than the temperature of point 3 (Fig. 2). There was a constant decline in the temperature across the sampling points 1, 2, and 3 through April to October, after when a sharp rise occurred. In the earlier period of the study, point 1 had the highest temperature, but point 3 overtook point 1 towards the end of the sampling period. Generally, the lowest surface water temperature was observed in August 2019, while the peak surface water temperature occurred at point 1 in November 2019.

An erratic and unrhythmic fluctuation pattern occurred in the pH of the surface water of the lagoon throughout the study period (Fig. 3). The highest pH occurred in June 2019, in the order of point 3, > point 2> Point 1, while the lowest pH occurred in November 2019 in the same order. The pH of the lagoon was reasonably stable from August to November 2019.

An irregular pattern was observed in the turbidity of the surface water from the lagoon (Fig. 4). The peak turbidity occurred in January 2020 in point 3> point 2> point 1, followed by November 2019 conversely in point 1> point 2> point 3. The lowest turbidity occurred in May 2019.

Generally, a rhythmic rise and fall in the pattern of electrical conductivity of the surface water occurred throughout the sampling period (Fig. 5). The electrical conductivity at point 1 was higher than the levels at other points in most of the study period. The highest values were recorded in June 2019 in point 2> point 1> point 3. In contrast, the lowest electrical conductivity occurred in January 2020. Notably, equal values were observed amongst the sampling points in November 2019.

An irregular pattern occurred in the dissolved oxygen of the surface water of the lagoon in no particular order (Fig. 6). An outstandingly high dissolved oxygen occurred at sampling point 1 in August 2019, which was the peak of the study period. Point 1 also recorded the lowest in the entire study period in April 2019. After when an outstandingly higher concentration was observed at point 3 than the other sampling points in May 2019.

The peak level of total dissolved solids occurred in June 2019 in the order of point 2> point 1> point 3, while the lowest occurred in January 2020 in the order of point 1> point 2> point 3 (Fig. 7). A close match occurred amongst the sampling points in August 2019.

The monthly average readings of the physicochemical parameters of the three sampling sites mean are shown in (Table 1). The highest mean temperature recorded in the lagoon during the study period was 32.1 ˚C in November 2019, while the lowest mean temperature of 26.1 ˚C was recorded in August 2019. The mean pH values recorded ranged from 3.6 to 8.5; the highest pH was recorded in June 2019, while the lowest was recorded in November 2019. The highest mean turbidity of 181.0NTU was recorded in January 2020, while the lowest was in May 2019. The mean electrical conductivity observed during the period of the study ranged from 0.01- 0.46mS/cm. The mean dissolved oxygen documented was highest in July 2019 at 262.0DO% and lowest in December 2019 at 73.0DO%. The mean total dissolved solids recorded during the study period ranged between 0.02 and 0.29 mg/l. It was highest in June 2019 and lowest in January 2020.

[*Key*: ˚C- *degree Celsius*, NTU- *nephelometric turbidity units, mS/cm-MilliSiemens per centimetre*, DO%- *percentage saturation, mg/l- milligrams per litre*].

Of the six male fishes examined in May 2019, five were infected, while seven female fishes were infected of the nine examined. A total of 278 enteric parasites were recovered from them (Table 2). The exact number of male and female specimens were examined in January 2020, and 239 parasites were recovered. Conversely, the same number of fish was examined in July 2019, but the least number of parasites was recovered. In November 2019, 14 males and a female fish were examined, but only 24 enteric parasites were recovered. In February 2020, three males and twelve females were examined, and 125 enteric parasites were re-

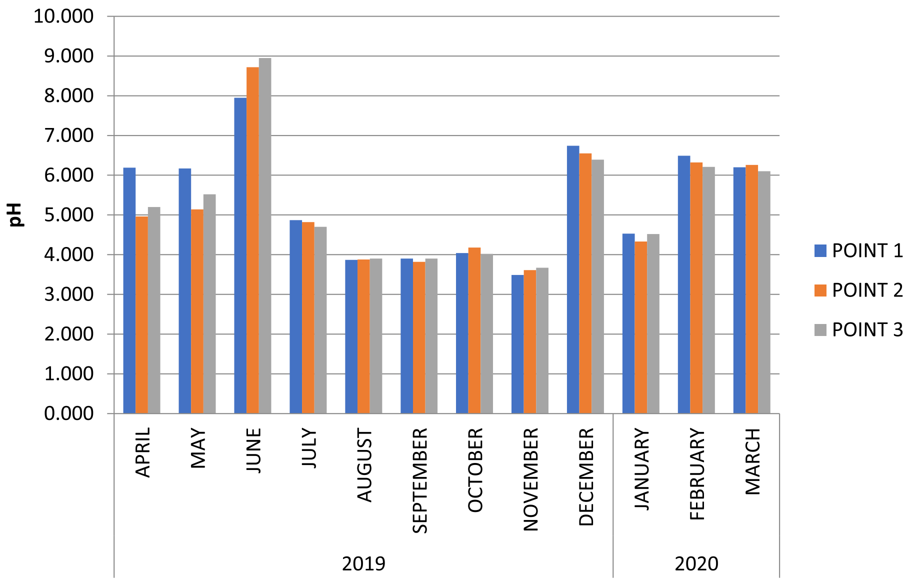


Fig. 3. Spatial and temporal variation in surface water pH.

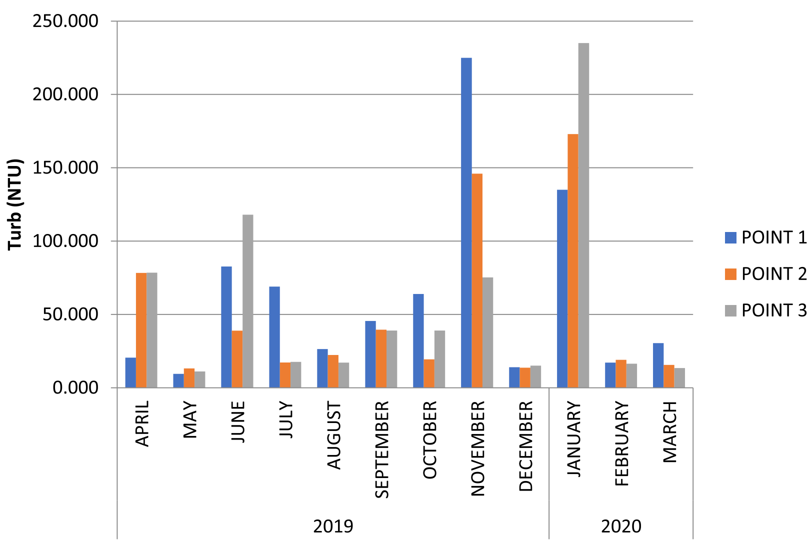


Fig. 4. Spatial and temporal variation in surface water turbidity.

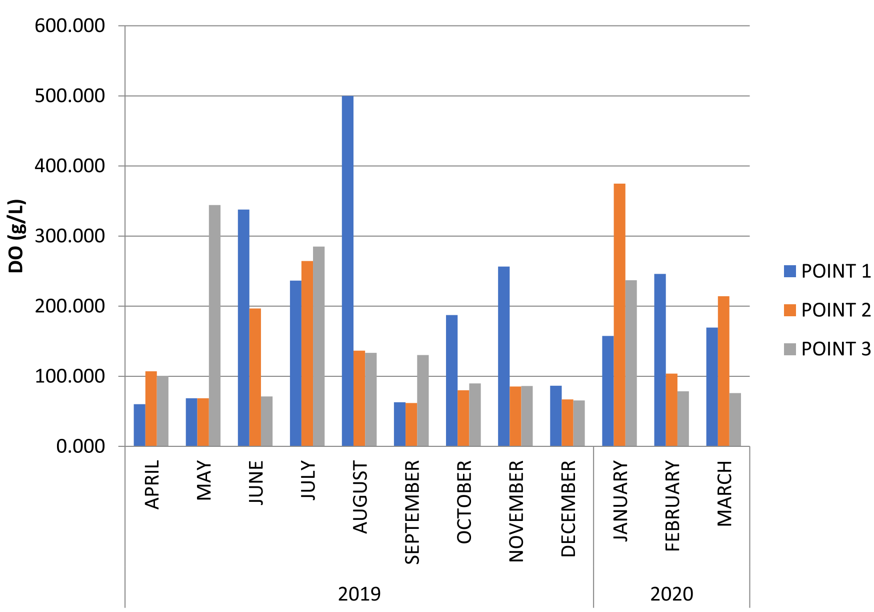


Fig. 5. Spatial and temporal variation in electrical conductivity of surface water.

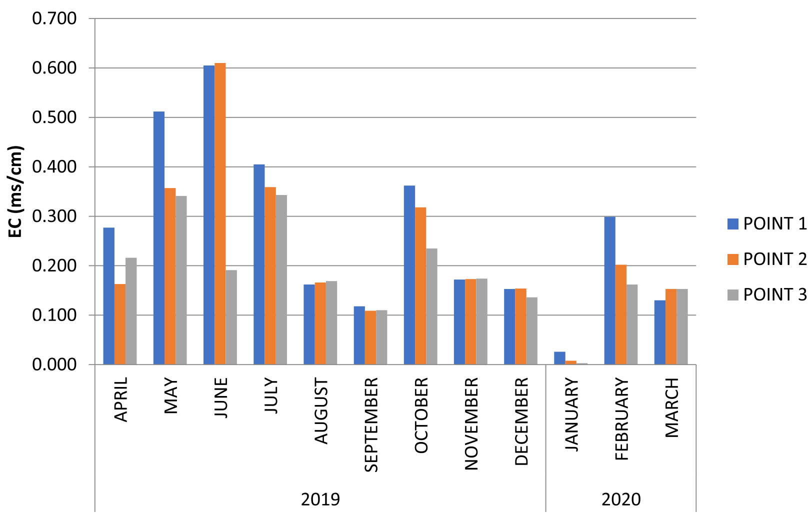


Fig. 6. Spatial and temporal variation in dissolved oxygen of surface water.

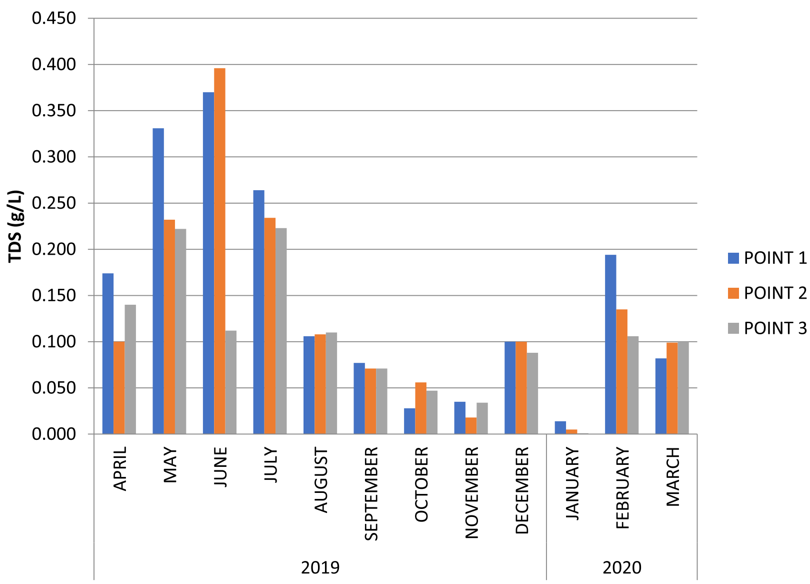


Fig. 7. Spatial and temporal variation in total dissolved solids of surface water.

Table 1
Monthly mean variations of the physicochemical parameters of the Lekki Lagoon.

MONTHS	TEMPERATURE (°C)	pH	TURBIDITY (NTU)	ELECTRICAL CONNECTIVITY (mS/cm)	DISSOLVED OXYGEN (DO%)	TOTAL DISSOLVED SOLIDS (mg/l)
April (2019)	31.6	5.5	59.1	0.21	89.3	0.14
May	31.0	5.6	11.2	0.40	160.5	0.26
June	27.7	8.5	79.8	0.46	201.9	0.29
July	27.4	4.8	34.6	0.36	262.0	0.24
August	26.1	3.9	21.9	0.16	256.6	0.11
September	26.7	3.9	41.3	0.11	85.1	0.07
October	26.8	4.1	40.7	0.30	119.1	0.04
November	32.1	3.6	148.7	0.17	142.7	0.03
December	31.4	6.6	14.3	0.15	73.0	0.10
January(2020)	28.7	4.5	181.0	0.01	256.4	0.02
February	31.5	6.3	17.5	0.22	142.8	0.15
March	30.6	6.2	19.8	0.15	153.3	0.10

covered. The variability is a function of multiple intrinsic and extrinsic interacting factors.

Correlation analyses between parasite abundance and physicochemical parameters investigated in this study are shown in (Table 3). There was a positive correlation between parasite abundance and all the physicochemical parameters investigated. Water temperature showed a positive correlation with pH and turbidity and a negative correlation with electrical conductivity, dissolved oxygen, and total dissolved solids. pH showed a positive correlation with electrical conductivity and total dissolved solids and a negative correlation

Table 2
Monthly parasite abundance indices in Synodontis clarias from Lekki Lagoon.

YEAR	MONTH	NUMBER OF FISHES EXAMINED MALE	FEMALE	NUMBER OF FISHES INFECTED MALE	FEMALE	NUMBER OF PARASITES RECOVERED	MEAN PARASITE ABUNDANCE
2019	April	7	8	2	2	14	0.9
	May	6	9	5	7	278	18.5
	June	2	13	0	7	85	5.7
	July	6	9	2	1	4	0.3
	August	3	12	0	1	24	1.6
	September	5	10	4	7	36	2.4
	October	11	4	4	1	10	0.7
	November	14	1	7	1	24	1.6
	December	9	6	4	2	29	1.9
2020	January	6	9	5	5	239	16
	February	3	12	2	12	125	8.3
	March	5	10	0	5	62	4.1

Table 3
Correlation matrix between physicochemical parameters and parasite abundance in S. clarias from Lekki Lagoon.

Parameters	Parasite abundance	Temp (°C)	pH	Turbidity (NTU)	EC (mS/cm)	DO (DO%)	TDS (mg/l)
Parasite abundance	1						
Temp (°C)	0.310422815	1					
pH	0.187654324	0.26943	1				
Turbidity (NTU)	0.229344708	0.058373	−0.25458	1			
EC (mS/cm)	0.021820796	−0.09809	0.479293	−0.357608688	1		
DO (%Do)	0.20961619	−0.38627	−0.07785	0.314278054	0.1102187	1	
TDS (mg/l)	0.215674641	−0.03492	0.641735	−0.415354859	0.8436758	0.279762	1

Table 4
Parasite T-test: two-sample assuming unequal variances.

	MALE	FEMALE
Mean	2.753247	6.970874
Variance	32.10936	204.7737
Observations	77	103
Hypothesized Mean Difference	0	
Df	141	
t Stat	−2.71958	
P(*T*<=*t*) one-tail	0.003679	
t Critical one-tail	1.655732	
P(*T*<=*t*) two-tail	0.007359	
t Critical two-tail	1.976931	

with turbidity and dissolved oxygen. Turbidity only showed a positive correlation with dissolved oxygen. There was also a positive correlation between electrical conductivity and total dissolved solids.

Key:Temp- Temperature
EC- Electrical conductivity
DO- Dissolved Oxygen
TDS- Total dissolved solids
°C- degree Celsius
NTU- nephelometric turbidity units mS/cm- MilliSiemens per centimetre
DO%- percentage saturation mg/l- milligrams per litre

There is a positive correlation between all the physicochemical parameters observed and the mean parasite abundance at $P>0.05$, except for conductivity which showed almost no correlation with the mean parasite abundance at $P<0.05$ as shown in Figs. 8(a-f) below:

Student T-test analysis was adopted to test the difference between the parasite abundance in the male fish specimens and the female (Table 4). The result showed that the statistical T-value (−2.72) was lower than the critical T-value (1.98); hence, the null hypothesis was rejected, indicating no significant difference in the level of infections between the males and female fish samples.

4. Discussion

The quality of the water determines the primary productivity, species composition, diversity, and abundance of an aquatic ecosystem. The physicochemical parameters of the water thus serve as an indicator of the general health of the aquatic environment. In the current study, the temperature of the aquatic habitat is typical of a tropical wetland (Imoobe and Adeyinka, 2009). The temperature in 2020 was pretty higher than the average temperature in 2019, which may be due to a sudden rise in anthropogenic activities. Gas flaring, emissions from automobiles, generators, and other incomplete combustion engines are capable of causing thermal pollution within the catchment area of the lagoon. Several aquatic faunas are stenothermal, but the currently investigated S. clarias may cope with temperatures below 35 °C without impact on its internal physiology as observed in the current study.

Only in June 2019 was the pH of the aquatic environment within an acceptable range. In most of the period of the study, the pH of the aquatic habitat was relatively acidic. The acidity of the aquatic environment from July to November 2019 was too acidic to support healthy habitat. The acidic condition of the water body may enhance the bioavailability of pollutants in the environment (Isibor et al., 2020), which may endanger the aquatic biota. The sustained acidity in 2019 may be associated with the predominant oil exploration activities around the lagoon.

High turbidity in the lagoon, particularly in November 2019 and January 2020, may be linked to the anthropogenic perturbations around the catchment area. The perturbations capable of discharging particulate matter into the water body are mainly notable for inflicting mechanical alterations on the architectural integrity of the fish gills. High turbidity may also impede the availability of sunlight to the aquatic primary producers at the base of the pyramid of biomasses (Isibor et al., 2016), which may, in turn, impact all other aquatic organisms at higher trophic levels (Isibor et al., 2018).

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulphate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminium cations (APHA 1992). Imoobe and Adeyinka (Imoobe and Adeyinka, 2009)

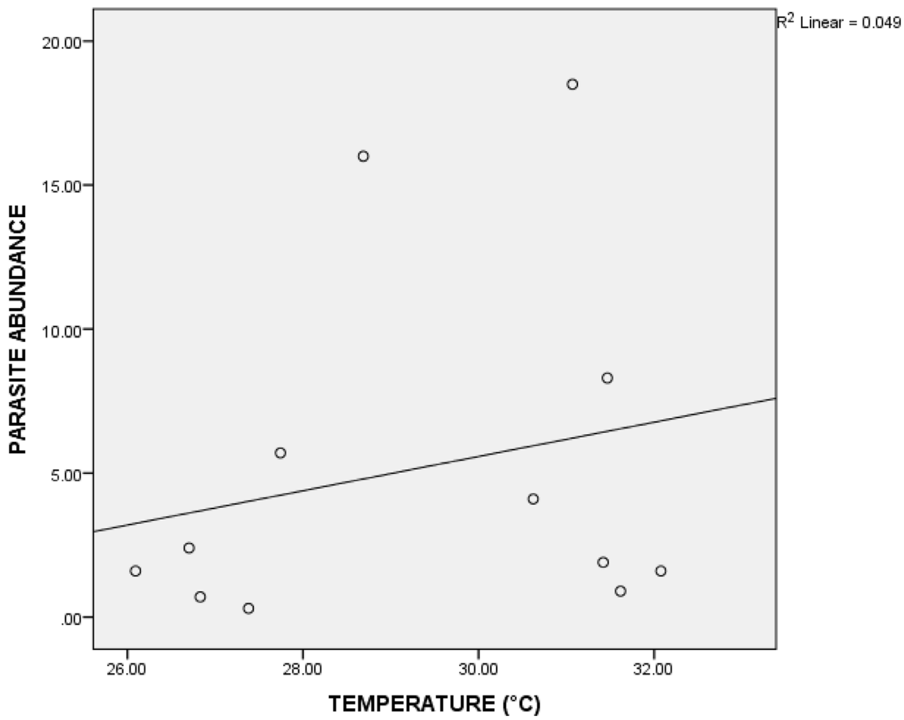


Fig. 8. 8a: Correlation between parasite abundance and temperature at $P>0.05$; Fig. 8b: Correlation between parasite abundance and pH at $P>0.05$; Fig. 8c: Correlation between parasite abundance and turbidity at $P>0.05$; Fig. 8d: Correlation between parasite abundance and electrical conductivity at $P>0.05$; Fig. 8e: Correlation between parasite abundance and dissolved oxygen at $P>0.05$; Fig. 8f: Correlation between parasite abundance and total dissolved solid at $P>0.05$; Key: °C- degree Celsius; NTU- nephelometric turbidity units; mS/cm- MilliSiemens per centimetre; DO%- percentage saturation; mg/l- milligrams per litre.

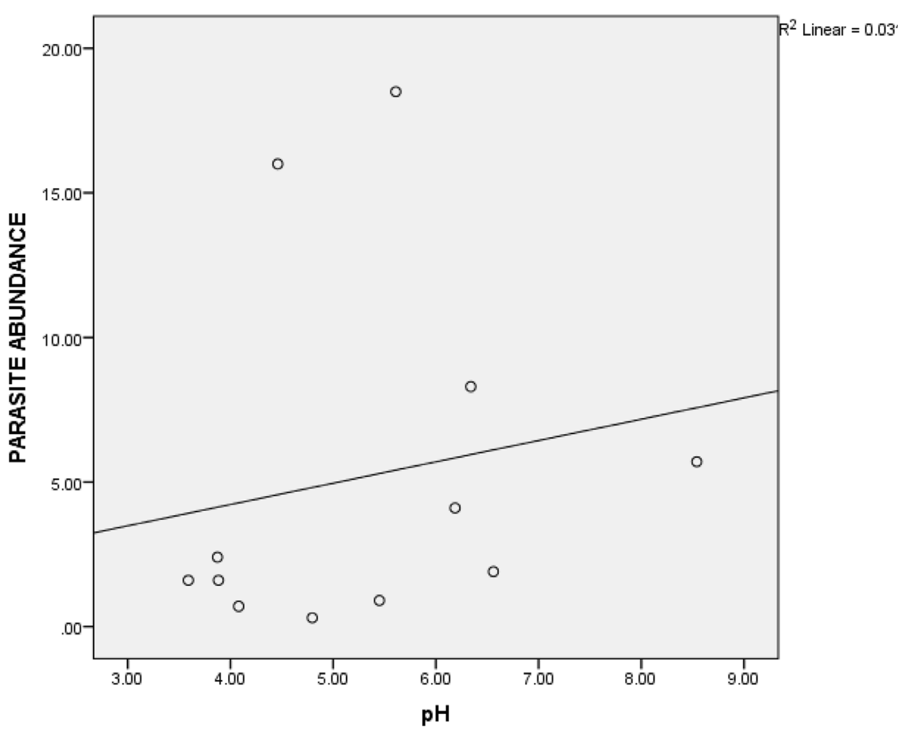
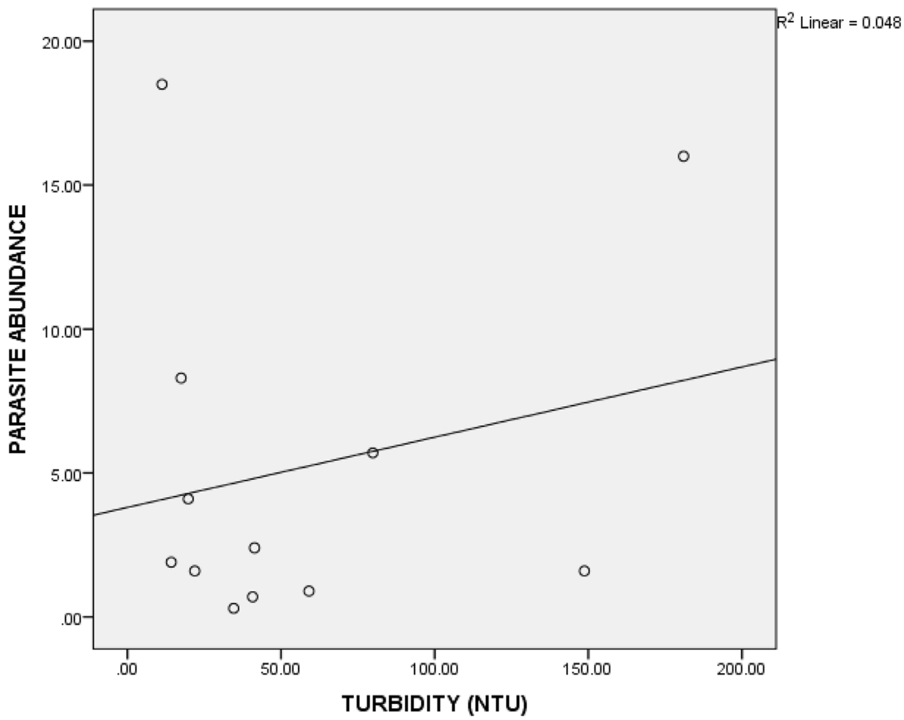


Fig. 8. Continued

emphatically demonstrated the influence of chloride, nitrate, and sulfate anions on the health of the Osse River. Shortly afterward, Isibor (Isibor, 2017) reported the roles of chloride, nitrate, sulfate, and phosphate on the trophic status of Osse River, which moderate the abundance of the zooplankton in the aquatic ecosystem. Abdul et al. [36] also described the background roles dissolved inorganic ions play in the dynamics of nutrient distribution in Lekki Lagoon. Several authors have used the strong correlation between ions and the conductivity of water samples to explain the status of Lekki Lagoon (Abdul et al., 2019; Opadokun et al., 2015). Organic compounds such as oil predominant in the catchment of the current study area do not conduct electrical current very well and therefore have a low conductivity (EPA, 2016) impact on the water.

Furthermore, conductivity may be affected by temperature, in the sense that the warmer the water becomes, the higher the conductivity. Discharges to aquatic environment that can change the conductivity depends on their make-up. A leaking sewage system could have raised the conductivity because of the presence of chloride, phosphate, and nitrate. An oil spill would lower the conductivity; hence, the relatively high electrical conductivity in 2019 at the lagoon indicates a domes-



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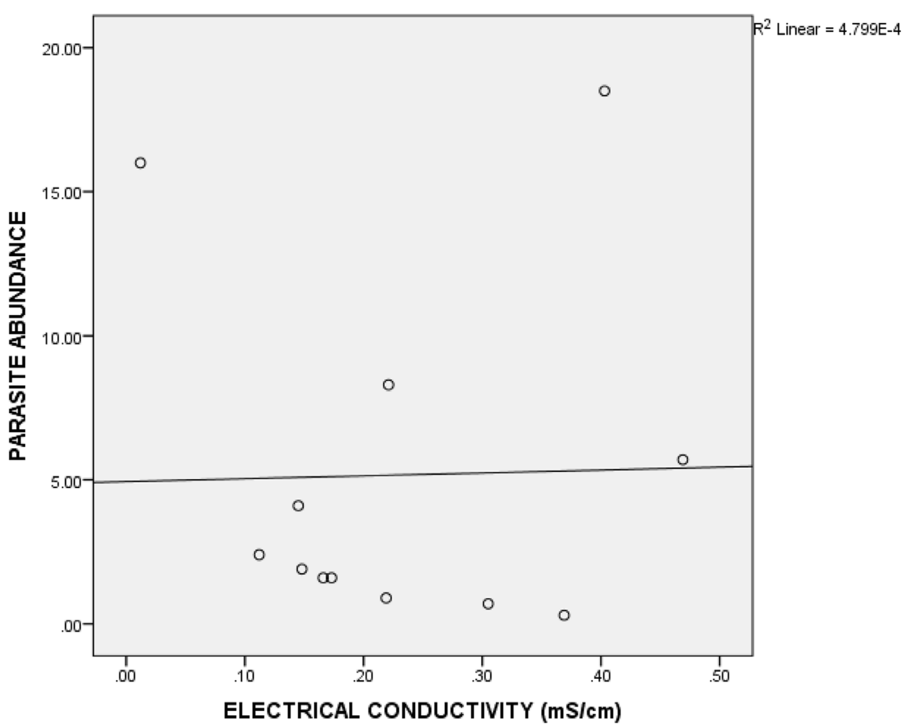

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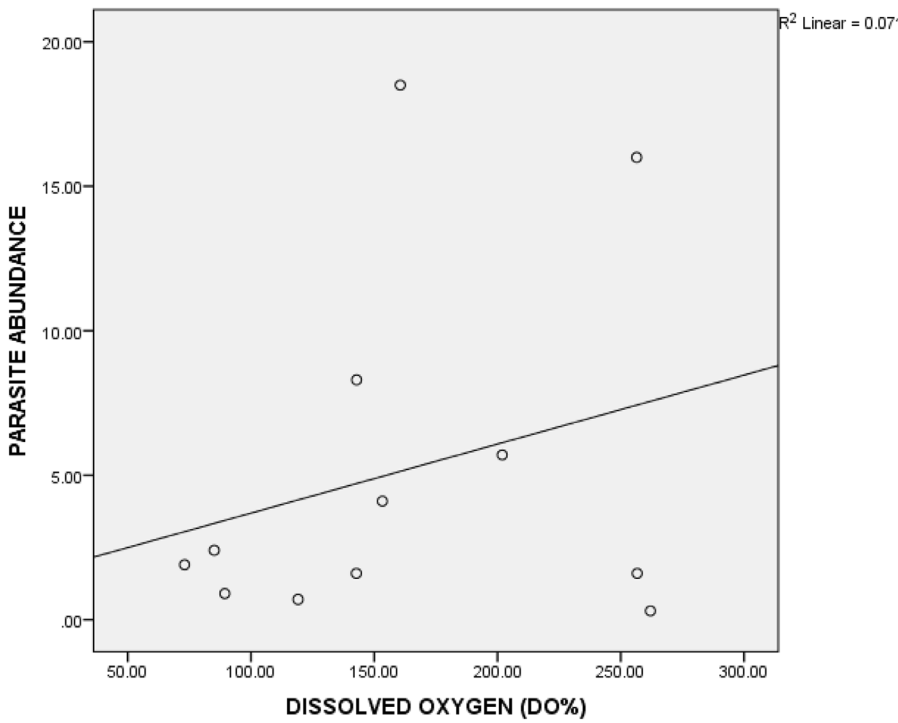
tic source of inorganic cations and anions. The high similarity in the fluctuation patterns of electrical conductivity and total dissolved solids further validates the presence of inorganic ions in the lagoon.

The high temperature in August 2019 coincided with minimal dissolved oxygen at points 2 and 3 because, at higher temperatures, water loses its oxygen retention capacity, which may be detrimental to aquatic fauna of low resilience. S. clarias may, however, thrive in the current state as the low oxygen level was not sustained in the subsequent months when the aquatic habitat had the chance to recover its required oxygen level following the stabilized temperatures. (Imoobe and Adeyinka, 2009) earlier reported on the importance of the regulatory capacity of Ovia River on its physicochemical properties to ensure continuous maintenance of aquatic health. (Abdul et al., 2018) later discovered that the aquatic habitat may have lost its recuperative capacity due to overwhelming persistent anthropogenic perturbations. In the current study, the lagoon may have been facing multi-stress factors which have the synergistic potential to outrun the recuperative capacity of the aquatic habitat in unexpectedly shorter time-space. Oil exploration is the anthropogenic activity around the lagoon that might impact the dissolved oxygen concentration in the surface water investigated. This pre-



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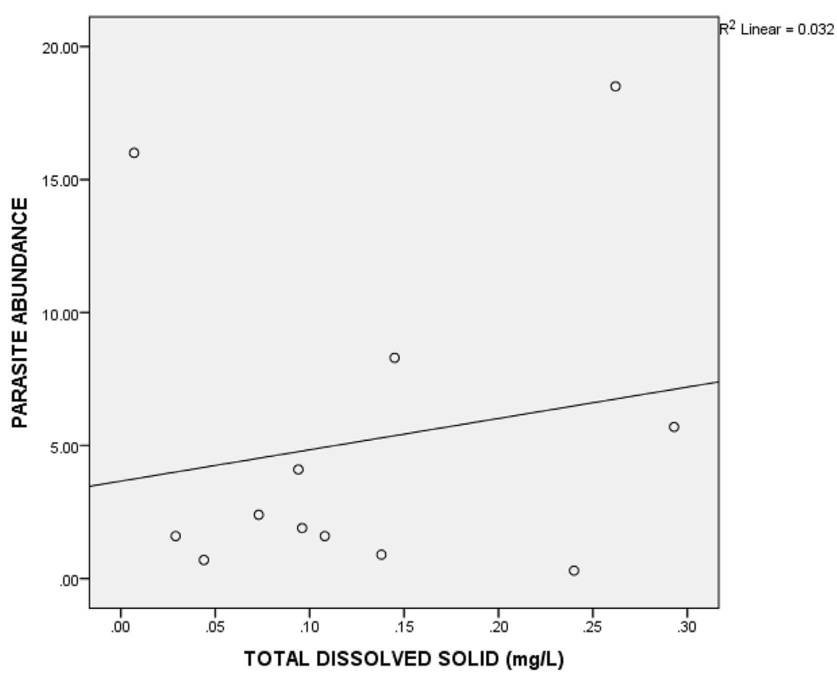

Fig. 8. Continued

dominant activity leaves oil film floating on the water's surface, which may evaporate or detoxify due to exposure to heat energy from the sunlight. However, the sun's intensity is not enough to impact the oil spill in the rainy season. Hence, point 1 may have had an attendant rise in oxygen concentration in August 2019 due to the heavy rains, which might have drifted the floating oil film towards points 2 and 3.

The overall physicochemical properties of the lagoon may appear somewhat perturbed but may not be of significant threat to resilient fish species like S. clarias. On the other hand, excess inorganic nutrients may have stimulated the primary productivity of the aquatic environment, thereby booming the availability of food resources for the fish, which partly explains the obese condition of the fish population. However, if this condition is sustained, eutrophication may ensue and lead to catastrophic episodes of algal bloom, hypoxia, reduced biodiversity. At this early stage of the environmental challenge, a prompt remedial measure is required. Previous studies such as (Abdul et al., 2019; Akinsanya et al., 2020; Isibor et al., 2020), which explored this lagoon, did not make this notable observation of soaring inorganic elements. Hence, further studies are required in the future to ascertain the trophic state of the aquatic habitat.

In the current study, a higher prevalence of enteric parasites occurred in the female S. clarias than the males. The findings of Akinsanya, 2015 (Akinsanya, 2015), who reported a higher prevalence of infection in female Synodontis filamentosus than the male, corroborate the current study. However, this study is at variance with the findings of Adegoroye et al., 2019 (Adegoroye et al., 2019), who reported a higher prevalence of helminth parasites in male fishes than their female counterparts. The high prevalence of intestinal helminth in the S. clarias of the lagoon could be due to the lack of proper waste disposal and management of septic systems. It is imperative to mitigate the indiscriminate waste disposal along the lagoon coastline and failed septic systems within the catchment area. Notably, there was no difference in the levels of parasitic infection between both sexes of the fish. Furthermore, results show that the parasites had no significant impact on the health of the host fish; this points to the fact that the prevailing anthropogenic activities had not seriously impacted the studied environment as of when the survey was conducted. There is, however, likely to be an impending disruption that might tremendously impact the environment and the health of the dependant populace (Isibor et al., 2016).

5. Conclusion

The results show that anthropogenic activities on the Lekki Lagoon have latent health and environmental impacts, prognoses of grave concern if not urgently mitigated. For informed remediation of the lagoon, for the preservation of its ecological services, the data from this study, in addition to future data, may help monitor the aquatic habitat.

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