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Aquaculture Potentials of Estuarine and Marine Species, *Polydactylus quadrifilis* and *Pomadasis jubelini* at the Layo Experimental Aquaculture Station (Côte d'Ivoire)

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Abstract

The experimentation for rearing of *Polydactylus quadrifilis* and *Pomadasis jubelini* fishes at the Layo's Experimental Aquaculture Station allowed to feed them with a food composed of 40% protein, supplemented with shrimp such as Penaeidae families (38, 4%), Palaemonidae (20%) and Aristeidae (19%). A mortality rate of 100% is observed in large specimens, while those of small size have shown high survival rates, ranging from 57%to 100%. Specific growth rates ranged from 0.9 to 2.8% for *Polydactylus quadrifilis* individuals and 1.1% to 2.7% for those of *Pomadasis jubelini*. The conversion index ranged from 1 to 2.46 for specimens of *Polydactylus quadrifilis* and from 0.9 to 2.2, concerning those of *Pomadasis jubelini*. The coefficients of variation stabilize between 11% and 17% for specimens of *Polydactylus quadrfiflis*, and the *Pomadasis jubelini* individuals have theirs stabilize between 10% and 16%. These species have aquaculture potentials to develop through a control of their breeding conditions.

Keywords: Experimentation ; rearing ; *Polydactylus quadrifilis* ; *Pomadasis jubelini*.

1. Introduction

The knowledge of the African rivers and watersfish fauna has been concerns of naturalists, scientists and development officials for some years. The main reason for this interest is that the exploitation of freshwater, brackish and marine fish populations in Africa is increasingly intensified by ever-increasing local populations (FAO, 2016). Also, the alarming acceleration of all degradation processes of the natural environment raises the major risk of regression and species disappearance (Lalèyè et al, 2004). Similarly, in many countries, fish is generally considered a cheap source of animal protein accessible to the most disadvantaged households (FAO, 2016&Kimou et al, 2016). The apparent world consumption of fish is estimated to 19.2 kg/ind/year (FAO, 2014a), and in recent years, tilapias have been the predominant species of African commercial fish farming (FAO, 2014b &Amoussou et al, 2016).

In Côte d'Ivoire, fish resources account for more than 50% of animal protein consumption, and annual per capita consumption is among others around 15 kg/ind/year (FAO, 2016), which includes the species of *Polydactylus quadrifilis* and *Pomadasis jubelini*. Fishproduction of Côte d'Ivoire is 75,611 tons, with an estimated annual demand of about 300,000 tons/year (FAO, 2014c). In addition, fish farming of Côte d'Ivoire produces about 3800 tons, which freshwater species, mainly composed of tilapia, are estimated to 2980 tons, compared with 820 tons of brackish water species produced in 2015 (FAO, 2016). National demand for fish products remains so strong and sustained. However, the ivorian maritime waters are naturally poor because of the narrowness of the continental shelf and the weakness of upwellings. Also, Ivorian are not fishermen, but practice more aquacuture, whose developpement would help reducing fish importation.

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Problem statement and purpose

In Ivory Coast, there is no brackish water and marine fish breeded by local aquaculturists. They breed only the inland water fish, as *Orechromis niloticus* and Clarias. So this present study proposes to attempt the cultivation of other species from brackish and marine with aquaculture potential (Konan, 2013). Threadfin, *Polydactylus quadrifilis* and the white carp, *Pomadasis jubelini*, are tested in order to provide to aquaculturists, new productive local species and contribute to ensuring the population, self-sufficiency in fish proteins. This first phase consists in characterizing the conditions of captivity of *Polydactylus quadrifilis* and *Pomadasis jubelini* in the breeding structures of the experimental aquaculture station of the Oceanology Research Center, atLayo (Côte d'Ivoire).

2. Material and Methods

2.1 Studies areas

The Layo experimental aquaculture station is located to 45 km in western of Abidjan, on the Abidjan-Dabou axis, between 5°-19° N, 4°-19° W (Figure 1). It was created in 1976 in the sector IV of the Ebrie lagoon and is supplied with brackish water by a pumping system allowing realization of the different aquaculture activities. The hydro-climate is strongly influenced by the lagoon mouth of a forest river, Agnéby which has an equatorial transition regime, characterized by a doubling of the annual flood related to the precipitation regime (Kamagaté et al, 2017). The physicochemical parameters of the rearing water devices were obtained throw the data provided by YSI33 salino-meter model coupled to a thermometer, WTW OXI 330 oximeter model and WTW 90 pH meter.

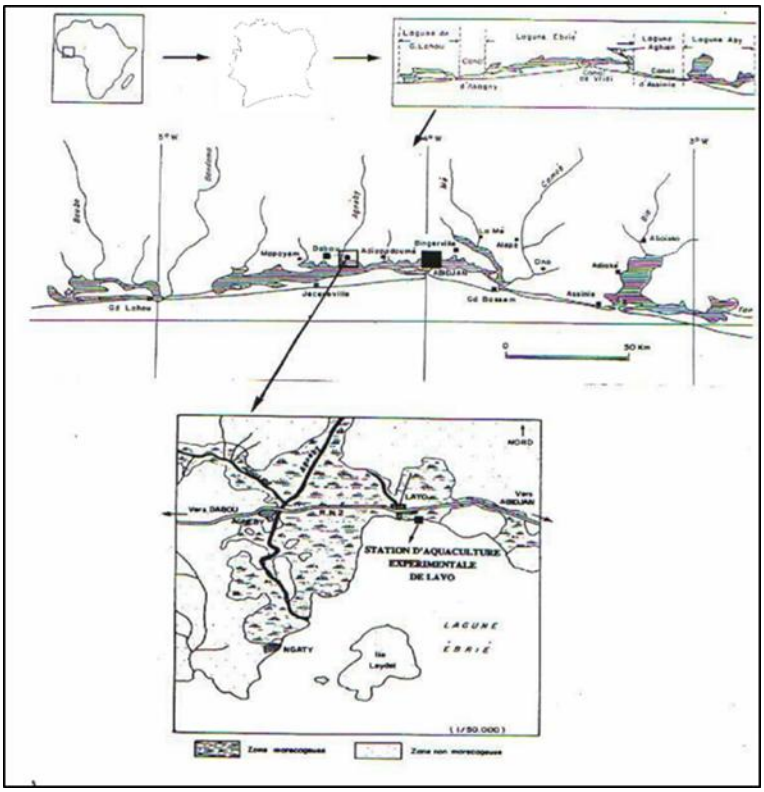

Figure 1. Location of the experimental aquaculture station of Layo.

2.2. Captivity studies of specimens

In order to establish a brood stock, two teams of fishermen from the Layovillage, are involved in the project, and stocked at the experimental aquaculture station, 51 live specimens of threadfin*Polydactylus quadrifilis* and 72 individuals of *Pomadasis jubelini* caught in the Ebrie lagoon.Fish were measured and weighed. *Polydactylus quadrifilis*s pecimens have a size between 12 and 20 cm (weight ranged on 13 to 50 g) and those of *Pomadasis jubelini* have a size rangedon 10 to 15 cm (weight between 12 and 45 g). Fishof each species are transferred immediately after the measurement and weighing, in two conditioning enclosures, of respective dimensions (6x5 m = 30 m^2), installed in the pond connected to the lagoon Ebrie.

Fish stay for 72 hours before being transferred for each species, in 09 breeding bins, measuring (2x2x1 m = 4 m^3), while taking into account homogeneity of sizes during storage in thebreeding bins. The station has 30breeding bins for breeding tests, that are provided by a pond water pumping system connected to the Ebrie lagoon.

Concerning *Polydactylus quadrifilis*, 36 specimens were used for the captivity study and the first 3 breeding bins contained 3 fisheach, size ranged on 16 to 17 cm (weight between 32 and 40 g). 3 other breeding bins had 4 fish each, size ranged on 14 to 15 cm (weight between 25 and 30 g) and the last 3 breeding bins contained 5 fish each, less than 14 cm in size (weight less than 25 g). For *Pomadasis jubelini* specimens, 45 fish were used in the study, because of their relatively smaller size. The first 3 breeding bins contained each,4 fish size ranged on 14 to 15 cm (weight between 33 and 45 g). The 3 secondbreeding bins contained each 5 fish, size ranged on 12 to 13 cm (weight between 20 and 30 g) and the last 3 bins had 6 fish each, less than 12 cm in size (weight less than 20 g).

2.3. Management of fish in captivity

The threadfin, *Polydactylus quadrifilis* and the white carp *Pomadasis jubelini* are both carnivorous fish that preferentially feed on shrimps and fish. During their enclosure 3 days, all the fish were fed at will, 3 times a day, with tilapia larvae and shrimp juveniles collected in the ponds and other rearing devices of the station with a mosquito net fabrics. Samples of these preys were treated with 10% formalin and identified in the laboratory of the Oceanological Research Center, with a binocular loupe, following the identification keys of (Schneider, 2000) &Tachet et al, 2003). During these 3 days, the dead fish are removed from the enclosure, measured and weighed. The survivors are transferred in the different breeding bins, taking account to their size. Feeding in the breeding bins continued for 10 days with shrimp fry, juveniles and tilapia larvae. Beyond 10 days, their diet was reinforced with a floating commercial food for tilapia, diameter 1 mm, formulated at 40% protein, 8.25% lipid, 9.5% ash and 18.48 $kJg.^{-1}$ gross energy (Koumi et al, 2015), distributed at a ratio of 5% of biomass in each breeding bins up to 60 days, then at 10% until the end of the 115 breeding days.

2.4. Studied parameters

The physicochemical parameters of breeding bins was study and biological parameters studied were chosen to estimate the survival, growth and hardiness of fishes(Koumi et al, 2015 &Durville et al, 2003).

2.4.1. Specific survival rates (RS)

The specific survival ratesis the most important parameter that enhances the validity of the results obtained throughout the study. Individuals of each species is count every 28 days in each breeding bins. The specific survival rates (Rs) of the *Polydactylus quadrifilis* and *Pomadasis jubelini* specimens were determined using the following formula, according to the size, during the 115 rearing days. They allow to define the ideal sizes to capture in the natural environment for their breeding, for the purpose of their brood stock constitution.

$$Rs = \frac{final\ fish\ number}{initial\ fish\ number} \times 100$$

2.4.2. Specific growth rate (SGR)

The Specific growth rate is defined as the daily weight gain of fish expressed as a percentage of its weight at t time. These data were estimated using total biomass in each breeding bin, during 115 days of experimentation.

$$SGR = [(\ln(fW) - \ln(iW) / \text{Breeding time})] \times 100$$

2.4.3. Conversion index (CI),

The conversion index (CI), which is the ratio of consumed dry food weight to fresh weight gained(Durville et al, 2003), also called the rate of transformation, is evaluated for each species every 28 days. It is widely used in aquaculture because of need of optimizing the food quantity relating to the the animal growth. This index is more interesting in terms of breeding when the value is small, since it indicates a low food intake for a significant growth, but it also shows the adaptation of a species to a type of food.The more fish benefits from the food distributed, the lower is the conversion index.

2.4.4. Fish growth

Growth of a fish can be defined as the increase in weight over time. The growth observed in captivity was obtained taking into account the initial biomass per breeding bin (fresh weight not eviscerated,expressed in grams) and their initial size (standard length expressed in millimeters).

These data are collected every 28 days on each fasting fish, until the 115th breeding days.

2.4.5. Coefficient of variation (Cv)

The coefficient of variation (Cv) of the weights, expressed as a percentage is calculated for each species every 28 days. It represents the variability of fish weight from the mean and provides information on the hardiness of a specie that can be appreciated by monitoring the change in weight for each growing period. If it decreases proportionally and/or stabilizes, the species may be considered able to acclimatizeto the artificial environment and adapt properly to rearing conditions.

3. Results

3.2. Physicochemical parameters of breeding bins

The average values of the physicochemical parameters recorded in the rearing devices vary from 2.70 ± 1.60 g/L to 4.20 ± 0.90 g/L for salinity. For dissolved oxygen, measurements range from 3.55 ± 0.65 mg/L to 6.26 ± 0.30 mg/L. The temperature of the water varies from 28.01 ± 0.22° C to 30.90 ± 1.80° C, while the pH varies between 6.90 ± 0.08 and 7.25 ± 0.15.

3.3. Inventory of prey distributed

Live prey distributed to captive fish is mainly composed of shrimp specimens from Penaeidae families (38.4%), which includes three species (*Penaeus notialis*, *Penaeopsis serrata*, *Penaeus keraturus*). The family Palaemonidae (20%) is represented by the species *Palaemon serratus* and *Nematopalaemon hastatus*, and the Aristeidae family (19%) is composed of the species *Aristeus varidens* and *Aristeus antennatus* (Table I).

Table I: Species of shrimp prey distributed to captive fish &

Families	Species	Percentages (%)
Penaeidae	*Penaeus notialis*	15
	Penaeopsis serrata	11,4
	Penaeus keraturus	12
Palaemonidae	*Nematopalaemon hastatus*	8,5
	Palaemon serratus	11,5
Aristeidae	*Aristeus varidens*	10,2
	Aristeus antennatus	8,8
Crangonidae	*Crangon crangon*	9,3
Solenoceridae	*Solenocerca africana*	7,2
Sqillidae	*Squilla manti*	6

3.4. Specific survival rates (RS)

During the conditioning phase of fish in the enclosure, 7 specimens of *Polydactylus quadrifilis*, larger than 18 cm, died after 3 days; 2 fish after 24 h, 3 fish after 48 and the 2 others on the third day. For *Pomadasis jubelini*, 13 fish larger than 16 cm died progressively; 4 fish after 24 h and 5 individuals, after 48 h and the other 4 on the third day. Survival rates at the end of enclosure conditioning are summarized in Table II.

Table II: Specific survival rate (RS) of captive fish.

	Size classes (cm) in enclosure				Size classes (cm) in breeding bins		
Polydactylus quadrifilis	> 18	17-16	15-14	< 14	17-16	15-14	< 14
Number	8	14	14	15	9	12	15
RS (%)	0%	57%	86%	100%	100%	100%	87%
Pomadasis jubelini	> 16	15-14	13-12	< 12	15-14	13-12	< 12
Number	13	21	20	18	12	15	18
RS (%)	0%	57%	75%	100%	100%	87%	84%

3.5. Specific growth rate (SGR)

The increase in biomass can be considered as a linear function on time. The results obtained (Figure 2) vary from 0.9% to 2.8% increase in weight per day for specimens of *Polydactylus quadrifilis*. Individuals of the first breeding bins (17-16 cm size) have rates ranging from 0.9% to 1.6%. Those of the following breeding bins (15-14 cm size) have rates varying from 1.3% to 1.95% then the rates vary from 2.1% to 2.8% among those of the third breeding bins (<14 cm). Regarding individuals of *Pomadasis jubelini*, an increase in weight per day from 1.1% to 2.7% was obtained. The individuals of the first breeding bins (15-14 cm size) have rates ranging from 1.1% to 1.9%. Those of the following breeding bins (13-12 cm size) have rates varying from 1.5% to 2.1% and then the rates vary from 1.8% to 2.7% among those of the third breeding bins (<12 cm).

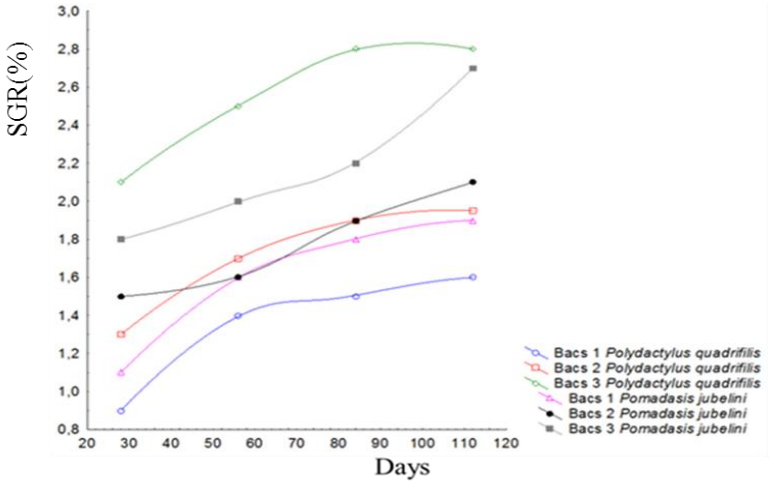

Figure 2. Variation in daily specific growth rates

3.6. Conversion index (CI)

The conversion index (CI), which represents the food quantity required to increase the weight of one unit for each magnification period, varies with species and growth periods (Figure 3). For specimens of *Polydactylus quadrifilis*, this index varies from 1 to 2.46. Individuals of the first breeding bins (17-16 cm size) have an index varying from 1 to 1.4 and those of the following breeding bins (15-14 cm size) have an index which varies from 1.45 to 1.9 then the index varies from 1.95 to 2.31 for those of the third breeding bins (<14 cm). For *Pomadasis jubelini*s pecimens, the conversion index ranged from 0.9 to 2.2. Individuals of the first breeding bins (15-14 cm size) have an index ranging from 0.9 to 1.2. Those of the following breeding bins (13-12 cm size) have an index which varies from 1.36 to 1.82 and the index varies from 1.7 to 2.2 in those of the third breeding bins (<12 cm).

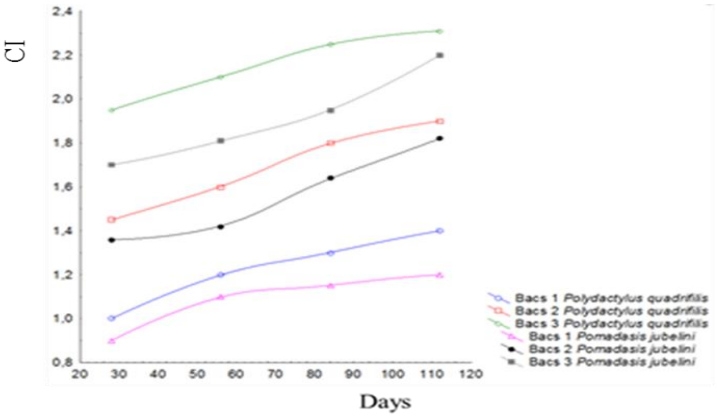

Figure 3. Variation of conversion indices

3.7. Growth observed in captivity

The evolution of mean weights as a function of time for the studied species followsa series of ascending curves. However, the coefficients of determination (r^2) remain low (r^2 = 0.74) for *Polydactylus quadriflis* specimens (Figure 4a). The individuals of *Pomadasis jubelini*, have coefficients of determination remaining weak (r^2 = 0, 76) (Figure 4b).

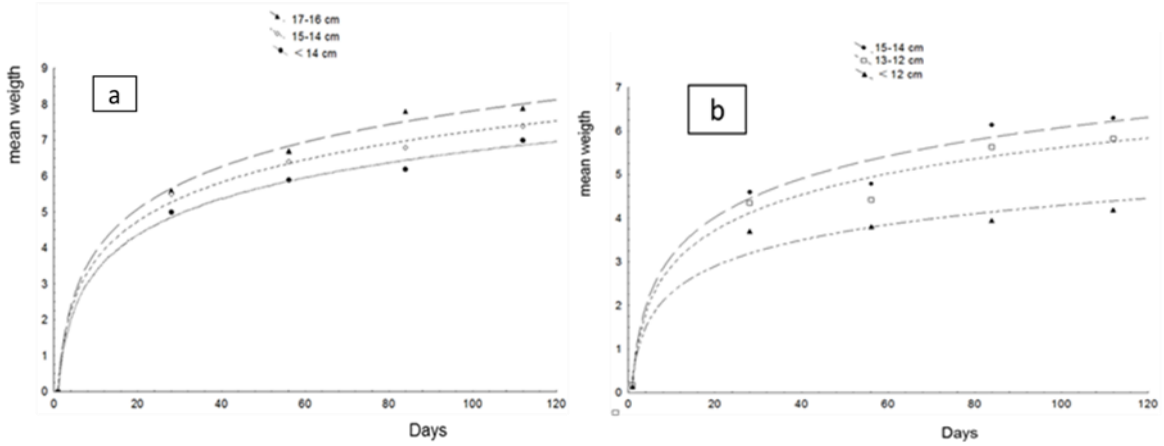

Figure 4. Growth curves of *Polydactylus quadrfiflis* specimens(a) and *Pomadasis jubelini* (b).

The slopes of the equations of the straight lines of the average weight evolution gains, which represents the growth rate, are between 0.03 and 0.06 (Table III). The highest growth rates are observed with *Polydactylus quadrifilis* specimens, whereas the lowest growth rates are obtained with *Pomadasis jubelini* specimens, indicating a relatively difficult adaptation of these two species.

Table III: Equations of the straight lines of evolution average weight gains

Species	Size	Coefficient of regression (r^2)	Equations
Polydactylus quadrifilis	17-16	0,74	y = 0,06x +1,98
	15-14	0,71	y = 0,05x +1,98
	< 14	0,74	y = 0,05x +1,76
Pomadasis jubelini	15-14	0,76	y = 0,05x +1,64
	13-12	0,75	y = 0,04x +1,55
	< 12	0,60	y = 0,03x +1,48

3.8. Coefficient of variation (Cv)

The coefficients of variation (Cv) obtained for *Polydactylus quadrfiflis* specimens (Figure 5a) and *Pomadasis jubelini* (Figure 5b) are low and vary very little during this study period. The coefficients of variation stabilize between 11% and 17% for the specimens of *Polydactylus quadrfiflis*, while for the *Pomadasis jubelini* specimens, the coefficients of variation stabilize between 10% and 16%.

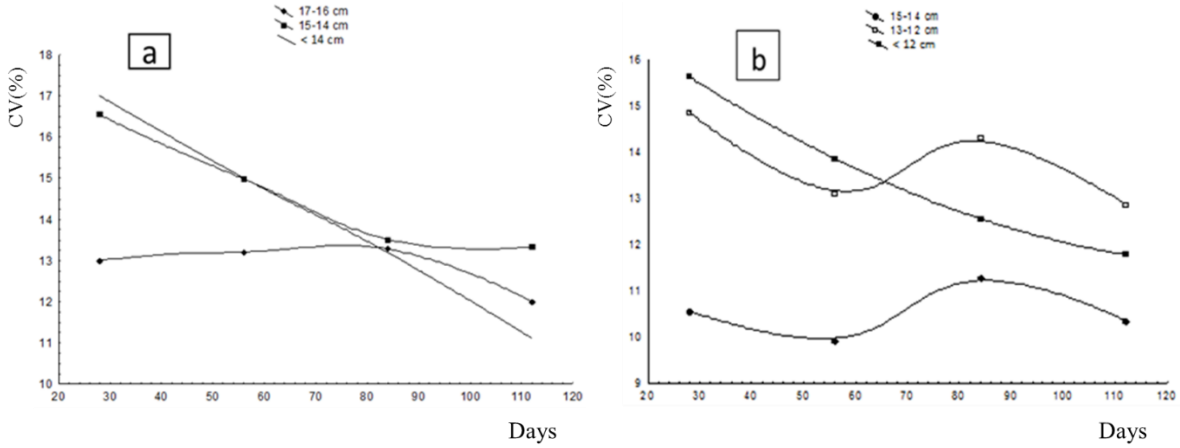

Figure 5. Curves of coefficients of variation of *Polydactylus quadriflis* specimens (a) and *Pomadasis jubelini* (b).

4. Discussion

The physicochemical parameters recorded show similar values obtained in moremonitored aquaculture farms in several studies(Konan et al, 2016 & Amon et al, 2013). The mean temperature (29.45 ± 1.12° C) observed in the station is similar to that recorded by Amon et al, (2013), with a thermal interval between 24°C and 30°C. According to Yao et al, (2006), the average pH values (7.07 ± 0.19) would be related to the buffer effect of thelagoon and rainwater in ponds. Alsofor Nobah et al, (2008), the pH require values between 6 and 9 for fish culture waters. The mean of dissolvedoxygen, (4.90 ± 0.46 mg / L) observed in ponds integrates the range of 4.5 to 9.4 mg/L, obtained by Kouassi et al, (2005),Amon et al, (2013) and Konan et al, (2016). The different values of dissolved oxygen are favorable for the survival of farmed fish. The lower salinity could be explained by the different ponds feed by the Ebrie lagoon, which has low salinity in this sector (Kouassi et al, 2005 &Yao et al, 2009).

For diet, our results confirm (Konan, 2013) telling that juveniles of *Polydactylus quadrifilis* prefer shrimp preys. They are mainly Penaeidae, Palaemonidae, Aristeidaeand crabs,but also stomatopods represented by squillidae. It's the same for specimens of *Pomadasis jubelini* whose preferential foods are molluscs, crustaceans and shrimps (Soumaïla et al, 2008 &Tidiani et al, 2007). The small size specimens of both studied species have a high survival rate reaching 100%. This would indicate that these individuals adapt more easily to the captivity conditions, as indicated by Sardovy (2001),who believes that post-larvae have better growth abilities in a controlled environment. The high mortality rate observed with specimens of *Polydactylus quadrifilis* greater than 18 cm in size, may be consequence of the exclusive shrimp diet administered to them and promiscuity in the breeding bins. Because, the diet of threadfins varies on the Guinean coast, the Lake Nokoue in Benin and Ebrie lagoon in Ivory Coast, according to thefish stage of development, in relation with the size of the intestine (Gnohossou, 2006)&Sidibé, 2003). In fact, sub-adults and adults of *Polydactylus quadrifilis* preferentially consume fish, some of which can reach 30 cm in length (Konan, 2013).

The high mortalities of *Pomadasis jubelini*s pecimens greater than 16 cm in size could be justified by, the diet provided which were composed only of shrimp and the attainment of sexual maturity at 15 cm for this species in the Ebrie lagoon (Tidiani et al, 2007 &Bodji et al, 2013). At this size, the physiological needs of these captured specimens can not be satisfied to ensure this reproductive function, they could not survive in the breeding bins. The mortalities observed in the breeding bins reflect in both fish species, the different densities necessary according to the sizes to be put in captivity in the aim of the constitution of broodsstocks. The specific growth rates, which allow a better appreciation of the growth potential of the fish, indicate variability according to the size classes of the species studied.

The increase in biomass is considered as a linear function of time, and regarding to the short period of our study (115 days of rearing), the results show that small specimens of *Polydactylus quadrifilis* and *Pomadasis jubelini* have the best specific growth rates. According to Beets & Hixon, (1994), this translates into a rapid growth of these specimens could be justified by an ease of adaptation to captive conditions and to the industrial feed, because the values currently observed in aquaculture ranged on 0.5% to 3%. However, values of 4 to 5% have already been obtained for juveniles of *Morone saxatilis*, but in very specific experimental conditions (Harmon & Peterson, 1994).

Conversion index or conversion rates are better for production when they are less than 3. They represent the food quantity required to increase the weight of one unit for each magnification period and vary with species and growth stages (Durville et al, 2003). Our experience has provided data on the biology and domestication capabilities of fish studied through the evaluation of conversion index. The low index with *Polydactylus quadrifilis*, which range from 1 to 2.46 and from 0.9 to 2.2 with*Pomadasis jubelini*, indicate that these fish could become potential candidates for aquaculture, although additional experiments are necessary to define the optimal production conditions.

The *Polydactylus quadrifilis* specimens have the highest growth rates, whereas the lowest growth rates are obtained with individuals of *Pomadasis jubelini*, reflecting a relatively difficult adaptation of these two species. According to Durville et al, (2003), low growth and average conversion index recorded with these specimens of *Polydactylus quadrifilis* and *Pomadasis jubelini* could indicate that they are malnourished or not assimilated the food distributed. In fact, these fish are entirely carnivorous in the natural environment, but have been feed with food composed of 40% protein the present study. The small variations of the coefficients of variation (Cv) obtained with the *Polydactylus quadrfiflis* specimens (11% to 17%) and *Pomadasis jubelini* (10% to 16%) indicate that these fish could be good candidates for domestication, unless their domestication conditions are improved. Because the duration of 115 days of experimentation is due to a flood of the breeding devices of the Layoexperimental station of aquaculture that, according to Kouassi et al, (2005), probably drained waters loaded in residues of agricultural fertilizers and pesticidesfrom neighboring farms of the station.

Conclusion

The present study provides information on the captive capacity of the marine species *Polydactylus quadrifilis* and *Pomadasis jubelini*, whose knowledge of development stages in breeding are still limited. This work on the determination of aquaculture potentials of new species made it possible to test, experiment and understand the adaptation capacities and breeding possibilities of these species from specimens caught in the natural environment. The abilities of studied fish to feed, grow and survive under artificial conditions reflect some potential for acclimatization. *Polydactylus quadrifilis* has a breeding ability for food, as it is a large, fast-growing and low-conversion fish. Similarly, *Pomadasis jubelini* shows breeding abilities but remains of medium size. This study will have to be deepened in order to succeed in breeding these fish.

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