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Characterization of the production factors of the fishing industry and specific diversity in the Aghien lagoon (Ivory Coast)

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Abstract
The study of fishing activity on the Aghien Lagoon (Ivory Coast, West Africa), conducted from April 2019 to May 2020 identified 402 fishermen. This population is composed of Ivorians (73.38%) and foreigners (26.62%). The fishing activity is controlled by two categories of fishermen: professionals who only fish (42.53%) and occasional fishermen with an accessory activity (57.47%). Ivorian fishermen are mostly farmer-fishermen. The fishing activity is dominated in this lagoon by adults between 30 and 45 years old (48.26%). These fishermen have a high literacy rate (73%). The fishing techniques used in this lagoon are pots, hawks, gillnets, longlines, beach seines and bamboo traps. The high presence of *Chrysichthys nigrodigitatus* in the catches of all the gears could lead to an imbalance in this ecosystem containing 45 species divided into 25 families and 8 orders.

Keywords: Aghien lagoon, artisanal fishing, fishing gear, Ivory Coast

1. Introduction
Lagoon fishing contributes to food and nutritional security without forgetting the monetary income and other socio-cultural utilities that it brings to the populations living in the rivers and lakes [1]. Thus, it constitutes an economic stake for these riparian communities [2]. In Ivory Coast, fishing activity is carried out by fishermen, fishmongers and smokers who play an important role in the development of fishery products [3]. Artisanal fishing therefore appears to be well structured, but the lack of information at certain stages constitutes a handicap in the development and conduct of development and management plans for this sector of activity [4]. The Aghien lagoon is no exception to this situation insofar as the work carried out on this lagoon show that no rational management plan has been formulated for this body of water [5]. This study on characterization of the production factors of the fishing is part of a series of works aimed at establishing a database on the fishing activity practiced in the lagoons of Ivory Coast with a view to a management plan for these water bodies. It was carried out on the Aghien lagoon in order to deepen knowledge about fishing in this lagoon. It attempts to describe the organization of fishermen, on the one hand; the machines, their techniques of use and their selectivity on the Aghien lagoon, on the other hand.

2. Materials and Methods
2.1. Description of the Study Area
The works were carried out on the Aghien lagoon in the locality of Akouyaté located between 5 ° 20'-5 ° 30 'N and 3 ° 50'-4 ° 00' W (figure 1)

2.2. Sampling collection
Daily monitoring of fishing activities on the Aghien Lagoon through surveys at selected sites in the study area were conducted during this study. The technique of data collection has 3 components. The survey by questionnaire which consisted of administering to each fisherman, a questionnaire for information concerning the civil status of the fisherman, his nationality, his level of education, his fishing gear and their selectivity and his activities related to fishing. The interview survey, which consisted of questioning the fishermen about the functioning of the fish sector in the study area. The direct observation of the facts, which consisted of following

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the actors in their different activities, allowed for the verification of the information collected from the questionnaires. The criteria for classifying fishermen, based on nationality and ethnicity, time spent fishing and the distribution of fishermen by age group are inspired [6-8]. The distribution of fishermen by level of education is done according to Boguhé *et al.* (2011) [9]. The data obtained were processed with Excel soft.
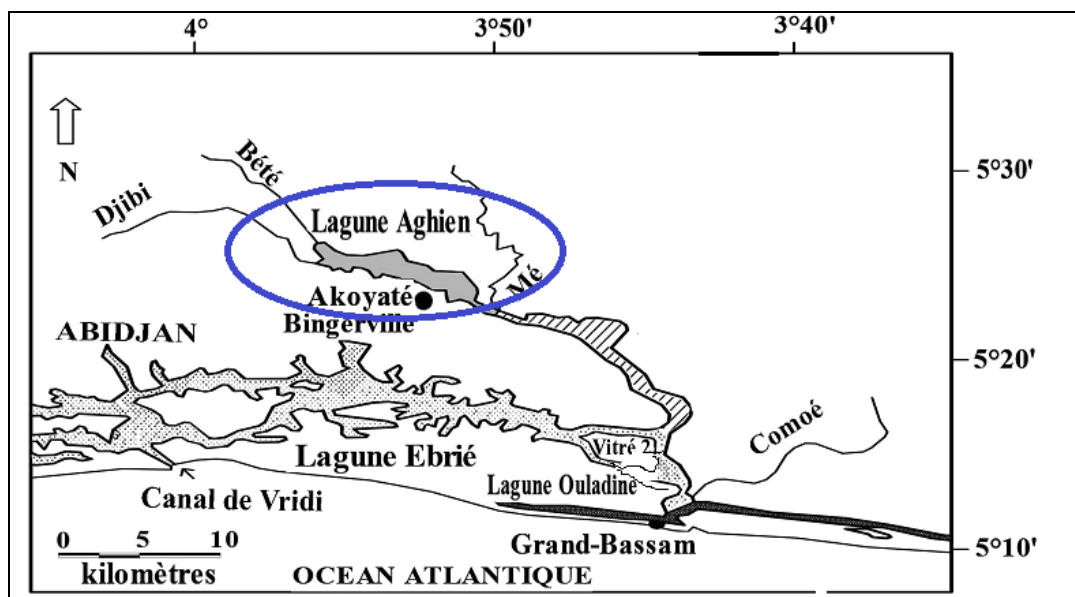

Fig 1: Geographical location of the survey stations (●) on the Aghien Lagoon

3. Results
3.1. Fishers
3.1.1. Nationalities
A total of 402 fishermen were counted on the Aghien Lagoon between April 2019 and May 2020. This workforce is made up of 295 Ivorians (73.38%) and 107 foreigners all Togolese (26.62%) (Figure 2).

3.1.2. Age range
The dominant age group in the population of fishermen surveyed is adults between the ages of 30 and 45 (48.26%). Older people (26.62%) outnumber younger people (25.12%) in this population (Figure 3).

3.1.3. Study level
The fishermen of the Aghien Lagoon who have a level of education (73%) are more numerous than the illiterate (27%). Figure 4 presents the distribution of literate fishermen according to the level of education. Fishermen with secondary education (49%) are more represented than those with primary education (24%).

3.1.4. Professional category
Two categories of fishermen have been identified throughout the Aghien Lagoon (Figure 5). These are: -professional fishermen who are the least numerous (42.53%). These are individuals who have only fishing as an activity and practice it all year round. -Occasional fishermen (57.47%), who fish to meet their food needs or to solve a specific financial problem, are the most present in this population. They combine fishing with other income-generating activities. They are mostly Ivorians. The majority of fishermen (88%) carry out their activity individually. Collective fishing accounts for 12% of this population.
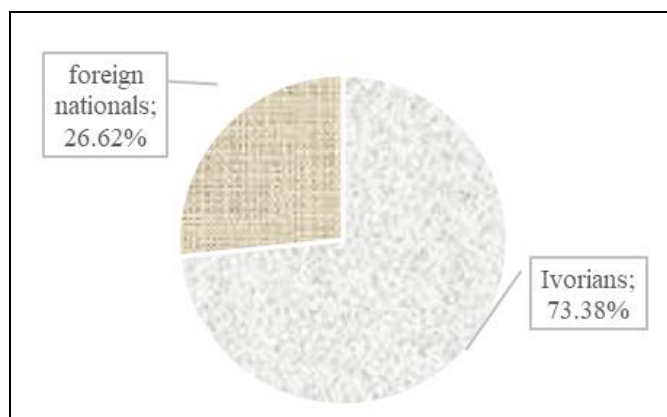

Fig 2: Distribution of fishermen identified on the Aghien lagoon from April 2019 to March 2020 by nationality
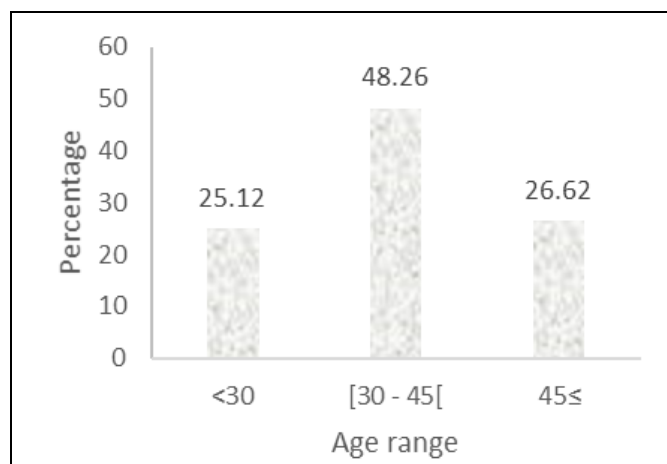

Fig 3: Distribution of fishermen identified on the Aghien lagoon from April 2019 to March 2020 by age range.

3.1.5. Activities related to fishing

The activities related to fishing, carried out by the fishermen on the Aghien lagoon are summarized in Table 1. In general, fishermen associate agriculture with fishing (50.50%). They are divided between 49.25% Ivorians and 1.25% foreigners. Only the Ivorians associate fishing with trade (06.22%), fish farming (00.5%), agriculture and sewing (00.25%).
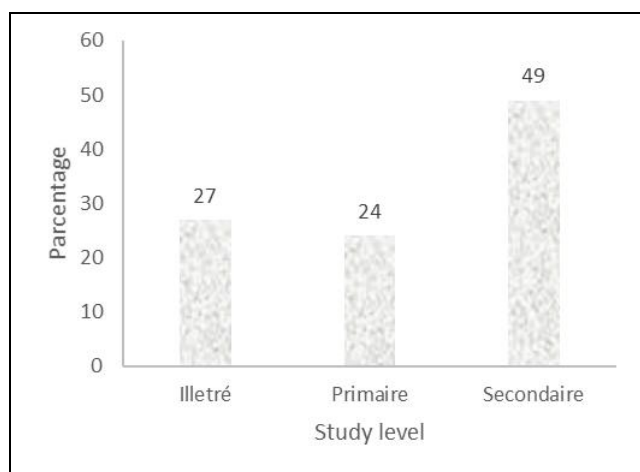

Fig 4: Distribution of fishermen identified on the Aghien Lagoon from April 2019 to March 2020 by study level
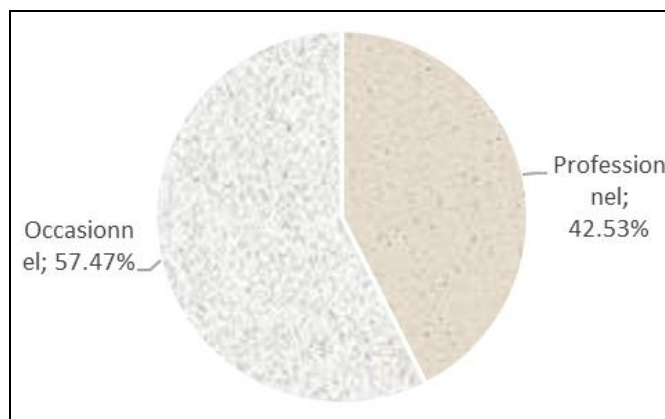

Fig 5: Distribution of fishermen identified on the Aghien Lagoon from April 2019 to March 2020 by occupational categories

3.1.6. Fishing equipment
3.1.6.1. Inventory and utilization rates

Six types of fishing gear are used by fishermen (Table 2). These are long lines, pots, bamboo traps, gill nets, beach seines and hawksbills. It appears from this table that professional fishermen use more gill nets (51.46%), longlines (17.54%) and pots (16.34%). The occasional fishermen prefer, in decreasing order, gill nets (94.37%), bamboo traps (91.77%), longlines (89.61%) and pots (88.31%)

Table 1: Activities identified among fishing communities in Aghien Lagoon from April 2019 to March 2020.

Activités	Ivorian		Foreigners	
	Number	Percentage	Number	Percentage
Fishing only	69	17,16	102	25,37
Fishing + Agriculture	198	49,25	5	01,25
Fishing + Trading	25	6,22	0	0
Fishing + Fish Farming	2	00,5	0	0
Fishing + Agriculture + Sewing	1	00,25	0	0
Total	295	73,38	107	26,62

Table 2: Inventory of fishing gear used by artisanal fishers on the Aghien lagoon, from April 2004 to March 2006

Fishing gear	Professional fishers	Occasional fishers
	Rate utilization (%)	Rate utilization (%)
Longlines	17,54	89,61
Fishnets	16,34	88,31
Bamboo trap	5,26	91,77
Fishnets	51,46	94,37
Beach seines	1,75	00,43
Éperviers	5,26	09,96

3.1.6.2. Sélectivité

The fishing gears used on the Aghien lagoon are in most cases, selective. Selective gear is defined as gear that catches essentially one or two types of fish, without excluding the others. This can be seen in Table 3.

Table 3: Gear selectivity

	Longlines	Fishnets	Bamboo trap	Fishnets			Beach seines	Éperviers
				Sm	Mm	Lm		
Chrysichthys maurus	X	X	X			X		
Chrysichthys nigrodigitatus		X	X					
Pomadasys jubelini	X							
Polydactylus quadrifilis						X		
Sarotherodon melanotheron					X			
Tilapia guineensis					X			X
Tylochromis jentinki jintinki								X
All species included				X			X	

Sm = small mesh; Mm = Medium mesh; Lm = Large mesh

The small mesh nets (10 mm to 30 mm) catch all small fish. Those of medium mesh (30 mm to 50 mm) catch mainly *Tilapia guineensis* and *Sarotherodon melanotheron*. Those of large mesh (50 mm and more) catch essentially *Polydactylus quadrifilis* and *Chrysichthys maurus*.

For the hawksbills, the gears are made for *Tylochromis jentinki jintinki* and *Tilapia guineensis*. Concerning the longlines, the targeted species are *Chrysichthys maurus* and *Pomadasys jubelini.*

The predominant species caught by the creels are *Chrysichthys nigrodigitatus* and *Chrysichthys maurus*. The bamboo traps catch exclusively *Chrysichthys maurus* and *Chrysichthys nigrodigitatus*. The beach seines capture all species regardless of size.

3.1.7. Captures
3.1.7.1. Specific richness
The present study identified 45 species in 25 families and 8 orders (Table 4).

Table 4: Orders, families, and species of fish sampled in Aghien Lagoon from April 2019 to March 2020.

Order	Family	Species
Osteoglossiformes	Notopteridae	*Papyrocranus afer*
	Mormyridae	*Marcusenius furcidens*
		Marcusenius ussheri
		Petrocephalus bovei
Elopiformes	Elopidae	*Elops lacerta*
Clupeiformes	Clupeidae	*Ethmalosa fimbriata*
		Pellonula leonensis
Characiformes	Distichodontidae	*Distichodus rostratus*
	Alestidae	*Brycinus longipinnis*
		Brycinus nurse
	Hepsetidae	*Hepsetus odoe*
Siluriformes	Schilbeidae	*Parailia pellucida*
		Schilbe mystus
	Clariidae	*Clarias ebriensis*
		Clarias gariepinus
		Heterobranchus isopterus
		Heterobranchus longifilis
	Claroteidae	*Chrysichthys auratus*
		Chrysichthys maurus
		Chrysichthys nigrodigitatus
	Mochokidae	*Synodontis bastiani*
Beloniformes	Hemiramphidae	*Hemiramphus balao*
Perciformes	Carangidae	*Caranx hippos*
		Trachinotus teraia
	Gerreidae	*Eucinostomus melanopterus*
	Haemulidae	*Pomadasys jubelini*
		Pomadasys rogerii
	Sciaenidae	*Pseudotolithus elongatus*
		Pseudotolithus senegalensis

Table 5: continuation and end

Ordres	Familles	Espèces
	Polynemidae	*Polydactylus quadrifilis*
	Monodactylidae	*Monodactylus sebae*
	Mugilidae	*Liza falcipinnis*
		Mugil cephalus
		Mugil curema
	Cichlidae	*Chromidotilapia guntheri*
		Hemichromis fasciatus
		Sarotherodon melanotheron
		Tilapia guineensis
		Tilapia mariae
		Tylochromis jentinki
	Gobiidae	*Bathygobius soporator*
	Sphyraenidae	*Sphyraena afra*
	Channidae	*Parachanna obscura*
Pleuronectiformes	Paralichthyidae	*Citharichthys stampflii*
	Cynoglossidae	*Cynoglossus senegalensis*
Total 8	25	45

3.1.7.2. Numerical Abundance
Perciformes dominate the fish catches on the Aghien Lagoon with a proportion of 52%. They are followed by Siluriformes (19%), Elopiformes (9%) and Clupeiformes (7%). The other orders account for 13% of this population (Figure 6). At the family level, the Cichlidae (32%) are the most represented in

the catches. The Claroteidae (14%), Elopeidae (9%), Clupeidae (8%) and Polynemidae (7%) are next. The other families represent 30% of the fish population (Figure 7). At the species level, Tilapia guineensis is the most abundant species in the Aghien Lagoon with 12% of all fish caught.

This species is followed by Elops Lacerta and Chrysichthys nigrodigitatus (9% each), Sarotherodon melanotheron (8%), Tylochromis jentinki and Polydactylus quadrifilis (7% each). The other species represent 48% of this total number (Figure 8)
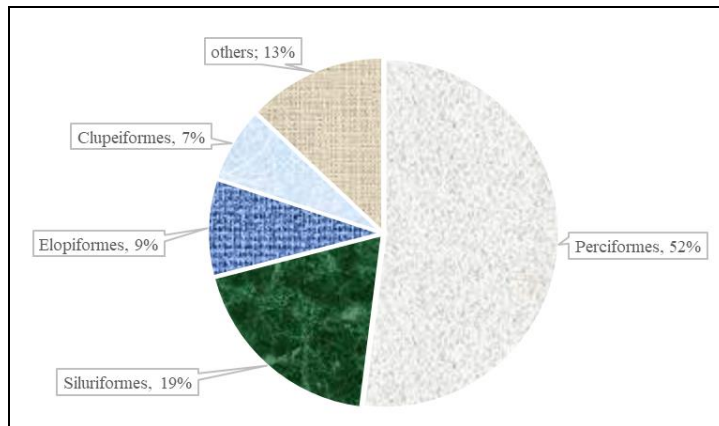

Fig 6: Numerical percentage of major fish orders caught in Aghien Lagoon from April 2019 to March 2020.
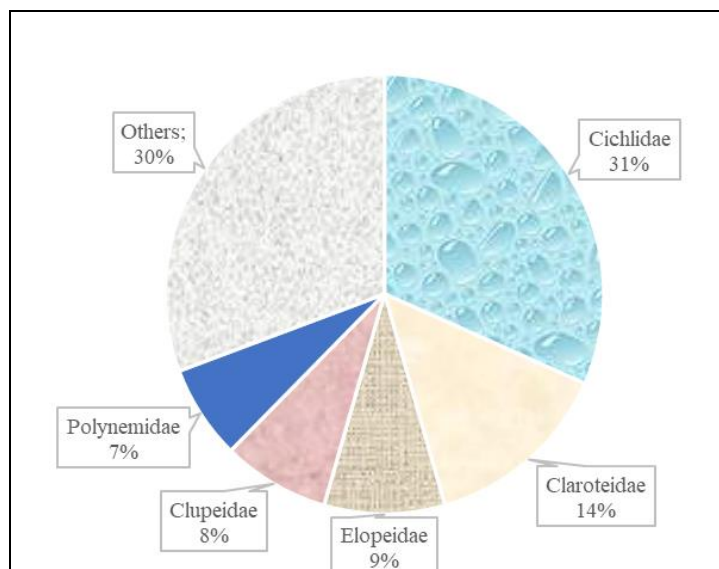

Fig 7: Numerical percentage of major fish families caught in Aghien Lagoon from April 2019 to March 2020
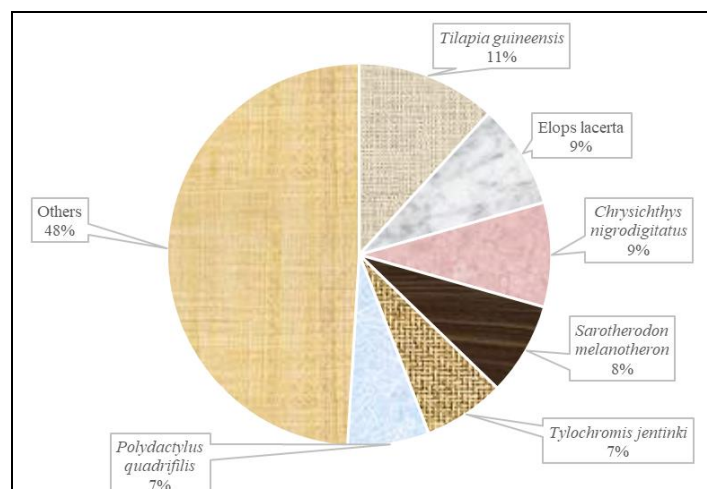

Fig 8: Numerical percentage of major fish species caught in Aghien Lagoon from April 2019 to March 2020

3.1.7.3. Weight abundance
In the Aghien Lagoon, the best represented orders are the Perciformes with 48%. This is followed by the Siluriformes and Clupeiformes (19% each) and the Elopiformes (9%) of the total weight of the catches. The proportion by weight of the other orders is 5% (Figure 9).

The family Clupeidae is the best represented with 19% of the total catch. This family is followed by Claroteidae (18%), Cichlidae (14%), Elopeidae (9%) and Haemulidae (7%). The other families constitute 33% of the weight percentage (Figure 10).

At the species level, the dominant species are in order *Chrysichthys nigrodigitatus* (17%), *Ethmalosa fimbriata* (10%), *Elops lacerta* and *Pellonula leonensis* (9%), *Pomadasys jubelini* (7%) and *Polydactylus quadrifilis* (6%). The proportion of other species was 42% (Figure 11)
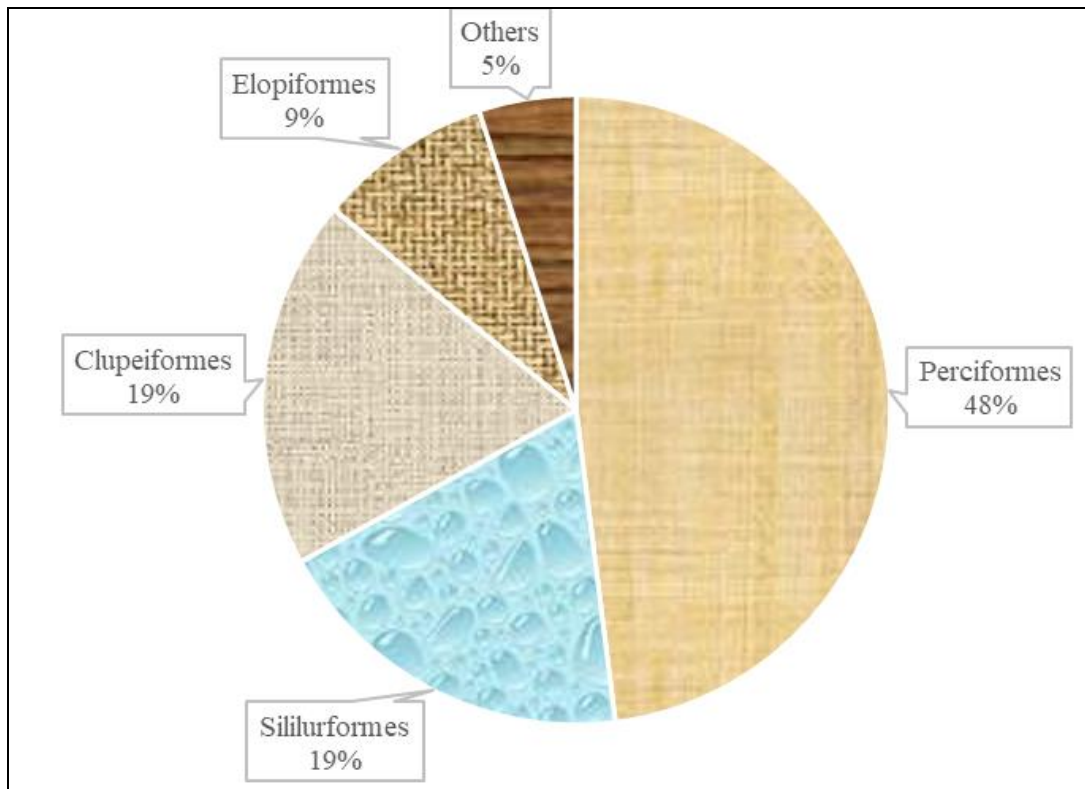

Fig 9: Weight percentage of major fish orders caught in Aghien Lagoon from April 2019 to March 2020
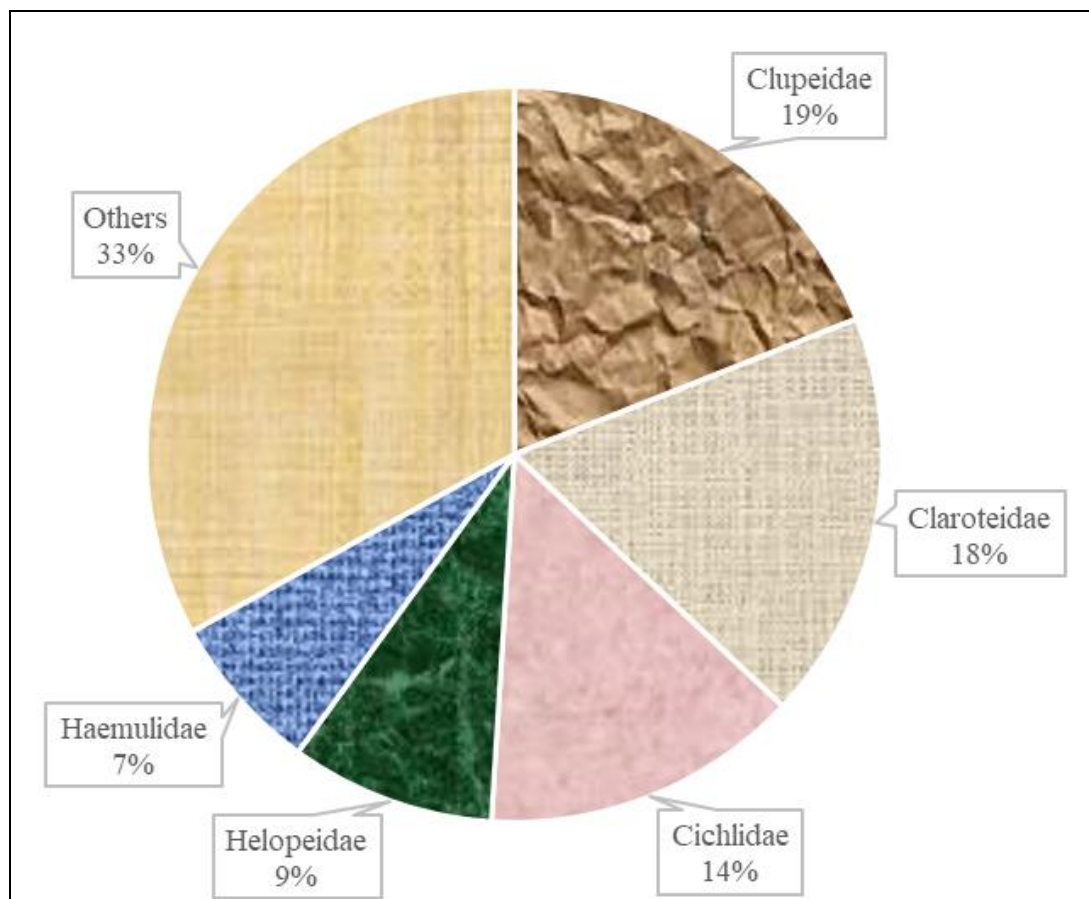

Fig 10: Weight percentage of major fish families caught in Aghien Lagoon from April 2019 to March 2020.
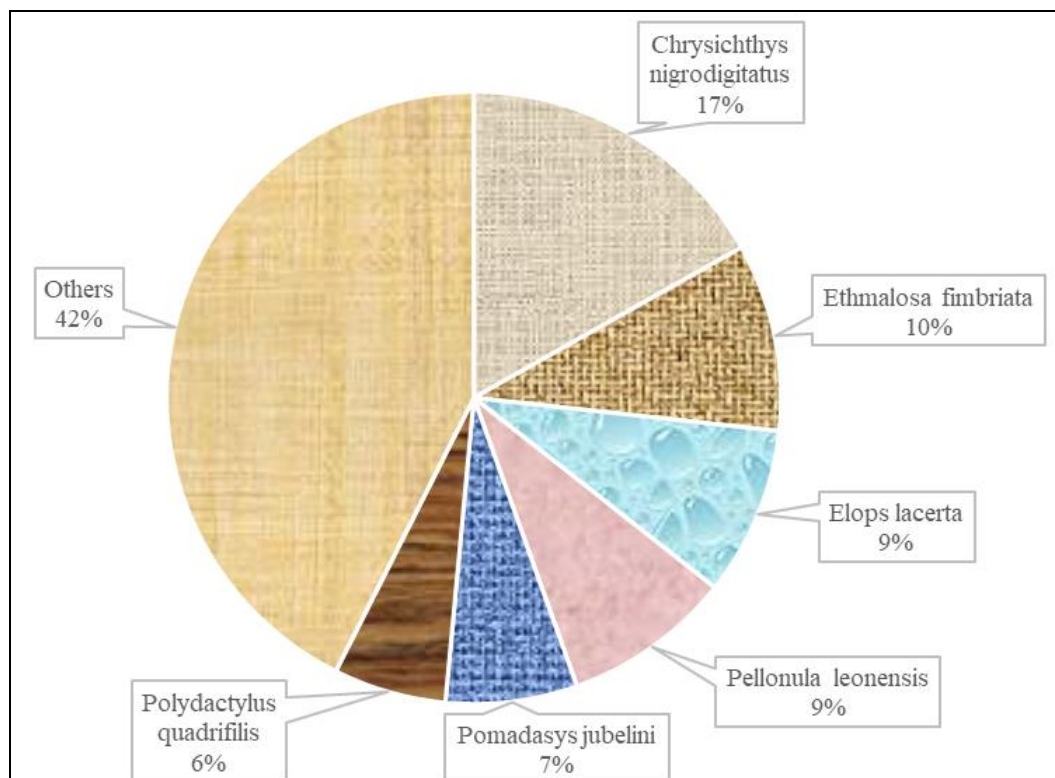
Fig 11: Weight percentage of major fish species caught in Aghien Lagoon from April 2019 to March 2020.

4. Discussion

In the Aghien lagoon, fishing is carried out by foreigners and Ivorians, the majority of whom are adults (48.26%) with a low participation of youth (25.12%). This result is consistent with those of several studies characterizing fishing communities in Ivory Coast [1,6,10]. The presence of foreign fishers could be explained by several reasons: (1) the proximity of their country of origin to Ivory Coast; (2) the ethnic and social characteristics of these fishermen are sometimes very similar to those encountered in Ivory Coast; (3) the high demand for fish, which is likely to guarantee an attractive price, is quite motivating for these foreign fishermen (Vanga, 2001) [6]; and (4) the existence in Ivorian legislation, of few binding provisions for foreign fishermen (Kien *et al*., 2015) [10]. The variable age would condition the professional conscience among fishermen. Indeed, the low enthusiasm of most young people can be explained by the fact that beyond their lack of experience in commercial fishing, they believe that the activity in question is not an asset that they can leave as an inheritance to their descendants. In this case, fishing constitutes a means of acquiring financial resources for the development of agricultural activities (Kien *et al*., 2015 [10] and Goli Bi *et al*., 2019 [11]. The results of the present study show that 50.50% of fishermen associate fishing with agriculture and among them 49.25% of Ivorians. This behaviour of fishermen would result from the fact that Ivorians have a tradition of subsistence fishing (Laë, 1997) [12]. In terms of type of gear, the occasional fishermen, mostly Ivorians, prefer gill nets (94.37%) to bamboo traps (91.77%), longlines (89.61%) and pots (88.31%). This trend is contrary to the results obtained by Boguhé *et al*. (2011) [9], Kien *et al*. (2015) [10] and Goli Bi *et al*. (2019) [11] talking about the Ivorian fishing community. This change in practice clearly shows that Ivorians now accept the gill net technique with courage; a courage that they lacked because they found the management of this type of gear too constraining and preferred traps and bamboo traps that were less expensive,

simple to manage and handle (Kien, 2016) [4]. The study of the selectivity of fishing gears shows that *Chrysichthys nigrodigitatus* is the only one caught by five gears out of the six. This result expresses the pressure on this species. This situation could threaten, in the long term, the qualitative availability of fishery resources, leading to an imbalance in the population to the benefit of tilapia (Vanga, 2001) [6]. It would therefore be important to consider sustainable management plans for the fishery resource on this body of water.

5. Conclusion

The exploitation of fishery resources on the Aghien lagoon is artisanal and individual. It is dominated by occasional, mostly literate, adult fishermen. Among the Ivorians, fishing is mainly a secondary activity. Gill nets are the most widely used engines in the Aghien lagoon. *Chrysichthys nigrodigitatus* is the most common species in the catches of various gears taken on this lagoon. Sustainable management of resources requires the authorities to carry out strict measures to prevent the collapse of the stock of this species and therefore an imbalance in this ecosystem. The conduct of any fisheries development policy must take into account the low level of education of certain actors.

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