International Journal of Research Studies in Biosciences (IJRSB)
Volume 4, Issue 4, April 2016, PP 1-12
ISSN 2349-0357 (Print) & ISSN 2349-0365 (Online)
http://dx.doi.org/10.20431/2349-0365.0404001
www.arcjournals.org

Effect of Anthropogenic Activities on Mangrove Crab Diversity in Cameroon Atlantic Coast

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Abstrat: *Crabs have a significant ecological role on mangrove structure and function. Their adaptations related to human pressures are poorly studied. This survey aims to determine the impact of mangrove degradation on crab diversity. Fourteen mangrove stands dominated by Rhizophora spp. were selected in some localities from Limbe to Kribi. Three methods were used for sampling (excavation, sight harvest and visual count) in 4 × 4 m^2 plots. The impact of human pressures on mangrove was evaluated using informal interviews, semi-structured questionnaire, field data and observations. In all, 25 species belonging to 16 genera and 9 families were collected. Sesarmidae family (10 species) were the most represented and abundant taxa (80.7%). Perisesarma alberti was the most frequent species (Ci = 94.11%), while Helice sp., Macrophthalmus sp., Maja squinado, Ocypode africana, Panopeus africanus, Portunus validus, and Sesarma spp. were rare (Ci = 5.88%). Wood harvested was largely practiced in all stands and Rhizophora spp. appears overexploited everywhere. According to the deforestation level, Cardisoma guanhami, Helice sp., Macrophthalmus sp., Panopeus africanus and Sesarma spp. must be considered as the indigenous species of non-degraded stands. The abundance of Chiromantes buettikoferi, C. angolense, Metagrapsus curvatus and Perisesarma alberti decreased in perturbed zones. Sesarmid and Portunid crabs were significantly impacted by deforestation throughout the areas. In relation with crab distribution, the indigenous crabs (Helice sp. and Maja squinado) of the Rhizophora zone and the terrestrial crabs (Cardisoma spp. and Uca tangeri) appeared to be the major threatened species.*

Keywords: *abundance, crab diversity, human activities, threatened species.*

1. INTRODUCTION

Mangrove species are dominated by a diverse and distinctive macro-faunal vertebrate and invertebrate assemblages which exert a strong influence on the ecosystem functioning and regulate the mangrove forest productivity [1, 2]. Among the resident mangrove fauna, brachyuran crabs are undoubtedly the most important component, high in species number, abundance and biomass compared with many other animals [3, 4]. About 6,793 valid species, including 93 families and 38 subfamilies have so far been discovered worldwide [5]. In this group, fiddler crabs particularly are considered to be the most abundant [6]. They form an important link between the primary detritus at the base of the food web and consumers of higher trophic levels [7].

Crabs have a wide range of adaptations that allow them to colonize niches created by the complex interaction of vegetation structure and tidal regime [8]. Furthermore, they play a pivotal role in mangrove ecosystem functioning [9, 10]. Crab burrowing activities significantly decrease ammonium and sulfite concentrations in mangrove soils, thus positively benefiting mangroves' productivity [11]. By consuming litter, crabs can promote nutrient mineralization and recycling within the forest. Furthermore, their role as bioturbators doubtlessly contributes to alter physiochemical characteristics of the soil and enhance its capability to retain organic carbon [12, 13]. More recently, the beneficial effect of *Uca* spp. activities on mangrove soil biogeochemistry can be strongly impaired by organic waste discharge was showed [4].

More than 90% of world's mangroves are located in developing countries, where impoverished human populations depend on their resources for subsistence [14]. Human impacts on mangroves, including climate change, have receive much attention of late mainly because mangrove deforestation is occurring at a rate of 1-2% per year, which implies that most forests will disappear within century [15]. Mangroves in Cameroon represent the most thriving ecosystems and the most impacted due to population increase and an oil platform close to the Gulf of Guinea [16]. Many areas have been strongly affected and the rapid population increase has especially lead to large-scale deforestation due to a growing demand for housing land and logging cultivation [17, 18]. This urbanization transformed hectares of forest characterised by mature stands of mangrove trees such as *Rhizophora* spp. and *Avicennia* sp. into highly degraded areas with a dramatic change in botanical assemblages [19].

Studies concerning the effects of industrial and/or domestic wastewater on crab diversity are recent [4, 20, 21]. The consequences of deforestation on mangrove fauna have not yet been documented in West Africa. The significant role of crabs as a engineer species starts to be recognized, but their ecological answers with respect to human pressures are poorly known compared to other aspects of their life such as diversity, distribution, sex ratio, ecological roles, feeding ecology, plant periodical migrations, physiological adaptations, domestic wastewater effects,… [22, 23, 24, 25, 26, 27, 28,29,30]. So, the aim of this study is to determine the impact of human pressures on mangrove crab biodiversity in Cameroon.

2. Materials And Methods

2.1. Study Site

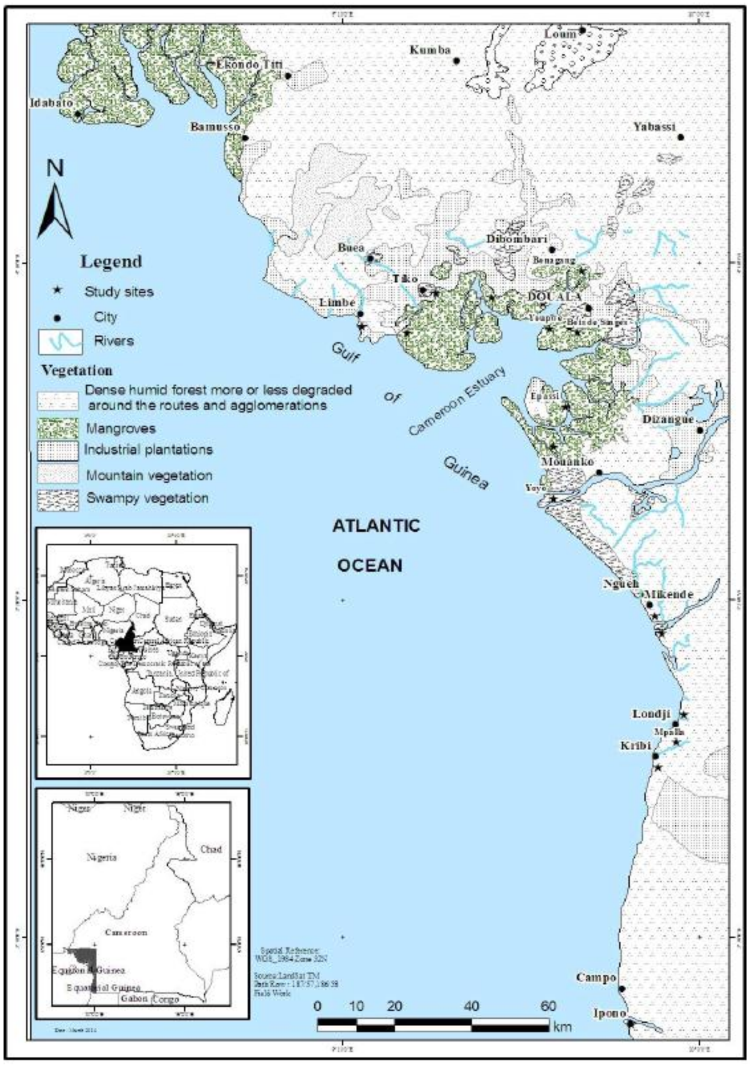

Figure1. *Location of mangrove areas in Cameroon Atlantic coast [31])*

The study was carried out in Cameroon in localities situated between Limbe (North Region) and Kribi (South Region) (2°61’-3°40’N and 9°10’- 9°55’E) where mangrove stands are dominated by *Rhizophora* spp. Fourteen study stations (Limbe, Tiko, Wouri estuary, Mouanko, Londji and Kribi) were selected based on accessibility and floristic composition (Figure 1). The area is dominated by two types of climate. In the north and center part, the climate belongs to a particular equatorial regime called Cameroonian regime, characterized by a long rainy season (March–November) and a short dry season (December–February) with annual average temperature of about 26.7 °C [17]. In the south Region (Kribi), the climate is of a typical equatorial regime with four seasons (two rainy seasons and two dry seasons well individualized), marked by high and stable temperatures of about 28.7 °C.

Heavy annual rainfalls are observed from more than 5,000 mm at Limbe area and decreased to about 3,000 mm at Kribi area. In the spring tide, the tidal regime reaches 3 m in the Cameroon Estuary, 1.2 m in the mouth of Nyong and 1.5 m in Kribi [32]. The annual variation in salinity ranges between 0 and 20‰. The relative humidity is always close to the saturation rate. Soils are grey or black muds, silty, sandy or clay texture, and deriving from fluvial sediments. The content of organic matter is relatively low, 1 to 3% with carbon: nitrogen ratio (C:N) often lower than 10 in the whole area.

The flora consists essentially of tree species. The herbaceous stratum represents < 1% of the entire vegetation. However, the flora remains poor with *Rhizophora racemosa* GF Meyer being largely the dominant vegetation in all sites. The faunal component includes vertebrates, such as birds, reptiles and fish, and a wide range of invertebrates, mainly crabs and molluscs which constitute the bulk of benthic diversity in the region [28]

2.2. Station Characterization

The methodology of evaluation used two generally known methods. A participative process (*Buttom up*) based on specific investigations with the populations followed by an analysis of field data and observations (*Down up*) (Appendix 1). A participative process data were generated through interviews and semi-structured questionnaire of local residents [17]. The households were sampled opportunistically (*i.e.*, respondents encountered in their houses were interviewed whereas people away from their home (if the residents were still carrying out their occupation) were not questioned). To avoid recurrent information, only one person (>20 years of age) per house was questioned. For field data and observations analysis, deforestation state into station areas was evaluated using the following formula:

Degradation state D (%) = (r/R) x 100

r: distance of mangrove destroyed during 5 years

R: distance of the initial mangrove 5 years ago.

Stations are then classified into two groups according to values of the degradation state: D > 50% indicates disturbed zones and D < 50% for not disturbed zones.

2.3. Crabs Survey

Mangrove forest was divided into three main zones: landward fringe, tree species belts, sand flat or mudflat. In each station, 500 m line transect was established across the zone according to the vegetation spread. To assess the abundance and density of the crab populations, crab individuals were sampled in randomly selected 4×4 m plots along the transect, using three techniques (visual count [23], excavation [33] and crab harvest [34]) depending on species found. Harvested crabs were sedated in cold water for a few minutes, washed and stored into 70% alcohol or in a field freezer for later processing. Identifications have been made in the field or later in laboratory using some identification keys [35,5]. Undetermined specimens were brought to the Royal Museum for Central Africa (Belgium) for identification.

2.4. Data Analysis

Data a given in terms of percentages (qualitative variables), mean ± standard deviation (quantitative variables) or absolute and relative densities (absolute density = number of individuals/m^2; relative density = number of individuals per species/total number of harvested individuals). A comparison of percentages is performed using the khi-square test. Two mean values were compared using the parametric student t-test (when normality and equal variance tests passed) or the nonparametric Mann-Whitney rang sum test (when conditions do not pass). Several mean values are compared using the one way ANOVA test. The relationship between environmental parameters and biotic variables were evaluated using Pearson’s correlation.

The occurrence indices of each species was determined using the formula: $\mathbf{C_i = N_i \times 100/N}$ [36] and interpreted as follow: (1) $Ci \leq 10$ for rare species, (2) $10 < C_i \leq 25$ indicates accessory species, (3) 50

< $C_i \leq 75$ for frequent or common species, (4) $75 < C_i < 100$ indicates constant species and (5) $C_i = 100$ indicates omnipresent species.

Statistical analysis was performed using STATISTICA 10, PAST 2.17 and PRIMER 9 softwares. The crab species richness recorded in the studied stations was compared using the Sander's rarefaction method [37]. Two non-parametric abundance-based estimators of species richness, the Chao 1 and the first-order jackknife and one non-parametric incidence-based estimator of species richness, the second-order jackknife, were used to estimate the potential number of crab species (observed and unseen) from samples and evaluate the sampling effort which is the ratio between observed species richness and theoretical species richness.

The species diversity of each community is evaluated using Shannon-Weaver, Margalef and Menhinick indices [38, 39, 40] while site evenness is evaluated using the Pielou's index [41].

3. Results And Discussion

3.1. Opinion of the Study Site Habitants

A total of 424 habitants of the study sites were interviewed (68.2% men and 31.84% women). In Wouri estuary, 180 persons were interviewed, 82 persons in Mouanko, 51 in Kribi, 42 in Londji, 34 in Limbe and 35 in Tiko. The mean age of respondents is 28±1.2 years for women (dominated by women farmer) and 35±0.6 years for men (dominated by wood cutters). Destructive activities (wood harvesting and sand extraction) are mostly done by men while women are frequently exerting less destructive activities (fishing and agriculture). Education level is higher for men (56% of respondents) than for women (22% of respondents). Women education level is weak probably for religious and economic reasons. Education level for two genders is higher in the Wouri estuary stations (65% of respondents) with regards of existence of various primary secondary and high schools in all villages. Access to basic social amenities, such as drinking water, schools and health centers is scarce and alternative livelihood opportunities are practically non-existent in the others stations.

Data allows noting an acute degradation of mangrove stands in Cameroon: nine disturbed stations (D > 50 %) and eight not disturbed stations (D < 50%) (Table 1). Mean duration of mangrove degradation in the stations is about 5 years. In all stations, wood harvesting (50.3%) is the principal cause of mangrove destruction; follow by sand and gravels extraction (26%). Exploitation of mangroves for fuel wood, charcoal production, construction and other uses have been identified as an important pervasive and intrusive threat to this ecosystem [42]. However, the extent of damage depends on intensity, persistence and periodicity of the disturbance [43]. In contrast, the little damage observed in not disturbed stations is probably due to their proximity with the terrestrial evergreen forest from which people collect wood for subsistence needs. Wood harvesting making place to ancillary activities such as agriculture (12.5%), dwellings (5.4%), breeding (3.1%), brackish water aquaculture (1.5%) and Non-Timber Forest Products (NTFPs) (1.2%). Moreover, damming up activities (for housing) followed by excavation of sediments (by sand extraction) also has an impact on mangrove biodiversity loss through the ground modification and habitat loss for some animals [19]. Human activities are known to have a massive impact on mangrove ecosystem, especially through deforestation [44]. These impacts can significantly transform the forests, triggering a negative cascade effect on the whole ecosystem assemblage leading to a reduction of biodiversity and functionality [45, 46,47].

Table1. *Station characteristics*

Mangrove state	Stations	Sampling effort (%)	species richness	D (%)	Major anthropogenic activity
Not disturbed	Londji I	72.50	11	48	Wood cut
	Londji II	90	10	42	Wood cut
	Yoyo I	91.33	10	30	Fishing
	YoyoII	84.25	9	41	Fishing
	Mbiako	90.25	6	20	Fishing
	Avion beach	66.75	8	34	Wood cut
	Appolo beach	82.75	8	45	Wood cut
	Mile six beach	89.50	8	49	Wood cut
disturbed	Bois de Singe	100	8	88	Wood cut
	Essenguè	100	13	91	Wood cut
	Pont du Wouri	80.70	7	64	Wood cut
	Mpalla	93.50	10	66	Wood cut

	Nziou	81	9	78	Sand and gravel extraction
	Bonamoung	94.50	8	67	Sand and gravel extraction
	Bonagang	84	7	52	Sand and gravel extraction
	Bon'Ewonda	100	8	56	Sand and gravel extraction
	Down beach	81	9	64	Wood cut

Wood harvesting activity is significantly frequent in Essenguè station (37%), Mpalla (35%), Londji I (68%), Londji II (59%), Wouri bridge (31%), Avion beach (42%), Down beach (38%), Apollo beach (47%) and Mile six beach (34%). Sand and gravel extraction is dominant in Nziou, Bonamouang, Bonagang and Bon' Ewonda stations for 53%, 49%, 36% and 44 % of respondents respectively. Fishing with 48%, 56% and 34% of respondents dominates in Mbiako, Yoyo I and Yoyo II stations respectively.

Rhizophora spp. (74.3%) followed by *Avicennia germinans* (20.7%) appear the two most threatened plant species. The edible crabs (58.4%) such as *Cardisoma* spp. are threatened animal species. *Rhizophora* spp. still called (red mangroves) is dominant and strongly marketed or directly used in the households for subsistence needs [48]. In the households, wood is used as firewood, house construction, fish smoking, clothes industry, traditional canoe construction and paddles, etc. [49,50]. In not disturbed stations (Londji and Mouanko) specially in the villages of Yoyo I, Yoyo II and Mbiako fishing and fish smoking are the major economic activities and so, *Rhizophora* spp. is much snuffed because content resin and to be burned in a fresh state [51,14]. In these villages, approximately 62% of annual fuel-wood harvest is used to smoke fish (ref).

3.2. Crab Diversity

Table2. *Crab species harvested in the mangrove forests of Cameron*

Families	Species	Number of individuals harvested
Gecarcinidae	*Cardisoma armatum* Herklots, 1951	103
	Cardisoma guanhumi Latreille, 1828	11
Grapsidae	*Pachygrapsus gracilis* Saussure, 1858	30
	Pachygrapsus transversus Gibbes, 1850	475
	Goniopsis cruentata A. Milne-Edwards, 1867	144
	Goniopsis pelii Herklots, 1851	331
Macrophthalmidae	*Macrophthalmus* sp.	19
Majidae	*Maja squinado* Herbst, 1788	4
Ocypodidae	*Ocypode africana* De Man, 1881	20
	Ocypode cursor Linnaeus, 1758	11
	Uca tangeri Eydoux, 1835	549
Panopeidae	*Panopeus africanus* A. Milne-Edwards, 1867	8
Portunidae	*Portunus validus* Herklots, 1951	54
	Callinectes pallidus Rochebrune, 1883	24
Sesarmidae	*Armases elegans* Herklots, 1951	117
	Chiromantes buettikoferi De Man, 1883	226
	Chiromantes angolense Brito Capello, 1864	425
	Metagrapsus curvatus Herklots, 1951	632
	Perisesarma alberti Herklots, 1951	709
	Perisesarma huzardi Herklots, 1951	777
	Perisesarma kamermani De Man, 1883	1580
	Sesarma sp.1	224
	Sesarma sp.2	76
	Sesarma sp.3	93
Varunidae	*Helice* sp.	5

A total of 6643 specimen of crabs, comprising 25 species belonging to 9 families and 16 genera were collected (Table 2). Significant differences in terms of species richness and abundance between stations were observed (Mann-Whitney test: $U = 95$ and 77 respectively, $n = 17$; $p< 0.005$). The sampling effort was relatively high and above 85.2%. The rarefaction curve of crab species richness collected according to the number of stations was obtained in Figure 2. The species richness grows proportionally with increase of stations number until reaching an asymptote. Indeed, for all stations, the observed crab richness was still underestimated. The sampling effort also confirmed that more crab species still remain to be caught in our study area. Londji I, Down Beach and Wouri bridge stations appear weakly sampling (E < 81%), while in Bois de singe, Bon'Ewonda and Essenguè stations, sampling effort reach 100%.

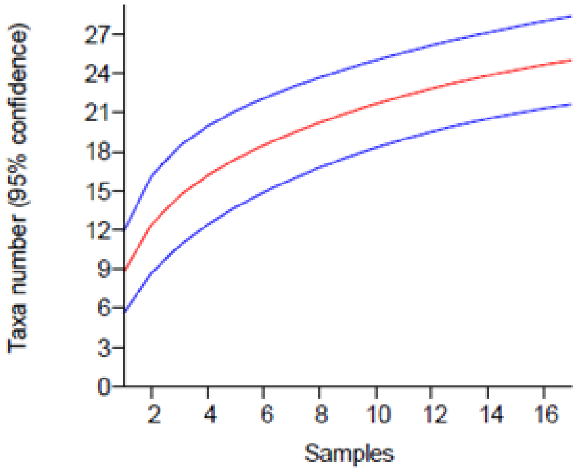

Figure2. *Rarefaction curve (red) of crab species richness collected according to station areas with a confidence (blu) of 95%*

The Sesarmidae family was both the most species richness with 10 species and the most abundant taxa (80.7% of individuals). Grapsidae family is represented by four species and Ocypodidae family by three species. Gecarcinidae and Portunidae families contain each two species, Macrophthalmidae, Majidae, Panopeidae and Varunidae families are represented only by one species each. This prevalence of Sesarmidae family had been also observed in several mangrove of the world. In peninsular Malaysia, 41 species were counted [3], 30 species in the East of Asia [52], including 46 species in India in particular [53], 23 species in Americas from which only 5 are associated the mangroves [54], 7 species in Western Africa [55] including 5 species in Guinea [56]. Species of this family constitute the key functioning elements of this ecosystem [57,58].

The highest values are recorded in the Essenguè, Mpalla, Londji I and Londji II stations with H' > 2; J > 0.8; Mg > 1.3 and Mn > 0.35 (Table 3). These stations are well diversified and several species are better represented. The lowest values are recorded in the Wouri Bridge station (H' =1.38; I = 0.71; Mg = 0.95 and Mn = 0.30) and Bonangang station (H' =1.58; J= 0.81; Mg = 1 and Mn = 0.35). In these stations, crabs are less distributed and 3 or 4 species are largely dominant. Shannon-Weaver and Pielou indices increase with species richness and sample size. Margalef and Menhinick indices give the same results, but are independent of sample size. Thus, the low values of these indices obtained in certain stations are allotted to the low number of species present and environmental degradation due to the anthropogenic pressures and biotic factors [59].

Table3. *Crab diversity and species richness in the sampling stations*

Parameters	**Wouri Estuary**						**Mouanko**			**Kribi**		**Londji**		**Tiko**		**Limbe**	
	Bois de singes	Bonangang	Bonamouang	Bon'Ewonda	Essenguè	Pont Wouri	Yoyo I	Yoyo II	Mbiako	Mpalla	Nziou	Londji I	Londji II	Avion beach	Appolo beach	Down beach	Mile Six beach
P	6	7	6	9	8	6	8	6	9	11	8	8	6	6	6	7	6
Ss (m^2)	96	112	96	144	128	96	128	96	144	176	128	128	96	96	96	112	96
N	713	406	710	448	1277	543	333	448	229	318	358	173	273	97	104	127	90
S	8	7	8	8	13	7	10	9	6	10	9	11	10	8	8	9	8
A (per m^2)	7.43	3.63	7.4	3.11	9.98	5.66	2.6	4.67	1.56	1.81	2.8	1.4	2.84	1.1	1.08	1.13	1
D	0.22	0.24	0.22	0.15	0.15	0.34	0.16	0.25	0.20	0.15	0.16	0.13	0.13	0.15	0.17	0.16	0.16
1-D	0.78	0.76	0.78	0.85	0.85	0.66	0.84	0.75	0.80	0.85	0.84	0.87	0.87	0.85	0.83	0.84	0.84
H'	1.72	1.58	1.72	1.96	2.18	1.38	1.98	1.69	1.68	2.02	1.96	2.20	2.17	1.98	1.92	1.97	1.92
Mn	0.30	0.35	0.30	0.38	0.36	0.30	0.55	0.43	0.40	0.50	0.48	0.84	0.61	0.81	0.78	0.80	0.84
Mg	1.07	1.00	1.07	1.15	1.68	0.95	1.55	1.31	0.92	1.39	1.36	1.94	1.60	1.53	1.51	1.65	1.56
J	0.83	0.81	0.83	0.94	0.85	0.71	0.86	0.77	0.93	0.92	0.89	0.92	0.94	0.95	0.92	0.90	0.92

***P**: Number of 4x4 m plots; **Ss**: Site surface; **N**: Sample size; **S**: Species richness; **A**: Absolute density; **D**: Dominance index; **1-D**: Simpson index; **H'**: Shannon Weaver index; **Mn**: Menhinick index; **Mg**: Margalef index; **J**: Pielou index*

3.3. Impacts of Deforestation on Crab Composition

In the harvested crabs, 3879 specimens comprising 20 species belonging to 8 families were counted in not disturbed stations. Sesarmidae family are represented by 10 species, Gecarcinidae, Grapsidae and Portunidae families by two species each, Ocypodidae, Macrophthalmidae, Majidae, Panopeidae and Varunidae families by one species each. In disturbed stations, 2768 specimens, grouped in 19 species and 6 families were recorded. Sesarmidae are represented by 8 species, Grapsidae by four species, Ocypodidae by three species, Portunidae by two species, and Gecarcinidae by one species each. There is a significant difference between the two stations only in term of abundance (Mann-Whitney test U=80; n=17; $p < 0.005$).

According to deforestation, crab assemblage shown a considerable variation in terms of species richness and abundance (Figure 3). Six species *Cardisoma guanhumi* Latreille, 1828, *Helice* sp., *Macrophthalmus* sp., *Panopeus africanus* A. Milne-Edwards, 1867, *Sesarma* sp.2 and *Sesarma* sp.3 species are strictly pledged in not disturbed stations. In the scale of this study, these species could be regarded as bio-indicators species of stable mangroves, but additional and thorough studies should be conducted to check this assumption. Four crab families (Macrophthalmidae, Majidae, Panopeidae and Varunidae) were not represented in disturbed stations and the number of species of Sesarmidae (from 10 to 8 species) and Gecarcinidae (from 3 to 1 species) families fallen down within disturbed stations. The decrease of species number of Sesarmid crabs was also reported in Kenya (East Africa) in the adjacent gap areas, where Sesarmid crabs were totally absent in the absence of mangrove trees [60].

Abundances of species *Chiromantes buettikoferi* De Man, 1883 (from 4.5 to 2.6% of specimens), *Metagrapsus curvatus* Herklots, 1951 (from 12 to 7.68% of specimens), *Sesarma* sp. (from 4.3 to 2.7% of specimens), *Chiromantes angolense* Brito Capello, 1864 (from 10.73 to 3.30% of specimens) and *Perisesarma alberti* Herklots, 1951 (from 16.61 to 6.42% of specimens) decreased within disturbed stations. Sesarmidae and Portunidae families' abundance decrease from 84.83 to 75.87% of specimens and from 1.7 to 0.8% of specimens respectively throughout deforestation. Conversely, Gecarcinidae, Ocypodidae and Grapsidae families' abundance increased from 1.12 to 2.14 % of specimens, 1.37 to 2.83% of specimens and 9.83 to 18.25% of specimens respectively.

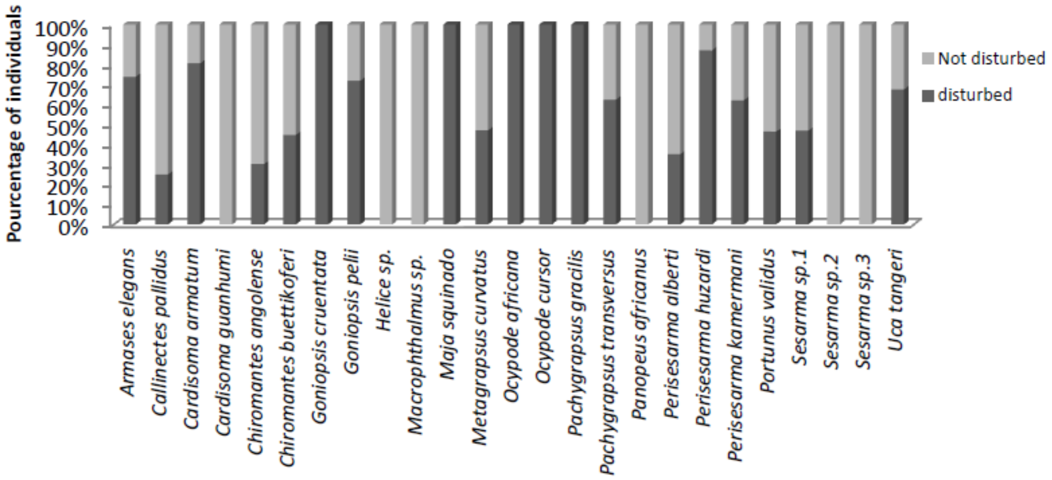

Figure3. *Variation of crab species abundances according to not disturbed and disturbed stations*

The importance of vegetation and channel distance on crab distribution has been described in the Wouri Estuary mangroves [29]. Vegetation is highly dominated by *Rhizophora* plant and that zone is the most diversified (18 crab species) which, two crab *Helice* sp. and *Maja squinado* Herbst, 1788 were strictly pledged. Some herbivorous crab families predominantly Sesarmidae family are known to depredate on *Rhizophora* propagules [61,62]. Therefore, the overexploitation of *Rhizophora* spp. lead the loss of some indigenous crabs (*Helice* sp., *Maja squinado*) and feed dependant crabs of this plant. Furthermore, *Cardisoma* spp. and *Uca tangeri* Eydoux, 1835 species are the most terrestrial crabs, because they live essentially close to back mangroves. With regards to anthropogenic activities such as agriculture, dwellings, breeding, aquaculture and wood harvested, these terrestrial crabs are mainly threatened more than *Callinectes pallidus* Rochebrune, 1883 and *Portunus validus* Herklots, 1951, crabs found only near channels (marine crabs). The studies relating to deforestation impact on crab biodiversity are poorly widespread. Thus, the disappearance of crabs could be influences a significant degree of nutriments cycle, ventilation and drainage of mangrove grounds, through the fall of bioturbation activities necessary to function of this ecosystem and mangrove forest growth and productivity fall down [1,57]. According to [15], the greatest current threat to mangrove survival however is deforestation and such continuing losses must be considered in tandem with the impact of climate change.

4. Conclusion

In Cameroon, mangrove crabs is diversified with 25 species. Sesarmidae family is the most diverse and the most abundant taxa. Mangrove forests undergo deforestation, which can reduce their crab diversity and prevent them from fully performing their multiple roles. Six crab *Cardisoma guanhumi, Helice* sp., *Macrophthalmus* sp., *Panopeus africanus, Sesarma* sp.2 and *Sesarma* sp.3 species appear as indigenous species in not disturbed stations. Abundances of species *Chiromantes buettikoferi, Metagrapsus curvatus, Sesarma* sp., *Chiromantes angolense* and *Perisesarma alberti* decreased throughout deforestation. Species of Ocypodidae, Gecarcinidae and Grapsidae families seem to be more resistant to deforestation than Sesarmidae and Portunidae families. Furthermore, the indigenous species *Maja squinado* and *Helice* sp. of *Rhizophora* spp. zone and *Cardisoma* spp. and *Uca tangeri* (terrestrial crabs) are the mainly threatened. However, some environmental factors have an influence on diversity of macrobenthos in mangroves. It would be interesting to follow the dynamics of crabs in relation to physical and chemical variables and domestic or industrial wastewater.

Acknowledgement

We gratefully acknowledge the IDEA WILD for field equipment grant of this work.

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Appendix1. Mangrove socio-economic survey questionnaire, Cameroon

1. **Identification of locality and respondents**

Number:………Date:…………………locality ……………..………gender: **F**□ **M**□; Age ………years ; Stay time in locality:………….. years;

Civil statute: **M**□ **S**□ **D**□ **W**□; Schooling level: **B**□ **S**□ **H**□;

Major activity: ………………………….. ;

2. **Characteristics of locality**

- Which are the majors activities harvested in mangrove?

Agriculture □ breeding □ Fishing □ Dwellings □ wood dealers □ Wood cut □

Sand and gravel extraction □ brackish water aquaculture □ Non-Timber Forest Products □ House construction □ Others Cited………………………………………………………………………

- Do you thing that our mangrove forests are changed**?** Yes □ No □

  - If yes, since how many years?

  0–5 years □ 5 – 10 years □ 10–15 years □ More than 15 years □

- Actually what is the vegetation state?

  Denser □ less dense □

-Actually what is the fauna state?

  Denser □ less dense □

- Which are the most threatened plant species?

  Cited: ……………………………………………………………………………………………………

-Which are the most threatened fauna species?

  Cited :……………………………………………………………………………………………………

- Do you use 'matanda' mangrove wood Yes □ No □

-If No, what other source of wood do you use ……………………………………………………

  - If yes, what do you use it for?

  Fish smoking □ Cooking □ sell □ Building Banda □ House construction □

  Beds □ Others (please specify) ---

-Which is the mean reason of this mangrove change?

Agriculture □ breeding □ Fishing □ Dwellings □ Wood cut □ wood dealers □

Sand and gravel extraction □ brackish water aquaculture □ Non-Timber Forest Products □

Climate change □ Others Cited…………………………………………………

- Do you harvest mangrove crabs in our locality? Yes □ No □

  - If yes, what do you use it for?

Cooking □ sell □ Treatment □ Fishing □ Cosmetics □ Others …………………………………

- How many types of crabs do you know?

  1 to 2 species □ 3 to 5 species □ more than 5 species □

- Do you thing that mangrove crabs are threatened? Yes □ No□

If yes, why ?..