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VARIATION IN THE INTESTINAL MORPHOLOGY AND BIOMETRIC CHARACTERISTICS OF SARDINELLA AURITA AND SARDINELLA MADERENSIS AT JAMES TOWN IN GHANA

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ABSTRACT

This study investigated the biology of *Sardinella aurita* (flat Sardinella) and *S. maderensis* (round Sardinella) at James Town in Ghana. A total of 40 round and flat Sardinella samples each were evaluated each month. The results showed significant difference between round and flat Sardinella with respect to intestinal weight (p=0.020), liver weight (p=0.002) and body weight (p=0.005). Intestinal weight of the round and flat Sardinella ranged from 86.5-113 g and 79-92 g respectively. Intestinal weight of round Sardinella was significantly higher than the flat Sardinella. Liver weight of flat Sardinella was significantly lower than the liver weight of round Sardinella. Mean intestinal content of round and flat Sardinella were 46.1±16.30 and 9.65±0.33 respectively. Relative gut mass for round Sardinella ranged between 0.022 and 0.120 whilst that of flat Sardinella ranged between 0.020 and 0.933. Relative gut length was similar for flat and round Sardinella. Mean Zhilers Index for flat and round Sardinella were 0.0752±0.004 and 0.091±0.005 respectively. Mean gonadosomatic index, Hepatosomatic index and Relative content mass recorded for flat Sardinella were 5.735±0.495, 0.346±0.034 and 0.006±0.000 respectively. This work recommend further study comparing catches from artisanal and semi-industrial vessels to obtain a broader knowledge of the growth and maturation of the species.

Key words: Relative gut length, Zhilers index, intestinal content, body weight, liver weight

Introduction

Sardinella belongs to the Clupeidae family (herrings and sardines). The family currently consist of 21 perceived species (Froese & Pauly, 2011). Sardinella are characterized by their explicit body and size reaches but are frequently mistaken for each other (Whitehead, 1985). The marine pelagic fish species *Sardinella spp.* are widely dispersed throughout the world's tropical and subtropical seas (Baali *et al*., 2020). Millions of people living along the coast in Ghana depend on the S*ardinella* fishery for their food and economic stability (Arizi *et al*., 2022). That is, *Sardinella* is crucial to the livelihoods and survival of many Ghanaian fishermen and the households who depend on them (Bailey *et al*., 2010). The round Sardinella (*Sardinella aurita*) and flat Sardinella (*Sardinella maderensis*), which are fished for commercial purposes throughout the whole Gulf of Guinea, are Ghana's most significant fisheries resources (F.A.O., 2016; Neokye *et*

al., 2021). Also, they play an important role of balancing the marine ecosystem. More than 40% of all domestic marine fish contribution comes from Sardinella (Amponsah *et al*., 2019). That makes *S. aurita* and *S. maderensis* essential economic species and updating of applicable biological information of this genus is necessary. Despite the importance of *Sardinella spp.,* their biomass over the past years have been fluctuating (Baali *et al*.,2017; Baali *et al*., 2020) hence the need to conduct studies to generate adequate data for their management on sustainable basis.

Ingestion, digestion and absorption of food can be understood using the morphology of the digestive tract and have recently been carried out for several species (Germano *et al*. 2013, Løkka *et al*. 2013; Dos Santos *et al*., 2015). Relative gut length as well as digestive somatic index could provide vital information in determining feeding type (Mazumder *et al*., 2018). In the context of *Sardinella* along the coast of Ghana, the relationship between intestinal morphology and biometric characteristics has not been studied extensively. The purpose of this study is therefore to provide basic information on the biology of flat and round Sardinella by examining the variations in intestinal morphology of the two species as well as analyze the length weight relationship between flat and round Sardinella.

This research add significant information to the Sardinella population in the Ghanaian coastal waters. This knowledge will also help fisheries managers to implement regulatory measures for this species to be exploited. Furthermore, the study will provide information that will help educate fishermen on the correct fishing methods to be used not only to increase capture but also to ensure the species' survival.

Experimentation

Study area

The research was carried out at James located in the Greater Accra Region of Ghana. James Town, a Ga-Mashie area that is the Metropolitan Assembly's oldest district immediately east of the Korle Lagoon. James Town lies between coordinates 5.5341° N and 0.2139° W.

Data collection

Data was collected for six months, from January 2020 to June 2020. Fish samples were taken from local commercial fishers at landing sites in James town in Ghana. In all, a total of 40 round and flat Sardinella samples each were evaluated each month. The length of Sardinella were measured in centimetre (cm) to the nearest 0.01cm using a fish measuring board whilst the weight was measured to the nearest 0.01 g using CAS electronic balance. Briefly, the whole digestive tract was removed on ice, rinsed with cold Tris-HCl buffer (0.01 M, pH 7, SIGMA-ALDRICH, France), exterior fat was removed, weighed and measured (Hani *et al*., 2018).

Data analysis

The following parameters were estimated using standard formulae;

Fulton's condition factor (K) = $\frac{w}{L^3}$ where; W= fish body weight in grams (g), L= fish length in centimeters (cm).

Zihlers index (ZI) $\frac{gut\ length\ (mm)}{(10 \times body\ weight)^{\frac{1}{3}}}$

(Zihler *et al*., 1981)

Gut parameters were calculated according to German and Horn, 2006 as follows

Relative gut length (RGL) = $\frac{Gut\ length\ (mm)}{Body\ length\ (mm)}$

Relative gut mass (RGM) = $\frac{Gut\ weight\ (g)}{Body\ weight\ (g)}$

Relative gut content mass

= $\frac{Weight\ of\ intestinal\ content\ (g)}{Body\ weight\ (g)}$

Results and discussion

Table 1 shows the biometric characteristics of *S. aurita* and *S. maderensis* studied over a six-month period.

TABLE 1

Biometric characteristic of round and flat Sardinella in James Town

Biometric characteristics	Fish	Range	Mean ± S.E.	p-value
Body length (cm)	Round	426.1 – 456.3	440.55± 4.97	0.936
	Flat	424.4 – 450.7	439.2 ±4.27	
Intestinal weight (g)	Round	86.5 – 113	99.75± 3.77	**0.020**
	Flat	79 – 92	86.17±2.45	
Intestinal length (cm)	Round	99.4 – 441.1	373.33±54.96	0.226
	Flat	429.0 – 469.5	444.72±6.62	
Intestinal content (g)	Round	9.4 – 99.4	46.1 ± 16.30	0.065
	Flat	8.4 – 11	9.65±0.33	
Liver weight (g)	Round	12.6 – 26.6	21.58± 2.27	**0.002**
	Flat	5.9 – 8.4	6.91±0.45	
Gonad (g)	Round	69.5 – 103	81.58± 5.60	0.810
	Flat	58.7 – 98.8	77.5±6.67	
Body weight (g)	Round	1432 – 1655	1547± 33.40	**0.005**
	Flat	1667 – 1780	1739±20.60	

Intestinal weight

There was a significant difference between round and flat Sardinella with respect to intestinal weight (P< 0.05). Intestinal weight of the round Sardinella ranged from 86.5-113g with a mean of 99.75±3.77g whilst intestinal weight of flat Sardinella ranged from 79-92g with a mean of 86.17±2.45g.

Liver weight

Liver weight of flat Sardinella was significantly lower than the liver weight of round Sardinella (P=0.002). Whereas flat Sardinella recorded liver weight ranging between 5.9-8.4 g with a mean of 6.91±0.45g, round Sardinella recorded a mean of 21.58±2.27g and ranged between 12 g and 26.6g.

Body weight

Body weight of round and flat Sardinella varied significantly (P=0.005). Mean body weight of round Sardinella (1547±33.40g) was significantly lower than mean body weight of flat Sardinella (1739±20.60g). Body weight of round Sardinella ranged between 1432g and 1655 g whilst that of flat sardine ranged between 1667g and 1780g.

Body length

There was no significant differencec in body length (P>0.05). Mean body length of round and flat Sardinella was 440.55±4.97 cm and 439.2±4.27 cm respectively. The body length of round Sardinella ranged from 426.1- 456.3 cm with flat Sardinella ranging from 424.6-450.7cm

Intestinal length

Intestinal length of round and flat Sardinella ranged from 99.4 to 441.1cm and 429.0 to 469.5cm respectively. The mean length was 373.33±54.96 cm and 444.72±6.62 cm for round and flat Sardinella respectively.

Intestinal content

The mean intestinal content of round and flat Sardinella were 46.1±16.30 g and 9.65±0.33 g respectively. Round and flat Sardinella recorded content ranging from 9.4 to 99.4 g and 8.4 to 11 g respectively.

Gonad weight

There was no significant difference in the size of gonad of round and flat Sardinella in the study area during the sampling period. Size of gonad recorded for round Sardinella ranged from 69.5 g to 103 g whilst that of flat Sardinella ranged from 58.7 to 98.8 respectively. The mean gonad sizes were 81.58±5.60 g and 77.5±6.67 g respectively.

TABLE 2

Biological parameters of flat and round Sardinella in James Town

RGM	K	RGL	ZI	RCM	GSI	HSI
			Flat Sardinella			
0.047±0.005	0.860±0.086	0.972±0.046	0.0752±0.004	0.006±0.000	5.735±0.493	0.346±0.034
			Round Sardinella			
0.070±0.007	0.831±0.086	1.044±0.050	0.091±0.005	0.055±0.006	6.500±0.671	1.237±0.051

RGM: Relative Gut Mass; K: Condition factor; RGL: Relative Gut Length; ZI: Zhilers index; RCM: Relative content mass; GSI: Gonadosomatic index; HSI: Hepatosomatic index

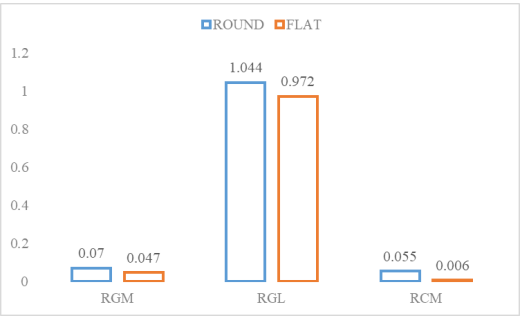

Fig 1: Relative Gut Mass (RGM:), Relative Gut Length (RGL) and Relative Content Mass (RCM) of round and flat Sardinella.

Relative Gut Mass (RGM)

The mean relative gut mass (RGM) recorded for flat Sardinella was 0.047±0.005 with round Sardinella recording a mean relative gut mass of 0.070±0.007. Relative gut mass for flat Sardinella ranged from 0.020 to 0.933 whilst RGM of round Sardinella ranged from 0.022 to 0.120 (Table 2, Fig 1).

Relative Gut Length (RGL)

Relative gut length (RGL) was similar for flat and round Sardinella. Mean RGL for flat and round Sardinella were 0.972±0.046 and 1.044±0.050 and ranged from 0.600 to 1.250 and 0.600 to 1.568 respectively (Table 2, Fig 1).

Relative Content Mass (RCM)

The mean relative content mass recorded in flat Sardinella was higher than that of round Sardinella. The mean RCM for flat and round Sardinella was 0.006 and 0.055 respectively. The Whereas RCM for flat Sardinella ranged

between 0.002 and 0.01, RCM for round Sardinella ranged between 0.026 and 0.10 (Table 2, Fig 1).

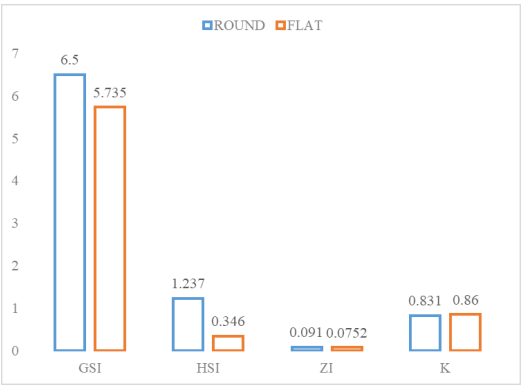

Fig. 2: Gonadosomatic index (GSI), Hepatosomatic index (HSI), Zhilers index (ZI) and Condition factor (K) of round and flat Sardinella.

Gonadosomatic index

Gonadosomatic index observed in flat Sardinella ranged between 2.15 and 9.41 whilst that of round Sardinella ranged between 5.73 and 12.15 whilst that of round Sardinella ranged between 3.15 and 12.00. The mean GSI for flat and round Sardinella was 5.73 and 6.50 respectively (Table 2, Fig 2).

Hepatosomatic index

Hepatosomatic index in flat Sardinella ranged between 0.11 and 6.92 whilst that of round Sardinella ranged between 0.13 and 8.88. The mean HSI for flat and round Sardinella was 0.34 and 1.23 respectively (Table 2, Fig 2).

Zhilers index

Zhilers index (ZI) recorded for flat Sardinella was lower than that of round Sardinella even though it was not significantly different. Mean ZI for flat Sardinella was 0.0752±0.004 with round Sardinella recording 0.091±0.005. The ranges of ZI for flat and round Sardinella were 0.049 to 0.112 and 0.059 to 0.144 respectively (Table 2, Fig 2).

Condition factor

Condition factor (K) ranged from 0.352 to 1.779 and 0.364 to 1.934 for flat and round Sardinella respectively. The mean condition for flat and round Sardinella was 0.860±0.086 and 0.831±0.086 respectively (Table 2, Fig 2).

Discussion

The present study shows there is a significant difference between *S. maderensis* and *S. aurita* with respect to intestinal weight, liver weight and body weight. Internal morphology (such as stomach shape, gut size and its length, etc.) give important clues about feeding ecology of fish (Karachle and Stergiou, 2010a). Also, the morphological examination of the digestive system is important for improving fish management and conservation (Wilson & Castro, 2010; Matheus *et al*., 2021).

Mean body length and body weight were not significantly different. This could be attributed to availability of nutrients and plankton density as well as fish with no distinction in terms of feeding capabilities. Gut length is an important morphometric character of the digestive tract relating to diet in fishes (Horn *et al*. 2005) and provides important information on species' feeding habits in fishes (Kramer and Bryant 1995). Additionally, the functional morphology of fish digestive tracts can be roughly predicted by intestinal length when it is taken into account alone (Davis *et al*., 2013). Although gut length were not significantly different, the variation observed could be related to prey size, being larger in those that consume smaller animals (Peretti *et al*., 2008). The mean intestinal content of round and flat Sardinella were 46.1±16.30 and 9.65±0.33 respectively. The longer the

intestinal length, the lesser the animal prey in diets (Davis *et al*., 2013). Round and flat Sardinella recorded content ranging from 9.4 to 99.4 and 8.4 to 11 respectively. There was no significant relation in the size of gonad of round and flat Sardinella. Size of gonad recorded for round Sardinella ranged from 69.5 to 103 whilst that of flat Sardinella ranged from 58.7 to 98.8 respectively. The size of the gonad is an indicator of the reproductive process The values of gonad weight obtained in this study was comparatively higher than the gonad weight (0.6 to 3.2g with average of 1.27 g) of *Sardinella longiceps* studied by Musallam *et al*. (2006). The Gonadosomatic index is useful for determining spawning days and seasons (Wagle, 2014). The GSI observed in this study for flat and round Sardinella were comparable to that of *Sardinella sindensis* (day, 1878) as reported by Hashmi *et al*., (2013). Relative gut mass which is an indicator of the feeding condition of fish is also known as digestive somatic index (Lloret & Planes, 2003). Relative gut mass is used to assess the tissue quantity as well as the amount of tissue dedicated by fish to their digestive tract (German & Horn, 2006). RGM of round Sardinella was higher than that of flat Sardinella which imply an increase in the gut size of round Sardinella to maximize nutrient extraction and energy from their diet and for maximum growth (Hani *et al*., 2018). This is a mechanism employed by animals to increase energy intake from food (Karasov & Douglas, 2013).

Relative gut length (RGL) and Zihler's index are two indices used to evaluate the dietary strategy of fish (Zihler, 1981). In addition, these parameters can be used to classify fishes into herbivorous, omnivorous and carnivorous (Pujante *et al*., 2017). RGL is also a rough measurement used as possible indicators to determine fish feeding habits based on their gut length (Hani *et al*., 2018). RGL was similar for flat and round Sardinella. The feeding habit of fishes could be predicted by their relative gut length. For instance, carnivorous fishes have RGL value smaller than 1 whilst that of omnivorous and herbivorous fishes have relative gut length between 1 and 3 and bigger than 3 respectively (Karachle & Stergiou, 2010a). The mean RGL for both flat and round Sardinella confirm they are carnivorous fish. This is confirmed by the feeding guilds as reported by Al-Hussaini (1947; 1949) who reported carnivorous fishes to have RGL ranging between 0.6-2.4. Zhilers index (ZI) recorded for flat Sardinella was lower than that of round Sardinella even though it was not significantly different. Mean ZI for flat Sardinella was 0.0752±0.004 with round Sardinella recording 0.091±0.005. The ranges of ZI for flat and round Sardinella were 0.049 to 0.112 and 0.059 to 0.144 respectively.

Knowledge on the general health condition of a fish can be known through HSI (Dambo *et al*., 2021). HSI indicates that this fish probably stores its energetic reserves in liver during the gonadal maturation period (Kouame, 2016). Liver weight of flat Sardinella was significantly lower than the liver weight of round Sardinella. Similarly, HSI of flat Sardinella was significantly lower than that of round Sardinella. This could imply, round Sardinella had access to increased levels of nutrients compared to flat Sardinella.

It was observed that Gonadosomatic index (GSI) of flat Sardinella was lower than that of round Sardinella. This could imply round Sardinella indicate had attained peak in spawning activity as at the time of sampling (Joson-Pagulayan *et al*., 2019).

The robustness of fish can be predicted using condition factor (K) as an indicator (Ahirwal *et al*., 2022b). The mean condition for flat and round Sardinella was 0.86±0.08 and 0.83±0.08 respectively. The K of fish is affected by sampling season, size composition as well as limited number of specimens (Froese, 2006). Age of fish, reproductive status and seasonality of natural diet are other factors that's influence K (Ahirwal *et al*., 2022a). Although no study was carried out on the physical and chemical parameters to confirm this, (Bagenal & Tesch, 1989) reported that if the condition factor (K) ≥ 0.05, the fish is in a good condition. The higher the K value, the better the state of well-being (Abobi & Ekau, 2013). The values of K observed in this study similar to that of Sardinella aurita reported by Baidoo *et al*. (2022). TThe majority of the most prevalent marine species' size ranges were smaller than their typically stated sizes (Baidoo *et al*., 2022). The low values of condition factor observed in this study could be ascribed to reduced food assimilation in the fish's bodies and a lack of food in the surroundings. Additionally, it might allude to the impact of the fish spawning cycle and the prevalence of fish people in the samples (Al-Ghanim, 2005; Al-Otaibi, 2022).

This study conclude that intestinal morphology and biometric characteristics of *S. aurita* and *S. maderensis* at James Town in Ghana to a large extent vary. A thorough understanding of the resources and current information on the characteristics of the aquatic resources along the Ghanaian coast are necessary for their protection and management. This study recommends fishermen to fish sustainably in other to improve capture because many of the species are large in size during the research. Further research should be undertaken comparing samples collected by both artisanal vessels and semi-industrial vessels to obtain a broader knowledge of the growth and maturation of the species.

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