International Journal of Fisheries and Aquatic Studies 2017; 5(6): 356-364

E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2017; 5(6): 356-364

www.fisheriesjournal.com
Received: 19-09-2017
Accepted: 20-10-2017

Romaric K Lalèyè
Laboratory of Hydrobiology and Aquaculture, Faculty of Agricultural Sciences, University of Abomey-Calavi, 01 BP: 526 Cotonou, Benin

Djiman Lederoun
Laboratory of Hydrobiology and Aquaculture, Faculty of Agricultural Sciences, University of Abomey-Calavi, 01 BP: 526 Cotonou, Benin

Antoine Chikou
Laboratory of Hydrobiology and Aquaculture, Faculty of Agricultural Sciences, University of Abomey-Calavi, 01 BP: 526 Cotonou, Benin

Philippe A Lalèyè
Laboratory of Hydrobiology and Aquaculture, Faculty of Agricultural Sciences, University of Abomey-Calavi, 01 BP: 526 Cotonou, Benin

Correspondence
Romaric K Lalèyè
Laboratory of Hydrobiology and Aquaculture, Faculty of Agricultural Sciences, University of Abomey-Calavi, 01 BP: 526 Cotonou, Benin

Metric and Meristic characterization of *Oreochromis niloticus* (Linnaeus, 1758) populations in the Mono, Oueme, and Volta River basins in Benin

Romaric K Lalèyè, Djiman Lederoun, Antoine Chikou and Philippe A Lalèyè

Abstract
A total of 222 fish specimens were collected for the characterization of *Oreochromis niloticus* populations of the Oueme, Mono, and Volta river basins in Benin. The main objective was to determine the number of strains therein, with the goal of taking a sample of living subjects and then to identify from these, upon a series of experimentations in controlled environments, the most efficient strain to be used in aquaculture. The fishes used were collected from May to September 2016 from lakes located in the Mono basin (Toho, Togbadji, and Nangbeto lakes), in the Oueme basin (lake Gobe), and from the Pendjari River in the Volta basin. On each individual, nineteen metric and six meristic characteristics were used. The results show that, in the Mono basin, the Togbadji fish populations differ from those of the Toho, Gobe and Pendjari. Toho fish populations are distinguished from those of Gobe and Pendjari. From these results, four different populations are to be distinguished in the three basins we have explored: the Mono population, the Oueme population, and the Volta population.
Keywords: Cichlidae, *Oreochromis niloticus*, morphometric, Mono, Oueme, Volta, West Africa
Keywords: Cichlidae, *Oreochromis niloticus*, morphometric, Mono, Oueme, Volta, West Africa

1. Introduction
Cichlids, whose tilapias are freshwater tropical fish, are well known for their high speciation rates and have high genetic and morphological diversity. This high diversity affects their morphology, ecology, behavior, and genomes [1, 2]. The most illustrative cases come from lakes Victoria, Tanganyika, and Malawi, which host 60% of all cichlid species in the world, numbering between 1800 and 2000 species [3, 4]. These cichlids consist mainly of monophyletic groups of closely related species that inhabit the same ecosystem and have evolved from a single ancestral species [5]. According to [6], there is a close relationship between the events that lead to the speciation of species and the colonization of new environments or the diversification of niches, which in turn can induce changes in behavior, morphology, and the physiology of the organism [7].

Oreochromis niloticus, object of our study, is a tilapia native to Africa and occupies a place of choice in aquaculture. It is a very hardy species that adapt easily to new environments, showing a wide range of biological responses to different environmental conditions in both livestock and natural environments [8, 9]. It is an omnivorous fish species [10]. [22] reported that in the Kenya Rift Valley, Nile tilapia colonized many newly formed habitats in a system characterized by numerous sub-river basins including a series of rivers, springs and lakes. This complex system hosts four of the seven subspecies of *Oreochromis niloticus* described by **[11]**: namely *O. n. baringoensis* from lake Baringo; *O. n. sugutae* from the Suguta river; *O. n. vulcani* from lake Turkana; the fourth subspecies being close to *O. n. baringoensis* but is genetically distinct from it [12].

For purposes of promoting fish farming, *O. niloticus* was introduced to Benin in 1979 and again in 1992 [13]. It has since been the first farmed fish in the entire country in terms of depth of understanding of its biology, its ecology, ease of rearing, etc. It is highly valued by consumers and its production does meet a real need within the population [14]. The production of *O. niloticus* in West Africa and particularly in Benin, however, encounter a number of difficulties, one of the most important of which is its low zootechnical performance, which is manifested in particular by its low growth rate and reproductive disorders [15].

In fact, recurrent signs of low growth rate and dwarfism are observed in most fish farms in Benin [16]. Among the reasons explaining this state of affairs, is the use of little-known broodfish of uncertain quality, originating from a variety of places, and introduced to fish farms. Another important issue is the occurrence of signs of consanguinity in the reproduction or multiplication of strains, leading to their genetic degeneration [16].

It is with the goal of solving the latter problem that the program aimed at expanding continental aquaculture in Benin (PROVAC) has been popularizing, starting in 2010, the production of tilapia monosexe males whose growth is 30% higher than that obtained from mixed breeding. This advance made by PROVAC represents a significant step forward in improving the production potential of tilapia in Benin. However, fish farmers continue to complain about the poor performance (relatively long production cycle, low growth rate, etc.) of currently available strains. Given those facts, it is imperative to look for tilapia varieties with a relatively shorter cycle and acceptable growth performance for fish farmers. The present study focuses on some of the wild varieties existing in Benin's watersheds (Mono, Oueme and Volta) in order to develop an information base which will help select a performing *Oreochromis niloticus* strain to be used in fish farming in Benin.

2. Materials and methods

The work involved 222 specimens collected from five *Oreochromis niloticus* populations encountered in the Mono basin (from Toho, Togbadji, and Nangbeto lakes), in the Oueme basin (lake Gobe), and in the Volta basin (Pendjari river) (Fig. 1). For each specimen, six meristic characters and nineteen measurements (Table 1) were used according to [17]. However, we have added the dorso-anal length which is the vertical distance measured from the end of the smallest spinal radius of the dorsal fin to the end of the smaller thorny radius of the anal fin. Measurements recorded at the tenth of a millimeter were made using a KREATOR caliper with 0.05 mm precision. Collected data (meristic and metric) have been the subject of Principal Component Analysis (PCA) using Past3 software 2003. Meristic and metric data were analyzed separately. For meristics, the raw was analyzed, while the metric data were standardized by converting the measurements expressed in millimeters (except for those relating to the head) to percent of the standard length [18, 19]. These are reported as a percentage of the length of the head. Mann-Whitney U tests were performed to verify the significance of the PCA results for both meristics and metrics data. The Bonferroni sequential test was applied for the correction of multiple comparisons [20, 21].

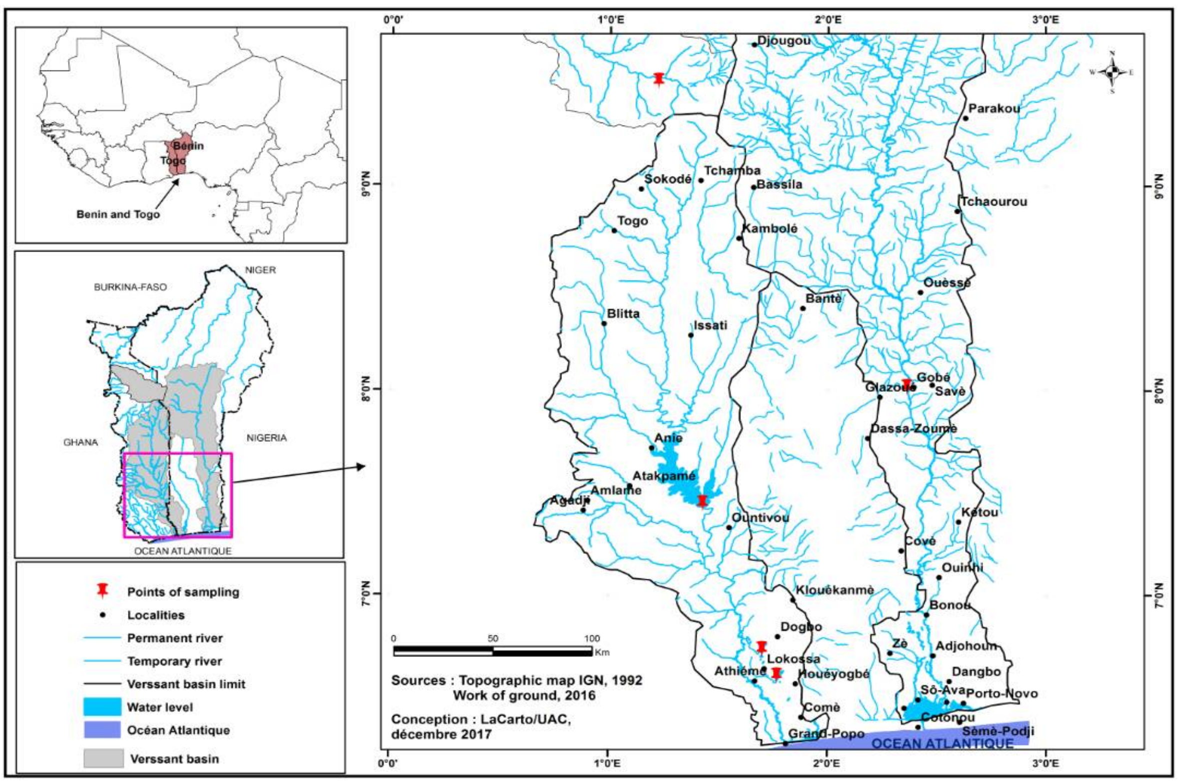


Fig 1: Geographical location of collection sites of the analyzed *Oreochromis niloticus* populations.

3. Results

3.1. Count analysis

A first Principal Component Analysis (PCA) was performed on 6 meristics (Table 1) for all examined specimens (n = 222) (Fig. 2). Contribution of the first three axes is presented in Table 1, and the results per basin are presented in Fig. 2. The Toho (Mono basin) specimens are mostly located in the negative part of PC 1, while the Togbadji and Nangbeto (Mono basin) specimens are mostly located in the positive part; however, there is an overlap between the three populations. Specimens of the Oueme basin are exclusively represented in the positive part, but they overlap with the Togbadji and Nangbeto specimens in the Mono and with the specimens in the Pendjari. Overall, according to PC 1, the populations of Toho and Gobe are clearly different from each other, while an overlap is observable between the other populations. The greatest score coefficients according to PC 1 are in decreasing order, namely: 1) the number of scales around the caudal peduncle, 2) the number of gill rakers around the first gill arch, 3) the number of predorsal scales, and 4) the number of rays at the dorsal (Table 2). According to PC 2, specimens of the Volta are exclusively in the negative part and clearly distinct from those of Toho and Togbadji (Mono basin), but they overlap with those of Nangbeto (Mono basin) and Gobe (Oueme basin). The highest PC 2 score coefficients are: the number of lateral line scales, the number of predorsal scales, the number of dorsal rays, and the number of gill rakers at the first branchial arch (Table 1).

Mann-Whitney U tests performed on all counts with Bonferroni sequential correction (Table 1) resulted in significant differences ($p<0.05$) in the number of scales around the caudal peduncle, the number of predorsal scales, the number of anal rays, the number of gill rakers at the first branchial arch, and highly significant differences ($p<0.001$) in the number of scales around the caudal peduncle, the number of predorsal scales, and the number of gill rakers at the first branchial arch (Table 2). The cloud of points of the number of scales around the caudal peduncle in terms of SL (Standard Length) and per pelvis (Fig. 3a) shows that the number of scales around the caudal peduncle is higher in Togbadji populations than in other populations. The point cloud of the number of gill rakers at the level of the first branchial arch as a function of SL and per basin (Fig. 3b) shows that the number of these is higher in the Pendjari and Gobe populations than in the other populations. These two characteristics make it possible respectively to clearly separate the populations of Togbadji from those of Pendjari, on the one hand, and the populations of Toho and Pendjari from those of Toho and Gobe, on the other hand.

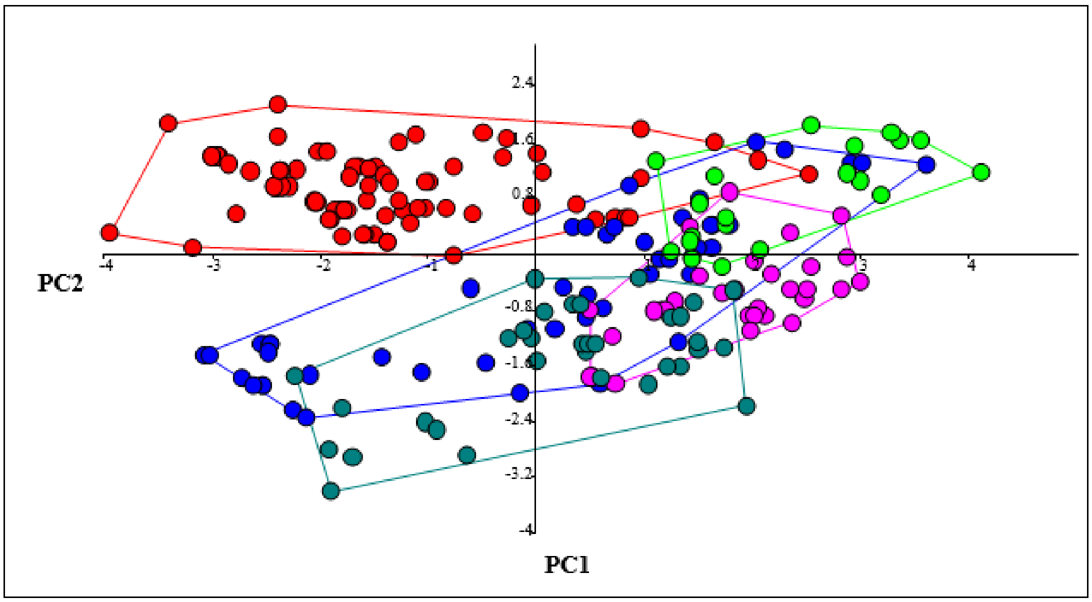
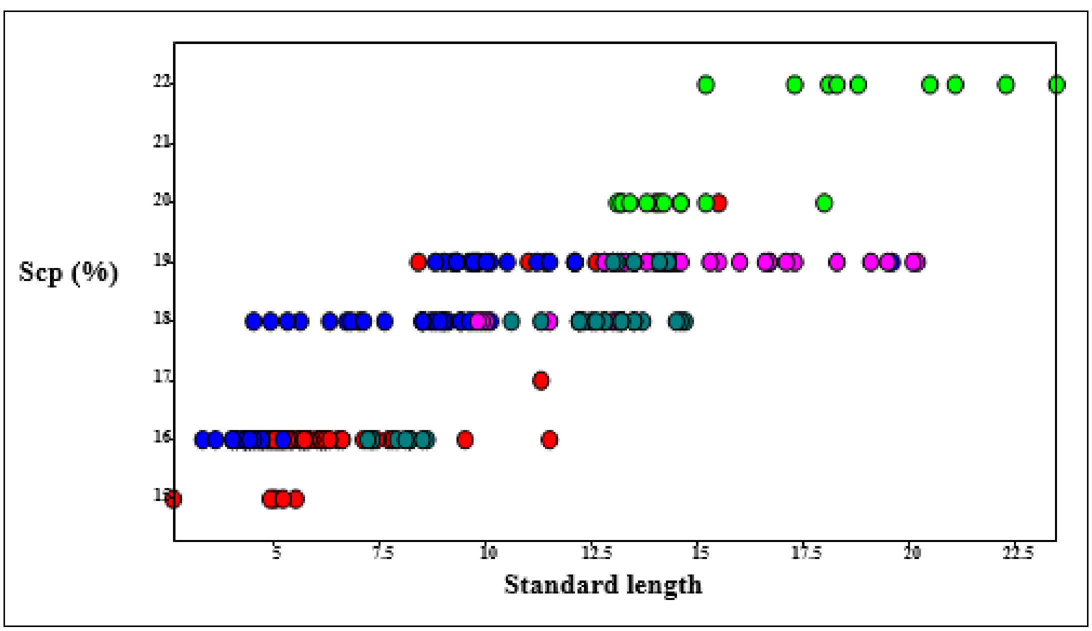


Fig 2: Cloud points of PC 1 vs. PC 2 of meristics of all the examined *Oreochromis niloticus* specimens (n = 222). Toho (○), Togbadji (○), Nangbeto (○), Gobe (○), Pendjari (○)



A

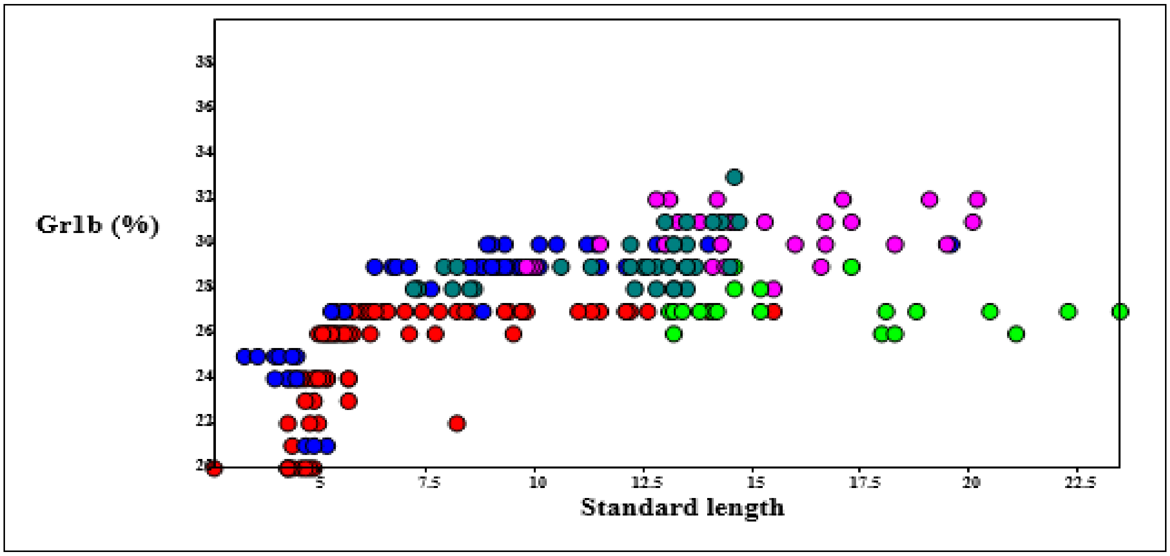


Fig 3: (a) Cloud points of the number of scales around the caudal peduncle (Scp) as a function of Standard Length ; (b) Point cloud of the number of gill rakers at the first branchial arc (Gr1b) as a function of the standard length of all the *Oreochromis niloticus* specimens examined (n = 222). Toho (○), Togbadji (○), Nangbeto (○), Gobe (○), Pendjari (○)

3.2. Analysis of the measurements

A second PCA was performed on 19 measurements for all specimens examined (n = 222). The contribution of the first three axes is presented in Table 3. The results are presented per basin (Fig. 4). According to PC 1, the Togbadji (Mono basin) and Gobe populations (Oueme basin), which overlap widely between themselves, are exclusively located in the positive part and overlap partially with the Pendjari populations in the Volta and which are mainly represented in the positive part of these same axes. Toho and Nangbeto populations are mainly in the negative part of the axis and overlap partially with those of Togbadji and Gobe (Fig. 4). Coefficients of the PC 1 scores that have the greatest value are in decreasing order, namely: 1) interorbital distance, 2) muzzle length, 3) dorso-anal length, and 4) pectoral length (Table 3). According to PC 2, the four populations overlap widely (Fig. 4). Coefficients of the highest PC 2 scores are in decreasing order as well: 1) interorbital distance, 2) snout length, and 3) pectoral length (Table 3).

Mann-Whitney U tests performed on all Bonferroni sequential correction measures (Table 4) has resulted in significant differences ($p<0.05$) for: interorbital distance, snout length, diameter of eye, length of anal spine, length of spine, and dorso-anal length; however, highly significant differences ($p<0.001$) were found for pelvic spine length. Point clouds characteristic of interorbital distance and of snout length as a function of length of the head, in each river basin, indicate that interorbital distance and snout length are higher in the Togbadji and Gobe populations than in others. (Fig. 5a & 5b). The dorso-anal dorsal-length plot of SL and pelvis shows that dorso-anal length is higher in the Pendjari (Volta basin) and Togbadji (Mono basin) populations as opposed to other populations (Fig. 5c). These characters do not allow differentiation between the species because of the overlap between these populations. In conclusion, of the 19 metric characters studied, none of them makes it possible to distinguish none of the five examined *Oreochromis niloticus* populations from the others.

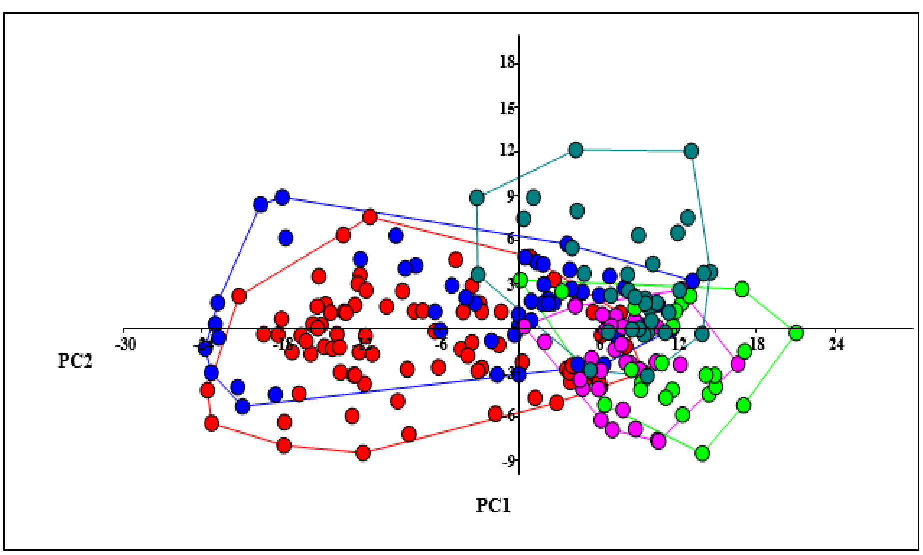


Fig 4: Cloud points of PC 1 vs. PC 2 measurements of all the examined *Oreochromis niloticus* specimens (n = 222). Toho (○), Togbadji (○), Nangbeto (○), Gobe (○), Pendjari (○)

Table 1: (A) Metric variables of the first three axes of the PCA on the six meristics for the 222 specimens examined and (B) results (p-values) of the MWU-tests for the six meristics. G = Gobe, N = Nangbeto, T = Toho, To = Togbadji, P = Pendjari. Gobe (n = 31); Nangbeto (n = 51); Toho (n = 83); Togbadji (n = 24); P (n = 35). NS = not significant. * = significant; ** = highly significant. In (A) the most important meristic values are in bold

	A			B									
	PC1	**PC2**	**PC3**	**T vs. To**	**T vs. N**	**T vs. G**	**To vs. N**	**To vs. G**	**N vs. G**	**Tvs. P**	**Pvs To**	**N vs P**	**P vs G**
Scales in lateral lines	0,169	0,727	0,01057	NS	NS	NS	NS	NS	NS	*	NS	NS	NS
Scales around the caudal peduncle	0,5347	0,01655	0,02086	NS	NS	NS	*	**	NS	NS	NS	NS	NS
Predorsal scales	0,4162	0,4801	-0,2227	NS	NS	NS	NS	NS	*	NS	NS	*	NS
Anal rays	0,3582	-0,108	0,8762	NS	NS	NS	NS	NS	NS	*	*	NS	NS
Rays on the dorsal	0,4079	-0,3679	-0,3982	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Branchiospines of the 1st branchial arch	0,4666	-0,306	-0,1536	NS	*	**	NS	**	NS	*	NS	NS	NS

Table 2: Counts carried out on five *Oreochromis niloticus* populations

	Oreochromis niloticus														
	Toho			**Gobe**			**Nangbeto**			**Togbadji**			**Pendjari**		
	Range	**Mean**	**N**	**Range**	**Mean**	**N**	**Range**	**Mean**	**N**	**Range**	**Mean**	**N**	**Range**	**Mean**	**N**
Scales in lateral lines	30-33	31	83	29-32	30	31	28-32	30	51	30-32	31	24	26-31	29	35
Scales around the caudal peduncle	15-20	16	83	18-19	19	31	16-19	18	51	20-22	21	24	16-19	18	35
Predorsal scales	9-12	10	83	9-11	10	31	9-13	11	51	10-12	12	24	9-11	10	35
Rays on the dorsal	27-30	28	83	29-31	29	31	29-30	29	51	28-30	29	24	28-30	29	35
Branchiospines of the 1st branchial arch	20-27	25	83	28-32	30	31	21-30	28	51	26-29	27	24	28-33	29	35
Anal rays	III.10-III.9	III.9	83	III.9-III10	III.10	31	III.10-III.9	III.9	51	III.9-III.10	III.10	24	III.9-III.10	III.10	35
Rays pelvic	I 5	I 5	83	I 5	I 5	31	I 5	I 5	51	I 5	I 5	24	I 5	I 5	35

Table 3: (A) Metric variables of the first three axes of the PCA pertaining to the 19 measurements carried out on the 222 specimens examined and (B) results (p-values) of the MWU-tests for the 19 measurements. G = Gobe, N = Nangbeto, T = Toho, To = Togbadji, P = Pendjari. Gobe (n = 31); Nangbeto (n = 51); Toho (n = 83); Togbadji (n = 2); P (n = 35). NS = not significant. * = significant; ** = highly significant. In (A) the most important meristic values are in bold

Variables en %	**A**			**B**									
	PC1	**PC2**	**PC3**	**T vs. To**	**T vs. N**	**T vs. G**	**To vs. N**	**To vs. G**	**N vs. G**	**Tvs. P**	**Pvs To**	**N vs P**	**P vs G**
Standard length	–	–	–	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Height of the caudal peduncle	-1,971	0,115	-0,405	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Length of the caudal peduncle	-1,307	0,188	0,135	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Maximum height of the body	-2,676	-0,373	-1,342	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Length of the head	-0,448	-0,657	-0,685	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Length of snout	-4,721	1,305	-0,318	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interorbital distance	-6,474	1,484	0,167	*	NS	NS	NS	*	NS	*	*	NS	NS
Eye diameter	-0,402	0,113	0,932	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
Predorsal length	-0,952	-0,656	-0,348	NS	NS	NS	NS	NS	NS	NS	NS	*	NS

Preanal length	-1,146	-1,220	-1,168	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Prepelvic length	-0,868	-0,805	-0,321	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Prepectoral length	-0,559	-0,647	-0,664	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Base length of the dorsal fin	-1,927	-0,981	-0,032	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Length of the backbone	-1,459	-0,571	0,441	NS	*	*	NS	NS	NS	NS	NS	*	NS
Anal fin length	-1,830	0,058	-0,295	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Length of anal spine	-1,224	-0,362	-0,207	*	NS	*	NS	NS	NS	NS	NS	NS	NS
Length of the pelvic spine	-1,186	-0,394	-0,106	**	*	**	NS	NS	NS	NS	NS	*	NS
Pectoral length	-2,851	-1,443	1,868	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Dorso-anal length	-4,561	-0,938	0,416	*	NS	NS	NS	*	NS	NS	*	NS	NS

Table 4: Measurements taken on five *Oreochromis niloticus* populations

	Toho			**Gobe**			**Nangbeto**			**Togbadji**			**Pendjari**		
Variables	**Range**	**Mean**	**N**	**Range**	**Mean**	**N**	**Range**	**Mean**	**N**	**Range**	**Mean**	**N**	**Range**	**Mean**	**N**
Standard length	2,6-15,5	6,6 ± 2,56	83	9,8-20,2	14,9 ± 2,7	31	3,3-19,6	8,2 ± 3,3	51	6,9 - 23,5	15,5 ± 4,15	24	7,2-14,7	11,65-2,52	35
In % of length head															
Length of snout	14,2-35,3	23,6 ± 4,7	83	27,2-39,2	31,33 ± 2,4	31	13,3-32,6	25,1± 4,8	51	21,7 44,2	30,8 ± 3,0	24	20,83-34,09	28,31-2,81	35
Interorbital distance	11,1-31,7	22,5 ± 4,7	83	27,2-38,5	32,5 ± 2,8	31	10-33,8	24,1 ± 6,0	51	21,7 44,2	35,3 ± 4,4	24	20,83-35,29	30,82-3,90	35
Eye diameter	11,1-20	15,8 ± 1,8	83	12,5-19,1	16,7 ± 1,6	31	9,0-21,4	16,4 ± 2,3	51	15,2 - 21,4	18,0 ± 1,7	24	14,29-21,62	17,62-1,47	35
In % of standard length															
Height of the caudal peduncle	6,9-14,8	10,5 ± 2,0	83	11-16,3	13,0 ± 0,9	31	4,4-14,2	10,1 ± 2,2	51	10,1 - 16,1	13,3 ± 1,5	24	7,79-14,16	12,06-1,40	35
Length of the caudal peduncle	3,8-11,6	7,5 ± 1,6	83	7,0-11,7	9,5 ± 1,1	31	4,5-11,2	8,2 ± 1,6	51	7,2 - 11,9	10,0 ± 1,1	24	6,82-10,61	8,48-1,03	35
Maximum height of the body	29,8-43,5	36,7 ± 3,2	83	34,9-40,6	38,2 ± 1,1	31	24,4-42,0	35,6 ± 4,0	51	36,9 - 44,2	40,7 ± 1,7	24	35,44-42,97	38,96-2,25	35
Predorsal length	30,6-40,8	35,8 ± 2,1	83	34,3-40,4	37,0 ± 1,6	31	30,2-40	36,3 ± 1,9	51	34,0 - 40,9	37,24 ± 1,7	24	28,89-39,77	36,38-2,38	35
Preanal length	63,1-80,7	72,0 ± 3,1	83	70,1-78,3	73,3 ± 1,5	31	63,4-77,2	72,0 ± 2,8	51	69,0 - 78,2	73,8 ± 2,6	24	72,22-78,76	75,01-1,64	35
Prepelvic length	32,1-4	38,8 ± 2,3	83	37,9-43,1	40,2 ± 1,2	31	35,5-42,8	39,2 ± 1,8	51	37,6 - 43,2	40,1 ± 1,5	24	36,11-45,12	40,55-1,83	35
Prepectoral length	28,5-35,3	31,9 ± 1,6	83	29,2-35,1	32,3 ± 1,2	31	24,4-33,6	31,0 ± 1,6	51	29,5 - 33,6	31,6 ± 1,1	24	29,93-36,36	32,49-1,35	35
Base length of the dorsal fin	47,3-62,6	56,9 ± 2,9	83	56,0-63,1	59,7 ± 1,5	31	48,8-63,4	58,5 ± 2,6	51	57,2 - 63,2	60,4 ± 1,5	24	59,18-70,13	62,56-2,14	35
Length of the backbone	7,6-13,4	10,6 ± 1,3	83	11,1-18,3	13,6 ± 1,4	31	6,6-15,6	12,9 ± 2,3	51	11,3 - 15,8	13,0 ± 1,0	24	13,11-16,88	14,93-0,98	35
Anal fin length	11,5-18,3	15,3 ± 1,7	83	13,9-19,8	17,5 ± 1,0	31	6,6-19,9	15,0 ±2,5	51	15,9 - 20,6	18,5 ± 1,0	24	14,81-18,98	16,99-0,91	35
Length of anal spine	10,9-16,3	13,6 ± 1,3	83	13,1-18,3	15,5 ± 1,2	31	8,8-19,3	14,2 ± 2,6	51	13,7 - 19,1	16,2 ± 1,3	24	13,99-18,58	16,44-1,05	35
Length of the pelvic spine	10,9-16,1	13,2 ± 1,1	83	13-16,9	15,1 ± 0,8	31	8,8-19,2	14,2 ± 2,6	51	13,0 - 17,1	15,3 ± 1,0	24	14,81-18,06	16,31-0,80	35
Pectoral length	26,9-40	34,5 ± 2,9	83	36,5-44,6	40,6 ± 1,9	31	30,3-45,4	38,5 ± 4,0	51	36,6 - 44,0	39,9 ± 2,0	24	29,93-46,21	38,72-4,55	35
Dorso-anal length	40,3-61,9	50,7 ± 5,2	83	52,3-61,8	56,1 ± 2,0	31	44,4-61,6	54,7 ± 4,2	51	55,0 - 63,7	59,7 ± 2,1	24	55,56-67,07	61,20-2,38	35

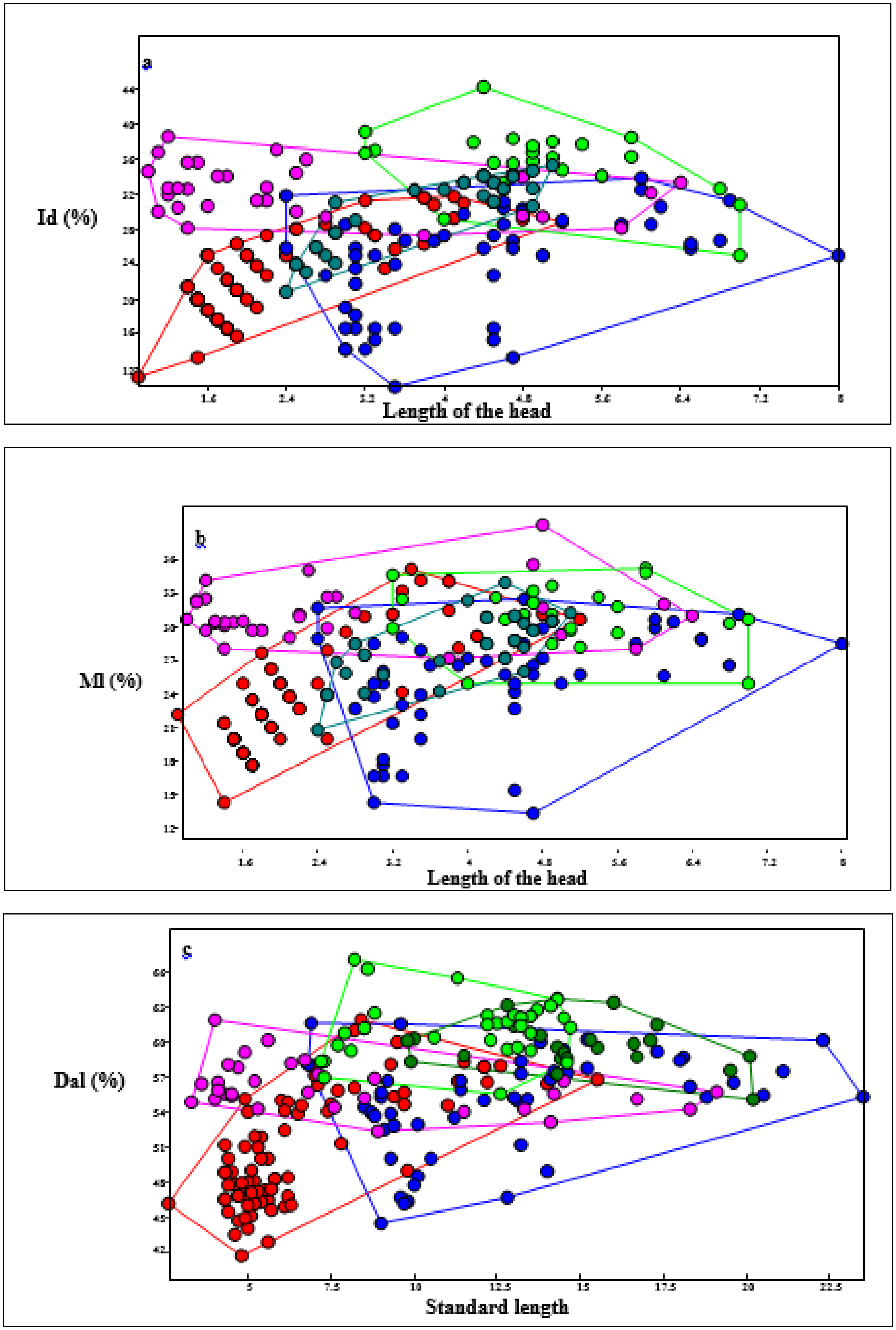


Fig 5 : (a) Cloud points of the interorbital distance (Id) as a function of length of the head; (b) Point cloud of muzzle length (Ml) as a function of head length; (c) Point cloud of dorso-anal length (Dal) versus standard length of all the examined *Oreochromis niloticus* specimens (n = 222). Toho (○), Togbadji (○), Nangbeto (○), Gobe (○), Pendjari (○)

4. Discussion

Since their introduction in 1979 [22], studies on the morphological characterization of *Oreochromis niloticus* in the rivers of Benin are almost non-existent. The only study available to our knowledge is that of [22] conducted on the Couffo, Mono, and Oueme basins populations. The present study takes into account body measurements as well as counts and combines more river basins and sampling points per basin-depending on how much doubt we have regarding the origin of some of the species or strains encountered in each basin. This is especially the case of the Mono basin [23]. Benin is endowed with five main river basins, namely the Mono, Couffo, Niger, Volta, and Oueme basins, and the main objective of this study is to characterize the different *Oreochromis niloticus* populations originating from some of those basins: the Oueme, Mono, and Volta basins. The Couffo and Niger basins have not been considered here. In fact, some Couffo fish are understood to have recently escaped from the Tohounon fish farm, and those harvested from the Niger basin are believed to come from stocked water reservoirs in the area. In the Mono, specimens were sampled from three water bodies: Toho, Togbadji, and Nangbeto. In the Oueme, the sampling took place in the Sucobe dam. In the Volta, the specimens were sampled from the Pendjari. The choice of these three basins and of the respective bodies of water was made taking into account several parameters such as the type of environment, the availability and frequency of the species in the waters, the species not having been recently introduced to the environment. Unlike the studies by [22], ours clearly shows that there are two fish populations in the Mono basin from the standpoint of meristic characters: one population type only encountered in Togbadji and a second population type encountered in Toho-Nangbeto. The number of scales around the caudal peduncle and the number of gill rakers at the level of the first branchial arch are the characters that have made it possible to segregate these populations. Doing so was the more necessary as we've considered, in this study, three stations instead of just one. Our study also shows that there is a difference between the Mono and Oueme populations. [22] obtained the same result as we have: however, he found that, in addition to the characters that we have determined to be discriminating, there are additional characters which also allow discriminating between the two populations, namely number of dorsal fin rays, number of spines at the level of the dorsal fin, number of scales at the lateral line, scales at the level of the operculum. From a metric point of view, our study shows that there is an overlap between the various populations, in addition to wide variability in the Toho-Nangbeto and Togbadji populations. However, no metric characters could help differentiate the Mono and Oueme populations, contrary to the results obtained by [22] which, instead, show that characters such as total length, standard length, head length, body height, interorbital distance, prepectoral length, length of the anal fin base, length of the pectoral fin, length of the pelvic fin, height of the caudal peduncle, and the dorso-anal length could help differentiate the Mono and Oueme populations. According to the same authors, differences observed between these populations based on the number of meristic and metric variables could be an indication that the individuals caught during the sampling process were not of the same stock. According to the authors, these differences may further reveal genetic mutations resulting from the physicochemical quality of the water in these waterbodies. Thus, the meristic variations observed in this study between the fish populations considered are due to variability within each of these populations [24]. Some traits are more pronounced in some populations than others. Along that line, the number of scales around the caudal peduncle, the number of gill rakers at the level of the first branchial arch, and the number of scales in lateral line are, respectively, much higher in the Togbadji, Pendjari, and Toho populations than in others. Several overlaps have indeed been observed between these populations.

At least two distinct strains are present in the lakes: the strain which originated from Côte d'Ivoire, the Burkina-Faso strain encountered in lake Toho and surrounding areas, and the one encountered in the dam lake and whose exact origin is not known. The morphological characteristics studied in this study have made it possible, based on the meristic and metric characters, to discriminate the five *Oreochromis niloticus* populations that we've examined. Genetic or molecular analyses as well as rate of growth tests conducted in natural or controlled environments will conclusively provide an answer to the question pertaining to the origin of the various *Oreochromis niloticus* strains reared in various breeding sites in Benin.

5. Conclusion

Our study focused on metric and meristic characterization of *Oreochromis niloticus* populations obtained from the Oueme (Gobe) and Mono (Toho, Togbadji and Nangbeto) basins in Benin. From the derived results, it appears that there are morphological differences between the five populations investigated. In fact, variations have been observed in some meristic characters such as the number of scales around the caudal peduncle and number of gill rakers at the level of the first gill arch. These two characters make it possible to distinguish the five *Oreochromis niloticus* populations from each other. On the other hand, meristic characterization has shown no possible discrimination between the populations examined. However, in-depth genetic characterization studies are called for, as by mitochondrial DNA polymorphism analysis (a practical tool for studying the spatial structure of subpopulations within a species), genetic differentiation between closely related species, or by the use of other tools, such as the microsatellite markers, to validate or invalidate the results obtained. Such studies are needed because the species evolves rapidly and tends to be polymorphic within itself.

6. Acknowledgements

The authors thank the members of the Laboratory of Hydrobiology and Agricultural, Faculty of Agronomic Sciences, University of Abomey Calavi, as well as the fishermen and the fishmongers who have contributed to the acquisition and the treatment of the samples of the different water bodies.

7. References

1. Chakrabarty P. Testing conjectures about morphological diversity in cichlids of Lakes Malawi and Tanganyika. Copeia 2005; 2:359-373.
2. Titus Chemandwa N, Dorothy Wanja N, Julien C, Jean-François A. Morphological variations of wild populations of Nile tilapia (*Oreochromis niloticus*) living in extreme environmental conditions in the Kenyan Rift-Valley. Env Biol Fish. 2016; 99:473-485.
3. Greenwood PH. African cichlids andevolutionary theories. In: Echelle AA, Kornfield I (eds) evolution of

fish species flocks. University of Maine at Orono press, Maine 1984.
4. Turner, Seehausen GF, Knight O, Allender ME, Robinson C. How many species of cichlid fishes are there in African lakes? Mol Ecol. 2001; 10(3):793-806.
5. Greenwood PH. The cichlid fishes of Lake Victoria, East Africa: the biology and evolution of a species flock. Bull Br Mus Nat Hist 1974; 6:1-134.
6. Schluter D. The ecology of adaptive radiation. Oxford University Press, Oxford, 2000.
7. Price TD, Qvarnstrom A, Irwin DE. The role of phenotypic plasticity in driving genetic evolution. Proc R Soc Lond B. 2003; 270:1433-1440.
8. Schofield PJ, Peterson MS, Lowe MR, Brown-Betersonn J, Slack WT. Survival, growth and reproduction of non-indigenous. Nile tilapia (*Oreochromis niloticus)* (Linnaeus, 1758). I Physiological capabilities to various temperatures and salinities. Mar Freshw Res. 2011; 62:439-449.
9. Grammer GL, Slack WT, Peterson MS, Dugo MA. Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) establishment in temperate Mississippi, USA: multi-year survival confirmed by otolithages. Aqua Inv. 2012; 7(3):367-376.
10. El-sayed AFM. Alternative dietary protein sources for farmed tilapia *Oreochromis* spp. Aquaculture. 1999; 179:149-168.
11. Trewavas E. Tilapiine Fishes of the Genera *Sarotherodon*, *Oreochromis*, and Danakilia. British Museum (Natural History), London, 1983, 583.
12. Nyingi D, De-vos L, Aman R, Agnese JF. Genetic characterization of an unknown and endangered native population of the Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) (Cichlidae; Teleostei) in the Loboi Swamp (Kenya). Aquaculture. 2009; 297:57-63.
13. Ahouansou Montcho S, Agadjihouèdé H, Montchowui E, Laleye PA, Moreau J. Population parameters of *Oreochromis niloticus* (Cichlidae) recently introduced in lake Toho (Benin, West Africa). Int J Fish Aqua Stud. 2015; 2(3):141-145.
14. Hachim EL, Failler P. Rapport n°5 de la revue de l'industrie des pêches et de l'aquaculture dans la zone de la COMHAFAT, 2013.
15. Merona B, Hecht T, Moreau J. Croissance des poissons d'eau douce africains dans C. Lévêque MN, Bruton GW, Ssentongo. Biologie et écologie des poissons d'eau douce africains, ORSTOM, 1994.
16. Almeida FM. Manuel de Production d'alevins de Tilapia (*Oreochromis niloticus*) au Bénin, MAEP, 2013.
17. Gourène G, Teugels G. Différenciation morphologique de souches des tilapias: *Oreochromis niloticus* et *O. aureus* (Teleostei; Cichlidae) utilisées en pisciculture. Cybium. 1993; 17(4):343-355.
18. Thys van den, audenaerde DFE. Bijdrage tot een systematishe bibliographische monographie van het genus Tilapia (pisces: Cichlidae). Ph. D. Thesis, Rijksuniversiteit Gent, Belgium, 1970, 261.
19. Teugels GG. A systematic revision of African species of the genus *Clarias* (Pisces, Clariidae). Annales du Musée Royal de l’Afrique Centrale. Sciences zoologiques, 247, Tervuren, Belgique, 1986, 199.
20. Rice WR. Analyzing tables of statistical test. Evolution. 1989; 43:223-225.
21. Decru E, Vreven E, Snoeks J. A version of the West African *Hepsetus* (Characiformes: Hepsetidae) with a description of *Hepsetus akawo* sp. nov. A redescription of *Hepsetus odoe* (Bloch, 1794). J Nat Hist. 2012; 46:1-23.
22. Amoussou TO, Toguyeni A, Imorou Toko I, Chikou A, Youssao AK. Analysis of Morphological Parameters of Wild Populations of *Oreochromis niloticus* (Linnaeus, 1758) of Three Hydrographic Basins of Southern Benin. Eur J Acad Ess. 2017; 4(1):1-11.
23. Lederoun D. Ichtyofaune du bassin du fleuve Mono (Bénin et Togo) : diversité, écologie et impacts anthropiques. Thèse de doctorat de l’Université de Liège, Belgique, 2015, 376.
24. Adepo-Gourène B, Gourène G. Différenciation morphologique des populations naturelles d’une sous espèce de tilapia *Sarotherodon melanotheron melanotheron* Rüppell, 1852 (Teleostei; Cichlidae) de Côte d’Ivoire. Sci Nat. 2008; 5(1):15-27.