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Diversity of phytoplankton for nutritional selectivity by *Galatea paradoxa* (born 1780) of lower sanaga delta, Cameroon

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Abstract
Background: In Cameroon, *Galatea paradoxa* clams are present in the delta of the low Sanaga in Mouanko. There are data gaps concerning clams associated to the present food potential in the low Sanaga. Strategy to domesticate this resource requires the knowledge of its bio-ecology. This study aimed to evaluate diversity of phytoplankton for nutritional selectivity by Manila clams within the lower Sanaga delta. Each point has been done a qualitative and quantitative sampling. Some liters of water were filtered with the net to plankton, content has been poured in a bottle in glass labeled and analyse to laboratory.
Results: A rich taxonomic diversity of phytoplankton (117 species, 75genera and 7 classes, all left in 5 phyla) was observed with an important specific richness of the *Cyanophyceae* classes (the richest 41 species; 35.0%) follows by the *Diatomophyceae* classes (35 species; 29.9%). *Rhodophyta's* phylum was absent. The most abundant classes were those of *Diatomophyceaes* (114; 33.3%) and *Cyanophyceaes* (111; 32.5%). Some likeness have been observed between sampling stations and index of Shannon (H') has been raised (H'>0: H'1=3.59; H'2=3.73; H'3 = 3.88); Equitability index (E) was close to 1 (E≈1: E1 = E2 = E3=0.96) and Dominance (d) was weak (d→0: d1=0.41; d2=d3 = 0.36). An important fraction of exploitable of clams bound both to the favorable conditions of environment and to absence of a minimal size of exploitation. Thus, diversity of phytoplankton and likeness observed between the stations could be due to the exchanges with the vicinity (contributions of continental waters and opening to the Atlantic Ocean) and to proximity between the stations.
Conclusions: Mouanko, a zone of mouth, could justify the favorable conditions of growth of clams. Site is a rich environment with nourishing matters necessary to support production of phytoplankton useful to clams, and could constitute favorable conditions to domesticate bivalves.

Keywords: diversity indices, bioecology, phytoplankton, clams, sanaga, Cameroon

Introduction: Background

Important component of the benthic marine ecosystem, the bivalves or the clams are especially exploited in the coastal zone [1]**.** The spatial and temporal characteristics generate fluctuations in natural population; there by contributing to strong variations of biomass and demographic structure being added to the effects of anthropic activities. Understanding the interactions between the species, its environment and its exploitation is a pledge to the apprehension of working on the dynamics of the population of clams and its control factors [2]. The phytoplankton is an element determining the profitable food chain to the wild or elevated shellfish. It constitutes the essential of food indeed for the bivalve lamellibranches. Among the 3 400 to 4 000 phytoplankton species [3], of which 300 can in some opportunities, to meet to densities as they have the capacity to color water. Moreover, about 70 species, either about 2% of the total number, have the possibility to give out potentially toxic substances to men through fish or the shellfish that he consumes [3]. An efflorescence of toxic phytoplankton's can modify the physiology or the biology of some species or communities important food chain or trophic levels that they support, dragging some changes thus in the marine ecosystems [4]. The clams are bivalve mollusks living buried in the sediments, in sheltered inshore zones, to the level of the low seas as the mouths of streams, the lagoons, the bays, such as Arcachon bay [5, 6]. In Cameroon, the clams *Galatea paradoxa* (born 1778) are present in the delta of the Low Sanaga in Mouanko. These bivalves constitute a big source of income for the local populations during the season of subsidence (November - June) where it is estimated that more than 8,000 tons are exploited with an income of more than 500 million of Frs CFA per year [1]. The strategy to domesticate this resource requires the knowledge of its bio-ecology; however according to the Cameroon Wildlife Conservation Society (CWCS), little or no bio-ecological study concerning this resource has been done again in Cameroon, and in particular Mouanko zones it targeted area of production. There are data gaps concerning *Galatea paradoxa* clams associated to the present food potential in the low Sanaga. Hence, does specific diversity of phytoplankton in this site where lives the clams is it known and for what nutritional potential? The present survey is conducted with the

aim to carry out an inventory in order to characterize the present phytoplankton in the *Galatea paradoxa* clam's environment, and state the nutritional potential of these bivalves in the delta of the lower Sanaga to Cameroon.

Methods

Site of Study

The study site has been diversely described [7] and falls within the Douala-Edéa wildlife reserve. The reserve straddled over 80% of the district of Mouanko. The site is located (3°38' N; 9°47'E) at the lower Sanaga River in the Malimba villages within Mouanko one of the nine (09) districts that make up the Department of the Sanaga Maritime of the Littoral region of Cameroon (Figure 1). The relief is generally flat with altitude generally varying between 1-50 m and rarely between 80-120 m [7]. Soils are argilo-sandy with weak water retention capacity. They are alluvium on the strands of the big rivers (Sanaga, Kwakwa) and are naturally fertile. Four groups of soils can be distinguished: acidic soils rich in iron; marine soils covered by the mangrove swamp; fluvial soils along the Sanaga River and its effluents and on the islets of sand in dry season; hydromorphic soils along the marshes [7]. The site has a vast and complex hydrographic network which ends in the Atlantic Ocean. The network include the rivers of Sanaga, the Dibamba, the Nyong, the Dipombé and some lakes notably the Tissongo and the Nsah lakes [7]. The climate of Mouanko is equatorial type extensively influenced by nearness of the Atlantic Ocean. Yearly average precipitation is between 2000 mm to 3000 mm and mono-modally distributed peak is in August with 600 mm. Moreover, yearly average temperature between 25 and 30°C. Four seasons are marked locally: a big dry season of December to mid-March; a small dry season of mid-March to April; a small rainy season from May to June and a big rainy season from July to November [7]. Flora here is varied and diversified. The coastal Atlantic forest in *Caesalpiniaceous*; the swampy forest flooded periodically of the low valleys of the Sanaga and the Nyong, with *Uapaca spp*,; the swampy forest flooded periodically of rear mangrove swamp, with *Guibourtia demeusei* and *Oxystigma manni*,; the forest on sandy coastal cords, with *Saccoglttis gabonensis* and *Klainedoxa microphylla* on sand, *Anthhostema aubryanum* and *Ctenolophon engleranus* on vase. The external high mangrove swamps to big *Rhizophora racemosa* and *Pandanus candelabrum* in border of estuary; the secondary forest close to the villages, that concentrated along the rivers and lakes, and constituted of a mosaic of cultures, and of secondary forests of variable ages. The reserve has numerous fauna species with aquatic and terrestrial fauna being threatened extensively by poaching, overfishing and the destruction of the mangrove swamp ecosystem [7]. The population of Mouanko is estimated at about 17.000 people [7], of which the majority livelihood is essentially fishing gears. The fluvial fishing is essentially based on the *Cichlidaes* the catfishes and the clams [7].

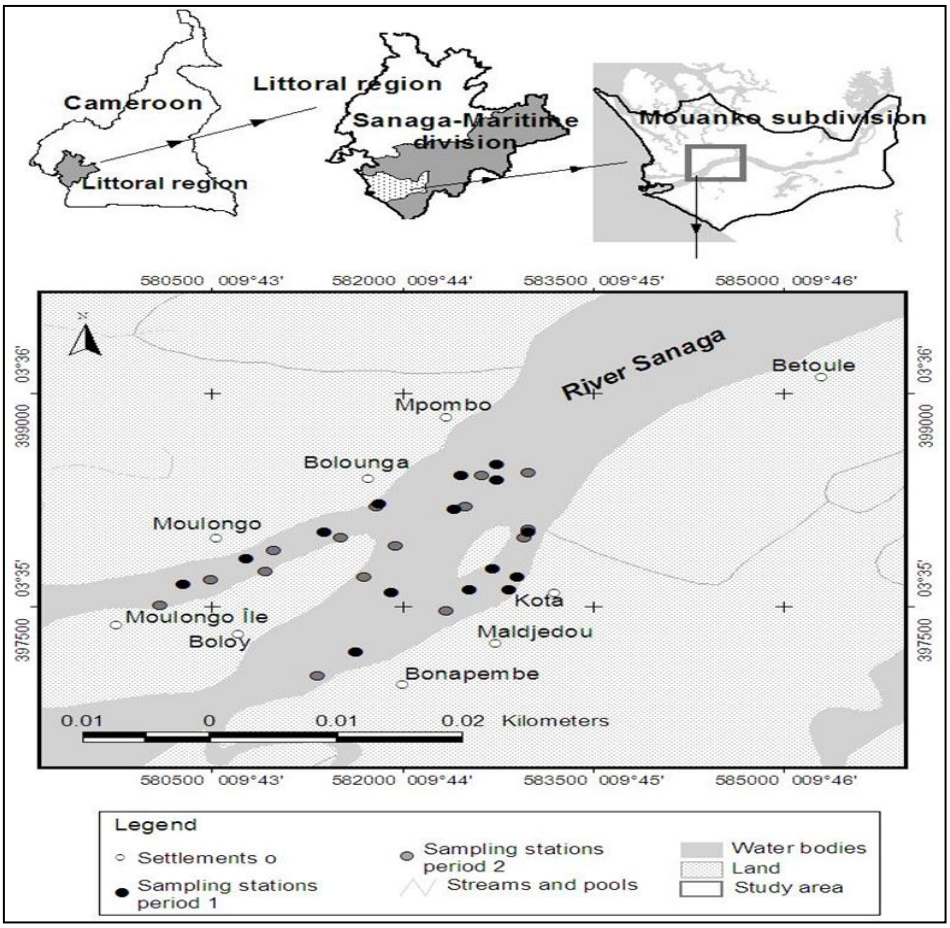

Fig 1: Map of the site of study showing the location of sampling stations [7]

Data Collection

Data collection took place between the period from April to October 2015 with the samplings at the morning between 6h and 9h. Two data collection trips were carried out from June to July 2015 in the Malimba villages. Sampling was done at three big stations within which the clams were concentrated, accessible and often collected by the villagers (Bolounga-Moulongo, Mpombo-Maldjedou and Betouli-Maldjedou) within 2 kilometer of river of an area of about 300 hectare. The recorded material used were in two stages: on the land (*in situ*) and to laboratory. *In situ*, the phytoplankton and clams were harvested and measured. There after some phytoplankton taken to the laboratory, to conduct qualitative and quantitative analysis of phytoplankton and dosage of chlorophyll (*Cl*). Afterward collections on the substrate, the samples of phytoplankton were transported for analysis in the laboratory of Biology of the Plant Organisms of the University of Douala. In every station, water, phytoplankton and clam samples were collected at constant at three depth levels (Under 1 m, 1 to 2 m and more than 2 m) according to the method of fishing (surface. basket and deep fishing) by experienced clam collectors as follows:

- Water sampling: a bucket of 10 liters was used to collect water then samples of up to one liter into polystyrene of 310 ml sampling bottles. A Multi-parameter (WATERPROOF mark) was used to record 5 parameters *in-situ*: temperature, pH, conductivity, salinity and TDS.
- The phytoplanktonic sampling *in situ*: The euphotic zones were assessed based on average to 50cm during the two sampling periods. Three points of samplings were randomized in every station. To every point has been done a qualitative and quantitative sampling. For the qualitative sampling, 200 liters of water were filtered with the help of the net to plankton; the content has been poured in a bottle in glass labeled of 60 ml. For the quantitative sampling, some liters of water were filtered with the help of the net to plankton; the content has been poured in a bottle in glass labeled of 500 ml. Every sample were fixed to formalin to 5% of its volume, homogenized and kept to the obscurity in an icebox.
- Substrate sampling: were collected using plastic bags from the different depths (under 1 to 7 meters) by divers. The same parameters as for water samples were measured in-situ.
- *Galatea paradoxa* sampling: were collected in plastic bags and size measurements were taken on Length, Height, Width and bulge on every individual using a caliper.

Data analysis

Laboratory Analysis

Water and phytoplankton samples were analyzed in the laboratory at the University of Douala.

Analysis of the Phytoplankton

The samples of phytoplankton were analyzed directly after every campaign to the laboratory, where they have been deposited to the obscurity during 24h before analysis. For every sampling, three coins samples have been appropriated.

Concerning the qualitative analysis, after siphoning and homogenization of the under sample, a drop went up between blade and gill that were later observed under a microscope. Several preparations were made for every area sample in order to observe a big number of species possible; identification was directly under a microscope in some cases. For difficult individuals to identify, drawings and photographs were done. Identification was possible with the keys of identification of Iltis [8], Bourrelly [9, 10, 11], Compère [12, 13, 14], Berne [15], Komarek et Anagnostidis [16], Grönblad et *al.* [17], Krammer et Lange-Bertalot [18, 19, 20]. For the quantitative analysis, 1ml of every coins sample were appropriately done with a micropipette and small volumes have been deposited by turns on the blade for numbering and further observation. The unit of numbering of filaments was fixed to 100µm as 1 individual. The colonies and the coenobes have been considered like 1 individual [8].

Studied parameters

Parameters bound to the phytoplankton

- **Specific richness (Sr)**

It is the total number of the various taxonomic categories to which belong the organisms appropriated to a station of sampling.

- **Indication of diversity of Shannon-Weaver [21]**

It considers abundance and the specific Richness at a time. It varies 0 (only one species or a species dominating all other very extensively) to S log (all species even have abundance) [22, 23].

$$H' = -\Sigma\ Pi \times \log_2 Pi$$

With Pi = ni / N where ni: number of the species, N: number of the population and Pi: Frequency of the species, H' in bits/individual.

H' is maximal when all species are also represented in the sample.

- **Indexe of Pielou's Equitability [24]**

It is the report of the real diversity to the maximal diversity [22]

$$E = H' / Hmax$$

With $Hmax = \log_2 S$ (S= number of present species)

H' = Shannon-Wearver index; Hmax= maximal diversity index

E = translates the quality of organization of a community, it is worth 0 when only one taxon dominates and 1 when all taxon have the same abundance.

- **Index of Berger – Parker's dominance (*d*)**

Establishes the dominance of the species and watch that so *d* is weak or *d* stretches toward 0, the diversity H' is big and the dominance is hopeless. So *d* stretches toward 1, one has the dominant species and a weak diversity [22]

$$d = Nmax/N$$

Nmax= maximal abondance; N = total abondance number's

- **Index of Sörensen's similarity (S)**

Either two environments, it varies 0 (absence of similarity) to

1 (identical environment).

$$S = 2a / (2a+b+c)$$

With a = number of species apartment to the two stations; b = number of species belonging solely at the first station; c = number of species belonging solely at the second station.

- Distribution of the population according to the size
- Relation Weight/ Length [25]: $P = aL^b$
- a and b represents the coefficients of the relation Indication of Elongation [26]:

$$E_i = H/L$$

When Ei is weak, the environmental conditions are favorable while the conditions are unfavorable when E_i is raised.
With P = weight (g); L = length (mm); H = height (mm); B = bulge (mm).

Statistical analyses

The collected data were subjected to descriptive and Inference statistical analyses using tables, graphics, a two-way ANOVA according to the model: $Y_{ijk} = \mu + z_i + t_j + e_{ijk}$ (i=1. 2.3.; j=1.2). Where Y_{ijk} is the response variable.µis general mean. z. the three zones and t the two time collection times. Statistically significance was assessed at p <0.05. Most of these data collation were inputted to Microsoft Excel 2007 and analysis conducted through SPSS freely software.

Results

Abundance and taxonomic diversity of phytoplankton

i) Specific Diversity

The analysis of the specific composition of the samples of the site permitted to count 117 species, 75 genera and 7 classes, all left in 5 phyla (Annex 1).

Phylum of *Chlorophytas* has been represented here by two classes to know the *Chlorophyceaes* and *Zygophyceaes*. The one of *Chrysophytas* by the *Diatomophyceaes*; *Euglenophyta* by the unique class of the *Euglenophyceaes*; *Pyrrhophyta* by its two main *Cryptophyceaes* classes and *Dinophyceaes* and finally the *Cyanobacterias* with the unique class of the *Cyanophyceaes*. Photo of some algae's phytoplankton seen to the microscopic optic microscope has been obtained (Annex 2).

From the table below only one phylum out of the 6 accounts for the classification of micro-algae's [11] though it has not been represented (phylum of the *Rhodophytas*). The class of the Cyanophyceaes was the richest (41 species; 35.0%), while the class less represented were *Cryptophyceae* (1 species; 0.9%) (Table 1).

Table 1: Specific Richness of site

Classes	Specific Richness	Proportion (%)
Cryptophyceae	1	0.9%
Dinophyceae	3	2.6%
Euglenophyceae	6	5.1%
Zygophyceae	13	11.1%
Chlorophyceae	18	15.4%
Diatomophyceae	35	29.9%
Cyanophyceae	41	35.0%
Total	117	100.0%

ii) Abundance

The abundance of the different classes composing the phytoplankton of the study zone has been determined and has been summarized in Table 2.

Table 2: Abundance of different classes

Classes	Abondance	Proportion (%)
Cryptophyceae	5	1.5%
Dinophyceae	11	3.2%
Euglenophyceae	28	8.2%
Zygophyceae	28	8.2%
Chlorophyceae	45	13.2%
Cyanophyceae	111	32.5%
Diatomophyceae	114	33.3%
Total	342	100.0%

Following our studied stations the most abundant classes of bivalves, were the *Diatomophyceaes* (33.3%) and the one of the *Cyanophyceaes* (32.5%); contrary to the one of the *Cryptophyceaes* (1.5%) that was the least abundant class.

The analysis of the different stations showed maximal abundance algal (40.9%) in the station 3 compared to the two other stations which are respectively 29.8% (station 2) and 29.2% (station 1). Inventory and characterization of taxon of clam's zone took place, and an abundance of the classes in the 3 stations understood between 0.0% and 15.0% (Figure 2).

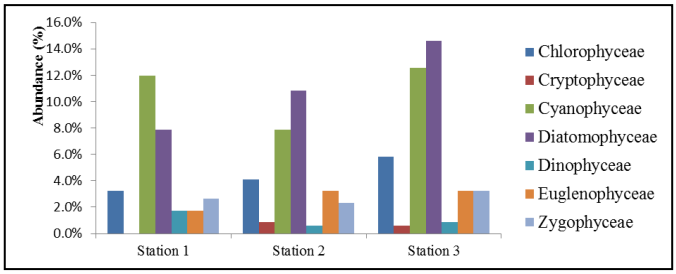

Fig 2: Abundance of the different classes according to the stations

Diatomophyceaes were more abundant than the *Cyanophyceaes* in the station 2 (37 against 27) and station 3 (50 against 43) seem less abundant than these in the station 1 (27 against 41). It was also noted the absence of the *Cryptophyceaes* (0.0%) in the station 1 comparatively in the two others where they are present but to weak proportion. The *Chlorophytas*, the *Euglenophytas* and the *Dinophyceaes* were present in all stations but to variable proportions.

iii) Diversity of Shannon-W, Equitability of Pielou and Dominance of Berger-Parker

The indexes of Shannon (H'), of Equitability (E) and of Dominance (d) are based on the proportions of genera observed. In each of the stations, they corresponded respectively to the following values (Figure 3):

- Station 1 (H'=3.59; E= 0.96; d=0.41);
- Station 2 (H'=3.73; E= 0.96; d=0.36);
- Station 3 (H'=3.88; E= 0.96; d=0.36)

The indexes were practically equivalent in all stations. It came out again from it of general manner that index of Shannon has been raised (H'>0); the Equitability was close to 1 (E≈1) and the Dominance was weak ($d \rightarrow 0$).

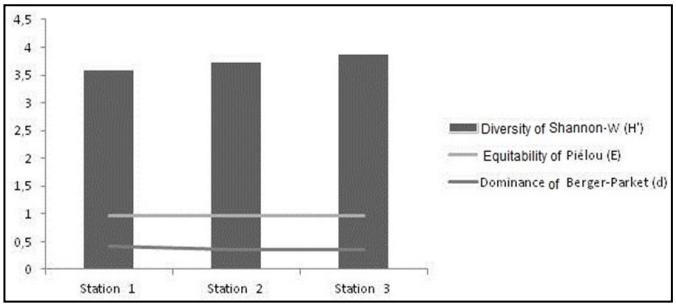

Fig 3: The indexes of Shannon, Equitability and Dominance to the three stations

iv) Sörensen Similarity index's

Similarity of the clams sampling zones has been observed and the Table3 summarized the values of Sörensen index's between the stations. Of these values have been consisted between 0.62 (stations 1 and 3) and 0.75 (stations 2 and 3).

Table 3: Similarity index's between stations

Station	Station 1	Station 2	Station 3
Station 1		0.63	0.62
Station 2			0.75
Station 3			

Inferential analysis (ANOVA) showed that there is a significant difference exists (F=29.81; p =0.03) between the sampling period (F=6.59; p=0.01). Concerning concentrations and also between concentrations of the stations and their sampling period. There is not a difference on the other hand between the station concentrations (F=0.12; p=0.89).

Trophy Statement

Overall, the phytoplanktonic biomass increased in all stations at the time of the first campaign and bass during the second (Fig.4).

In this study, different indicators have been kept to assess trophic statement of waters as total Phosphor, Transparency and Chlorophyll *a* concentration. According to the criteria's established by the O.C.D.E. [27], the study zone presents a more or less uniform Eutrophic statement (Table 4). The total Phosphor Concentration (PT) seem comparatively a lot more elevated in the station 2 in the two other stations where they are weak. Average values of Chl *a* have been increasing (10.8 to 12.1) along the stations, with an optimum to 19.6 in the station 2.

Table 4: Trophic statement of site according the O.C.D.E criteria's

Indicators	Station 1	Station 2	Station 3
Secchi***** m (m)	0.18	0.18	0.17
Secchi***** min (m)	0.17	0.16	0.15
Chl*a*m (mg.m^{-3})	10.8	11.5	12.1
Chl*a*max (mg.m^{-3})	18.5	19.6	19.1
PT***** m (mg·m-3)	10.2	40.4	1.8
Trophic statement	Eutrophic	Eutrophic	Eutrophic

PT: Total Phosphor concentration; m: annual average; max: maximal value; min: minimal value

Besides the phosphorated compounds, the nitrogenous compounds also constitute necessary nourishing matter for the photosynthesis. Table 7 permits to observe a lot more high concentrations in nitrates in the site compared to those of the phosphorated compounds above. The middle concentrations are respectively 224.6 mg.m^{-3}de NO_3^- * (station 1); 315.7 mg.m^{-3} of NO_3^-*(station 2) and 2716.3 mg.m^{-3} of NO_3^- *(station 3) (Table 5).

Table 5: Average of values to some physicochemical parameters per station

Parameters	Station 1	Station 2	Station 3
Temperature*(°C)	23.73	23.72	23.97
Salinity*(µeq/ l)	26.84	27.03	26.5
PO_4^{3-}*(mg/l)	0.01	0.04	0.0017
NO_3^-*(mg/l)	0.22	0.31	0.27
Transparency* min (cm)	17	16	15
Transparency* (cm)	18.08	17.8	17
Depth (m)	2.4	2.5	2.9

(*) Values gotten of complementary works on the clams in the setting of the Domestication project's [7]

Biometric Analysis of the clams

Conditions of the *Galatea paradoxa* clams life's in Mouanko

Table 6 presents Elongation index's in each station. It is weak (Ei<1) with an average of 0.8 ± 0.1 in the station 1 and 0.7± 0.1 in the stations 2 and 3.Theses weak values translate favorable environmental conditions on the whole for the life of the clams.

Table 6: Elongation index's per station

Station	Elongation index's (Ei)		
	Minimum	Maximum	average
Station 1	0.6	0.9	0.8 ± 0.1
Station 2	0.6	0.9	0.7± 0.1
Station 3	0.6	0.9	0.7± 0.1
Sampling Zone's	0.6	0.9	0.7± 0.1

Galatea paradoxa clams condition index's shown that it is more important in the station 1 compared to the two other (Table 7); therefore conditions of growth of the clams are there better.

Table 7: Condition index's per station

Station	Condition index's (K)		
	Minimum	Maximum	average
Station 1	1.0	8.1	2.8 ±1.1
Station 2	0.8	9.7	2.5 ±1.5
Station 3	0.8	9.7	2.5 ± 1.6
Sampling Zone's	0.8	9.7	2.6 ± 1.4

Discussion

The aim of this study was to inventory and to characterize phytoplankton present in the environment of the *Galatea paradoxa* clams and to assess the nutritional potential around these bivalves in the delta of the low Sanaga to Cameroon. The clams which possess a powerful to filtration (70 liters per day) with the help of its two siphons, eat planktonic and benthic algae's and other microorganisms in addition to inorganic particles [22].

Abundance and taxonomic diversity of phytoplankton

Specific diversity

The site presents a big taxonomic diversity where 204 taxa (117 species, 75genera, 7 classes and 5 phyla) obtained. Anyinkeng [28] in Buea (South-west of Cameron) choose 66 phytoplankton species, belonging to 44 genera, 34 families and 6 phyla inside water sampling zone. So the least quantities of species and genera observed, although higher phyla belonging *Bacillariophyta*, *Charophyta*, *Chlorophyta*, *Cyanobacteria*, *Mioza* and *Euglenophyta* inside the Buea water sampling zone obtained. The number of recorded species (117) was lower compare to those gotten in tropical zone by Ba [29] which stood between 170 and 174 species. Moreover, Motto [30] counted 124 species in the Londji River, Kribi, South of Cameroon. In 2007 in waters inshore Tunisians, the works of Hamza [31] showed the existence of 400 species in the gulf of Gabes. The important richness of the phytoplankton in the low Sanaga could be due to the contributions of continental waters and to the opening from the zone to the Atlantic Ocean. This result is superior to the one of Folack *et al*. [32] in the golf of Fos, and to the one Travers and Kim [33] to the outlet of Caronte that recovered 64 taxa and 125 taxa respectively. Absence of the *Rhodophytas* in zone could be explain by the fact that in the biomass algale of the soudanian water's, the main groups that there generally intervenes are *Chlorophytaes, Euglénophyteses, Diatomophyceas* and *Cyanophytaes* [9, 10, 11]. The *Rhodophytas* being most often the navy algaes and their presence in the soft waters being limited little to about thirty genera frequent. As about the *Cryptophyceaes* and *Dinophyceaes*, the less represented, they are represented only by some genera in the soudanian water's [8]. The *Cryptomonas* genus (*Cryptophyceae*) is very less abundant in this region while at *Dinophyceaes*, the three fluently met genera belong to the subclass of *Dinophycidaes*, order of *Peridinialeses* among which the both genera of *Peridinium* and *Ceralium* (Table 1). Phytoplanktonic community of the low Sanaga presented a taxonomy dominated by *Diatomophyceaes, Chlorophytas*, *Cyanophyceaes* and *Euglenophyceaes*, characteristic of rich areas in organic substances [34]. The representatives of these groups, and notably the *Scenedesmus* and *Microcystises* genera, are known for their predilection for eutrophic zones [35]. Phytoplankton is therefore greatly influenced by the environmental changes [36, 37, 38], is considered like being the first biologic community to answer eutrophication.

The specific diversity could be bound to abundance

Abundance

The most abundant classes were the one of *Diatomophyceaes* (114; 33.3%) and the one of *Cyanophyceaes* (111; 32.5%); while the least abundant class remained the one of *Cryptophyceaes* (5; 1.5%). This result is similar to the one of team of Folack [32] on the phytoplankton in the shackle of Carteau, where the class of *Diatomophyceaes* was dominant in the 3 stations of sampling with a dominance of Diatoms. Inside the golf of Gabes has been recovered 5 classes of which those of *Dinoflagelleses* and *Diatoms* predominated the phytoplanktonic community [22].

Analysis of the different stations showed a maximal abundance algal (40.9%) in station 3 compared to the two other stations where it corresponds respectively to 29.8% (station 2) and to 29.2% (station 1). The abundance following different classes according to stations was observed fora maximum proportion of 15.0% (Figure 2).

Cyanophyceaes was more abundant than *Diatomophyceaes* in the stations 2 and 3 seem less abundant than these in station 1. It also has noted an absence of the *Cryptophyceaes* (0.0%) in station 1 comparatively in the two others where they are present but to weak proportion. Abundances of phytoplankton in Buea water sampling zone showed more abundant *Chlorella sp* and *Nitzschiasp* [28]. The low Sanaga is a rich environment in nourishing matters (Table 4) necessary to the phytoplanktonic production. This production more or less uniform in the different stations (Figure 3) revealed the existence in station 1, of an important abundance of *Diatomophyceae* and *Cyanophyceae*; and a total absence of *Cryptophyceae*. While in the two other stations, *Diatomophyceae* and *Cyanophyceaes* are stayed abundant but one rather noted the presence of *Cryptophycea* to weak proportion.

Some phytoplanktonic taxa are capable to produce some phycotoxines [39]. In the setting of this study, 13 genera have can be identified according to the literature [40, 41, 42] and belonging in groups of the *Chlorophytas*, *Cyanophyceaes* and *Diatomophyceaes*. Bivalves are the healthy vectors that are not affected by these toxins but are rather toxic for the secondary consumers like men [39, 31, 22].

The clams eat phytoplankton mainly [25], necessary for their growth [29]. The important exploitable fraction in Mouanko could be conditioned by the geographical localization and regulation of the clams in force. Indeed, growth of the clams is continuous in tropical regions, fast during or after rains when the nutriments dragged of the vicinity increases the phytoplanktonic production; contrarily in the moderated regions where the growth is interrupted during the winter when the temperature of water is very weak and food is more or less present [43].

Diversity of Shannon-W, Equitability of Piélou and Dominance of Berger-Parker

The indications of Shannon (HS'), of Equitability (E) and of Dominance (d) are based on the proportions of kinds observed. Some likeness have been observed between the stations of sampling and it came out again from it that the indication of Shannon has been raised (H'>0: H'1=3.59; H'2=3.73; H'3 = 3.88), this result gotten in water of surface is relatively similar to the one of Folack *et al*. [32] that got 3.59 (station 1), 3.80 (station 2) and 3.49 (station 3). Drira [22] in the golf of Gabes found indications of elevated Shannon also with an average of 3.04±0.74 bits.cellules-1 of which a maximum to 4.2 bits.cellules-1. It would explain itself by the concomitant presence of several species, and due to the fact that in a general manner the community phytoplanctonique would be exclusively inshore [22]. The Equitability was close to 1 (E≈1: E1 = E2 = E3=0.96) and the Dominance was weak (d→0: d1=0.41; d2=d3 = 0.36). These indications showed that in every station, a big specific diversity and an almost hopeless dominance would exist therefore. All taxa having had the same abundance practically.

Similarity Sörensen index's

The values of Sörensen index's between stations (Table 3) were respectively: 0.63 (stations 1 and 2); 0.62 (stations 1 and 3) and 0.75(stations 2 and 3). This result would explain by the fact that some similarities would exist between the stations because the indexes have been raised (near toward 1). Likeness observed between these stations (S→1) could explain by the existing proximity between these last.

Trophic statement's

On the whole, the phytoplanktonic biomass has been raised in all stations at the time of the first campaign and bass during the second (Figure 4). According study in Malaysia, healthy environments are a symbolic representation of greater diversity of organisms than influence state of one's [44]. In addition, different indicators kept according to the criteria's established by O.C.D.E. [27], to assess trophic levels of waters permitted to conclude that, zone presents a eutrophic state more or less uniform (Table 6). Specifically these indicators revealed that: Concentrations in total phosphor (PT) seem a lot more elevated in station 2 comparatively in the two other stations where they are weak. Total phosphor (PT) that is the nourishing element whose content limits encourages the growth of algae's and aquatic plants usually in continental environment. There is linkage between concentration of phosphor, productivity of the lake and its trophic level's. Eutrophic lake's has a strong concentration of phosphor, it can be present in water in particles form or in dissolved form. In this study, only the dissolved phosphor form has been measured out.

The Chl*a* average presented increasing values (10.8 to 12.1) along the stations, with an optimum to 19.6 in station 2. Chlorophyll *a* (Chl*a*) is an indicator of the biomass of present microscopic algae's in the lake. Concentration of Chl*a* increased with concentration of the nourishing matters. Eutrophic lake's often has an important production of algae's integrated on euphotic zone. Chl*a* the only pigment capable to produce the chemical energy, its quantity is very variable of a type of algae to another and depends of the luminous regime, to which it is acclimatized and also of the richness of the middle in nourishing matter [23].

The nitrogenous compounds also constitute necessary nourishing matter for the photosynthesis. Study noted a lot more elevated concentrations in nitrates in the site compared to those of the phosphorated compounds. Middle concentrations are respectively 224.6 $mg.m^{-3}$ of NO_3^- *(station 1); 315.7 $mg.m^{-3}$ of NO_3^-*(station 2) and 2716.3 $mg.m^{-3}$ of NO_3^-*(station 3) (Table 7).

Transparency of water or Secchi depth (measured with a disk of Secchi) decreases with the increase of the quantity of algaes in the lake. Eutrophic lake's is characterized by a weak transparency of water [27].

The superficial masses of water can be distinguished by their oversaturation in dissolved oxygen. In opposite, weak rates of oxygen prevail in the underlying waters situated to 2 m of depth. Beyond this one, the conditions of anoxia get settled. This variation of concentration in oxygen dissolved in a rich environment in organic substances is characteristic of greatly eutrophic environment [45].

The life *Galatea paradoxa* clams condition's in Mouanko

The Low Sanaga (Mouanko) is a zone that opens up on the Atlantic Ocean; the environmental conditions and of clams growth seemed favorable (weak Ei). Indeed *Galatea paradoxa* clams live buried in the sediments in sheltered inshore zones, to the level of low seas as the mouths of streams, lagoons, and bays [5]. These conditions appeared more favorable in the station 1 that in the two other stations (Table 7). Measure of the growth solely from length could prove to be nevertheless insufficient because it only informs on an axis of growth whereas this last can achieve itself according to several measurements [46]. The analysis of the clam's morphometric could bring ample precisions therefore on their growth. However, the nutritional potential provided from the phytoplankton would be a non-negligible explanation for the Condition index's favorable to the presence of this bivalve in the low Sanaga.

Conclusion

The present study was about the phytoplanktonic productivity and the state of growth of the clams in the delta of the Low Sanaga in Mouanko. This study reveals *Galatea paradoxa* clams in Mouanko have a high taxonomic diversity of the phytoplankton (117 species,75 genera and 7 classes, all left in 5 phyla) with an important specific richness of the *Cyanophyceae* classes (the richest 41 species; 35.0%) follows directly by the one of the *Diatomophyceae*(35 species; 29.9%)only phylum of the *Rhodophyta* was absent. Abundance of *Diatoms* and *Cyanophyta* were some likenesses have been observed between the stations. The Low Sanaga proved to be a rich environment in nourishing matters necessary to the production of the phytoplankton. In the setting of this study, several genera of toxic phytoplankton have can be identified and belonging to the groups of *Chlorophyta*, *Cyanophyta* and *Diatoms*. This zone also presented an important fraction of exploitable clams bound on the one hand to the favorable conditions of the environment and on the other hand to the absence of a minimal size of exploitation defined by the system of regulation of this path. Thus, the diversity of phytoplankton and the likeness observed between the stations in the Low Sanaga could be due to the exchanges with the vicinity (contributions of continental waters and opening to the Atlantic Ocean) and to proximity between the stations. Mouanko, a zone of mouth, presented an abundance in food (phytoplankton) of the bivalves, it could justify the observation of the favorable conditions of growth of these therefore in this zone.

Declarations

Ethics approval and consent to participate

Not applicable Ethics approval and consent to participate. The data and other materials that support the findings of this study are available from the corresponding author upon reasonable request.

Consent for publication

Authors give consent for publication after each contribution. All authors read and approved the final manuscript freely.

Availability of data and material
The availability of data and material remains guaranteed by the corresponding author for any future solicitation

Competing interests
Authors have not declared any conflict of interests during each step of reading and may have influenced the study.

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Mr Adolphe DIKOUME Ph.D student from the University of Douala designed the study, conducted the experiments, and wrote the manuscript. Dr Gordon AJONINA from the University of Douala and CWCS conducted the experiments, did freely statistical analyses. Pr Minette TOMEDI from the University of Doula designed freely the study.

Authors' contributions
AD designed the study, conducted the experiments, and wrote the manuscript. GA conducted the experiments, did statistical analyses. MT designed the study. All authors read and approved the final manuscript.

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