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Fecundity of Some Commercially Important Demersal Fish Species in Ghanaian Coastal Waters, West Africa

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Abstract: The study highlights the importance of fecundity in estimating the reproductive potential of some key fishes encountered within the Ghanaian coastal waters and its usefulness in sustainable fishery management. A total of 600 female fish specimen including *Dentex congoensis*, *Dentex angolensis*, *Pagellus bellottii*, *Pagrus caeruleostictus*, *Decapterus puntactus*, *Caranx crysos*, *Trachurus trecae* and *Decapterus rhonchus* were assessed. The respective gonads were obtained by sampling the local catches at six coastal fish landing sites in Ghana between from March 2016 to February 2017. Obtained samples were measured for standard lengths with the eggs from the anterior, middle and posterior regions of respective ovaries (stages III & IV) weighed for the estimation of absolute and relative fecundity. Estimated absolute fecundity ranged from 0.4×10^6 ova for *Trachurus trecae* of 3.03×10^6 ova for *Dentex angolensis*. Further, computed relative fecundity ranged from 151.45 (*Pagrus caeruleostictus*) to 500.05 (*Decapterus puntactus*). Additionally, the length-fecundity relationship as well as the weight-fecundity relationship portrayed a positive relationship which indicates that large sized and big fish species produce more eggs than the small-sized fishes. Implicatively, continuous harvesting of large-sized fishes in the absence of appropriate management measures may result in reduced recruitment. Thus, implementation of management measures such as mesh size regulation as well as stringent adherence to minimum legal landing size of key commercial fishes in Ghana's coastal fishing operations are urgently backed.

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INTRODUCTION

Fish fecundity is an integral component of the biology of fishery that directly impacts the stock recruitment, fish production and the management of the stock in general. Fecundity in itself is generally described as the number of mature oocytes (ripening eggs) found in the female just prior to or during spawning

(DeMartini and Sikkel, 2006; Ganias *et al*., 2014). In addition to its importance to the biology and reproductive capacity of the of the females, fecundity data and its relation with other morphological characters such as size, length and weight gives an indication on factors affecting the population size (Gomez-Marquez, 2003). Ideally, fecundity increases with increase in size of fish (Bagenal, 1978) hence data on fecundity can be used to understand fish survival, specific races, population or stocks and hatchery estimations (Lasker, 1985). The fecundity and its relation to female size make it possible to estimate the potential of egg output (Chondar, 1977) and the potential number of offspring in a season and reproductive capacity of fish stocks (Qasim and Qayyum, 1963).

In general the fecundity aspect of reproduction is deeply associated with the studies of population dynamics and fishery management practices. The study of the reproductive biology of the fishes is one key estimator of the reproductive potentials of the stock with an eye on maximizing catch sustainably. Over the years, few researchers have studied the fecundity of some fishes in Ghana. Studied on the fecundity of a clupeid at Cape Coast, Mireku *et al.* (2016) on the reproductive biology of *Serotherodon melanotheron* and Abobi *et al.* (2014) on African carp, *Labeo senegalensis* in the White Volta. However attempts at estimating the fecundity of different fish species across the coast of Ghana has not been documented in the recent past. This scarcity of marine fish fecundity data has been global concern (Tomkiewicz *et al*., 2003). This study is an attempt in bridging the information gap in fecundity of commercially important marine fish stocks especially in West Africa.

MATERIALS AND METHODS

Study area: Ghana lies between latitudes 4° and 2°N and longitudes 4°W and 2°E and has a coastline that stretches 560 km (350 miles) on the Gulf of Guinea. The coastline stretches from Half Assini in the western region down to Denu in the Volta region (Fig. 1). However, the study focused on six fish landing sampling sites, Keta (Volta region), Apam, Elmina (Central region), Sekondi and Half Assini (Western region) and Tema in the Greater Accra region (Fig. 1).

Sampling: The fish species which formed the basis of this study were purchased from fisher folks who used multifilament fishing gears at six coastal fish landing sites across the coast of Ghana. The period of sampling frequency was monthly for one year (March, 2016 to February, 2017) on the following species: *Dentex congoensis*, *Dentex angolensis*, *Pagellus bellottii*, *Decapterus puntactus*, *Pagrus caeruleostictus*, *Caranx crysos*, *Trachurus trecae* and *Decapterus rhonchus*. After purchase, the samples were immediately preserved in iced chest and transported to the laboratory at the Marine and Fisheries Sciences Department, University of Ghana for analysis. At the laboratory, Total Length (TL) and Standard Lengths (SL) were measured to the nearest 0.1 cm using 100 cm graduated wooden measuring board. Body Weight (BW) was taken using electronic digital balance with 0.01 g accuracy. The whole ovary was removed from each female fish (with maturity stages III & IV). Samples were identified to the species level using the identification keys by Kwei and Ofori-Adu (2005). However, maturity stages were assessed using

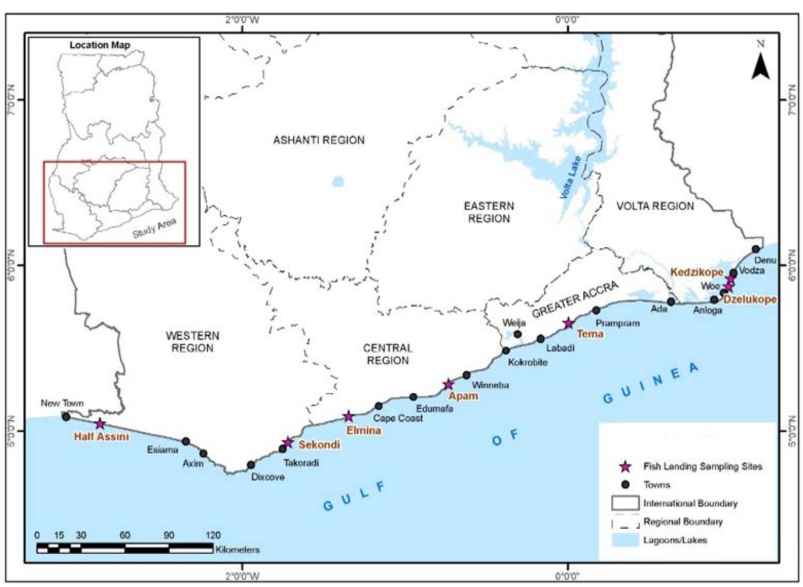

Fig. 1: Map of Ghana showing the sampling sites

identification keys by McDonough *et al.* (2005). In all, a total of 599 mature female ovaries were collected with the following distribution: *Pagrus caeruleostictus* and *Trachurus trecae* (31), *Dentex angolensis* (85, *Dentex congoensis* (127), *Decapterus puntactus* (182), *Pagellus bellottii* (122), *Caranx crysos* (10) and *Decapterus rhonchus* (11).

Laboratory analysis: All the fish samples were dissected and ripe ovaries (stages III & IV) were collected and preserved in Gilson's fluid. The ovaries were then shaken vigorously until the eggs were freed from the ovarian tissues, where necessary lumps of ovary tissues were manually teased apart by hand. A filter paper in a funnel was used sieve out the eggs from the fluid and then left to air dry during which time they turn from creamy white to translucent golden yellow and becomes hard. Fecundity was estimated by counting the number of mature ova from a known weight of mature/ripe ovary (Murua *et al*., 2003). The eggs were weighed and three known subsamples were obtained from the anterior, middle and posterior regions of both the ovaries following James *et al*. (1978). The subsamples were spread evenly on a Petri dish with a few drops of water and the number of mature ova was counted using a colony counter and average number of three portions was used to determine the fecundity by the following equation:

Absolute fecundity: Absolute fecundity was estimated following the expression (Murua *et al*., 2003):

$$\frac{\text{Total ovary weight}}{\text{Weight of subsample} \times \text{No. of ova in the subsample}}$$

Relative fecundity: Relative fecundity was computed as the ratio of absolute fecundity to the total weight of fish. (Murua *et al*., 2003).

Fecundity-length/weight relationship: Fecundity-length relationship as well as the Fecundity-weight were estimated as per the formula given by Bagenal (1978): $F = a\ SL^b$; $F = a\ TW^b$ where a and b are constants, L is the standard length (cm), F is fecundity and TW is body weight (g).

Data analysis: Lengths, body weights and fecundity values were log transformed before plotting for the relationship between them. Relationship between body weight and absolute fecundity for the assessed fish species was subjected to statistical regression analysis. Significant difference using student t or z test was estimated at p value of 0.05 with 95 % confidence interval. Graphs and tables were generated using Excel Statistical tool Pac.

RESULTS AND DISCUSSION

Length and weight distribution: *Decapterus puntactus* and *Caranx crysos* recorded the lowest and highest figures in terms of both mean standard length and mean body weight, respectively. The former recorded the least mean standard length and body weight of 11.08 cm and 26.76 g, respectively while the latter recorded the highest mean standard length and body weight of 31.28 cm and 568.8 4 g (Table 1).

Length and absolute fecundity relationship: The relationships between Absolute Fecundity and lengths for the respective fish species are shown in Table 2. The highest mean Absolute Fecundity was 3.03×10^6 eggs with corresponding mean standard length and total weight of 17.66 cm and 197.02 g, respectively recorded for *Dentex angolensis* while the least was recorded by *Trachurus trecae at* 0.43×10^6 eggs (Table 2) with mean standard length of 13.44 and total weight of 40.97 g. The relationships are found to be linear and were expressed by their respective equations. Their r^2 were all found to be significant at the respective p values (Table 3).

Analysis of regression showed *C. crysos* had the highest positive correlation with an $r^2 = 0.418$ while *D. angolensis* exhibited the lowest with $r^2 = 0.00$. Overall, all the assessed fish species showed a positive relationship between length and corresponding absolute fecundity (Table 3).

Body weight and absolute fecundity relationships: The relationships between Absolute Fecundity and total body weights are shown in Table 4 the relationship indicate a linear one with positive correlations recorded for all the species at the respective p values (Table 4). Analysis of regression showed *D. rhonchus* had the highest positive correlation with an $r^2 = 0.405$ while *D. angolensis* exhibited the lowest with $r^2 = 0.0061$.

The srudy shows the mean relative fecundity by species with *Decapterus puntactus* recording a better egg per gram body weight value of 500.05 g/body weight (g) compared to *Caranx crysos* (333.32) with *Pagrus caeruleostictus* recording the least 151.45 g/body weight (g).

The mean monthly absolute fecundity by species is shown in Fig. 2. Mean AF fluctuated across the months with most of all species sampled recording high peaks between May to July while some few others around October. The months of August and January recorded the least Absolute Fecundity.

The Absolute Fecundity varied significantly between the species and also the months. The Sparids *Dentex angolensis* and *D. congoensis* had the highest fecundity with 3.033675×10^6 and 2.788218×10^{6} ova, respectively while the Carangid *Trachurus tracae* recording the least

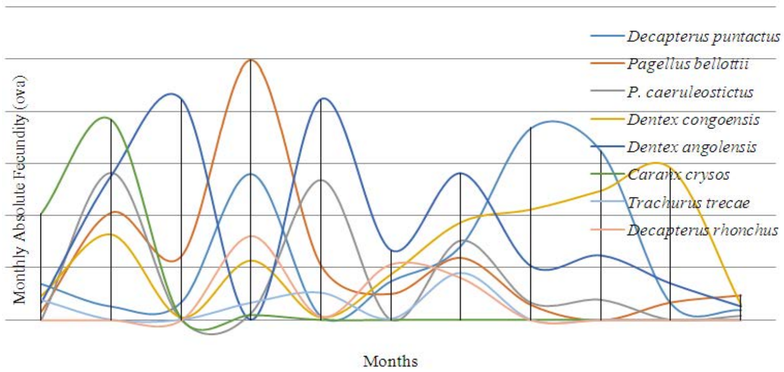

Fig. 2: Monthly variation in Absolute Fecundity for the selected species

Table 1: Mean Length and weight measurements for all species

Species	No. sampled	Mean standard length (cm)	Range	Mean total body weight (g)	Range
Decapterus puntactus	182	11.08 ±2.30	8.4-19.3	26.76 ±16.99	9.5-90.15
Pagellus bellottii	122	16.40 ±2.32	12.6-28.2	139.82 ±67.56	56.36-563.63
Pagrus caeruleostictus	31	20.75 ±3.27	15.0-27.4	341.18 ±151.07	96.2-594.95
Dentex congoensis	127	14.39 ±1.68	10.5-19.6	92.56 ±36.18	32.8 - 227.11
Dentex angolensis	85	17.66 ±2.35	12.2-22.2	197.02 ±85.86	57.9-544.0
Caranx crysos	10	31.28 ±5.88	23.6-40.6	568.84 ±321.17	34.6 - 1285.54
Decapterus rhonchus	11	27.61 ±2.73	22.15-30.0	425.59 ±104.46	271.65-511.6
Trachurus trecae	31	13.44 ±1.34	11.0-15.8	40.97 ±16.59	18.2-81.1

Table 2: Mean absolute and relative fecundity for all species

Species	No. of sampled	Total absolute fecundity (ova)	Mean absolute fecundity (ova)	Range	Mean relative fecundity (ova)
Decapterus puntactus	182	2435826 ±12335.1	13383.66	673.33-64093.33	500.05
Pagellus bellottii	122	2758792 ±37050.3	22613.05	1261.0-45942.96	161.73
Pagrus caeruleostictus	31	1601814 ±57111.7	51671.42	3608.73-263477.5	151.45
Dentex congoensis	127	2788218 ±34005.6	21954.47	952.89-232744.67	237.18
Dentex angolensis	85	3033675 ±33239.57	35690.3	4154.38-174592.8	181.15
Caranx crysos	10	1896065 ±321.2	189606.5	18904.44-388733.3	333.32
Decapterus rhonchus	11	2162848 ±187136.6	196622.5	2808.0-521324.1	461.99
Trachurus trecae	31	432823.1 ±13522.12	13962.04	700.0-50574.22	340.77

Table 3: Relationship between Length and Absolute fecundity

Species	Species No.	Equation	R^2	p-values (p<0/05)*
Decapterus puntactus	182	y = 2.1261x+1.6871	0.1558	p<0.01
Pagellus bellottii	122	y = 0.67x+3.303	0.009	p<0.04
Dentex angolensis	85	y = 0.0087x+4.3719	0.0000026	p<0.05
Caranx crysos	11	y = 4.661x-1.8737	0.4183	p<0.03
Ttachurus trecae	31	y = 4.861x-1.536	0.2141	p<0.02
Decapterus rhonchus	11	y = 6.5827x+4.569	0.1572	p<0.04
Pagrus caeruleostictus	31	y = 2.6676x+0.9609	0.1418	p<0.04
Dentex congoensis	127	y = 1.1598x+2.8393	0.0261	p<0.011

*Significant level

Table 4: Relationship between Body weight and Absolute fecundity

Species	Species No.	Equation	R^2	p-values (p< 0.05)
Decapterus puntactus	182	y = 0.6805x+3.0342	0.1244	p<0.04
Pagellus bellottii	122	y = 0.3289x+3.447	0.0198	p<0.03
Dentex angolensis	85	y = 0.1657x+4.009	0.0061	p<0.013
Caranx crysos	11	y = 1.6637x+0.3847	0.1117	p<0.01
Trachurus trecae	31	y = 1.1216x +2.1668	0.1739	p<0.04
Decapterus rhonchus	11	y = 4.0105x-5.5832	0.4047	p<0.03
Pagrus caeruleostictus	31	y = 0.8318x+2.4021	0.1875	p<0.03
Dentex congoensis	127	y = 0.7309x+2.7617	0.0915	p<0.002

*Significant level

fecundity with 0.432823×10^6 ova. *Caranx crysos*, though having the fourth highest AF could be regarded as the most fecund. The variations in fecundity observed was is in line with Khallaf and Authman (1991) who opined that fecundity is not a constant feature but fluctuates with variations in environmental conditions and species specific factors. Murua *et al*. (2003); Mekkawy and Hassan (2012), also submitted that different fish species reflect marked differences in their reproductive patterns and exhibit different reproductive potentials in terms of fecundity. The mean RF ranged from 151.45 ova g^{-1} of body weight in *Pagrus caeruleostictus* to 500.05 ova g^{-1} body weight in *Decapterus puntactus*.

The result of the length and body weight and AF show a generally linear and positive association at varying p values. In terms of length, *Caranx crysos* recorded the strongest association with fecundity (r^2 = 0.42) while *Dentex angolensis* recorded the least (r^2 = 0.0000026). In the association between body weight and fecundity, *Decapterus rhonchus* had the strongest association with r^2 = 0.405 and *Dentex angolensis* with the weakest positive association (r^2 = 0.0061). These positive relationships are in line with the findings of several researchers who reported a straight line relationship between fish length and weight with fecundity. Sikoki and Anyanwu (2003) all reported positive relationships between total fecundity in a number of fishes.

All coefficients (b) estimated during this study, with the exception of *Decapterus rhonchus* were within the expected range of 2.5-3.5 and 2.0-4.0 (LeCren, 2006) who posited that generally, despite the many variations in fish forms among species, when b is close to 3, its indicative that fish grow isometrically. The monthly variation in AF among the species could be indicative of the different peak spawning; most of the species sampled demonstrated an increasing AF trend with peaks cutting across the months of June through October. An exception to this trend was demonstrated by *Dentex congoensis* which recorded its highest peak in December.

The months of June and July appears to be peak months of high Gonadosomatic index and absolute fecundity in most of the fish species. This could be attributed, to a large extent on the availability of food materials brought about by the upwelling season spanning from June to October. From the management perspective the information on the fecundity peak months by species and those of the Gonado Somatic Index can be used in establishing closing seasons to allow for the respective species to spawn before being exploited.

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