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Original article

Length–Weight Relationship and Sexual Maturity Stages of Bluefish: *Pomatomus saltatrix* (L, 1766) in Tripoli Coast, Libya

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ABSTRACT

Pomatomus saltatrix (L, 1766) is an important commercial fish in several countries, and that suffer from overfishing problems. In this study, 50 individuals of P. saltatrix were conducted during the fall, (October-November, 2022), on the Tripoli coast. Their total lengths and total weights were measured. The sex of the fish was determined, and the stages of sexual maturity were identified. The results showed that their lengths ranged 23.5-35cm, total weights 139-408g. The relationship between length and weight was negatively allometric, the number of males was higher than that of females, and all stages of sexual maturity were present.

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INTRODUCTION

The Bluefish, *Pomatomus saltatrix* is a member of the Perciforms, which belongs to the Pomatomidae; It is a commercial continental shelf fish that is worldwide distribution [1-3]. The morphological characteristics of *P. saltatrix* (Plate 1), are that its body is long and silvery in color on the dorsal side with a black spot at the base of the pectoral fin; The head is solid at the top and contains a large mouth with strong teeth; The two dorsal fins are close together, The pelvic fin is short and the anal fin consists of two spines [4].

Plate 1. Morphology of Pomatomus saltatrix

The bluefish lives along the coasts near the sandy or muddy bottom covered with herbs, up to a depth of 50 meters; The common total length of this fish is 30-40cm and may reach to 100cm in long. This fish moves in groups Individuals reproduce during the spring and summer seasons [4]. The reproduction process depends on several factors, including: water Temperature and current movement; It feeds on different species of fish, crustaceans and molluscs such as cephalopods, especially squid [5-8]. *P. saltatrix* is caught quantities have decreased and it faces the risk of overfishing through the bad use of fisheries, which represents illegal or randomly, or through the use of illegal fishing tools, or

fishing during the sexual maturation and reproductive seasons. Many individuals are also exposed to Intensive fishing operations for the purpose of providing sufficient quantities of market requirements in the coastal areas that they use as a source of food, which leads to a decrease in their stocks and productivity, which may lead to the disappearance of a vital food and economic source, in addition to the negative impact to the food net, disrupting the ecosystem and a major cause of biodiversity loss [8-12]. This study may be the first in Libya on one of the aspects of the biology of *Pomatomus saltatrix*. The aim of this study was to know the relationship between length and weight, and to study the stages of sexual maturity of this fish on the coast of Tripoli.

METHODS

Study setting

A total of 50 individuals of *Pomatomus saltatrix* were collected during the fall October-November, 2022 from Tripoli coast- Libya.

Morphometric measurements

The total length (cm), which starts from the front of the mouth to the end of the tail was measured using a ruler, and the total weight (g) was measured by using a sensitive scale.

Anatomy of fish

The dissection begins from the cloacal opening to the gills and then transversely. The sex of the fish and the stages of sexual maturity are known from the external characteristics of the gonads (Plate 2).

Plate 2. Gonads of Pomatomus saltatrix

Determining the stages of sexual maturity

The stages of sexual maturity, as exhibited in table 1, were determined according to the method done by Yeldan and Avsar [13], which was divided into five stages.

Table 1. Sexual maturity stages of Pomatomus saltatrix

Stage		Characters
I	Immature stage	Their ovaries are cylindrical, thin, and occupy approximately a quarter of the body cavity, while the testicles are flattened, thin, and semi-transparent, occupying approximately a quarter of the body cavity.
II	Beginning of maturation	The gonads are larger than the mature stage, and occupy about a third of the body cavity. The ovaries are provided with a few blood vessels. The testicles are white in color.
III	Ripe stage	The gonads increase in size, occupying approximately half of the body cavity, and are equipped with many blood vessels. The ovaries are pink in color and the eggs appear in the form of granules that can be seen with the eyes, while the testicles are yellowish-white in color.
IV	Spawning stage	The gonads occupy a large area of the abdominal cavity, the ovaries appear pink to orange in color, and the gametocytes are large in size and can be expelled by simple pressure on them. As for the testicles, they appear mature in white color and the release of semen can be observed upon slight pressure.
V	Spent stage	The gonads are flabby and occupy less than half of the body cavity. The color of the ovaries is between orange and red, with the presence of remnants of eggs, in addition to the presence of folds on the outer edge of the ovary. As for the testicles, they appear as white pieces and contain the remains of semen, with folds on the outer side of the testicle.

Statistical methods

-Total Length and weight were measured to find the relationship between Length and weight through the equation $W=aL^b$, where; L= total length(cm), W=total weight, a, b are Constants; a: represents the rate of change of weight relative to length; b: is the rate of regression, where the value 3 is considered the scale to determine the relationship of length to weight. If "b" is equal to 3, it is isometric. If it is higher than 3, the relationship is positive, if it is less than 3, the allometric relationship is negative [14-15].

A two-way ANOVA was used to determine the rate of difference in total lengths and stages of sexual maturity using Microsoft Excel 2010.

RESULTS

Morphometric measurements

The length of the bluefish ranged from 23.5 to 35cm, with a mean of 28,13. The standard deviation is 2.4279; their total weights range from 139 to 408g, with a mean of 209.86 and a standard deviation of 56.2638.

Length- weight relationship

The relationship between length and weight was negatively allometric (Figure 1), as the value of b=2.6546, and the correlation coefficient was $r^2 = 0.86$.

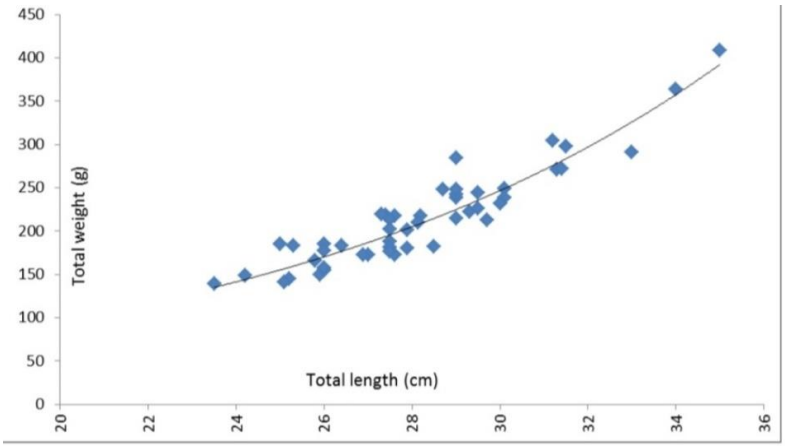

Figure 1. Length- weight relationship of pomatomus saltatrix.

Sex ratio

Through dissecting the bluefish and determining their sex, it was found that the ratio of males to females was higher, as it was 1:3.

Stages of sexual maturity

The sexual maturity stages were determined according to the method of Yeldan and Avsar [13], which was divided into five stages (table 1); It was found that the highest percentage was the third stage (Ripe stage) at 36%, followed by the fourth stage (Spawning stage) at 30%, while the first stage (Immature stage) had the lowest percentage (6%) (Figure 2).

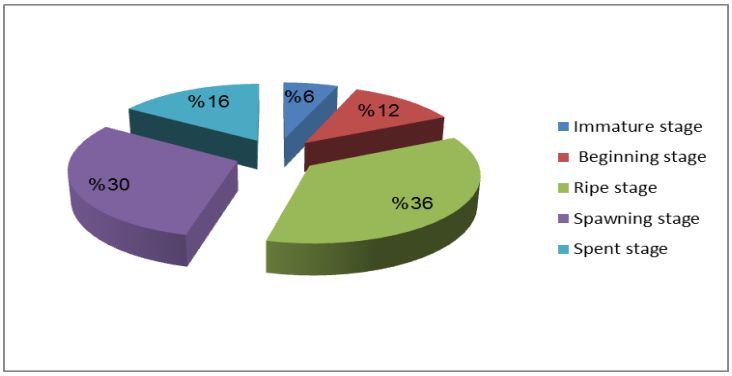

Figure 2. Sexual maturity stages of pomatomus saltatrix.

It also became clear that the longest and heaviest individuals were in the fourth stage "spawning stage", where they were 35cm and 408g (Table 2).

Table 2. Stages of sexual maturity of Pomatomus saltatrix

Stage		Total length (CM)	Total weight (g)	(%)
I	**Immature stage**	31.5-27.5	298-219	%6
II	**Beginning of maturation**	33-26.9	291-173	%12
III	**Ripe stage**	34-23.5	364-139	%36
IV	**Spawning stage**	35-27.9	408-201.2	%30
V	**Spent stage**	29-25.0	248-154	%16

When performing the parametric test, two-way ANOVA (Table 3), to find the difference between total lengths and stages of sexual maturity, it was found that there were no statistically significant differences, as the F-value was less than F crit and the P-Value was greater than 0.05.

Table 3. The difference between the lengths and stages of sexual maturity using two-way ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	44.93333333	2	22.46667	3.663043	0.074239	4.45897
Columns	85.33333333	4	21.33333	3.478261	0.06288	3.837853
Error	49.06666667	8	6.133333			

DISCUSSION

The length and weight measurements are one of the basics of applying law $W=aL^b$ to find the relationship between length and weight [14-15]. This study was shown that the length range is from 23.5 to 35 cm; This differs from other studies [16-22], where the length ranges were (8.6-25.0; 48.0-75.5; 8.4 -45.3; 13.2-21.7; 9.2-23.4; 11.6-22.2; 12.5-20.2cm).

The relationship between length and weight is an important because it gives information such as growth rates, age at first maturity, stock identification, and the study of population dynamics; It is also useful in fisheries management around the world, and it can also be used in health status factor [17,23,24,25]. The parameters of the relationship between length and weight are affected by several factors, including: the external environment, the degree of stomach fullness, gonad maturity and reproduction [24,26,27]. This study showed that the relationship between length and weight was negative (b = 2.6546) and this is consistent with several studies, including the study of [17,19,26] where the values of b were 2.8; 2.77; 2.50. While it does not agree with several other studies, that exhibited positively allometric with values of 3.05; 3.22; 3.32; 3.33 [16,18, 20, 21]. It is not possible to distinguish the male from the female except after examining the gonads, the length and weight does not indicate the gender of the bluefish.

The dominance of males over females was revealed, as the ratio of males to females was 1:3. This indicates that the female ratio for this study represents a quarter of the population and may represent a threat to the density of individuals in the groups. This differs from the study de [28], where the male ratio was lower than females, 1:1.6.

Studying the reproductive strategy of fish is an important in fisheries management, which improves understanding of egg production methods through studying the gonads, where their maturation stages can be seen with the macroscopic or microscope [8,28].

During its life cycle, *P. saltatrix* passes through different stages of maturity, where mature females lay large numbers of eggs, which form a planktonic mass that is fertilized. The eggs hatch into larvae and grow, migrate to food areas then mature [28, 29]. Methods for studying the stages of sexual maturity in fish vary depending on the general phenotype of the gonads, which includes: size, shape, color, length of the gonads, etc. [3,28,30]. In this study, the method of [13] was used to determine Maturity stages of the *P. saltatrix* (Table 1), this contrasts with other studies (Table 2). The number of maturity stages that were used in the current study showed consistency with the number in the study of [3,31], which included 5 stages for both sexes "males and females" (Immature, Resting, Developing, Ripe), while it differed with the method used in the study of [28,32], where the stages of sexual maturity for females were five stages (Immature, Developing, Spawning, Spent, Regeneration) and for males, four stages (Immature, Developing, Spawning, Spent).

Through this study, it became clear that there are all stages of sexual maturity in *P saltatrix*, and the highest percentage were in the third stage (stage ripe) 36% and the fourth stage (spawning stage) 30%, which indicates that the stage of its maturity, laying of eggs, and readiness for reproduction was the fall. This disagree with [4], which stated that its

reproductive season is in the spring and summer.
Many commercial fish, including *P saltatrix* had the risk of extinction for several reasons, the most important of which is overfishing, in addition to random fishing, which includes bycatch through nets to catch other fish, and fishing during the seasons of reproductive and sexual maturity This negatively affects their productivity and stock, thus exposing their numbers to decrease, which may affect the ecosystem and biodiversity. Fishermen have an important role in reducing the aggravation of this problem by making them aware of the danger of indiscriminate fishing and its negative consequences on fish stocks and marine wealth, [4,6,8-12].

CONCLUSION

Pomatomus saltatrix is one of the commercial Osteichthyes in the world. It is characterized by being a great swimmer, a strong predator, and a migratory fish. Human activities negatively affect their reproduction and numbers. The current study indicates that there is a negatively allometric relationship between length and weight, and that the percentage of females is less than males, and all stages of sexual maturity of bluefish were present.

Conflict of interest

The authors declared no conflict of interest.

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العلاقة بين الطول والوزن ومراحل النضج الجنسي لسمكة المغرس بساحل طرابلس، ليبيا

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الملخص

تعتبر سمكة المغرس من الأسماك التجارية الهامة في العديد من دول العالم، والتي تعاني من مشاكل الصيد الجائر. أجريت هذه الدراسة على 50 فرداً من سمكة المغرس خلال فصل الخريف (أكتوبر-نوفمبر 2022) بساحل طرابلس. وتم قياس أطوالها وأوزانها الكلية. وكذلك معرفة جنس السمكة وتحديد مراحل النضج الجنسي. أظهرت النتائج أن أطوالها تراوحت بين 23.5 – 35 سم، والأوزان الكلية 139 – 408 جرام. كانت العلاقة بين الطول والوزن الومترية سالبة، وعدد الذكور أعلى من عدد الإناث، وأن جميع مراحل النضج الجنسي موجودة.

الكلمات الدالة. سمكة المغرس، سمكة زرقاء، النضج.