Sex Ratio and Gonadosomatic Index Of *Nemipterus japonicus* (Bloch, 1791) in Coastal Waters of Samar, Philippines: Update for Fishery Education

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Abstract: Since the Japanese threadfin bream, *Nemipterus japonicus*, is a commercially abundant and significant species in Samar, its reproductive biology must be evaluated for fisheries management. A total of 396 fish samples (177 males and 219 females) were collected from August 2020 to July 2021. The fish's standard length (SL) and fork length (FL) were measured in millimeters (mm), while its body weight (BW) and gonadal weight (GW) were recorded in grams. Females measured 105-237 mm in length, while males measured 105-230 mm. Of the total catch, the female population dominated almost all months except for December, February, and April, of which males were more abundant. The overall sex ratio was 1:1.24, which deviates from the expected 1:1 ratio. Females showed dominance in most size groups except 175–188 and 203-216 mm. Monthly variation in GSI showed that the spawning season has two peaks, with the highest value in April (GSI = 2.82 in females, 1.88 in males) and a secondary spike in September (GSI = 2.0 in females, 1.35 in males). This shows that the spawning month occurs during the dry and wet seasons. Based on this study, it is recommended that the collection of *N. japonicus* be regulated from February to March and July to August to allow spawning before capture.

1. Introduction

Globally, the fishing industry provides food, nutrition, employment, and a means of subsistence for hundreds of millions of people. However, the FAO (2006) estimates that 74% of the fish stocks are already overexploited, depleted, or declining due to a lack of management. As a result, adequate scientific knowledge of fish biology is required to manage all fish stocks. Policymakers, coastal managers, and implementers rely on this type of data to set fisheries objectives (Hossain et al., 2019).

Understanding a fish species' fundamental reproductive behavior, including its sex ratio and gonadal indices (GSI), is critical for developing timely management strategies to protect sexually mature stock populations. The gonadosomatic index (GSI) is a valuable tool for determining a fish's gonadal development and spawning season (Lin et al., 2021). Additionally, this index indicates the proportion of a fish's body weight. Meanwhile, studies on the sex ratio are critical for understanding population dynamics because they provide information about the proportion of male and female fish in a population, the dominant sex of fish, and an estimate of female spawning biomass (Adebiyi, 2013).

The Samar Sea is one of the Philippines' most productive trawling grounds, with abundant pelagic and demersal fishery resources. However, the area's marine resources have deteriorated over the years (The Samar Sea Fisheries Management Plan, 2016). For instance, there were 50 economically important fish species in 1981 but only 10 in 1991. Furthermore, destructive fishing practices reduce fish catch from 8 to 3.5 kg/day (ICLARM, 1993).

Nemipterus japonicus (Bloch, 1791) (Nemipteridae), more commonly known as the Japanese threadfin bream, is a significant component of Samar's demersal fishery. The Red Sea, Persian Gulf, East Africa, and Indo-Malay Archipelago are all home to this marine fish (Kerdgari et al., 2009; Russell, 1993). This small to medium-sized fish has a pinkish body coloration with a prominent red-suffused, yellow blotch below the lateral line. *N. japonicus* is primarily found in sandy or muddy substrates between 5 and 80 meters below the surface and is caught using hook and line or a bottom trawl (Russel, 1993). This type of fish is popular among consumers in Samar due to its low price, delicately flavored meat, and year-round availability.

Certain biological characteristics of this species have been extensively studied, for example, in the Mediterranean (Bakhsh 1994; Elhaweet 2013), the Northern Persian Gulf (Kerdgari et al., 2009), Egypt (Amine 2012), Malaysia (Nettely et al., 2016), and India (Acharya 1990; Gopal and Vivekananda, 1991; Raje, 1996; Raje 2002; Rajkumar et al., 2003; Manojkumar; 2004; Kizhakudan et al., 2008; Rajesh et al., 2013; Rajesh et al., 2013) Despite this extensive research in other countries, the biology of this species is still poorly understood in the Philippines; hence, this study is being conducted. The information gathered is important for the formulation of future management initiatives for the sustainable exploitation of Japanese threadfin bream in Samar.

2. Objectives

The purpose of this study is to determine the sex ratio and gonadosomatic index (GSI), which are aspects of the reproductive biology of threadfin bream, *N. japonicus*, with an intention to provide an update on fishery education, especially as to the spawning period before capture.

3. Methodology

3.1 Collection of Samples

To capture the entire seasonal cycle, samples of N. japonicus were collected at the Samar Fish Market in Catbalogan City over a 12-month period, from August 2020 to July 2021. The samples were transported to the laboratory and preserved in a freezer until examination and analysis were done. A total of 396 specimens, 177 (45%) males and 219 (55%) females, were collected for this research.

3.2 Body Measurements

In the laboratory, standard length (SL) and fork length (FL) for every fish sample were measured using a measuring board with a ruler calibrated in cm. The collected measurements were converted to the nearest 1 mm. The body weight (BW) was determined in grams (g) using a weighing balance. The gonads of the specimens were collected and checked through macroscopic observation after dissection and were weighed using a digital weighing scale. The gonadal weight (GW) of the fish was weighed to the nearest 0.01 g.

3.3 Sex Ratio

Sex was determined by observing the gonads macroscopically after dissecting the specimen. The sex ratio for different months and length groups was estimated as the ratio of females to males in the catch.

3.4 Gonadosomatic Index (GSI)

To determine the spawning season, the gonadosomatic index (GSI) was calculated using the following formula:

$$GSI (\%) = (GW/BW) *100$$

Where: GW = weight of the gonad (g)

BW denotes the fish's body weight (g).

The GSI was calculated for both sexes, and the GSI value for each month was also determined.

3.5 Data Analyses

The significant difference between male and female fish samples was analyzed through the chi-squared test. A one-way ANOVA was performed to find the variation in the GSI. At p 0.05, statistical analyses were considered significant.

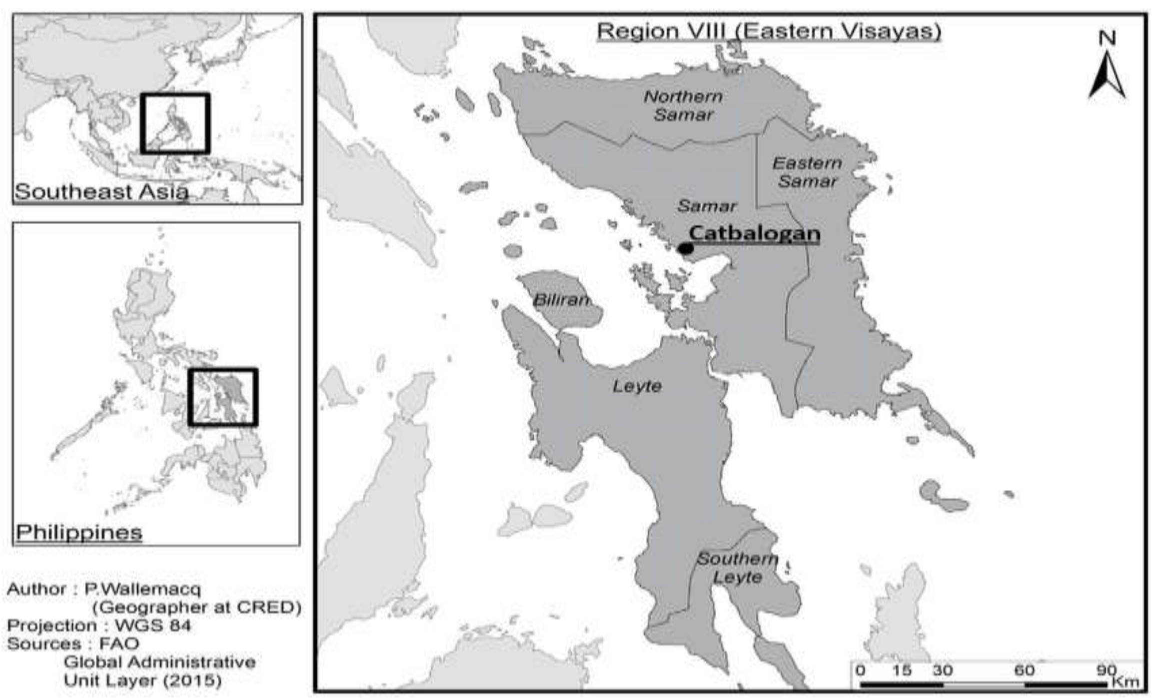

Figure 1: Map showing the sampling location of the study

4. Results and Discussion

4.1 Sex Ratio

The sex ratio is a crucial aspect of fish reproductive biology because it provides information about its potential reproductive success. In this study, the female dominates with 219 (55%) individuals, while the male has 177 (45%) (Table 1). The average sex ratio from August 2020 to July 2021 was 1:1.24. Elhaweet (2013) reported an M: F value of 1:1.29, consistent with the current observation. A similar observation was also reported in the Northern Persian Gulf with a 1:2.6 ratio (Kerdgari et al., 2009) and in the Suez Gulf-Red Sea with a 1:1.2 ratio (Amine, 2012). However, this contrasts with Nettely (2016) and Raje (2002) results, where males outnumbered females.

The statistical analysis demonstrates that the sex ratio of *N. japonicus* is not significantly different ($X^2 = 0.215$, $P > 0.05$), although females outnumber males in terms of abundance. This means that males and females are equally represented in the population during the investigation and do not stray from the expected 1:1 ratio. This also means that the population is in balance and that competition for mates may not occur.

Table 1. Sex ration of *N. japonicus* in various months and length groups from August 2020 to July 2021

	Male	Female	Total (N)	Sex Ratio M:F	X^2 value	Significance P value
Months						
Aug ‘20	13	17	30	1:1.31	0.53	NS
Sept	14	18	32	1:1.29	0.50	NS
Oct	12	20	35	1:1.67	2.00	NS
Nov	14	21	35	1:1.50	1.40	NS
Dec	18	15	33	1:0.83	0.27	NS
Jan ‘21	13	19	32	1:1.46	1.12	NS
Feb	17	13	30	1:0.76	0.75	NS
Mar	10	18	28	1:1.80	2.28	NS
Apr	22	11	33	1:0.50	3.67	NS
May	9	18	27	1:2.00	3.31	NS
Jun	21	24	45	1:1.14	0.20	NS
Jul	14	25	39	1:1.07	8.64	**
Total	177	219	396	1:1.24		
Length Group (mm)						
105-118	6	6	12	1:1.00	0.00	NS
119-132	12	28	40	1:1.29	6.40	**
133-146	39	44	83	1:1.67	0.30	NS
147-160	51	53	104	1:1.50	0.03	NS
161-174	15	34	49	1:0.83	7.36	**
175-188	30	23	53	1:1.46	0.92	NS
189-202	11	17	28	1:0.76	1.28	NS
203-216	8	6	14	1:1.80	0.28	NS
217-230	5	5	10	1:0.50	0.00	NS
231-244	0	3	3	1:2.00	3.00	NS
Total	177	219	396	1:1.14		

Meanwhile, month-wise observation revealed that females are abundant throughout the year, except for February (1:0.76), April (1:0.50), and December (1:0.83). The lowest ratio was recorded in April at 1:0.50, while the highest value was recorded in May at 1:2.0. The sex ratio was not significant in any month except July ($X^2 = 8.64$, $P \geq 0.05$).

In terms of length, the largest specimen obtained in this study was 237 mm, found in the female population, while the smallest size was 105 mm, observed in both sexes. Females outnumbered males in all length groups except 175–188 mm and 203-216 mm. Meanwhile, a sex ratio of 1:1 was observed in the 105–118 mm and 217–230 mm ranges. Only the chi-square test values of 119–132 mm (X2 = 6.40; P > 0.05) and 161–174 mm (X2 = 7.37; P > 0.05) were found to be significant. It was also observed in this study that female *N. japonicus* dominated the smaller-length group. The current research backs up Murty's (1984) findings, which showed that males and females grow at different rates, with males reaching longer lengths. Males grow faster than females since they require less energy for reproduction and gamete formation (Clarke, 1983), whereas female fish slow down at sexual maturity (Haddy, 2007).

4.2 Gonadosomatic Index (GSI)

The highest GSI for both sexes implies that the spawning and breeding period of *N. japonicus* was in April during the dry season. Other research, such as that by Kerdgari et al. (2013, 2009), and Raje (2002), has reported on species' spawning strategies in the same way as this study. However, this contrasts with the previous studies of Manojkumar (2004) in Veraval water in India, where the spawning period of *N. japonicus* is November–December with a secondary peak in February.

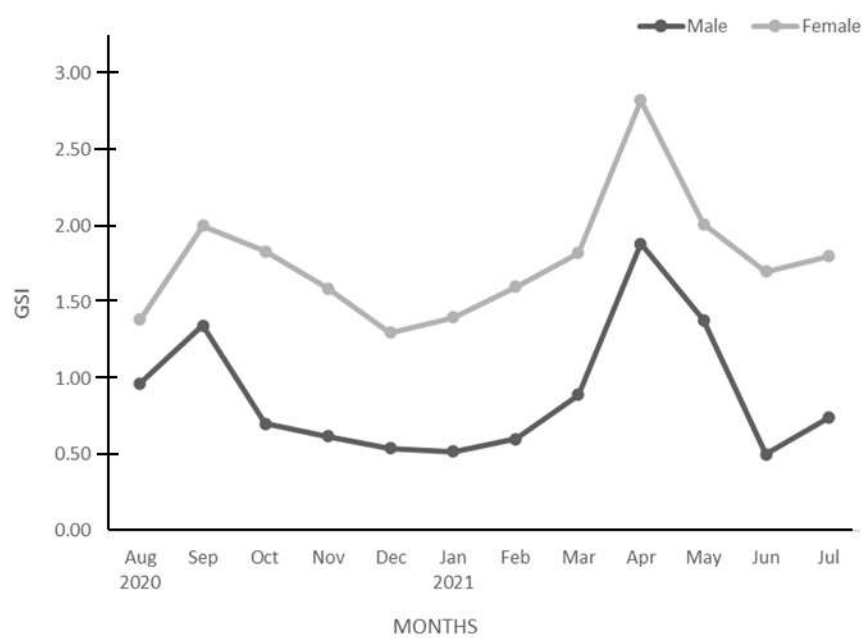

Figure 2: Gonadosomatic Index of *N. japonicus*

Eggleston (1970) first reported that Nemipterus species are probably multiple spawners, releasing eggs at several spawnings throughout the breeding season. This variation in the spawning period of the threadfin bream N. japonicus across regions is likely due to environmental factors such as wind and current (Backhsh, 1996). As a result, various studies suggest a major and minor peak spawning.

In addition, although GSI values between males and females are different, results show synchronicity in the reproductive cycle for both sexes. Therefore, *N. japonicus* may be a group spawner. Fish congregate in group spawners because sperm from one male can fertilize the eggs of many females and eggs from one female can be fertilized by many males (Karleskint et al., 2010). This synchronized spawning of both sexes is necessary to ensure successful fertilization.

5. Conclusion and Recommendation

The study concludes that the sex ratio of *N. japonicus* was in favor of females and abundant in most months except December, February, and April. Females are usually smaller in size compared to males. The spawning season of *N. japonicus* in the coastal waters of Samar shows two peaks in April and September, which coincide with the dry and wet seasons. To ensure the sustainable utilization of the species, the harvest shall be regulated from February to March and July to August to allow spawning before capture. This measure is recommended as a fishery management strategy. It is also suggested that some aspects of reproductive biology, like fecundity, size at first maturity, length-weight relationship, and reproductive stages be incorporated in the study.

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