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Systematic Status of six Mugilidae Species in the Ivorian Lagoons

KONAN Kouakou Théodore[1], ADÉPO – GOURÈNE Abouo Béatrice[2], KONAN Koffi Mexmin[1], and GOURÈNE Germain[1]

[1]Department of Environment and Aquatic Biology, University Nanguy Abrogoua, 02 BP 801 Abidjan 02, Ivory Coast

[2]Department of Animal Genetic, University Nanguy Abrogoua, 02 BP 801 Abidjan 02, Ivory Coast

ABSTRACT: We applied a meristic characters and stomach shapes description approach to resolve the taxonomic status among two genera and six species (*Mugil curema* Valenciennes, 1836, Mugil *cephalus* Linnaeus, 1758, *Mugil bananensis* (Pellegrin, 1927), *Liza grandisquamis* Valenciennes, 1836, *Liza dumerili* (Steindachner, 1870), *Liza falcipinnis* (Valenciennes, 1836) of the Mugilidae family living in the Ivorian Lagoons. Moreover the systematic relationship of *M. bananensis* among other mullet species was investigated in the present study for the first time. Hierarchical cluster analyses of meristic characters in the present study were very discriminative in terms of taxonomic classification of the mullets. According to meristic data in UPGMA tree, all six species were grouped in two main branching. In the first branch, *L. falcipinnis* and *L. grandisquamis* were clustered as closest taxa, and being the sister group to the *Mugil curema*. In the second branch, *L. dumerili* and *M bananensis* were clustered as a most differentiated species respectly from all other *Liza* and *Mugil* species. *L. dumerili* described in this study was near to those described in Lower Guinea that those described in Ivory Coast. *Liza* genus is probably non-monophyletic assemblage. The stomach of the *Mugil* genus species were characterized by two pyloric caeca contrary to the species of *Liza* genus that had more than two pyloric caeca. However, stomach shapes were different between these species except to *M. curema* and *M. bananensis*.

KEYWORDS: Systematic, meristic, morphological, stomach, species, Mugilidae, lagoons.

1 INTRODUCTION

Mullets have worldwide distribution and inhabit tropical and temperate seas; a few spend their lives in freshwater [1]. Despite the ecological and economical importance of grey mullet [2], the taxonomy and evolutionary relationships among the species so far remains largely unresolved [3]. A major reason is that most morphological characters classically used in species identification and/or systematics are remarkably similar within the family **(**[4]-[5]**)**. Mugilidae taxonomy and nomenclature have still not been finalized [3], with between 14 and 20 genera being recognized as valid according to the most recent revisions ([5]**,** [6]-[1]**)**. The Integrated Taxonomic Information System recognizes 16 valid genera [7], while [8] list 20 valid genera. Most of these are included in the genera *Mugil* and *Liza*, which have 12 and 23 species respectively. These two genera currently represent 40% of the species richness within the family Mugilidae [8].

Six species of Mugilidae are signalized in West African estuaries and lagoons under different names (*M. cephalus, M. curema, M. bananensis, L. falcipinnis, L. dumerili* and *L. grandisquamis*).

In Ivory Coast, the Mugilidae are one of the highly exploited species ranking close to Cichlidae, Clupeidae and Carangidae in fisheries importance in the Aby, Ebrié and Grand-Lahou lagoon systems [9]. In spite of this, knowledge on these species in Ivory Coast remains fragmented and most fisheries statistics of Ivory Coast to not provide adequate information to allow assessment of species richness of this family in artisanal and commercial fisheries. Records from the Fisheries Department groups all species of this family under the term “mullet”, because of the difficulty of distinction of different species**.**

To date limited number of studies on morphologic between species and genera in the Mugilidae family in the Ivorian lagoons has been found [9]. These autors investigated five species (*Mugil cephalus, M. curema, L. falcipinnis, L. dumerili* and

L. grandisquamis) of the Mugilidae family with morphologic data only in Ebrie lagoon. On the other hand, it appears that there is lack of systematic studies comprising all the species using morphologic, morphometric and meristic data together in this lagoon. Also the systematic position of *M. bananensis* among other mullet species was investigated in the present study for the first time using meristic characters.

Meristic characters have been widely used in studies of fish populations and species. Unlike body proportions or coloration, meristic characters are fixed usually at or before metamorphosis and remain constant throughout the life of an individual [10]. Variation in meristic characters stems from both genetic variation between populations and species, and from environmental variation, which, within genetically controlled limits, can directly affect the number of parts formed in developing embryos and larvae. Some reviews of factors known to affect meristic characters in fishes include references [11], [12], [13] and [14].

The aim of this study is to contribute to the understanding of the systematic relationship of the Ivorian lagoons Mugilidae species using meristic characters and stomach description.

2 MATERIAL AND METHODS

2.1 MATERIAL

A total of 792 specimens were collected in the lagoons of Ebrie, Aby and Grand-Lahou (Figure 1): 537 specimens between February 2007 and August 2009 in the lagoon of Ebrié and 144 specimens in Grand-Lahou and 111 specimens in Aby respectively in March 2010 and September 2011. All samples were collected from commercial fishing.

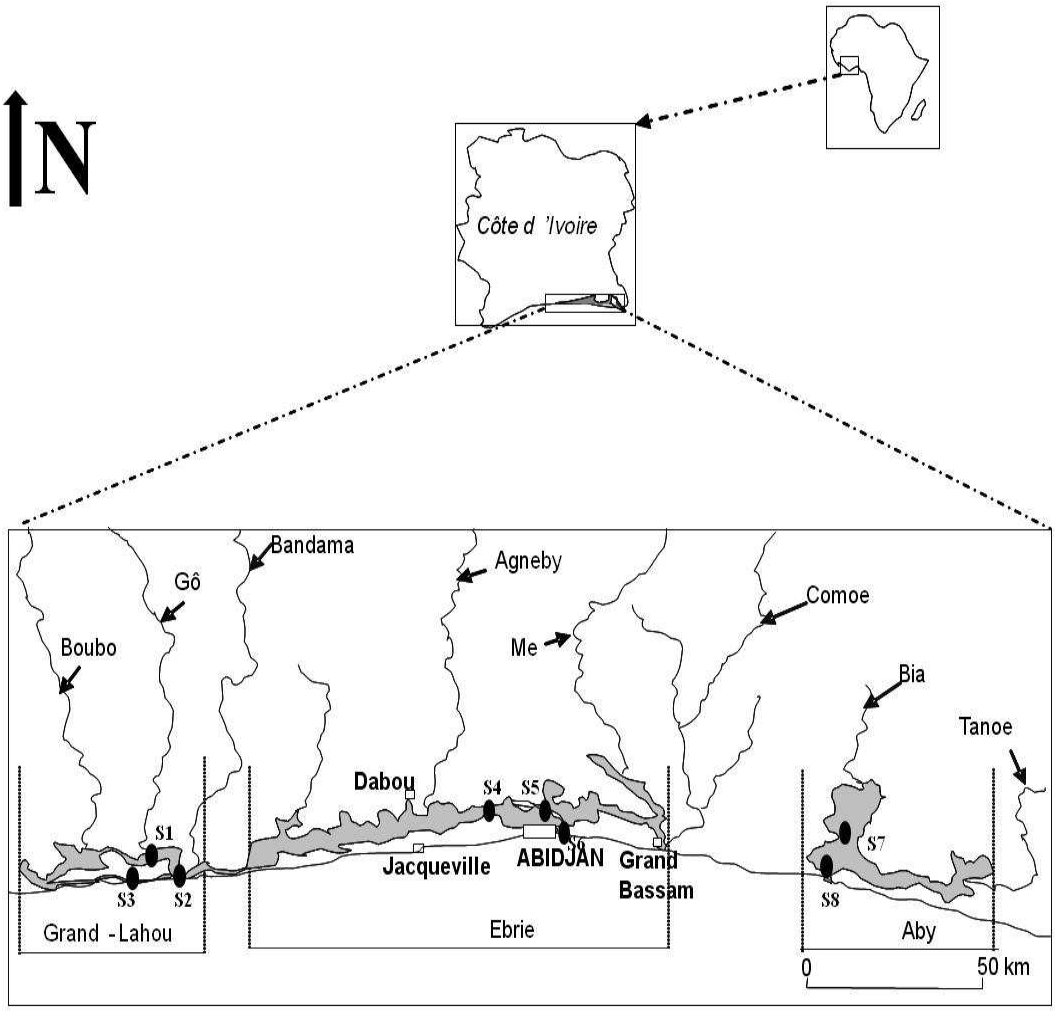

Figure 1: Map showing the sample sites in the different lagoon (Grand-Lahou (S1, S2, S3), Ebrie (S4, S5, S6) and Aby (S7, S8)).

Eleven meristic characters used to describe mullets were examined using the number of: first dorsal rays (DR1), second dorsal rays (DR2), pelvic soft rays (PeR), pectoral soft rays (PcR), anal soft rays (AR), anal spines (AS), scale lines (ScL), scales on longitudinal line (ScLL), branchiospines on the inferior part of the first branchial (Inf Brsp), branchiospines on the superior part of the first branchial (Sup Brsp) and microbranchiospines of the first branchial arch (MicBrsp) under a binocular microscope.

After stomach shapes description, pyloric caeca were enumerated for each species.

Table 1. Location and biological features of mullet species. Minimal-Maximum (Min – Max) of Standard length (SL) of each species.

sites	Location	*Liza dumerili*	*Liza falcipinnis*	*Liza grandisquamis*	*Mugil curema*	*Mugil bananensis*	*Mugil cephalus*
S1	5°18' N 5°11' W	14	16	0	3	8	8
S2	5°16' N 5°02' W	7	11	10	8	5	24
S3	5°13' N 5°20' W	11	9	6	0	16	6
S4	5°30' N 4°20' W	13	26	4	0	8	13
S5	5°29' N 4°04' W	47	56	38	33	43	86
S6	5°27' N 3°95' W	6	11	11	21	19	61
S7	5°23' N 3°22' W	3	12	0	0	24	7
S8	5°14' N 3°27' W	10	15	0	14	21	19
Total		111	156	69	79	224	144
SL (Min - Max (mm))		120.29 - 267.15	136.36 - 281	89.82 - 198.96	118.31 - 271	97.94 - 232.57	147.04 - 460

2.2 MULTIVARIATE ANALYSES

Meristic characters were used in the multivariate analyses. It was submitted to a canonical discriminant function analysis (DFA), and discriminant function (DF) scores were used in hierarchical cluster analyses using STATISTICA 7.1 statistical package program. The DFA combines a selection of meristic measures to produce a mathematical function, which can be used to classify individuals into groups. In hierarchical cluster analyses, UPGMA dendogram based on Squared Euclidean distance was constructed to monitor taxonomic relationships among the species that does not plot actual distances but rescales the distance to numbers between 0 and 100.

3 RESULTS

3.1 MERISTIC ANALYSIS

Observed meristic characters of nine mullet species (Table 2) were in the range of their description given by [1]. Highly significant ($p < 0.001$) differences between species were observed from all meristic characters. Dorsal rays (DR1), anal spines (AS) and pelvic soft rays (PcR) were constant in each group and could not be computed in the Univariate analysis.

Table 2. Observed meristic counts of the six mullet species.

Species	DR2	PcR	AR	ScL	Sup Brsp	Inf Brsp	MicBrsp	ScLL	PC
Liza dumerili	I 7 - 9	15 – 17	III 8 – 10	10 – 13	15 – 18	26 – 43	57 – 73	34 – 41	7
Liza falcipinnis	I 8 - 10	14 – 18	III 8 – 12	11 – 14	27 – 50	58 – 72	91 – 127	34 – 41	+ 20
Liza grandisquamis	I 7 - 9	14 - 17	III 8 – 9	9 – 10	32 – 39	40 – 47	87 – 105	25 – 30	8
Mugil curema	I 7 – 9	14 – 17	III 9 – 10	11 – 13	26 – 44	50 – 70	103 – 123	36 – 40	2
Mugil bananensi	I 8 - 9	14 – 17	III 7 – 8	11 – 13	19 – 39	26 – 45	65 – 84	34 – 40	2
Mugil cephalus	I 8	16 – 18	III 7 – 8	13 – 15	43 – 58	62 – 89	123 – 165	40 – 44	2

The first discriminant function explained 50.1% of between group variability and the second, third fourth and fifth explained 33.45%, 9.5%, 6.63%, 0.32% respectively (Table 3). Component loadings showed that AR, Inf Brsp, Sup Brsp, ScLL, MicBrsp characters are playing key role to differentiate species respectively (Table 4). Variables are ordered in the table 3 by size of discriminating within the species according the test of lambda of Wilk.

Table 3. Contribution of meristic variables to the canonical functions. *, indicate largest correlation between each variable and any discriminant function

Meristic	Fonction 1	Fonction 2	Fonction 3	Fonction 4	Fonction 5
DR2	-0.12	-0.30	0.20	-0.10	-0.88*
PcR	-0.13	-0.02	0.06	-0.04	0.19*
AR	-0.21	-0.89*	0.07	-0.27	0.20
ScL	-0.34	0.18	0.33	-0.38*	-0.02
Sup Brsp	-0.30	0.08	-0.72*	-0.38	-0.01
Inf Brsp	-0.63*	-0.04	0.22	0.53	0.15
MicBrsp	-0.55*	0.12	-0.43	0.17	-0.16
ScLL	-0.30	0.24	0.41	-0.55*	0.20

The UPGMA cluster analysis did not cluster species on the bases of current meristic status of Mugilidae (Figure 4). Two main branching were produced: *Mugil bananensis* and *Liza dumerili* seen to be meristically most divergent from the other species and was branched as a first group. In the second branch, *L. falcipinnis* was clustered as a closest taxa to *L. grandisquamis*, being the sister group to *M. curema* and *M. cephalus* were branched more divergently from these two species.

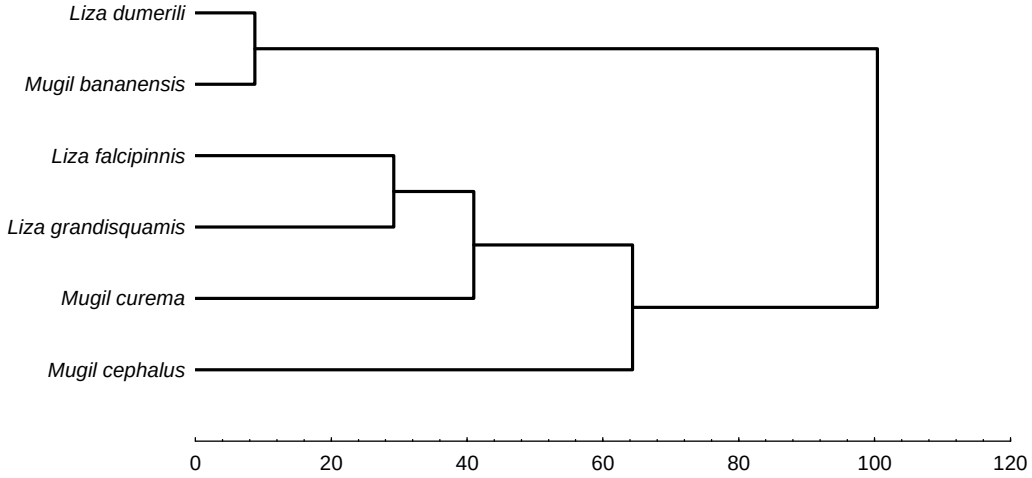

Figure 3. UPGMA tree of Squared Euclidiean distances based on meristic data.

Table 3: Discriminatory power of meristic characters retained by stepwise discriminant analysis. Variables ordered by size of discriminating within the species; ***: p<0.001.

Meristic	ʎ-Wilk	F	dl	p
AR	0,13	997,56	5	***
Inf Brsp	0,31	347,16	5	***
Sup Brsp	0,37	266,15	5	***
ScLL	0,48	168,33	5	***
MicBrsp	0,56	119,15	5	***
DR2	0,72	59,18	5	***
ScL	0,73	57,49	5	***
PcR	0,93	12,06	5	***

3.2 STOMACH DESCRIPTIONS

The species of the *Mugil* genus were characterized by two pyloric caeca contrary to the species of *Liza* genus that had more than two pyloric caeca (Figure 4). However, stomach shapes were different between these species except to *M. curema* and *M. bananensis*.

- *Mugil cephalus*: a conical stomach with two pyloric caeca of approximately equal length.
- *M. bananensis* and *M. curema*: a stomach slightly swollen to the œsophagus-stomach junction level; with a saucer shape, stomach has two pyloric caeca of which one short and other length.
- *Liza falcipinnis: stomach with a* very muscular part and a handle less muscular with of which a pointed end. Stomach downstream side is covered in more pyloric caeca (more than twenty) arranged on two superimposed levels with.
- *Liza grandisquamis*: stomach formed to two very muscular parts with eight (8) equal length pyloric caeca.
- *Liza dumerili*: stomach slightly narrow of which the superior part had seven (7) pyloric caeca. Them size diminish progressively to the pylorus.

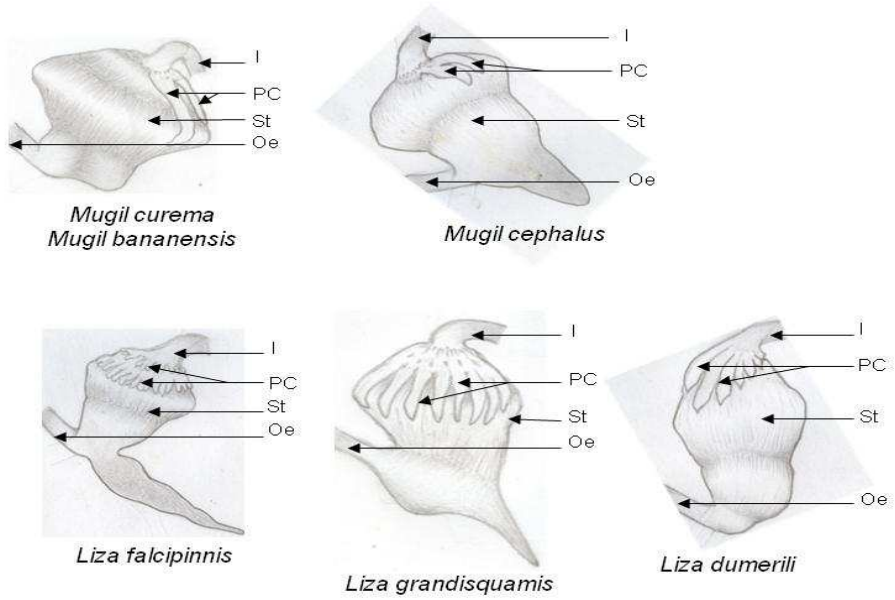

Figure 4. Stomach shape and the pyloric caeca of different Mugilidae species: I: Intestine, PC: pyloric caeca, Oe: oesophaga, St: stomach.

4 DISCUSSION

Previous investigations using various anatomical characters have provided conflicting hypotheses on the systematic relationships within the family Mugilidae **(**[6], [15]**,** [4]- [5]**)**. Taxonomic description of fishes has commonly relied on the description of unique sets of morphological characters. Meristic characters in the present study were rather more discriminative in terms of taxonomic classification of the mullets. Superior and inferior branchiospines and microbranchiospines on the first branchial arch, scales on longitudinal line, anal fins and pectoral fins, and also pyloric caeca were most discriminative characters in the present classification of mullets. Such characters are phylogenetically informative to distinguish between species of the Mugilidae. Meristic characters and stomach descriptions permit to the reference [16] to identify *Mugil soiuy* from the Aegean Coast of Turkey. The same method permit to the author [17] to characterize *Mugil cephalus*, *Liza ramada*, *Chelon labrosus, Oedalechilus labeo, Liza aurata, Liza abu, Liza saliens, Liza carinata* in the Mediterranean Sea.

The present meristic analysis within the family Mugilidae did not reveal similar pattern of morphologic results among the species. UPGMA tree splited *Liza* and *Mugil* genera species each one into two main clusters. In the first group, *M. cephalus* was clustered with its sister species *M. curema*, supporting monophyletic status of *Mugil* genera. The results revealed that *M. bananensis* was morphologically more divergent than *M. cephalus* and *M. curema* from the other Ivorian taxa. However, in a molecular systematic using phylogenetic analyses of nucleotide sequence variation at three mitochondrial loci (16S rRNA,

cytochrome oxidase I, and cytochrome b) study made by the reference [7], *M*. *curema*, *M*. *cephalus* and *M*. *bananensis* were clustered into a single, well-supported clade. According to the reference [7] in the same study, a greatest genetic differentiation was observed between *L*. *dumerili* and all the other *Liza* species studied, while *L. falcipinnis* and *L. grandisquamis* were relatively the closest taxa. This observation corroborate our result. *L*. *grandisquamis* is grouped within the *Liza* genera and sister group into *Liza falcipinnis*. However *L. dumerili* was clustered separately of the two other species of *Liza* genera. Systematic status to this species is very controversial. *L. dumerili* described in this study was near to those described by the author [18] in Lower Guinea that those described by the reference [9] in Ivory Coast. Some authors have suggested that geographically distant populations should be recognized as different subspecies. The reference [19], studying mullets from Mauritania and Senegal, recognized *L. dumerili* in two subspecies: *L. saliens dumerili* from the north with 37-42 scales in longitudinal series, and *L. saliens hoefleri* in the south with 33 - 42 scales. The reference [20] recognized two subspecies of *Liza dumerili*: *L. d. dumerili* characterized by 37- 41 branchiospines and distributed from Senegal to the Niger River; and *L. d. canaliculatus* characterized by 45-55 branchiospines and distributed from the Congo River to Mozambique. According to the reference [15], *Liza* is probably non-monophyletic assemblage and new genera are currently being split from it [21].

Our present study indicated that the three *Mugil* species were characterized by Stomach with two pyloric caeca, while those of *Liza* genus had more two. *M. cephalus* stomach shape was clearly separated from M. curema and M. bananensis that were morphologically similar. However, pyloric caeca and stomach shape of the species *Liza* genus were both clearly different from each other.

To summarize, meristic characters and stomach descriptions have been successfully used for these six species problematic identification and showed a clear distinction between them. However, except to stomach descriptions, pyloric caeca didn't discriminate each species of the *Mugil* genus. The meristic parameters were the most determinative in the differentiation of these species. For a better understanding of these species, this study should be complemented with genetic and osteological analyses to verify the morphological differences. This study showed 6 species against 5 recorded by [9]. In addition, further systematic analyses are necessary for a better description of the *Liza* genus, mostly for *Liza dumerili* species. A key to species of mugilid fishes is given as follows:

Key to species of Mugilidae in Ivory Coast

Genus *Mugil* Linnaeus, 1758

1. - 9 (rarely 10) anal soft rays ..... *Mugil curema*

   - 7 à 8 anal soft rays **2**

2 **-** 11 à 13 scale lines ; 26 – 45 branchiospines on the inferior part of the first branchial arch ; 19 – 39 branchiospines on the superior part of the first branchial arch ..... *Mugil bananensis*

- 13 à 15 scale lines ; 62 – 89 branchiospines on the inferior part of the first branchial arch ; 43 – 58 branchiospines on the superior part of the first branchial arch ; 123 à 165 microbranchiospines on the first branchial arch ..... *Mugil cephalus*

Genre *liza* Jordan et Swain, 1884

1. - 25 à 30 scales on longitudinal line ..... *Liza grandisquamis*

   - 34 – 41 scales on longitudinal line 2

2. 9 (rarely 8 or 10) anal soft rays ; 26 – 43 branchiospines on the inferior part of the first branchial arch ; 15 – 28 branchiospines on the superior part of the first branchial arch ..... *Liza dumerili*

1. 11 (rarely 10 or 12) anal soft rays ; 58 – 72 branchiospines on the inferior part of the first branchial arch ; 27 – 50 branchiospines on the superior part of the first branchial arch ..... *Liza falcipinnis*

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REFERENCES

[1] J. S. Nelson, Fishes of the World. John Wiley and Sons, New York, pp. 262 – 263, 2006.

[2] J. M. Thomson, "The grey mullets", *Oceanography* and *Marine Biology* - An *Annual Review*, vol. 4, pp. 301-355, 1996.

[3] I. J. Harrison, M. Nirchio, C. Oliveira, E. Ron and J. Gaviria, "A new species of mullet (Teleostei: Mugilidae) from Venezuela, with a discussion on the taxonomy of *Mugil gaimardianus*", *Journal of Fish Biology*, Vol. 71, pp. 76-97, 2007.

[4] L. P. Schultz, "A revision of the genera of mullets, fishes of the family Mugilidae, with descriptions of three new genera", *Proceedings of The United States National Museum,* vol. 96, pp. 377-395, 1946.

[5] J. M. Thomson, "The Mugilidae of the world", *Queensland Military Memorial Museum*, vol. 41, pp. 457-562, 1997.

[6] J. Ghasemzadeh, Phylogeny and Systematics of Indo-Pacific mullets (Teleostei: Mugilidae) with special reference to the mullets of Australia, Ph. D. dissertation. Macquarie University, Sydney, p. 397, 1998.

[7] J.-D. Durand, K.-N. Shen, W.-J. Chen, B.W. Jamandre, H. Blel, K. Diop, M. Nirchio, F. J. García De León, A. K. Whitfield, C.-W. Chang and P. Borsa, "Systematics of the grey mullets (Teleostei: Mugiliformes: Mugilidae): Molecular phylogenetic evidence challenges two centuries of morphology–based taxonomy", *Molecular Phylogenetics and Evolution*, vol. 64, pp. 73-92, 2012.

[8] W. N. Eschmeyer and R. Fricke, Catalog of fishes, electronic version: http://research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp (5 May 2011).

[9] J-J. Albaret and M. Legendre, "Biologie et écologie des Mugilidae en lagune Ebrié (Côte d'ivoire). Intérêt potentiel pour l'aquaculture lagunaire", *Revista De Biologia Tropical*, vol. 18, n° 4, pp. 281-304, 1985.

[10] K. J. Robert and M. A. Barnett, "An inverse correlation between meristic characters and food supply in mid-water fishes: evidence and possible explanations", *Fishery bulletin*, vol. 73, n° 2, pp. 284 – 298, 1975.

[11] G. W. Barlow, "Causes and significance of morphological variation in fishes", *Systematic Zoology*, vol. 10, pp. 105-117, 1961.

[12] J. H. S. Blaxter, Development: Eggs and larvae. *In:* W. S. Hoar and D. J. Randall (Eds.), Fish physiology, vol. 3, pp. 177-252, 1969.

[13] E. T. Garside, "Developmental rate and vertebral number in salmonids", *Journal of the Fisheries Research Board of Canada*, vol. 23, pp. 1537-1551, 1966.

[14] J. A. Fowler, "Control of vertebral number in teleosts-an embryological problem", *Quarterly Review of Biology,* vol. 45, pp. 143-167, 1970.

[15] I. J. Harrison and G. J. Howes, "The pharyngobranchial organ of mugilid fishes; its structure, variability, ontogeny, possible fonction and taxonomic utility", *Bulletin of the British Museum of Natural History (Zool.)*, vol. 57, pp. 111–132, 1991.

[16] M. Kaya, S. Mater, and A. Y. Korkut, "A New Grey Mullet Species "Mugil so-iuy Basilewsky" (Teleostei: Mugilidae) from the Aegean Coast of Turkey", *Turkish Journal of Zoology*, vol. 22, pp. 303-306, 1998.

[17] C. Turan, M. Gürlek, D. Ergüden, D. Yağlıoğlu and B. Öztürk, "Systematic Status of Nine Mullet Species (Mugilidae) in the Mediterranean Sea", *Turkish Journal of Fisheries and Aquatic Sciences,* vol. 11, pp. 315-321, 2011.

[18] I. J. Harrison, Mugilidae. *In* : M. L. J. Stiassny, G. G. Teugels and C. D. Hopkins (Eds.), Poissons d'eaux douces et saumâtres de basse Guinée, ouest de l'Afrique centrale. Faune et flore tropicales. Edition IRD, vol. 2, pp. 450 – 471, 2007.

[19] M . Delais, "Notes d'ichtyologie ouest-africaine. IX. Sur *Liza Dumerili* Stein et *hoefleri* Stein", *Bulletin de l'Institut Fondamental d'Afrique Noire,* vol. 16, pp. 592-598, 1954

[20] E. Trewavas and S. E. Ingham, "A key to the species of Mugilidae (Pisces) in the Northeastern Atlantic and Mediterranean, with explanatory notes", *Journal of Zoology (London)*, vol. 167 , pp. 15-29, 1972.

[21] J. Ghasemzadeh, W. Ivantsoff, Aarn, "Historical overview of mugilid systematics, with description of *Paramugil* (Teleostei : Mugiliformes : Mugilidae), new genus", *Aquaculture*, vol. 8, n° 1, pp. 9-22, 2004