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Original Research Article

Population Dynamics of the Common Cuttlefish *Sepia Officinalis* from the Coastal Water of Côte d'Ivoire

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Abstract: Population parameters such as asymptotic length ($L\infty$), growth coefficient (K), mortality rates (Z, F and M), exploitation level (E) and recruitment pattern of the common cuttlefish *Sepia officinalis* were estimated using length–frequency data from the Ivorian coastal water. Asymptotic length ($L\infty$) was 31.50 cm and growth coefficient (K) was estimated at 0.500 year^{-1}. Total mortality (Z) for *S. officinalis* was 1.32 year^{-1}, while natural mortality (M) and fishing mortality (F) were 0.94 and 0.38 year^{-1}, respectively. The growth performance index (φ') was 2.69 and the exponent "*b*" of the length–weight relationship was 2.77 during the study period. The asymptotic wet weight estimated from length–weight relationship was 2869.57 g. Exploitation level (E) of *Sepia officinalis* was 0.29. The recruitment pattern was continuous with one major peak in the months of July–August. The exploitation level (0.29) and lower fishing mortality (0.38 year^{-1}) indicate that the common cuttlefish is under-exploited from Ivorian coastal waters.
Keywords: population dynamics, *Sepia officinalis*, length–weight relationship, Côte d'Ivoire.

INTRODUCTION

The common cuttlefish, *Sepia officinalis* Linnaeus, 1758, is found in the Northeast Atlantic, in the east of Atlantic and throughout the Mediterranean [1]. On the coast of Senegal and Guinea, it constitutes the most abundant cephalopod in the captures. Recent studies showed that it the most abundant species in the unloading at the fishing port of Abidjan after fish. For example, in 2014, according to the management of aquaculture and fisheries of Côte d'Ivoire (DAP), more than 600 tons were captured in coastal water of Côte d'Ivoire.

Several works have been conducted on *Sepia officinalis* from coastal water of Senegal, Tunisia and Mauritania about reproduction, growth, fishing and the diet [2, 3]. In Côte d'Ivoire, some studies, related to the reproduction and the diet of these animals have been done [4].

Despite these recent studies, population dynamics for *S. officinalis* remain largely unknown. The dynamics of a stock are described from life-history parameters such as natural mortality, fishing mortality, maturity, life-span, recruitment and growth [5, 6].

For the management of mollusc resources, knowledge of various population parameters and exploitation level (E) of that population is required. There are many tools for assessing exploitation levels and population dynamics of a stock. Of those, FAO-ICLARM Stock Assessment Tools (FISAT) has been most frequently used for estimating population parameters of fin-fish and shell-fish [7-9], because it needs only length–frequency data. The advantage of this technique is that within 1 year it is possible to assess any fish stock if sufficient length–frequency data is available.

The objective of the present study was to estimate the population parameters and exploitation level of *Sepia officinalis* to assess the stock position of the species from Ivorian coastal waters.

MATERIALS AND METHODS

The study was conducted in the economic exclusive zone of Côte d'Ivoire. This maritime frontage, located in the golf of Guinea, is delimited in North by the African West coast, in the South by the equator, the West by the Cape of the Palms (8° W) and in the East by 2°30 E [10]. (Fig.1).

Samples of cuttlefish *S. officinalis* were collected from the fishing port and the commercial trawl catches of Abidjan between January 2015 and December 2015. During unloading, and at the laboratory, dorsal length of mantle (Dlm) of 1200 individuals was measured to the nearest 1cm and total weight was taken by an electronic balance of 1 g accuracy.

The data were then grouped into Dlm classes by 1cm intervals. Subsequently the data were analyzed using the FISAT software as explained in detail by [11]. Asymptotic length (L∞) and growth coefficient (*K*) of the von Bertalanffy growth function (VBGF) were estimated by means of ELEFAN-1 [12]. K-scan routine was conducted to assess a reliable estimate of the *K* value. The estimates of L∞ and K were used to estimate the growth performance index [13] of *S. officinalis* using the equation:

$\varphi' = 2\ \text{Log10}L_\infty + \text{Log10}K$.

To establish the length–weight relationship, the commonly used relationship $W = aLD^b$ was applied [14, 15] where W is the weight (g), LD the dorsal mantle length (cm), "a" the intercept (condition factor) and "b" is the slope (growth coefficient, i.e. fish relative growth rate). The parameters "a" and "b" were estimated by least squares linear regression on log–log transformed data: log10 W= log10 a + b log10 LD.

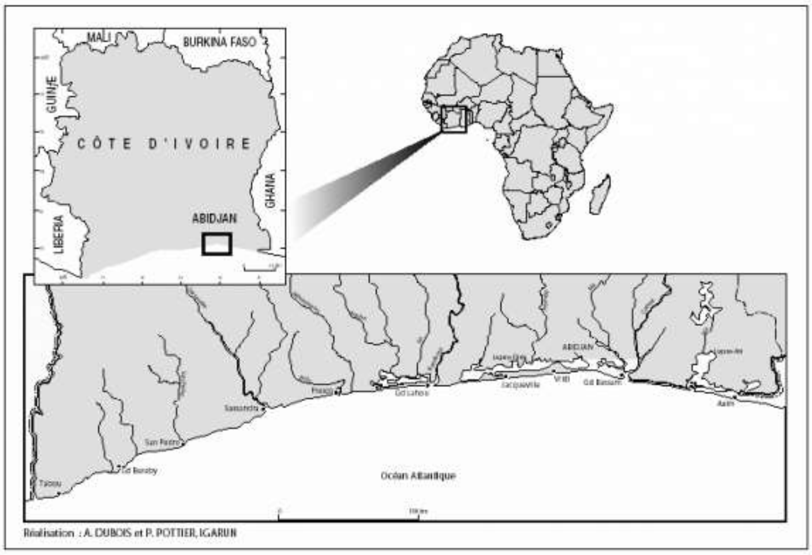

Fig-1: Sampling locations in the coastal water of Côte d'Ivoire

The coefficient of determination (r^2) was used as an indicator of the quality of the linear regression [16]. Additionally, 95% confidence limits of the parameters "a" and "b" and the statistical significance level of r^2 were estimated.

The inverse von Bertalanffy growth equation [17] was used to find the lengths of the *S.officinalis* at various ages. Then VBGF was fitted to estimates of length-at-age curve using non-linear squares estimation procedures [18]. The VBGF is defined by the equation:

$$LDt = L_\infty\ [1 - e^{(-K(t-t0))}]$$

where LDt is the mean length at age t, L∞ the asymptotic length, K the growth coefficient, t the age of the *S.officinalis* and t_0 is the hypothetical age at which the length is zero [19]. The total mortality (*Z*) was estimated by a length converted catch curve method [13]. Natural mortality rate (M) was estimated using the empirical relationship of [20]:

$$\text{log10}M = -0.0066 - 0.279\ \text{log10}L_\infty + 0.6543\ \text{log10}K + 0.4634\ \text{log10}T$$

where M is the natural mortality, L∞ the asymptotic length, K refers to the growth coefficient of the VBGF and T is the mean annual habitat temperature (◦C) of the water in which the stocks live. Once Z and M were obtained, then fishing mortality (F) was estimated using the relationship:

$$F = Z - M$$

where Z is the total mortality, F the fishing mortality and M is the natural mortality. The exploitation level (E) was obtained by the relationship of [21]:

$$E = \frac{F}{Z} = \frac{F}{F + M}$$

The recruitment pattern of the stock was determined by backward projection on the length axis of the set of available length–frequency data as described in FISAT. This routine reconstructs the recruitment pulse from a time series of length–frequency data to determine the number of pulses per year and the relative strength of each pulse. Input parameters were L∞, K and t_0 (t_0 = 0). Normal distribution of the recruitment pattern was determined by NORMSEP [22] in FISAT.

RESULTS AND DISCUSSION

Growth parameters

Asymptotic length (L∞) of the VBGF was 31.5cm and the growth coefficient (K) was 0.5 year^{-1} for *S. officinalis*. The computed growth curve using these parameters is shown over the restructured length distribution in Fig. 2. The observed maximum length was 29.70 cm and the predicted maximum length was 31.50 cm (Fig. 3). The best estimated value of K was 0.5 year^{-1} (Fig. 3). Information on the size-composition of the fishery is critical in establishing management measures aimed at sustainable exploitation of the resources. Size structure of *S. officinalis* observed reflects the length distribution of the catch, representing almost all size categories including juveniles. The ranges of L∞ with a wide range of K parameters were analysed to determine the optimum pairs of growth constants with best fit. L∞ is the largest theoretical mean length that a species could attain (granted it grows throughout life) in its habitat given the ecological peculiarities of that environment, and K is the speed it grows towards this final size. Comparisons of growth rates of populations and species are important in fisheries science and ecology for a range of management and academic reasons [23]. The comparison with growth parameters obtained in other studies show differences in *S. officinalis* from the different areas in the world (Table 2). It is observed that the present L∞ value (31.50 cm) of *S. officinalis* from Ivorian coastal waters is very close to India *Sepia* but K Value is not similar. The value of L∞ obtained by [24] with the females of *S. officinalis* (31.5cm) is similar with the present study, but there is difference with the males (29.5). According to the Table 2, the highest value of L∞ (40 cm) is from Gulf of Aden [25] and the lowest value (29.5cm) is in Manche [24]. The highest (1.27 year^{-1}) value of K is observed in Manche waters and lowest value (0.5 year^{-1}) is from the present study.

The index of growth performance (φ′) is a useful tool for comparing the growth curves of different populations of the same species and/or of different species belonging to the same order [26]. The growth performance index (φ′) calculated in this study was equal to 2.69. This value is close to those obtained by sanders [25] (φ′=3.2) and abdusammad *et al* [27] (φ′=3.00) concerning the cuttlefish *Sepia*, respectively in the gulf of Aden (1979) and in India (2004).

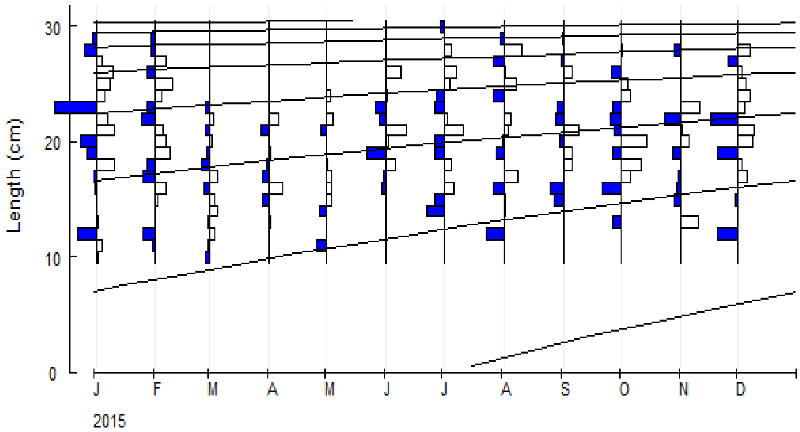

Fig-2: Restructured length–frequency distribution with growth curves superimposed using ELEFAN 1 (L∞ = 31.50 cm and *K*= 0.500 year^{-1})

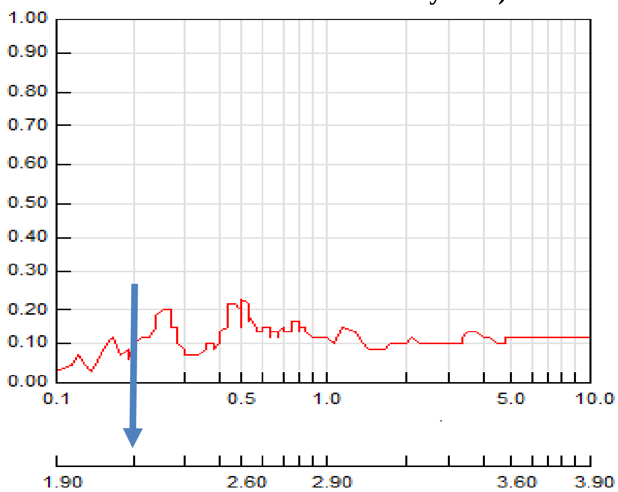

Fig-3: Estimation K of *S.officinalis* from Ivorian coastal water

Table 1: Population parameters of *S. officinalis* in coastal waters of Côte d'Ivoire

Population parameters	Values
Asymptotic length (L∞)in cm	31.5
Growth coefficient, K ($year^{-1}$)	0.500
Natural mortality, M ($year^{-1}$)	0.94
Fishing mortality, F ($year^{-1}$)	0.38
Total mortality, Z ($year^{-1}$)	1.32
Exploitation level (E)	0.29
Length range (cm)	10-29.7
Weight range (g)	197-2900
Sample number (N)	1200

Table 2: Parameters of von Bertalanffy growth function of *S.officinalis* from different countries

Location	Species	*L∞* (cm)	*K* ($year^{-1}$)	(*φ'*)	*T* (°C)	Source
Ivory Coast	*S. officinalis*	31.5	0.500	2.69	20.1	Present study
Manche	*S. officinalis*♀	29.5	1.27	-	-	[24]
Manche	*S. officinalis*♂	31.5	1.23	-	-	[24]
India	*S. pharaonis*	31.9	0.92	3		[27]
Gulf of Aden	*S. pharaonis*	40	1.00	3.2	-	[25]

Length–weight relationship

The length of individuals ranged from 10.0 to 29.7cm and the weight from 197 to 2900 g. The length–weight relationship curve is presented in Fig.4. The calculated length–weight equation in exponential form the equation is W= 0.203$LD^{2.77}$ (r^2 = 0.97; P < 0.01).The computed growth coefficient (b) was 2.77.

The growth coefficient b generally lies between 2.5 and 3.5 and the relation is said to be isometric when it is equal to 3 [28]. At the present study, estimated b (2.77) lies between the values mentioned by [28] and significantly smaller then isometric value (3) at 5% level. Table 3 summarizes previously published values of the coefficients "a" and "b" for *Sepia*. The values of "b" show variation, ranging from 2.561[29] to 2.78 [30].The exponent "b" of the size–weight relationship in *Sepia officinalis* is generally different from 3 as shown in Table 3. Negative allometric relationships, where growth in length is significantly higher than a corresponding increase in weight; have been described in many cuttlefish species [31, 32].

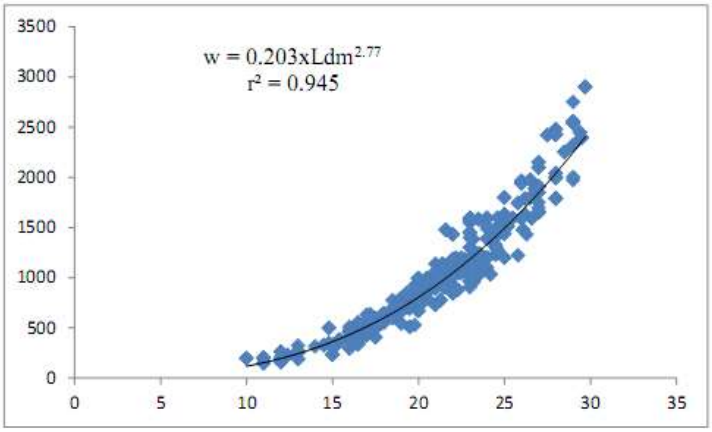

Fig-4: Length–weight relationship of *S.officinalis* from Côte d'Ivoire

Table 3: Previously published values of the coefficients "*a*" and "*b*" for *Sepia* from various locations

Location	species	a	b	Length units	Source
Ivory Coast	*S. officinalis*	0.203	2.77	cm	Present study
Senegal	*S. officinalis*(♀)	0.26	2.75	cm	[2]
English Channel	*S. officinalis*	0.243	2.78	cm	[29]
Spain	*S. officinalis*	0.264	2.70	cm	[33]
Manche	*S. officinalis*	0,0011	2.561	cm	[28]
Manche	*S. officinalis*	$5.62E^{-4}$	2.67	cm	[34]
golfe de gascogne	*S. officinalis*	0,261	2.703	cm	[35]

Mortality and exploitation

Length converted catch curve analysis produce total mortality estimates value of Z = 1.32 year^{-1} for the common cuttlefish *S.officinalis* (Fig. 5). Natural mortality (M) was 0.94 year^{-1} and fishing mortality (F) was 0.38 year^{-1} for the species (Table 1). Exploitation level (E) of *S. officinalis* in the coastal water of Côte d'Ivoire was 0.29 (Table 1).

Higher natural mortality (0.94 year^{-1}) observed than fishing mortality (0.38 year^{-1}) of *S. officinalis* seen in the present study indicates the unbalanced position in the stock. The lower value of E (E = 0.29) indicates the 'under-fishing' condition of *S. officinalis* in the study area. According to [21], the yield is optimized when F =M; therefore, when E is more than 0.5, the stock is over-fished.

Recruitment pattern

The recruitment pattern of *S. officinalis* was continuous throughout the year and the only major peak observed was during July–August (Fig. 6). The peak pulse produced 28.54% of the observed recruitment during the study period.

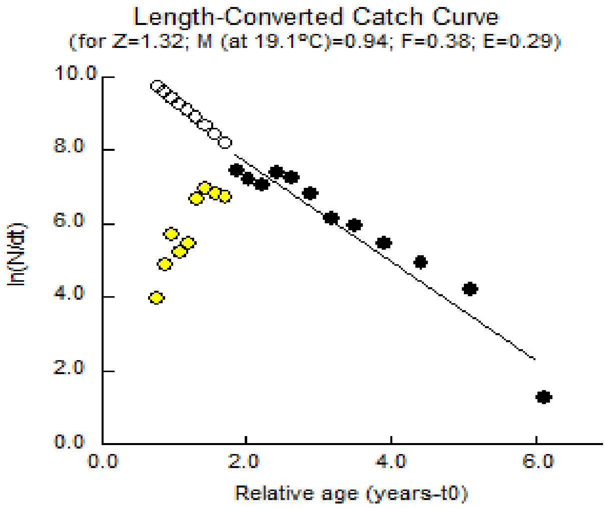

Fig-5: Length converted catch curve of *Sepia officinalis* in Côte d'Ivoire

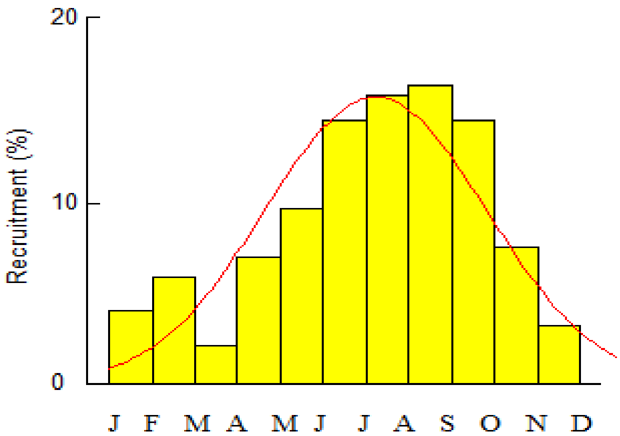

Fig-6: Recruitment pattern of *S. officinalis* from Ivorian coastal water

CONCLUSION

From the present study, it could be concluded that the stock of the common cuttlefish *Sepia officinalis* shows the potential for exploitation in coastal water of Côte d'Ivoire. Recruitment is continuous throughout the year and is marked by a large peak in July-August. According to the Length converted catch curve analysis, the stock of this species is under exploited. More exploitation is possible and could be an option for the livelihood of the coastal communities of the area.

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