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Study of the Zootechnical Performance of *Tilapia cabrae* and *Oreochromis schwebischi* in a Controlled Environment: The Case of the Mbolet Fish Farm in Lambaréné, Gabon

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ABSTRACT

Background: The study of the zootechnical performance of *Tilapia cabrae* and *Oreochromis schwebischi* was carried out at the Mbolet fish farm in Lambaréné in Gabon in order to evaluate the growth and reproductive performance of these two species.

Methods: For this purpose, 226 fish (113 of *T. cabrae* with an average weight of 30.55±9.5 g and 113 *O. schwebischi* with an average weight of 20.64±10.5 g), were distributed in four 6 m^2 tanks with two replicates per species for the growing phase which lasted 60 days. For the reproductive phase, 42 selected mature fish, including 6 males and 36 females of each species, were placed in six 2 m^2 ponds with three replicates per species for 78 days.

Result: The survival rate, the number of reproductions per species and the absolute, relative and system productivities were determined. It was found that the average weight gain, daily individual growth and specific growth rate were significantly ($p<0.05$) higher in *T. cabrae*, 48.1±5.51 g, 0.8±0.092 g/day and 1.57±0.066% g/day respectively, than in *O. schwebischi*, 27.11±9.23 g, 0.45±0.15 g/day and 1.38±0.051% g/day respectively. At the end of reproduction, the absolute productivity of *T. cabrae* (234.75±24.71 larvae/female/egg-laying) was significantly higher ($p<0.05$) than that of *O. schwebichi* (104.68±46.64 larvae/female/laying). System productivity was significantly higher ($p<0.05$) in *O. schwebichi* (11.34±2.29 larvae/m^2/day) compared to that of *T. cabrae* (4.12±1.73 larvae/m^2/day). Thus, on a fish farm, the use of these species may be possible.

Key words: Growth performance, *Oreochromis schwebichi*, Reproductive performance, *Tilapia cabrae.*

INTRODUCTION

The increase in the world's population has led to a correspondingly greater demand for proteins, particularly animal proteins (Caillavet *et al*., 2019). At the fisheries level, the improvement of fishing techniques and the extension of fishing areas leading to an increase in catches have made it possible to satisfy part of this protein demand (Adeoti *et al*., 2018). According to FAO (2020), in the period 1961-2017, the average annual growth rate of total food fish consumption increased at 3.1%, outpacing annual population growth rate (1.6%). At the global level, it is estimated that 61% of fish stocks are exploited to their maximum and 29% are overexploited. The stocks directly threatened by exploitation are mainly those of economic interest (Kumar *et al*., 2020). They are particularly targeted and are subject to strong fishing pressure that is often beyond their level of viability. This situation of overexploitation can also be observed in Africa in general (Lallemand *et al*., 2016) and in Gabon in particular, in the Moyen Ogooué, fishing is used by the local population as a subsistence mean by providing them with income (DPPAMO, 2019). The Mbolet fish farming station recommends the implementation of a project that consists of producing marketable fish using the most caught species in order to satisfy part of the demand and massively produce fry of species from these fisheries, notably *Oreochromis schwebischi* and *Tilapia cabrae* for sequential restocking. Indeed, these species are the most encountered and caught in the fishing areas (DPPAMO, 2019). Moreover, the captive breeding of these two species, which are still poorly understood, considerably limits the implementation of such a project.

The general objective of this work is to contribute to the knowledge of the zootechnical performance of the species *Tilapia cabrae* and *Oreochromis schwebischi.*

MATERIALS AND METHODS

This study was carried out at the Mbolet fish farm in Lambaréné in the Moyen-Ogooué Province in Central-West

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Table 1: Stocking conditions.

Species	*Oreochromis schwebischi*		*Tilapia cabrae*	
Ponds	B1Os	B2Os	B1Tc	B2Tc
Total	56	57	56	57
Mean weight (g)	14.62±10.8	26.66±4.02	32.08±5.01	29.02±2.4
Surface (m^2)	6	6	6	6
Density (individuals/m^2)	9.33	9.5	9.5	9.5

B1Os: Pond1 of *O. schwebischi*; B2Os: Pond2 of *O. schwebischi*; B1Tc: Pond1 of *T. cabrae*; B2Tc: Pond2 of *T. cabrae*.

Gabon with an average annual temperature of 26.1°C and an average rainfall of 1999 mm (Sonwa *et al.,* 2020) for an altitude of 0° 46′ 48″ South and a longitude of 10° 14′ 2″. The climate in this area is of humid tropical savannah type (Aw).

It is located in the ''Petit Paris 3" quarter, behind the regional hospital, on the shore of Lake Mbolet at the coordinates -0.698681 and 10.253984. Two species of fish were used in this experimental trial. These were *Tilapia cabrae* and *Oreochromis schwebischi*. These fish were caught in the fisheries of Moyen-Ogooué and brought to the station. The experimental samples were taken at the fingerling stage with an average weight of 30.55±9.5 g for *T. cabrae* and 20.64±10.5 g for *O. schwebischi.* In order to monitor the growth of these two species in a controlled environment, they were conditioned for one month. Then, 113 fish were used for each species. Four groups were made up, two for each group of each species. The loading of the fish took into account the number of fish, their weight and density in 6 m^2 tanks (Table 1). Water was pumped into the ponds from the surrounding lake. This phase lasted 2 months and allowed not only the development of the fish but also the maturation of their gonads. The fish were fed three times a day (9 am, noon and 3 pm) with the feed which characteristics are given in Table 2. The feed was presented to the animals in the form of 4 mm diameter pellets.

Table 2: Incorporation rate of the ingredients and chemical composition of the formulated feed.

Ingredients	Incorporation rate (%)
Fine wheat bran	19.45
Peanuts	19.45
Sardine crums	48.62
Wheat flour	4.86
Cassava flour	4.86
Palm oil	2.43
Salt	0.16
Vitamins	0.16
Total	100
Chemical composition	
Dry matter (%)	74
Organic matter (%MS)	90
Ashes (%MS)	10
Crude protein (%MS)	30
Lipids (%MS)	2.4
Crude cellulose (%MS)	6

The sampling of fish carried out every 15 days, allowed the determination of weight gain, the quantity of feed distributed and the number of deaths. At the end of the two months of growth, sexing was carried out in the different groups on the basis of the sexual dimorphism that is marked in these species. Thus, the observation of the genital papilla permitted to identify the male from the female.

For breeding, after the selection of fish broodstock, the fish were distributed in six 2 m^2 ponds. There were 15 individuals (3 males and 12 females) per tank. The total numbers of 72 fish, of which 36 *T. cabrae* and 36 *O. schwebishi* were used. They were weighed and divided into 6 groups (3 groups per species). The loading of the fish took into account the number of fish, their weight and density (Table 3).

Larvae/juveniles were collected every fortnight depending on the species. The monitoring of the reproduction was spread over 78 days during which the data on the number of dead broodstock, number of reproductions carried out in each group, number of larvae produced per female and weight of the females that produced them were collected.

The fish were fed trice a day (9 am, noon and 3 pm), except the day before the control fisheries. The feed and

Table 3: Selected broodstock.

Species	*T. cabrae*			*O. schwebischi*		
Ponds	B1Tc	B2Tc	B3Tc	B1Os	B2Os	B3Os
Number of males	3	3	3	3	3	3
Number of females	12	12	12	12	12	12
Total	45	45				
Males MW (g)	110.83±6.11			63±4.38		
Females MW (g)	46.05±1.96			30±3.33		

MW: Mean weight; B1Tc: Pond1 of *T. cabrae*; B2Tc: Pond2 of *T. cabrae*; B3Tc: Pond3 of *T. cabrae*; B1Os: Pond1 of *O. schwebischi*; B2Os: Pond2 of *O. schwebischi*; B3Os: Pond3 of *O. schwebischi*.

Table 4: Zootechnical parameters.

Parameters		Formulae	Observations
Growth parameters	Absolute weight gain (AWG)	AWG (g) = Final B - Initial B	B = The ichtyobiomass
	Daily individual growth (DIG)	$DIG\ (g/day) = \frac{(Faw - Iaw)}{Duration\ of\ the\ production}$	Faw = Final average weight; Iaw = Initial average weight.
	Specific growth rate (SGR)	$SGR\ (\%/day) = \frac{Ln\ Faw - Ln\ Iaw}{Duration\ of\ the\ production} \times 100$	
	Consumption index (CI)	$CI = \frac{Quantity\ of\ feed\ distributed}{AWG}$	
	Protein efficiency coefficient (PEC)	$PEC = \frac{AWG}{Q \times \%\ proteins\ of\ the\ feed}$	Q = Quantity of feed distributed
	Survival rate (SR)	SR (%) = (Final N/Initial N) × 100	N = Number
Reproductive parameters	Survival rate of broodstock (SR)	$SR\ (\%) = \frac{Initial\ number - Number\ of\ deaths}{Initial\ number} \times 100$	
	Relative productivity (larvae/g of female)	$RP\ (larvae/g\ of\ female) = \frac{Number\ of\ larvae\ produced}{Weight\ of\ females\ producing\ larvae}$	
	Productivity of the system (larvae/m²/day)	$PS\ (larvae/m^2/day) = \frac{Number\ of\ larvae\ produced}{Surface\ area \times Duration\ of\ the\ reproduction}$	

the fish were weighed using an electronic scale of the brand Ororudo (capacity: 5 kg and accuracy: 1 g). The pH and temperature were measured daily trice a day (9 am, noon and 3 pm) using a VWR multi-functional pH meter and the transparency using a Secchi disk daily at 12:00 pm. From these data, different zootechnical parameters were calculated (Table 4).

The statistical analysis of the results (on growth performance) was done using the 95% confidence interval method (Appendix 8). When the 95% confidence intervals of two compared means are disjoint, then there is a significant difference at 5% level between them. For reproductive performance, the statistical analysis of the results was carried out using the R software commander version 3.4.3. The test used was Student's mean comparison at the 5% level.

RESULTS AND DISCUSSION

Physicochemical parameters of the water during the growth phase

Samples of the physicochemical parameters of the water during grow-out are summarized in Table 5. From this table, no significant difference ($p>0.05$) was observed between the different times with regard to pH and temperature.

Table 5: pH, temperature and transparency of the water used as a function of the sampling time.

Parameters	9 am	Noon	3 pm
pH	8.43±0.40[a]	8.97±0.49[a]	9.16±0.42[a]
Temperature (°C)	28.41±0.36[a]	29.02±0.55[a]	29.9±0.55[a]
Transparency (cm)	46.66±5.11		

a: Averages with the same lower case letters on the same line are statistically identical.

The pH varied from 8.43±0.40 to 9.16±0.42 and the temperature from 28.41±0.36°C to 29.9±0.55°C. Transparency averaged 46.66±5.11 cm.

Evolution of absolute weight gain (AWG)

The evolution of the AWG of the two fish species during the two months of grow-out is presented in Fig 1. It shows that, irrespective of the fish species, AWG increased from the beginning of the trial to the end (day 60). Indeed, during this period, the AWG of *T. cabrae* increased from 832.44 g to 2459.22 g and that of *O. schwebischi* from 497.93 g to 1504.48 g. The total AWG obtained was 1626.78 g and 1006.55 g for *T. cabrae* and *O. schwebischi* respectively. Statistical analysis showed a significant difference ($p<0.05$) between these total AWG.

Daily individual growth (DIG)

Fig 2 shows the DIG of the two fish species during the two months of grow-out. Fig 2 shows that, for both fish species, DIG rates decreased from the beginning of the trial to the end (day 60). During this period, the DIG of *T. cabrae* decreased from 1.475 g to 0.8 g and that of *O. schwebischi* from 0.7 g to 0.45 g. Thus, at the end of the trial, the average DIG recorded was 0.45 g/day for *O. schwebischi* and 0.8 g/day for *T. cabrae*. Statistical analysis revealed a significant difference ($p<0.05$) between these DIG.

Specific growth rate (SGR)

Fig 3 shows the SGR of the two fish species during the two months of grow-out. Fig 3 shows that for both fish species, the SGR rates decreased from the beginning of the trial to the end (day 60). Indeed, during this period, the SGR of *T. cabrae* decreased from 3.76 to 1.57% g/day and that of *O. schwebischi* from 2.7 to 1.38% g/day. Thus, at the end of the trial, the average SGR obtained was 1.38% g/day for *O. schwebischi* and 1.57% g/day for *T. cabrae*. Statistical analysis revealed a significant difference ($p<0.05$) between these SGR.

Consumption index (CI)

The CI of the two fish species during the two months of grow-out is presented in Fig 4. From Fig 4, it can be seen that, irrespective of the fish species, the CI increased from the beginning to the end of the trial (day 60). Indeed, during this period, the CI of *T. cabrae* increased from 3.05 to 3.64 and that of *O. schwebischi* from 1.86 to 2.93. Thus, at the end of the trial, the recorded CI were 3.64 for *O. schwebischi* and 2.93 for *T. cabrae*. Statistical analysis revealed no significant difference ($p<0.05$) between these CI.

Protein efficiency coefficient (PEC)

The PEC of the two fish species during the two months of grow-out is shown in Fig 5. Fig 5 shows that the PECs of all fish species decreased from the beginning of the test to the end (day 60). In fact, during this period, the PEC of *T. cabrae* increased from 0.015 to 0.00994 and that of *O. schwebischi* from 0.0095 to 0.0085. Thus, at the end of the trial, the mean PEC recorded were 0.00994 for *T. cabrae* and 0.0085 for *O. schwebischi*. Statistical analysis revealed no significant difference ($p>0.05$) between these PEC of each period of the trial. Growth parameters measured in *T. Cabrae* and *O. Schwebischi* are recorded in Table 6.

Physicochemical parameters during the breeding phase

The sampling of physicochemical parameters of the water during the grow-out phase is summarized in Table 7. From this table, it can be observed no significant differences ($p>0.05$) between the different times with regard to pH and temperature. The pH varied from 8.83±0.44 to 9.64±0.35 and

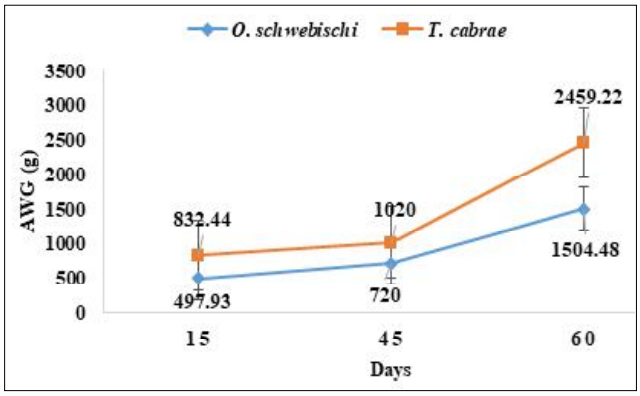

Fig 1: Evolution of AWG (g) of *T. cabrae* and *O. schwebischi.*

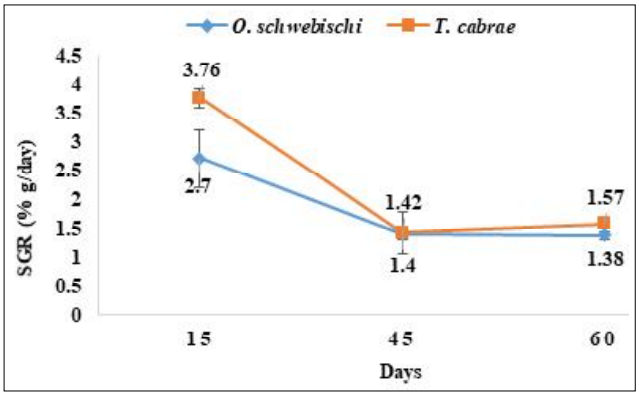

Fig 3: Evolution of SGR (% g/day) of *T. cabrae* and *O. schwebischi.*

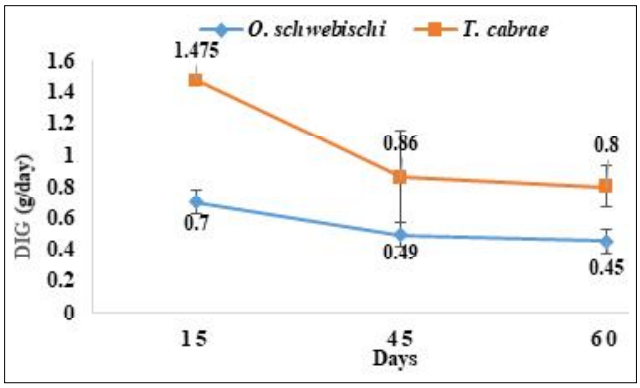

Fig 2: Evolution of DIG (g/day) according to species.

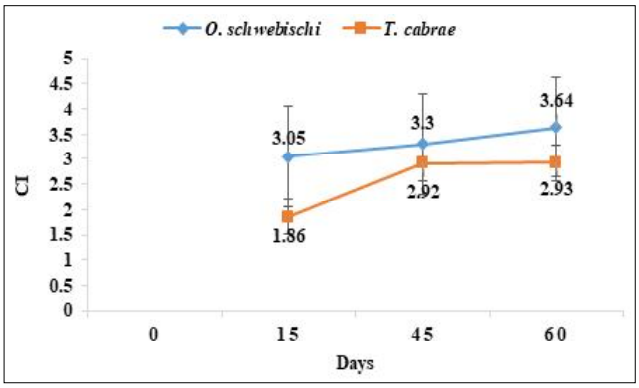

Fig 4: Evolution of CI according to days.

the temperature from 28.61±0.12 to 30.30±0.09°C. Transparency averaged 51±1.25 cm.

Absolute productivity (AP)

The AP of *O. schwebischi* and *T. cabrae* females is shown in Fig 6. It shows that the AP of *O. schwebischi* (104.68) was significantly ($p<0.001$) lower than that of *T. cabrae* (234.75).

Relative productivity (RP)

Fig 7 shows the RP of *O. schwebischi* and *T. cabrae*. From Fig 7, it can be seen that the RP recorded in *O. schwebischi* (3.46) was significantly ($p<0.001$) higher than that of *T. cabrae* (2.62).

System productivity (SP)

Fig 8 shows the SP of *O. schwebischi* and *T. cabrae*. From Fig 8, it can be seen that the productivity of the system in *O. schwebischi* (11.34) was significantly ($p<0.001$) higher than that of *T. cabrae* (4.12).

The breeding parameters measured in *T. cabrae* and *O. schwebischi* are given in Table 8.

Physicochemical parameters during the growth phase

The average pH values recorded during the present study are higher than those obtained by Koné *et al*., (2012) (7.86±0.08 and 7.9±0.07) with growing *Oreochromis niloticus* fingerlings in Côte d'Ivoire. Thus, these values obtained wouldn't have negatively influenced the growth of the fish.

The average temperatures obtained during the present study corroborate those advised by Amoussou *et al*., (2016) (24 and 32°C).

The observed mean turbidity value is included in the standard recommended by Zerbi (2004), 45 to 60 cm.

Absolute weight gain (AWG), daily individual growth (DIG), specific growth rate (SGR), consumption index (CI) and protein efficiency coefficient (PEC)

The results of the present study showed that AWG, DIG and SGR are more interesting in *T. cabrae* than in *O. schwebischi*. CI and PEC are comparable for both species. Generally, *T. cabrae* seems to be more interesting than *O. schwebischi*. Moreover, the AWG obtained in *T. cabrae* and *O. schwebischi*, are lower than those observed in *O. niloticus* (65.3, 95.7 and 101.6 g/fish) by Iga Iga (2008). In this study, the DIG of *T. cabrae* and *O. schwebischi* are lower than those reported by Dibala *et al*. (2018) 1.36 g/day in *O. niloticus*, a fish of the same family. The SGR values are higher than those obtained by Celine *et al.,* (2008) in Benin with *Tilapia zillii* (0.85% g/day) and 0.74% g/day for *T. guineensis*.

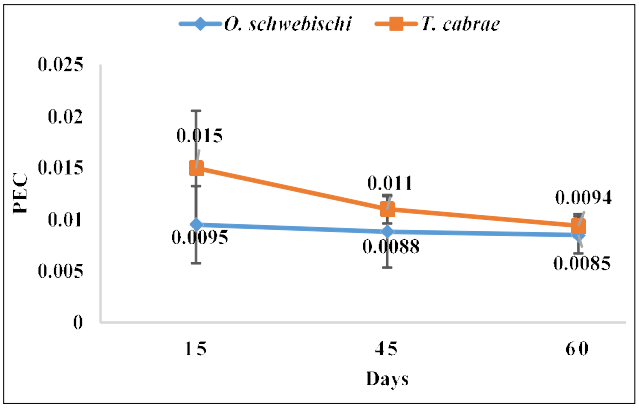

Fig 5: Evolution of PEC according to fish species.

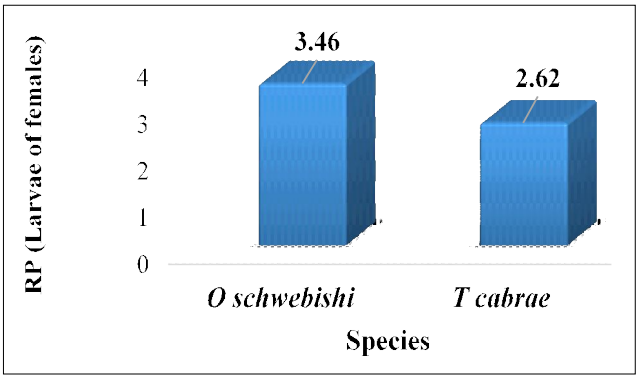

Fig 7: Relative productivity according to females of *O. schwebischi* and *T. cabrae*.

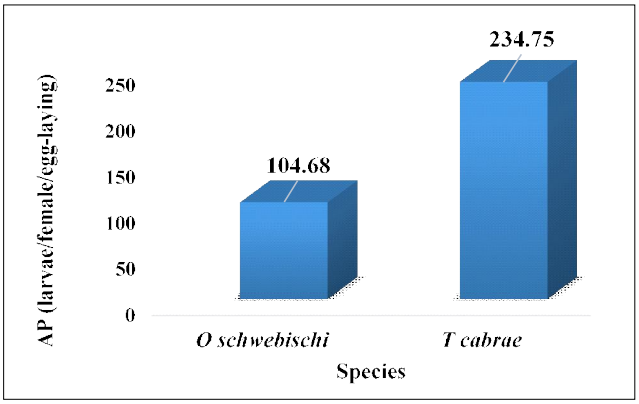

Fig 6: Absolute productivity according to females of *O. schwebischi* and *T. cabrae*.

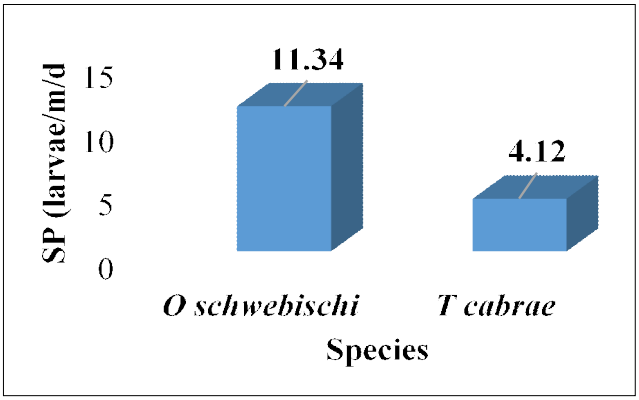

Fig 8: Productivity of the system according to the females *O. schwebischi* and *T. cabrae*.

Table 6: Summary of growth parameters according to *T. cabrae* and *O. schwebischi.*

Parameters	*O. schwebischi*	*T. cabrae*
AWG (g)	27.11±9.23[a]	48.01±5.51[b]
DIG (g/day)	0.45±0.15[a]	0.8±0.092 [b]
SGR (% g/day)	1.38±0.051[a]	1.57±0.066[b]
CI	3.64±0.64[a]	2.93±0.57[a]
PEC	0.0085±0.0013[a]	0.094±0.0008[a]

a, b: Averages with the same lower case letters on the same line are statistically identical.

Table 7: pH, water temperature and transparency in the ponds.

Parameters	9 am	Noon	3 pm
pH	8.83±0.44	9.16±0,36	9.64±0.35
Temperature (°C)	28.61±0.12	29.41±0.16	30.30±0.09
Transparency (cm)	51±1.25		

a: Averages with the same lower case letters on the same line are statistically identical.

Table 8: Summary of reproduction parameters in *T. cabrae* and O. *schwebischi.*

Parameters	*O. schwebischi*	*T. cabrae*
AP (larvae/female/egg-laying)	104.68±46.64[a]	234.75±24.71[b]
RP (larvae/g of female)	3.46±0.62	2.62±0.32
SP (larvae/m^2/day)	11.34±2.29 [a]	4.12±1.73[b]

a, b: Averages with the same lower case letters on the same line are statistically identical.

The CI obtained in this study are higher than the 1.5 and 2.5 standards recommended by Iga Iga (2008), which reflects the poor utilization of the feed by these species. Furthermore, the PEC observed during grow-out monitoring are much lower than those reported by Bahnasawy *et al.*, (2009), which were 2.43 for 17% proteins in the diet and 1.36 for 35% proteins. The differences observed between these results would be related not only to the animal species, stocking density, physiological conditions and origin of the fish but also to the quality of the feed (Mensah *et al.*, 2014).

Physicochemical parameters during the breeding phase

The pH and temperature values recorded during the present study are within the tolerance limit interval (6.52<pH<10.84) and between 28°C and 35°C given by Ouédraogo (2000), making the environment suitable for the breeding of these species.

The average turbidity observed during this study for the breeding was in line with the findings of Zhang *et al.*, (2017) for a transparency between 40 and 60 cm.

Absolute productivity

The number of larvae produced by a female *T. cabrae* during an oviposition is higher than that of a female *O. schwebischi*. These results could be due to the level of intensified parental care. Indeed, in order to ensure the survival of their young, *T. cabrae* perform passive parental care producing more eggs and therefore more larvae, while *O. schwebischi* females perform oral incubation (active parental care) (Arizi *et al.*, 2014).

Relative productivity

In this study, the relative productivities in *O. niloticus* and in *T. cabrae* are lower than those reported by Dhraïef *et al.*, (2010) (9.3 larvae/g of female). The difference observed could be justified not only by the stress caused by handling and life in captivity but also by the animal species studied.

System productivity

In the present study, system productivity was higher in females of *O. schwebischi* than in females of *T. cabrae*. The reproductive performance obtained in these broodstock is lower than that reported by Dhraïef *et al.*, (2010) in *O. niloticus* females, *i.e.* system productivities of 17.2, 32.5 and 11.9 larvae/m^2/day.

CONCLUSION

At the end of this work focused on the contribution to the knowledge on zootechnical performance of *Tilapia cabrae* and *Oreochromis schwebischi* in captivity, it was found that *T. cabrae* showed good growth performance in terms of average weight gain, daily individual growth and specific growth rate compared to *O. schwebischi*. Regarding breeding, although *T. cabrae* females showed the highest absolute productivity, the number of breedings, relative and system productivities obtained were better in *O. schwebischi* females. Based on these results, the use of *Tilapia cabrae* and *Oreochromis schwebischi* in captivity can be recommended.

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