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RESEARCH ARTICLE

EXPLOITED BIVALVE MOLLUSCS IN THE EBRIE LAGOON - CÔTE D'IVOIRE: ACTORS INVOLVED AND MARKETING CHANNELS

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ABSTRACT

Background: Bivalves are bilaterally symmetrical aquatic molluscs characterised by a shell composed of two calcified valves that cover the bilaterals. Despite the dietary, economic and ecological importance of bivalve molluscs, few studies have been devoted to the exploitation of this resource in Côte d'Ivoire. The aim of this study is therefore to find out about the organisation and players involved in bivalve mollusc fishing in the Ébrié lagoon. **Methods:** Sampling of bivalve molluscs took place between July and September 2021 at the landing stages in the village of Vridi AKO. Data were collected from survey forms, interviews and analyses of fishermen's catches. **Results:** This study revealed that two (2) species of bivalve molluscs, *Mytilus édulis* and *Cerastoderma glaucum*, were caught in the Ebrié Lagoon and landed at Vridi AKO. *Cerastoderma glaucum* is the most common species (FI = 100%) and the most abundant (Ar = 93.60%) in landings, unlike *Mytilus édulis* (FI = 25% and Ar = 6.40%). The actors involved in this sector are non-nationals, of Ghanaian nationality, mostly married (57.50% of fishmongers and 66.67% of fishers), with a low level of education, with an illiteracy rate of 83% among fishers and 90% among fishmongers. Concerning the marketing circuit, bivalves were sold in 25-litre containers at 2,500 CFA francs per container. Fishermen's catches were sold to fishmongers. The fishmongers resell them either on skewers or by the pound for 3 bivalves at 100 Fcfa at local markets and hotel complexes. The daily income per fisherman ranged from 1,000 to 15,000 CFA francs, and from 500 to 3,000 CFA francs for the fishmongers. **Conclusion**: The fishing and marketing of bivalve molluscs in Côte d'Ivoire is a lucrative activity for stakeholders, and has an important food and socio-economic value. It would be advisable to organise stakeholders in the sector into cooperatives and to build the capacity of young people to modernise bivalve mollusc fishing techniques.

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INTRODUCTION

Côte d'Ivoire, like most countries in sub-Saharan Africa, has a severe shortage of animal protein (Fantodji and Mensah, 2000). Most of its protein resources of aquatic origin are fish. Unlike European and Asian countries, where several fishery products were valued (Drago et al., 2023), there is very little data on bivalve molluscs in Africa. Bivalves are aquatic molluscs with a symmetry of two calcified valves covering both sides of the body, characterised by a shell made up of the right and left sides of the body. They are highly prized by many populations because of their high nutritional value (Drago, 2023). Their flesh contains a multitude of nutrients, including proteins, lipids, vitamins, minerals and trace elements, some of which are particularly valuable because they are often lacking in our diet: iron, zinc, copper, selenium, manganese, iodine, fluorine, etc. (Facbmann et al., 1995). Ecologically, bivalve molluscs played an important role in the ecosystem by stabilising the seabed (Reneerkens et al., 2005) and increasing benthic biodiversity (Stoner et al., 2005). Furthermore, bivalve molluscs were exploited for their significant commercial interest in several countries, for the production of pearls (Martínez-Fernández et al., 2003), and as a source of calcium in animal feed (Bouyé et al., 2013). In African countries, particularly in Côte d'Ivoire, researchers do not seem to be more interested in marine bivalve molluscs. Indeed, the work carried out only concerns biology and ecology (Bellemans et al., 1988; Haure et al. 2008; Le Loeuff and Intès., 1993; Dabouineau and Ponsero, 2004). However, in lagoon waters, this activity is second only to fishing for fish. In Côte d'Ivoire, fishing for bivalve molluscs is an alternative activity to fishing for fish. However, there is a lack of data on the population and the stakeholders involved in managing this activity. The aim of this study is therefore to highlight the species exploited, the organisation and the actors involved in bivalve mollusc fishing in the Ébrié lagoon.

MATERIEL AND METHODS

Study area: Ivorian lagoon system runs parallel to the shore of the Gulf of Guinea, between 2°50' and 5°25' longitudes West and 5°02' and 5°42' latitudes North (Tastet and Guiral, 1994). Ébrié lagoon was central to the lagoon complex. It was located between 3°40' and 4°50' west longitude and 5°2' and 5°10' north latitude, a surface area was 560 km^2 and stretches 130 km from west to east along the Ivorian coastline, with an average width of 4 km. This lagoon was the largest in West Africa (Marchand and Martin, 1985). Sampling area was Vridi AKO village. Covering an area of 0.9 km^2, Vridi AKO was located on the lagoon cordon and bounded to the south by the sea, to the north by the Ebrié Lagoon, to the east by the Vridi canal and to the west by the Brakré classified forest (Figures 1 and 2).

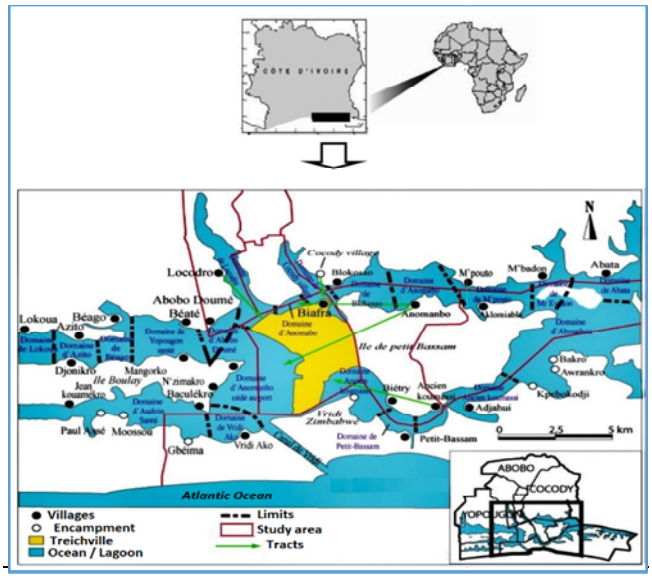

Figure 1. Localisation of the study area from July to September 2021

Figure 2. Landing site for bivalve molluscs captured in the Ebrié Lagoon from July to September 2022

Data collection: Data was collected monthly from July to September 2021. Two (2) trips were made per month. The bivalve species sampled at the Vridi Ako shoreline came from commercial fishing. In the laboratory, bivalves were identified using the dichotomous keys of Le Neuthiec (2013) and Prié (2013). Socio-economic surveys were carried out using two survey sheets. One survey form was designed to interview fishermen and the other for fishmongers. A total of 70 stakeholders (30 fishermen and 40 fishmongers) were interviewed. Information was collected on catching gear, fishing methods, different species caught, fishing area, species sold, destinations of the catches, selling method and price, processing before sale, potential customers, daily quantities sold and the places where the catches were sold. Information was also sought on age, level of education, marital status and nationality of of actors.

Data processing

Two indices were used to analyse bivalve mollusc harvesting data. These were:

(1) Frequency index (FI): FI = 100 x (Xi/ P) où Xi = Presence or absence of a species *i*; P = Number of samples

According to Hyslop (1980), the classification of occurrence index values is as follows: FI ≥ 75% : Frequently occurring species ; 75% < IF ≤ 50% : Common species ; 50% < FI ≤ 25% : Occasional species; 25% < FI ≤10% : Rare species ; si IF < 10% : Incidental species.

(2) Relative abundance (Ar) : Ar = 100 x (qi/qt) with qi : Numerical abundance of species *i* ; qt : Total numerical abundance of species captured

The income of fishermen and fishmongers was determined by calculating the average selling price of bivalve molluscs sold on local markets using the market price estimation method proposed by MBangala et al. (2001). The formulas are all given in Table I.

Survey data was processed using Sphinx Plus².

Tableau I. Summary of the formulas used to estimate the income of actors involved in bivalve mollusc fishing in the Ebrié Lagoon from July to September 2021

Actors	Formulas	Abbreviation definition
Fishermen	Pmv = ∑pvi/ni Rnr = Qt x pc	**Pmv :** Average sales price
		Pvi : Sales price
		ni : Total number of people charging
		Rnr : Harvesters' net income
		Qt : Amount collected; **Pc** = Average selling price by local unit
Buyers	Pma = ∑Pai/ni Rna = Qt (Pv – De)	**Pma :** Average buying price
		Pai : Purchase or selling price of harvesters;
		ni : Total number of people charging
		Rna : Buyer's net income (Fcfa) ; **Pv :** Selling price (Fcfa)
Resellers	Rnr = Pa – Pv	**Pa :** Buying price (fcfa) **; Qtité :** Total quantity bought
		Rnr : Reseller net income **; Pa** : Price (Fcfa) per unit.

RESULTS

Specific diversity of bivalve molluscs exploited: Qualitatively, two (2) species of bivalve molluscs, *Mytilus edulis* Linnaeus, 1758 and *Cerastoderma glaucum* (Bruguière, 1789) were sampled in the Ebrié Lagoon and landed at Vridi AKO from July to September 2021 (Figure 3). Quantitatively, *Cerastoderma glaucum* or Glaucous cockle was the most frequent species with FI = 100% and the most abundant with Ar = 93.60% in the landings. The species *Mytilus édulis* or common mould had a frequency of 25% and an abundance of 6.40% (Table II).

Figure 3. Different species of bivalve molluscs sampled in the Ebrié Lagoon from July to September 2021. A: *Cerastoderma glaucum*; B: *Mytilus édulis*; DV: Dorsal view; VV: Ventral view

Tableau II. Indice de fréquence et Abondance des espèces débarquées de juillet à septembbre 2021

Species	Frequency index (%)	Abundance index (%)
Cerastoderma glaucum	100	93,60
Mytilus édulis	25	6,40

Socio-economic profile of fisheries actors: Social profile of actors showed that the bivalve mollusc fishermen were exclusively men of Ghanaian nationality and Anwolan ethnicity. Among women fishmongers, 99% were Ghanaian nationality of Anwolan ethnicity and 1% were Malian nationality of Soninké ethnicity. In terms of the age range of the actors (Figure 4), age of fishermen varies between 19 and 39. 70% of the fishermen were under 30 age. Women fishmongers range from 30 to 60 age. They represented 48% of the population surveyed. 47% of women fishmongers were under 30 age. Concerning the level of education of the actors (Figure 5), the majority of fishermen had a low level of schooling.

Among the fishermen interviewed, 83% were illiterate, 10% had primary education and 7% secondary education. 90% of the women fishmongers interviewed were illiterate, 7% had primary education and 3% secondary education. In terms of marital status, 67% of the fishermen surveyed were married and 33% were single. Among the women fishmongers, 57.5% were married, 10% were widows and 32.5% were single (Figure 6). In terms of economic profile, the way in which bivalve molluscs were sold differed from one actor to another. Of the two species caught, *Cerastoderma glaucum* was the only edible one. It was sold fresh in 25-litre containers. A bowl costs an average of 2,500 CFA francs. The daily earnings of the fishermen vary from 1,000 Fcfa to 15,000 Fcfa (Figure 7). Fishmongers were both buyers and sellers. Bivalve molluscs were sold either on skewers for 1 to 50 Fcfa, or in heaps for 3 to 100 Fcfa. The daily profits of the fishmongers vary from 500 Fcfa to 3000 Fcfa (Figure 8).

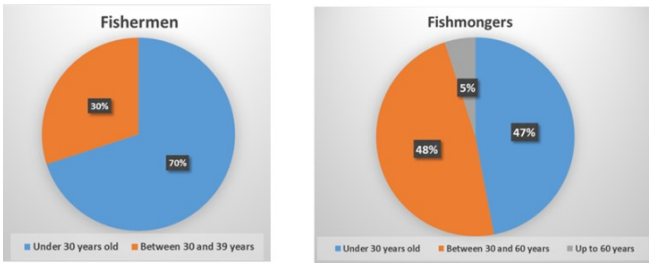

Figure 4. Age range of actors involved in bivalve mollusc fishing in the Ebrié Lagoon from July to September 2021

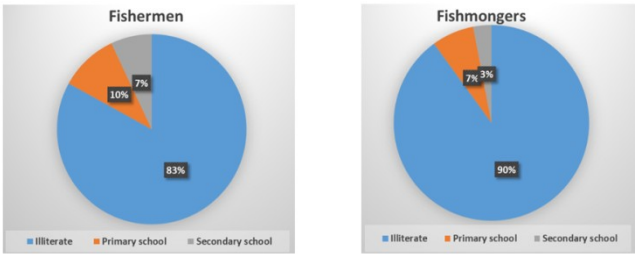

Figure 5. Education level of actors involved in bivalve mollusc fishing in the Ebrié Lagoon from July to September 2021

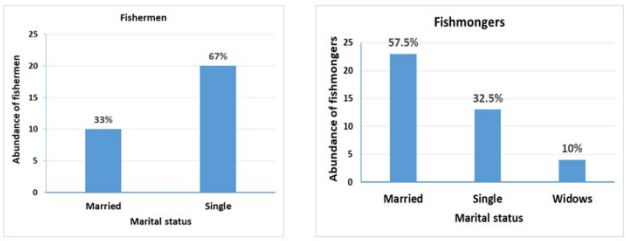

Figure 6. Marital status of actors involved in bivalve mollusc fishing in the Ebrié Lagoon from July to September 2021

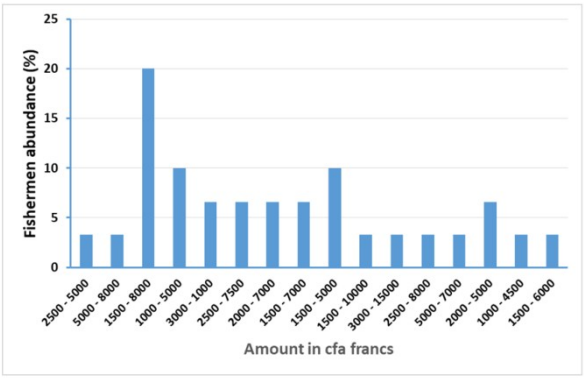

Figure 7. Daily profits of fishermen involved in bivalve mollusc fishing in the Ebrié Lagoon from July to September 2021

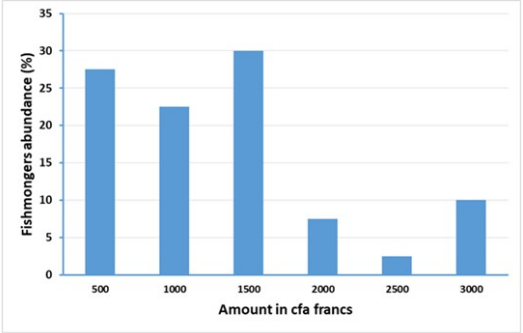

Figure 8. Daily profits of Fishmongers involved in the marketing of bivalve molluscs from the Ebrié Lagoon from July to September 2021

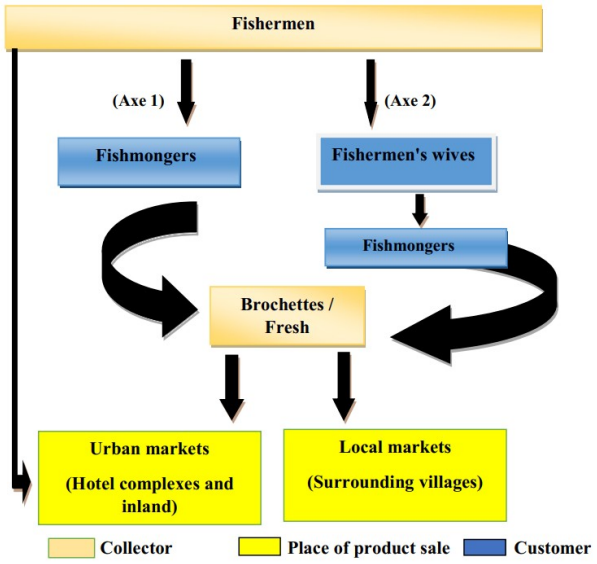

Figure 8. Distribution channel for bivalve molluscs collected in Ebrié Lagoon from July to September 2021

Bivalve mollusc marketing circuit: Analysis of the bivalve mollusc marketing circuit identified three axes: axis 1 included the fishermen, the fishmongers and the urban markets. Axis 2 included fishermen, fishermen's wives, fishmongers and local markets. In axis 3, the fisherman sold his products directly to the local market, urban markets or hotel complexes. Fishermen sold their catches either to fishmongers or to their wives. The fishmongers and the fishermen's wives will in turn process the bivalve molluscs into kebabs or otherwise. Fresh bivalve molluscs/skewers were sold either on local markets in the surrounding villages or on urban markets and hotel complexes (Figure 8).

DISCUSSION

The results of the survey revealed two (2) species of bivalve molluscs harvested in the Ebrié Lagoon and landed at Vridi AKO. These data fall short of the observations of Sankaré and Etien (1991) who counted four (4) species of bivalve molluscs in the Ebrié lagoon. A concordance was noted with the work of Soro et al (2021) who found two (2) species of bivalves *Crassostrea tulipa* (Lamarck, 1819) and *Perna perna* (Linnaeus, 1758) in the eastern part of the Ebrié lagoon. However, a difference was noted in the species captured by Soro et al (2021). This difference is linked to the sampling period and area. The work carried out by Sankaré and Etien (1991) covered the entire Ébrié lagoon for a whole year, whereas the present study only covered the months of July to September and only the Vridi AKO area. The difference in the species sampled can be explained by the preferred habitats frequented by these species. *Crassostrea tulipa* is a mangrove species and *Perna perna* or brown mussel colonises rocky coasts. In quantitative terms, *Cerastoderma glaucum* or glaucous-shelled mussel was the most frequent and abundant species landed, unlike *Mytilus édulis* or common mussel. The gregarious instinct of *C. glaucum* could justify its high abundance. In fact, the glaucous cockle is an endogenous bivalve, living buried in the substrate or covering itself with fine sand or sandy mud. These observations contradict those of Nikula and Vainola (2003). According to these authors, *C. glaucum* was a solitary species. As for *M. édulis*, it lives attached to rock in the tidal range. These results were confirmed by Binder (1968) and Zabi and Le loeuff (1994), who found this species clinging to outcrops as part of their studies on the biological diversity of the Ébrié lagoon. The socio-economic study of those involved in bivalve mollusc fishing showed a predominance of young people under 30 years old. This predominance of young people could be explained by the fact that bivalve mollusc fishing was an activity that requires a great deal of physical effort. Indeed, in the absence of adequate diving equipment, those involved were obliged to dive and hold their breath for several minutes underwater. The actors involved in this sectorwere non-nationals, Ghanaians, mostly married (57.50% of fishmongers and 66.67% of fishermen), with a relatively low level of education (illiterate, 83% of fishermen and 90% of fishmongers). This shows that the activity does not require a high level of education but rather a certain level of responsibility. The way in which bivalve molluscs were sold differs from one distributor to another. *Cerastoderma glaucum*. It was sold fresh or processed into skewers. This observation contrasted with Western markets, where mussels were sold by kilogram. The marketing channel shows that fishermen, who were at the bottom of the value chain, could decide, depending on their means, to sell to fishmongers or give their catch to their wives. In general, it was women who transport products from landing areas to consumer markets. These results were consistent with those of Kebe and Charbit (2010) who presented women as being very active in the marketing of seafood products in Senegal.

CONCLUSION

The Ebrié Lagoon is a breeding ground for bivalve molluscs, which are harvested by traditional fishermen. In addition to fish, *Cerastoderma glaucum* species is of interest to these fishermen. The income for all the actors was 250,000 CFA francs. Adding this income together, the sale of bivalves brings in 3,000,000 CFA francs a year for all those interviewed. As for the profits made by each actor, we note a profit of 600,000 F CFA for buyers and resellers and 1,200,000 CFA francs for fishermen. The marketing of bivalve molluscs is therefore a lucrative activity and the income obtained could enable the actors to live decently and be exempt to poverty.

Conflict of interest statement and source of funding: The authors declare that they have no conflicts of interest and no funding source.

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