

1 **Reproductive performance and economic analysis of fry production in the Brazilian**  
2 **strain of *Oreochromis niloticus* in Côte d'Ivoire**

3 **Abstract**

4 This study evaluated the reproductive performance and fingerling production cost of  
5 *Oreochromis niloticus*, Brazilian strain. The trials were conducted in concrete tanks at a  
6 stocking density of 1.6 fish/m<sup>2</sup> for broodstock. Larvae, stocked at 1,000 larvae/m<sup>3</sup> in 1 m<sup>3</sup>  
7 hapas, were reared and fed for 28 days. The total number of larvae produced by 18 females of  
8 the Brazilian strain was 5,261 ± 387. The average number of larvae produced per female was  
9 292.33 ± 15.6. The production potential of this strain corresponded to 0.55 ± 0.02 larvae per  
10 gram of female body weight. The initial mean larval weight was 0.01 ± 0.001 g. After 28 days  
11 of rearing, larvae reached a mean weight of 1.01 ± 0.05 g. The average survival rate obtained  
12 was 82.63 ± 3.37%. The average production cost was 13.21 CFA francs per fingerling. These  
13 results show that the Brazilian strain of *Oreochromis niloticus* exhibits promising  
14 reproductive performance and a production cost suitable for the Ivorian market and fish  
15 farming environment.

16 **Keywords** :Nile tilapia; Brazilian strain; reproduction; production cost; Côte d'Ivoire

17 **1. Introduction**

18 The global supply of aquatic products was estimated at 171 million tonnes in 2016, with more  
19 than half originating from capture fisheries, contributing 53.18% of total production (Sissao *et*  
20 *al.*, 2019). However, aquaculture is experiencing rapid expansion, with an annual growth rate  
21 of around 13%, and has been the main source of fish for human consumption since 2014  
22 (FAO, 2018). This trend occurs in a context of increasing global demand for fishery products,  
23 mainly driven by population growth and the need for sustainable management of natural  
24 resources (Diana, 2009; FAO, 2018). In this context, improving aquaculture production  
25 systems has become a priority at the global level.

26 In Côte d'Ivoire, fish farming was introduced as early as the 1950s, but its development  
27 remains limited despite significant physical, climatic, human, and hydrographic potential  
28 favorable to the growth of the sector. Fish nevertheless represents the main source of animal  
29 protein in the diet of Ivorian populations, with an average consumption estimated at 15.4 kg  
30 per capita per year (Glasser, 2003). In 2000, national production covered only about 30% of

31 annual fish demand, estimated at 250,000 tonnes, forcing the country to import nearly 70% of  
32 its consumption, mainly in the form of frozen fish (FAO, 2002).

33 Nile tilapia (*Oreochromis niloticus*), particularly the local Bouakéstrain, accounts for nearly  
34 90% of the species farmed by Ivorian fish farmers (MIRAH, 2014). However, the relatively  
35 low zootechnical performance of this strain has been a major constraint to the development of  
36 national aquaculture. To address this limitation, the Government of Côte d'Ivoire introduced  
37 an improved strain of *Oreochromis niloticus* from the Federative Republic of Brazil, with the  
38 aim of increasing productivity, enhancing the profitability of fish farming operations, and  
39 reducing the country's dependence on fish product imports.

40 In this context, the present study aims to analyze the reproductive and growth performance of  
41 broodstock and fry from this improved strain, as well as to determine the production cost of  
42 fry under station conditions. These parameters are essential indicators for assessing the  
43 techno-economic viability and the prospects for sustainable dissemination of this strain in  
44 Côte d'Ivoire.

## 45 **2. Materials and Methods**

### 46 **2.1. Description of the Study Site**

47 The study was conducted at the Inland Fisheries and Aquaculture Research Station (SRPAC)  
48 of the CNRA. It is located in central Côte d'Ivoire, 6 km from Bouaké, specifically within the  
49 Kongodékro classified forest (7°37' N latitude and 5°02' W longitude). The station covers an  
50 area of 114 ha. The facility includes ponds, tanks, an aquarium room, a hatchery, a biosecure  
51 area, and a quarantine unit. It has 50 concrete tanks of various volumes, 14 raceways, and 20  
52 sorting tanks. The station comprises 80 ponds, covering a total water surface area of 2.5 ha.  
53 Individual pond sizes range from 50 m<sup>2</sup> to 1000 m<sup>2</sup>. These ponds are arranged in series and  
54 are supplied with water by gravity from the Kan dam and by pumping from a borehole.

### 55 **2.2. Biological Material**

56 The tilapia species used in this study was *Oreochromis niloticus* (Brazilian strain). This strain  
57 is considered improved because its growth performance has been enhanced compared to the  
58 local strain through selective breeding and crossbreeding. The broodstock used in this  
59 experiment consisted of representatives of the 39th selected generation originating from  
60 Brazil. These fish were introduced to the SRPAC in July 2014. A total of 48 broodstock were

61 used, including 12 males and 36 females. These broodstock were used to produce larvae,  
62 which were subsequently reared into fry.

### 63 **2.3. Measurement of Physicochemical Parameters**

64 The monitoring of water physicochemical parameters was carried out twice a week  
65 throughout the experimental period. Measurements were taken using a multiparameter device  
66 (HANNA). The parameters considered in this study were temperature, pH, and dissolved  
67 oxygen.

### 68 **2.4. Experimental Procedure**

69 Prior to the onset of reproduction, male and female broodstock were kept separately in  
70 holding tanks to ensure proper conditioning. Each broodstock individual was then weighed  
71 before being introduced into the reproductive units. Two reproduction cycles were conducted  
72 in two concrete tanks of 15 m<sup>2</sup> each. The stocking density was set at 1.6 individuals/m<sup>2</sup>, with a  
73 sex ratio of 1 male to 3 females (El-Sayed, 2020), corresponding to 6 males and 18 females  
74 per tank. The average weight of males was  $996 \pm 87$  g, while that of females was  $527 \pm 58$  g.  
75 The broodstock were fed a commercial pelleted feed containing 36% crude protein,  
76 administered at a daily ration equivalent to 2–3% of biomass (El-Sayed, 2020). Fourteen days  
77 after stocking for reproduction, larvae were collected. A total of 200 larvae were individually  
78 weighed to determine their initial mean weight. The broodstock were then individually  
79 weighed and returned to resting concrete tanks according to sex and weight class. This  
80 rotation system helps reduce physiological stress and prepares the fish for subsequent  
81 reproductive cycles.

82 For larval rearing, 3,000 larvae were stocked in three hapas at a density of 1,000 larvae/m<sup>3</sup>.  
83 The larvae were fed a commercial feed containing 55% crude protein. Feeding rates were  
84 gradually adjusted according to age (El-Sayed, 2020). Thus, feeding rates of 25%, 20%, 15%,  
85 and 10% of biomass were applied during the first, second, third, and fourth weeks,  
86 respectively. During each sampling operation, conducted weekly, 50 larvae were randomly  
87 collected from each hapa and individually weighed to determine the mean weight, which was  
88 used to adjust the feeding ration accordingly. The larval rearing period lasted 28 days.

### 89 **2.5. Zootechnical and Reproductive Parameters**

90 Zootechnical and reproductive performances were evaluated using the following parameters  
91 (Castel and Tiews, 1980; Guillaume *et al.*, 1999):

92 **Daily growth (g/day)**= (final weight – initial weight) / (rearing duration)(1)

93 **Survival rate (%)** = ((number of survivors) / (initial number) x 100)(2)

94 **Number of fry per female (Fry/female)** =

95 (total number of fry produced per collection) / (total number of females )(3)

## 96 **2.6. Economic Parameters**

97 The economic analysis focused specifically on production costs related to feed, which is  
98 considered the main expense in aquaculture. Labor cost for the 42-day rearing period was set  
99 at 21000 CFA francs, corresponding to 500 CFA francs per day.

100 Several economic parameters were calculated:

101 **Cost of broodstock feed (CFA francs)** =Quantity of feed used x Cost per kilogram of feed  
102 (1450 FCFA / Kg)(4)

103 **Cost of fry feed (CFA francs)** = Quantity of feed used x Cost per kilogram of feed (9000  
104 FCFA / Kg)(6) ;

105 **Total expenditure (CFA francs)** =Cost of broodstock feed (CFA francs) + Cost of larval  
106 feed (CFA francs) + Labor cost (CFA francs) (7) ;

107 **Production cost (CFA francs per fry)**=Total expenditure (CFA francs) / Number of fry (8).

108

## 109 **2.7. Statistical analysis**

110 The data were recorded in Microsoft Excel (version 2016) and analyzed using Statistica 7  
111 software. Descriptive statistics (means and standard deviations) were calculated for each  
112 zootechnical and economic parameter.

113

## 114 **3. Results**

### 115 **3.1. Physicochemical characteristics of the rearing environment**

116 During the experiments carried out in the breeding tanks, the mean water temperature was  
117  $28.4 \pm 2.2$  °C. The dissolved oxygen concentration showed an average value of  $4.5 \pm 0.3$   
118 mg/L, while the mean pH recorded was  $7.1 \pm 0.35$  (Table I).

119

**Table I: Physicochemical parameters of the rearing facility**

Physicochemical parameters	Mean values
Temperature (°C)	28.4 ± 2.2
Dissolved oxygen (mg/L)	4.5 ± 0.3
pH	7.1 ± 0.35

120

**3.2. Weight growth and survival rate of broodstock**

122 During the reproduction period, broodstock of the «Brazil» strain showed a moderate increase  
123 in their mean body weight (Table II). In males, weight increased from 996 ± 87 g to 1,034 ±  
124 79 g, whereas in females it rose from 527 ± 58 g to 572 ± 68 g. The recorded daily growth  
125 rate was estimated at 1.2 ± 0.39 g/day for males and 1.4 ± 0.40 g/day for females.

**3.3. Reproductive performance**

127 Reproduction of broodstock from the «Brazil» strain yielded an average of 5,261 ± 387 larvae  
128 per cycle. The mean individual weight of larvae at collection was 0.01 ± 0.001 g. Each female  
129 produced an average of 292.33 ± 15.6 larvae, corresponding to a specific productivity of 0.55  
130 ± 0.02 larvae per gram of female (Table II).

**3.4. Larval growth and survival**

132 After 28 days of rearing in happas, the larvae reached the fingerling stage, with a mean weight  
133 of 1.01 ± 0.05 g. The daily growth rate during this phase was estimated at 0.033 ± 0.0094  
134 g/day. The average survival rate obtained was 82.63 ± 3.37% (Table II).

135

136

137

138

**Table II: Zootechnical and reproductive parameters of the «Brazil» strain of Nile tilapia (*Oreochromis niloticus*)**

140

Phases	Parameters	Mean values
<b>Broodstock</b>	Initial male weight (g)	996 ± 87
	Final male weight (g)	1,034 ± 79
	Initial female weight (g)	527 ± 58
	Final female weight (g)	572 ± 68
	Daily growth rate – males (g/day)	1.2 ± 0.39
	Daily growth rate – females (g/day)	1.4 ± 0.40

	Survival rate (%)	100 ± 0
<b>Larval phase</b>	Number of larvae produced per cycle	5,261 ± 387
	Meanlarvalweight (g)	0.01 ± 0.001
	Number of larvae per female	292.33 ± 15.6
	Number of larvae per g of female	0.55 ± 0.02
<b>Fingerling phase</b>	Final mean weight of fingerlings (g)	1.01 ± 0.05
	Daily growth rate (g/day)	0.033 ± 0.0094
	Survival rate (%)	82.63 ± 3.37

141

### 142 **3.5. Economic parameter**

143 The economic parameters related to larval production are presented in Table III. The cost of  
 144 feed for broodstock amounted to 7845 FCFA, while that used for larvae reached 28800  
 145 FCFA. The total number of fingerlings produced during the trial was 4,363 individuals. In  
 146 addition, the total expenditure was estimated at 57645 FCFA, corresponding to a unit cost of  
 147 13.21 FCFA per 1 g fingerling produced.

148 **Table III: Selected economic parameters of larval production**

<b>Parameters</b>	<b>Mean values</b>
Broodstockfeedquantity (g)	5412
Broodstockfeedcost (FCFA)	7845
Larvalfeedquantity (g)	3209
Larvalfeedcost (FCFA)	28800
Labor cost (FCFA)	42000
Total expenditure (FCFA)	57645
Number of fingerlings	4363
<b>Production cost per fingerling (FCFA)</b>	<b>13.21</b>

149

150

### 151 **4. Discussion**

152 During this study, the physicochemical parameters of the water remained within the  
 153 ranges considered optimal for the reproduction and growth of Nile tilapia (*Oreochromis*  
 154 *niloticus*), namely a temperature between 26 and 30 °C, a dissolved oxygen concentration  
 155 above 4 mg/L, and a pH ranging from 6.5 to 8.0 (El-Sayed, 2006; FAO, 2019).

156 The weight evolution of *Oreochromis niloticus* broodstock of the «Brazil» strain showed a  
 157 clear increasing trend in both sexes, rising from 996 ± 87 g to 1,034 ± 79 g for males and

158 from  $527 \pm 58$  g to  $572 \pm 68$  g for females. This progression reflects the good adaptation of  
159 the broodstock to the experimental conditions, characterized by favorable water quality and a  
160 protein-rich diet. The differences observed between sexes can be explained by distinct  
161 physiological strategies: males allocate a significant portion of energy from feed to somatic  
162 growth, whereas females invest more in vitellogenesis and egg production (Toguyenet *al.*,  
163 2016; Sifaet *al.*, 2019). This differential energy allocation justifies the slightly higher growth  
164 observed in females. Furthermore, the daily growth rate of broodstock, estimated at  $1.2 \pm 0.39$   
165 g/day for males and  $1.4 \pm 0.40$  g/day for females, appears higher than values reported in  
166 earlier studies conducted in Côte d'Ivoire (Lazard, 1980), but is consistent with results  
167 obtained in genetic improvement programs in West Africa, where rates between 1.0 and 1.5  
168 g/day have been reported (Bentsen *et al.*, 2017). The 100% survival rate confirms the  
169 robustness of the rearing protocol and the good control of experimental conditions, largely  
170 exceeding the minimum threshold of 90% generally accepted in tilapia aquaculture  
171 (Mabrokeet *al.*, 2018).

172 Regarding reproductive performance, the average number of larvae produced per cycle was  
173  $5,261 \pm 387$ , corresponding to a mean fecundity of  $292.33 \pm 15.6$  larvae per female and  $0.55 \pm$   
174  $0.02$  larvae per gram of female. These results are comparable to those obtained with other  
175 improved strains in Ghana and Nigeria, where fecundity levels ranging between 200 and 300  
176 larvae per female have been reported (Ayinlaet *al.*, 2019; Attipoeet *al.*, 2021). However, some  
177 studies conducted using diets enriched with essential fatty acids and vitamins report higher  
178 performances, reaching up to 350 larvae per female (Yakubu *et al.*, 2020). The difference  
179 observed in the present study may be related to the feed composition used for broodstock.  
180 Although the diet had a high protein content (48% crude protein), suitable for tilapia  
181 requirements, it did not include specific supplementation with micronutrients essential for  
182 reproduction, such as long-chain polyunsaturated fatty acids (HUFA) or fat-soluble vitamins.

183 At the larval stage, the individual weight of collected larvae ( $0.01 \pm 0.001$  g) is consistent  
184 with standards reported for *Oreochromis niloticus* (Ridha & Cruz, 2018). However, after 28  
185 days of rearing in happas, the average survival rate recorded ( $82.63 \pm 3.37\%$ ) remains below  
186 international benchmarks, which generally range between 85 and 95% under controlled  
187 conditions (Azevedo *et al.*, 2015; Abdel-Tawwabet *al.*, 2020). Several factors may explain this  
188 reduced survival rate. On one hand, the larval stocking density applied (1,000 individuals/m<sup>2</sup>)  
189 likely increased feeding competition and promoted cannibalism, a well-documented

190 phenomenon in tilapia (Melard&Philippart, 2018). On the other hand, the nature of the feed  
191 provided, consisting of a powdered diet with 67% protein, although energy-rich, may have  
192 presented limitations in terms of digestibility and availability of polyunsaturated fatty acids,  
193 which are essential for larval development (El-Sayed *et al.*, 2019). Finally, the manual  
194 “broadcast feeding” method used under field conditions results in heterogeneous feed  
195 distribution, which may increase growth disparities and mortality.

196 These findings raise several avenues for improvement. The incorporation of live feeds such as  
197 rotifers or natural zooplankton during the first days post-hatching could enhance larval  
198 survival, as demonstrated by recent studies conducted in Côte d’Ivoire and Cameroon (Konan  
199 *et al.*, 2022; Ngueguimet *et al.*, 2023). Moreover, reducing initial stocking densities or  
200 transferring larvae earlier into ponds could limit the intensity of cannibalism and improve  
201 survival rates. Finally, more rigorous monitoring of physicochemical parameters, particularly  
202 ammonia and nitrites, would help better identify the causes of the observed mortalities.

203 From an economic perspective, although the quantity of feed distributed to broodstock was  
204 higher than that provided to larvae, larval feed was more expensive due to its higher protein  
205 content (55% compared to 36% for broodstock feed). According to Thabet (2017), the  
206 production cost of a 2 g fingerling in geothermal water, including all fixed and variable costs,  
207 is estimated at 13.83 FCFA. In the present study, the production cost of a  $1.06 \pm 0.6$  g  
208 fingerling was slightly lower, at 13.21 FCFA. This relatively small difference can be explained  
209 mainly by two factors. First, the infrastructure used in the experimental setup has already been  
210 depreciated, thereby reducing fixed costs (equipment depreciation and initial investments).  
211 Second, some operational costs were not fully integrated into the estimation, particularly  
212 certain indirect and variable expenses (full maintenance, indirect labor, energy, or secondary  
213 inputs, depending on the case). Thus, the observed cost reflects more an experimental or  
214 partially consolidated production cost rather than a complete economic cost. Nevertheless,  
215 these results indicate that fingerling production in hatchery conditions can achieve a relatively  
216 competitive cost level, which represents a potential advantage for the aquaculture sector by  
217 facilitating farmers’ access to quality fingerlings at lower cost.

218

## 219 **5. Conclusion**

220 The study showed that a stocking density of 1.6 ind/m<sup>2</sup> and feed quality significantly  
221 influence the zootechnical performance of Nile tilapia (*Oreochromis niloticus*) broodstock of  
222 the “Brazil” strain. The broodstock exhibited excellent survival (100%) and satisfactory  
223 growth, while larval survival reached 82.63%. The production cost of a 1.06 g fingerling was  
224 estimated at 13.21 FCFA, providing useful information for the economic planning of  
225 production. These results highlight the need to optimize both stocking density and feeding  
226 strategies in order to improve fingerling production and the profitability of hatchery systems.

## 227 **Conflict of Interest**

228 The authors declare that they have no conflict of interest.

## 229 **Authors' Contributions**

230 All authors contributed to this article according to their respective roles.

## 231 **6. References**

- 232
- 233 **1. Abdel-Tawwab, M., Monier, M.N., Hoseinifar, S.H., & Faggio, C. (2020).** Fish response  
234 to hypoxia stress: Growth, physiological, and immunological biomarkers. *Reviews in*  
235 *Aquaculture*, 12(2), 1093–1110.
  - 236 **2. Attipoe, F.Y.K., Blay, J., & Asmah, R. (2020).** Tilapia aquaculture in Ghana: current  
237 status and future prospects. *Aquaculture Reports*, 18, 100-415.
  - 238 **3. Ayinla, O.A., Adeoye, A.A., & Omitoyin, B.O. (2019).** Assessment of cage aquaculture  
239 development in West Africa: challenges and opportunities. *African Journal of Aquatic*  
240 *Science*, 44(4), 357–370.
  - 241 **4. Azevedo, P.A., Cho, C.Y., Leeson, S., & Bureau, D.P. (2015).** Growth, nutrient and  
242 energy utilization of *Oreochromis niloticus* fed diets with varying digestible energy to protein  
243 ratios. *Aquaculture*, 437, 34–41.
  - 244 **5. Bentsen, H. B., Gjerde, B., Nguyen, N. H., Rye, M., Ponzoni, R. W., Palada-de Vera,**  
245 **M. S. & Eknath, A. E. (2017).** Genetic improvement of farmed tilapias: Genetic parameters  
246 and selection responses in growth of Nile tilapia (*Oreochromis niloticus*) after six generations  
247 of selection in the GIFT program. *Aquaculture*, 468(1), 206–217.
  - 248 **6. Castel, J. D., & Tiews, K. (1980).** Report of the EIFAC, IUNS and ICES Working Group  
249 on Standardization of Methodology of Fish Nutrition Research. Hamburg, Germany.
  - 250 **7. Diana, (2009).** Situation mondiale des pêches et de l'aquaculture 2016 –Food and 227p.
  - 251 **8. El-Sayed, A.F.M. (2006).** Tilapia culture. CABI Publishing, Wallingford, UK, 277 p.

- 252 **9. El-Sayed, A.F.M., Monier, M.N., &Faggio, C. (2019).** Fish response to environmental  
253 stressors: Physiological and biochemical biomarkers. *Reviews in Aquaculture*, 11(4), 1410–  
254 1426.
- 255 **10. El-Sayed, A.F. M.(2020).** Tilapia Culture (2nd ed.). Academic Press, Elsevier. 358 p.
- 256 **11. FAO.(2002).** Biodiversité et introduction de poissons en Côte d’Ivoire : enjeux  
257 économiques et écologiques, 124p.
- 258 **12. FAO.(2019).** Water quality and aquaculture: A global review. FAO Fisheries and  
259 Aquaculture Technical Paper, 647, 116 p.
- 260 **13. FAO. (2018).** La situation mondiale des pêches et de l’aquaculture 2018. 254p.
- 261 **14. GlasserF. (2003).** L’influence des facteurs externes sur la reproduction de la carpe  
262 herbivore (*Ctenophatyngodonidello*) en zone tropicale : une approche descriptive et  
263 expérimentale. Thèse de doctorat, Université de Renne I France, In : Bonhoulou R. (éd).  
264 Etude morphologique et zootechnique d’*Oreochromisniloticus*. *Sarotherodonmelanotheron* et  
265 de leurs hybrides en milieu d’élevage. Mémoire du diplôme d’ingénieur des Techniques  
266 Agricoles. Option Elevage. Institut National Polytechnique Felix Houphouët Boigny de  
267 Yamoussoukro.
- 268 **15. Guillaume, J.,Kaushik, S., Bergot, P., &Métailler, R. (1999).** Nutrition et alimentation  
269 des poissons et crustacés. Paris, France.
- 270 **16. Konan, K.F., Yao, K.A., Kouassi, N.C., Anvo, M.P.M., & Doumbia L. (2022).**  
271 Influence of live feed on growth and survival of *Oreochromis niloticus* larvae reared in  
272 hatchery conditions in Côte d’Ivoire. *International Journal of Fisheries and Aquatic Studies*,  
273 10(3), 120–126.
- 274 **17. Lazard, J. (1980).** La pêche en eau libre et le développement de la pisciculture dans les  
275 eaux continentales ivoiriennes : cas de la ferme piscicole de Natio-Kobadara (Korhogo).  
276 Thèse de Doctorat, Université des Sciences et Techniques du Languedoc, Montpellier, France,  
277 213 p.
- 278 **18. Lazard J. 2009.** La pisciculture des tilapias. *Cahiers Agricultures*, 18 (2-3): 174–182.
- 279 **19. Mabroke, R.S., Haroon, A.M., &Shalloof, K.A.S. (2018).** Effects of stocking density on  
280 growth and water quality in Nile tilapia (*Oreochromis niloticus*) ponds. *Egyptian Journal of*  
281 *Aquatic Biology and Fisheries*, 22(1), 45–56.
- 282 **20. Mélard, C., & Philippart, J.C. (2018).** Reproductive management and early life history  
283 of *Oreochromis niloticus* (Linnaeus, 1758) under controlled conditions: implications for  
284 hatchery performance. *Aquaculture Reports*, 9, 12–21.

- 285 **21. Ngueguim, J.R., Nguenga, D., &Kengne, T. (2023).** Contribution de la pisciculture à la  
286 sécurité alimentaire et à la réduction de la pauvreté au Cameroun : état des lieux et  
287 perspectives. *Revue Camerounaise des Sciences et Techniques Halieutiques*, 4(2), 55–68.
- 288 **22. Ridha, M.T., & Cruz, E.M. (2018).**Comparative evaluation of three strains of Nile  
289 tilapia (*Oreochromis niloticus*) under Kuwaiti farming conditions. *Aquaculture Research*,  
290 49(2), 789–799.
- 291 **23. Thabet,R. (2017).** Etude comparative de l'élevage du Tilapia du Nil  
292 "*Oreochromisniloticus*" entre les eaux douces et géothermales en Tunisie.*Centre Technique*  
293 *d'Aquaculture -Tunisie*, 61 p.
- 294 **24. Toguyeni, A., Koumi, A.R., Anvo, M.P.M., Aboua B.R.D., &Toko I.I. (2016).**  
295 Influence du sexe et du régime alimentaire sur la croissance et la composition corporelle de  
296 *Oreochromisniloticus* (Linnaeus, 1758). *International Journal of Biological and Chemical*  
297 *Sciences*, 10(5), 2223–2234.
- 298 **25. Sifa, L., Chenhong L., Jian C., &Xiaowen S. (2019).** Sexual dimorphism and growth  
299 performance in *Oreochromis niloticus* under controlled breeding conditions. *Aquaculture*  
300 *Research*, 50(8), 2162–2171.
- 301 **26. Sissao, R., Anvo, M.P.M.,&Toguyeni, A.(2019).**Caractérisation des performances  
302 zootechniques de la population de tilapia du Nil (*Oreochromisniloticus*) du lac de la vallée du  
303 Kou (Burkina Faso).*International Journal of Biological and Chemical Sciences*13(6): 2603-  
304 2617
- 305 **27. Yakubu, A., Afolayan, A., Olayemi, M., &Sogbesan A. O. (2020).** Reproductive  
306 performance and fry output of Nile tilapia (*Oreochromis niloticus*) fed diets supplemented  
307 with essential fatty acids and vitamins. *Journal of Applied Aquaculture*, 32(4), 301–312.

308

309

310

311

312