Original Research Article

Salinity tolerance of *Dormitator lebretonis* (Pisces: Eleotridae: Steindachner, 1870) reared in water tanks: Implications for coastal wetland and swamp valorizations

ABSTRACT

Dormitator lebretonis (Eleotridae: Steindachner, 1870) is a fish species that inhabits West African coastal environments from Senegal to Angola where this squeaker appears to be an important component of the artisanal fisheries. In particular, this eleotrid is widespread in Benin coastal waters including wetlands, and is intensively exploited for food. The current rearing experiment aimed to determine the salinity levels that favor the survival and growth factors of this squeaker. Six (6) treatments corresponding to six (6) salinity levels (0‰, 5‰, 10‰, 15‰, 20‰, 25‰) and three replicates with 15 individuals of *D. lebretonis* per replicate were considered for the experiment. Appropriate salinity levels were obtained from a mixture of sea water and fresh water. Overall, within each six (6) treatments, physicochemical features showed insignificant (P>0.05) variations. Regardless of rearing water salinity (0‰ - 25‰), *D. lebretonis* displayed high survivals ranging between 86.66% (salinity: 0‰) and 100% (salinity: 5‰ - 20‰). Percent weight gained (PWG: 7.94±0.01% - 14.39±0.02%) were moderate and significantly (P<0.05) varied with treatments. Also, significant (P<0.05) variations in the condition factors (K) were recorded, with means ranging between 1.68±0.04 and 1.92±0.01. Nevertheless, specific growth rates (SGR) did not show any significant ($F_{5,18}$=0.328; P=0.890) variations across treatments. These findings could serve as reference data for an extensive aquacultural valorization of *D. lebretonis* in numerous Benin coastal wetlands and swamps.

Keywords*: Coastal waters, Eleotridae, growth performances, Salinity, Valorization*

1. INTRODUCTION

Salinity is one of the top key factors that affect the water quality and the biological resources of aquatic ecosystems. In particular, in brackish waters such as lagoons and estuaries, salinity displays a wide range of effects such as food intake, locomotion activity, metabolism, spawning, growth and survival of fishes [1,2,3,4]. In such brackish waters, fishes are permanently under osmoregulation pressures in order to manage periodic changes in water salinity that greatly influences directly or indirectly the physiological conditions and bioenergetics of fishes [5]. Many studies point out the impacts of water salinity variations on shellfisheries, fisheries and the survival of various fish species in aquaculture industries [6,7]. Salinity variations affect the competitive interactions between organisms and can even serves as physical barriers in the distribution and abundance of a wide array of marine and brackish water animals [8,9,10].

In the Benin coastal waters, recent ichtyological surveys indicated that *Dormitator lebretonis* (Pisces: Eleotridae: Steindachner, 1870) is of high commercial and economic values and heavily exploited in artisanal fisheries [11]. The species inhabits brackish areas, estuaries, lagoons and mangroves that stand as preferred habitats, but can also be found occasionally in typically freshwater habitats and mainly in swamps and aquatic vegetation habitats [12,11]. In Benin, *D. lebretonis* are prominent and abundant in coastal waters such as Lake Nokoué, Porto-Novo Lagoon, Lake Ahémé and the Coastal Lagoon, and constitutes in these ecosystems, an important fisheries component [10,11]. Because *D. lebretonis* anatomically possess accessory respiration structures, this eleotrid seems tolerate a wide range of salinities [13,14]. Recent studies on feeding ecology indicated that in the wild, the species ingests detritus, insects and shrimps that dominate the diet. With regards to spawning, after hatching, the larvae reach the sea and the juveniles recolonize estuaries and other surrounding brackish water bodies [15]. *Dormitator lebretonis* is consumed fried or smoked with corn meal, rice, yam, potato etc. and widely used for sauce seasoning in replacement of shrimps that have become very expensive because of stocks decreases [16,11].

Notwithstanding the relatively high commercial and economic value of *D. lebretonis* in Benin, habitats are being degraded causing major threats to the species. These disturbances led to a high depletion of the species stocks in the Benin coastal waters. Hence, there is a needs of the valorization of the multitude freshwater and brackish water wetlands through the farming of this squeaker. Consequently, knowledge on the behavior and growth performance of *D. lebretonis* reared in different salinity levels are needed to assess survivals and growth rates in the perspective of fish farming in wetlands. The current study investigates the growth performance and survival of *D. lebretonis* reared in different ranges of salinity in order to contribute to a better understanding of the optimal conditions for rearing the species in wetlands.

2. MATERIAL AND METHODS

2.1. Sampling, acclimatization and experiment set-up

Sampling of Dormitator lebretonis: Live individuals of *D. lebretonis* (Fig.1) were collected at Lake Nokoué in Ganvié village located between 6°28'30.74" N and 2°23'22.3 "E. Samplings were made in aquatic vegetation/swamps and in open water using a seine (80 cm x 71 cm x 94 cm). Once caught, they were hold in oxygenated plastic packages (1 m x 42 cm) containing water from samplings sites. Packaged fish samples were then transported to the experimental site of AFRICA PRO FISH located at Ouidah town where rearing disposal was set.

Fig.1. Individual of *Dormitator lebretonis* captured in Lake Nokoué

***Acclimatization technique*:** Once transported to the experimental site, the 412 individuals of *D. lebretonis* collected were stored in 3 tarpaulin tanks of 1 m^3 (1m x1m x1m) each. *Dormitator lebretonis* individuals were then acclimatized for two weeks in a water of 10‰ - salinity brought from the sampling sites. The water was renewed every three (3) days and the salinity was readjusted using a stock of 35‰ - sea water. An aerator of 110 l/min of capacity ensured a permanent availability of dissolved oxygen which mean value was about 6.7 mg/l. Also, during this acclimatization phase, water temperature approximated 28.7°C, ammonium 0.1mg/l, nitrite 0.06mg/l, nitrate 0.71mg/l and pH 6.8. Fish individuals were fed daily *ad libitum* with a Skretting brand feed of 30% protein content.

***Experiment set-up and treatments*:** A total of eighteen (18) tanks of 1m^3 (1m x1m x1m) each were used for the rearing experiment (Fig. 2). Because *D. lebretonis* prefers habitats with low water levels (Sonon *et al.,* 2021) [11], the tanks were filled with water to a height of 25 cm, making a water volume of 250 l per tank. All the tanks were placed under shed to reduce sun influence. A tank of 2 m^3 was used to store the seawater collected from Atlantic Ocean at Ouidah seashore (Fig 2) while the fresh water was obtained from a borehole dug located in the experimentation site. Six (6) levels (0‰, 5 ‰, 10‰, 15‰, 20‰, 25‰) of salinities were considered in the current experiment. The brackish water for experimental tanks was obtained by mixing the seawater and the freshwater until getting the appropriate salinity. A refract meter (VISTA model) was used to measure the water salinity. Six (6) treatments T1, T2, T3, T4, T5 and T6 with 3 replicates per treatment were considered for the experiment and corresponded to salinities 0‰, 5‰, 10‰, 15‰, 20‰, and 25‰, respectively. A total of 270 individuals of *D. lebretonis* was used for the whole experiment and 45 individuals were assigned to each treatment. Thus, fifteen (15) individuals were placed per tank representing a replicate. The 45 individuals of *D. lebretonis* used per treatment for the experiment were submitted to ANOVA test that revealed that initial mean weights (2.77±0.11 g - 2.94±0.05g) through treatments were not significantly different ($F_{5,264}$= 0.892, p=0.487).

2.2. Water follow-up

***Water salinization, renewal and siphoning*:** To obtain the appropriate salinity corresponding to each treatment, seawater (35‰) was mixed with fresh water from the borehole of the experimental site. A refract meter of salinity range between 0 and 100 ‰ was used to monitor and adjust the salinity until the desired value was obtained. Every day, the water in the tapeline tanks was partially renewed by evacuating 10% of the rearing water and replaced by a mixture of freshwater and seawater. The salinities of the tanks was thus readjusted using a refract meter. The waste products from the leftover feed and fish feces are highly toxic and can cause mortality. Therefore, they were siphoned from the tanks every day during the experiment using a siphon.

***Follow-up of water quality*:** Physicochemical parameters such as dissolved oxygen (mg/l), temperature (°C) and pH were measured twice a day to the nearest 0.1 mg/l, 0.1°C and 0.1, respectively using the HANNA Multi-parameter (HI9829). Salinity was measured with a refract meter to the nearest 1‰. Also, ammonia (mg/l), nitrite (mg/l) and nitrate (mg/l) were measured twice a week with an ammonia/nitrite/nitrate test Kit (SERA Test kit).

Fig. 2. Water tanks used for the experiment.

2.3. Feeding and monitoring of growth/mortality

During the four (4) weeks-experiment, *D. lebretonis* individuals were fed twice a day (08:00 and 16:00) with commercially balanced feed for tilapia (Skretting®). Nutritional values of the food were as follow: protein (30%), fat (8%), crude fiber (3%), moisture (10%), ash (8%) and humidity (12%). To monitor growth and mortality, each tank was examined every day to check for dead fish individuals that were then removed immediately using a scoop net. Growth was assessed once a week through control fishing. This consisted of emptying the fish from the tapeline tanks and measuring morphometric parameters such as total length (TL), standard length (SL) and weight (W) of individual fish. TL and SL were measured to the nearest 0.1 cm with an ichthyometer and the weight was measured to the nearest 0.01g with an electric scale (Camry). At the end of the experiment, individual fish was weighed and their total body length was recorded.

2.4. Data analysis

Fish individual weight and length data were recorded in Excel spreadsheet 2016 (Ink; Microsoft office Professional Plus) and used for growth evaluation and to compute the condition factor (K). Survival rates (SR), weight gain (WG), specific growth rate (SGR) and condition factor (K) were evaluated through the following formulae [17,18]:

Survival Rate $(\mathrm{SR},\%) = \frac{\text{Final number of fish}}{\text{Initial number of fish}} x\ 100$

Percentage Weight Gain (PWG) = $\frac{\text{Final body weight} - \text{Initial body weight}}{\text{Initial body weight}}\ \mathrm{x}\ 100$

Specific Growth Rate $(\mathrm{SGR},\%) = \frac{\ln(\text{Final weight}) - \ln(\text{Initial weight})}{\text{Rearing period in days}} x\ 100$

Fulton's Condition Factor $(\mathrm{K}) = \frac{\text{Final body weight}}{(\text{Final standard length})^3} x100$

Also statistical analysis such as ANOVA 1 test was performed on the physicochemical data and the mean value of each parameter was computed. The growth performance

of the fish was analyzed by a one-way analysis of variance followed by the Tukey's multiple range test to compare differences among treatment means.

3. RESULTS

3.1. Water quality parameters

Table 1 shows mean ± (SD) values of water quality parameters during the experimentation. Overall, regardless of treatment, the water quality was globally suitable for the survival and growth of *D. lebretonis* reared in tanks. With regards to the six (6) treatments, mean water temperature ranged between 28.21±0.12 ^{o}C and 29.21±0.47^{o}C, mean dissolved oxygen between 4.21±0.45 mg/l and 4.86±0.68 mg/l and mean pH between 6.55±0.25 and 6.75±0.42. Also, mean ammonium varied from 0.06±0.25 mg/l to 0.08±0.24 mg/l, mean nitrite from 0.06±0.03 mg/l to 0.08±0.02 mg/l and mean nitrate from 0.66±0.048 mg/l to 0.80±0.48 mg/l. In general, for each six (6) treatments of salinities 0‰, 5‰, 10‰, 15‰, 20‰ and 25‰, respectively, one-way Anova run on physicochemical features failed to show significant difference (P>0.05) with statistics (F, P) ranging between $F_{2,165}$=0.060 and $F_{2,165}$=0.343 (*p:* 0.051 - 0.942) for temperature, between $F_{2,165}$=0.265 and $F_{2,165}$=4.731 (P: 0.058 - 0.951) for dissolved oxygen and between $F_{2,165}$=0.135 and $F_{2,165}$=3.27 (P: 0.058-0.874) for pH. Ammonia ($F_{2,21}$=0.20 - $F_{2,21}$=4.60 with P: 0.179 - 0.833), nitrite ($F_{2,21}$=0.1 - $F_{2,21}$=3 with P: 0.250 - 0.833) and nitrate ($F_{2,21}$=0.000 - $F_{2,21}$=1.4 with P : 0.417 - 1.00) showed the same trends. Nevertheless, significant variations (P<0.05) of water physicochemical parameters were recorded between different treatments during the experimental study with statistics $F_{5,330}$=3.054, P=0.012 for temperature; $F_{5,330}$= 44.61, P=0.000 for dissolved oxygen and $F_{5,330}$=5.111, P=0.000 for pH. Also, significant variations (P<0.05) were recorded for ammonium with $F_{5,42}$=6.963, P=0.000; for nitrite ($F_{5,42}$=3.216, P=0.023) and for nitrate with $F_{5,42}$=4.547, P=0.005.

Table 1. Mean (±SE) values of water quality parameters during the rearing of *Dormitator lebretonis* in water of different salinities (0‰, 5‰, 10‰, 15‰, 20‰, 25‰).

	Treatments					
Parameters	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
DO (mg/l)	4.35±0.582	4.86±0.213	4.21±0.452	4.66±0.363	4.36±0.691	4.29±0.843
Temp (T°C)	28.21±0.12	28.31±0.71	28.21±0.12	28.38±0.16	28.33±0.23	29.21±0.11
pH	6.55±0.116	6.73±0.137	6.68±0.134	6.68±0.083	6.75±0.082	6.66±0.075
Amm (mg/l)	0.08±0.004	0.08±0.006	0.06±0.006	0.06±0.006	0.07±0.004	0.08±0.004
Nitrite (mg/l)	0.07±0.006	0.06±0.004	0.08±0.004	0.07±0.004	0.06±0.004	0.07±0.003
Nitrate (mg/l)	0.72±0.032	0.66±0.048	0.8±0.048	0.74±0.048	0.66±0.048	0.74±0.048

DO: Dissolved oxygen, Temp: Temperature, Amm: Ammonium

3.2. Survival rates and growth performances

Growth performance parameters such as initial weight (IW), final weight (FW), percent weight gain (PWG), specific growth rate (SGR), survival rate (SR) and condition factor (K) of *D. lebretonis* reared in different level of salinity were summarized in Table 2 and represented in Figures 3 and 4. Over the experimental period, survivals were high and ranged between 86.66% (salinity: 0‰) to 100% (salinity: 5‰, 10‰, 15‰, 20‰). A survival of 96.66% was recorded for the highest salinity (25‰) tested. One-way ANOVA run on the survivals and growth performances of *D. lebretonis* revealed that the survival rates varied significantly ($F_{5,264}$= 4.311; *P*=0.006) among treatments. Also, with regards to the six (6) treatments, there were significant ($F_{5,264}$=18.160; *P*=0.000) variations in the condition factors (K) with means ranging between K=1.68±0.04 (salinity: 15‰) and K=1.92±0.01 (salinity:10‰). In contrast, percent weight gained (PWG) weekly from different treatments did not show any significant ($F_{5,18}$=0.324; *P*=0.892) variations among treatments. Nevertheless the highest value (PWG=14.39±0.02%) was recorded for salinity 20‰ and the lowest value (PWG=7.94±0.01%) was recorded for salinity 25‰. Likewise, weekly specific growth rate (SGR) did not show any significant ($F_{5,18}$=0.328; *P*=0.890) variations among treatments. The highest SGR (0.65±0.11%/day) was recorded for salinity 15‰ while the lowest value (0.27±0.07) was recorded for salinity 25‰.

Table 2. Growth performances and survivals (%) of *Dormitator lebretonis* reared in different water salinity (0‰, 5‰, 10‰, 15‰, 20‰, 25‰).

	Treatments					
Parameters	S1=0‰	S2=5‰	S3=10‰	S4=15‰	S5=20‰	S6=25‰
I W(g)	2.89±0.09	2.88±0.06	2.90±0.14	2.94±0.05	2.88±0.07	2.77±0.11
FW(g)	3.26±0.10^{b}	3.11±0.09^{a}	3.27±0.12^{b}	3.33±0.08^{b}	3.18±0.18^{b}	2.99±0.15^{a}
PWG (%)	10.38±0.05^{a}	8.22±0.03^{b}	9.66±0.02^{a}	13.38±0.03^{c}	14.39±0.02^{c}	7.94±0.01^{b}
SR (%)	86.66±2.26^{a}	100±0.00^{b}	100±0.00^{b}	100±0.00^{b}	100±0.00^{b}	96.66±0.66^{ab}
SGR (%. day^{-1})	0.56±0.24^{b}	0.41±0.15^{b}	0.57±0.10^{b}	0.65±0.11^{c}	0.49±0.13^{b}	0.27±0.07^{a}
K	1.85±0.03^{b}	1.74±0.09^{a}	1.92±0.01^{b}	1.68±0.04^{a}	1.83±0.04^{b}	1.79±0.00^{a}

IW: Initial weight, FW: Final weight, SR: Survival rate, SGR: Specific growth rate, K: Condition factor. Values are represented as triplicate mean±SE, with 15 fish in each replicate. Different superscripts within a row indicate significant (p<0.05) differences among means.

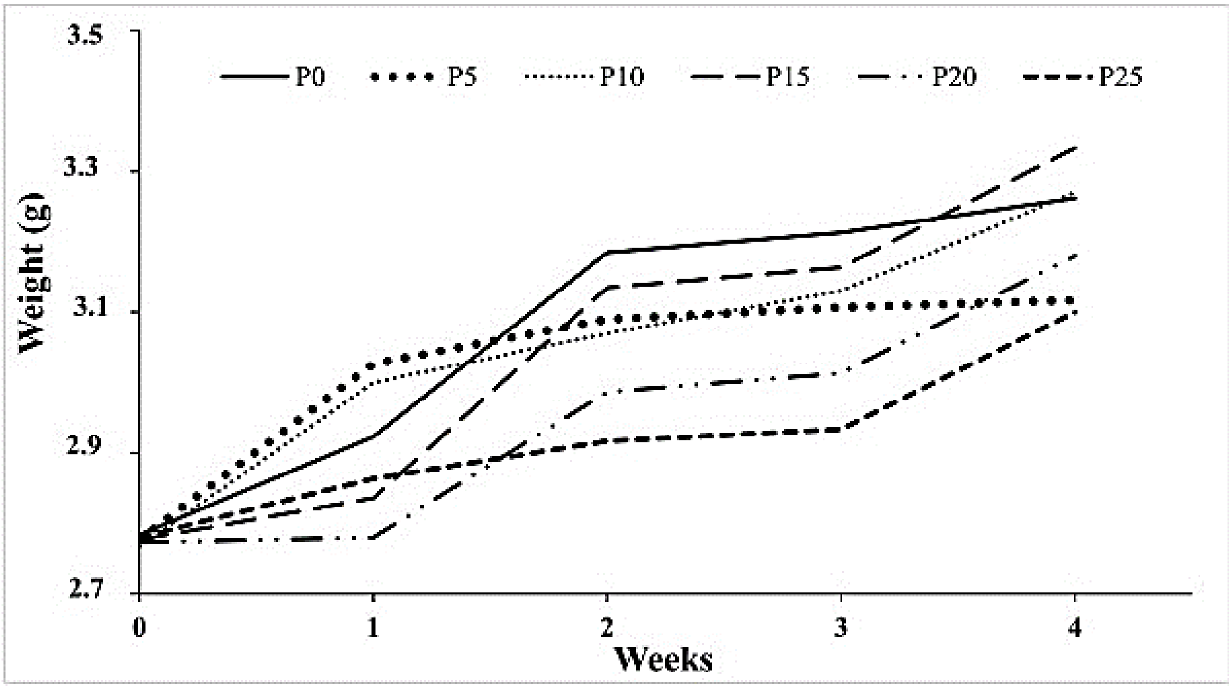

Fig. 3. Trends of body weight of *Dormitator lebretonis* reared during 4 weeks in water of different salinity (0‰, 5‰, 10‰, 15‰, 20‰, 25‰).

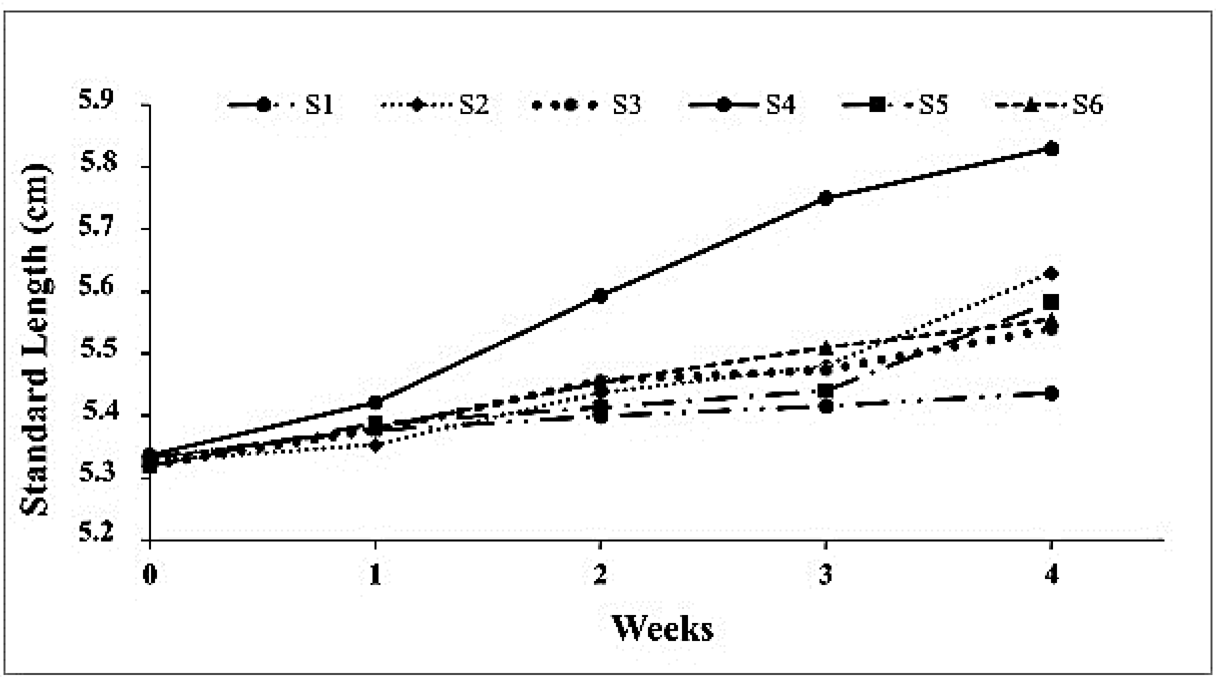

Fig. 4. Trends of standard length of *Dormitator lebretonis* reared during 4 weeks in water of different salinities (0‰, 5‰, 10‰, 15‰, 20‰, 25‰).

DISCUSSION

In the current experiment of *Dormitator lebretonis* reared in water of variable salinity concentrations, the water quality parameters (**Table 1**) recorded during the whole experiment were suitable for the survival and growth of *D. lebretonis* regardless of treatments. These water features were similar to those reported by Sonon et al. (2021) [11] in this eleotrid habitat in Lake Nokoué where water temperature ranged between 27.5 - 31.1^{o}C, pH between 5.8 - 7.55, and dissolved oxygen between 0.55mg/l - 8.9 mg/l. In contrast, *Dormitator latifrons,* the most cultivated Eleotrid in Mexico, seems tolerate higher water temperature (31.9°C - 32.3°C) and higher pH (7.2 - 8). However, lower variations of dissolved oxygen (6.4 - 7.3 mg/l) were reported by Basto-Rosales et al. (2019) [19] for *D. latifrons* reared in concrete tanks in Mexico compared to those of *D. lebretonis* reared in tarpaulin tanks. Overall, in this experiment, there were no significant variations (*P*>0.05) in water features within tanks suggesting that, globally, the water quality remained invariable during the fish culture. Indeed, one-way Anova statistics (F, *P*) ranged between $F_{2,165}$=0.060 and $F_{2,165}$=0.343 (*P:* 0.051-0.942) for temperature, between $F_{2,165}$=0.265 and $F_{2,165}$=4.731 (*P*: 0.058 - 0.951) for dissolved oxygen and between $F_{2,165}$=0.135 and $F_{2,165}$=3.27 (*P*: 0.058-0.874) for pH. Also, F ranged between $F_{2,42}$=0.20 and $F_{2,42}$=4.60 (*P*: 0.179 - 0.833) for ammonia, between $F_{2,42}$=0.1 and $F_{2,42}$=3 (*P*: 0.250 - 0.833) for nitrite and between $F_{2,42}$=0.000 and $F_{2,42}$=1.4 (*P* : 0.417 - 1.00) for nitrate. Thus, mean values of physicochemical parameters such as temperature (28.21±0.12 to 29.21±0.47^{o}C), pH (6.55±0.25 to 6.75±0.42), dissolved oxygen (4.21±0.45 to 4.86±0.68 mg/l), ammonium (0.06±0. 25 to 0.09±0.24 mg/l), nitrite (0.06±0.03 to 0.08±0.02 mg/l), and nitrate (0.66±0.048 to 0.80±0.48 mg/l) were not limiting factors in the expression of growth and survival potential in *D. lebretonis* subjected to different salinity levels.

In this study, high percentages of survival of *D. lebretonis* were recorded regardless of treatment and varied between 86.66% and 100%. In particular, the treatments of salinity 5‰, 10‰, 15‰ and 20‰ showed 100% of survival and similar to those recorded by Basto-Rosales et al. (2019) [19] in concrete tanks where *D. latifrons* survival ranged between 99% and 100% when reared in fresh water. Overall, percentages of survival were significantly different ($F_{5,264}$= 4.311; *P*=0.006) between group of treatments of different salinities (0‰, 5‰, 10‰, 15‰, 20‰, 25‰). This high survival recorded regardless of treatment indicated that *D. lebretonis* tolerate a high range of salinity (0‰ - 25‰), suggesting that this eleotrid is an euryhaline fish species. The presence of accessories organs that allow the species to utilize atmospheric oxygen may explain this high rusticity and survival [19].The great tolerance in salinity and the adaptive air breathing behavior allow *D. lebretonis* to colonize most Benin brackish waters such as Porto-Novo lagoon, Lake Nokoué, Lake Ahémé, Coastal Lagoon showing a wide range of salinity varying nearly between 0‰ and 25‰ [20,11]. Furthermore, in the Coastal Lagoon, *D. lebretonis* were caught in a water of 30‰ – salinity indicating that this eleotrid may support sea water. Also, when reared in a 0‰-salinity (treatment1), the resulting survival (86.66±4.44%) still relatively high indicating that *D. lebretonis* is able to survive and to growth in a typically freshwater. In Benin, *D. lebretonis* individuals were common in the freshwater floodplains of the Ouémé River, the Sô River and the Mono River where they were relatively abundant during a short period of flooding [10,21,22]. They mostly originated from their reproduction grounds such as swamps and adjacent aquatic grasses from where they were dragged in the open water during flooding [10,21]. Also, results on the population structure reported by Sonon et al. (2023) [23,24] and the findings from the current experiment agreed with that reported by Quesada (2017) [25] in the Cross River and Chiloango River in Guinea, some freshwaters of salinity between 0 and 5‰ where *D. lebretonis* constituted an important component of the fish fauna.

This wide range of salinity (0-30‰) tolerated by *D. lebretonis* could be an adaptation to the coastal habitats by developing a high osmoregulation potential. Probably, the species has evolved in an euryhaline aquatic environment characterized by variable hydrological regimes that yearly include floodings from rivers during rainfall associated with intrusions of seawater. As results, in both habitats (freshwater, brackish water), *D. lebretonis* individuals exhibit high survivals and high growth performances. Navarro-RodrÍguez et al. (2010) [26] reported similar observations with *D. latifrons*, a fish species occurring abundantly in the Boca Negra Estuary in Mexico. When transported abruptly from freshwater and placed directly in different levels of salty water, 97.5 % of individuals of *D. latifrons* survived in a water of salinity up to 35‰ [19]. In the current rearing experiment, though percentages of *D. lebretonis* survival were quite high and significantly ($F_{5,264}$=4.311 *P*=0.006) different between groups of treatments, insignificant ($F_{5,18}$=0.328, P=0.890) variations of specific growth rate (SGR) were recorded among the six treatments and lower than that reported by Basto-Rosales et al. (2019) [19] for *D. latifrons* where SGR approximated 5.5%.day^{-1}. This finding suggested that the range of salinity (0 - 25‰) considered did not significantly affect the specific growth rate (SGR) of *D. lebretonis*. Nevertheless, though not significant, relatively lower values of SGR were recorded in a 25‰ water salinity. Overall, regardless of treatments, *D. lebretonis* exhibited relatively high condition factors (K) that significantly ($F_{5,264}$=18.160; P=0.000) varied across treatments. Indeed, high salinity levels may directly affect fish physiology causing the reduction of growth rate and survival. In addition, osmoregulation mechanism needs energy and species with lower metabolic rates utilize about 20 to 50% of the total energy available [27]. Nevertheless, in this study, *D. lebretonis* showed high condition factors (K>1) with means ranging between K=1.68±0.04 (15‰) and K=1.92±0.09 (10‰) suggesting that the species showed good wellbeing compared with those recorded for *Dormitator maculatus* in the Alvarado Lagoon, in Mexico where K ranged between 0.16749 and 0.20856 [28].

As results, *D. lebretonis* tolerate freshwaters and brackish water habitats of salinity ranging between 0% and 25-30% allowing higher survival and growth performances. Consequently and as suggestion, extensive commercial culture of *D. lebretonis* could be implemented in the fresh and brackish swamps habitats that are widely available at the Benin coastal waters. Likewise, some other existing numerous isolated freshwater swamps could be valorized through the rearing of *D. lebretonis* for food production and the improvement of grassroots revenues.

CONCLUSION

The current research on salinity tolerance of *Dormitator lebretonis* reared in water tanks indicated that this eleotrid tolerate a wide range of salinity ranging between 0‰ and 25‰ that lead to a high potential of survival and growth performance. These findings could serve as reference data for the valorization of numerous coastal wetlands and swamps through an extensive rearing of *D. lebretonis* to increase the species stocks and to improve the revenue of the fishermen.

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