



## Profile and Antibiotic Susceptibility of *Vibrio* Bacteria Associated with Some Fishery Products Sold in Certain Markets of Yaoundé, Cameroon (Central Africa)

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### Abstract

Fish is an important source of animal protein for people in sub-Saharan Africa. These fish can be contaminated by bacteria called *Vibrio*, which can make people very sick. The main aim of this study was to look at the different types of *Vibrio* bacteria found in fish products (such as sea bass, carp and mackerel) sold in three markets in Yaoundé (Mfoundi, Acacia and Mendong). Isolations were performed on TCBS medium, followed by identification using macroscopic, microscopic and biochemical methods. We checked how well the antibiotics would work using the agar diffusion method (antibiogram) in accordance with CASFM recommendations (2023). Seven antibiotics were chosen for the analysis: amoxicillin, cefotaxime, chloramphenicol, amoxicillin + clavulanic acid, ciprofloxacin, nalidixic acid and doxycycline. In total, 61 types of bacteria were identified, which came from five different groups. *Vibrio alginolyticus* (34.43%), *V. parahaemolyticus* (32.79%), *V. cholerae* (19.67%), *V. fluvialis* (8.20%) and *V. mimicus* (4.92%). The highest *Vibrio* levels were found in the mackerel skins sample, with an average of 5.28 log<sub>10</sub> (UFC/g), while the lowest was found in the mackerel inner organs sample, with an average of 0 log<sub>10</sub> (CFU/g). Tests showed that the bacteria were resistant to seven different antibiotics (AMC, AMX, CTX, CHL, DOX, CIP, NAL). There were also some cases of the bacteria being resistant to more than one antibiotic. *V. cholerae* was resistant to AMC and AMX in several markets. These results show that better health checks are needed on fishery products and that we need to watch how resistant antimicrobials are in Cameroonian markets.

**Keywords:** *Vibrio* Species; Diversity; Fisheries Products; Antibiotic Susceptibility

## Introduction

In recent decades, the fishing and farming of aquatic animals has grown. People are eating more and more aquatic products. These products are seen as vital for our day-to-day lives and for making a living, and they are also a good source of protein and other nutrients that our bodies need [1]. The amount of fishery products (like fish, shellfish and other animals that live in water) went up from 71.9 million tons in 1990 to 185.5 million tons in 2023. In Cameroon, the amount of fish produced went up by 4% compared to 2022, increasing from 233.3 thousand tons to 241.5 thousand tons. In 2023, people in the country ate an estimated 18.1 kg of fish per person per year [2]. Fish is a great way to get important nutrients, especially for people who don't get enough protein, vitamins and minerals in their diet [3]. Fishery products are an important source of protein for people in developing countries: In Cameroon, a country in Central Africa, fish is a big part of what people in the city eat, and the city of Yaoundé is a big market for fish [4,5]. Even though fish are important, they can sometimes make you sick if you don't handle them properly. The number of food poisoning outbreaks around the world has made people more aware of how important food safety is [6]. The main agents responsible for these foodborne infections are microorganisms. Some of the bacteria that can cause contamination in communities include species from the genera *Salmonella*, *Shigella*, *Escherichia*, *Yersinia*, *Vibrio* and *Campylobacter* [7]. *Vibrio* is a bacterial genus comprising several pathogenic species (*Vibrio parahaemolyticus*, *Vibrio mimicus*, *Vibrio vulnificus*, and *Vibrio cholerae*) responsible for several diseases in humans. *Vibrio cholerae*, the type species, is responsible for cholera, a highly contagious gastrointestinal disease transmitted via contaminated food or water, which presents as severe diarrhoea [8]. This bacterium infects both children and adults; it is estimated that each year, there are 1.3 to 4 million cases of cholera and 14,300 to 21,000 deaths from the disease worldwide [9]. In 2023, 45 countries reported cases of cholera, compared with 44 cases in 2022 and 35 in 2021 [10]. A report following the various cholera outbreaks in Cameroon revealed that three (03) regions (Centre, Littoral and South) out of ten (10) had reported 18,322 cases as of 30 May 2023, spread across 22 cases districts out of the 64 districts comprising these three regions. As of 30 July 2023, the number of regions reporting cases had risen to four, with 25 districts affected. In the Littoral region, 18 districts were affected from the start of the epidemic in 2021, nine of which continue to experience cholera. As

of 30 July 2023, the district of New Bell had reported 70 new cases and 7 new deaths, with an estimated case fatality rate of 2.9%. This health district is home to one of Cameroon's 10 central prisons (New Bell Central Prison) [11]. In 2004, a study was conducted on the use of antibiotics during a cholera epidemic in the Douala region of Cameroon. Costs were calculated based on the rates applied by the National Supply Agency. For the 5,020 confirmed cases of cholera treated in the 14 hospitals in Douala from January to September 2004, consumption amounted to 499,746 doxycycline tablets, 235,881 amoxicillin tablets, 122,781 sachets of rehydration salts, and 60,217 500 ml bags of Ringer's lactate, according to some authors [12]. In Cameroon, very few studies have been conducted on fishery products (fish) consumed in the city of Yaoundé, which could be a potential reservoir for *Vibrio*. This is despite the available information on the antibiotic resistance of these pathogens. Diseases linked to these microorganisms remain a problem: this is the case with the cholera epidemic, which remains a serious health issue and is very difficult to control. The aim of this study is to assess the species diversity and antibiotic susceptibility profile of *Vibrio* bacteria associated with fish (sea bass, carp, mackerel) sold in three urban markets in the city of Yaoundé, Cameroon. More specifically, the aim was firstly to isolate and identify the *Vibrio* species present in the various tissues (skin, gills, viscera) of the three fish species, secondly to quantify the total aerobic mesophilic flora and finally to assess the susceptibility of the isolates to antibiotics commonly used in human medicine.

## Materials and Methods

### Study setting and sampling site

The study was conducted in three markets in the city of Yaoundé, the capital of Cameroon (3°52'N, 11°31'E): Mfoundi Market, a large, busy central market; Acacia Market, a medium-sized neighbourhood market; and Mendong Market, a market on the outskirts of the city. These sites were selected for their representativeness of the different categories of fish product sales outlets in the city. Microbiological analyses were carried out at the Laboratory of Hydrobiology and Environment, Faculty of Sciences, University of Yaoundé I.

### Biological material and sampling

The biological samples comprised three species of fish: sea bass (*Dicentrarchus labrax*), carp (*Cyprinus carpio*) and mackerel (*Scomber scombrus*). For each species, two individuals per market

were selected at random. Three anatomical compartments were analysed for each fish: the skin, gills and viscera. The samples were collected aseptically and transported in sterile bags to the laboratory within two hours.

### Bacterial isolation and identification

For each sample, one gram of tissue was homogenised in 9 mL of sterile physiological saline (0.9% NaCl), thus forming a  $10^{-1}$  stock solution. The isolation of Total aerobic mesophilic count (TAMC) and bacteria from the genus *Vibrio* was conducted through the utilisation of the surface spreading method. A volume of 100  $\mu$ L of each sample was collected using a sterile micropipette and deposited onto the surface of Thiosulfate Citrate Bile Salts (TCBS) agar that had previously been poured into sterile Petri dishes (90 mm in diameter). The inoculum was distributed uniformly across the surface using a sterile rake or spreader until complete absorption was achieved. Subsequently, the plates were subjected to an incubation process at a temperature of 37°C for a duration of 24 hours. The identification of *Vibrio* species began with a study of their motility patterns type and Gram staining. Gram staining is a method of staining bacteria that provides information on the morphology and structure of the bacteria wall. The colour, size and shape of colonies on TCBS agar were used as parameters. The process of classical biochemical identification has facilitated the identification of enzymes including oxidase, lysine decarboxylase, ornithine decarboxylase, urease, tryptophanase and  $\beta$ -galactosidase [13]. A suspension in sterile distilled water was prepared from a colony of the pure culture on an alkaline nutrient agar. The bacterial suspension was distributed in the capsules of the API 20E system (BioMérieux, France). After 24 hours of incubation at 37°C, the metabolites formed were visualised by colour reactions or the addition of reagents. The APIDENT 2.0 software was used to numerically determine the corresponding bacterial species. The identification rate was maintained at least at 98%. Isolated bacteria were enumerated using an OSI brand colony counter. Bacterial abundances are expressed in decimal logarithmic units of colony forming units (CFU) per gramme of water sample. Total aerobic mesophilic count (TAMC) were isolated using PCA (Plate Count Agar).

### Antibiotic susceptibility testing

Antibiotic susceptibility was assessed using the agar diffusion method on Mueller-Hinton agar, in accordance with CASFM

recommendations [14]. Seven antibiotics were tested, belonging to different families: chloramphenicol (CHL, 30  $\mu$ g), amoxicillin (AMX, 30  $\mu$ g), cefotaxime (CTX, 30  $\mu$ g), amoxicillin + clavulanic acid (AMC, 20+10  $\mu$ g), doxycycline (DOX, 30  $\mu$ g), ciprofloxacin (CIP, 5  $\mu$ g) and nalidixic acid (NA, 30  $\mu$ g). The inoculum was prepared to a turbidity of 0.5 McFarland. Inhibition zone diameters of bacteria isolates were measured and then compared to National Committee of Clinical Laboratory Standards [15]. The sensitive (S) category means that the strain is susceptible to the antibiotic treatment given at the normal dose. In the intermediate category (I), the success of the therapy is not predictable. If the antibiotic is used at a higher dose than usual, the treatment will be effective. Intermediate means moderately susceptible or moderately resistant. The resistant (R) category means that there is a high probability of treatment failure regardless of the type of antibiotic treatment, or that the strain will not be affected regardless of the type of treatment.

## Results

### Macroscopic, microscopic and biochemical Characteristics of Isolated Bacteria

Macroscopic examination of cultures on TCBS medium revealed two morphological types of colonies. Green colonies (2–5 mm, flat, with regular edges) were presumptive for *V. parahaemolyticus* and *V. mimicus*. Yellow colonies (2–5 mm, flat to convex, translucent, with regular edges) were presumptive of *V. cholerae*, *V. alginolyticus* and *V. fluvialis*. Microscopic observation following Gram staining revealed isolated, Gram-negative, curved rod-shaped cells, confirming the morphological characteristics of the genus *Vibrio*. Table 1 shows the biochemical profiles of the strains studied, as well as these different species identified.

The distribution of isolates by species shows a predominance of *V. alginolyticus* (34.43%), followed by *V. parahaemolyticus* (32.79%), *V. cholerae* (19.67%), *V. fluvialis* (8.20%) and *V. mimicus* (4.92%).

### Total aerobic mesophilic count (TAMC) and *Vibrio* species isolated at three sites

Figure 1 shows the TAMC results at three sampling sites: Mfoundi market, Acacia market, and Mendong market. These results demonstrate that microbial concentrations vary from sample to sample. The highest contamination level across the

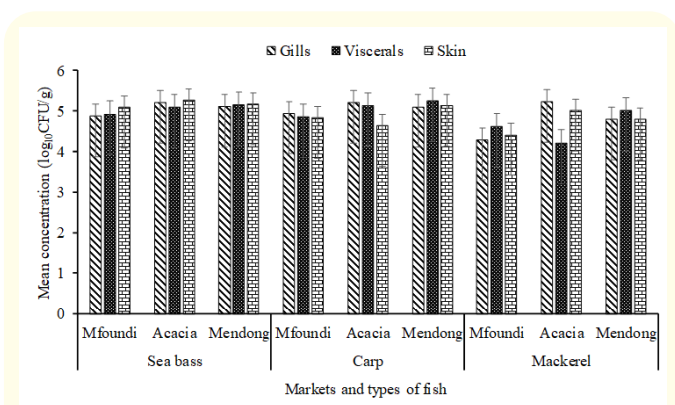
Biochemical tests	Biochemical characteristics				
	Green		Yellow		
	<i>V. parahaemolyticus</i>	<i>V. mimicus</i>	<i>V. cholerae</i>	<i>V. alginolyticus</i>	<i>V. fluvialis</i>
Glucose	+	+	+	+	+
Lactose	-	-	-	-	-
Sucrose	-	-	+	+	+
Catalase	+	+	+	+	+
Urease	+	+	-	+	-
Indole	+	+/-	+	+	-
H <sub>2</sub> S	-	-	-	-	-
Gas	-	-	-	-	-
Mannitol	+	+	+	+	+
Mobility	+	+	+	+	+
Citrate	+	+	+	+	+
Proportion (%)	32.79	4.92	19.67	34.43	8.20

**Table 1:** Biochemical characteristics of different species isolated.

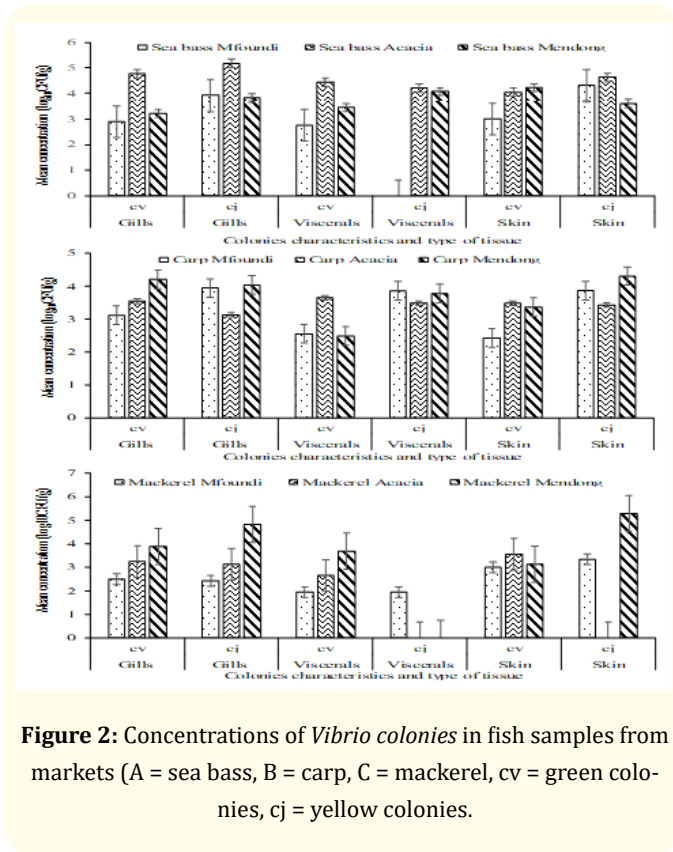
(+: positive; -: negative; +/-: variable).

three markets was  $5.27 \pm 5.16 \log_{10}$  (CFU/g) in sea bass skin samples and the lowest was  $4.21 \pm 3.62 \log_{10}$  (CFU/g) in mackerel viscera samples. Regarding sea bass: Across all three markets, slightly higher concentrations were observed in the sea bass skin. Skin samples had the highest average concentrations, with a maximum of  $5.27 \pm 5.16 \log_{10}$  (CFU/g), while viscera samples had the lowest. For carp, gill samples showed slightly higher average concentrations, with a maximum of  $5.20 \pm 5.00 \log_{10}$  (CFU/g), while the lowest concentrations were found in skin samples across all sampling sites. The highest concentrations of mackerel were found in gill samples ( $5.22 \pm 4.67 \log_{10}$  CFU/g), while the lowest concentrations were observed in viscera samples. Over all, the mackerel samples had the lowest concentrations.

The five (05) *Vibrio* species mentioned above were isolated from samples (sea bass, carp, mackerel) taken from the three markets. For each market, the frequency of *Vibrio* occurrence varied from one fish to another and from one part to another (skin, viscera, gills) after 24 hours of incubation on TCBS medium. As illustrated in Figure 2, the concentration of *Vibrio* colonies in fish samples from markets is depicted. In the case of sea bass, the highest levels of yellow colonies were observed in the gills, with an average concentration of  $5.18 \pm 5.23 \log_{10}$  (CFU/g). The concentrations of yellow colonies range from  $2.77 \pm 1.80 \log_{10}$  (CFU/g) to  $4.42 \pm 4.26 \log_{10}$  (CFU/g) on the viscerals, and from  $3.01 \pm 0.00$  to  $4.62 \pm 4.46 \log_{10}$  (CFU/g) on the skin. In the case of carp, the highest levels of yellow colonies were observed on the skin, with an average concentration of  $4.31 \pm 3.05 \log_{10}$  (CFU/g). The values ranged from  $2.43 \pm 2.95$  to  $4.31 \pm 3.053 \log_{10}$  (CFU/g). The concentrations of yellow colonies range from  $3.12 \pm 3.08$  to  $4.21 \pm 4.35 \log_{10}$  (CFU/g) on the gills, and from  $2.56 \pm 2.58$  to  $3.86 \pm 2.10 \log_{10}$  (CFU/g) on the viscerals. The highest levels of yellow colonies were observed in the gills of mackerel, with an average concentration of  $5.28 \pm 4.79 \log_{10}$  (CFU/g). The values ranged from  $2.43 \pm 2.41 \log_{10}$  (CFU/g) to  $4.82 \pm 4.58 \log_{10}$  (CFU/g). The concentrations of yellow colonies range from  $3 \pm 2.95$  to  $5.28 \pm 4.79 \log_{10}$  (CFU/g) on the skin, and from  $0 \pm 0 \log_{10}$  (CFU/g) to  $3.69 \pm 3.28 \log_{10}$  (CFU/g) on the viscerals. Across all marketplaces, the viscera are the least contaminated anatomical regions.



**Figure 1:** Concentrations of total aerobic mesophilic count (TAMC) isolates in fish samples from the markets (Mfoundi, Acacia, Mendong).



**Figure 2:** Concentrations of *Vibrio* colonies in fish samples from markets (A = sea bass, B = carp, C = mackerel, cv = green colonies, cj = yellow colonies).

### Antimicrobial Susceptibility Patterns among *Vibrio* Strains Isolated

Antibiogram tests were conducted across all three markets (Mfoundi, Acacia, Mendong) on 50 *Vibrio* isolates obtained from fish (sea bass, carp, mackerel), with 40% *V. alginolyticus*, 34% *V. parahaemolyticus*, 16% *V. cholerae*, 6% *V. fluvialis* and *V. mimicus* identified. As illustrated in Figure 3, the antibiotic susceptibility profile of *Vibrio* isolates from fish at the Acacia Market is demonstrated. The percentage of isolates demonstrating sensitivity to the majority of the antibiotics tested against *Vibrio cholerae* is 50% or higher. These include CIP, NA, CTX, CHL, AMX and DOX. However, it is notable that 100% of the isolates demonstrated resistance to AMC, and 25% exhibited resistance to CTX, AMX and DOX (Figure 3). With regard to *Vibrio alginolyticus*, the isolates are susceptible to the following antibiotics at a rate of 50% or more: CIP, NA, DOX and CTX. However, 25% of the isolates demonstrated resistance to CTX, CHL and DOX (Figure 3). With regard to *V. parahaemolyticus*, the isolates are susceptible to the following antibiotics at a rate of 38% or higher: CIP, NA, DOX, CTX,

AMC, CHL and AMX. *V. parahaemolyticus* isolates demonstrate resistance to certain antibiotics, with 25% exhibiting resistance to CHL and 12.5% to AMC and CTX. With regard to *V. mimicus*, it has been demonstrated that 100% of isolates are susceptible to CIP, NA, DOX, CTX, and AMX. It is noteworthy that 100% of the subjects exhibited complete resistance to CHL. It is noteworthy that all *V. fluvialis* isolates are susceptible to NA, CHL and DOX. It is evident from Figure 3 that 100% of isolates are resistant to AMC, CIP and CTX. As illustrated in Figure 4, the antibiotic susceptibility profile of *Vibrio* isolates from fish at the Mfoundi market is demonstrated. *Vibrio alginolyticus* exhibits a percentage of isolates that are susceptible to or resistant to the following antibiotics: DOX, CHL. However, the isolates demonstrated 83% resistance to CIP, 67% resistance to AMC, NA and CTX, and 33% resistance to AMX and DOX. The study revealed a 100% susceptibility of *Vibrio cholerae* isolates to nalidixic acid (NA), ciprofloxacin (CIP), ampicillin (AMX), ceftriaxone (CTX) and chloramphenicol (CHL). However, a 50% susceptibility was observed for amoxicillin (AMC) and doxycycline (DOX). However, the results demonstrated a 50% level of resistance to DOX (Figure 4). With regard to *V. parahaemolyticus*, the isolates demonstrated a high degree of sensitivity to the antibiotic DOX (100%). *V. parahaemolyticus* isolates demonstrate resistance to a wide range of antibiotics, including AMC, NA, CIP, AMX and CTX, with 100% resistance observed in certain cases. With regard to *V. mimicus*, it has been demonstrated that 100% of isolates are susceptible to CIP, NA and CHL. It is noteworthy that all strains exhibit complete resistance to AMC, AMX, CTX and DOX. It is evident that all *V. fluvialis* isolates are susceptible to AMC, CHL and DOX, and are resistant to NA, CIP and CTX. Figure 5 presents the antibiotic susceptibility profile of *Vibrio* isolates obtained from fish at Mendong Market. Furthermore, the percentage of isolates demonstrating sensitivity to the majority of the antibiotics tested for *Vibrio cholerae* exceeds 50%. These include CIP, NA, CHL, AMC, AMX, CTX and DOX. However, it is noteworthy that 50% of the isolates demonstrate resistance to CIP and DOX. With regard to *V. parahaemolyticus*, the isolates are susceptible to the following antibiotics with a percentage of 50% or more: CIP, NA, CHL, DOX, CTX and AMX. *V. parahaemolyticus* isolates demonstrate comparatively low levels of resistance to a limited number of antibiotics, with 75% exhibiting resistance to AMC, 25% to AMX, and 17% to DOX and CHL (Figure 5). With regard to *Vibrio alginolyticus*, the isolates demonstrate a sensitivity rate of 50% or more to the following antibiotics: CIP, CHL, NA, DOX, CTX.

However, it has been demonstrated that these bacteria exhibit 50% resistance to AMC, 25% to CIP and CTX, and 20% to NA, CHL and DOX each.

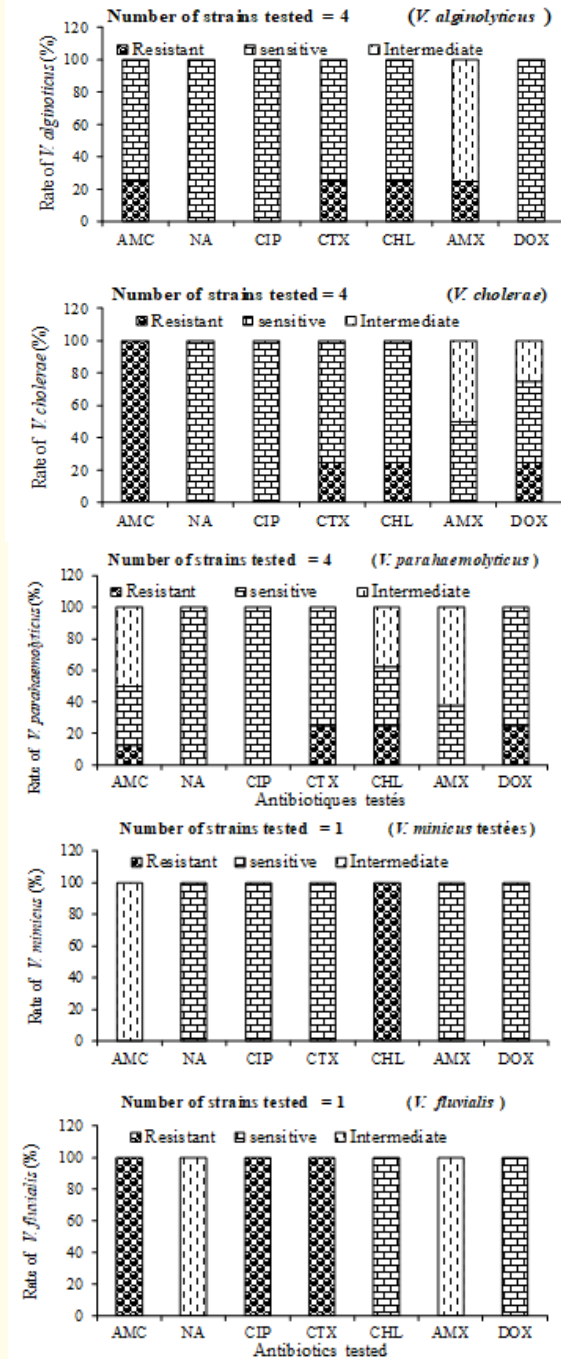


Figure 3: Antibiotic susceptibility profiles of *Vibrio* isolates from the Acacia market.

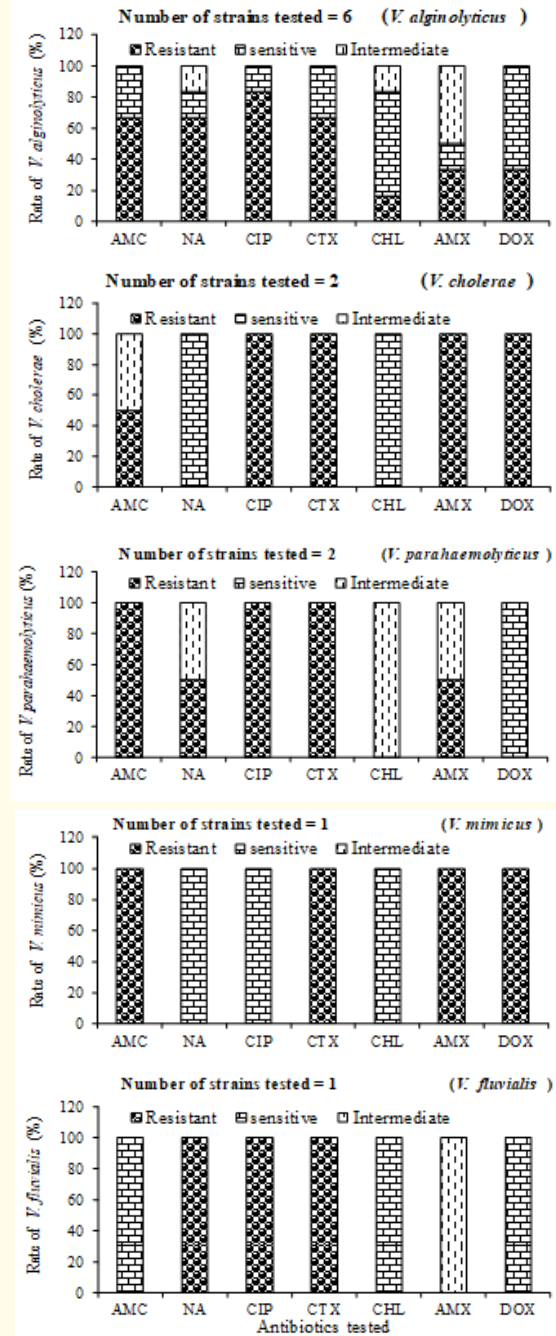


Figure 4: Antibiotic susceptibility profiles of *Vibrio* isolates from the Mfoundi market.

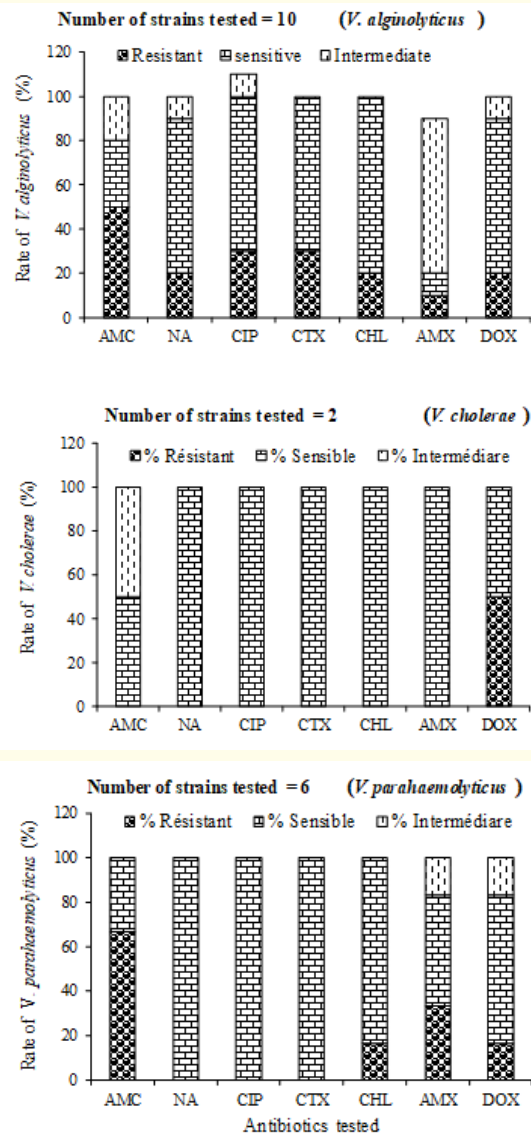


Figure 5: Antibiotic susceptibility profiles of *Vibrio* isolates from the Mendong market.

## Discussion

The detection and identification of *Vibrio* in fish samples necessitated the isolation of the bacteria on selective media (TCBS), followed by the characterisation of the isolates. A total of 50 isolates belonging to the genus *Vibrio* were characterised from fish samples obtained from all of the markets surveyed (Mfoundi, Acacia, Mendong). Five species were identified: The predominant

species were found to be *V. alginolyticus* (40%), followed by *V. parahaemolyticus* (32%), *V. cholerae* (16%), *V. fluvialis* (6%), and *V. mimicus* (1%). The results obtained from this study suggest that *Vibrio alginolyticus* and *Vibrio parahaemolyticus* are the most prevalent isolates in the fish samples analysed. The prevalence of *V. alginolyticus* in the fish population serves as a confirmation of its classification as a native species within the aquatic ecosystem [16]. The high prevalence of *V. parahaemolyticus* could be related to water temperature. Indeed, the species has been identified in samples from the aquatic environment when the water temperature exceeds 20°C [17]. Indeed, this predominance of *V. alginolyticus* over other *Vibrio* species had already been observed by some authors during their work on the prevalence and diversity of *Vibrio* strains in water, and also when using fish from aquaculture farms in the Ebrié Lagoon [18]. Meanwhile, the species *Vibrio cholerae* has been recorded in 16% of all samples analysed. This finding indicates that fish, being aquatic creatures, can also act as a reservoir for *Vibrio*. It remains dormant there during periods when epidemics are dormant. Indeed, despite this low percentage, it poses a high public health risk as pathogenic strains (*V. cholerae* 01, *V. cholerae* 0139, *V. cholerae* non-01/non-0139). This could be the starting point of an outbreak in endemic regions [7]. The enumeration of *Vibrio* species demonstrated that all samples exhibited signs of contamination at varying concentrations. The maximum contamination was observed in the yellow colonies on mackerel skins, with a concentration of  $5.28 \pm 4.79 \log_{10}$  (CFU/g), which is close to  $5.29 \times 10^4 \log_{10}$  (CFU/g). The highest levels of contamination were observed in isolates of *V. alginolyticus*, which were found to be associated with *V. cholerae*. The highest contamination peaks were observed in the gills of sea bass at  $5.18 \pm 5.23 \log_{10}$  (CFU/g), in mackerel skins at  $5.28 \pm 4.79 \log_{10}$  (CFU/g), and in carp skins at  $4.31 \pm 3.05 \log_{10}$  (CFU/g). The viscera constitute the parts least contaminated by *Vibrio*. The high level of contamination observed in the gills and skin can be explained by the fact that fish filter water through their gills, and the skin is in direct contact with the aquatic environment. Mackerel were, in general, the least contaminated fish. This could be explained by the bacteriostatic effect of cold [18]. The total aerobic mesophilic count (TAMC) study enabled the microbial load to be assessed. The maximum contamination level observed across the three markets was  $5.27 \pm 5.16 \log_{10}$  (CFU/g) in the sea bass skin sample, while the minimum was recorded at  $4.21 \pm 3.62 \log_{10}$  (CFU/g) in the mackerel offal sample from the Acacia market. Fresh produce has

been found to have higher microbial loads than imported products. This phenomenon could be attributed to inadequate handling and storage of fresh products intended for sale in our markets, or to substandard storage practices once the products reach the traders. This poses a significant health risk to consumers. Overall, isolates of *Vibrio* species demonstrate a high degree of susceptibility, which varies between different species and antibiotic types. With regard to resistance, the utilisation of antibiotics in both human and veterinary medicine exerts selective pressure on commensal or pathogenic bacteria in humans or animals, which can be disseminated into the natural environment (inland waters, coastal waters or soil via livestock effluent or domestic wastewater). This phenomenon has the potential to precipitate the emergence and subsequent dissemination of genetic determinants of antibiotic resistance into other microbial communities within the environment [19]. The dissemination of this bacterium is facilitated by its shared phylogeny within the bacterial world. With regard to *Vibrio* resistance, this is attributable to a number of mechanisms, including transferable plasmid and chromosomal resistance [12]. Consequently, multidrug resistance is frequently acquired via transferable genetic elements within the Vibrionaceae [20, 21], a phenomenon explained by their genetic proximity. In addition, the penicillinase phenotype can be readily identified through its resistance to beta-lactams [19]. This phenomenon can be used to explain the resistance exhibited by the majority of isolated species to amoxicillin, amoxicillin+clavulanic acid and cefotaxime. *Vibrio cholerae* isolates from all three markets demonstrated sensitivity rates of 50% or higher for the antibiotics NA, CIP, CHL, DOX, CTX, AMX and AMC in two of the markets. In a similar vein, these isolates demonstrated resistance rates of 50% or higher for the antibiotics AMC and DOX in all three markets, and 25% for CTX in one market and AMX in another. Despite documented cases of susceptibility, the *Vibrio* isolates demonstrate resistance to the antibiotics commonly utilised as therapeutic agents in medical facilities. These are cases of multidrug resistance, involving two to four antibiotics. It was demonstrated that certain strains of *Vibrio cholerae* were susceptible to the antibiotics nalidixic acid (NAL), ciprofloxacin (CIP), chloramphenicol (CHL), tetracycline (TCX), doxycycline (DOX) and amoxicillin (AMX) [7]. In addition, the same study revealed that these strains were resistant to the antibiotics amoxicillin (AMX), doxycycline (DOX) and amoxicillin (AMX). The observed resistance to  $\beta$ -lactams (AMC, AMX) is hypothesised to be attributable to the production of penicillinase-type  $\beta$ -lactamases. It

was observed that the various species exhibited differing levels of susceptibility and resistance, which were contingent on the specific antibiotic employed. It is important to acknowledge the increasing prevalence of microbial resistance to antibiotics, which poses a significant challenge to the management of *Vibrio*-related diseases.

## Conclusion

The *Vibrio* species isolated comprised 40% *V. alginolyticus*, 32% *V. parahaemolyticus*, 16% *V. cholerae*, 6% *V. fluvialis* and 6% *V. mimicus*. The high prevalence of *V. alginolyticus* in the samples analysed confirms that this species is part of the native flora of the aquatic environment. Consequently, it would represent normal flora in fishery products, but this in no way excludes the risk associated with consuming such products. The isolated fish species (sea bass, carp, mackerel) exhibited a higher total aerobic mesophilic flora in local fresh products (sea bass, carp) than in imported frozen products (mackerel). Furthermore, the antibiotic susceptibility testing carried out demonstrates that the sensitivity rate of the isolated bacteria is high in comparison to the resistance rate for certain isolated species. However, *V. cholerae*, the bacterium responsible for cholera epidemics in certain strains, exhibits a resistance rate of 50% or more to the antibiotics AMC and DOX, and 25% to CHL and CTX. This well-documented multidrug resistance poses a significant threat to populations who consume fish purchased in our markets.

## Conflict of Interest

The authors declare that they have no competing interests.

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