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Influence of physicochemical parameters on the spatial distribution of pelagic copepods in the Fatala River estuary (Boffa, Republic of Guinea)

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Abstract

This study, carried out between July and October 2020 in the Fatala River estuary (Boffa prefecture, Republic of Guinea), aimed to assess the specific diversity of pelagic copepods and to analyze their spatial distribution in relation to the physicochemical parameters of the environment. This estuary, subject to significant anthropogenic pressures linked to mining, agricultural, fishing and domestic activities, presents a high vulnerability to water quality degradation. Copepod samples were collected during four field campaigns using a zooplankton net and then identified in the laboratory. Physicochemical parameters (temperature, salinity, conductivity, dissolved oxygen, pH) were measured in situ, while suspended solids, turbidity, nitrates and phosphates were analyzed in the laboratory. The taxonomic analysis identified 59 species, distributed in two orders: Calanoida (89.83%) and Cyclopoida (10.17%). These species belong to 17 families and 27 genera. The community is largely dominated by *Paracalanus aculeatus* (25.14%), *Aetideus armatus* (18.93%), *Paracalanus scotti* (15.07%) and *Paracalanus parvus* (9.83%), together representing nearly 69% of the total abundance. The results show a clear spatial heterogeneity. In the upstream stations (S1 to S5), copepod densities vary between 0.00 and 499.34 individuals/m^3, with an average of 258.352 individuals/m^3, a reduced specific diversity (Shannon index H' ≤ 0.19) and the total absence of copepods at some stations. These low densities are explained by unfavorable environmental conditions, characterized by an acidic pH (6.3–6.7), low salinity, reduced mineralization, as well as very high phosphate concentrations (up to 28.6 mg/L). Conversely, the downstream stations (S6 to S14) present much higher densities, between 1733.51 and 4565.77 individuals/m^3, with an average of 3248.89 individuals/m^3, a higher specific richness and more favorable physicochemical conditions: alkaline pH, increased salinity and conductivity, moderate turbidity. The dominance of a limited number of euryecious species reflects an ecological imbalance typical of estuarine environments subject to multiple anthropogenic pressures.

Keywords: Zooplankton; Copepods; Species; Estuary; Pelagic; Density; Physicochemical Parameters

1. Introduction

Estuarine ecosystems play a fundamental ecological role as transition zones between freshwater and marine environments. Their high productivity makes them essential habitats for many aquatic species, including zooplankton, of which copepods represent a dominant group (Mouny, 1983; Chaalali, 2013). These small crustaceans play a key role in aquatic food webs, ensuring the transfer of energy from primary producers (phytoplankton) to secondary consumers (fish, invertebrates, etc.) (Rolland, 2004).

The spatial distribution of copepods is strongly influenced by physicochemical factors of the environment, such as temperature, salinity, dissolved oxygen, pH or nutrients such as nitrates and phosphates (Moison, 2009). These

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parameters condition not only the structure of planktonic communities, but also their seasonal and spatial dynamics (Trégouboff & Rose, 1957).

In tropical estuaries, often subject to strong anthropogenic pressures (urbanization, agriculture, mining activities, industrial discharges), changes in water quality can lead to significant ecological imbalances, particularly affecting copepod communities (CCLME, 2014). However, in the Guinean context, few studies have focused on the relationship between environmental parameters and the distribution of zooplankton in estuaries, particularly that of the Fatala River, a strategic system for local biodiversity and human activities.

This study aims to fill this knowledge gap by analyzing the influence of physicochemical parameters on the spatial distribution of pelagic copepods in the Fatala River estuary (Boffa prefecture). It will help assess the ecological state of the environment and provide a solid scientific basis for the sustainable management of this ecosystem.

2. Methodology

Copepod sampling was carried out on board a 15 hp motorized boat, during four campaigns, in fourteen (14) fixed stations (Figure 1). Samples were taken using a Hensen-type plankton net, with a 55 µm mesh and an opening diameter of 70 cm. Samples were collected by vertical lines, from the bottom to the surface.

During each campaign, three samples were taken per station, or 42 samples per campaign, for a total of 168 samples over the four missions. The samples were fixed in 5% formalin.

Taxonomic identification of copepods was carried out under a binocular microscope, using the determination keys of Rose (1933) and Trégouboff & Rose (1978).

In parallel with biological sampling, in situ measurements were made on temperature, salinity, conductivity, dissolved oxygen and pH, using multi-parameter probes. The concentrations of suspended matter, turbidity, nitrates and phosphates were determined in the laboratory according to standard physicochemical analysis protocols.

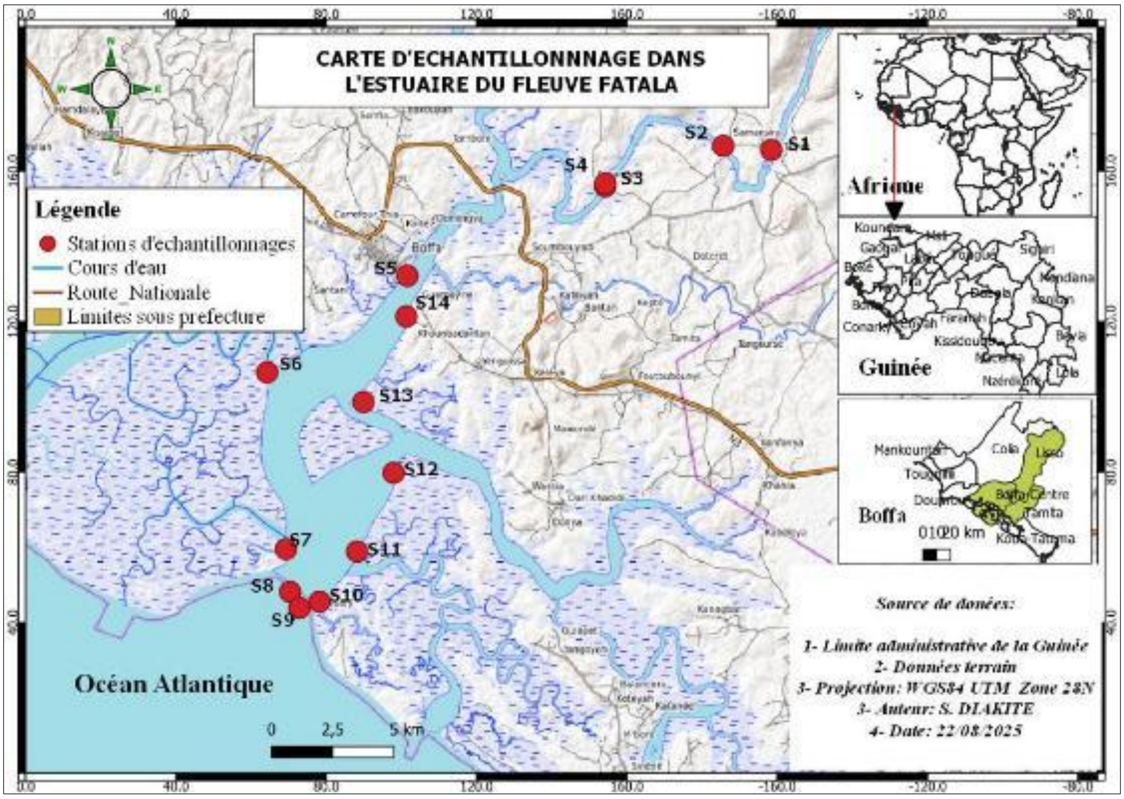

Figure 1 Sampling map

2.1. Statistical analyses

To average copepod densities at a station, descriptive statistics techniques were used to calculate the arithmetic mean of the density values collected at that station. The collected data were processed using Excel 2010 spreadsheet. The Shannon diversity index (1948) also called Shannon-Wiener index was calculated using the following formula

$$H' = -\sum_{i=1}^{S} pi.\log2(\mathrm{pi})$$

Where H' corresponds to the Shannon index ; S is the number of species; pi the relative frequency of the ith species: pi = ni/N where ni = the number of individuals counted for a species present; N is the total number of individuals counted, all species combined.

3. Results and discussion

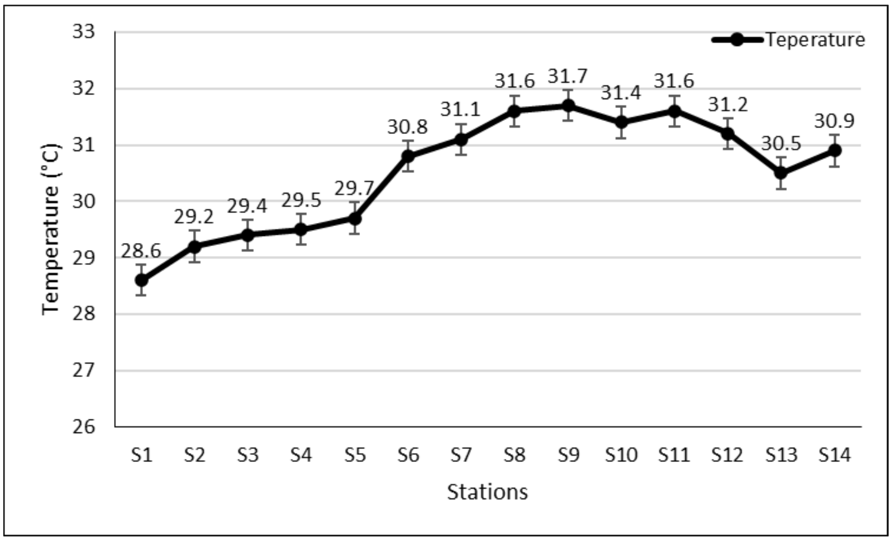

Figure 2 Temperature variation depending on the stations

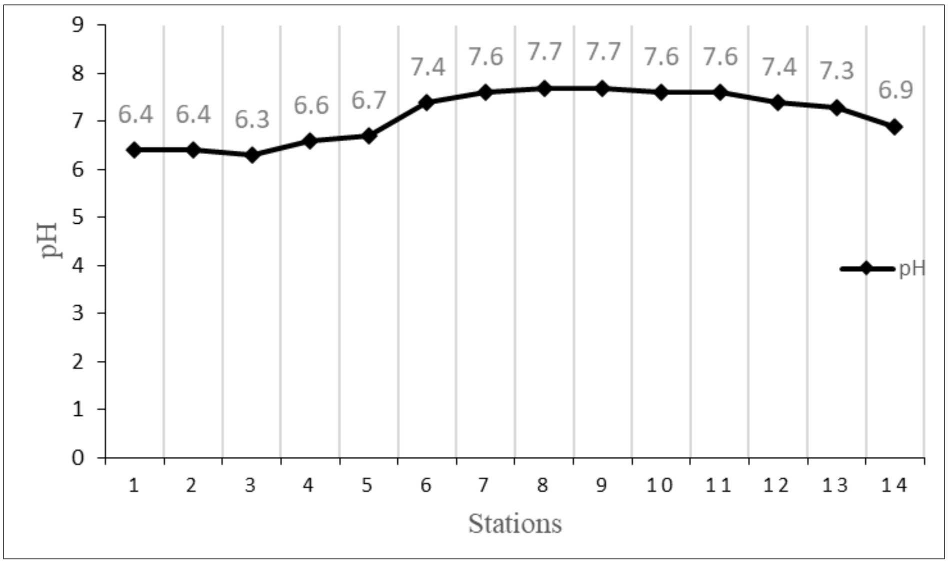

Figure 3 Variation of pH depending on the stations

The results of the physicochemical analyses carried out to assess water quality are presented in Figures 2 to 10. These figures successively show the measured values of temperature, pH, conductivity, suspended matter, turbidity, nitrates, phosphates, salinity and dissolved oxygen. Thus, they provide an initial overview of water quality during the sampling period.

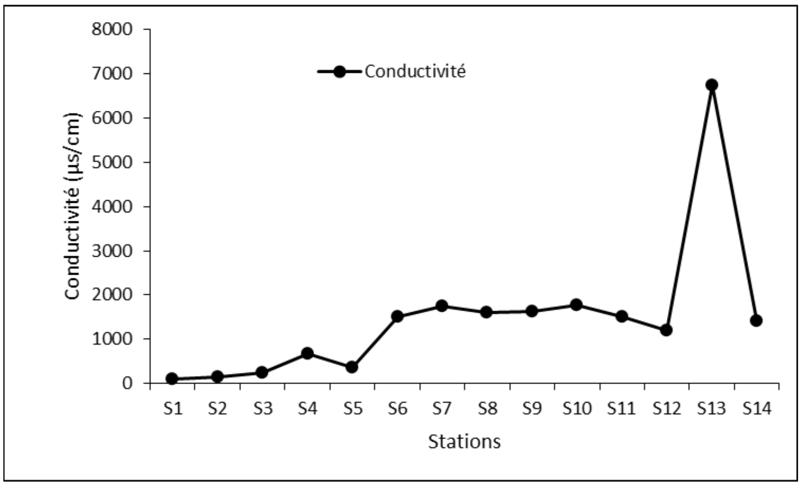

Figure 4 Variation in conductivity depending on the stations

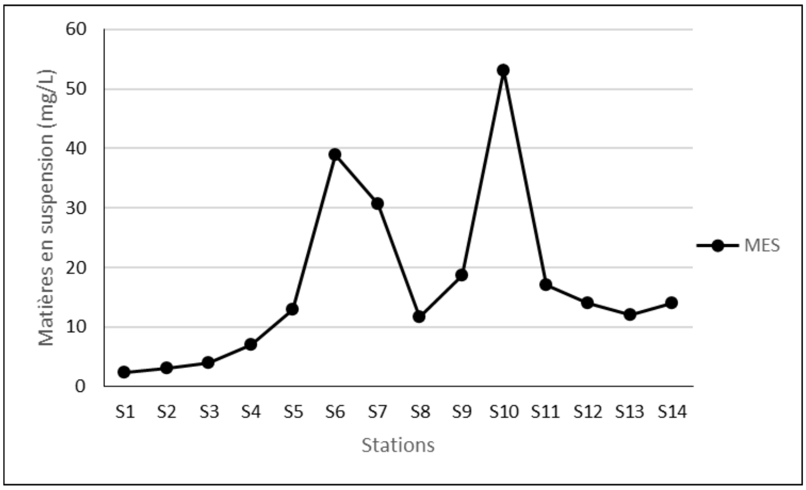

Figure 5 Variation in the quantity of suspended solids depending on the stations

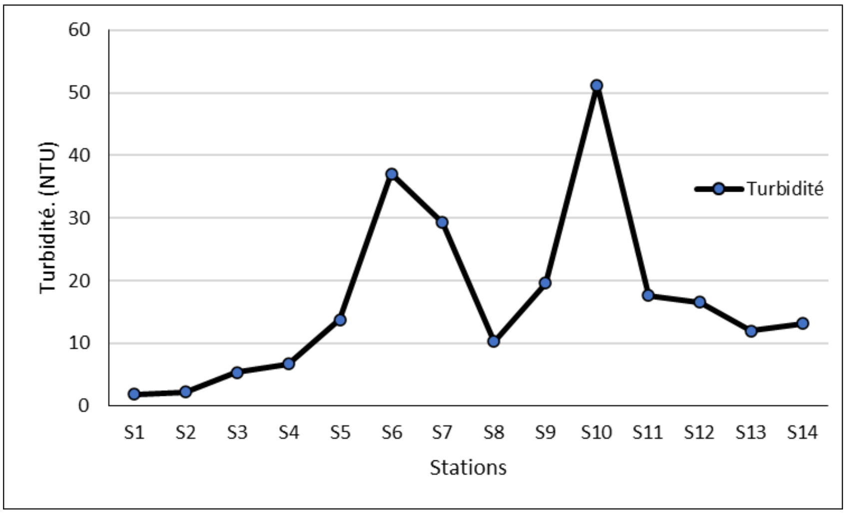

Figure 6 Variation of turbidity depending on the stations

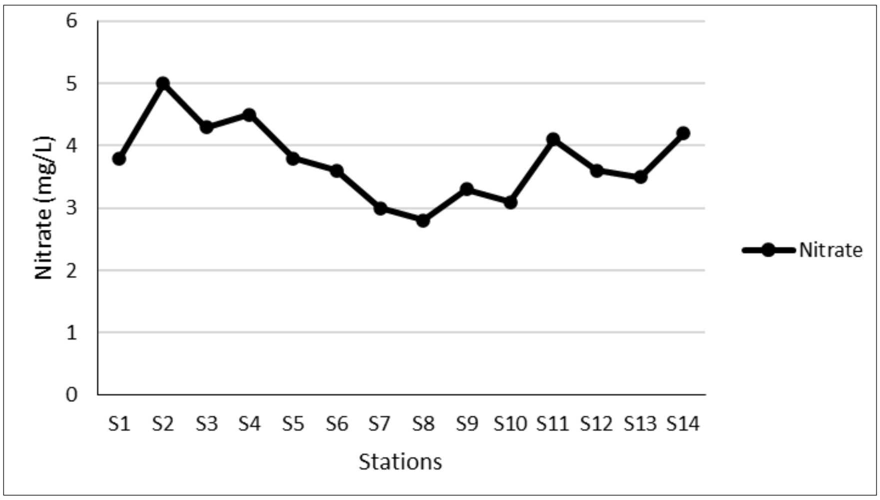

Figure 7 Variation in the quantity of nitrate depending on the stations

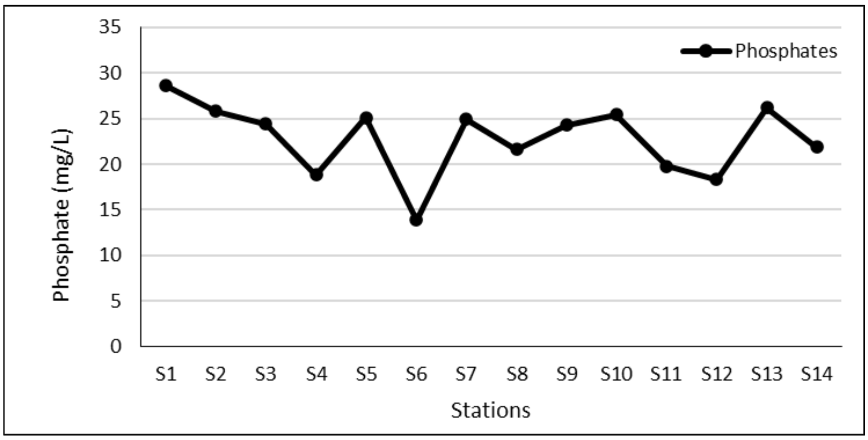

Figure 8 Variation in the quantity of Phosphate depending on the stations

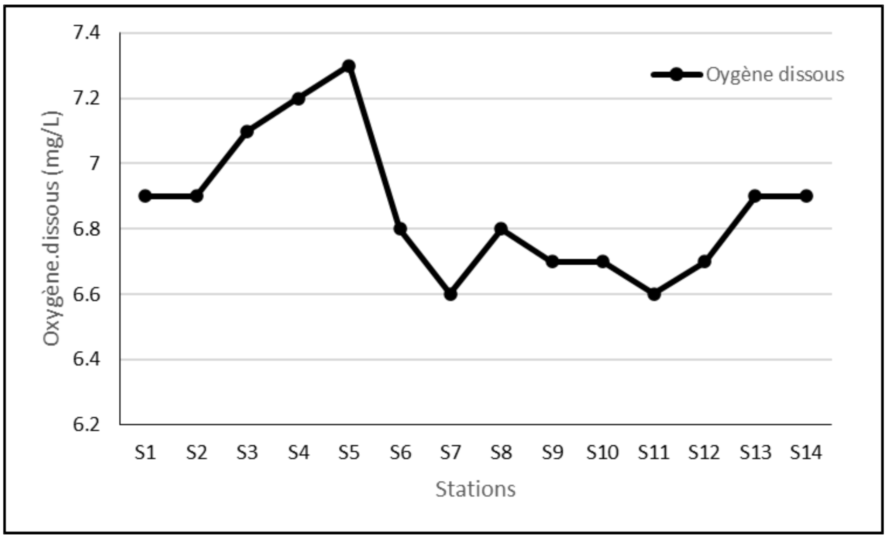

Figure 9 Variation of Oxygenenot dissolved according to the stations

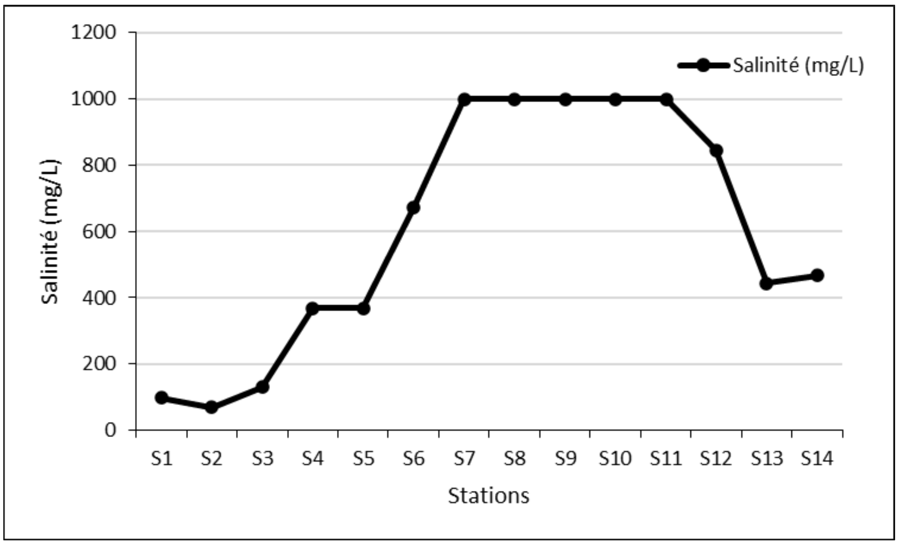

Figure 10 Variation of salinity depending on the stations

The analysis of the physicochemical parameters measured along the longitudinal gradient of the Fatala estuary highlights several indicators of degradation of water quality, reflecting a combination of anthropogenic pressures and natural factors.

Water temperature ranged from 28.6 °C at station 1 (upstream) to 31.7 °C at station 9 (downstream), significantly exceeding the average value of 25 °C recommended by AGRBC (2015) and the biological suitability thresholds of 25 to 27 °C defined by the International Office for Water (2003). The lowest temperatures were recorded upstream, notably at stations 1 (28.6 °C) and 2 (29.2 °C), while the highest were located downstream, at stations 8 (31.6 °C) and 9 (31.7 °C). Spatial variation remained moderate (3.1 °C difference), which is comparable to the observations of N'Guessan et al. (2015) in the Sassandra estuary. However, these relatively high temperatures can reduce the solubility of dissolved oxygen, promote the proliferation of algae and opportunistic microorganisms, and thus alter the ecological quality of the environment.

The pH shows a significant longitudinal variation, with a tendency to increase from upstream to downstream. Stations 2, 3, 4 and 5, located near inhabited areas and the port of Boffa, show values below 7, probably related to domestic and port discharges and mining activities. The lowest pH (6.3) was recorded at station 3. On the other hand, more alkaline values, reaching 7.7, were observed at stations 8 and 9, downstream, which could be explained by the presence of limestone rocks on the seabed.Despite some episodes of slight acidity, all measurements are within the tolerance range (6–9)recommended by the International Office for Water (2003) and AGRBC (2015), which is consistent with the trends observed by N'Guessan et al. (2015) in the Sassandra River estuary. For comparison, the waters of the Beht basin in Morocco have a significantly higher pH, ranging between 8 and 8.8 (Lakhili et al., 2015).

Electrical conductivity values show strong spatial heterogeneity, ranging from 86.3 µS/cm at station 1 to 6750 µS/cm at station 13, close to the mouth. Stations located upstream (stations 1 to 5) record conductivities lower than the reference average of 800 µS/cm set by AGRBC (2015), indicating the predominance of low-mineralized freshwater. On the other hand, the very high values measured downstream reflect the direct influence of saline marine waters, as well as the effects of runoff loaded with dissolved salts and the dissolution of coastal rocks. These results are consistent with the observations of Lakhili et al. (2015) in Morocco and N'Guessan et al. (2015) in Ivory Coast, who also reported a significant increase in electrical conductivity in estuaries under the influence of marine waters.

Suspended solids (SS) also exhibit high spatial variability, with concentrations ranging from 2.3 mg/L (station 1) to 53 mg/L (station 10). The lowest levels were recorded at the upstream stations (S1 to S5), respectively 2.3; 3.0; 4.0; 7.0 and 13 mg/L, where the influence of the tide is reduced. Downstream, particularly at station 10, the maximum concentration is attributable to the effect of high tide promoting the resuspension of particles, increased erosive potential, as well as anthropogenic activities, particularly those related to the nearby artisanal fishing port of Marara. This value exceeds the threshold of 50 mg/L set for the “good” class by the International Office for Water (2003). All other stations remain below this limit, indicating a localized but significant degradation of water quality downstream.

Turbidity measurements follow a similar trend to that of suspended solids. They vary between 1.8 NTU (station 1) and 51.2 NTU (station 10), with a clear increase from upstream to downstream. This increase is the result of a combination of factors including human activities, sediment inputs by runoff, tidal resuspension, and proximity to the artisanal fishing port. Despite this increase, all stations comply with the thresholds of the International Office for Water (2003), which sets the limit for “average” quality at 70 NTU.

Nutrient concentrations reveal significant pollution. Nitrate levels range from 2.8 mg/L at station 8 to 5.0 mg/L at station 2, far exceeding historical levels recorded in Guinean estuaries (0.1 to 0.5 mg/L according to Yanchilenko et al., 1988) as well as the 2 mg/L threshold corresponding to “very good” water quality according to the criteria of the International Office for Water (2003). This increase is probably linked to the intensive use of nitrogen fertilizers in agricultural areas of the watershed. The leaching of these fertilizers leads to a transfer of nitrates into the hydrographic network, promoting ecological imbalances such as eutrophication, with increased risks of algal proliferation and toxicity for aquatic fauna. In addition, nitrification, the process of transforming ammonia into nitrates, consumes a significant proportion of dissolved oxygen, which can worsen the chronic hypoxia already reported in other estuaries such as the Seine (GIP Seine-Aval, 2009).

Phosphate concentrations are of particular concern, with values ranging from 13.9 mg/L (station 6) to 28.6 mg/L (station 1), well above environmental standards. According to the International Office for Water (2003), water is considered to be of "very good quality" when phosphates are less than 0.1 mg/L. The values observed in the Fatala estuary therefore classify these waters in the "poor quality" category. This contamination is probably linked to the excessive use of phosphate fertilizers, the residues of which, not absorbed by crops, are carried into aquatic environments by runoff or infiltration. Possible untreated domestic discharges may also contribute to this high phosphate load.

Dissolved oxygen concentrations ranged from 6.6 mg/L to 7.3 mg/L. Stations located upstream, particularly stations 3, 4, and 5, had the highest levels (7.1, 7.2, and 7.3 mg/L), likely due to high photosynthetic activity associated with riparian vegetation. The lowest values (6.6 mg/L) were observed downstream at stations 7 and 11, areas subject to higher temperatures, thermal stratification, and a higher organic load. According to the International Office for Water (2003), these concentrations indicate overall "good" water quality, although below the threshold of 8.0 mg/L recommended by the Canadian Council of Ministers of the Environment (CCME, 1996) for marine and estuarine waters. This discrepancy highlights a certain vulnerability of the ecosystem to increasing environmental stress.

The highest salinities were recorded at the mouth of the estuary, particularly at stations 7 to 11, where they reached up to 1000 mg/L. This high salinity results from the direct influence of marine waters, with seawater containing an average of 35 g of dissolved salts per kilogram of water (Hervé, 2017). In contrast, the upstream areas have significantly lower salinities, with the lowest value being measured at station 2 (68.4 mg/L). This low salinity is likely linked to the continuous input of continental freshwater, whose salinity is generally less than 0.5 g/L (IFREMER, 2004). The longitudinal salinity gradient observed in the Fatala estuary is typical of estuarine systems, marked by saline intrusion downstream and progressive dilution upstream, although the values remain significantly lower than those observed in other estuaries such as the Loukkos estuary in Morocco (El Morhit et al., 2012), which could be explained by a higher river discharge, less marine intrusion or a specific geomorphological configuration of the estuary.

4. Qualitative study of copepods

The systematic inventory of copepods revealed the presence of 59 species belonging to 2 orders (figure 11), 17 families (figure 12) and 27 genera (figure 13).

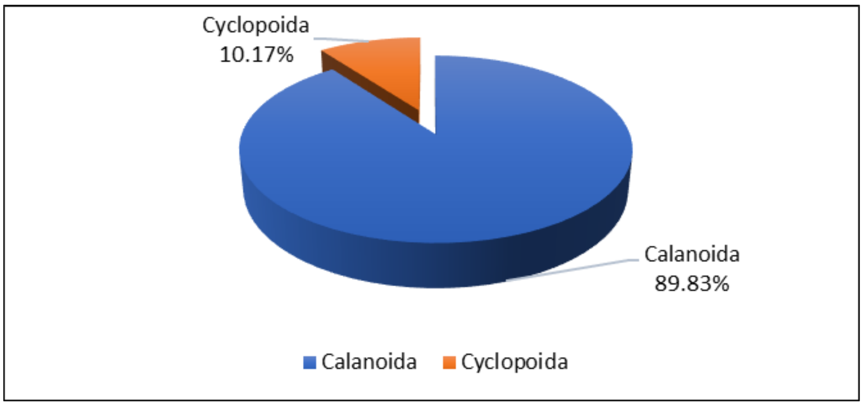

Figure 11 Proportion of the different orders of copepods

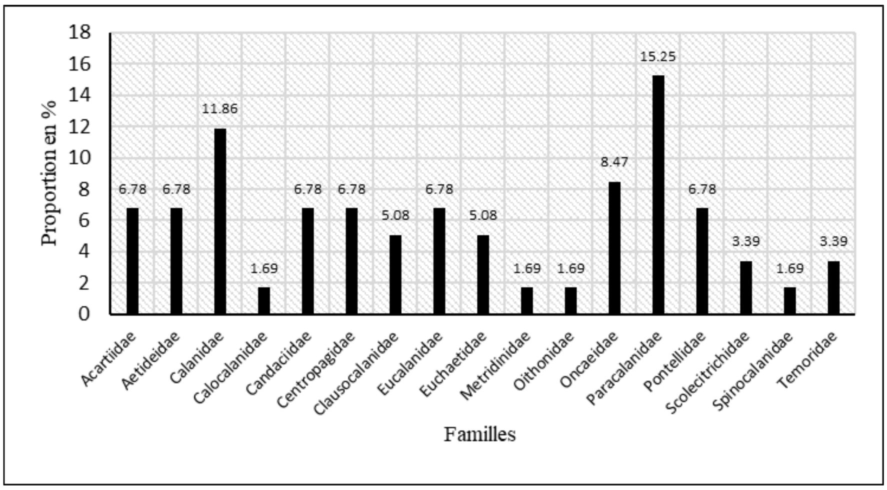

Figure 12 Proportion of the different copepod families

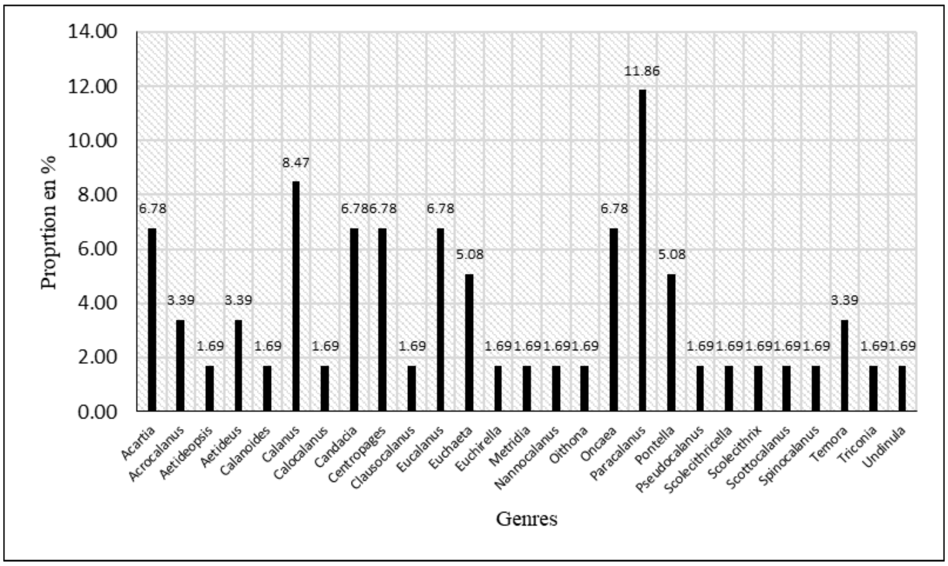

Figure 13 Proportion of the different genera of copepods

The taxonomy of the collected copepods highlights a clear dominance of the order Calanoida, which represents 89.83% of all identified individuals, compared to only 10.17% for the order Cyclopoida (Figure 11). This predominance reflects a community structure typical of pelagic environments, generally associated with open marine or coastal environments with high productivity. These results broadly confirm the observations of Sow et al. (2024), who also reported a strong dominance of the order Calanoida (73.67%) in the Tinguilinta River estuary.

At the family level, 17 families were identified, among which Paracalanidae (15.25%), Calanidae (11.86%) and Oncaeidae (8.47%) stand out for their abundance (Figure 12). On the other hand, the families Calocalanidae, Metridinidae, Oithonidae and Spinocalanidae with 1.69% each, as well as Clausocalanidae and Euchaetidae (5.08% each), are among the least represented. This composition reflects a relatively balanced family diversity, dominated by a few families well adapted to local ecological conditions.

At the generic level, 27 genera were identified. The most abundant were Paracalanus (11.86%), followed by Calanus (8.47%), then Acartia, Candacia, Centropages and Eucalanus, each with 6.78% (Figure 13). These genera, all from the order Calanoida, confirm its supremacy both taxonomically and functionally in the structuring of the planktonic community. Conversely, several genera appear poorly represented, with an abundance of 1.69% each, including Aetideopsis, Calanoides, Calocalanus, Clausocalanus, Euchirella, Metridia, Nannocalanus, Oithona, Pseudocalanus, Scolecithricella, Scolecithrix, Scottocalanus, Spinocalanus, Triconia and Undinula. This low representation could be explained by a more marked ecological specialization or by unfavorable environmental conditions (salinity, nutrient availability) in the area studied.

4.1. Quantitative study of copepods

Figures 14a and 14b, Figure 15, Figure 16 and Table 2 present respectively the proportions of the different copepod species identified, the species densities per station, the Shannon index per station, as well as the overall copepod diversity index.

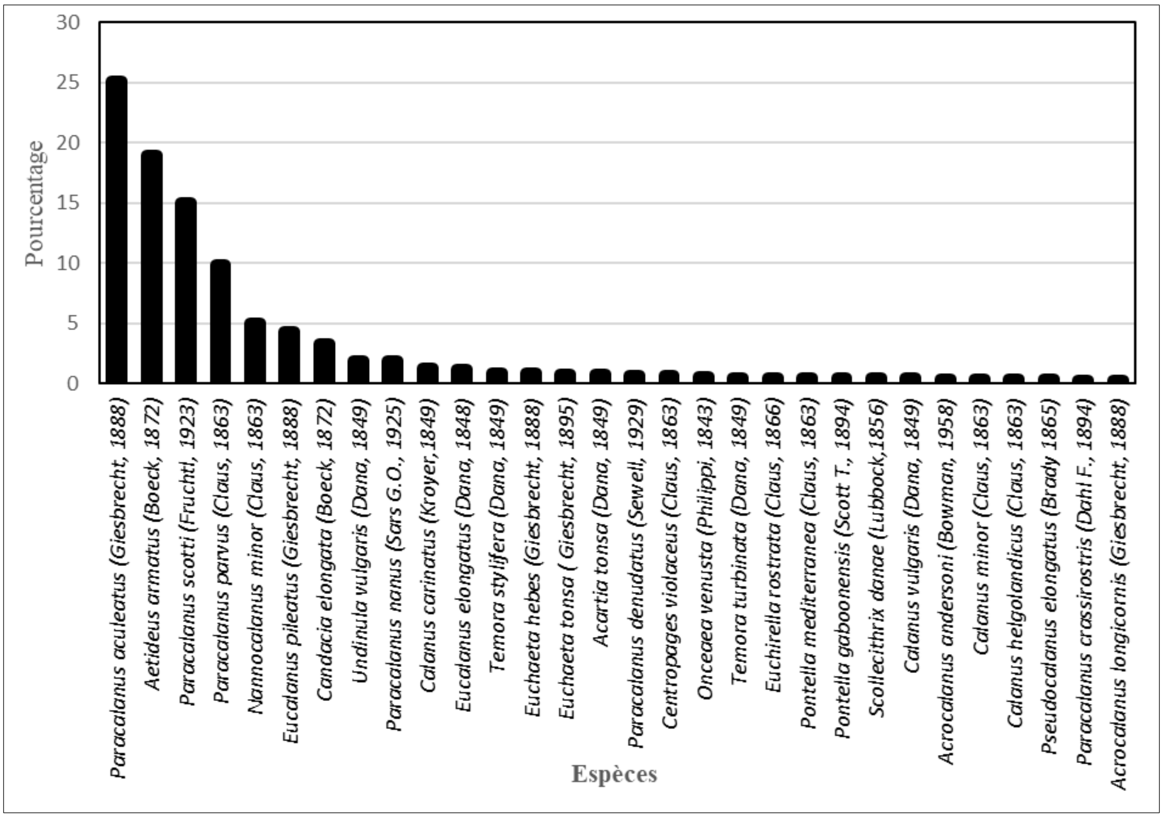

Figure 14a Proportion of copepod species

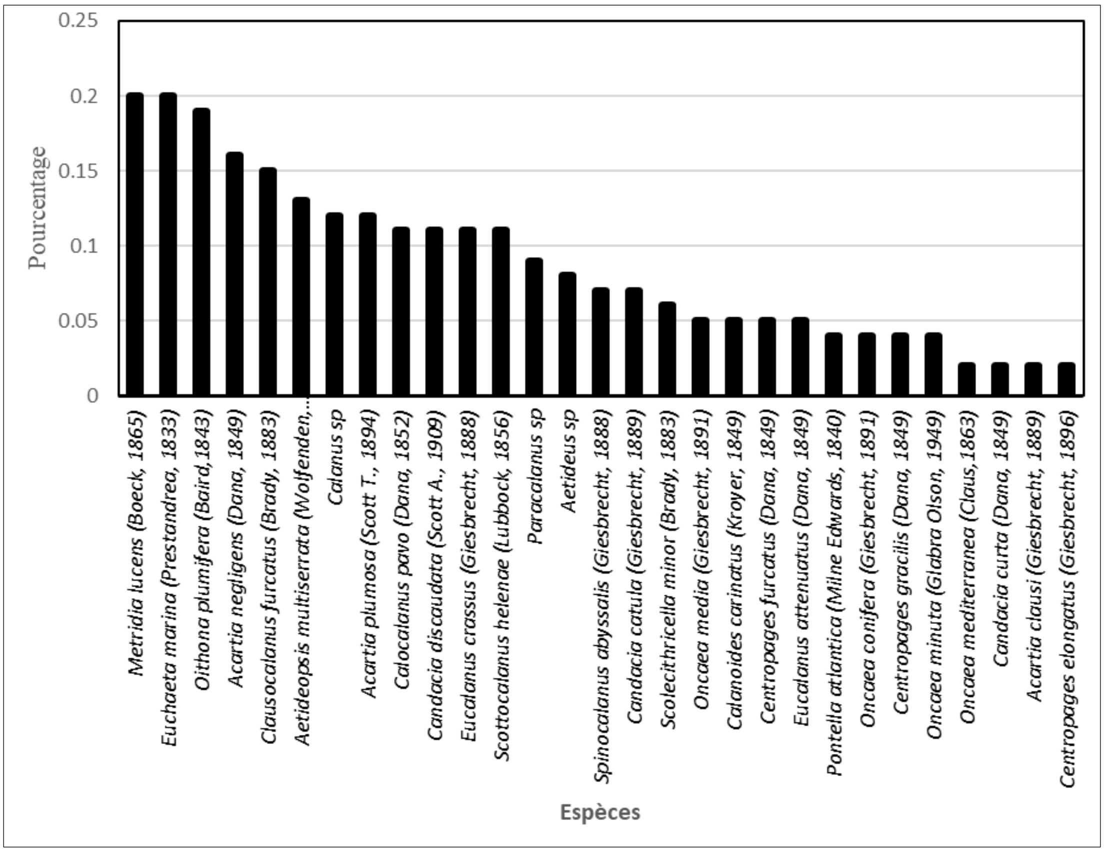

Figure 14b Proportion of copepod species

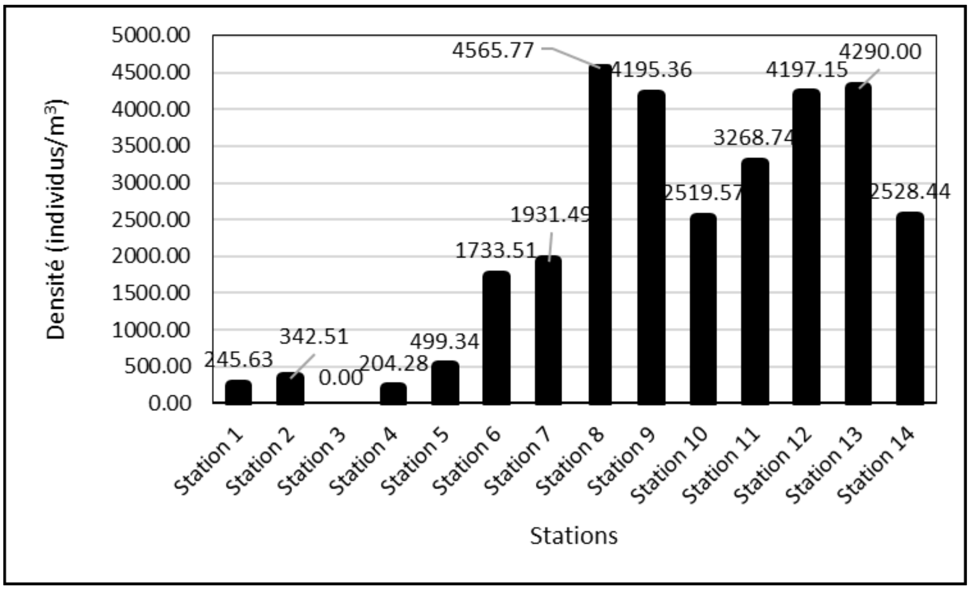

Figure 15 Density of copepod species per station

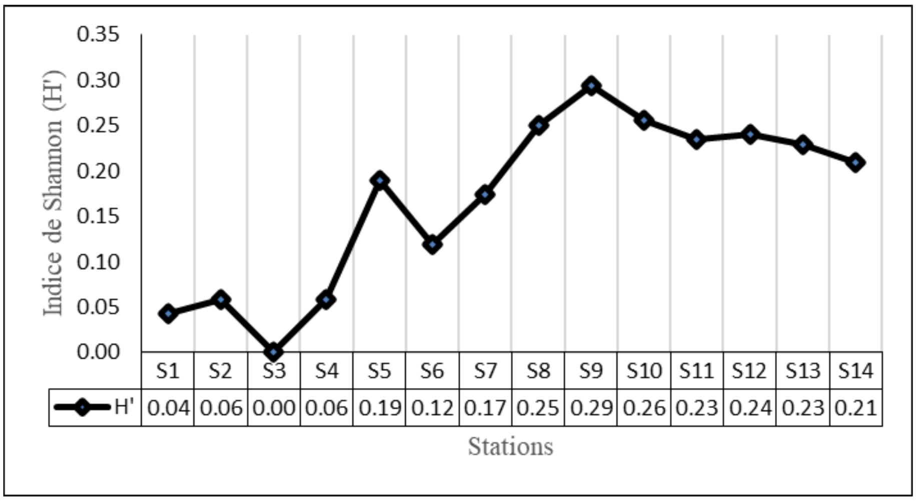

Figure16 Shannon index of copepod species by station

Table 1 Shannon index of copepod species

No.	Copepod species	H'	No.	Copepod species	H'
1	*Paracalanus aculeatus*	0.30	31	*Calanus helgolandicus*	0.02
2	*Paracalanus scotti*	0.29	32	*Aetideopsis multiserrata*	0.02
3	*Aetideus armatus*	0.26	33	*Acartia neglectens*	0.02
4	*Paracalanus parvus*	0.23	34	*Acartia plumosa*	0.02
5	*Eucalanus pileatus*	0.17	35	*Euchaeta marina*	0.02
6	*Candacia elongata*	0.17	36	*Scolecithrix danae*	0.02
7	*Nannocalanus minor*	0.15	37	*Scottocalanus helenae*	0.02
8	*Calanoides carinatus*	0.07	38	*Scolecithricella minor*	0.02
9	*Euchaeta hebes*	0.07	39	*Metridia lucens*	0.02
10	*Euchaeta tonsa*	0.07	40	*Oncaea mediterranea*	0.02
11	*Pontella gaboonensis*	0.07	41	*Paracalanus spp*	0.01
12	*Eucalanus elongatus*	0.06	42	*Calocalanus pavo*	0.01
13	*Calanus carinatus*	0.06	43	*Acrocalanus longicornis*	0.01
14	*Undinula vulgaris*	0.06	44	*Spinocalanus abyssalis*	0.01
15	*Acartia tonsa*	0.06	45	*Eucalanus crassus*	0.01
16	*Temora stylifera*	0.06	46	*Eucalanus attenuatus*	0.01
17	*Paracalanus crassirostris*	0.05	47	*Calanus spp*	0.01
18	*Paracalanus nanus*	0.05	48	*Aetideus spp*	0.01
19	*Calanus minor*	0.05	49	*Candacia discaudata*	0.01
20	*Centropages violaceus*	0.05	50	*Candacia catula*	0.01
21	*Paracalanus denudatus*	0.04	51	*Candacia curta*	0.01
22	*Pseudocalanus elongatus*	0.04	52	*Acartia clausi*	0.01
23	*Calanus vulgaris*	0.04	53	*Centropages elongatus*	0.01

24	*Euchirella rostrata*	0.04	54	*Centropages gracilis*	0.01
25	*Temora turbinata*	0.04	55	*Centropages furcatus*	0.01
26	*Acrocalanus andersoni*	0.03	56	*Pontella Atlantica*	0.01
27	*Pontella mediterranea*	0.03	57	*Oncaea minuta*	0.01
28	*Onceaea venusta*	0.03	58	*Oncaea conifera*	0.01
29	*Oithona plumifera*	0.03	59	*Oncaea media*	0.01
30	*Clausocalanus furcatus*	0.02			

Figures 14a and 14b highlight a copepod community dominated by a small number of species, including *Paracalanus aculeatus* (25.14%), *Aetideus armatus* (18.93%), *Paracalanus scotti* (15.07%) and *Paracalanus parvus* (9.83%), which together account for nearly 69% of the total abundance (Figure 14a). This strong dominance can be interpreted as a reflection of a high ecological tolerance of these species to variations in environmental conditions, a common characteristic among taxa ubiquitous in estuarine environments.

This trend is consistent with the results of Zerouali & Melhaoui (2002), who recorded 57 species of pelagic copepods in the Ras Kebdana region, in the northeastern Moroccan Mediterranean, with *Paracalanus parvus* as the most abundant species (37%). Conversely, several species are marginally represented, such as *Oncaea mediterranea*, *Candacia curta, Acartia clausi* and *Centropages elongatus*, each representing only 0.02% of the total (Figure 14b). This rarity could reflect a high sensitivity to environmental disturbances, often observed in specialist species.

Figure 15 shows that in the upstream area of the estuary (stations S1 to S5), copepod density remains generally low, ranging from 0.00 individuals/m^3 at station S3 to a maximum of 499.34 individuals/m^3 at station S5. This low density appears to be directly linked to unfavorable physicochemical conditions. The pH values between 6.3 and 6.7, although within the general tolerance range (6–9), remain relatively low and indicate a slight acidity that may affect the physiological functions of copepods. In addition, salinity (97.9 to 368 mg/L) and electrical conductivity (86.3 to 671 µS/cm) indicate low mineralization and ionic instability of the environment, conditions that are not conducive to the survival of zooplankton. The complete absence of copepods at station S3, where the pH reaches 6.3, suggests a critical threshold that could compromise the reproduction and viability of these organisms.

Beyond natural constraints, the upstream area is subject to increased anthropogenic pressure, particularly due to excessive nutrient input, particularly phosphates. Although these elements are essential for the productivity of aquatic systems, their excess disrupts the trophic balance. The measured concentrations reached up to 28.6 mg/L at station S1, well above the reference values proposed by the International Office for Water (2003) (0.5–1 mg/L) and the AGRBC (2015), which recommends a maximum threshold of 1 mg/L. This nutritional overload results mainly from the use of chemical fertilizers in riparian agricultural areas, the residues of which are carried to the estuary by runoff or infiltration. This situation favors eutrophication processes, causing phytoplankton blooms that can unbalance the food web and reduce copepod density.

Regarding dissolved oxygen, measurements taken in this area show concentrations around 6 mg/L, in line with the criteria of the International Office for Water (2003), which qualifies this value as "good". However, these levels remain below the CCME recommendation (1996), which sets an optimal threshold at 8.0 mg/L for estuarine environments, suggesting that the environment is only moderately favorable to the survival of copepods.

Stations S1 to S5 are also subject to diffuse anthropogenic pressures, particularly related to mining activities, artisanal fishing ports and intensive agriculture. These practices increase suspended solids (SS) concentrations, influencing turbidity and trophic dynamics. Nevertheless, the values observed in this area remain below the threshold of 50 mg/L recommended by AGRBC (2015), suggesting that, under current conditions, this parameter is not a significant limiting factor.

Station S5 stands out for its relatively high density (499.34 individuals/m^3), probably due to locally more favorable physicochemical conditions (pH at 6.7, increasing salinity and conductivity), reflecting a transition to a more stable estuarine environment. However, the entire upstream area remains generally unfavorable to the optimal development of copepods, due to the combination of restrictive abiotic factors and intense anthropogenic pressures, lastingly affecting the diversity and abundance of zooplankton.

Conversely, the downstream area of the estuary presents significantly more favorable environmental conditions. There, a higher density of copepods is observed, accompanied by a more alkaline pH (up to 7.7), salinity reaching 1000 mg/L and increased conductivity, promoting an optimal osmotic balance. Turbidity remains moderate (particularly at stations S8, S9, S12 and S13), allowing better light penetration and supporting primary production, which translates into greater food availability for zooplankton.

However, high variability remains between downstream stations. The lowest densities are recorded at S6, S7, S10 and S14 (between 1733 and 2528 individuals/m^3), while stations S8, S9, S11, S12 and S13 show significantly higher values, peaking at 4565 individuals/m^3 at station S8 (Figure 15). This disparity is mainly explained by turbidity and suspended solids levels. The most turbid stations (S6, S10) have conditions limiting photosynthesis, which affects the trophic base of copepods. Furthermore, the proximity of fishing ports (S10, S14) exposes these stations to anthropogenic discharges (hydrocarbons, heavy metals, organic waste), which can cause direct toxicity to plankton. Finally, the low salinity (467 mg/L) and slightly acidic pH (6.9) observed at S14 could also constitute stress factors.

Figure 16 confirms this trend by revealing very low specific diversity in the upstream stations (S1 to S5), with Shannon indices below 0.19. Station S3, where no copepods were observed, has a zero index (H' = 0.00), reflecting biological exclusion potentially linked to extreme abiotic conditions. A progressive increase in diversity is observed from station S6, culminating downstream (S8 to S11), with a maximum reached at S9 (H' = 0.29). This progression reflects an improvement in ecological conditions and a more balanced structuring of the communities.

Table 1 shows an uneven distribution of Shannon indices by species. *Paracalanus aculeatus* (H' = 0.30), *Paracalanus scotti* (0.29) and *Aetideus armatus* (0.26) contribute the most to the overall diversity, demonstrating a high ecological tolerance. Other species such as *Paracalanus parvus* (0.23) and *Eucalanus pileatus* (0.17) also contribute significantly. In contrast, the majority of species recorded display very low indices (H' ≤ 0.05), indicating a reduced abundance or a limited distribution. This structure, dominated by a few ubiquitous species and a host of rare species, is typical of estuarine environments, where the spatiotemporal variability of abiotic conditions strongly shapes the composition and distribution of zooplankton communities.

5. Conclusion

The study of copepod communities in the Fatala River estuary identified a total of 59 species, divided into two orders, 17 families, and 27 genera, with a clear predominance of the order Calanoida, representing 89.83% of the individuals recorded. This species richness, although relatively high at the regional scale, masks an unbalanced community structure, dominated by a small number of euryecious species, such as *Paracalanus aculeatus, Aetideus armatus* and *Paracalanus scotti*, strongly represented in all stations.

The results reveal a strong spatial heterogeneity, directly influenced by physicochemical gradients and anthropogenic pressures. Upstream stations, subject to marked acidity, low mineralization and nutrient overload, particularly phosphates reaching concentrations up to 28.6 mg/L, present very low or even zero densities and reduced specific diversity. Conversely, downstream stations, characterized by higher salinity, pH and conductivity as well as moderate turbidity, offer a more favorable environment for the development and structuring of diverse zooplankton communities.

The rarity of sensitive species and the dominance of tolerant taxa reflect an ecological disturbance typical of estuarine environments subject to multiple pressures, including agricultural, mining and port discharges. These results confirm the role of copepods as relevant bioindicators of the quality of aquatic ecosystems, particularly in transition zones.

From this perspective, it is strongly recommended to establish an integrated environmental monitoring program that combines physicochemical and biological measurements, enabling continuous assessment of the estuary's ecological status and guiding sustainable management actions. Priority should be given to reducing nutrient inputs from agricultural sources, limiting diffuse pollution, and restoring natural habitats to preserve planktonic biodiversity and maintain the essential ecological functions of the Fatala River estuary.

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Compliance with ethical standards

Ethically, this study was conducted following standard scientific practices in hydrobiology and ecology, and was reviewed and validated by competent researchers and university professors in the field.

Disclosure of conflict of interest

The authors declare no conflict of interest

References

[1] AGRBC - Decree of the Government of the Brussels-Capital Region (2015). Physicochemical quality of surface water, 8p.

[2] CCLME – Canary Current Large Marine Ecosystem Project. (2014). Assessment of land-based activities that may constitute sources of marine and coastal pollution in the countries of the Canary Current Large Marine Ecosystem. Study report, 110 p.

[3] CCME- Canadian Council of Ministers of the Environment. (1996). Water quality guidelines for dissolved oxygen in marine and estuarine waters for the protection of aquatic life, 6 pp.

[4] Chaalali, A. (2013). Long-term evolution of the Gironde estuarine ecosystem (PhD thesis, University of Sciences and Technologies - Bordeaux I, France). Thesis in biogeochemistry and ecosystems, NNT: 2013 BOR14795, 256 p.

[5] El Morhit, M., Fekhaoui, M., Serghini, A., El Blidi, S., El Blidi, A., Yahyaoui, A., & Hachim, M. (2012). Study of the spatio-temporal evolution of hydrological parameters characterizing the water quality of the Loukkos estuary (Morocco). Bulletin of the Scientific Institute, Rabat, Life Sciences Section, 34, 151–162.

[6] GIP Seine-Aval. (2009). Water quality and contamination: Nutrient dynamics in the Seine estuary (6p).

[7] Hervé (2017). Salinity. The water in our aquariums is salty, 10p.

IFREMER (2004). Network of Breton estuaries. Water quality - Presentation and analysis of results. 2002-2004 campaign. Final report, 211p.

[8] Lakhili, F., Benabdelhadi, M., Bouderka, N., Lahrach, H., & Lahrach, A. (2015). Study of the physicochemical quality and metallic contamination of surface waters in the Beht watershed (Morocco). Scientific article, 16 p.

[9] Moison, M. (2009). Experimental and numerical approach to the individual behavior of Temora longicornis (Muler, 1792), a calanoid copepod typical of the Eastern Channel: responses to biotic and abiotic forcing. Doctoral thesis in Geosciences, Ecology, Paleontology, Oceanography from the University of Lille 1 - Sciences and Technologies, 300p.

[10] Mouny P (1998). Spatio-temporal structure of zooplankton and suprabenthos in the Seine estuary. Dynamics and role of the main species in the pelagic trophic chain. Doctoral thesis in Marine Environment, 42p.

[11] N'guessan Y. A, Wango T. E, Konan K. E, Adingra A, Amani E. M, Monde S, Affian K and Aka K (2015). Hydrology and morphology of the Sassandra River estuary, Lower Ivory Coast. Scientific article, 12p.

[12] International Office for Water. (2003). Water Quality Assessment System for Rivers – SEQ-Eau Presentation Report (version 2). Ministry of Ecology and Sustainable Development, Water Agencies, 106p.

[13] Rolland, N. (2004). Cycle de vie annuel des copépodes calanoïdes arctiques dans la Polynie des eaux du nord : Une étude basée sur 24 mois de collecte par des pièges à particules séquentiels (Mémoire de maîtrise, Université Laval, Québec, Canada). Faculté des sciences et de génie, Université Laval. 55 p.

[14] Rose, M. (1933). Pelagic copepods (Fauna of France, No. 26). Paris: Lechevalier. 374 p.

[15] Shannon CE (1948) A mathematical theory of communication. Bull. Syst. Tech. J. 27: 379-423.

[16] Sow, M.D, S. Diakité., A. Guissé., O. Sangaré and L. Konaté (2024). Anthropogenic effects on the physicochemical quality and copepod population of the waters of the Tinguilinta River estuary in Boké-Guinea. Bulletin of Agricultural Research of Benin (BRAB) – Volume 34 - Number 02. Pages (pp.) 62-87.

[17] Trégouboff, G., & Rose, M. (1957). Manual of Mediterranean Planktonology (Vol. 1, Text, 225 p). Paris: National Center for Scientific Research.

[18] Trégouboff G. & Rose M. (1978) Manual of Mediterranean planktonology. Edit. CNRS, 587 p.

[19] Yanchilenko, A., Cheremetiev, V, & Camara S., MM (1988). Oxygen production and primary production in the coastal zone of the Republic of Guinea. Bulletin of the Rogbané Center, No. 4, 4, 54-67.

[20] Zerouali, F., & Melhaoui, M. (2002). Specific diversity and biomass of pelagic copepods in the Ras Kebdana region (Moroccan Mediterranean coast). Proceedings of the Agronomic and Veterinary Institute (Morocco), 22(2), 91–102.