POPULATION DYNAMICS AND EXPLOITATION PARAMETERS OF *CALLINECTES AMNICOLA* (ROCHEBRUNE, 1883) IN THE LAGOON COMPLEXES OF SOUTH BENIN, WEST AFRICA

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ABSTRACT

To ensure the sustainable management of fisheries resources in Benin, the population dynamics of *Callinectes amnicola* are being studied in two locations: the lake Nokoué-Porto-Novo lagoon complex and the lake Ahémé-Coastal lagoon complex. Monthly recordings of carapace length were conducted on 5,850 crabs from lake Nokoué-Porto-Novo lagoon complex between February 2017 and January 2018, while 2,252 crabs from lake Ahémé-Coastal lagoon complex were analyzed using FiSAT II software to determine population dynamics parameters. The estimated asymptotic carapace lengths ($L\infty$) were found to be 14.70 cm and 17.85 cm for lake Nokoué-Porto-Novo lagoon complex and lake Ahémé-Coastal lagoon complex, respectively. The growth rate (K) was calculated as 3.1 for lake Nokoué-Porto-Novo lagoon complex and 0.63 for lake Ahémé-Coastal lagoon complex. Estimates of fishing mortality (F) were determined as 6.97 $year^{-1}$ for lake Nokoué-Porto-Novo lagoon complex and 0.66 $year^{-1}$ for lake Ahémé-Coastal lagoon complex. The size at first capture was estimated to be 11.87 cm for lake Nokoué-Porto-Novo lagoon complex and 11.20 cm for lake Ahémé-Coastal lagoon complex. The current exploitation rates were found to be 0.60 for lake Nokoué-Porto-Novo lagoon complex and 0.3 for lake Ahémé-Coastal lagoon complex. These findings indicate that the stock of *Callinectes amnicola* is overexploited in lake Nokoué-Porto-Novo lagoon complex, while in contrast, it is not overexploited in lake Ahémé-Coastal lagoon complex. The stocks in lake Nokoué-Porto-Novo lagoon complex have reached a critical level of overexploitation. Therefore, it is necessary to reduce the level of species exploitation in this complex while respecting the optimal carapace length.

Key words : *Coastal lagoon; Crab; lake Ahémé; lake Nokoué; Porto-Novo lagoon.*

DYNAMIQUE DES POPULATIONS ET PARAMÈTRES D'EXPLOITATION DE *CALLINECTES AMNICOLA* (ROCHEBRUNE, 1883) DANS LES COMPLEXES LAGUNAIRES DU SUD-BÉNIN

RÉSUMÉ

Dans la perspective de contribuer à une gestion durable des ressources halieutiques au Bénin, la dynamique des populations du crabe *Callinectes amnicola* est étudiée par l'estimation de la croissance, la mortalité, le recrutement et le taux d'exploitation de l'espèce. Pour ce faire, la longueur de la carapace des crabes a été enregistrée mensuellement entre février 2017 et janvier 2018. Au total, 5850 longueurs de carapace de crabes du complexe lagunaire lac Nokoué-lagune de Porto-Novo et 2250 du complexe lagunaire lac Ahémé-lagune Côtière ont été utilisées dans le logiciel FiSAT II pour estimer les différents paramètres.

Les longueurs de carapace asymptotique estimées $L\infty$ sont respectivement de 14,70 cm et de 17,85 cm pour le complexe lac Nokoué-lagune de Porto-Novo et le complexe lac Ahémé-lagune Côtière, tandis que le taux de croissance (K) est de 3,1 dans le complexe lac Nokoué-lagune de Porto-Novo et de 0,63 dans le complexe lac Ahémé-lagune Côtière. La mortalité par pêche est de 6,97 an^{-1} pour le complexe lac Nokoué-lagune de Porto-Novo et de 0,66 an^{-1} pour le complexe lac Ahémé-lagune Côtière.

La taille à la première capture est respectivement à 11,87 et 11,20 cm pour le complexe lac Nokoué-lagune de Porto-Novo et le complexe lac Ahémé-lagune Côtière.

Les taux d'exploitation actuels de 0,60 pour le complexe lac Nokoué - lagune de Porto-Novo et de 0,3 pour le complexe lac Ahémé - lagune Côtière montrent que le stock est surexploité dans le complexe lac Nokoué - lagune de Porto-Novo contrairement au complexe lac Ahémé - lagune Côtière.

Mots clés : Crabe ; lac Ahémé ; lac Nokoué ; lagune Côtière ; lagune de Porto-Novo.

INTRODUCTION

In West Africa, crabs are natural resources of interest and are the subject of active artisanal fisheries (d'Almeida & Fiogbé, 2008 ; Dessouassi, 2014). They represent an important food resource for humans and are the subject of a particularly developed economic activity (Akin-Oriola *et al.*, 2005 ; Sankaré, 2007 ; Gnimadi *et al.*, 2008; Babatunde, 2008; Lawal-Are, 2009 ; Thiam & Diallo, 2010). Several studies have demonstrated their overexploitation in Ivorian, Ghanaian and Nigerian lagoons (Sankaré, 2007 ; Abowei *et al.*, 2010; Addo *et al.*, 2018). In Benin, the level of fish exploitation has been the subject of several scientific studies (Chikou, 2006 ; Niyonkurou, 2007 ; Montchowui, 2009 ; Ahouansou-Montcho *et al.*, 2011 ; Lederoun *et al.*, 2015 ; Lederoun *et al.*, 2016 ; Sossoukpè *et al.*, 2016 a; Sossoukpè *et al.*, 2016 b; Djidohokpin *et al.*, 2017). Crab fisheries are no exception to the overexploitation of Benin's water bodies (Programme de Développement de la Pêche et de l'Aquaculture, 2014). Indeed, the main commercial species *Callinectes amnicola* (Rochebrune, 1883) is exploited to such an extent that the individuals caught for some times have been small or simply the volume of catches has dropped significantly (d'Almeida & Fiogbé, 2008). Apart from this subjective information on the level of exploitation of *Callinectes amnicola*, there are no scientific studies on the population dynamics of this species in the lagoons of southern Benin.

The analysis of the population dynamics of this main species of crab caught by artisanal fishing is carried out in this study to situate fisheries managers and scientists on the real exploitation status of the species in Benin’s lagoon complexes

Specifically, the study intends to estimate the growth parameters of the species populations, total mortality, fishing mortality and natural mortality, as well as the exploitation rate.

MATERIALS AND METHODS

Study Area

Benin is situated within the intertropical zone, experiencing a highly variable climate that is both hot and humid. The lagoon complexes under study are exclusively found in the southern region of the country and exhibit a sub-equatorial climate, characterized by two distinct rainy seasons of varying significance and two dry seasons. The initial rainy season spans from mid-March to mid-July, while the second occurs from mid-September to mid-October. The two dry seasons extend from July to September and from October to March. Three hydrological seasons are distinguished in the lagoon complexes (Gnohossou, 2006). These are :

1- the "dry" season : from December to March when continental inputs are negligible, evaporation is maximum and the maritime influence is predominant ; transparency, temperature and salinity reach their maximum value at the time when the water level is minimal ;

2- the "rainy" season : from April to July when temperatures reach their minimum;

3- the "flood" season: from August to November when salinity and pH become minimal while dissolved oxygen reaches its maximum values.

The study area includes the two lagoons complex of southern Benin :

- the lake Nokoué-Totchè channel -Porto-Novo lagoon complex and

- the lake Ahémé -Aho channel -Coastal lagoon complex.

The Figure 1 provided the overall view of the study area.

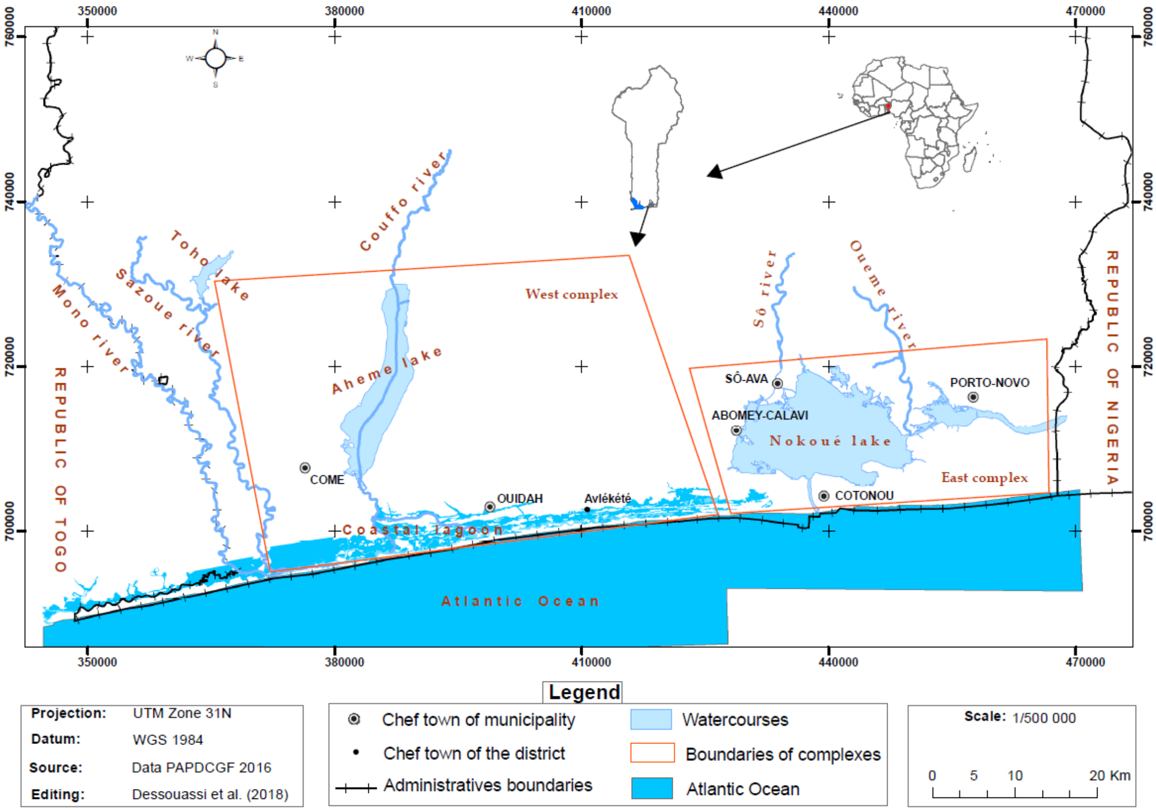

Figure 1. Map of the study area

The lake Nokoué-Porto-Novo lagoon complex

Situated in the southeastern region of the Beninese lagoon network (6°25'N, 2°36'E), this lagoon complex enjoys direct connectivity to the Atlantic Ocean via the Cotonou channel, while also connecting to the Porto-Novo lagoon through the Totchè channel. Commonly referred to as the East lagoon complex, it constitutes the brackish portion of the RAMSAR 1018 site. The complex comprises two main water bodies: lake Nokoué and the Porto-Novo lagoon. Lake Nokoué, spanning an average surface area of 160 km^2, extends approximately 20 km in an east-west direction and measures 11 km in width from north to south (Roche International, 2000).

The lake Ahémé-Coastal lagoon complex

It is still known as the West lagoon complex, which represents the brackish portion of the RAMSAR 1017 site. The complex is situated between 6°20' and 6°40' North latitude and 1°55' and 2° East longitude (Programme Intercommunal de Réhabilitation du complexe fluvio-lacustre du lac Ahémé et ses chenaux, 2013). It consists of three main components: To the west, there are the Mono and Sazoué estuaries.

The freshwater supply to the complex comes from the Mono river and the Sazoué river, which flow into the coastal lagoon. The natural hydrographic pattern of the Mono river is characterized by a single, distinct flood occurring primarily in August and September.

However, the construction of the Nangbéto hydroelectric project in 1987 significantly altered its flow regime (Oyédé *et al.*, 2002 ; Rossi, 1996).

In the central part of the complex lies lake Ahémé, which receives freshwater from the Couffo river. The lake has a length of 24 km and varies in width from 2 to 5.5 km. Its surface area is 78 km² during low water levels and expands to 100 km² during high water levels (Pliya, 1980). The lake is an inland water body with steep banks. Depths in the southern region of the lake are less than 1.5 m, while they range from 1.5 to 2.5 m in the central and northern parts (Dessouassi, 2014 ; Direction de la Production Halieutique, 2017).

Origin of the data

In this study, the width of crab carapaces (Figure 2) collected from artisanal fisheries in the two lagoon complexes between February 2017 and January 2018 was utilized. The database consisted of a total of 5,850 carapace widths from crab specimens in the eastern lagoon complex and 2,252 carapace widths from the western lagoon complex.

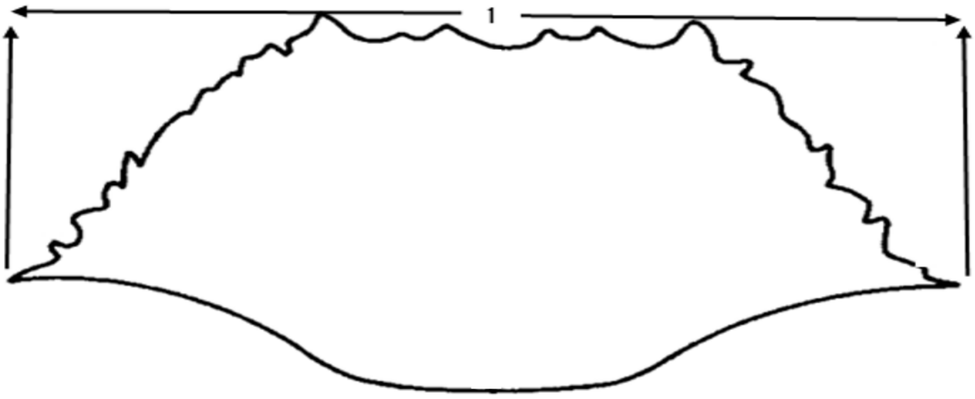

Figure 2. Carapace of portunid crabs which showing measurement of width (l) (Williams, 1974)

DATA PROCESSING

Growth parameters

The growth performance index was determined from the equation of :

Φ'= Log_{10} K + 2Log_{10} l∞ (Pauly, 1983).

The growth parameters: growth coefficient (K), asymptomatic carapace width (l∞) of the crab carapace were estimated from the ELEFAN/FiSAT II software (Gayanilo *et al*., 2005) using the carapace widths database. The software is designed for fish but also applied to crabs (Sankaré, 2007 ; Sara, 2010 ; Abowei *et al.*, 2010 ; Dash *et al.*, 2013 ; Chutapa *et al.*, 2014 ; Dessouassi, 2014 ; Goussanou *et al.*, 2018).

Age at zero width ($\mathbf{T_o}$) was calculated from the following formula :

$Log_{10}(-T_o) = -0.392-0.275Log_{10}l\infty-1.038Log_{10}K$ (Pauly, 1983 ; Lederoun *et al.*, 2015 ; Dash *et al.*, 2013).

The longevity of crabs is obtained from the formula:

$\mathbf{T_{max}}=3/(K+t_o)$ (Pauly, 1983)

Mortality parameters and exploitation rate

Total mortality **(Z)**

The FiSAT II software was used to estimate the total mortality rate (Z) using the catch curve method with carapace widths, as described by Pauly (1983). Z represents the slope of the descending portion of the catch curve. To calculate Z, specific points along the descending part of the curve are selected. Typically, the first point chosen is the one immediately following the point of maximum ordinate. The last selected point should correspond to a length no greater than 0.95 times $l\infty$ in order to avoid biases resulting from the small number of specimens with large lengths (Pauly, 1983).

Natural mortality (M)

The calculation of natural mortality (M) can be performed using the method proposed by Pauly (1983), taking into account several factors. One important factor is the inverse relationship between M and the maximum observed length, which is influenced by both longevity (T_{max}) and growth coefficient (K). However, this relationship alone is insufficient for a precise evaluation of M. To address this limitation, Pauly (1983) introduced the concept of mean annual environmental temperature.

A multiple correlation could be established in which M is such that :

$Log_{10}M = a + bLog_{10}W + cLog_{10}K + dLog_{10} T$ (Pauly, 1983)

with a = -0.21 ; b = -0.0824 ; c = 0.6757 ; d = 0.4627.

It was calculated from the FiSAT II software routines by inserting the mean annual temperature (28°C) recorded during the study.

Fishing mortality (F)

It is obtained by the formula: $F=Z-M$

Exploitation rate (E)

The exploitation rate is given by the formula :

$E=Z/F$

The size at the first capture (l_{C50}) and the optimal width (lopt)

The size at first capture is determined from the curve of Cumulative catch probability as a function of the width of the catches.

As for the optimal width, it is determined by the formula:

$lopt=l\infty\ 3/(3+M/K)$

K= Crab growth coefficient

$l\infty$= Asymptomatic width of the crab shell

M= Natural mortality rate of crabs

Yield and biomass per recruit

Knowing Z and M, the fishing mortality rate F can be obtained by a difference. From these elements, other FiSAT routines allow the diagnosis of possible overexploitation by reference to the yield-per-recruit calculations according to the Beverton and Holt (1966) production equation, which is itself integrated in a FiSAT subroutine (Gayanilo *et al.*, 2005).

The Beverton & Holt (1966) model expresses the relative yield per recruit (Y/R)', allowing the relationship between yield and fishing effort to be determined for different first-catch sizes. It belongs to the category of length-based models (Sparre &Vanema, 1998).

The FiSAT II software has allowed the application of the Beverton & Holt (1966) model, which is used to evaluate the relative yield and biomass per recruit.

The relative biomass per recruit (B'/R) is estimated from the following relationship

(B'/R) =(Y'/R)/F.

(B'/R): Biomass per recruit

(Y'/R): Yield per recruit

F: Fishing mortality

Other parameters are provided in this model such as E_{max}, $E_{0.1}$ and $E_{0.5}$ expressed graphically. E_{max} = Exploitation with maximum productive yield. $E_{0.1}$: Exploitation rate for an increase in Y'/R of l/10th compared to E = 0; $E_{0.5}$: Value of E below which the stock has been reduced by 50% of its unexploited biomass.

Recruitment

Recruitment refers to the process in which a specific age group of the studied taxon becomes part of the exploitable stock for the first time (Ahouansou Montcho, 2011). According to the same author, in tropical regions, recruitment is closely associated with the reproductive activity of the spawners and provides insights into the breeding season of the species under investigation. The size at recruitment refers to the size at which individuals become susceptible to fishing. It represents the age at which the youngest individuals capable of being caught are found. To model seasonal recruitment for crabs, frequency data of carapace widths are reorganized within the FiSAT software (Sparre & Venema, 1998 ; Pauly, 1983 ; Chutapa *et al*., 2014). This process involves retroactively projecting the length frequency data onto a one-year time scale by following the trajectory described by the Von Bertalanffy growth curve (Ahouansou Montcho, 2011 ; Lederoun *et al*., 2015). Subsequently, the distribution is analyzed using the maximum likelihood method, and its Gaussian components are separated using the "NORMSEP" (normal separation) procedure (Pauly, 1983 ; Ahouansou Montcho, 2011).

RESULTS

Estimation of growth parameters

The carapace width ($l\infty$), growth coefficient (K), and growth performance index (ϕ') of the crab *Callinectes amnicola* are 14.70 cm, 3.10 yr-1, and 2.82, respectively, in the eastern lagoon complex. In the western lagoon complex, they are 17.85 cm, 0.63 yr-1, and 2.30, respectively. The theoretical ages To and Tmax are -0.29 years and 1.25 years, respectively, in the East lagoon complex, and -0.59 years and 4.18 years, respectively, in the West lagoon complex (Figure 3).

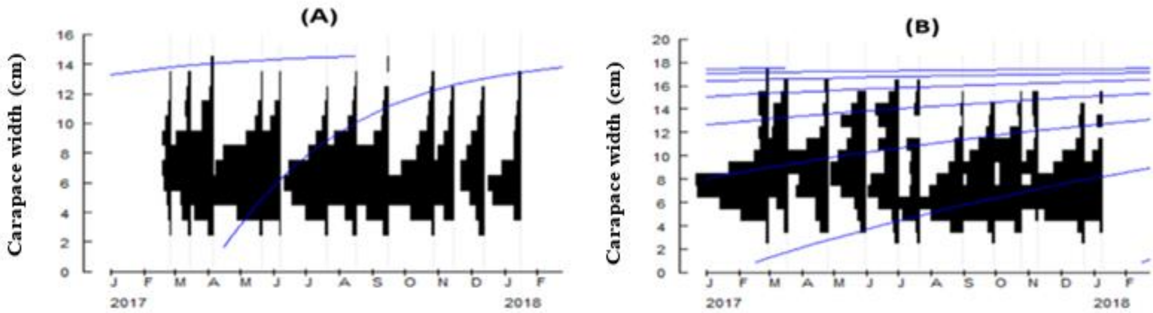

Figure 3. Growth curves obtained from length frequency histograms in *Callinectes amnicola* (A) the eastern lagoon complex and (B) the western lagoon complex.

Mortality parameters and exploitation rate

Total mortality was estimated at 11.54 in the eastern lagoon complex and 2.20 in the western lagoon complex.

Natural mortality is 4.56 and 1.54 on the East and West lagoon complexes respectively. Fishing mortality is estimated at 6.97 and 0.66 for the East and West lagoon complexes respectively.

Exploitation rates are estimated at 0.60 on the East lagoon complex (Figure 4 A) and 0.30 on the West lagoon complex (Figure 4 B).

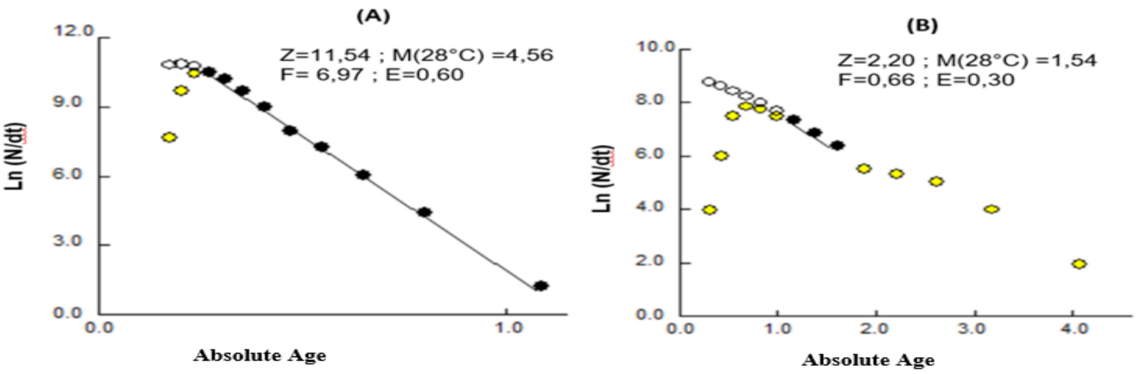

Figure 4. Catch curves based on restructured lengths using FiSAT software in *Callinectes amnicola*: (A) the East lagoon complex and (B) the West lagoon complex.

Size at first-capture (l_{C50}) and optimal size (lopt)

The size at first catch (l_{C50}) was found to be 5.74 cm in the East lagoon complex and 7.49 cm in the West lagoon complex (Figure 5). Additionally, the sizes l_{C25} and l_{C75} were determined to be 4.74 cm and 6.75 cm, respectively, in the East lagoon complex, while in the West lagoon complex they measured 6.13 cm and 8.86 cm, respectively. Moreover, the optimal size was identified as 9.86 cm in the Eastern lagoon complex and 9.89 cm in the Western lagoon complex.

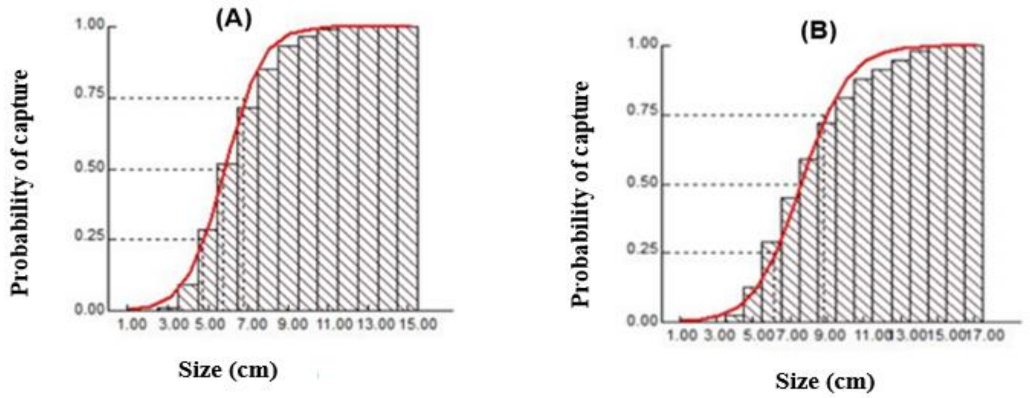

Figure 5. Catch probability curve for *Callinectes amnicola*: (A) East lagoon complex (B) West lagoon complex.

Yield and biomass per recruit

The relative yield per recruit curves Y'/R indicate a maximum exploitation rate (Emax= 0.53) for the East lagoon complex and Emax= 0.64 for the West lagoon complex (Figure 6). The exploitation rate $E_{0.1}$ is 0.45 for the East lagoon complex and 0.50 for the West lagoon complex. The exploitation rate $E_{0.5}$ is 0.31 and 0.33 on the East and West lagoon complexes respectively.

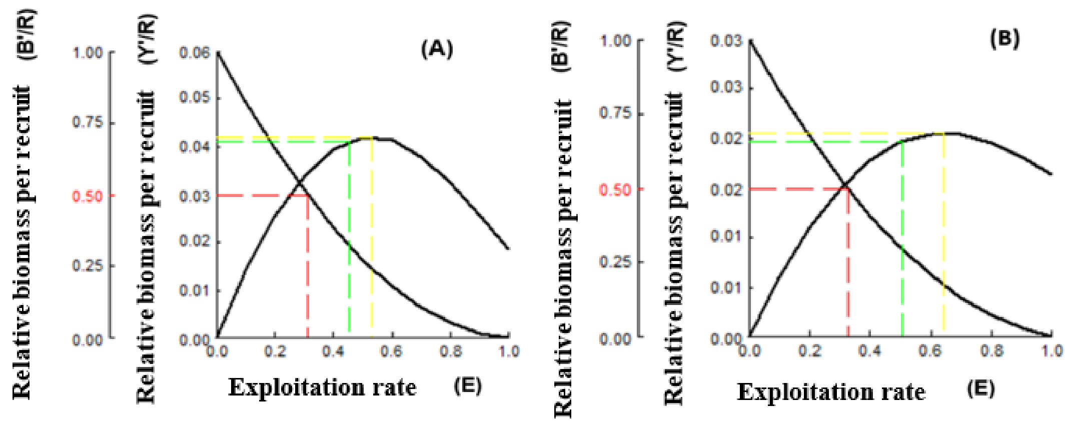

Figure 6. Yield and biomass per recruit curves for *Callinectes amnicola*: (A) East lagoon complex (B) West lagoon complex

Recruitment pattern

Recruitment is spread over the whole year in both lagoon complexes. In the eastern lagoon complex, recruitment is bimodal with a first peak from April to August and a second peak between September and October. In the Western lagoon complex recruitment shows a uni-modal trend with a peak in recruitment between April and September.

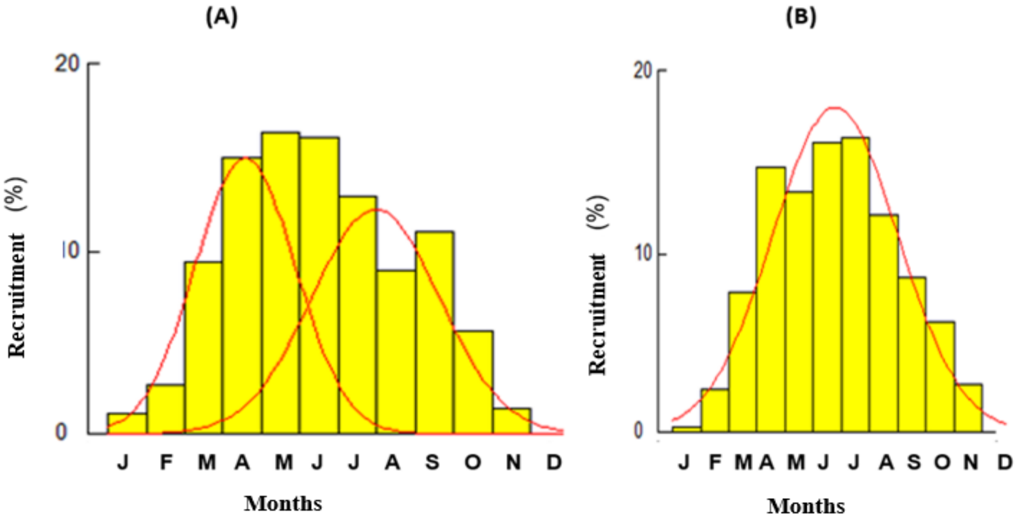

Figure 7. Recruitment pattern curves for *Callinectes amnicola*: (A) East lagoon complex (B) West lagoon complex.

DISCUSSION

Estimation of growth parameters

The asymptotic inter-spine width (l∞) of *C. amnicola crabs* in the Eastern lagoon complex (l∞=14.70 cm) is lower than that in the Western lagoon complex (l∞=17.85 cm). This difference can be attributed to the higher fishing pressures exerted on crabs in the Eastern complex compared to the western complex, which allows crabs to grow to larger sizes before being caught. According to Niyonkuru (2007), fishing pressure has the effect of reducing the asymptotic size l∞ of exploited organisms. In our study, the value of l∞ obtained in the eastern complex (14.70 cm) is relatively higher than the value reported by Goussanou et al. (2018), which was 12.6 cm in the same environment. This discrepancy may be explained by their sample size (1287 specimens) compared our study's sample size (5850 specimens). Additionally, the collection area of the specimens could also play a role, as many fishermen sell their catches directly on the water before returning to the pier. However, the l∞ obtained in the eastern complex is very close to the asymptotic length l∞ (16 cm) reported by Sankaré (2007) in the Aby-Tendo-Ehy complex in Côte d'Ivoire.

In terms of longevity, *C. amnicola* crabs have a maximum lifespan of 1.25 years in the Eastern lagoon complex, while in the Western complex, they can live up to 4.18 years. This difference is due to the lower likelihood of crabs being caught in the Western complex, resulting in a relatively longer lifespan compared to the Eastern complex where survival chances are lower. The main reason for this is that crab fishing is predominantly carried out by females in the Western lagoon complex.

The estimated growth rate (K value) in the Eastern complex is 3.1 year-1, which is higher than the growth rate in the Western lagoon complex (0.65 year-1). This indicates that the crab population in the Eastern complex primarily consists of fast-growing juveniles, whereas the Western complex has larger crabs that grow relatively slowly.

Furthermore, the growth rate of crabs in the Eastern complex is also higher than that in the Aby-Tendo-Ehy complex in Côte d'Ivoire, as reported by Sankaré (2007).

The growth performance, as indicated by the ϕ' value, is better in the Eastern lagoon complex (ϕ'=2.83) compared to the Western lagoon complex (ϕ='2.30). This difference can be explained by variations in environmental conditions, such as salinity and food availability. The Nokoué-Totchè channel-Porto-Novo lagoon complex is known as the most productive in West Africa (Lalèyè, 1995), while the Western complex is experiencing changes in water conditions, including closure and displacement of the lagoon mouth. Mouth closures have been documented in 1999 and 2015 (Roche International, 2000; Direction de la Production Halieutique, 2015), and a new closure and displacement was observed during our research in November and December 2017. The release of freshwater from the Nangbéto dam also contributes to the freshwater influx into this complex (Rossi, 1996). These conditions have a negative impact on the growth of *C. amnicola* crabs. Table 1 summarizes the main growth parameters from our study and previous studies on Portunidae crabs.

Table 1. Main growth parameters of the present study and other previous studies on Portunidae crabs

Countries	**Study areas**	**Species**	**l∞ (cm)**	**K (an-1)**	**Φ'**	**Authors**
Benin	East Lagoon Complex	*Callinectes amnicola*	14.70	3.1	2.83	Current study
Benin	West Lagoon Complex	*Callinectes amnicola*	17.33	0.63	2.30	Current study
Benin	East Lagoon Complex	*Callinectes amnicola*	12.60	0.3	1.678	Goussanou *et al.* (2018)
Nigeria	Okpoka Creek Niger Delta	*Callinectes amnicola*	6.18	1.71	-	Abowei *et al.* (2010)
Ivory Coast	Aby-Tendo Complex	*Callinectes amnicola*	16	0.8	-	Sankaré (2007)
Thailand	Kung Krabaen Bay	*Portunus pelagicus* (male)	16.73	1.13	-	Chutapa *et al.* (2014)
Thailand	Kung Krabaen Bay	*Portunus Pelagicus* (Female)	14.26	2.75	-	Chutapa *et al.* (2014)
India	Veraval, Guarat	*Portunus Sanguinolentus*	17.87	1.2	-	Dash *et al*.(2013
Indonesia	Lawele Bay	*Scylla serrata*	21.1	1.38	-	Sara (2010)

Mortality parameters and exploitation rates

In the western lagoon complex, natural mortality is higher than fishing mortality in contrast to the eastern lagoon complex and Okpoka lagoon in Nigeria's Niger Delta (Abowei *et al.* 2010).

In the Western lagoon complex, the current exploitation rate (E=0.30) is lower than the exploitation rate (E_{50}=0.33) at which the stock is reduced by half. We can therefore deduce that the stock in this complex is under-exploited (Miller, 2001).

In the Eastern lagoon complex, the current exploitation rate (E=0.60) is not only higher than the exploitation rate (E_{50}=0.31), but also higher than the maximum exploitation rate (E_{max}=0.53). The stock is overexploited.

The species management at Western lagoon complex (Benin) and at Lawele bay is suitable in contrary of the management at the others ecosystems mentioned in Table 2.

Table 2. Summarizes the mortality and exploitation parameters from this and previous studies of Portunidae crabs

Country	Study Areas	Species	Total Mortality (Z)	Fishing Mortality (F)	Natural Mortality (M)	Exploitation Rate (E)	Authors
Benin	East Lagoon Complex	*Callinectes amnicola*	11.54	6.97	4.56	0.60	Current study
Benin	West Lagoon West	*Callinectes amnicola*	2.2	0.66	1.54	0.30	Current Study
Benin	East Lagoon Complex	*Callinectes amnicola*	5.39	4.35	1.04	0.81	Goussanou *et al.* (2018)
Nigeria	Okpoka Creek, Niger Delta	*Callinectes amnicola*	5.19	3.89	1.30	0.75	Abowei *et al.* (2010)
Thailand	Kung Krabaen Bay	*Portunus pelagicus* (Male)	8.15	4.53	3.98	0.55	Chutapa *et al.* (2014)
Thailand	Kung Krabaen Bay	*Portunus pelagicus* (Female)	6.95	4.88	2.07	0.77	Chutapa *et al.* (2014)
India	Veraval, Gujarat	*Portunus sanguinolentus*	4.69	2.85	1.84	0.61	Dash *et al.* (2013)
Indonesia	Lawele Bay	*Scylla serrata* (Male)	3.68	1.15	2.53	0.31	Sara (2010)

Size at first catch (lc_{50}), optimal widths (l_{opt}) and management measures

In both lagoon complex, the inter-spine widths of first catches (l_{c50}) of the crabs caught are smaller than the inter-spine widths of first sexual maturity (l_{50}) (Dessouassi *et al.*, 2019), as are the optimal inter-spine widths for the species (l_{opt}); this confirms that the catches of *C. amnicola* in the two lagoon complex are mostly small. These are indicators of poor exploitation of the *C. amnicola* stock in both lagoon complexes. For the Eastern lagoon complex, the level of exploitation should be reduced and the optimal inter-spine width respected. For the Western lagoon complex, the fishing effort can be maintained, but the optimal inter-spine width can be respected (Table 3).

Table 3. Decision parameters for optimal management of crab stocks in the lagoon complexes of southern Benin

Lagoon Complexes	**l_∞(cm)**	**l_{C50}(cm)**	**l_{50}(cm)**	**$l_{optimal}$ (min-max)** (cm)	**E**	**E_{50}**	**E_{max}**	**Diagnosis of fisheries**
East	14.70	5.74	11.87	9.86 (2.50-14.26)	0.60	0.31	0.53	Over fishing
West	17.85	7.49	11.20	9.89 (2.83-16.65)	0.30	0.32	0.64	Under fishing

Managers frequently regulate crab fishing, especially in countries where they are valuable in the local market (FAO-SmartFish, 2014). Measures include imposing quotas or catch limits (a specified number of crabs per day), limiting the amount of gear and licensing the sale of crabs. These measures are generally not suitable for managing community-based fisheries. Measures applicable to all crab fishing techniques include crab fishing techniques include the imposition of minimum catch sizes, which vary according to the species (Table 4), the prohibition of catching females or grained females, and the prohibition of certain fishing gear such as gillnets and harpoons. Some countries prohibit the capture of crabs during the breeding season.

Table 4. Minimum catch sizes for some crab species

Country	**Species**	**Minimal Catch Size**	**Authors**
New Caledonia	*Scylla serrata*	13-14 cm	IFREMER (1991)
Madagascar	*Scylla serrata*	11 cm	FAO-SmartFish (2014) ; Kasprzyk & Level (2018)
Australia	*Portunus Pelagicus*	6 cm	Johnson *et al.* (2010)
Indonesia	*Portunus Pelagicus*	11.5 cm	Zairon *et al.* (2015)

Minimum catch sizes for crabs must be set by the Administration in charge of fisheries in Bénin. The optimal lengths correspond to these minimum sizes. Also, the capture of grained females during the reproduction period from February to May should be prohibited (Dessouassi *et al.*, 2018).

CONCLUSION

The examination of population dynamics in *C. amnicola*, based on artisanal catches in the eastern lagoon complex (lake Nokoué-Totchè channel-Porto-Novo lagoon) and the western lagoon complex (lake Ahémé-channel Aho-Coastal lagoon), reveals distinct patterns. The catches in the Eastern complex are primarily composed of juvenile crabs, whereas the Western complex exhibits relatively larger-sized catches. The stocks in the Eastern lagoon complex (lake Nokoué-Totchè channel-Porto-Novo lagoon) have reached a critical level of overexploitation. It is necessary to reduce the level of *C. amnicola* crab exploitation in this complex while adhering to the optimal inter-spine width. In contrast, the stocks in the western lagoon complex are underexploited. The fishing effort can be increased while still maintaining the optimal inter-spine width. Therefore, it is recommended to prohibit the catching of crabs (*C. amnicola*) with inter-spine widths less than 9.86 cm and 9.89 cm in the Eastern and Western lagoon complexes, respectively, to ensure sustainable exploitation of the stocks. Consequently, further studies on gear selectivity should be conducted to determine the appropriate mesh size for crab scales and the inter-spine spaces for traps.

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