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The Effect of Sausage Tree Fruit (*Kigelia africana*) on Gonadal Development and Growth Performance of *Oreochromis andersonii*

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ABSTRACT

In Zambia fish farms, *Oreochromis andersonii* is an important common indigenous fish species. Naturally, safe phytochemicals can effectively improve fish reproduction performance and their production potential. Therefore, this study was conducted to determine the effect of *Kigelia africana* on the gonadal development and the performance of *Oreochromis andersonii*. A total of 96 male fingerlings were randomly assigned to four dietary treatments (D1-D4), and each treatment group had three replicates. The D1, D2, D3, and D4 groups were formulated to receive 0, 50, 100, and 150 g of powdered *Kigelia africana*/kg, respectively. The fish were fed the diets for 9 weeks, followed by the study parameter measurements at the end of the experiment. The highest mean body weight and gonadal weight were (29.8 ± 0.63 and 0.09 ± 0.010 g, respectively) for fish in the D2 group. There was no significant difference between the mean body weight of fish in different groups, but their mean gonadal weights differed significantly. The gonadal somatic index of fish differed significantly among treatment groups, with those in D2 having the highest mean value (0.36 ± 0.060). The highest mean standard length (103.3 ± 0.63 mm) and total length (126.0 ± 0.11 mm) of fish were observed for D1 and D2 groups, respectively. Additionally, the mean values for those parameters decreased with increasing *Kigelia africana* in the diet. The physicochemical parameters of water, including temperature and dissolved oxygen, ranged 16.8-23.1℃ and 0.6-2.2 mg/L, respectively; these were generally at low levels considering the optimum requirements for this fish species. In conclusion, *Kigelia africana* improved gonadal growth and development but did not promote overall fish growth. The best gonadal growth/development results of *Kigelia africana* powder were observed at a level of 50 g/kg, which can be used as a performance booster in the aquaculture production of *Oreochromis andersonii*.

Keywords: Aquaculture, Gonadal development, Growth, *Kigelia africana*, *Oreochromis andersonii*, Sausage tree

INTRODUCTION

Zambia is endowed with 12 million hectares of water bodies and 8 million hectares of wetlands (FAO, 2021) that can support the production of enough fish for consumption and export. Fish is a crucial source of income, food, and nutrition in Zambia; however, the estimated annual deficit of 108,000 tons of fish and fish products necessitates strategies to increase production (Genschick et al., 2017; FAO, 2021). Even with over 70% contribution of captured fish to the national catch, the existing supply shortfall presents an opportunity for aquaculture to flourish (Genschick et al., 2017; Avadí et al., 2022). Although Zambia presently ranks fifth in aquaculture production in Africa, with a 1.11% contribution to the regional share (Adeleke et al., 2021), there is a dire need to increase production to reduce the demand-supply gap. Additionally, this gap is projected to increase further by 2030, with a possibility of import as the primary contributor to fish supply for local consumption (Tran et al., 2019).

It is noteworthy that increased aquaculture production to reduce the fish demand-supply gap requires innovations in science and technology to improve the existing aquaculture production techniques (Maulu et al., 2019; Kaminski et al., 2022). Many factors constrain aquaculture production, inter alia, the cost of fingerlings and feed, the quality and quantity of fingerlings, diseases, and inadequate extension (Adeleke et al., 2021). The insufficient quantities of fish have been attributed to the low survival rate, low fecundity, and high mortality rate of hatchlings, especially among small-scale farmers (Adeleke et al., 2021; Avadí et al., 2022). The inadequacy in the quantity and quality of fingerlings is a concern that necessitates urgent interventions at every stage of fingerling production. Some crucial stages of fingerling production include induced egg spawning and milt production, egg fertilization, incubation, hatching, and nursery management (Emeka et al., 2014). Additionally, controlled production through the application of natural or synthetic substances, such as hormones and growth promoters, has been one of the interventions used to increase the

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quality/quantity of fingerlings (Emeka et al., 2014). These substances manipulate the sex, productive viability, and growth of fish.

Many synthetic drugs, including hormones (like 17α-methyl testosterone), and growth promoters, such as oxytetracycline, have improved fish production. However, the growing fears over drug/chemical residues in animal/fish products, which affect human health and cause antimicrobial resistance, have attracted attention to natural phytochemicals (Manosroi et al., 2004; Reda et al., 2013; Emeka et al., 2014; Abaho et al., 2021). Consequently, many beneficial phytochemicals have been evaluated and developed into drugs with little or no side effects (Adedeji et al., 2006; Emeka et al., 2014). In an effort to enhance production, medicinal plants, such as *Gercinia kola*, *Kigelia africana (K. africana)*, and *Macuna pruriens* have been experimented on fish, and the results revealed improved performance (Musthafa et al., 2018; Abaho et al., 2021). In particular, *K. africana*, an aphrodisiac, is reported to increase testosterone and enhance fertility and has been used to manage infertility, poor libido, and sexual asthenia in men (Nabatanzi et al., 2020). However, despite the reports of *K. africana* use in men, there is still a paucity of knowledge about its potential effects on fish biology. Hence, it is necessary to explore its potential role in influencing the reproductive and productive characteristics of farmed fish in Zambia.

Furthermore, Adeleke et al. (2021) found that many countries are currently focusing on indigenous catfish and tilapia species for aquaculture production. Similarly, Avadí et al. (2022) and Genschick et al. (2017) reported that Zambia is among the largest producers of tilapia fish, of which *Oreochromis andersonii (O. andersonii)* is regarded as the tastiest and preferred species by consumers in Zambia (Malumbe and Musuka, 2013). There have been deliberate calls for promoting *O. andersonii* production and establishing gene banks for its conservation (Kefi and Mwango, 2018). Despite the urgent need for improved productivity and/or production of tilapia species, particularly *O. andersonii* (Genschick et al., 2017; Kefi and Mwango, 2018), few studies have ventured into the manipulation of their reproduction to improve productivity through the application of safe phytochemicals. Hence, this study could contribute to the knowledge addressing the potential of *K. africana* for productivity improvement of *O. andersonii*. The objectives were to determine the gonadal somatic index of *O. andersonii* fed on different levels of dried *K. africana* fruit and assess the influence of *K. africana*-containing diet on the growth performance of *O. andersonii.*

MATERIALS AND METHODS

Ethical approval

This study was conducted with strict and routine supervision by the institutional committee on animal research, The University of Zambia. Additionally, fish handling and experimentation were performed in compliance with the guide for the care and use of agricultural animals in research and teaching (CCAC, 2005).

Study area

The research was carried out at the Chilanga fish farm, Lusaka, Zambia, from July to September 2021. The study area is located at latitude 15° 33’ 51’ 'S, longitude 28° 16’ 13’ ‘E, and altitude of 1205 meters above sea level. Chilanga fish farm is a government-owned farm under the Department of Fisheries, Ministry of Fisheries and Livestock, Lusaka, Zambia. Furthermore, the average annual precipitation in Zambia ranges 800-1400 mm, while the temperature during winter is within the range of 10-20℃, and during the hot, dry season, it ranges 20-30℃ (RCCC, 2021).

Fingerling collection and feed formulation

Oreochromis andersonii fingerlings were sourced from Kalimba farms in Lusaka, Zambia. The procured fish comprised an all-male population. Up on delivery, a few sample fish were weighed. Their average body weight, standard length, and total length were 28.7 ± 1.4 g, 9.01 mm, and 12.24 mm, respectively. All the fingerlings were then conditioned for 10 days in plastic fish tanks when fed on the formulated diet without *K. africana*. Fresh *K. africana* fruits were sourced from Milambo farms in Barlastone park, Lusaka, Zambia. Before the diet formulation, these fruits were washed using clean water, cut into smaller pieces, sun-dried, and ground into powder using a locally fabricated pounding machine (Zambia), and this was performed following Vipinkumar et al. (2019).

Experimental diets were formulated to contain 32% crude protein using maize meal (11.39% crude protein) and low-fat soya bean meal (44.76% crude protein) for each treatment. Diet formulation was done manually using the simultaneous equation method and algebraic expression (Afolayan and Afolayan, 2008). Then, all the ingredients were accurately measured using a digital scale (Sartorius, Lab Instruments GMbH and Co. KG, Gottingen, Germany) with a precision of 0.1 g, for processing. The processing procedure was performed following Vipinkumar et al. (2019). After measurements, the ingredients were accordingly mixed in a clean bucket. The resultant mash was pressed through an artisanal mincer for pelleting. Additionally, cassava flour (One Banja Co. Ltd, Lusaka, Zambia) was added as a binder. All the pelleted diets were air-dried at room temperature and kept frozen until the start of the experiment. The feed

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ingredients used, their corresponding proportions, and the composition of different dietary groups are summarized in Table 1.

Table 1. Ingredients in the experimental diets of tilapia (*O. andersonii)* fingerlings

Variables	**Experimental diets**			
Feed ingredients (kg)	**D1**	**D2**	**D3**	**D4**
Maize meal	1.88	1.88	1.88	1.88
Soya bean meal	2.94	2.94	2.94	2.94
Premix*	0.03	0.03	0.03	0.03
Methionine	0.04	0.04	0.04	0.04
Cassava (binder)	0.01	0.01	0.01	0.01
DCP	0.019	0.019	0.019	0.019
Vegetable oil	0.04	0.04	0.04	0.04
Salt	0.01	0.01	0.01	0.01
K. africana (g/kg)	0	50	100	150
****Chemical composition (DM %)**				
Crude protein	34.40	32.40	33.03	34.01
Ash	6.28	5.59	5.08	5.66
Moisture	7.14	7.94	6.65	6.14
Crude fat	4.44	4.45	4.94	4.35
Crude fiber	5.33	8.15	8.20	8.38
Metabolizable energy	3.28	3.27	3.34	3.51

DCP: DiCalcium Phosphate, *K. Africana: Kigelia africana*, Vit: Vitamin, *the composition per kg of premix: Vit. A: 4,000,000 I.U, vit. B1: 1,000 mg, vit. B2: 2,400 mg, vit. B6: 2,000 mg, vit. B12: 2 mg, folic acid: 400 mg, Niacin: 15,000 mg, vit. C: 10,000 mg, vit. D3: 400,000 mg, vit. E: 40,000 mg, vit. K3: 5,000 mg, Biotin: 25 mg, vit. B5: 4,000 mg, lysine: 2,800 mg, zinc: 6,000 mg, iron: 6,000 mg, selenium: 30 mg, copper: 1,000 mg, manganese: 10,000 mg, iodine: 250 mg, D1: 0 g/kg, D2: 50 g/kg, D3: 100 g/kg, and D4: 150 g/kg, **Determined based on standard methods (AOAC, 1995).

Study design and sampling

This study employed a completely randomized design and a positivism paradigm to generate data on the effect of *K. africana* on gonadal growth and development in fish. A total of 12 plastic fish tanks measuring 6 mm thick, with dimensions of 55 cm in length, 40 cm in width, and 33 cm in height, were used, and each tank contained plastic plates for holding the feed. The tanks were placed on 6-inch concrete bricks in a pond and filled with borehole water to a volume of 50 liters each. A total of 96 male fingerlings with an average weight of 28.7 ± 1.4 g were used for this study. These were randomly assigned to 12 tanks, with each tank containing eight fingerlings. In this case, four treatment groups, each with three replications (three tanks), were used. The treatment groups included control without supplementation of *K. africana* (Group D1), Group D2 (50 g/Kg *K. africana*), Group D3 (100 g/kg *K. africana*), and Group D4 (150 g/kg *K. africana*). The formulated diets were then assigned randomly to the tanks, and each group of fish was fed at 5% body weight/day in two equal portions in the morning (10:00-10:30 hours) and afternoon (15:00-15:30 hours) for 60 days. Every after feeding, a netting material with appropriate holes to allow aeration was used to prevent predation from birds and other predators. Furthermore, the tanks were thoroughly cleaned once a fortnight with water and clean burlap-like materials from gunny sacks.

Physico-chemical quality of water

During fish feeding experimentation with the treatment diets, the temperatures and dissolved oxygen were monitored daily, and their average values were obtained each week. These parameters were measured with a water quality checker (ProDSS, Miami, USA) according to the manufacturer's specifications. Data were recorded in ℃ and ml/L for temperatures and dissolved oxygen, respectively.

Body length and weight measurements

The standard and total lengths of *O. andersonii* were measured at the end of the experiment using a one-meter measuring board with a precision of 0.1 mm, as previously described by Önsoy et al. (2011). Every fortnight, samples were randomly weighed using a digital scale (AND HR200 Lab analytical balance, USA) with a precision of 0.0001 g to monitor the changes. At the end of the experiment, each fish was sacrificed by the pitching method using a needle and then wiped using a napkin before taking weight measurements. The body and gonadal weights were then measured following the previously described procedure (Yadav et al., 2016). The gonadal weights were obtained following body weight measurements. This involved dissecting fish to obtain the gonads and weighing using a digital weighing scale (AND HR200 Lab analytical balance, USA) with a precision of 0.0001 g.

Gonadal somatic index

The mean weights of the fish and gonads were used to compute the Gonadal somatic index (GSI) based on a formula (Sturm, 1978);

$$\text{Gonadal somatic index} = \frac{\text{weight of gonads}}{\text{weight of fish}} \text{ x } 100$$

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Gonadal development

At the end of the experiment, the gonadal maturity stages of the fish were determined based on macroscopic characteristics, including the gonadal color and condition and gonadal morphometric characteristics, as described by Kefi et al. (2012). The gonads were then classified into stages according to the previously described procedure (Nikolsky, 1963) that classify gonadal maturity into six stages, namely immature (Stage I), quiescent (Stage II), maturing (Stage III), mature (Stage IV), running (Stage V), and spent (Stage VI).

Data analysis

In the Statistical Analysis System Software package (SAS institute, 2004), data were analyzed using descriptive statistics, including means and standard errors of means (SE). The various fish traits, namely, body length, body weight, gonadal weight, and GSI, were analyzed by ANOVA test using the General Linear Model, a univariate analysis procedure. The considered model was; $X_{ijk} = u + A_i + B_j + AB_{ij} + e_{ijk}$

Where, X is the dependent variable representing the value of the measured trait, u denotes the overall mean, A_i refers to the effect of treatment (diet) groups with four levels (i = D1, D2, D3, and D4), B_j signifies the effect of the tank, AB_{ij} is the interaction between the main effects, e_{ijk} defines the random error term. The least-square difference test was used to determine the pairs whose means differed. In all cases, significance was taken at a level of $p < 0.05$. The data for maturity stages were descriptively analyzed using the measure of central tendency (frequencies).

RESULTS

Mean standard length and total length

The mean standard length (SL) and the total length (TL) of *O. andersonii*, fed on the experimental diet containing different amounts of *K. africana* fruit, are presented in Table 2. The highest mean SL (103.3 ± 0.09 mm) was observed for fish in the D1 group, while those in the D4 group had the lowest mean SL (91.71 ± 0.12 mm). Generally, fish in the D2 treatment had the highest mean TL (126.0 ± 0.11 mm), while D3 treatment had the lowest mean TL (122.8 ± 0.14 mm). The results revealed significant differences among the treatment groups in terms of the mean SL of fish ($p < 0.05$). The results revealed significant differences between the mean SL of fish in the D1, D2 with D3 and D4 groups ($p < 0.05$). Furthermore, there was no significant difference among the four groups with regard to the mean TL of fish ($p > 0.05$).

Mean weight and gonadal somatic index

The mean body weight, gonadal weight, and GSI of *O. andersonii*, fed on different experimental diets, are presented in Table 3. The *O. andersonii* in the D2 group had the highest mean body weight (29.8 ± 0.63 g), while those in the D3 group had the lowest mean body weight (27.4 ± 0.72 g). The mean fish gonadal weight from group D2 was numerically higher (0.09 ± 0.010 g) than other treatment groups. The *O. andersonii* in the D2 group had the highest GSI (0.36 ± 0.060 g), while those in the D1 group had the lowest mean GSI value (0.14 ± 0.032). The results indicated no significant difference among the treatment groups in terms of the mean body weight of *O. andersonii* ($p > 0.05$). The mean gonadal weight of *O. andersonii* differed significantly among dietary treatments ($p < 0.05$). Additionally, the results showed significant differences in the GSI of *O. andersonii* when dietary treatments were compared ($p < 0.05$). Regarding the mean gonadal weight of *O. andersonii*, the current study results revealed significant differences among D2, D3 with D1 and D4 ($p < 0.05$). The results showed no significant difference between the gonadal weight *O. andersonii* in the D2 and D3 groups ($p > 0.05$). The results also indicated that the GSI of *O. andersonii* in the D2 and D3 groups were significantly higher than the GSI of those in the D1 and D4 groups ($p < 0.05$). The results showed no significant difference between the GSI of *O. andersonii* in the D2 and D3 groups ($p > 0.05$).

Maturity status of the gonads from *Oreochromis andersonii*

The maturity status and occurrence frequency of gonads among *O. andersonii* fed with the different levels of *K. africana* are presented in Table 4. The gonads were classified as immature, active, or quiescent stages of development within each dietary treatment. The highest proportion of fish (53.33%) in the D1 group had quiescent gonads, while no fish in the same group had immature gonads. Most fish (56.25%) in the D2 group had active gonads, while a few (6.25%) in the same group had immature gonads. The majority of fish (60%) in the D3 group had active gonads, whereas 6.67% of the same group had immature gonads. Regarding the D4 group, the highest proportion (55.56%) had quiescent gonads, while 11.11% of *O. andersonii* had immature gonads.

Levels of dissolved oxygen in fish tanks

The average levels of dissolved oxygen (mg/L) in a week for all tanks are presented in Figure 1. For the morning measurements, the highest average level of dissolved oxygen (2.2 mg/L) in the tanks was observed in week 9, while the

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lowest level (0.6 mg/L) was in weeks 1, 4, and 6. Regarding the afternoon measurements, the highest average level of dissolved oxygen (2.8 mg/L) was recorded in week 2, whereas the lowest average value (0.7 mg/L) was noted in week 1.

Average temperature variations

The average weekly temperature readings for all tanks are presented in Figure 2. Regarding the morning readings, the highest average temperature (21.1℃) in the tanks was recorded in week 9, while the lowest average temperature value (16.8℃) was in week 2. With regard to the afternoon measurements, the highest average temperature value (23.1℃) was noted in week 8, whereas the lowest average temperature (17.9℃) was in week 4.

Table 2. The mean standard length and total length of *Oreochromis andersonii*, fed with different levels of *Kigelia africana* powder

Variables \ Dietary treatments	D1	D2	D3	D4
SL (mm)	103.3 ± 0.09[a]	102.9 ± 0.10[a]	98.0 ± 0.12[b]	91.71 ± 0.12[b]
TL (mm)	125.6 ± 0.10[a]	126.0 ± 0.11[a]	122.8 ± 0.14[a]	123.3 ± 0.15[a]

Values are Mean ± SE, [a, b] means with dissimilar superscripts within a row differ significantly ($p < 0.05$), SL: Standard length of fish, TL: Total length of fish, mm: Millimeters; D1: 0 g/kg, D2: 50 g/kg, D3: 100 g/kg, and D4: 150 g/kg

Table 3. The mean weights and gonadal somatic index of *Oreochromis andersonii* fed with different levels of *Kigelia africana* powder

Variables \ Dietary treatments	D1	D2	D3	D4
Body weight (g)	28.9 ± 0.65[a]	29.8 ± 0.63[a]	27.4 ± 0.72[a]	28.1 ± 0.87[a]
Gonadal weight (g)	0.04 ± 0.008[b]	0.09 ± 0.010[a]	0.08 ± 0.010[a]	0.04 ± 0.008[b]
GSI	0.14 ± 0.032[b]	0.36 ± 0.060[a]	0.33 ± 0.050[a]	0.18 ± 0.030[b]

Values are Mean ± SE, [a, b] means with dissimilar superscripts within a row differ significantly ($p < 0.05$), GSI: Gonadal somatic index, D1: 0 g/kg, D2: 50 g/kg, D3: 100 g/kg, and D4: 150 g/kg

Table 4. Gonadal maturity status among groups of *Oreochromis andersonii* fed with different levels of *Kigelia* powder

Gonadal maturity (stages) \ Dietary treatments	D1	D2	D3	D4
Immature	0 (0)	1 (6.25)	1(6.67)	2 (11.11)
Active	7 (46.67)	9 (56.25)	9 (60.00)	6 (33.33)
Quiescent	8 (53.33)	6 (37.50)	5 (33.33)	10 (55.56)
Total	15 (100)	16 (100)	15 (100)	18 (100)

The total number within dietary treatment was used to obtain percentages of gonads for each treatment, D1: 0 g/kg, D2: 50 g/kg, D3: 100 g/kg, and D4: 150 g/kg

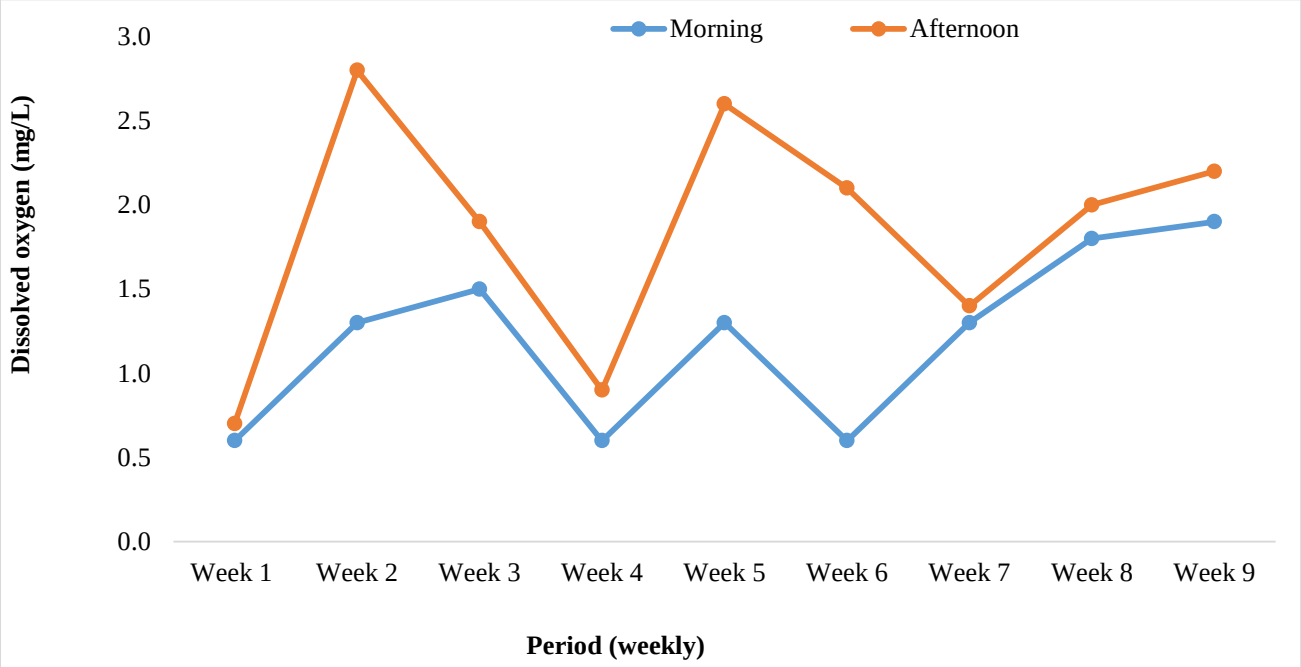

Figure 1. Average levels of dissolved oxygen in water tanks containing *Oreochromis andersonii* fish

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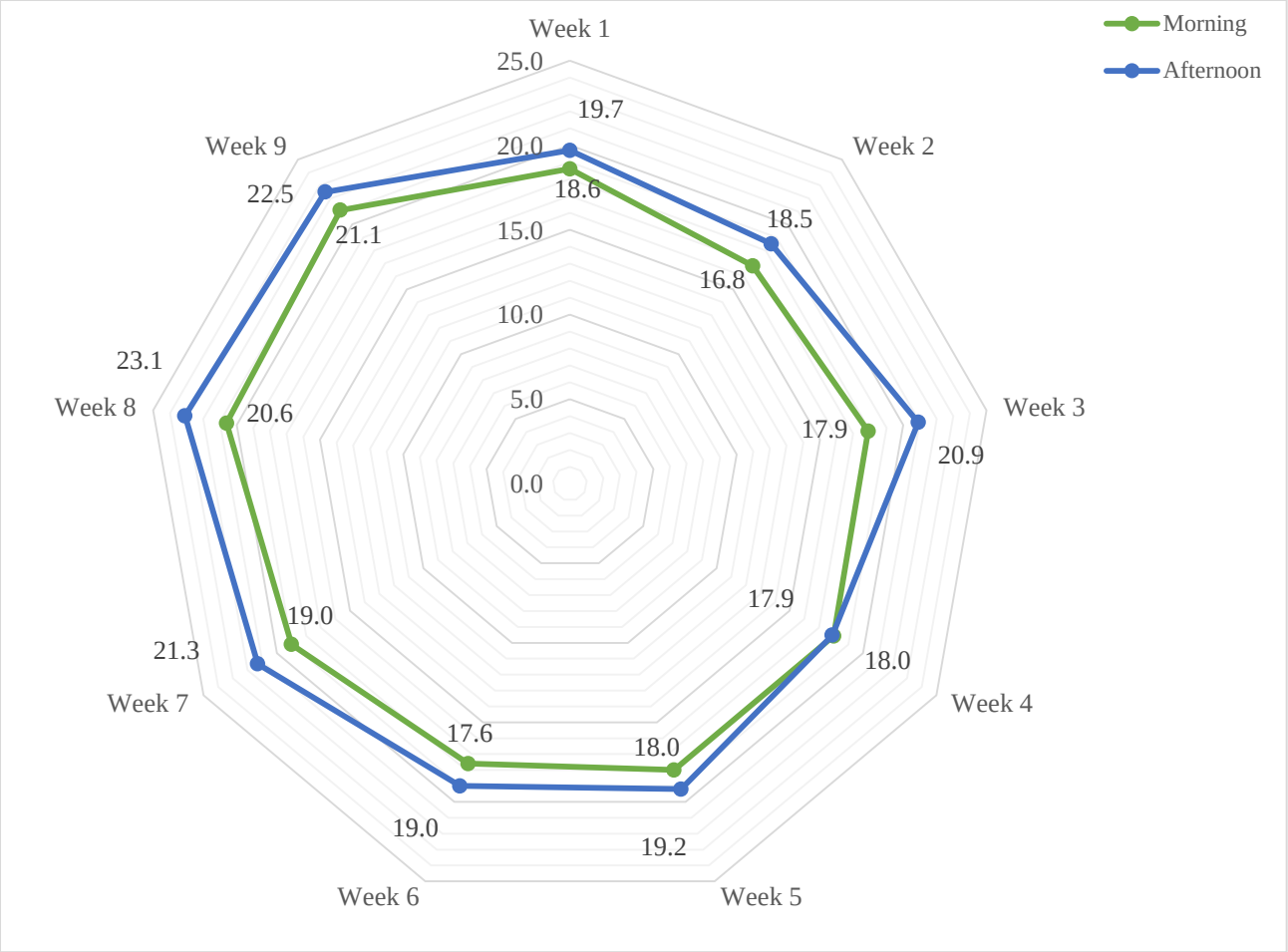

Figure 2. Temperature variations (℃) during the nine weeks of feeding *Oreochromis andersonii* fish with different levels of *Kigelia* powder

DISCUSSION

The results of the current study showed that *K. africana*-containing diet could affect some, but not all, biological parameters of *O. andersonii*. With regard to the SL and TL parameters, the observed higher mean values for *O. andersonii* in the D1 group compared to other treatment groups and the decrease in mean SL and TL of *O. andersonii* followed by an increase in *K. africana* levels indicated that increasing *K. africana* level did not significantly improve the SL and TL of male *O. andersonii*. Of note, the rate of fish growth can appropriately be identified through the rise in body weight and length (Awas et al., 2020). Thus, the inclusion of *K. africana*, at the levels used in the current study did not increase the growth of male *O. andersonii*. Chivandi et al. (2011) recommended *K. africana* as potential supplement for fish growth due to its substantial proportions of nutrients, such as lipid (49.2%) and crude protein (35.7%). Nevertheless, such nutrients can be directed towards gonadal development instead of overall growth since fish can prioritize the available resources for various body functions, such as basal metabolism, movement, immune system, growth, and reproduction (Salze et al., 2013). Furthermore, the contribution of other factors, such as the pharmacological dose, fish growth phase, feed availability and quality, and the general fish condition to the SL and TL cannot be underestimated (Önsoy et al., 2011).

The present results revealed no significant differences in the mean body weight of fish, which is consistent with a previous study report on average weights of *Oreochromis niloticus* (*O. niloticus*) in control and *K. africana*-containing diets (Ndour et al., 2021). Besides the resource prioritization strategy, the observed minimal or no growth of *O. andersonii* in the current study could be attributed to the low dissolved oxygen levels in the water tanks. A previous study by Li et al. (2020) indicated an increase in growth rate and weight gain for a closely related fish species, *O. niloticus*, which had a higher dissolved oxygen level (5 mg/L), compared to the current study. Again, another possible reason for the insignificant effect of *K. africana* in the current study was the ambient temperature (16.8-23.1℃), which was generally lower than the recommended optimal range (25-30℃) for the growth of *Oreochromis* species (El-Sherif and El-Feky, 2009). El-Sherif and El-Feky (2009) noted that temperatures lower than optimal reduced feed intake, feed conversion ratio, and weight gain. Accordingly, future studies may be needed to validate the effect of *K. africana*-containing diets on *O. andersonii*, particularly under the recommended temperature and dissolved oxygen levels.

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Although *K. africana*-containing diet did not affect the fish body weight, it could significantly affect their gonadal weights. The current findings disagree with an earlier study by Adeparusi et al. (2010) that reported no significant difference between the weight of testes among the dietary treatments. The observed disparity in the findings was most probably due to age and fish species differences. Nevertheless, the same authors reported a significant effect of *K. africana* on the sperm quality parameters of *Clarias gariepinus*, namely sperm count, motility, and fertilization ability, particularly in the 100 g/kg dietary group (Adeparusi et al., 2010). It is noteworthy that testicular weight is an anatomical indicator of fertility and a marker for reproductive capability, directly proportional to the level of testosterone produced (Banihani, 2018). In light of this, it is plausible that some phytochemicals present in *K. africana* influenced steroid/testosterone production in *O. andersonii*, which in turn promoted the gonadal development as observed in the D2 group. However, these phytochemicals perhaps possessed a dose-dependent characteristic in their pharmacological actions considering the observed lower gonadal weights of fish in the D3 and D4 groups.

Most earlier studies reported the presence of phytochemicals in *K. africana*, such as β-sitosterol, stigmasterol, Zinc, and vitamin E that are associated with enhanced reproductive performance (Chivandi et al., 2011; Oseni and Williams, 2018; Fagbohun et al., 2019; Nabatanzi et al., 2020). For example, stigmasterol stimulated gonadal development in *O. nilotucus*, similar to androgen hormones (Yusuf et al., 2019). On the other hand, some phytosterols may also be precursors for the de novo biosynthesis of steroid hormones (Tarkowská, 2019). For instance, sitosterol is a precursor for plant steroid hormones like brassinosteroids, as well as the animal steroids hormones like progesterone and testosterone and its derivatives (Tarkowská, 2019). Zinc influences the male reproductive system through the gonadotropic hormones, and is also required to convert testosterone into its active form, called dihydrotestosterone (Oseni and Williams, 2018; Baltaci et al., 2019). Furthermore, vitamin E was confirmed to improve gonadal development (Pamungkas et al., 2014). It is required for the synthesis and excretion of gonadotrophic hormones and also improves sperm quality through its antioxidant activity (Rajesh and Mendon, 2001; Chivandi et al., 2011; El-Sayed and Izquierdo, 2021). Considering the presence of these phytochemicals and the aforementioned roles, the observed gonadal weight increment in the current study could be ascribed to the use of *K. africana* in the trial diets.

One of the important parameters in reproductive biology is GSI, a means used to measure the sexual maturity of animals, including fish, in correlation to the ovary or testes development (Kiran, 2015). According to Yadav et al. (2016), this parameter is considered during the breeding mechanism and seed production; thus, assessment of the GSI, including *O. andersonii*, contributes to understanding the fish breeding mechanism for aquaculture production and fish conservation. The current findings agree with an earlier study that confirmed the GSI increment with gonadal development and maturation of male fish (Yadav et al., 2016). Based on the current GSI findings, it can be concluded that *K. africana* could be used to improve the development of *O. andersonii* gonads. It is noteworthy that the beneficial effects are significant at lower pharmacological doses considering the observed mean gonadal weight, GSI, and the proportion of active gonads of *O. andersonii* in the D2 group. The *K. africana* at lower doses (50 g/kg), as used in D2, could probably lead to better results. So far, this study has confirmed that increasing *K. africana* levels results in higher proportions of immature gonads in *O. andersonii*.

CONCLUSION

Oreochromis andersonii remains one of the important native fish species suitable for aquaculture production, and has the potential to improve the livelihoods of small-scale farmers in Zambia. However, the full productivity, production potential, and benefits of *O. andersonii* will only be harnessed by manipulating its reproductive performance. The current study has found that *K. africana* fruit can enhance the gonadal development and maturity of *O. andersonii* fingerlings. Additionally, the development and maturity of gonads were significantly enhanced by the dietary treatment containing 50 g/kg of *K. africana*. However, the plant was not found to enhance overall fish growth at the inclusion levels studied. It is recommended that further studies be conducted using the *K. africana* fruit at levels lower than 50 g/kg to investigate further the observed beneficial effects of this plant. A larger sample size is recommended in future studies to replicate the current study.

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Availability of data and materials

The data from the present study are available on request from the corresponding author.

Competing interests

Authors declare no conflict of interest regarding this publication.

Authors' contribution

Pharaoh Collins Sianangama conceived, designed, supervised the study, and reviewed the manuscript, Emeldah Nundwe designed the study and collected the data. Sylvia Jana Harrison and Eva Nambeye supervised the study and reviewed the manuscript. Rubaijaniza Abigaba analyzed data and wrote the manuscript. All authors read and approved the final manuscript for publication.

Ethical consideration

The authors declare that this manuscript is original and is not being considered elsewhere for publication. All authors have consented to publish it in this journal.

REFERENCES

Abaho I, Masembe C, Akoll P, and Jones CLW (2021). The use of plant extracts to control tilapia reproduction: Current status and future perspectives. Journal of the World Aquaculture Society, 53(3): 593-619. DOI: https://www.doi.org/10.1111/jwas.12863

Adedeji OS, Farinu GO, Ameen SA, and Olayeni TB (2006). Effects of bitter kola (*Garcinia kola*) as growth promoter in broiler chicks from day old to four weeks old. Journal of Animal and Veterinary Advances, 5(3): 191-193. Available at: https://medwelljournals.com/abstract/?doi=javaa.2006.191.193

Adeleke B, Robertson-Andersson D, Moodley G, and Taylor S (2021). Aquaculture in Africa: A comparative review of Egypt, Nigeria, and Uganda Vis-À-Vis South Africa. Reviews in Fisheries Science & Aquaculture, 29(2): 167-197. DOI: https://www.doi.org/10.1080/23308249.2020.1795615

Adeparusi EO, Dada AA, and Alale OV (2010). Effects of medicinal plant (*Kigelia africana*) on sperm quality of African catfish *Clarias gariepinus* (burchell, 1822) broodstock. Journal of Agricultural Science, 2(1): 193-199. DOI: https://www.doi.org/10.5539/jas.v2n1p193

Afolayan MO and Afolayan M (2008). Nigeria oriented poultry feed formulation software requirements. Journal of Applied Sciences Research, 4(11): 1596-1602.

Association of official analytical chemists (AOAC) (1995). Official methods of analysis, 16th Edition. AOAC International., Arlington, USA. Available at: https://www.cabdirect.org/cabdirect/abstract/19951414840

Avadí A, Cole SM, Kruijssen F, Dabat MH, and Mungule CM (2022). How to enhance the sustainability and inclusiveness of smallholder aquaculture production systems in Zambia?. Aquaculture, 547: 737494. DOI: https://www.doi.org/10.1016/j.aquaculture.2021.737494

Awas M, Ahmed I, and Sheikh ZA (2020). Length- weight relationship of six coldwater food fish species of river Poonch, Pir Panjal Himalaya, India. Egyptian Journal of Aquatic Biology and Fisheries, 24(2): 353-359. DOI: https://www.doi.org/10.21608/ejabf.2020.82230

Baltaci AK, Mogulkoc R, and Baltaci SB (2019). The role of zinc in the endocrine system. Pakistan Journal of Pharmaceutical Sciences, 32(1): 231-239. Available at: http://uam-web2.uamont.edu/facultyweb/sims2/Zinc%20and%20Endocrine%20System.pdf

Banihani SA (2018). Ginger and testosterone. Biomolecules, 8(4): 119. DOI: https://www.doi.org/10.3390/biom8040119

Canadian Council on Animal Care (CCAC) (2005). Guidelines on: The care and use of fish in research, teaching and testing. Canadian Council on Animal Care., Ottawa, Canada. p. 87. Available at: https://ccac.ca/Documents/Standards/Guidelines/Fish.pdf

Chivandi E, Davidson B, and Erlwanger K (2011). *Kigelia africana* seed: Proximate, mineral, vitamin E, fibre, amino acid and fatty acid composition. International Journal of Food Science and Technology, 46(10): 2153-2158. DOI: https://www.doi.org/10.1111/j.1365-2621.2011.02730.x

El-Sayed AM and Izquierdo M (2021). The importance of vitamin E for farmed fish—A review. Reviews in Aquaculture, 14(2): 688-703. DOI: https://www.doi.org/10.1111/raq.12619

El-Sherif MS and El-Feky AMI (2009). Performance of nile tilapia (*Oreochromis niloticus*) fingerlings. II. influence of different water temperatures. International Journal of Agriculture and Biology, 11(3): 301-305. Available at: https://www.cabdirect.org/cabdirect/abstract/20093124839

Emeka U, Iloegbunam NG, Gbekele-Oluwa AR, and Bola M (2014). Natural products and aquaculture development. IOSR Journal of Pharmacy and Biological Sciences, 9(2): 70-82. DOI: https://www.doi.org/10.9790/3008-09247082

Fagbohun OF, Babalola OO, Agboola FK, Joseph JS, Malindisa S, and Msagati TAM (2019). Evaluation of phytochemicals, antioxidants, trace elements in *Kigelia africana* fruit extracts and chemical profiling analysis using UHPLC-qTOF-MS2 spectrometry. Biological Trace Elements Research, 195: 679-695. DOI: https://www.doi.org/10.1007/s12011-019-01869-2

Food and agriculture organization (FAO) (2021). Case studies from the united republic of Tanzania and Zambia. Financing fisheries in Africa. Fisheries and aquaculture division, Food and Agriculture Organization of United Nations., Rome, Italy. pp. 1-16. Available at: https://www.fao.org/3/cb7968en/cb7968en.pdf

Genschick S, Kaminski AM, Kefi AS, and Cole SM (2017). Aquaculture in Zambia: An overview and evaluation of the sector's responsiveness to the needs of the poor. Penang, Malaysia: CGIAR research program on fish Agri-food systems and Lusaka, Zambia. Department of Fisheries, Working Paper: FISH-2017-0. pp. 1-32. Available at: http://pubs.iclarm.net/resource_centre/FISH-2017-08.pdf

Kaminski AM, Little DC, Middleton L, Syapwaya M, Lundeba M, Johnson J, Huchzermeyer C, and Thilsted SH (2022). The role of aquaculture and capture fisheries in meeting food and nutrition security: Testing a nutrition-sensitive pond polyculture intervention in rural Zambia. Foods, 11(9): 1334. DOI: https://www.doi.org/10.3390/foods11091334

Kefi AS and Mwango J (2018). Is the culture of exotic fish species the answer to low fish productivity? A case study on the use of *Oreochromis niloticus* in Zambia. International Journal of Fisheries and Aquaculture, 10(11): 129-139. DOI: https://www.doi.org/10.5897/IJFA2018.0703

Kefi AS, Kang'ombe J, Kassim D, and Katongo C (2012). Grwoth, reproduction and sex ratios in *Oreochromis andersonii* (Castelnau 1861) fed with varying levels of 17α-methyl testosterone. Journal of Aquaculture Research & Development, 3(8): 1000155. DOI: http://www.doi.org/10.4172/2155-9546.1000155

Kiran BR (2015). Study of gonado-somatic index of cyprinid fish, *Salmostoma untrahi* (Day) from Bhadra Reservoir, Karnataka. International Journal of Research in Engneering and Science, 1(1): 6-10. Available at: https://www.arcjournals.org/pdfs/ijres/v1-i1/2.pdf

Li J, Huang K, Huang L, Hua Y, Yu K, and Liu T (2020). Effects of dissolved oxygen on the growth performance, haematological parameters, antioxidant responses and apoptosis of juvenile GIFT (*Oreochromis niloticus*). Aquaculture Research, 51(8): 3079-3090. DOI: https://www.doi.org/10.1111/are.14684

Malumbe D and Musuka CG (2013). The most preferred and tasty fish in Zambia: A case study of three Copperbelt Province markets. Pakistan Journal of Nutrition, 12(11): 960-965. DOI: https://www.doi.org/10.3923/pjn.2013.960.965

Manosroi J, Petchjul K, and Manosroi A (2004). Effect of fluoxymesterone fish feed granule on sex reversal of the hybrid, Thai red tilapia (*Oreochromis niloticus Linn.* x *Oreochromis mossambicus Linn*.). Asian Fisheries Science, 17: 323-331. DOI: https://www.doi.org/10.33997/j.afs.2004.17.4.005

Maulu S, Munganga BP, Hasimuna OJ, Haambiya LH, and Seemani B (2019). A review of the science and technology developments in Zambia's aquaculture industry. Journal of Aquaculture Research and Development, 10(4): 1000567. Available at: https://www.aquacultureinafrica.com/?p=1653

Musthafa MS, Asgari SM, Kurian A, Elumalai P, Ali ARJ, Paray BA, and Al-Sadoon MK (2018). Protective efficacy of *Mucuna pruriens* (L.) seed meal enriched diet on growth performance, innate immunity, and disease resistance in *Oreochromis mossambicus* against *Aeromonas hydrophila*. Fish & Shellfish Immunology, 75: 374-380. DOI: https://www.doi.org/10.1016/j.fsi.2018.02.031

Nabatanzi A, Nkadimeng SM, Lall N, Kabasa JD, and McGaw LJ (2020). Ethnobotany, phytochemistry and pharmacological activity of *Kigelia africana* (Lam.) Benth. (Bignoniaceae). Plants, 9(6): 753. DOI: https://www.doi.org/10.3390/plants9060753

Ndour PM, Fall J, Loum A, Sagne M, Diagne NF, Samb SM, Ndong D, and Diouf M (2021). Effects of *Kigelia africana*, *Beta vulgaris* and *Ricinodendron heudelotti* as feed additive on growth performance, survival and whole-body composition of Nile tilapia (*Oreochromis niloticus*) Linnaeus, 1758 fry. International Journal of Fisheries and Aquatic Studies, 9(1): 398-402. DOI: https://www.doi.org/10.22271/fish.2021.v9.i1e.2426

Nikolsky GV (1963). The ecology of fishes. Academic Press., London. p. 352.

Önsoy B, Tarkan S, Fİlİz H, and BİlgeG (2011). Determination of the best length measurement of fish. North-Western Journal of Zoology, 7(1): 178-180. Available at: http://www.biozoojournals.ro/nwjz/content/v7n1/nwjz.101401.Onsoy.pdf

Oseni OA and Williams OD (2018). *In-vitro* compositional investigations of antioxidants, phytochemicals, nutritional and minerals in the fruit of *Kigelia africana* (Lam.) Benth. International Journal of Contemporary Research and Review, 9(8): 20259-20268. DOI: https://www.doi.org/10.15520/ijcrr/2018/9/08/585

Pamungkas W, Tahapari E, and Darmawan J (2014). Gonadal development and spawning frequency of tilapia (*Oreochromis niloticus*) that feeded by vitamin e supplementation. Berita Biologi, 13(3): 239-244. DOI: https://www.doi.org/10.14203/beritabiologi.v13i3.661

Rajesh KM and Mendon MR (2001). Role of vitamins and minerals in fish and shellfish nutrition. Aqua International, pp. 18-22.

Reda RM, Ibrahim RE, Ahmed EG, and El-Bouhy ZM (2013). Effect of oxytetracycline and florfenicol as growth promoters of the health status of cultured *Oreochromis niloticus*. Egyptian Journal of Aquatic Research. 39(4): 241-248. DOI: http://www.doi.org/10.1016/j.ejar.2013.12.001

Red Cross Crescent Climate Centre (RCCC) (2021). Climate profiles of countries in Southern Africa: Zambia. In Baily M, Heinrich D, and Kruczkiewicz A (Editors.), Climate factsheet. Red Cross Crescent Climate Centre, The Hague, Netherlands. pp. 1-5. Available at: https://www.climatecentre.org/wp-content/uploads/Climate-Profiles-of-Countries-in-Southern-Africa-Zambia.pdf

Salze G, Alami-Durante H, Barbut S, Marcone M, and Bureau DP (2013). Nutrient deposition partitioning and priorities between body compartments in two size classes of rainbow trout in response to feed restriction. British Journal of Nutrition, 111(8): 1361-1372. DOI: https://www.doi.org/10.1017/S000711451300384X

Sturm MGL (1978). Aspects of the biology of *Scomberomorus maculatus* (Mitchill) in Trinidad. Journal of Fish Biology, 13(2): 155-172. DOI: https://www.doi.org/10.1111/j.1095-8649.1978.tb03423.x

Tarkowská D (2019). Plants are capable of synthesizing animal steroid hormones. Molecules, 24(14): 2585. DOI: https://www.doi.org/10.3390/molecules24142585

Tran N, Chu L, Chan CY, Genschick S, Phillips MJ, and Kefi AS (2019). Fish supply and demand for food security in Sub-Saharan Africa: An analysis of the Zambian fish sector. Marine Policy, 99: 343-350. DOI: https://www.doi.org/10.1016/j.marpol.2018.11.009

Vipinkumar VP, Ramachandran C, Reshma G, Salini KP, and Athira PV (2019). The blue bonanza: A manual for on the job training programme for VHSE students on advances in fisheries & aquaculture techniques, Central Marine Fisheries Research Institute, Kochi, p. 277. Available at: http://eprints.cmfri.org.in/14147/1/The%20Blue%20Bonanza_2020.pdf

Yadav KC, Raizada S, and Mishra A (2016). Study of gonado-somatic index of male and female giant snakehead fish, *Channa marulius* (Hamilton, 1822). Journal of Experimental Zoology, India, 19(2): 719-721. Available at: https://www.cabdirect.org/cabdirect/abstract/20163324514

Yusuf NS, Andayani S, Risjani Y, and Faqih R (2019). Feed enriched with methanol extract of tongkatali Eurycoma longifolia Jack root for masculinization of Nile tilapia *Oreochromis niloticus*. AACL Bioflux, 12(5): 1481-1490. Available at: http://bioflux.com.ro/docs/2019.1481-1492.pdf

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