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ASSESSING THE SIZE-STRUCTURED STOCK OF THE SWIMMING CRAB *Callinectes amnicola* (CRUSTACEA: PORTUNIDAE) IN THE CROSS RIVER, NIGERIA

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ABSTRACT

An important aspect of the size-structured stock is the assumption that individuals progress from one size class to another after a certain time. In this study, a total of 2581 monthly samples of the swimming crab *Callinectes amnicola* were collected from the landings of the artisanal crab fishery in the Cross River, Nigeria over a period of 13 months, from January 2021 to January 2022. Crabs ranged in length from 6.5 cm to 15.5 cm, with most crabs caught during the dry season. The fewest crabs (n=23) were caught in August 2021, and the most (n=662) were caught in January 2021. Because moulting and other physiological obstacles make it difficult to determine crab age, length frequency data were used instead. Swimming crab assessment was based on some basic growth parameters of the von Bertalanffy growth function and the Beverton and Holt growth model. The results showed that the asymptotic length and growth rate were 16.28 cm and 0.940 per year, respectively. The best growth index was estimated to be 2.40, while longevity and mortality were 3.19 years and 3.46 per year, respectively. The calculated exploitation rate of 0.41 was below the guideline of 0.5 and the maximum yield per recruit of 0.421, confirming an underfished stock. Sustainable exploitation of the Cross River swimming crab was recommended by reducing efforts on already exploited fishery resources.

Keywords:
Crab fishery
Exploitation rate
Growth function
Length-based models
Sustainable yield

How to Cite

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INTRODUCTION

Crabs are an economically important resource in high demand by commercial and artisanal shellfish fisheries. They are of high food value and have the potential for export (Ovat et al., 2018). China, the United States of America, Japan, Korea, and Thailand are among the top five consumers of crab (Adeogun et al., 2011). Crabs have a high market value, especially in Asian countries such as Japan, Taiwan, Hong Kong, and Singapore (Agbayani, 2001). There is also a growing market for mud crab meat as a value-added product and for frozen soft-shelled mud crab in the United States (Wickins and Lee, 2002). A steady increase in live crab exports is expected to play an important role in foreign exchange earnings if properly exploited (Adeogun et al., 2009). In Nigeria, the crab fishery in the Badagry Lagoon alone yielded an estimated average gross revenue of N6.66 million in 2010 (Adeogun et al., 2011).

The freshwater crab fishery, including the Cross River fishery, uses stock assessment models to assist in management. These models estimate the size and trend of a population, as well as reference points and their status relative to those points, and provide the information needed to apply harvest control rules. Fish stock assessments typically use a version of an age-structured population dynamics model that relies on age composition data. However, the irregular moulting of crustacean exoskeletons eliminates potential age indicators, making it difficult to obtain such data (Cronin-Fine and Punt, 2020).

Population dynamics models based on size rather than age are appropriate for assessing the abundance of species such as crabs that grow slowly. Various types of data such as size composition (Abowei et al., 2010) and tag recapture (Ama-Abasi et al., 2019) have been widely used to assess fish stocks in the Cross River State and beyond. However, many indigenous fisheries use size-structured stock methods for assessment [e.g. West African fiddler crab *Uca tangeri* stocks in the Mbo River, Nigeria (Okon and Hart, 2014); swimming crab *Callinectes amnicola* stocks in Okpoka Creek, Nigeria (Abowei et al., 2010)].

Unfortunately, no such studies have been conducted on crayfish in the Cross River. Most studies focus on finfishes and neglect shellfishes completely, except for the early work by Enin (1995) and Nwosu and Wolfi (2006) on the African shrimps *Macrobrachium machrobrachiun* and *M. vollenhovenii*, respectively, which still do not refer to crayfishes. In the Cross River State and Nigeria as a whole, crabs are harvested in the wild as there is currently no crab farming, notwithstanding the many prospects reported for this species and other portunid crabs (Moruf and Lawal-Are, 2017). Mikpon et al. (2020) also reported that most economically important aquatic resources, including crabs, are harvested by both industrial and artisanal fisheries in an unsustainable and uncontrollable manner. This excessive focus on the wild crab to support the stocking population can put undue pressure on the crab stock, resulting in overexploitation, reducing genetic diversity, and jeopardising this important resource (Zhang et al., 2021; Sakib et al., 2022).

The Cross River crab fishery can be effectively managed through studies that reveal population dynamics. Sakib et al. (2022) found that recruitment pattern, growth, and mortality rate (total, fishing, and natural mortality) are the three most important factors contributing to fish population fluctuation. However, the importance of parameters such as longevity, exploitation rate, and catch probability to population dynamics cannot be overstated. Abowei et al. (2010) observed year-round recruitment of *C. amnicola* in Okpoka Creek, Nigeria, with a large peak in May and a small peak in November, covering the wet and dry seasons, respectively. The study also found an overall mortality rate of 3.37 per year and an exploitation rate of 0.75, suggesting that *C. amnicola* in this creek dies more from human impact than natural causes (Abowei et al., 2010). Similarly, in another species (*C. sapidus*) in the Bardawil Lagoon, Egypt, an overall mortality rate of 6.35 per year and an exploitation rate of 0.59 was observed, which is above the standard exploitation limit of 0.50 (Mehanna et al., 2019). However, Rouf et al. (2021) observed a lower E value of 0.43 for female orange mud crab *Scylla olivacea* in Bangladesh, a situation where fishing mortality was lower than natural mortality and the traditional exploitation limit was not exceeded. The present study, therefore, attempts to determine the exploitation status and other population parameters of *C. amnicola* in the Cross River, Nigeria, so that appropriate formulation of management and conservation strategies for this fishery can be recommended.

MATERIALS AND METHODS

The Cross River is one of the flood rivers that flow to the Cross River estuary in Nigeria. It is located between latitudes 4°45'' and 6°15'' N and longitudes 8°00'' and 8°55'' E (Fig. 1). Along with other rivers in the region, it hosts a wide range of freshwater species, including crayfish and other crustaceans. These resources are exploited using a variety of fishing gear and techniques.

A total of 2581 samples of *C. amnicola* were collected weekly from landings of the artisanal crab fishery using square nets at the Itu station in the Cross River. Crabs (Fig. 2) were identified using the standard identification brochure by Schneider (1990). Sampling was conducted from January 2021 to January 2022, representing a 13-month period. Pauly (1987) advised a sample size of at least 1500 over a continuous six-month period.

Our sample size and sampling procedure met this criterion and were considered adequate to achieve the desired results. The extent of sampling months in the present study was intended to cover the entire annual cycle with adequate overlap to track annual differences in growth patterns, as recommended by Gulland and

Fig 1. A map of the Cross River estuary indicating the Cross River

Rosenberg (1992). Collected samples were immediately placed on ice and taken to the laboratory of the Institute of Oceanography, College of Calabar, Nigeria, within 4 hours, for length and abundance measurements.

To satisfy part of the FiSAT program requirements, the Cross River surface water temperature (SWT) was determined. Weekly water temperatures were measured on site using a hydro-thermometer. At the end of sampling, temperature data were averaged and recorded. The average temperature of 28.1 °C determined in the present study was within the temperature range (26.3 - 31.8 °C) measured by Ama-Abasi et al. (2022) in the Cross River.

In the laboratory, carapace length was measured with a caliper to the nearest 0.1 cm as the distance from the tip of one lateral spine to the tip of another spine at the opposite end. Weekly data were later combined into monthly data to fit the Electronic Length Frequency Analysis (ELEFAN) program (see Table 1). The FiSAT II software was downloaded free of charge from the Food and Agriculture Organization website at https://www.fao.org/fishery/en/topic/16072/en. The FiSAT II software is a fish assessment tool from the Food and Agriculture Organization and the International Center for Living Aquatic Resources Management (FAO-ICLAM).

Fig 2. A picture of the swimming crab *Callinectes amnicola* obtained from the Cross River estuary

Table 1. Length–frequency data of the swimming crab *Callinectes amnicola* of the Cross River used for the computation

Mid-length	2021 January	February	March	April	May	June	July	August	September	October	November	December	2022 January
6.5	0	0	0	0	1	0	0	0	0	0	0	1	0
7.5	0	0	0	1	0	0	0	0	0	0	0	3	0
8.5	0	0	0	0	42	0	0	0	0	0	0	84	1
9.5	16	0	0	45	51	16	0	0	1	3	3	105	34
10.5	184	18	184	40	72	55	14	1	2	8	42	62	22
11.5	296	138	87	63	18	68	47	5	24	33	60	24	17
12.5	154	177	41	15	0	2	18	17	25	13	15	26	13
13.5	12	23	13	3	6	1	0	0	0	0	0	8	1
14.5	0	1	4	0	1	0	0	0	0	0	0	0	0
15.5	0	0	1	0	0	0	0	0	0	0	0	0	0

The asymptotic carapace length (L) and growth constant (K) of the von Bertalanffy growth function (VBGF) were estimated using the ELEFAN unit of the FiSAT II program. The following equations were used to estimate the VBGF parameters (L and K):

$$L_t = L_\infty \left(1 - e^{K(t-t_0)}\right) \quad (1)$$

where t = age of crab measured in year, L = the average carapace length at age t measured in cm, t_0 is the imaginary age when L = 0, and K = growth coefficient per year.
To estimate the growth performance index (Φ'), values of L_∞ and K were substituted in the following equation:

$$\phi' = Log K + 2 Log L_\infty \quad (2)$$

To estimate the total mortality (Z) of the swimming crab, a length-converted catch curve was used with an average temperature of 28.1 as revealed by the SWT measurements. Longevity, denoted as t_{max}, was estimated following the equation:

$$t_{max} = 3/K \quad (3)$$

Natural mortality was deduced from the equation as shown below:

$$Z = M + F, \text{ and } M = Z - F \quad (4)$$

where M and F are natural and fishing mortalities, respectively, estimated from the FiSAT program.
The exploitation rate (E) of the swimming crab was estimated to reveal the proportion of the swimming crab that is subjected to fishing mortality, as shown below:

$$E = F / Z \quad (5)$$

Other computations of the length-frequency data include a backward calculation to reveal the recruitment pattern; a likelihood of capture to estimate the chance for which a particular length class of the crab can be captured during fishing; a virtual population analysis to determine the relationship between fishing mortality, crab population, and length class; and a knife edge selection to determine the relative yield per the recruitment of the exploited crab population.

RESULTS

The results of the FiSAT analysis are summarized in Table 2. The study revealed that the asymptotic length (L_∞) and growth constant (K) of VBGF were 16.28 cm and 0.940 yr^{-1}, respectively. Histograms showing the length frequency distribution of the swimming crab used to calculate the L_∞ and K parameters are provided in Figure 3. The best growth performance index (Φ') was estimated to be 2.40 (Fig. 4), while longevity (L) was 3.19 years.

Table 2. Growth parameters and performance index of the swimming crab *Callinectes amnicola* in the Cross River, Nigeria

Growth parameters	Symbols	Estimates
Asymptotic length (cm)	L_∞	16.28
Growth constant (yr^{-1})	K	0.940
Growth performance index	Φ'	2.40
Longevity (yr)	$\mathscr{L}$	3.19
Total mortality	Z	3.46
Natural mortality	M	2.04
Fishing mortality	F	1.42
Exploitation rate	E	0.41

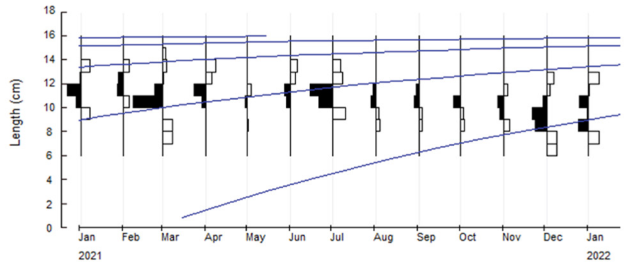

Fig 3. Von Bertalanffy growth curves of the swimming crab *Callinectes amnicola* in the Cross River, Nigeria. Curves are drawn over the peaks and troughs of the length frequency histograms.

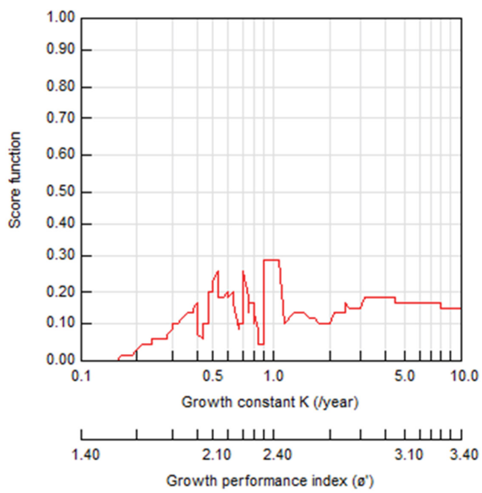

Fig 4. Growth performance index of the swimming crab *Callinectes amnicola* in the Cross River, Nigeria

The length-converted catch curve yielded estimated values for total mortality (*Z*), natural mortality (*M*), and fishing mortality (*F*) of 3.46, 2.04, and 1.42 per year, respectively, with an exploitation rate (*E*) of 0.41 (Fig. 5).

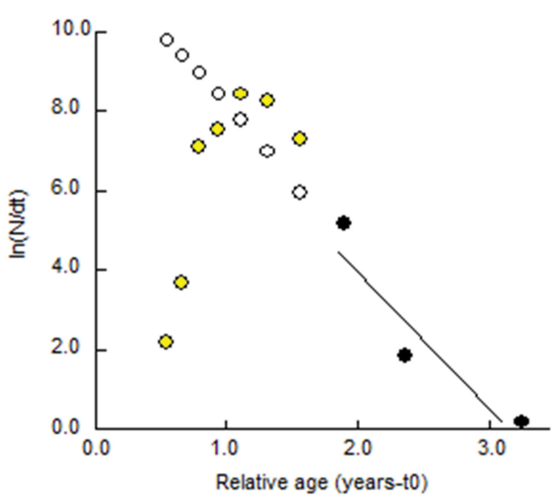

Fig 5. Length-converted catch curve of the swimming crab *Callinectes amnicola* in the Cross River, Nigeria. Black scatter plot refers to length classes of crabs under full exploitation used in the regression analysis; Yellow scatter plot refers to length classes of crabs not under full exploitation and not used in the regression analysis; transparent scatter plot refers to length classes of crabs used to estimate the probability of capture.

The recruitment rate of the swimming crab was observed in all months of the year, with a large peak between May and July (Fig. 6). It was observed that the probability of capture varied with the size of the crab (Fig. 7).

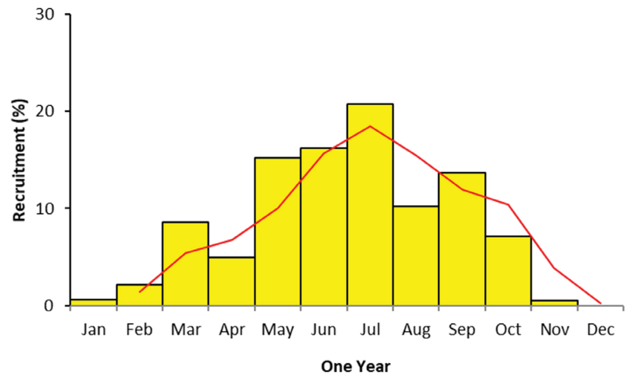

Fig 6. Annual recruitment regime of the swimming crab *Callinectes amnicola* in the Cross River, Nigeria

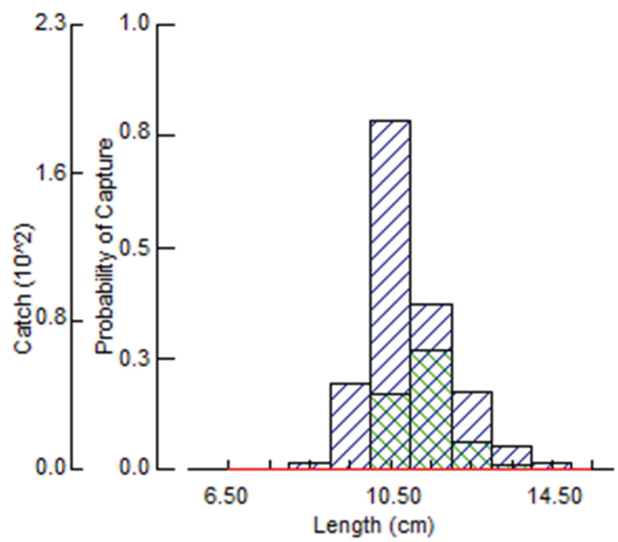

Fig 7. Likelihood of capture of the swimming crab *Callinectes amnicola* in the Cross River, Nigeria

According to the results of the catch analysis, 25 percent of the swimming crabs could be caught at a length of 10 cm, 50 percent at 10.5 cm (length at first catch, L_{50}), and 75 percent at 11 cm (Fig. 8).

The virtual population plot in Figure 9 shows the relationship between fishing mortality and average crab length. The results show the decimation of survivors (younger cohorts or small individuals) triggered by natural mortality such as predation and later by fishing mortality. Fishing pressure was observed to be greatest between 10.0 and 14.5 cm. The results of the relative yield per recruit (*Y'/R*) model show that at an exploitation ratio (*E*) of 0.1 *Y'/R* = 0.355, at an exploitation ratio (*E*) of 0.5 *Y'/R* = 0.278, and at a maximum exploitation ratio (*E*) *Y'/R* = 0.421 (Fig. 10). Yield isopleths giving the ratio of length at first catch to length at infinity (L_c/L_∞) gave a definite value of 0.645 (Fig. 11).

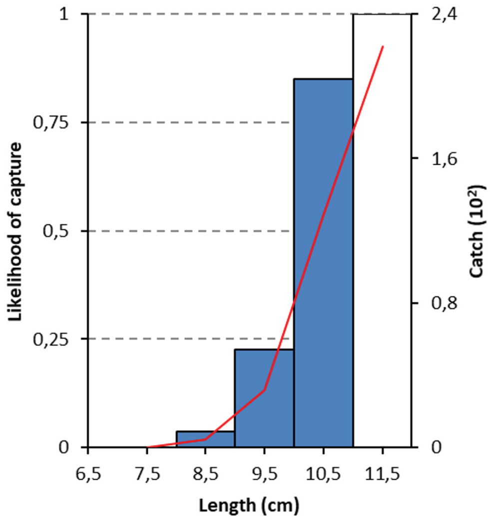

Fig 8. Extrapolation of the likelihood of capture of the swimming crab *Callinectes amnicola* from the ascending arm of the catch curve. The sizes at which 25, 50 and 70 percent of the crab population could be susceptible to capture are 10.0, 10.5, and 11.0 cm, respectively.

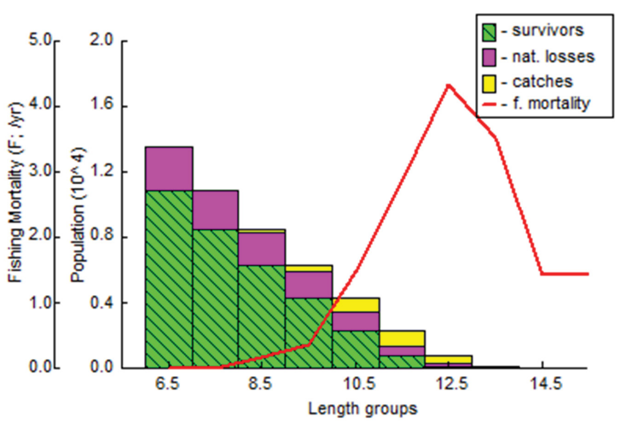

Fig 9. Length-based virtual population display of the swimming crab *Callinectes amnicola* in the Cross River, Nigeria. Different colour bands represent the number of survivors, natural losses, number of crabs caught, and mortality due to fishing.

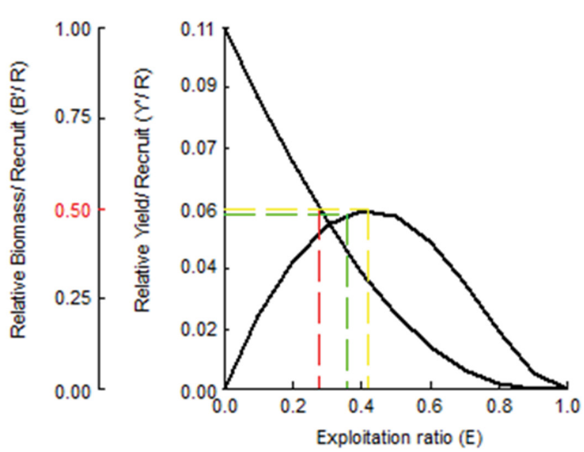

Fig 10. Relative yield per recruit and biomass per recruit of the swimming crab *Callinectes amnicola* in the Cross River, Nigeria using the 2-D selection ogive option ($E_{0.1}$ = 0.355, $E_{0.5}$ = 0.278, E-max = 0.421)

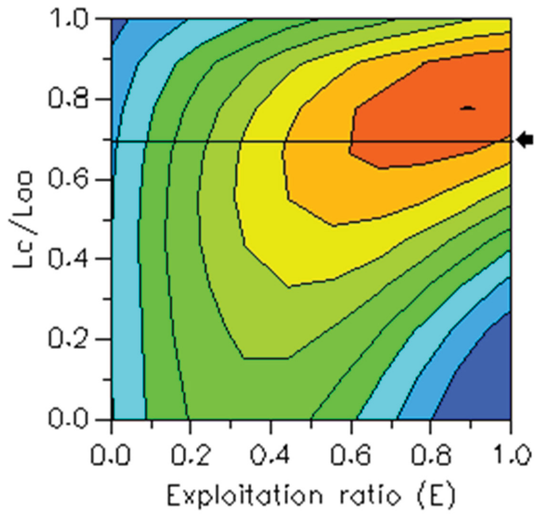

Fig 11. Yield isopleths for the predicted response of relative yield per recruit to changes in length at first capture and exploitation rate of the swimming crab *Callinectes amnicola* in the Cross River, Nigeria. The dark arrow at the right of the isopleths points to the definite value of the critical ratio, L_{50}/L_{∞} = 0.645.

DISCUSSION

The objective of this study was to assess the population of the swimming crab using length frequency data from the Cross River estuary, Nigeria. The use of length frequency in population studies helps determine the length class of the target species most affected by mortality from overfishing or overexploitation.

Modeling length frequency data is very important for assessing the population of slow-growing organisms such as crabs and tropical fishes, whose ages are difficult to determine from their growth rings. In crustaceans, the exoskeletons that are supposed to provide age information are lost due to moulting, making it difficult to estimate growth and encouraging the use of length-frequency data. The widely used classical growth models of Beverton and Holt (1957) and Ricker (1975) are usually fitted to the average length at a probable age of one year class. Because crustacean growth is asynchronous with a year class, the classical Von Bertalanffy growth function of Pauly and Gaschutz (1979) was extended to account for the seasonality of growth.

The asymptotic length (L_{∞}) and growth constant (K) of the VBGF are 16.28 cm and 0.940 yr^{-1}, respectively, and the growth constant is considered high when the values are greater than 1. The K value of 0.940 yr^{-1} obtained in the present study was higher than the 0.47 and 0.50 yr^{-1} obtained by Sakib et al. (2022) for male and female mud crab *Scylla olivacea*, respectively, in the Sundarbans, Bangladesh. However, the present K value was similar to the value of 0.90 yr^{-1} reported by Rouf et al. (2021) for male *S. olivacea* in the Sundarbans, Bangladesh. It is evident from the present and previous studies that K values may be influenced by sample size. While Rouf et al. (2021) used a total of 3191 specimens, which is closer to the 2581 specimens used in the present study, Sakib et al. (2022) used a small sample size of 1848 crabs. Although the present study used pool data for its analysis, it is important to note that male crabs generally have a higher growth rate than female crabs. This could be due to the fact that much of the energy of mature female crabs is expended on reproduction and the proportion of remaining energy is insufficient to support somatic growth, as is the case with male crabs. This could lead to lower growth in the female crab (Rouf et al., 2021).

The best growth performance index (*Φ'*) was estimated to be 2.40, which is higher than the value of 2.0 reported by Sakib et al. (2022) for *S. olivacea*, but lower than the values of 4.34 and 4.21 reported by Rouf et al. (2021) for the same *S. olivacea*. This growth index is important in aquaculture because species with higher values always have a better growth rate in captivity and would perform well within the shortest possible breeding period. However, habitat conditions, such as pollution, food supply, etc., can affect the growth performance of a species. Ama-Abasi et al. (2022) reported variations in ecological and environmental variables and a possible influence of climate change in the Cross River that may have been responsible for the low growth performance of *C. amnicola* observed in the present study. Therefore, the best growth performance as an index of aquaculture selectivity could be where habitat conditions are most favorable.

The estimated longevity of *C. amnicola* in the present study is relatively higher (3.19 years) than the 1.75 years reported by Abowei et al. (2010), but not as high as the 6.38 and 6.0 years reported by Sakib et al. (2022) for male and female *S. olivacea*, respectively. However, the longevity of the present study is similar to the 3.57 years reported by Sugilar et al. (2012) for the swimming crab *Portunus trituberculatus* and the 3.33 and 3.95 years reported by Rouf et al. (2021) for male and female *S. olivacea*, respectively. Crab longevity could vary due to several factors, including species, location, fishing pressure, predators, and environmental quality. In the present study, the observed low longevity of *C. amnicola* could be attributed to the constant variation in environmental quality, as well as the low growth performance.

The total mortality (*Z*) of *C. amnicola* in the Cross River estuary was 3.46 yr^{-1}. Natural mortality (2.04 yr^{-1}) was observed to be higher than fishing mortality (1.42 yr^{-1}), while the exploitation ratio (0.41) estimated in the present study was lower than the benchmark value of 0.5 set by Gulland (1971), and the overexploitation value of 0.75 reported by Abowei et al. (2010) in Okpoka Creek, Nigeria. This could be inferred to mean that *C. amnicola* in the Cross River estuary is not overexploited. The report of Abowei et al. (2010) also gave a higher total mortality rate of Z = 5.19 yr^{-1} for the same species in a Nigerian creek. This means that the crabs in the present study died more often from natural causes than from fishing. This could be further explained by the fact that the size structure of the swimming crab was dominated by younger cohorts, which are more susceptible to predation by fish and also vulnerable to poor environmental conditions caused by pollution. Researchers such as Andem et al. (2013), Asuquo et al. (2018), and Ifon and Asuquo (2021) had reported incessant pollution of the Calabar River. Pollution of the water bodies can predispose aquatic organisms to parasitic infestation. This is supported by the work of Ekanem et al. (2013) who reported the susceptibility (61.54%) of small blue crab *C. ambicola* (5.0–9.9 cm) to parasites such as Trichodina and nematodes. It is interesting to also note that no parasites were isolated from the largest-sized crab (15.0–19.9 cm) assessed by Ekanem et al. (2013).

The recruitment rate of the swimming crab was observed in all months of the year. Similar recruitment has been reported by several researchers as typical of tropical fin and shellfish (Etim et al., 1994; Nwosu and Wolfi, 2006; Nwosu et al., 2010; Ama-Abasi and Uyoh, 2020; Rouf et al., 2021; Sakib et al., 2022). However, there was seasonal variation in the recruitment of the studied crab, with major abundance at the peak of the rainy season (from May to July). Two minor peaks were also observed, making a total of three recruitment peaks of *C. amincola* in the Cross River estuary. However, Abowei et al. (2010) reported two peaks (one major, one minor) for *C. amnicola* in Okpoka Creek, Nigeria. The differences in the recruitment pattern of *C. amnicola* from the different studies could be explained. The higher recruitment observed in the present study could mean that the crabs in the Cross River estuary are able to spawn more asynchronously than those of Okpoka Creek. Probably, this could explain the reason for the lower exploitation rate and fishing mortality observed in the present study.

The size structure of the swimming crabs in the study area indicates the presence of 3-year classes dominated by small individuals, which is a clear indication that the lower Cross River is a nursery ground for this species. Oh et al. (1999) also observed the same size class for the population structure of the regular shrimp *Crangon crangon* in Port Erin Bay of the Irish Sea. The probability of capture was observed to vary with crab size; 25, 50, and 75 percent of the crabs that were susceptible to capture were 10 cm, 10.5, and 11 cm in length, respectively. Younger cohorts or smaller individuals were more susceptible to natural mortality such as predation, pollution, or disease than fishing mortality. However, fishing pressure was at its peak on crabs between 10.0 and 14.5 cm in carapace length.

The relative yield per recruit (*Y'/R*) revealed that at 10% exploitation ratio (*E*), *Y'/R* = 0.355; at 50%, *Y'/R* = 0.278; and at maximum, *Y'/R* = 0.421. These values were at variance with 0.47, 0.31, and 0.49, respectively, reported by Abowei et al. (2010). The difference between the present and previous results could be due to different sampling waters, as the former study sampled a creek while we sampled a river. Also, results are expected to vary by geographical region. The computed exploited rate of 0.41 was lower than the maximum yield per recruit value of 0.421 obtained from the ogive selection procedure. This confirms that the stock of *C. amnicola* in the Cross River is not overexploited.

Yield isopleths given the ratio of length at first capture to length at infinity (L_c/L_∞) produced a definite value of 0.645. This value is similar to 0.65 and 0.71 previously reported by Rouf et al. (2021) and Sakib et al. (2022), respectively. Although these values were not directly reported by the authors, we used the available data from their works to compute the L_c/L_∞ for comparison's sake. Adopting the quadrants rule stipulated by Pauly and Soriano (1986), an L_c/L_∞ ratio of 0.645 and an *F/Z* ratio of 0.410 would classify *C. amnicola* into quadrant A, implying under-fishing. As a rule of thumb, L_c/L_∞ = 0.5 – 1.0 and E = 0.0 – 0.5 classify organisms into quadrant A, which implies under-fishing as observed in the present study; quadrant B implies enumetric fishing requesting no management intervention; quadrant C represents a developed fishery; and quadrant D implies overfishing.

CONCLUSIONS

The results of the present study indicate that the swimming crab *C. amnicola* is underfished in the Cross River. The underfishing of *C. amnicola* in the Cross River could be due to overdependence on other fishery resources, resulting in neglect of this important fishery. This means that these crayfish were harvested below the rate that could produce the maximum sustainable yield. We advise reducing fishing pressure on other fish stocks that are suffering from overfishing. Sustainable exploitation of *C. amnicola* and other edible crab species that are underfished in the Cross River and beyond should be expedited.

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PROCJENA VELIČNSKE STRUKTURE STOKA RAKA PLIVAČA *Callinectes amnicola* (CRUSTACEA: PORTUNIDAE) U RIJECI CROSS, NIGERIJA

SAŽETAK

Važan aspekt veličinskih strukturiranih zaliha jest da jedinke nakon određenog vremena prelaze iz jedne veličinske klase u drugu. U ovoj studiji, ukupno 2581 uzoraka rakova plivača (*Callinectes amnicola*) uzorkovano je tijekom 13 mjeseci, od siječnja 2021. do siječnja 2022. U rijeci Cross, Nigerija. Rakovi su bili dugi od 6,5 cm do 15,5 cm, a većina rakova ulovljena je u sušnoj sezoni. Najmanja učestalost (n=23) rakova ulovljena je u kolovozu 2021., dok je najveća učestalost (n=662) bila u siječnju 2021. Budući da je teško odrediti starost rakova zbog presvlačenja i drugih fizioloških prepreka, podaci dužinske učestalosti su korišteni umjesto toga. Procjena rakova plivača temeljila se na nekim osnovnim parametrima rasta von Bertalanffyjeve funkcije rasta i Bevertonovog i Holtovog modela rasta. Rezultati pokazuju da su asimptotska duljina i stopa rasta bile 16,28 cm, odnosno 0,94 cm godišnje. Najbolji indeks rasta procijenjen je na 2,40, dok su dugovječnost i smrtnost iznosili 3,19 godina, odnosno 3,46 godišnje. Izračunata stopa iskorištenja od 0,41 bila je niža od referentne vrijednosti (0,5) i najvećeg prinosa po vrijednosti (0,421), što potvrđuje nedovoljno izlovljen stok. Preporučeno je održivo iskorištavanje rakova plivača rijeke Cross smanjenjem napora na već iskorištenim ribolovnim resursima.

Ključne riječi: izlov rakova, stopa iskorištavanja, funkcija rasta, modeli temeljeni na duljini, održivi prinos

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