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Growth Parameters and Condition Coefficient of Three Species from Bas-Kouilou (Congo Brazzaville): *Chrysichthys auratus*, Geoffroy, 1809, *Liza falcipinnis*, Valenciennes, 1836 and *Pellonula vorax*, Gunther, 1868

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Abstract

The study of the morphometric parameters of the three most abundant species in the lower course of the Kouilou River (*Chrysichthys auratus*, *Liza falcipinnis* and *Pellonula vorax*) was carried out. The standard length of *Chrysichthys auratus* varies between 43.57 and 210 mm, for an average of 96.70 ± 28.63 mm; the weight varies between 2.92 and 140.83 mg, an average of 73.03 ± 21.62 mg. The condition coefficient is equal to 4.42 ± 1.52. *Liza falcipinnis* has a standard length which varies between 59.9 mm and 158.08 mm for an average of 88.15 ± 29.74 mm; its weight varies between 4.77 and 76.21 mg, an average of 18.61 ± 11.82 mg. The condition coefficient is equal to 2.47 ± 1.57. *Pellonula vorax* has a standard length which varies between 60.33 mm and 117.72 mm; for an average of 80.48 ± 17.75 mm; the weight varies between 3.61 and 25.17 mg, an average of 9.03 ± 3.61 mg. The condition coefficient is equal to 2.17 ± 0.57. These three species have a minor allometric growth.

Keywords

Kouilou River, *Chrysichthys auratus*, *Liza falcipinnis*, *Pellonula vorax*, Growth Parameters, Condition Coefficient

1. Introduction

The weight-to-length ratio is a critically important piece of data used in fisheries

assessment and fish biology [1] [2]. Indeed, the length and weight can provide information on the composition of stocks, the duration of life, mortality, growth and production [3] [4]. This tool provides information about the structure and function of ichthyological populations. It can be used to assess fish population health and distribution [5], fishing pressure and pollution induce significant changes in communities fish. Among other things, the decline in biodiversity, the average size of captures, of their trophic level, which requires the use of models global and analytical for the rational management of these resources. These models most often require knowledge of the height-weight relationship of different populations. However, in many species there may be modification of the shape body weight or weight variation during growth, depending on example of the reproduction cycle or food availability. The condition coefficient then makes it possible to monitor the evolution of the state of plumpness fish. It is considered a good instrument for comparing the overall physiological state of populations over a seasonal cycle or between basins with different ecological conditions [6]. Currently, very little data are available on the weight-length relationship of the ichthyofauna of the brackish waters of the Congo. It is in this context that a study of the mophometry and the condition coefficient was carried out on the 3 most abundant species of the brackish waters of Bas-Kouilou (Republic of Congo).

2. Materials and Methods

2.1. Sampling Site

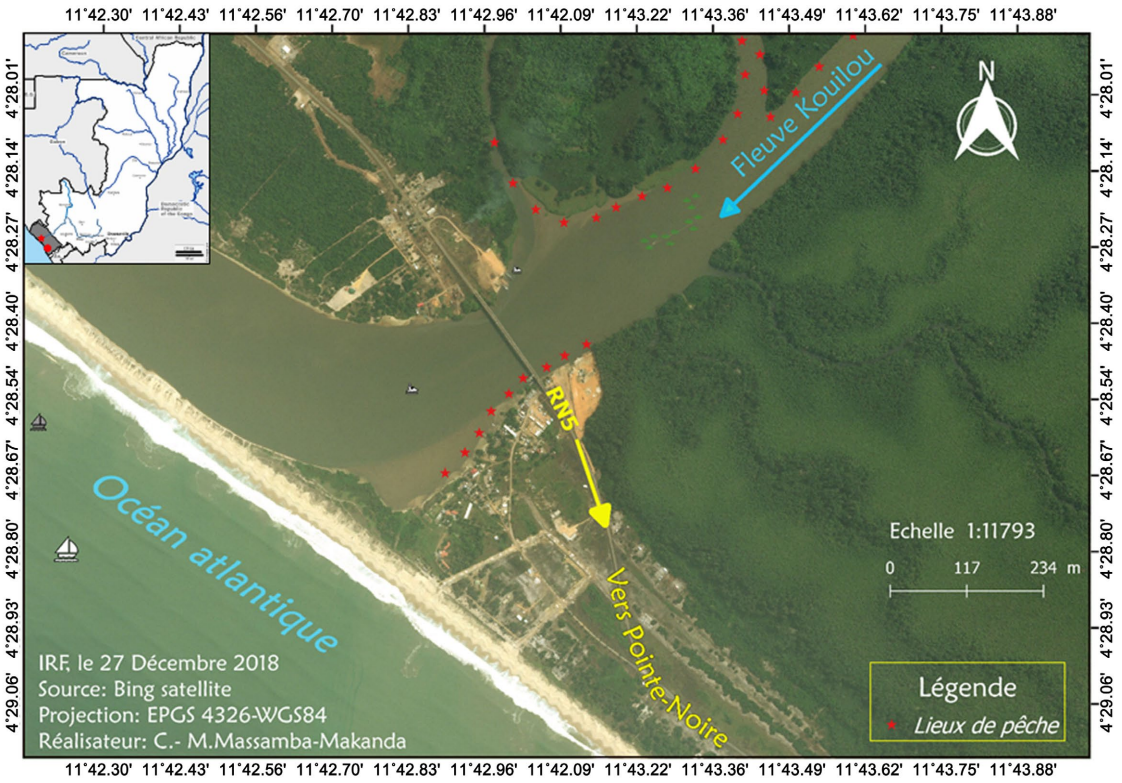

Figure 1. Location of the sampling site (IRF, 2018).

Sampling was carried out at two (2) stations (Figure 1), station 1 is downstream from the bridge over the Kouilou while station 2 is upstream from the bridge. The stations were selected based on their accessibility. The geographic coordinates recorded at this site are as follows: −4˚21'67" South latitude and 11˚42'83" East longitude.

2.2. Data Collection

For field data collection, we conducted inventories using a battery of gillnets and a cast net. The various samples were taken on September 8 and 9, 2018, at the lower reaches of the Kouilou River. The fish specimens were then fixed using 10% formalin and preserved in tanks containing 5% formalin. The biological material was brought back to the laboratory for biometric characterization.

2.3. Morphometric Characterization

The measurements were taken to the nearest millimeter using an electronic caliper. The metrics taken were expressed as a percentage relative to the standard length or head length. The meristic characters were determined for each specimen as proposed by the following authors [7]-[9].

2.4. Standard Weight-Length Relationship

Knowledge of measurable parameters such as weight and size remains very important for estimating growth in fish [10]. Indeed, standard length measurements and weight measurements of specimens have made it possible to establish a relationship between these two parameters [11].

$$P_t = a\mathrm{LS}^b$$

with, P_t: total weight; LS: standard length; a: constant; b: allometry coefficient.

The value of b provides information on the type of growth of the species considered. When the growth in weight is equal to the growth in size, it is said to be isometric when $b = 3$ and allometric if $b \neq 3$. When $b < 3$, the growth is minor allometric, that is to say that the growth in weight is less than the growth in size. In the case where $b > 3$, the growth is major allometric, because the growth in weight is greater than the growth in size [12] [13].

2.5. Data Processing

Morphometric data were standardized to study variations related to age differences between specimens. Microsoft Excel software was used for the processing of various data.

3. Results

Three species of fish from Bas-Kouilou were selected for morphometric characterization (*Chrysichthys auratus*, *Liza falcipinnis* and *Pellonula vorax*).

3.1. Biometric Characterization of *Chrysichthys auratus*

The main measurements were made on 70 individuals of *Chrysichthys auratus*

(Figure 2).

Figure 2. Specimen of *Chrysichthys auratus* (LARBEA, 2018).

3.2. Metric and Meristic Characters

The results on metrics and meristics carried out on the 70 specimens of *Chrysichthys auratus* are mentioned in Table 1. The standard length of the specimens is between 43.57 and 210 mm for an average of 96.70 ± 28.63 mm. The meristic data are as follows: Dorsal: II.5 - 6; Anal: iii.8 - 10; Pelvic: i.5 - 6; Pectoral: I.7 - 9 and 8 - 9 + 13 - 15 gill rakers.

Table 1. Metric and meristic characters of *Chrysichthys auratus*.

Metric characters	Minimum	Average	Maximum	Standard deviation
Standard length (mm)	43.57	96.70	210	28.63
As a percentage of standard length				
Height of caudal peduncle	8.58	9.75	14.78	0.83
Length of caudal peduncle	10.08	17.58	22.72	1.85
Body height	18.16	21.91	35.18	2.41
Head length	28.30	31.29	43.40	2.19
Predorsal distance	37.17	39.56	55.52	2.40
Preanal distance	64.68	71.59	97.02	3.99
Prepelvic distance	42.85	52.90	77.53	3.86
Prepectoral distance	24.23	27.07	39.55	2.65
Backbone length	10.80	20.79	39.13	8.14
Anal length	10.05	13.33	69.47	7.52
Pelvic length	10.63	16.45	24.08	1.86
Pectoral length	15.01	20.84	33.37	2.57
Length of adipose tissue	7.91	12.90	19.67	2.57
Fat height	2.43	5.41	9.73	1.95
Dorsal-adipose distance	8.97	24.82	38.01	3.54
Spine length	14.24	19.82	27.52	2.51
Length of pectoral spine	13.04	17.65	27.50	2.01
Length of mandibular barbels	8.74	13.59	21.67	2.58

Continued

As a percentage of head length				
Snout length	22.07	35.98	41.54	2.77
Inter orbital distance	22.91	29.36	35.24	2.92
Eye distance	18.47	26.44	35.84	3.25
Meristic characters	**Minimum**		**Maximum**	
Rays on the dorsal	II.5		II.6	
Rays at the anal	iii.8		iii.10	
Rays to the pelvis	I.5		I.6	
Rays at the chest	I.7		I.9	
Branchiospines (Part sup + inf)	8 - 13		9 - 15	

3.3. Size Structure

The 70 specimens of *Chrysichthys auratus* with a standard length between 43.57 and 210 are distributed in 20 size classes (Figure 3). The class interval is equal to 8. Classes (4, 5, 7, 10 and 11) are the most abundant with a total number of 40 specimens. As for the other classes, they are less rich with a maximum of five specimens each.

3.4. Weight-Length Relationship

The weight-length relationship in *Chrysichthys auratus* is represented by the power curve shown in Figure 4. The 70 specimens retained have standard lengths ranging from 43.57 to 210 mm, or an average of 96.70 ± 28.63 mm; their weight is between 2.92 and 140.826 g, average is 73.03 ± 21.62 g. The regression equation linking these two morphometric parameters is of the type $Pt = 0.036\ LS^{2.745}$ with a determination coefficients $R^2 = 0.94$ and a significant correlation coefficient r = 0.97. The allometric coefficient (b = 2.73) shows a minor allometric growth reveals a significant correlation ($p < 0.05$).

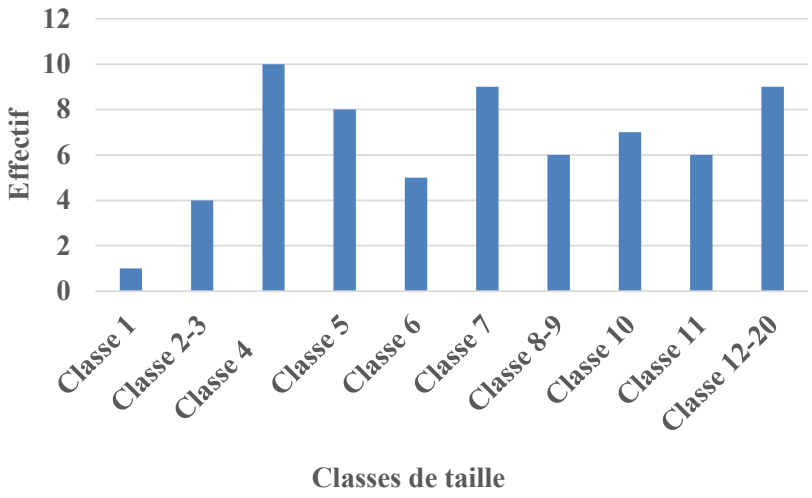

Figure 3. Distribution of *Chrysichthys auratus* specimens by size class.

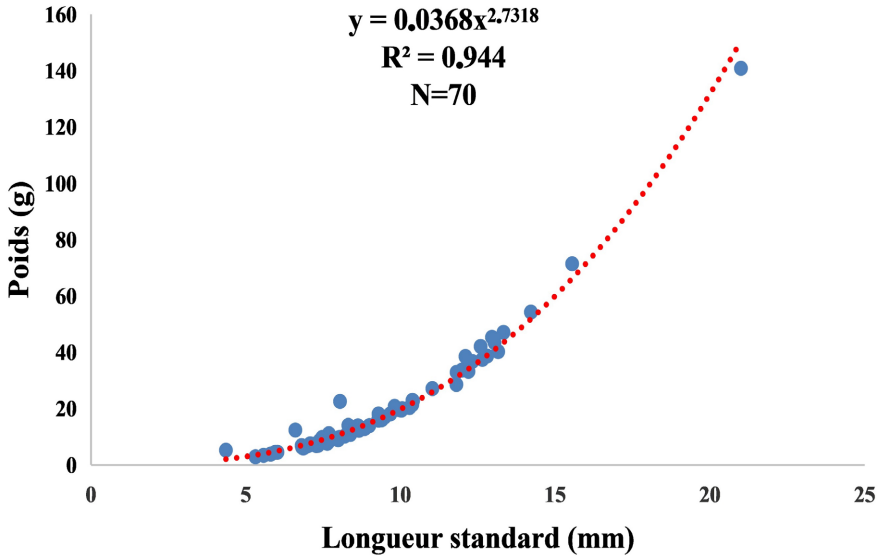

Figure 4. Representation of the weight-length relationship of *Chrysichthys auratus*.

3.5. Biometric Characterization of *Liza falcipinnis*

The morphometric study of *Liza falcipinnis* (Figure 5) was carried out from 52 specimens.

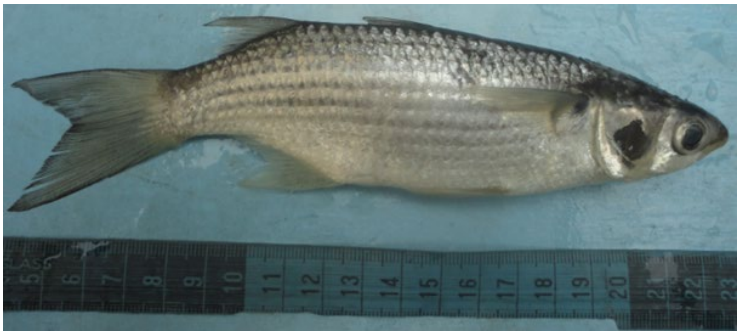

Figure 5. Specimen of *Liza falcipinnis* (LARBEA, 2018).

3.6. Metric and Meristic Characters

The metrics and meristics performed on 52 specimens of *Liza falcipinnis* are recorded in Table 2. These metrics reveal that the standard length of *Liza falcipinnis* varies between 59.90 and 147.96 mm for an average of 88.15 ± 29.74 mm.

Table 2. Metric and meristic characters of *Liza falcipinnis*.

Metric characters (mm)	Min	Max	Average	Standard deviation
Standard length	59.90	147.96	88.15	29.74
As a percentage of standard length				
Length of the backbone 1	1.47	12.33	6.07	2.55
Height of caudal peduncle	10.73	96.24	15.96	17.14

Continued

length of caudal peduncle	1.34	21.82	17.45	2.80
Body height	1.81	30.60	24.89	4.02
Head length	1.56	30.56	26.83	4.10
Predorsal distance (//d1)	3.28	57.50	51.15	7.75
Preanal distance	6.00	88.62	67.95	12.10
Prepelvic distance	3.42	43.24	38.32	7.00
Prepectoral distance	2.50	39.11	28.00	4.95
Length of the backbone 2	1.69	13.05	10.60	2.36
anal length	4.76	43.72	17.76	6.64
pelvic length	3.37	41.41	19.18	4.20
Pectoral length	3.19	43.58	22.97	5.39
As a percentage of standard length				
Snout length	2.77	33.08	25.02	4.43
Eye diameter	3.97	43.98	29.68	5.59
Inter orbital distance	3.14	44.07	34.63	5.79

Meristic Characters	**Minimum**	**Maximum**
Rays at the back 1	IV	IV
Rays at dorsal 2	i.7	i.10
Ray at the anal	III.9	III.10
Radius to the pelvis	I.5	I.5
Radius to the chest	i.12	i.16
Branchiospines (sup + inf)	26 - 41	29 - 48
Scales in longitudinal line	34	36
Scales between LL and dorsal 1	4.5	5.5
Rows of scales	11.5	12.5
Scales around the caudal peduncle	15	16

The scalar formula obtained from the meristic data is as follows: ED1LL: 4.5; ELL: 34 - 36; EPC: 15 - 16; RE: 11.5 - 12.5. The lateral line is absent. The following rays are counted: Dorsal 1 (D1): IV; Dorsal 2 (D2): i.7 - 10; Anal: III.9 - 10; Pelvic: I.5; Pectoral: i.12 - 16 and 26 - 29 + 41 - 48 gill rakers.

3.7. Size Structure

The distribution of 52 specimens of *Liza falcipinnis* by size class (standard length), gave us 20 classes with their numbers (Figure 6). The class interval is equal to 7. The numbers of size classes 1, 2, 3, 4 are very important, compared to other classes, except classes 15 - 20 which have no specimen.

3.8. Weight-Length Relationship

The weight-length relationship in *Liza falcipinnis* is illustrated in Figure 7. P_t =

$4E{-}0.5LS^{2.825}$ represents the regression equation linking these two parameters with a coefficient of determination $R^2 = 0.97$ and a correlation coefficient r = 0.98. The length-weight relationship is of the exponential type and gives a good description of the relationships between the standard length of the fish because it clearly shows that the weight of individuals increases as a function of size. The value of b is less than 3 and equal to 2.825, which shows that *Liza falcipinnis* has a minor allometric growth type. The very high value of the overall correlation coefficient (r = 0.98) reveals a significant correlation ($p < 0.05$).

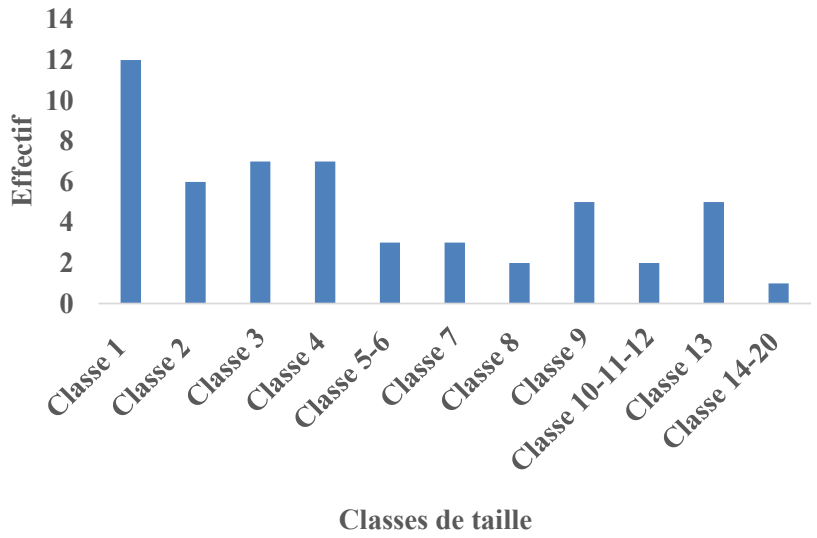

Figure 6. *Liza falcipinnis* specimens by size class.

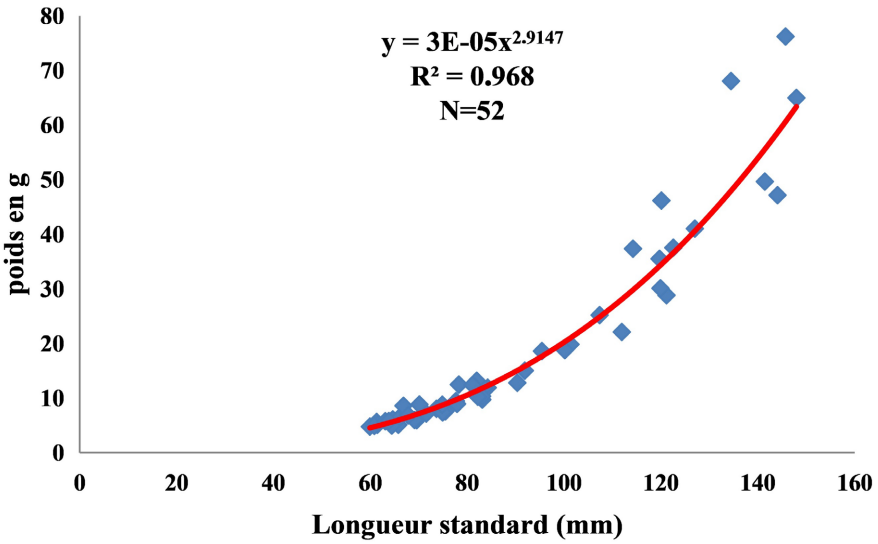

Figure 7. Representation of the weight-length relationship in *Liza falcipinnis*.

3.9. Biometric Characterization of *Pellonula vorax*

Morphometric characterization of *Pellonula vorax* was carried out on 50 specimens (**Figure 8**).

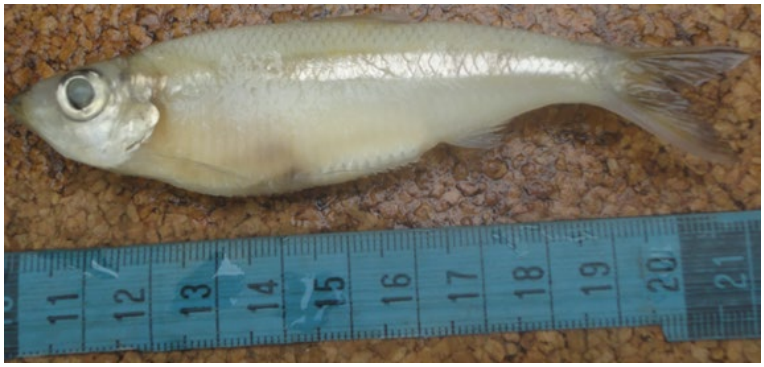

Figure 8. Specimen of *Pellonula vorax* (LARBEA, 2018).

3.10. Metric and Meristic Characters

The results of metrics and meristics performed on 50 specimens of *Pellonula vorax* are reported in Table 3.

Table 3. Metric and meristic characters of *Pellonula vorax*.

Metric characters (mm)	Min	Max	Average	Standard deviation
Standard length	60.33	117.72	80.48	17.75
As a percentage of standard length				
Height of caudal peduncle	8.19	11.01	9.70	0.68
length of caudal peduncle	10.56	14.75	12.83	1.01
Body height	22.26	36.44	25.49	2.48
Head length	20.38	29.22	25.51	1.83
Predorsal distance	41.91	50.64	47.25	1.62
Preanal distance	26.24	76.08	71.92	6.83
Prepelvic distance	46.87	54.66	50.92	1.62
Prepectoral distance	22.71	33.31	26.31	2.48
Backbone length	14.05	22.11	17.50	1.68
anal length	14.44	22.75	17.59	1.61
pelvic length	12.24	17.18	14.09	1.08
Pectoral length	14.15	18.96	17.30	0.96
As a percentage of head length				
Snout length	19.54	37.88	29.49	3.94
Eye diameter	26.71	40.39	33.01	3.00
inter orbital distance	13.05	26.80	18.30	2.97
Meristic characters	**Minimum**		**Maximum**	
Rays on the dorsal	ii.14		ii.15	
Rays to the anal	ii.14		ii.17	
Pelvic rays	i.7		i.7	

Continued

Rays on the pectoral	i.12	i.13
Number of gill rakers	13 - 23	15 - 28
Number of preventral shields	8	9
Number of post ventral shields	11	12
Scales in lateral line	42	44
Scales between LL and dorsal	4	4.5
Scales around the caudal peduncle	14	15

Pellonula vorax specimens from the lower course of the Kouilou is between 60.33 mm and 117.72 mm for an average of 80.48 ± 17.75 mm.

The counts gave the following results: RD: ii.14 - 15; RA: ii.14 - 17; Rpel: i.7; Rpect: i.12 - 13; EPC: 14 - 15; EDLL: 4 - 4.5; ELL: 42 - 44; NE: 8 - 9 + 11 - 12 and 13 - 15 + 23 - 28 gill rakers.

3.11. Size Structure

Pellonula vorax specimens range in size from 60.33 mm to 117.72 mm standard length, an average of 82.06 ± 17.75 mm. The weight is between 3.61 and 25.17 g, average is 9.03 ± 3.61 g. They were divided into 7 size classes (Figure 9). The class interval is 9. Class 1 of *Pollunula vorax* contains the largest number of specimens, while class 3 has no individuals.

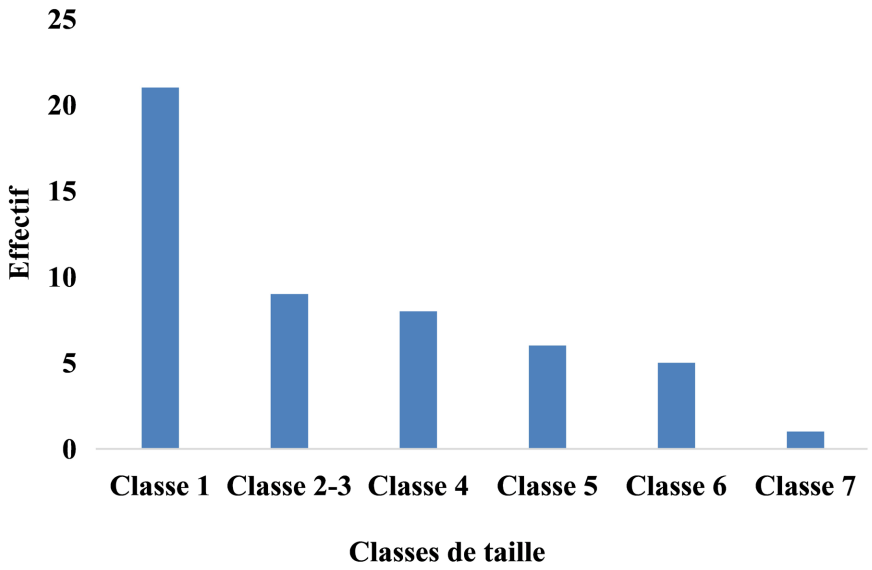

Figure 9. Distribution of *Pellonulla vorax specimens* by size class.

3.12. Weight-Length Relationship

The weight-length relationship in *Pellonula vorax* is illustrated in Figure 10. The coefficient of determination $R^2 = 0.75$ and the correlation coefficient r = 0.96. The

coefficient b is equal to 2.53 reflecting a minor allometric growth. The regression equation linking these two morphometric parameters is of the type Pt = 0.0001 LS $^{2.5304}$ with a determination coefficients $R^2 = 0.75$, a significant correlation (r = 0.87). This value of the correlation coefficient reveals a significant correlation ($p < 0.05$). The allometric coefficient (b = 2.53) shows a minor allometric growth.

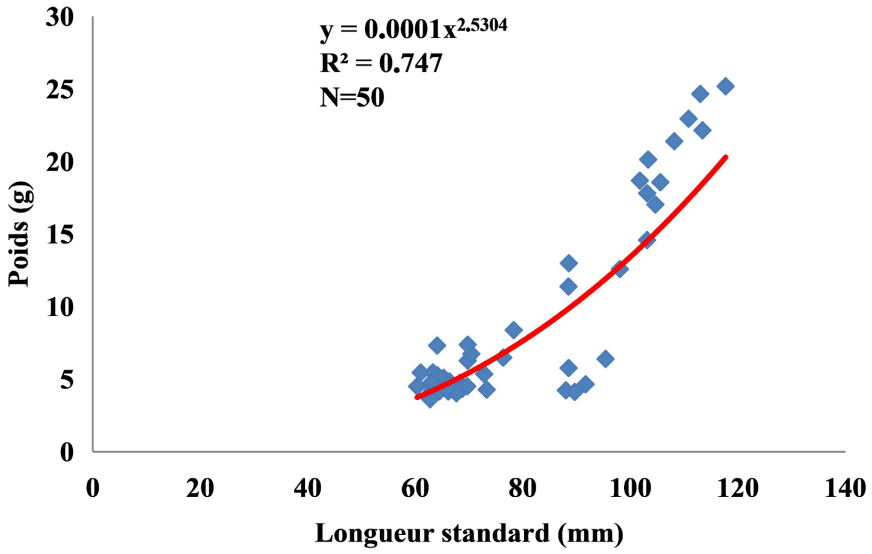

Figure 10. Representation of the weight-length relationship in *Pellonulla vorax*.

There is a strong correlaton between the standard length and the weight for the three studied species: *Chrysichthys auratus* (r = 0.98), *Liza falcipinnis* (r = 0.97) and *Pellonula vorax* (r = 0.86). The value of b is inferior to 3, the three species have minor allometric growth (Table 4).

Table 4. Growth parameters.

Families Species	N	P = aLS^b	a	b	CI of b at 95%	SE of b	R^2	r	
				Claroteidae					
Chrysichthys auratus	72	Pt = 0.036LS$^{2.745}$	20.229	2.915	2.764 - 3.066	0.075	0.968	0.98	A^-
				Mugilidae					
Liza falcipinnis	52	Pt = 3E−0.5LS$^{2.915}$	0.037	2.732	2.574 - 2.890	0.079	0.944	0.97	A^-
				Clupeidae					
Pellonula vorax	50	Pt = 0.0001LS$^{2.5304}$	13.422	2.53	2.094 - 2.967	0.217	0.747	0.86	A^-

3.13. Condition Coefficient of *Chrysichthys auratus*

The results of the condition coefficients of the three species studied are recorded in Table 5. It emerges from this table that the species reaching the highest molecular mass has the highest condition coefficient, it is the case of *Chrysichthys auratus*.

Table 5. Morphometric parameters and condition coefficients of *Chrysichthys auratus*, *Liza falcipinnis and Pellonula vorax*.

Species	Length (mm)			Weight (g)			K		
	Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD
C auratus	43.57	210.00	96.7 ± 28.63	2.92	140.83	73.03 ± 21.62	2.10	6.34	4.22 ± 1.52
L. falcipinnis	59.90	147.96	88.15 ± 29.74	4.77	64.97	35.04 ± 11.82	2.07	2.87	2.47 ± 1.57
P. vorax	60.33	117.72	80.48 ± 17.75	3.61	25.17	9.03 ± 3.61	1.57	2.78	2.17 ± 0.57

4. Discussion

Chrysichthys auratus specimens from Bas-Kouilou have a standard length which varies between 43.57 mm and 210 mm, for an average of 96.70 ± 28.63 mm. The two values obtained, minimum and maximum on the standard length of the specimens of the present study are lower than those of specimens (98.8 mm to 230 mm) and 270 mm standard length found by [14] in the Dimonika Biosphere Reserve and by Stiassny *et al.* (2007). The minimum body height is 18.16% of the standard length, which is the same as (18.2%) found by [14]. The maximum length of the head is 43.40% of the standard length against 35.2% for [14]. A maximum of II.6 rays at the dorsal, a minimum of iii.8 rays at the anal and a minimum of I.5 at the pelvic were counted, identical to those obtained by [8] [14]. The value found on the maximum I.9 of the pectoral is the same found by. This value is higher than that found by [14]. The difference would probably be due to a count carried out on a large number and the larger size of specimens in this study. The number of gills rakers (13 - 15), minimum and maximum found on the first arch branchial is similar to that of [14]. The values (8 - 9) obtained correspond to the minimum and maximum of the gill rakers located on the upper part of the first branchial arch. These values are different and higher than those found by [14], the observed difference could explained by the lack of sampling, our sampling was more representative in number of specimens than that of the Dimonika biosphere reserve. *Chrysichthys auratus* is a species that exhibits minor allometric growth, that means, it grows slightly faster than it gets fat. The maximum standard length of *Liza falcipinnis specimens* found is 158.08 mm, a value lower than that obtained by [8] who found a maximum of 410 mm. The other metric values are close to those obtained by [9] in the Ebrié lagoon complex (Ivory Coast). The maximum head length is 30.56% of the standard length versus 29.06%; the average snout length is 25.02% of head length versus 27.33%; maximum snout length is 33.08% versus 32.57% and minimum interorbital diameter is 3.14% of head length versus 3.15% for [9]. A maximum of III rays at the first dorsal; a minimum of III.8 rays at the anal; a minimum of i.7 rays at the pelvic were counted. Results identical to those obtained by [10]. A maximum of i.10 rays at the second dorsal and a maximum of I.16 rays at the pectoral scales were obtained, a result identical to that found by [15]. A minimum of 35 scales in a longitudinal line was obtained, results similar to those counted by [16] [17]. We also counted a maximum of III.10 rays at the anal fin against III.12 found by [9]; III.11 obtained by [8] [18] similarly a

minimum of (26 - 41) gill rakers was obtained on the whole of the first gill arch against (27 - 44) gill rakers obtained by [9]. These slight differences observed are due to environmental factors. *Liza falcipinnis* is a species with minor allometric growth, that is to say that it grows faster than it grows. *Pellonula vorax* specimens in the present study have a maximum standard length equal to 117.72 mm. This maximum is higher than that found by [8] [19] who obtained 134 mm and 102.8 mm. The observed difference could be due to the appearance of ecotypes [20]. The meristics obtained are practically close to those found by [8] [19]. ii.14 rays on the dorsal; a minimum of ii.14 rays on the anal and a minimum of 24 gill rakers on the lower part of the first branchial arch results identical to those obtained by [8]. A minimum of 26 scales on the longitudinal line were counted, a result identical to that counted by [19]. Several dissimilarities were observed: the number of ventral shields and the maximum of scales on the longitudinal line. Concerning the shields, there are 8 - 12 pre-ventral shields and 9 - 11 post-ventral shields found against 12 - 16 pre-ventral and 8 - 10 post-ventral for [8]; a maximum of 44 scales was found compared to 46 scales for [21]. All these observed differences are probably due to the appearance of ecotypes, the appearance of new races or subspecies or even to the habitat structure. *Pellonula vorax* from Bas Kouilou shows a minor allometric growth type that is, it grows faster than it gets fat.

Finally, the two-day sampling period captures seasonal or environmental variability and how weather or water quarter quality during the sampling period might have influenced the results or whether these conditions were typical for the region.

5. Conclusion

This study provided knowledge on the biometrics and the condition coefficient of the most abundant species of the Bas-Kouilou ichthyofauna: *Chrysichthys auratus*, *Liza falcipinnis* and *Pellonula vorax.* The standard length of *Chrysichthys auratus* varies between 43.57 and 210 mm. *Pellonula vorax* has a standard length that varies between 60.33 mm and 111.72 mm. The standard length of *Liza falcipinnis* is between 27.58 mm and 158.08 mm. These three species have a minor allometric growth. The study of the condition coefficients shows that *Chrysichthys auratus* is the species with the best plumpness, because it has the highest condition coefficient (0.00422 ± 0.00152). The predictions lead us to say that *Chrysichthys auratus* has the best aquaculture potential compared to *Liza falcipinnis* (0.00247 ± 0.00157) and *Pellonula vorax* (0.00217 ± 0.00057).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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