Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 28(3): 383– 401 (2024)
www.ejabf.journals.ekb.eg

Some of the Biological Aspects of the Brushtooth Lizardfish *Saurida undosquamis* (Richardson, 1848) Collected from the Commercial Markets of Port Said Governorate, Egypt

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ARTICLE INFO
Article History:
Received: April 15, 2024
Accepted: May 9, 2024
Online: May 24, 2024

Keywords:
S. undosquami,
Biology,
Length- weight relationship

ABSTRACT

Saurida undosquamis is a globally dispersed species. It is a well-known commercial species belonging to the Synodontidae family from the Red Sea and Suez Gulf of Egypt. 200 samples were collected from commercial markets in Port-Said, Egypt. After species identification, the morphometric characteristics were estimated for each sample. The length-weight relationship and Fulton condition factor were also calculated. Moreover, after fish dissection, the internal organs were removed to measure the organosomatic indicators, and the fish gut length was measured to be compared with its total length. The contents of the stomach were classified to calculate the percentage of each type to detect the feeding habit of these fish. Finally, samples of the internal organs were prepared for the histological sections. The morphometric data revealed that *S. undosquami* had canines found in two rows. The total and standard-length averages were 24.94± 1.64 and 21.41± 0.34cm, respectively. The growth pattern of the examined fish is a negative allometric pattern. Both sexes were in good health, as the Fulton factor was more than one. The highest organ ratios were recorded for the hepatosomatic and gonadosomatic indices. The most abundant food content in the stomach was fish. The histological sections reflected the similarities between *S. undosquami* and the other teleosts recorded in the previous study. In conclusion, the biological knowledge about lizardfish in Port Said Governorate provided by this study helped to afford the required information to support the resource's utilization. There is a need for further investigations that link more between these different biological parameters concerning environmental conditions.

INTRODUCTION

In comparison with the rest of animal protein supplies, fish meals offer a significant and inexpensive source of protein, minerals, and vitamins. In developing nations, fish makes up more than 30% of the total animal protein consumed per capita **(Wang *et al*., 2015; Mahmoud & Al-Khshali, 2022)**.

In the Red Sea, *Saurida undosquamis* (brushtooth lizard fish) individuals are widely distributed. It is one of the essential and main commercial species belonging to the Synodontidae family from the Suez Gulf and the Red Sea of Egypt **(Abd-Elghany, 2017; Mehanna, 2022)**. It is a carnivorous fish that targets mainly crustaceans and planktonic invertebrates for feeding **(Kadharsha *et al*., 2013; Manojkumar & Pavithran, 2016; Ozyurt *et al*., 2017)**.

Weight-length relationships can provide an essential information about differences in multiple conditions and fitness in aquatic habitats and, altogether with other data, mortality in the growth and separation of unit stock **(Froese, 2006; Mehanna & Farouk, 2021)**. **El-Ganainy (1997)** reported that the maximum size of this fish species is approximately 50cm; nevertheless, landings often show a size range of 15 to 35cm.

Studying a fish species' biometry, including its morphometric traits and meristic measurements, is crucial since it aids in fish identification **(Zubia *et al*., 2015; Sartimbul *et al*., 2018)**. Accurate fish identification was a necessary prerequisite for studying the biology, fisheries, and distribution of the relevant species **(Muthaiah, 1996)**. Taxonomically speaking, morphometric and meristic factors are the main sources of information used to differentiate between species. These characteristics are frequently employed to distinguish between various morphotypes and to identify various stock units **(Jayasankar, 1989; Lourie *et al*., 1999, Doherty & McCarthy, 2004)**.

The gut length ratio or relative gut length can be used to compare different fish types based on food. The ratio of the fish's total length to the length of its intestine is known as the relative gut length **(Susilo *et al*., 2021)**. Organ mass to body weight is calculated using organosomatic indicators. Organosomatic indices have been utilized extensively in ecological and experimental investigations in conjunction with other body measurements **(Schlenk *et al*., 2008)**.

According to **Metcalfe *et al*. (1986)**, various types of food are essential to the processes that keep organisms functioning. There is evidence that vertebrates including certain fish species have well-conserved the feed consumption regulation, just like mammals do **(Volkoff, 2016; Delgado *et al*., 2017)**.

Consequently, the main objectives of the present study were to detect the biology of one of the most traded fish in Port Said markets, *S. undosquamis*. The biological investigations involved the external morphometric measurements and their relationships, and the internal organs descriptions. All these factors help in species identification and a better understanding of species evaluation and adaptation and hence fish industry.

MATERIALS AND METHODS

Ethics statement

The research animal care ethical committee of Port Said University's Faculty of Science verified all investigations performed according to protocol ERN: PSU. Sci.47.

Sampling area

S. undosquamis samples were collected from commercial markets in Port Said, Egypt. 200 samples were gathered and placed in ice boxes, and transported directly to the parasitology laboratory at the Faculty of Science, Port Said University, for further investigations.

Samples identification and data collection

Samples were identified according to the external general characteristics described by **Golani (1993)**. The morphometric characteristics were estimated for each sample (Fig. 1) as follows: total length (Tl), standard length (Sl), forked length (Fl), head length (Hl), body depth (Bd), snout length (Sl), eye diameter (ED), maxillary length (Maxl), mandible length (Manl), pre dorsal length (Pr-d), post dorsal length (Po-d), pre pectoral length (Pr-p), post pectoral length (Po-p), pre ventral length (Pr-v), and post ventral length (Po-v).

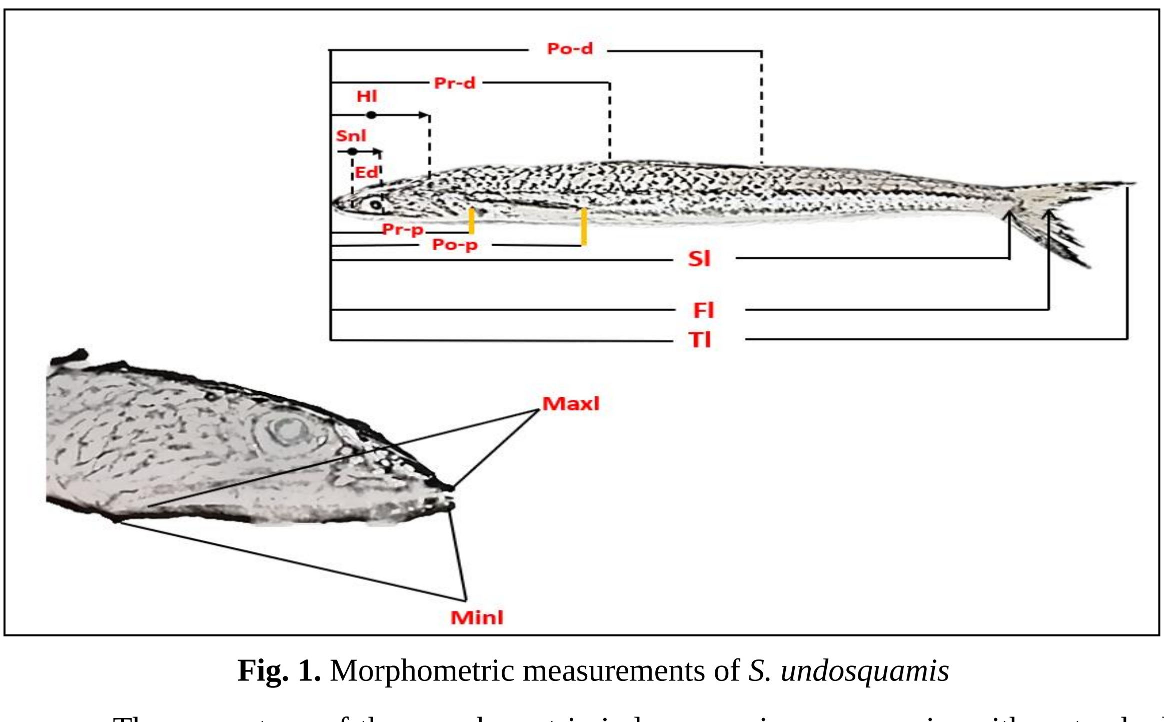

Fig. 1. Morphometric measurements of *S. undosquamis*

The percentage of the morphometric index was given concerning either standard or head length described by **Heneish and Rizkalla (2021)** as follows:

$$Index\ range\ 1 = \left(\frac{Morphometric\ Parameter\ (1)}{Standrd\ length}\right) \times 100$$

$$Index\ range\ 2 = \left(\frac{Morphometric\ Parameter(2)}{Head\ \ length}\right) \times 100$$

The morphometric parameters (1) included Hl, Bd, Pr-d, Po-d, Pr-p, Po-p, Pr-v, and Po-v, while another set of morphometric parameters (2) comprised Ed, Snl, Maxl, and Manl.

Length weight relationship

The total length (**L**) and weight (**W**) relations were used to gather data on the species' growth pattern. The parabolic equation was used to determine the statistical relationship between these fish parameters. It was converted into a logarithmic form to produce a regression equation and a straight line, which are as follows:

$$W = aL^{b}$$ **(Le-Cren, 1951)**

$$Log\ W = log\ a + b\ log\ L$$

Where, **W** represents the fish's weight in gram (g); **L** is its total length in centimeter (cm), and **b** is the regression line slope (the Allometric coefficient), as well as the exponent describing the rate of change of weight with length. The degree of association between TL and TW was determined using the determination coefficient (**r^2**). If the specific gravity of the function is constant, the fish grows symmetrically or isometrically when **b** = 3. If not, it is positive allometric for **b**> 3 and negative allometric for **b**< 3. Fish that grow isometrically develop a consistent body shape; positive allometric growth indicates a deeper body shape as length increases relative to weight; negative allometric growth indicates a more slenderized fish as weight increases relative to length **(Riedel *et al*., 2007)**.

The condition factor was calculated based on the sex of the samples. According to **Gupta *et al*. (2011)**, the condition factor "K" characterizes the fish's condition based on the following equation:

$$K = (BW \div TL^{3}) \times 100$$

Where, **BW** is the body weight (g); **TL** is the total length of the fish (cm), and **K** is the condition factor. The factor 100 is used to bring the value of **K** closer to the unit. Fish that had a condition factor of more than one (1) were categorized as high, whereas fish that had a condition factor lower than one (1) were categorized as low. Fish that are in better condition will have higher **K** levels than those that are not.

Organosomatic indicators

After fish dissection, the main organs (stomach, intestine, liver, spleen, kidney, and gonad) were removed from the body of each fish (Fig. 2). They were immersed in 0.9% NaCl to remove any attached blood debris. The organs were dried separately on clean filter paper and then weighed to the nearest 0.01g. The relation between each organ to the body weight was calculated according to the formula used by **Sokal and Rohlf (1969)**, with a minor modification as follows:

$$Or = (Ow \div Bw) \times 100$$

Where, **Or** refers to the organ ratio; **Ow** is the organ weight, and **Bw** is the total body weight of each fish.

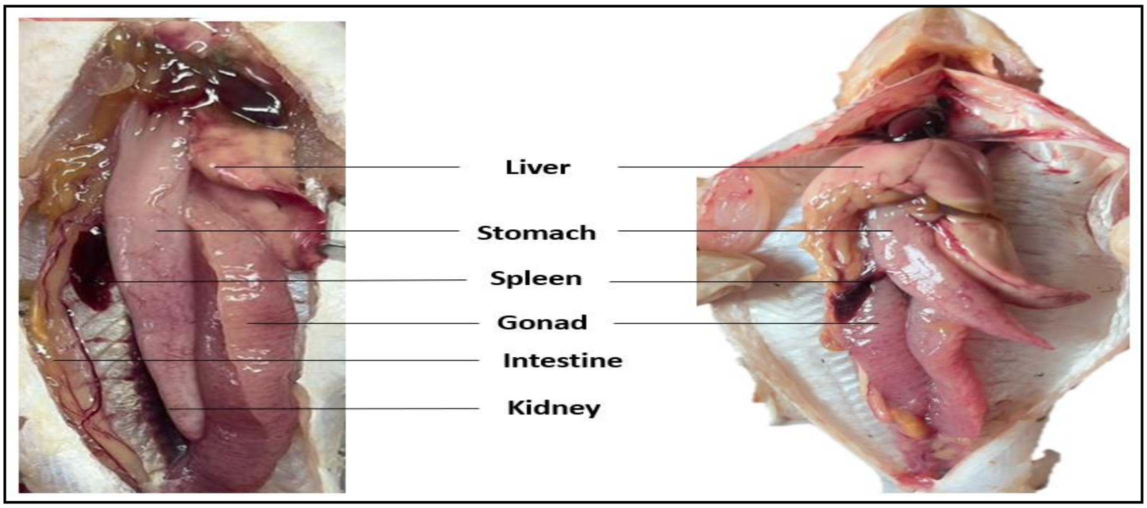

Fig. 2. Internal organs within the visceral cavity of *S. undosquamis*

Stomach and intestine analysis

The lengths of the stomach and intestine were measured first to compare them with the total body length. The contents of the stomach were isolated in a clean petri dish containing a considerable quantity of NaCl to facilitate the examination. The stomach contents were examined by the ocular eye at first and then microscopely. The dominance of each type was calculated according to the following:

$$D = (n \div N) \times 100$$ **(Hynes, 1950)**.

Where, **D** is the dominance of each type; **n** denotes the number of fish in which each type dominates, and **N** refers to the total number of examined fish.

Histological study

Samples of the stomach, liver, spleen, kidney, and gonads were removed directly after fish dissection, and they were then preserved in 10% buffered formalin. Samples were fixed, embedded in paraffin, and then cut into 4µm-thick blocks before being stained with hematoxylin and eosin **(Humason, 1979)**. To observe and record aspects of biological interest, prepared slides of the various organs were mounted and checked using an Optika Italy microscope paired with a Euromex CMEX camera.

Statistical analysis

Data were provided as mean ± standard error, or mean ±SE. Version 20 of the Statistic Programme Sigma Stat (SPSS) was used to analyze all the data. Student's *T*-test was used to detect the degree of significance. A statistically significant value was defined as $P < 0.05$.

RESULTS

The body shape of *S. undosquamis* is fusiform. It is brownish-grey dorsally and creamy-white ventrally with a complete lateral line (Fig. 3A). The head is small and pointed, and the mouth is terminal with two rows of canines. Generally, these canines vary in size, but the internal raw size is much larger than the external one (Fig. 3B). The dorsal fin has soft rays ranging between 11 and 12, and it is located almost in the middle of the dorsal side (Fig. 3C). The caudal fin is forked, while the ventral fin is characterized by being in the thoracic ventral position (Fig. 3D and 3E). The cloacal opening is immediately above the anal fin in a mid-ventral position (Fig. 3F).

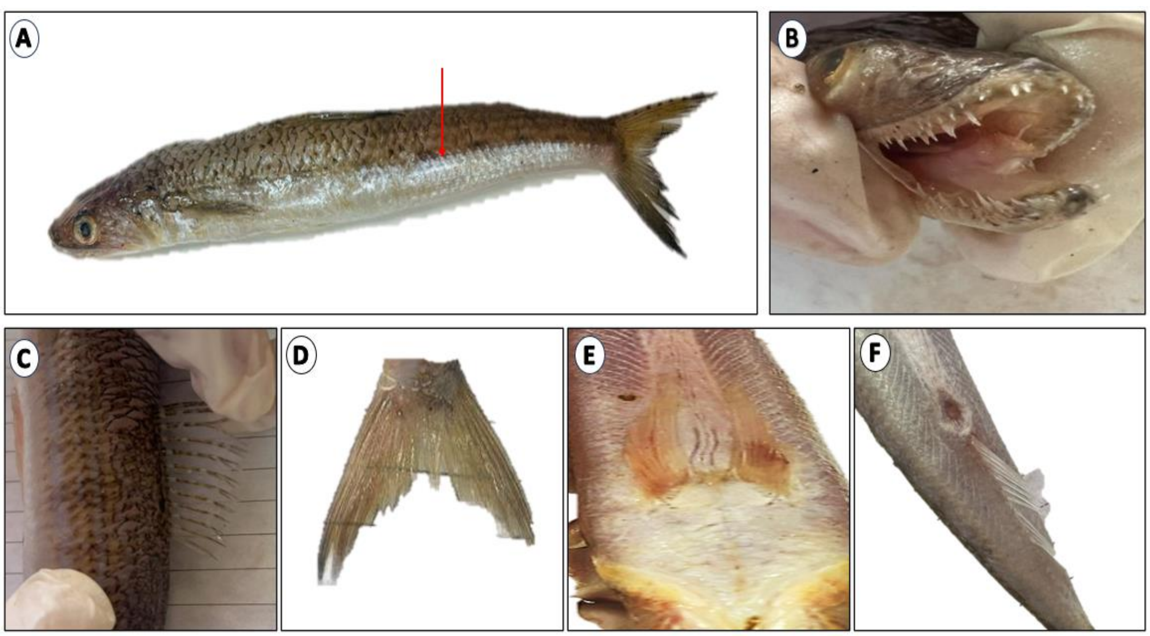

Fig. 3. The external morphology of *S. undosquamis.* **(A)** Lateral view, **(B)** Mouth position and type of teeth, **(C)** Dorsal fin, **(D)** Caudal fin, **(E)** Ventral fin, and **(F)** Anal fin and cloaca. Red arrow; complete lateral line

The total, standard and head length averages were 24.94± 1.64, 21.41± 0.34, and 4.89± 0.09cm, respectively. The different morphometric indices that used the standard and head lengths are shown in Table (1). The average of Minl/HL was 69.2± 3.03, while that of Max/HL was 47.05± 2.05. The index of the head and body depth with the standard length of the body were somewhere close to each other as they measured 22.91±0.42 and 24.19±0.40, respectively.

Table 1. Average and ranges of *S. undosquamis* main morphometric characters

Morphometric character		Range		Mean ± SE
		Minimum	Maximum	
Measurements	Tl	22	35	24.94±1.64
	Fl	20	32	23.24±٠.٤2
	Sl	١9	30	٢١.41±0.34
	Bd	4	6	5.18±0.11
	Pr-p	3.1	6.81	4.15±1.04
	Po-p	3.28	10.52	6.29±1.71
	Pr-d	6.41	12.5	7.79±1.64
	Po-d	9.1	17	11.22±2.02
	Pr-v	4.89	8.57	5.67±0.87
	Po-v	6.99	12.3	8.42±1.50
	Hl	3.50	6.50	4.89±0.09
	Snl	0.50	2	1.20±0.06
	Ed	0.5	1	0.6±0.02
	Maxl	1.48	3.34	2.34±0.36
	Minl	2.22	4.87	3.44±0.40
Indices	BD/**Sl**	20	28.57	24.19±0.40
	Pr-p/**Sl**	16.32	22.70	19.38±1.76
	Po-p/**Sl**	17.26	35.07	29.38±2.73
	Pr-d/**Sl**	33.74	41.67	36.38±3.25
	Po-d/**Sl**	47.89	56.67	52.41±4.19
	Pr-v/**Sl**	25.74	28.57	26.48±1.24
	Po-v/**Sl**	36.79	41.00	39.33±2.21
	Hl/**Sl**	16.67	27.27	22.91±0.40
	Snl/**HL**	11.11	50	24.46±1.17
	Ed/**Hl**	9.23	20	12.39±0.62
	Maxl/**Hl**	42.29	51.38	47.05±2.05
	Minl/**Hl**	63.43	74.92	69.2±3.03

The length and weight of *S. undosquamis* males ranged from 22 to 33cm and 68 to 246gm, respectively. The females' length varied from 23 to 35cm, while their weights ranged from 71 to 250gm. The relation between the length and weight of *S. undosquamis* is shown in Fig. (4); the logarithmic regression equation was calculated as follows:

$$Males\ Log\ W = -1.2466 + 2.35\ L$$
$$Males\ W = 0.0986 \times L^{2.35}$$

$$Females\ Log\ W = -1.2771 + 2.37L$$
$$Females\ W = 0.0782 \times L^{2.37}$$

The value of the regression coefficient **b**-value for males was 2.35, while it was 2.37 for females. The values in both sexes were less than 3, referring that the growth pattern of the examined fish is a negative allometric pattern.

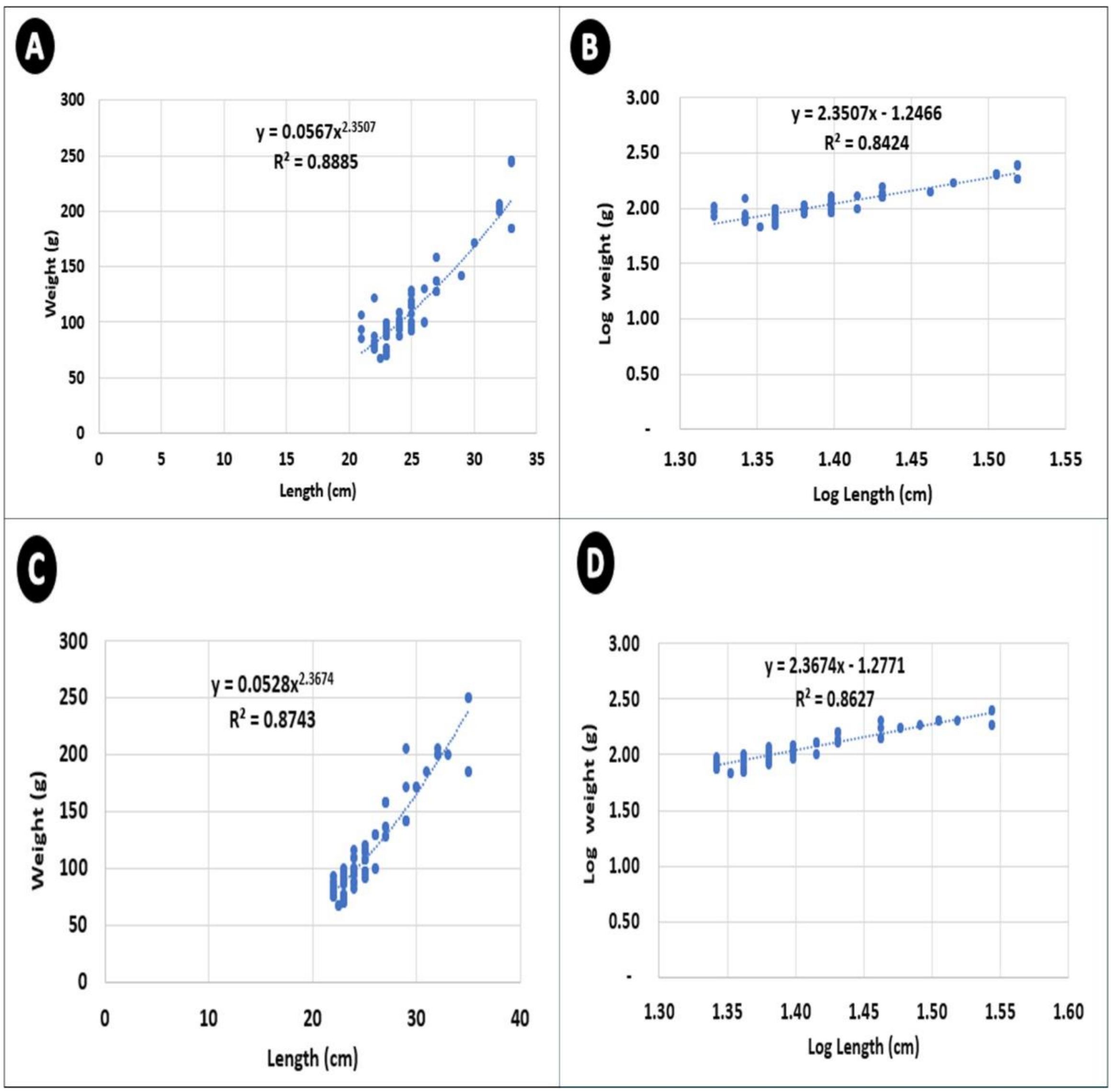

Fig. 4. Length-weight, and log-log relationship of *S. undosquamis*. **(A- B)** Males (N= 100). **(C- D)** Females (n= 100)

In the condition factor test, males *S. undosquamis* ranged in length from 22 to 33cm, and weight ranged from 68 to 246gm. The females ranged in length from 23 to 35cm, while weight ranged from 71 to 250gm. There was no significant difference between both sexes in the weight and length relation depending on the condition test. Both sexes were in an appropriate state, as the condition factor was more than one (Fig. 5).

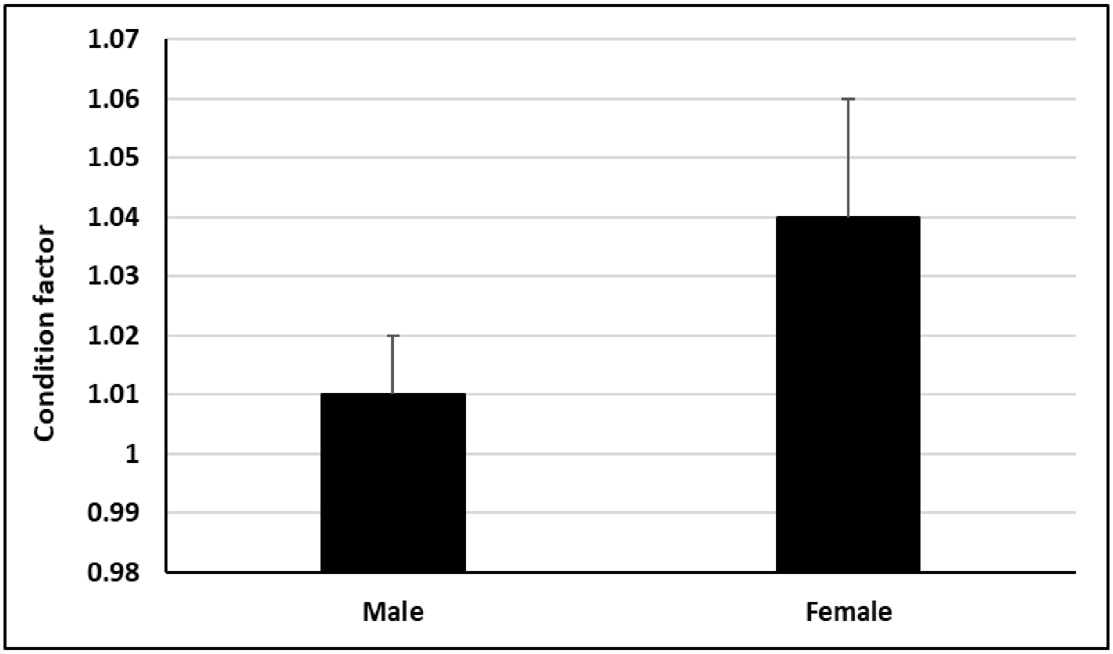

Fig. 5. Condition factor differences depending on fish sex (N=100/ Sex)

The pyloric portion of the stomach appeared to be attached directly to the intestine that was divided into three partitions (Fig. 6A). The averages of the total length of lizardfish and the digestive tract (stomach, and intestine) are shown in Fig. (6B). The intestine length was significantly higher than the stomach ($P< 0.03$).

The ratios between the weights of the different organs (stomach, intestine, liver, spleen, kidney, and gonad) concerning the total body weight of *S. undosquamis* are shown in Fig. (7). The highest organ ratio was recorded for the liver (2.74± 0.56), which represented the hepatosomatic index, followed by the gonad/ gonadosomatic index (2.47± 0.02). On the other hand, the lowest organ ratio was recorded for the spleen (0.27± 0.06).

The stomach contents varied between algae, worms, mollusks, arthropods, and fish (Fig. 8A, F). The percentage of each type of dominance is summarized in Fig. (8G). The parasitic helminths represented 30% of the stomach contents and were found in two forms parasitic trematodes and nematodes (Fig. 8D, E). Fish represent the most prevalent type in the stomach recording a percentage of 42%. Conversely, the lowest percentage was recorded for algae (3%) (Fig. 8G).

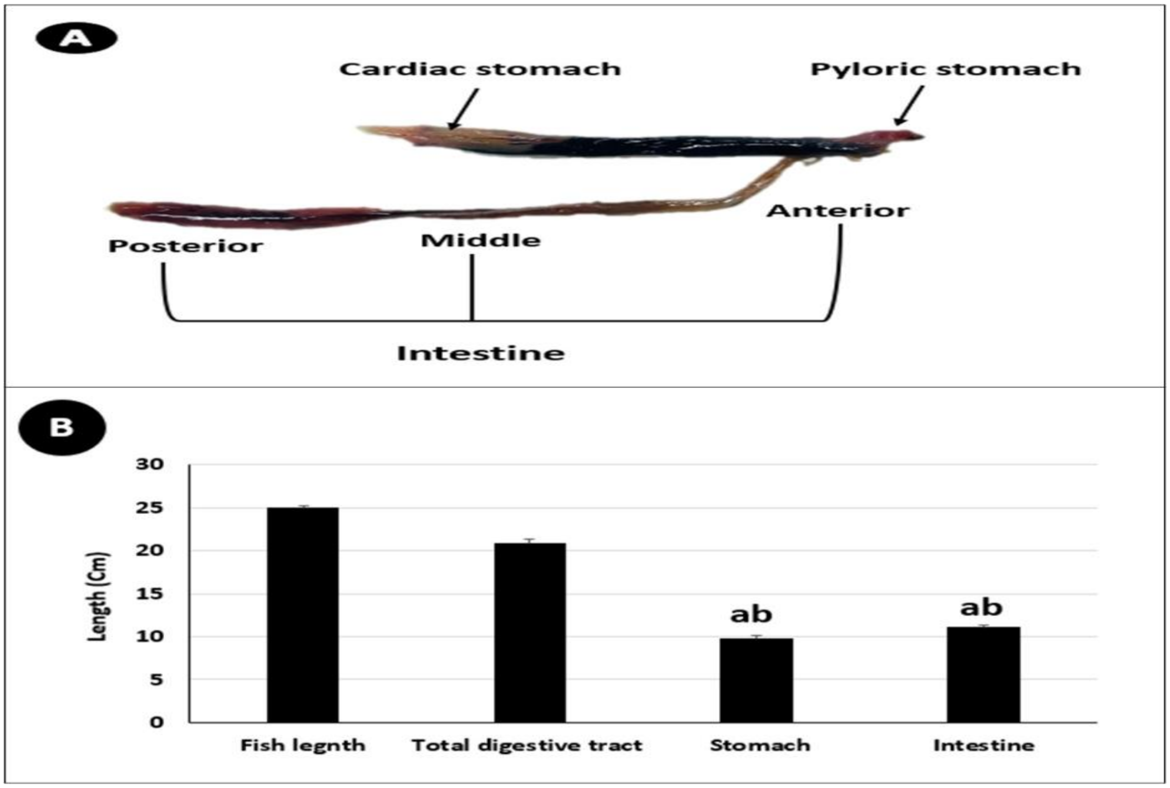

Fig. 6. Stomach and intestine length analysis showing: **(A)** Different parts of stomach and intestine, and **(B)** The averages of the digestive tracts (stomach & intestine) in comparison with fish length. a; significant difference in comparison with fish length, b; significant difference between stomach and intestine

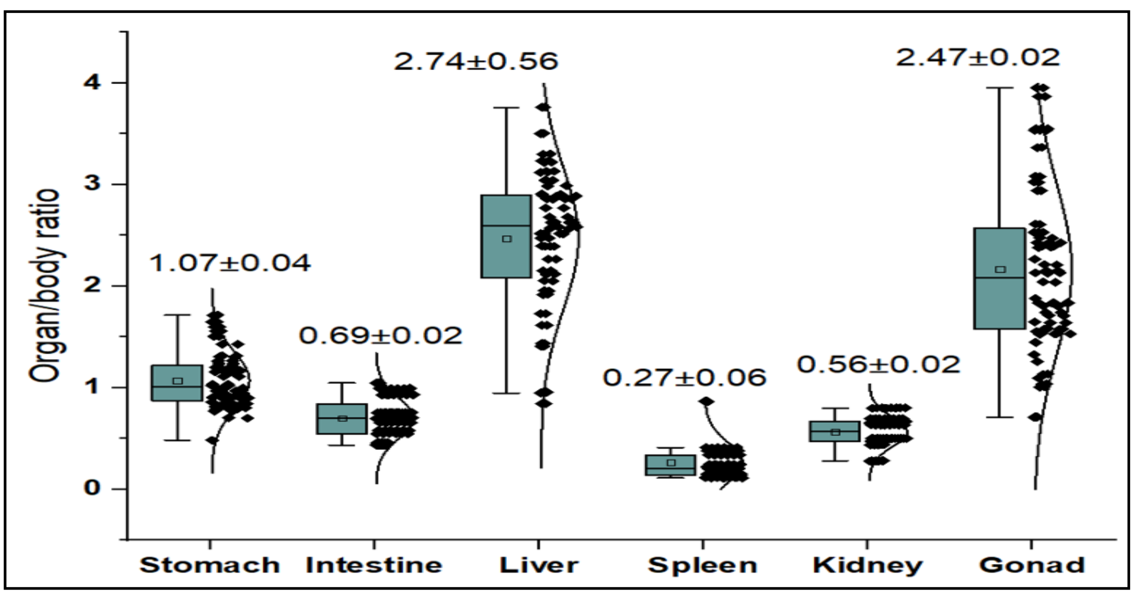

Fig .7. Organosomatic indicators of *S. undosquamis* in relation to total fish weight

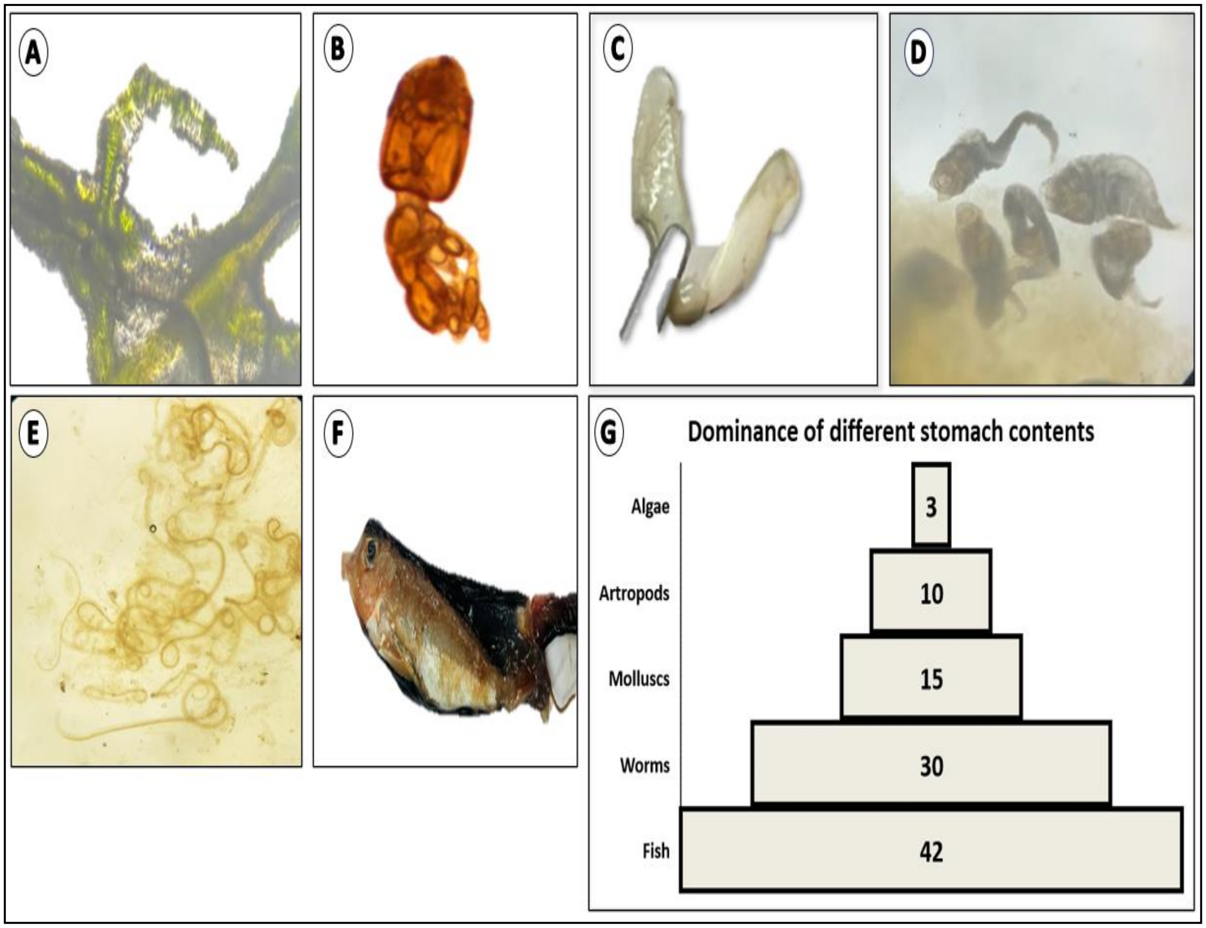

Fig. 8. Stomach contents of *S. undosquamis* showing: **(A)** Algae, **(B)** Arthropods, **(C)** Molluscs, **(D)** Trematodes, **(E)** Nematodes, **(F)** Fish, and **(G)** Dominance percentage of different stomach contents

The muscle bundles were arranged in different quadrilateral shapes, with multiple peripheral nuclei (Fig. 9A). The stomach muscular layer was bordered by external serosa and composed of two muscle fiber types: internal thick longitudinal fibers and outer circular fibers. Internally, between the external muscularis and the internal mucosae, there was a thick submucosa. The mucosa was divided into round-tipped main folds that varied in length and width (Fig. 9B). This layer was enriched by gastric glands and blood vessels (Fig. 9C). The parasites could be noticed embedded in the submucosa of the infected fish (Fig. 9D).

Regarding the liver tissues (Fig. 10A), the presence of the central vein, which was lined with the endothelial cells, was noticed. The hepatocytes with central nuclei were normally arranged in the parenchyma and separated by sinusoids. The histological sections of the lizardfish kidney showed the presence of renal glomeruli that are surrounded by numerous distal and proximal convoluted tubules. In addition, melonomacrophage centers (MMCs) of different shapes and sizes were also observed (Fig. 10B). The spleen was mainly composed of white and red palps which enclosed blood sinusoid, and the melonomacrophage centers were also widely abundant in the splenic tissues (Fig. 10C).

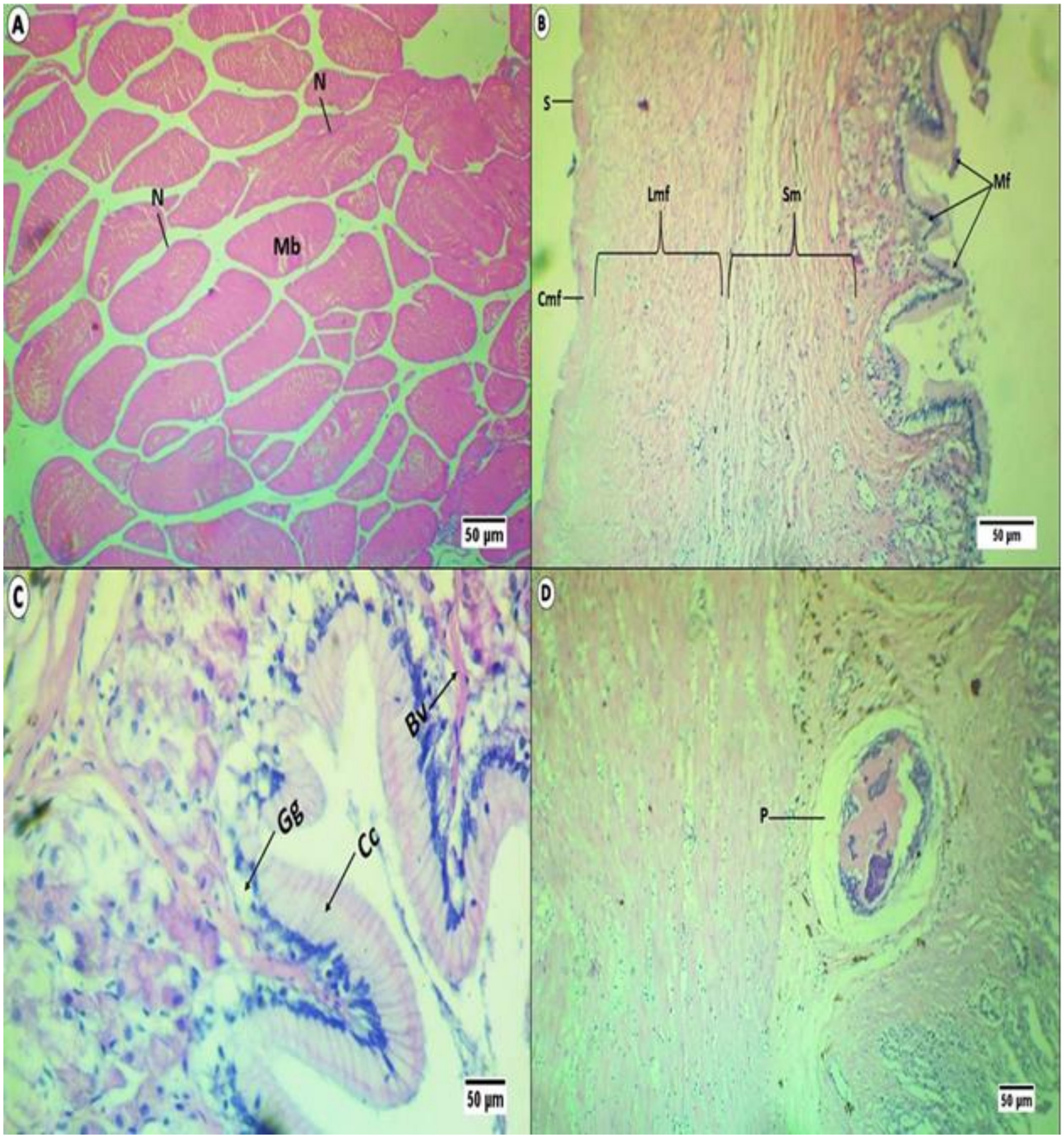

Fig. 9. Photomicrographs of *S. undosquamis* muscles and stomach tissue sections showing: **(A)** Muscle bundles, **(B)** Stomach layers, **(C)** Mucosal folds of the stomach, and **(D)** Parasitic worm in the stomach. Mb; muscle bundles, N; nucleus, S; serosa, Cmf; circular muscle fibers, Lmf; longitudinal muscle fibers, Sm; submucosa, Mf; mucosal folds, Cc; columnar cells, Gg; gastric glands, Bv; blood vessels, P; parasitic worm

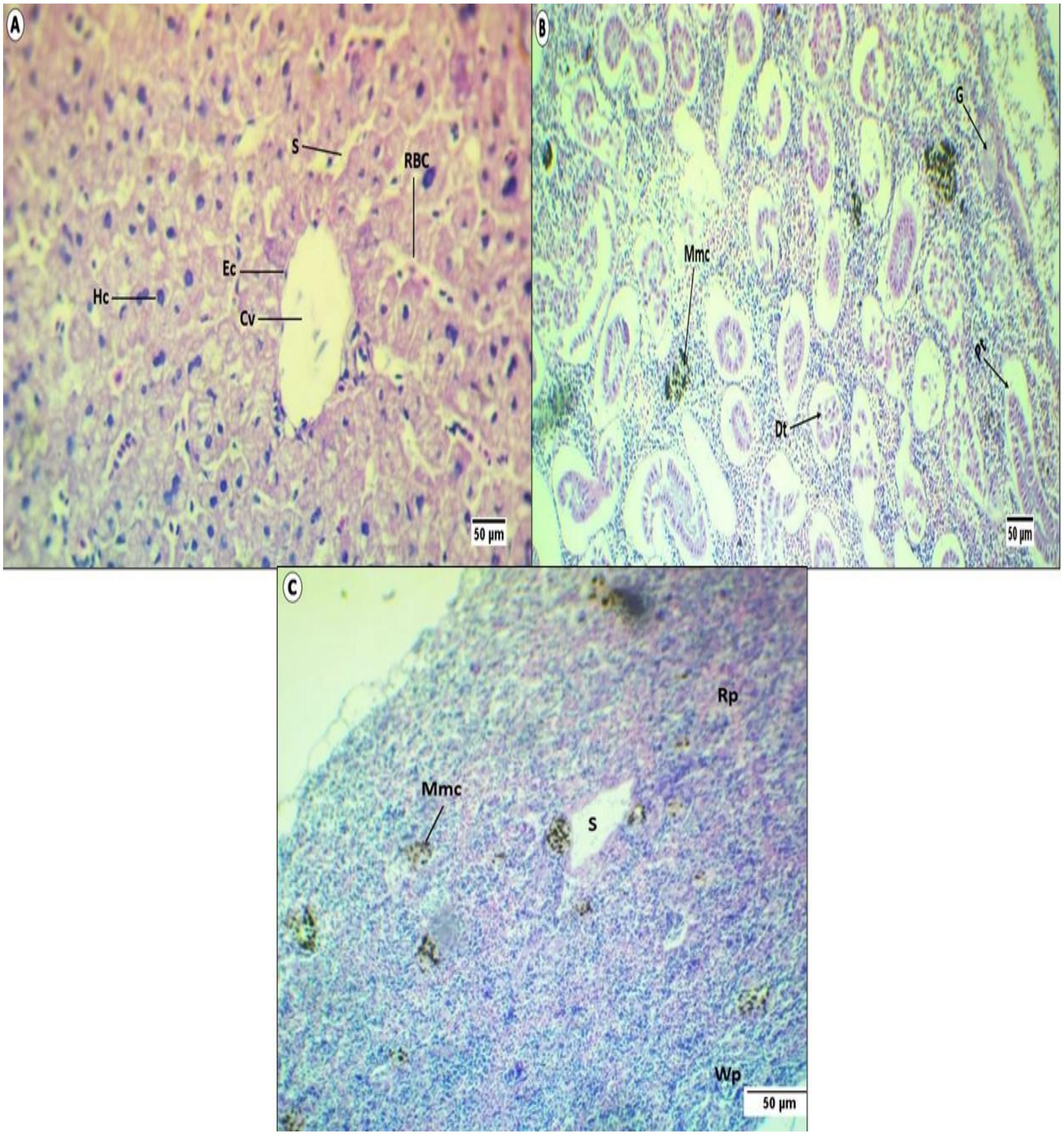

Fig. 10. Photomicrographs of *S. undosquamis* liver, kidney, and spleen sections showing: **(A)** Liver, **(B)** Kidney, and **(C)** Spleen. Cv; central vein, Ec; endothelial cells, Hc; hepatocytes, S; sinusoid, RBC; red blood cell, Mmc; melonomacrophage, G; glomerulus, Pt; proximal tubules, Dt; distal tubules, Rp; red palp, Wp; white palp

The testis sections were characterized by the presence of seminiferous tubules filled with several germinal cysts. These cysts were filled with many germinal cells at various developmental stages with liberated sperms in the center (Fig. 11A, B). The different stages of oocysts development can be noticed in the ovary sections of *S. undosquamis* (Fig. 11C).

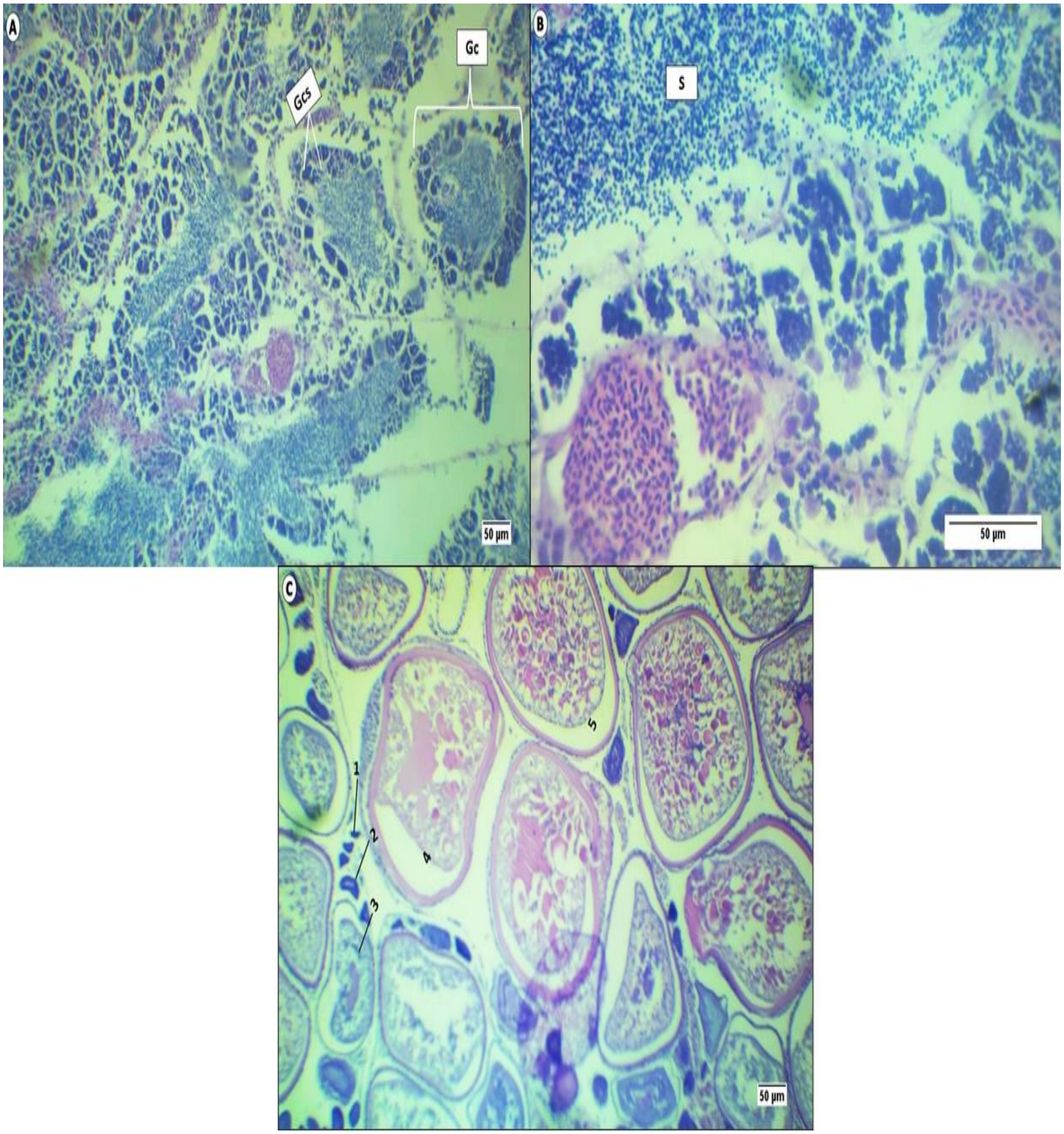

Fig. 11. Photomicrographs of *S. undosquamis* gonads tissue sections showing: **(A- B)** Testis, and **(C)** Ovary. Gs; germinal cysts, Gcs; germinal cells, S; sperms, 1–5; different stages of oocyst maturity

DISCUSSION

Morphological information can also be paired with other biodiversity descriptions, which include taxonomic and phylogenetic variations, to create global indicators of changes at regional levels, as suggested by **Dézerald *et al*. (2020)** and **Herrera *et al*. (2020)**, or in biodiversity, as suggested by **Su *et al*. (2021)**. Therefore, this study focused on giving a considerable description of the outer morphometric measurements and internal biological and histological characteristics of *S. undosquamis* in Port Said Governorate, Egypt.

The averages of the total and standard length were 24.94± 1.64 and 21.41± 0.34cm, respectively. These values were smaller than those recorded in the North of the Persian Gulf by **Rahimibashar *et al*. (2012)**, who recorded 33.86± 7.52cm for total length, and 28.76± 6.53 for standard length. All the morphometric indices concerning either standard length or head length in this study are also smaller than those stated in samples collected from Japan as previously reported by **Inoue and Nakabo (2006)**. This may be due to differences between sample collection and the length range in each area.

In length-weight relationship, the regression coefficient (b) of *S. undosquamis* was less than 3, referring that the growth pattern of this species is a negative allometric pattern. This result coincides with that of **Çiçek and Avşar (2011)**, who also reported a negative allometric growth pattern; the regression coefficient b-value was determined to be 2.35 for males and 2.37 for females. **Chhandaprajnadarsini *et al*. (2019)** estimated b= 2.81 for males, and 3.04 for females along the Mumbai coasts, India. **Mehanna (2022)** determined b= 2.9602 for males, 3.047 for females in the Red Sea, Egypt.

The fish condition factor (K) estimates the degree of general health condition, plumpness or fatness, and the relationship between abiotic and biotic factors in fish physiological states. Several factors can affect the condition factor greatly as sex, age, and season **(Froese, 2006; Famoofo & Abdul, 2020)**. The condition factor for females was higher than the males, but generally, the values of both sexes were higher than one, which means the good health condition of both sexes.

The gut length to fish length ratio was 0.83, and this matches the feeding habit of this species as they are considered carnivores fish, as carnivores usually have a gut ratio of less than one **(Susilo *et al*., 2021)**. The highest content of the examined samples was recorded for small fish; this finding agrees with the result of **Rahimibashar *et al*. (2012)**. The results of teeth shape, contents of the stomach and the relationship between the length of the gut and fish length indicated that this species likely ate carnivorous foods. Worms came in the 2nd stage with the highest stomach contents; these worms are parasitic trematodes and nematodes as described by **Abd-Elghany (2017)** and **Cipriani *et al*. (2022)**.

The stomach displays different modifications based on food types and feeding habits. The stomach is responsible for masticating, digestive secretion purposes, and storage of food that enables the fish to consume large meals **(Kumar & Tembhre, 1996; Castro *et al*., 2014; Le *et al*., 2019)**. In this study, the muscular is a thick layer that plays a role in controlling the passage of food particles to the intestine. This outcome concurs with that of a previous study describing the digestive tract of lizardfish, *Synodus variegatus* **(Alabssawy *et al*., 2019)**. The rest of the histological sections of *S. undosquamis* are similar to the prior descriptions reported for most teleosts **(Sales *et al*., 2017; Boonanuntanasarn *et al*., 2020; Majumder, 2023)**.

CONCLUSION

This study describes *S. undosquamis* biology in two outlines. The first description involves general morphometric measurements, while the second line includes the internal organ relations and their histological data. There is a need for further investigations that would link more closely between these two outlines. Moreover, studying these parameters depends on ecological conditions.

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