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(Research Article)

Influence of Physico-Chemical Parameters on Fish Behavior in Lake Guessabo (Côte d'Ivoire)

Attoubé Ida MONNEY [1, *], Mamadou BAMBA [2], Kouakou Jean-Baptiste ABO [1], Olga Rosemonde N'DRI [1], Kouakou Sévérin ATTOUNGBRE [1] and Tidiani KONE [1]

[1] *Laboratory of Biodiversity and Tropical Ecology, Faculty of Environment, Jean Lorougnon Guédé University, Daloa, Côte d'Ivoire.*

[2] *Laboratory of Natural Environments and Biodiversity Conservation, Faculty of Biosciences, Félix Houphouët-Boigny University, Abidjan, Côte d'Ivoire.*

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Abstract

Video surveillance is a non-invasive method that allows fish to be observed in their natural habitat without disturbance. This study, conducted in Lake Guessabo, aimed to identify the main activities of fish in order to contribute to better biodiversity conservation. Physico-chemical parameters of the water were measured *in situ*, and four unbaited cameras were installed between 7:00 a.m. and 6:00 p.m. at two study stations. The results showed that environmental conditions were similar between the stations. Six fish species were recorded, mainly engaging in feeding (84 % at S1 and 100 % at S2) and reproductive (16 % at S1 and 0 % at S2) activities. The species *Coptodon zillii* stood out for its high level of activity and the diversity of its behaviors. Observations indicated that dissolved oxygen, water transparency, and depth strongly influence feeding and reproductive behaviors. These findings confirm the effectiveness of video surveillance as a tool for studying fish behavior and promoting the sustainable management of aquatic ecosystems.

Keywords: Video surveillance; Fish behavior; Environmental parameters; Lake Guessabo

1. Introduction

Lake ecosystems are reservoirs of biodiversity and sensitive indicators of the ecological health of aquatic environments [1, 2]. In West Africa, inland lakes not only host a rich diversity of fish species but also provide essential resources for local food security and economic activities [3, 4]. Understanding how fish interact with their environment is therefore fundamental for assessing the health and functioning of these ecosystems. Fish behaviors-whether related to reproduction, feeding, or social interactions-re cosely influenced by the physico-chemical conditions of the water, such as temperature, dissolved oxygen, conductivity, and transparency [5, 6, 7]. Variations in these parameters can affect not only species distribution but also the behavioral dynamics of the entire fish community [8, 9]. However, despite their importance, such relationships remain poorly documented in Ivorian lakes, limiting the ability to anticipate the impacts of environmental and anthropogenic changes.

Lake Guessabo, located in the central-western region of Côte d'Ivoire, represents an ideal model for exploring these interactions. Situated upstream of Lake Buyo, it exhibits a diversity of littoral habitats and varying levels of human pressure [10]. Although several ichthyological surveys have been carried out in this area [11, 10], no detailed study has yet analyzed the influence of physico-chemical parameters on fish behavior in this lake. Understanding the relationship between environmental conditions and fish behavior is essential for the conservation and sustainable management of fishery resources. In the absence of such data, managers have limited tools to predict the effects of environmental

* Corresponding author: Attoubé Ida MONNEY

disturbances or human pressures on fish populations. In this context, the present study aims to evaluate the influence of water physico-chemical parameters on fish behavior in Lake Guessabo. Specifically, it seeks to (i) determine the physico-chemical characteristics of the sampling stations, (ii) observe and identify the types of fish behaviors displayed, and (iii) analyze the relationships between physico-chemical parameters and observed behaviors.

2. Material and methods

2.1. Study Area

Lake Guessabo is located in the central-western region of Côte d'Ivoire, between latitudes 6°57' and 7°2' N and longitudes 6°45' and 6°46' W [10] (Figure 1). It forms the upstream section of Lake Buyo and covers an area of approximately 27 km^2, with depths ranging from 0.5 to 20 meters. Two sampling stations (S1 and S2) were selected, each divided into three points, based on accessibility and the level of human disturbance observed. Station S2 is characterized by stronger anthropogenic influence than S1 (Figure 1). Both stations feature riparian vegetation and a substrate composed mainly of sand, gravel, and plant debris.

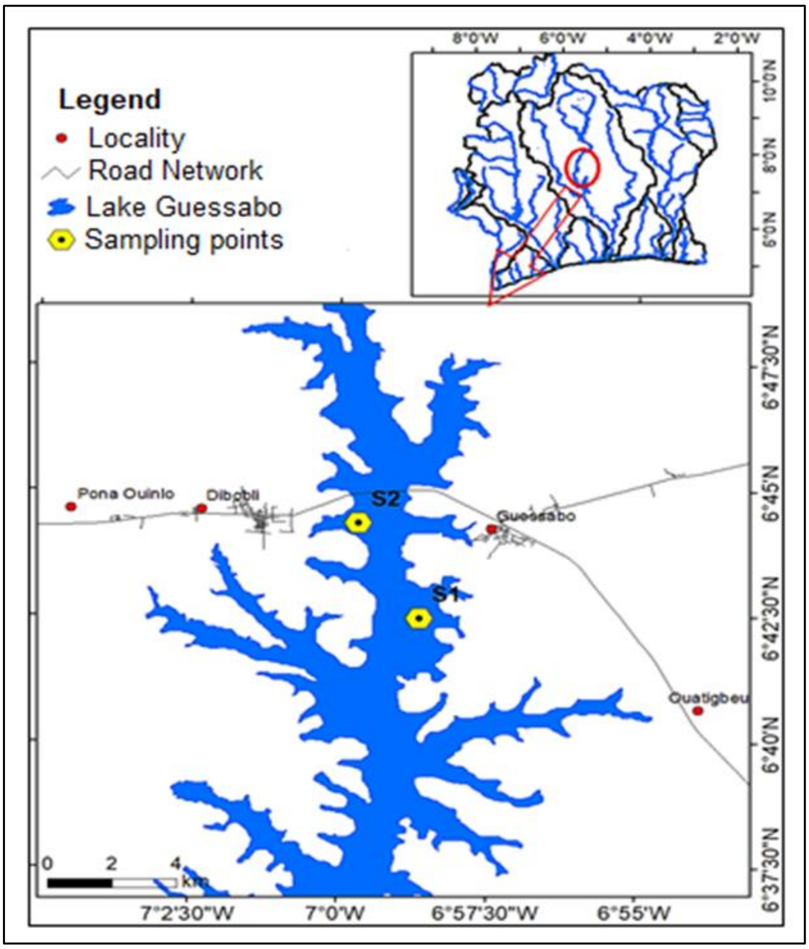

Figure 1 Sampling stations in Lake Guessabo (Côte d'Ivoire)

2.2. Data Collection

2.2.1. Measurement of Environmental Parameters

Water temperature (°C) and electrical conductivity (µS/cm) were recorded monthly between 7:00 and 8:00 a.m. using a HINKIS multiparameter device. Dissolved oxygen (mg/L) was measured with an AZ 8403 oximeter. Water transparency was estimated using a 30 cm Secchi disk, while depth (cm) was determined with a graduated and weighted rope. This study was conducted from February to August 2024 in Lake Guessabo.

2.2.2. Fish Observation

Fish behavior was monitored using four video recording systems with a minimum detection range of 20 m [12]. Each system consisted of a camera (brand: APENAM; model: M80; 20 MP; 4K resolution; wide-angle lens) mounted horizontally on a support to facilitate the identification of individuals within the field of view [13]. Before deployment, the indicator light of each camera was covered with black adhesive tape to avoid disturbing fish behavior.

The devices were manually installed, with each recording session lasting 1 hour and 30 minutes. At the end of each session, the cameras were retrieved for battery replacement. In each habitat, four deployments per camera were carried out over four days per month, between 8:30 a.m. and 5:30 p.m. This study was conducted from February to August 2024 in Lake Guessabo.

2.2.3. Data Analysis

In the laboratory, the recorded videos were transferred to DVDs and analyzed on a computer using **GOM Player** and **VLC** software. These programs allowed slow-motion playback and image adjustment (contrast, brightness, saturation) to facilitate fish identification [14]. Species were identified using the identification keys of [15, 16], with taxonomic updates based on **FishBase** [17].

The observed behaviors were categorized according to several criteria, particularly reproductive behaviors, defined following [18], [19] and [20]. These activities include:

- Guarding of eggs and larvae;
- Nest construction;
- Spawning behavior;
- Egg fertilization;
- Reproductive aggregation.

Feeding behaviors were defined according to the activity types proposed by [21] and [12]:

- Food collection on aquatic vegetation;
- Food collection on the bottom;
- Food collection within the water column.

2.3. Kruskal–Wallis and Mann–Whitney Tests

The non-parametric Kruskal–Wallis and Mann–Whitney tests were applied to evaluate the significance of differences in behavioral frequency between stations. The level of significance was set at $p < 0.05$. All statistical analyses were performed using STATISTICA software version 7.1.

2.4. Spearman's Rank Correlation Coefficient

Spearman's rank correlation coefficient was used to examine relationships between fish behaviors and environmental variables.

3. Results

3.1. Environmental Characteristics

Five parameters were measured in this study: temperature, dissolved oxygen, transparency, depth, and conductivity (Table 1). Maximum, minimum, and mean values of these parameters were determined for each station. The results of the environmental variables are presented in Table 1. The mean values of the physico-chemical parameters showed no significant differences between stations (Kruskal-Wallis; $p > 0.05$). Water temperature reached its maximum value at station S1 (27.53 ± 0.55 °C) and its minimum at station S2 (27.30 ± 0.85 °C). Dissolved oxygen was higher at S2 (2.62 ± 0.50 mg/L) and lower at S1 (2.62 ± 0.65 mg/L). Mean electrical conductivity was lower at S1 (48.66 ± 2.51 µS/cm) and higher at S2 (50 ± 5.29 µS/cm). Water transparency was lower at S1 (44 ± 15.69 cm) and higher at S2 (46.46 ± 19.01 cm). Finally, mean depth was shallower at S1 (83.83 ± 4.23 cm) and deeper at S2 (91.75 ± 3.15 cm).

Table 1 Mean values and standard deviations of physico-chemical parameters at stations S1 and S2 of Lake Guessabo between February and August 2025.

Stations	Values	Temperature (°C)	Conductivity (µs/cm)	Dissolved oxygen (mg/L)	Transparency	Depth
S1	Min	26.5	46	2.14	33.5	68.6
	Max	28.2	56	3.36	68.3	121.2
	Mean	27.33	50	2.62	46.47	91.77
	Sta devi	0.85	5.29	0.65	19.02	26.85
S2	Min	26.9	46	2.22	34.2	67.3
	Max	27.9	51	3.17	62.1	97.4
	Mean	27.53	48.67	2.6	44	83.83
	Sta devi	0.55	2.52	0.5	15.69	15.27

Stan devi= standard deviation ; min= minimum ; max = maximum

3.2. Species Observed in the Habitats of Lake Guessabo

The deployment of unbaited cameras in the littoral zone of Lake Guessabo allowed the identification of six fish species belonging to three families: Alestidae, Cichlidae, and Cyprinidae, each represented by two species (Figure 2). The observed species were: *Brycinus macrolepidotus*, *Brycinus* sp, *Coptodon zillii*, *Enteromius macrops*, *Enteromius sublineatus*, and *Oreochromis niloticus* (Table 2). Spatially, six species were recorded at station S1 and five at station S2. This difference was not significant (Mann–Whitney test; $p > 0.05$).

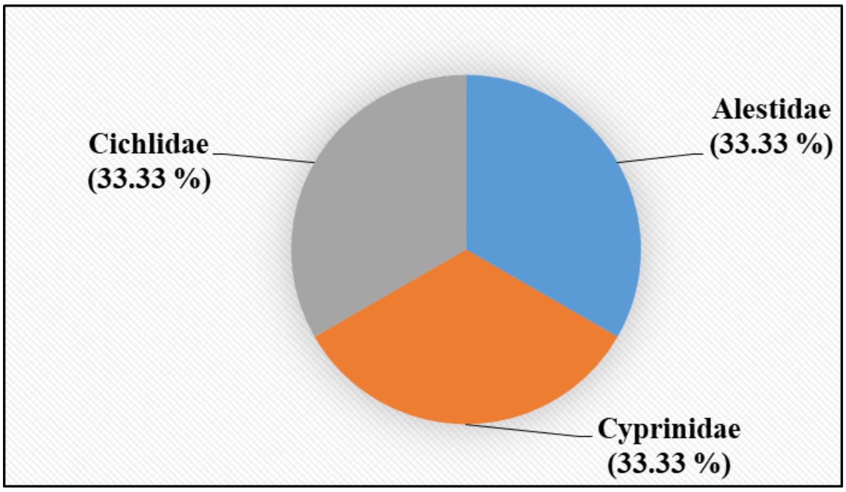

Figure 2 Proportions of the most abundant families in terms of species in Lake Guessabo.

Table 2 List of fish species observed at the different stations using unbaited cameras during the period from February to June 2024

		Stations	
Familly	Species	S1	S2
Alestidae	*Brycinus macrolepidotus*	+	-
	Brycinus sp.	+	+
Cichlidae	*Coptodon zillii*	+	+
	Oreochromis niloticus	+	+

Cyprinidae	*Enteromius macrops*	+	+
	Enteromius sublineatus	+	+
3	6	6	5

3.3. Abundance of Fish Observed in Lake Guessabo

A total of 117 fish were observed within the camera field of view in Lake Guessabo. The dominant families were Cyprinidae (58 individuals; 49.57 %), followed by Cichlidae (37 individuals; 31.62 %) and Alestidae (22 individuals; 18.80 %) (Figure 3). Fish abundance differed significantly among families (Kruskal–Wallis test; $p < 0.05$). Among the species, *Enteromius macrops* was the most abundant (42 individuals; 35.89 %), followed by *Coptodon zillii* (21.36 %), *Brycinus macrolepidotus* (14.52 %), *Enteromius sublineatus* (13.67 %), and *Oreochromis niloticus* (10.25 %) (Figure 4). These differences were statistically significant (Mann–Whitney test; $p < 0.05$).

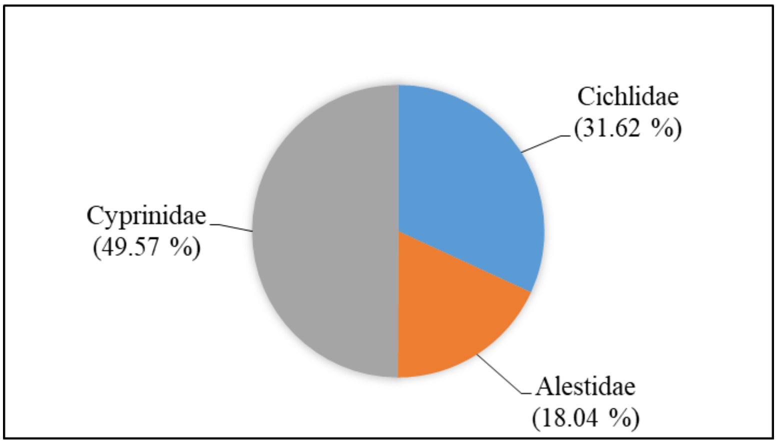

Figure 3 Relative abundance of families in terms of individuals.

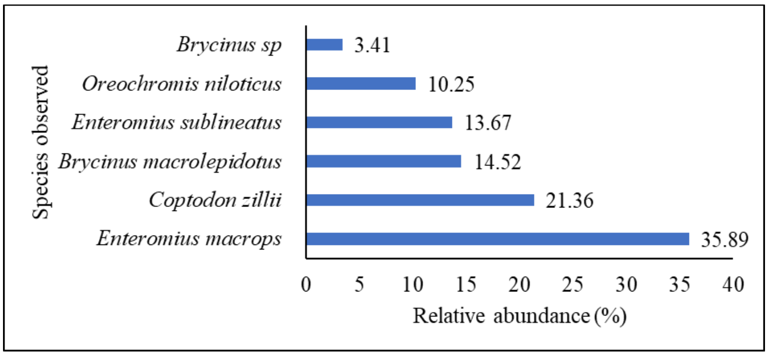

Figure 4 Relative abundance of species observed in Lake Guessabo

3.4. Different behaviors exhibited by fish in the littoral habitats of Lake Guessabo

This study identified two types of behavior exhibited by fish within the field of view of the cameras installed at all stations (Table 3). These behaviors include feeding and reproduction.

At station S1, two types of behavior (feeding and reproduction) were observed, whereas at station S2, only one type of behavior (feeding) was observed (Table 4). At station S1, feeding behavior accounted for 83.33 % of all types of behavior observed (Figure 5). At station S2, feeding accounted for 100 % of the behavioral activities observed (Figure 6).

Table 3 Proportions of types of behavior exhibited by fish at all stations

Behaviors observed	Criteria observed	Proportions (%)
	Food collection from grasslands	22.13
Feeding behavior	Food intake from the bottom substrate	65.16
	Food intake from the water column	12.71
Reproductive behavior	Parental care of eggs and nests	83.33
	Egg laying	16.67

Table 4 List of types of behavior observed by station

	Stations	
Behavior	S1	S2
Feeding	+	+
Reproduction	+	-
Total 01	**02**	**01**

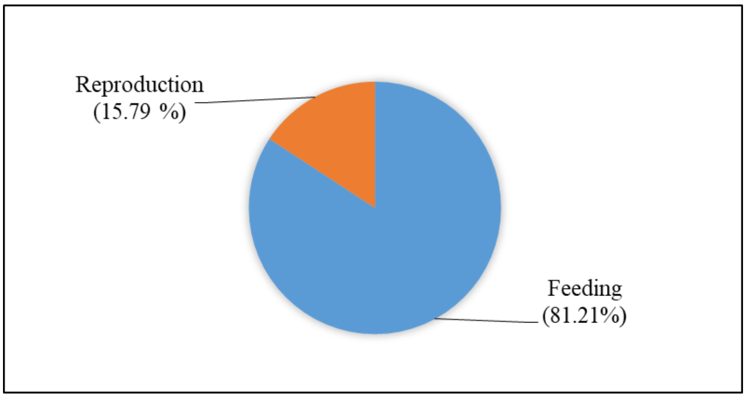

Figure 5 Proportions of types of behavior observed at station S1

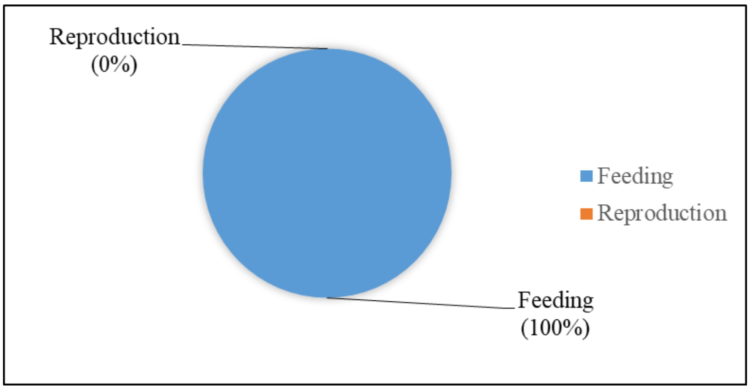

Figure 6 Proportions of types of behavior observed at station S2

3.5. Types of behavior observed by species

Records show that individuals of *Brycinus macrolepidotus*, *Enteromius macrops*, Brycinus sp and *Oreochromis niloticus* frequented habitats solely for feeding purposes (Table 5). These species collected food from the bottom, seaweed beds, and water column for nourishment. In contrast, individuals of *Coptodon zillii* in this lake exhibited two types of behavior: feeding and reproduction.

Table 5 Types of behavior recorded in fish in Lake Guessabo

Species	Feeding	Reproduction	Total
Brycinus macrolepidotus	+	-	01
Oreochromis niloticus	+	-	01
Enteromius macrops	+	-	01
Coptodon zillii	+	+	02
Total	04	01	

3.6. Influence of physicochemical parameters on feeding and reproduction

Spearman's correlation analysis between physicochemical parameters and fish activities (feeding and reproduction) revealed that dissolved oxygen levels, transparency, and depth strongly influence fish activities (Table 6). Dissolved oxygen levels and transparency are positively correlated with reproduction, while dissolved solids levels are negatively correlated with these parameters.

Table 6 Correlation values between physicochemical parameters and types of behavior.

Environmental parameters	Feeding	Reproduction
Temperature (°C)	-0.24	-0.17
Conductivity (µs/cm)	0.25	-0.22
Dissolved oxygen level (mg/L)	0.18	0.79
Transparency (cm)	0.17	0.65
Depth (cm)	0.82	-0.76

4. Discussion

The physicochemical analysis shows that the measured variables do not differ significantly between stations. This homogeneity of values is thought to be linked to the similarity of the watersheds in the study area. According to, it can also be explained by the circulation of water masses, facilitated by the small size of the sampling area, as well as by mixing caused by winds, fishing activities, and river traffic. This finding is consistent with that of [23] at Lake Buyo, where the temperature difference between the surface and the bottom of the water remains low regardless of the season.

This study identified six species of fish that use Lake Guessabo to meet their biological needs. This result is comparable to that obtained by [14] in the part of Lake Buyo located in Taï National Park, where eight species were recorded in the littoral zone for the same needs. In the present study, the families Cichlidae, Cyprinidae, and Alestidae are the most represented. This dominance can be explained by the high ecological tolerance of these groups, which are able to withstand a wide range of environmental conditions [24]. In addition, these families are characterized by a diverse diet and high behavioral plasticity, allowing them to adapt to different habitats depending on food availability [25].

In Lake Guessabo, two types of fish behavior were observed (feeding and reproduction), compared to four (feeding, reproduction, escape, and predation) in the protected part of Taï National Park. This difference is probably due to the contrasting ecological conditions between the two areas, with the unprotected part being subject to strong anthropogenic pressure.

Feeding is the most frequent behavior, accounting for 84 % of observations at station S1 and 100 % at station S2. This is because fish feed throughout their lives, while reproduction only concerns mature individuals.

The low number of species and behaviors recorded at station S2 could be linked to human activities (fishing, agriculture, pollution), which cause significant stress on aquatic ecosystems. According to [26], water degradation is due to pollution, changes in physical and chemical characteristics, and land use. Similar results were reported by [27] in Mali, where anthropogenic activities have reduced the ichthyological biodiversity of the Senegal River.

Furthermore, *Coptodon zillii* is the most active species, exhibiting the greatest diversity of behaviors and a high frequency of activity. This abundance can be explained by its high reproductive capacity and varied diet. Although mainly herbivorous, *Coptodon zillii* also consumes a wide range of animal and plant foods. Rising water levels enrich coastal habitats with nutrients and phytoplankton, which favors this species [28]. These observations are consistent with those of [29] in Egypt, who showed that *Coptodon zillii* feeds on diatoms, algae, plant tissue, and organic detritus.

The results of this study show that certain water parameters strongly influence the biological activities of fish. Dissolved oxygen and transparency promote reproduction, while excessive levels of dissolved solids limit this activity. Depth, on the other hand, has an indirect effect by providing different habitats conducive to spawning and feeding.

Dissolved oxygen is an essential factor for the survival and reproduction of fish. High levels allow for good respiration, facilitate egg maturation, and improve larval survival [30, 31]. In Côte d'Ivoire, [32] observed the same effect in Lake Taabo, confirming that oxygen plays a triggering role in reproduction.

Transparency reflects water turbidity. Good transparency allows fish to better locate their prey and sexual partners, which promotes feeding and reproductive success [33, 34]. In Lake Buyo, [35] showed that decreased transparency reduces feeding and reproductive behavior.

Depth also plays an important role, as it creates a diversity of habitats. Some species choose deep areas for spawning, while others prefer shallow areas rich in food [36]. This explains the positive correlation observed between depth and biological activity.

On the other hand, high total dissolved solids content can be harmful. It increases water conductivity, causes physiological stress, and disrupts egg development [37, 38]. Similar results have been reported in the Bia River, where pollution has affected fish reproduction [39].

Thus, our results confirm that dissolved oxygen, transparency, and depth promote fish reproduction and feeding, while water that is too rich in dissolved matter limits these activities.

5. Conclusion

Physicochemical analysis showed that the water in Lake Guessabo is of good quality and favorable to aquatic life. The use of an unbaited camera allowed fish to be observed without disturbance in their natural environment. Six species were identified, mainly belonging to the Alestidae, Cichlidae, and Cyprinidae families. Feeding behavior was the most frequently observed, with a marked dominance of *Coptodon zillii*, the species exhibiting the greatest diversity and frequency of behaviors. Observations indicate that dissolved oxygen, transparency, and depth strongly influence feeding and reproductive behaviors. To complement these results, studies over a longer period, including nighttime and deep-water recordings, are needed to better understand the behavioral dynamics of fish in this lake.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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