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Research Article

Length-Weight Relationship (LWR), Gonadosomatic Index (GSI) and Fecundity of *Johnius borneensis* (Bleeker, 1850) from Lower Agusan River basin, Butuan City, Philippines

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ABSTRACT

Length-weight relationship (LWR) and Reproductive phenology of *Johnius borneensis* (Bleeker, 1850) collected from Lower Agusan River was studied from the months of May 2017 to January 2018. Throughout the sampling period, a total of 304 specimens with 185 female and 119 males were examined and analyzed. The overall sex ratio is 2:1 with female preponderance. LWR of females showed positive allometric growth (b>3; p=0.0000) while male specimens followed negative allometric (b<3; p=0.000). Ovarian GSI showed to peak in reproduction during September. Fecundity-length and fecundity-weight shows low correlation coefficient in their relationship. *J. borneensis* had a short reproductive period with this it is highly recommended that fishing be strictly restricted during its spawning season (September) for this fish species to propagate their population in the area.

Keywords: Length-weight relationship; Reproductive phenology; Lower Agusan River; Allometric growth

INTRODUCTION

The Lower Agusan River is one of the most important estuaries in Mindanao. This is utilized by people as a water resource to supply agricultural lands and a water system to transports forest products to its neighboring areas [1]. Estuaries serves as spawning and nursery grounds for fish species [2]. Sciaenids were one of the most abundant fish species in an estuary.

The Sharpnose Hammer Croaker, *Johnius borneensis*, locally known as "Guama" is a brackish-freshwater fish and bentho-pelagic dwellers. They are noisy and bottom oriented fish [3]. Accordingly, guama is originally a marine fish species [4]. In support, *J. borneensis* was a marine-estuarine fish [5].

Classical methods have been used to monitor current population and condition. Some of these are the length-weight relationship (LWR) which is used to assess the weight from length or the conversion of growth in length equations to growth in weigh [5]. LWR is essential to determine the seasonal variation in the fish growth [6]. A change in the LWR provides important clues in determining whether the presence of environmental cues can alter the growth and development of fish.

Gonadosomatic index (GSI) and fecundity are one of the most essential parameters in studying the reproductive biology of every fish. GSI is a parameter that is used to study the spawning biology of the fish. It also assesses the level of ripeness of the ovary [7]. GSI serves as an indicator of the reproductive seasonality of fish species [8]. On the other hand, fecundity is the total egg production or the egg laying capacity of every fish during spawning seasons [7]. Fecundity is an avenue for the reproductive biology which it explains variation in the level of production which increases the amount of fish during harvest [9].

Previous study on the LWR of *J. borneensis* revealed that females followed positive allometric while male possess negative allometric growth. In terms of the reproductive phenology, fecund and mature to spawning individuals were showed to peak in April [3].

The information on the LWR and some reproductive biology of *J. borneensis* in the Lower Agusan River is important to determine their current condition such as their dwindling abundance in the river. It is also essential for management, conservation and aquaculture production since the mentioned fish species was consumed by the people residing near the said river.

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This study was aimed to determine the length-weight relationship, gonadosomatic index, sexual maturity stages, sex ratio of the male and female and the fecundity. This is a continuation study conducted by Chennie L. Solania from the months of February until April 2017.

MATERIALS AND METHODS

Study site

The study was conducted in the Lower Agusan River basin (Figure 1). This river basin starts from Talacogon, Agusan Del Sur and empties to Butuan bay forming an estuary. This river basin is one of the most important water system in Mindanao. It also provides abundant brackish-freshwater fish, crustaceans, crabs and mud shells for the locality.

Collection and specimen processing

A total of 304 individuals of *J. borneensis* with 185 female and 119 male were caught and examined. Sampling of fishes was completed in 9-months duration starting from May 2017 to January 2018. Method of fish collection includes the use of gill nets, palangre and sapyaw. Selection of Guama was based on their abundances in the study area. The number of examined fish depends upon the availability of the samples from the tap fisher folk. Total length was measured from the snout to the tip of the peduncle using a ruler and weight using top beam balance. Gonad samples were sorted as to male and female and determined their maturity stages. Fish gonads were weighed and measured for GSI measurement and ovaries with maturity stages IV-VII were preserved for fecundity analysis (Figure 2).

The transformation is made using natural logarithm of total length and weight which is represented by the formula: Log W= b log L + log a.

The coefficient of determination (r^2) of length and weight was determined in the regression analysis.

Length-weight relationship

LWR is expressed by the equation $W=aL^b$; where W=total weight (g), L=total length (cm), a=slope and b=intercept. The "b" is an exponent with a value between 2.5 and 3.5 to describe the normal dimensions of the relative well-being [9].

Gonadosomatic Index

This parameter was calculated using the formula: GSI=[(gonad weight)/ (body weight)] x 100

Fecundity

Fecundity was expressed using volumetric method, in which eggs were mixed to 50mL distilled water and three aliquot were taken from the 50mL mixed eggs [3] with the formula:

Fecundity=nV/v

Where n=number of eggs, V=total volume and v=volume of the subsample

Maturity Stages

The gonad maturity stages of J. borneesis were adapted from Hoda and Ajazuddin [10].

Statistical Analysis

Determination of linear relationship and correlation coefficient

Figure 1: Fish collection sites in the Lower Agusan River basin, Butuan City, Philippines.

was performed using SPSS software. Pearson Correlation Test was also used for the correlation of fecundity-length and fecundity-weight relationship.

RESULTS AND DISCUSSION

Length-weight relationship

A total of 304 specimens of *Johnius borneensis* with 185 female and 119 male individuals were examined and analyzed during the 9-months study. LWR parameters were shown in Table 1, Figure 3a and Figure 3b.

Female length ranges from 10.2 cm to 35.9 cm while body weight range from 9.97 g to 192.56 g. Male total length ranges between 9.7

Figure 2: *Johnius borneensis* "Guama" caught from Lower Agusan River basin.

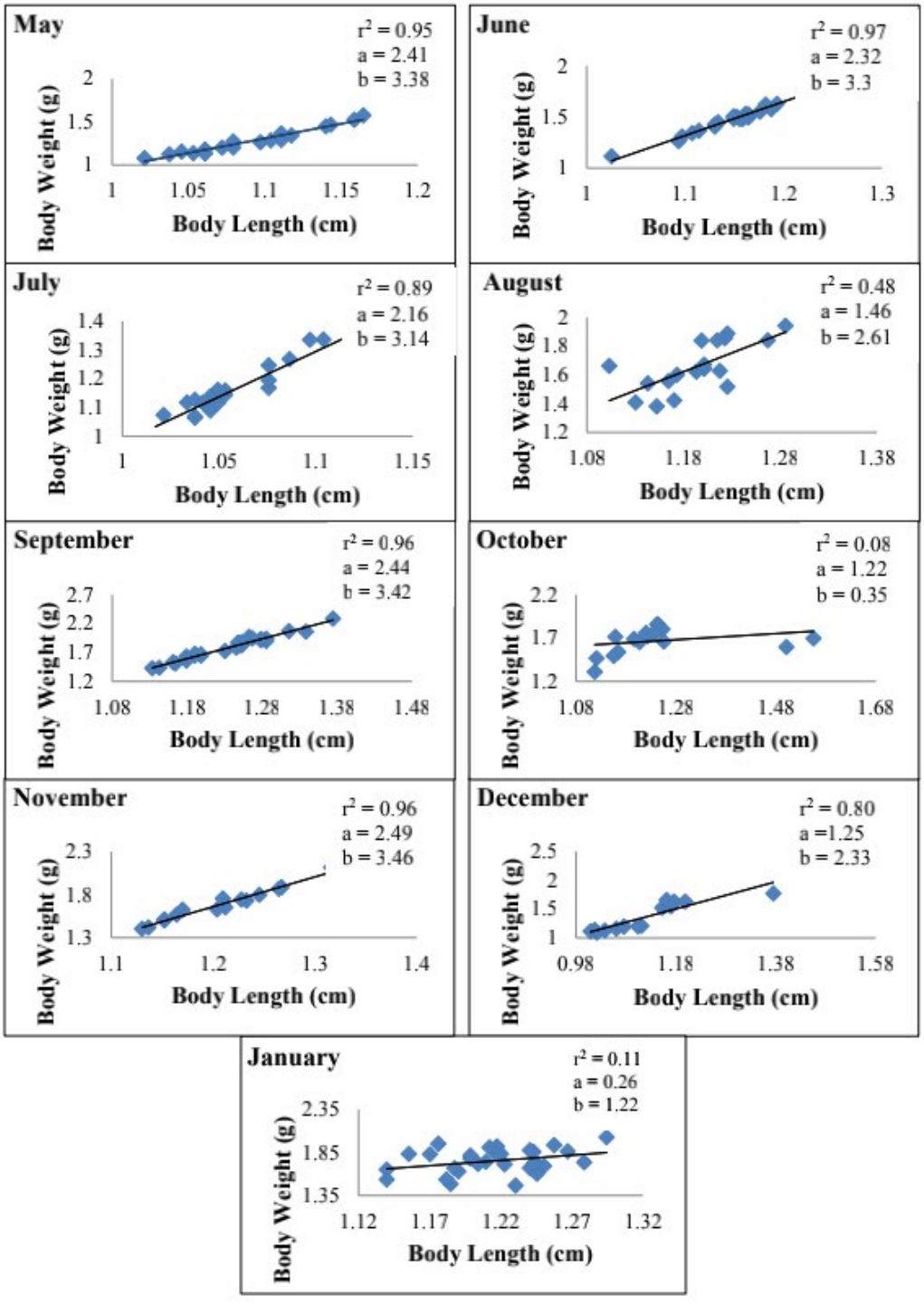

Figure 3a: Length-weight relationship of female *Johnius borneensis* in Lower Agusan River basin from the month of May 2017 to January 2018.

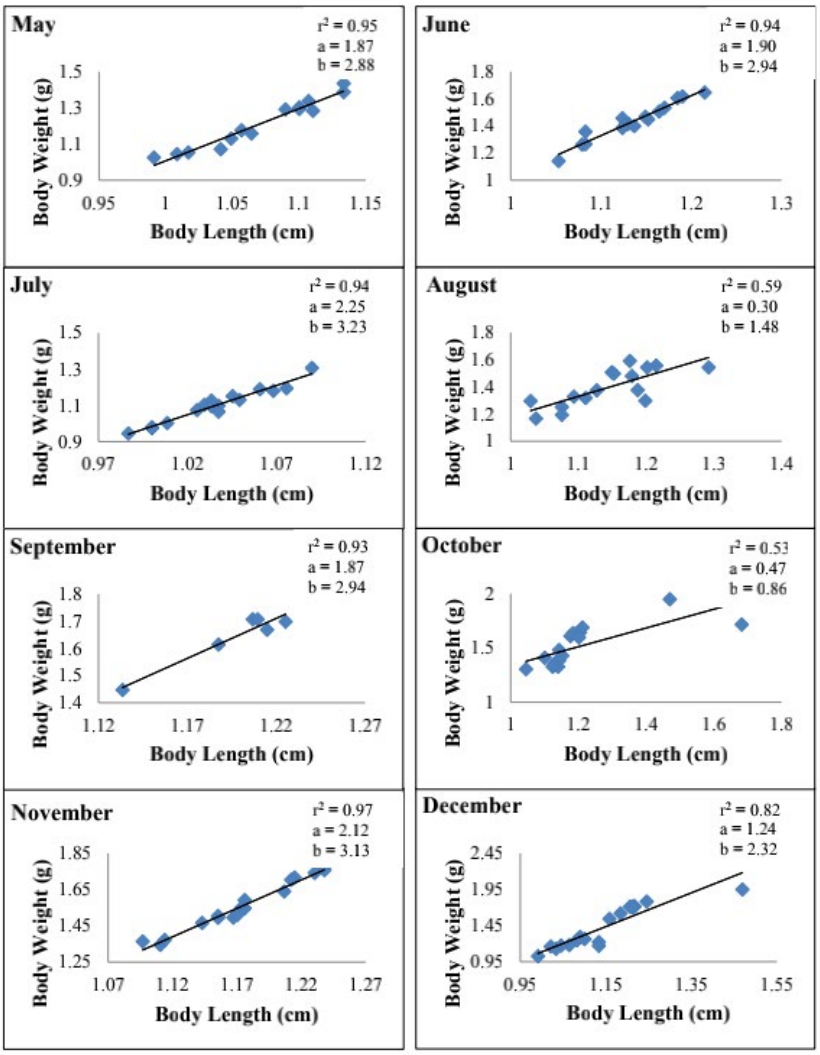

Figure 3b: Length-weight relationship of male *Johnius borneensis* in Lower Agusan River basin from the month of May 2017 to January 2018.

Table 1: Length-weight relationship of *Johnius borneensis* collected from May 2017 to January 2018.

Month	Sex	n	a	b	r^2
May	Male	14	1.87	2.88	0.95
	Female	18	2.41	3.38	0.95
June	Male	16	1.90	2.94	0.94
	Female	25	2.32	3.31	0.97
July	Male	16	2.25	3.23	0.94
	Female	20	2.16	3.14	0.89
August	Male	16	0.30	1.48	0.59
	Female	18	1.46	2.61	0.48
September	Male	6	1.87	2.94	0.93
	Female	27	2.44	3.42	0.96
October	Male	16	0.47	0.86	0.53
	Female	17	1.22	0.35	0.08
November	Male	17	2.12	3.13	0.97
	Female	15	2.49	3.46	0.96
December	Male	18	1.24	2.32	0.82
	Female	15	1.25	2.33	0.80
January	Male	0	0	0	0
	Female	30	0.26	1.22	0.11

cm to 48.1 cm while the body weight range from 8.81 g to 88.91 g. Female specimens are larger in size and are usually heavier than males due to the presence of reproductive products.

In all the studied months, strong correlation was showed in the regression analysis between the weight and length of *Johnius borneensis* except in females in the months of October and January (r^2=0.08 and r^2=0.11 respectively). Female individuals exhibited positive allometric growth (b>3) which indicates that when the fish weight increased, the body size would also increase. On the other hand, males growth pattern follows negative allometric growth (b<3). This growth pattern implies that the male specimens become slender or thinner as it increases in length. Growth of fish usually indicates the increased in length and weight which is an appropriate characteristics to determine the population analysis at a particular time.

Similar results have been found out in the LWR and regression analysis of *J. borneensis* in Lower Agusan River basin in which female specimens possess positive allometric growth (b=3.35; r^2=0.98) while male follows negative allometric growth (b=2.90; r^2=0.88)[3]. Other sciaenids studies revealed that both male and female species follows positive allometric growth such as in *Johnius sina*, *Johnius macropterus*, *Johnius dussumieri*, and *Dendrophysa russelli* which had (b>3) value [11].

Variation in the LWR can be substantial depending on the population, season and environmental conditions [12]. In addition, sorting into classes, sex, state of the stomach and maturation are some of the factors that affect the well-being of fish individuals [13].

Sexual maturity

Fish gonads undergo morphological changes before they reach at full maturity. This change is the maturation of the fish gonads. The stages of gonad maturation are based on common visible macroscopic features in the gonads of both male and female with different phases of reproductive cycles. Sexual maturity of *J. borneensis* was shown in Table 2.

There were more immature, maturing virgin and maturing specimens (stage I, II and III) caught in the month of June 2017 as depicted in Table 2. In September more matured, gravid and spawning individuals (stage IV, V and VI) were recorded in females.

Sciaenids species exhibit a single spawning season but appeared to be in two batches which is in the months of April and September [3,10]. The minimum body length for mature (stage IV) female fish is 10.2 cm, gravid (stage V) with 10.9 cm, spawning (stage VI) individuals is 10.4 and for spent (stage VII) is 14.4 cm while male specimens with 10cm, 10.5 cm, 10.7 cm and 13.9 cm for stages VI, V, VI and VII respectively. Based from the other studies of *J. borneensis*, the first length at maturity is above 13.7 cm were mature and below 11.5 were immature [3]. Although, sciaenids fish species matures at the size of 14-16 cm total body length [4]. Other literature reviews shows that *J. sina*, *J. dussumieri*, *J. macropterus* and *D. russelli* matured at the size of 15.2 cm, 16.8 cm, 13.6 cm and 14.4 cm, respectively. Advanced maturity stages of *J. dussumieri* was observed in the months of March, April, June, August and September which indicates spawning season between the months of March and September [11].

Sex ratio

From 304 specimens of *J. borneensis* caught and examined, 185 were females and 119 were males giving a sex ratio of 2:1. Table 3 shows preponderance of female over male individuals. The dominance of the fish sex is due to the schooling behavior, growth and its maturity. Female bias may result to less energy input of females towards reproduction thereby lowering female mortality [14].

Gonadosomatic Index

Gonadosomatic index has always been reliable for gonad maturity

Table 2: Maturity stages of *Johnius borneensis* from May 2017 to January 2018.

Month	Sex	Stage							Total
		I	II	III	IV	V	VI	VII	
May	Female	0	2	4	5	5	2	0	18
	Male	0	7	0	3	2	2	0	14
June	Female	0	4	4	3	6	8	0	25
	Male	2	6	2	4	2	0	0	16
July	Female	0	4	5	2	3	6	0	20
	Male	1	4	3	4	0	4	0	16
August	Female	0	3	4	3	2	6	0	18
	Male	0	2	4	7	2	1	0	16
September	Female	0	0	0	2	9	16	0	27
	Male	0	0	1	1	2	2	0	6
October	Female	1	0	3	5	2	4	2	17
	Male	1	5	3	3	2	2	0	16
November	Female	0	3	1	2	3	5	1	15
	Male	2	1	9	3	0	0	2	17
December	Female	0	2	3	5	1	4	0	15
	Male	0	4	5	5	2	2	0	18
January	Female	1	6	5	2	3	9	4	30
	Male	0	0	0	0	0	0	0	0

and spawning estimation of every fish species. Calculated testicular and ovarian GSI value of *J. borneensis* was expressed in percentage in Table 4 with graphical illustrations in Figure 4a and Figure 4b.

Result shows that the ovarian GSI increases in the month of August, peaking in September and declines in October when fully spent ovaries were observed (Figure 4a). Recrudescence of the ovary was observed in the month of November to January. The testicular GSI was higher in May and September as shown in Figure 4b.

Months with the highest peak in the GSI indicates the spawning season of fish species. The increase in the GSI value indicates the development of the gonads [15]. Literature reviews revealed that sciaenids fish species have single spawning season but occur in two batches [10]. Similar result has been recorded in *J. elongatus* in which the GSI values for the male and female species exhibits sharp peaks during the months of April and September [10]. The mean GSI value varies from month to month. A monthly change of the GSI values not only reflects the spawning season but it also indicates the ovarian activity or reproductive cycle of every fish species [16].

Female fish species usually have higher GSI value than in males. This means that the body weight is inversely proportional to its gonad weight. However, female species have heavier gonad weight due to the presence of eggs contained in the enlarged ovary when it reaches its maturity stages. Low value of the GSI in case for male species was due to very low energy investment during gamete production [16].

Fecundity estimation

Fecundity was determined from 130 females with different sizes and weight ranges. Estimated fecundity from stage IV to stage VII was shown in Table 5. Highest number of spawning female individuals and highest fecundity was observed in the month of September which leads to the conclusion that September was one of the spawning seasons of *J. borneensis*. Based from the other study of *J. borneensis* in the Lower Agusan River, this species also spawns in the month of April [3]. These results are provided from the fact that the reproductive biology of sciaenids fish species spawns once a year but in two batches [10]. Similarly, *J. elongatus* species also spawns twice a year from the month of January-February to March-April and August-October with a resting period in the months of June and July [10].

Fish fecundity varies according to many factors which include age, size, type of fish, seasons and availability of their food [7]. Knowledge on the fecundity is essential to determine the spawning potentials and its success.

Table 3: Sex ratio of *J. borneensis*.

Stage	Counts		Sex ratio		Total	Ratio %
	Female	Male	Female	Male		
I	2	6	1	3	8	2.63
II	24	29	1	1	53	17.43
III	29	27	1	1	56	18.42
IV	29	30	1	1	59	19.41
V	34	12	2	1	46	15.13
VI	60	13	4	1	73	24.01
VII	7	2	3	1	9	2.96
Total	185	119	13	9	304	100
Mean			**2**	**1**		

Table 4: Mean GSI of *J. borneensis* in different months.

Month	No. of female	GSI%	No. of male
May	18	1.94	14
June	25	2.24	16
July	20	1.82	16
August	18	2.07	16
September	27	2.80	6
October	17	1.32	16
November	15	1.36	17
December	15	1.74	18
January	30	1.66	0
Total	**185**		**119**

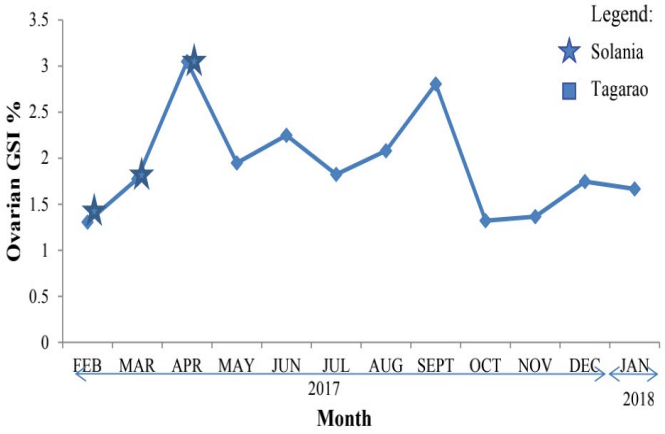

Figure 4a: Mean GSI value of female *J. borneensis* from Lower Agusan River basin. Note that only gonads from stages IV to VII were reflected.

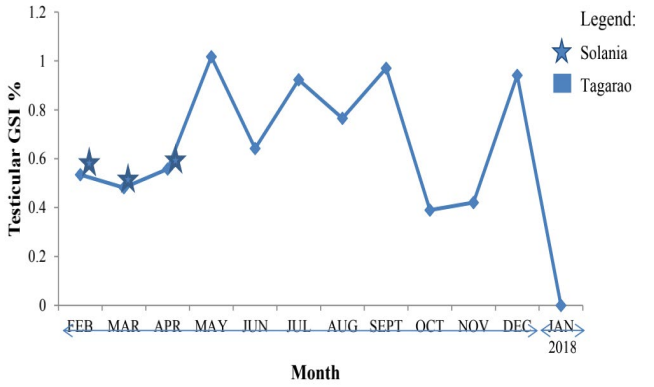

Figure 4b: Mean testicular value of male *J. borneensis* from Lower Agusan River basin. Note that only gonads from stages IV to VII were reflected.

Table 5: Fecundity estimates of mature and spawning female of *J. borneensis*.

Stage	Number of individuals	Estimated fecundity range (No. of eggs)
IV	29	2,750 - 584,200
V	34	5,500 - 649,050
VI	60	8,800 - 1,450,450
VII	7	94,750 - 448,550

Fecundity-length relationship

The fecundity-length relationship of *J. borneensis* shows low correlation coefficient as shown in Table 6. This means that the body length was not correlated to its fecundity. Low correlation can be attributed to the size and general structure of the fish [10]. Similar results have been found out in *J. borneensis* in the Lower Agusan estuary in which their fecundity was also not correlated to its body length (r^2=0.0006) with a very low correlation coefficient [3].

When the fecundity and body length was not correlated, this means that even though the fish species was about to reach its maximum body length, the female gonads are still not mature thus, not capable for spawning. In short, the body length is not a determination for bringing out the fecundity of the female gonads.

Fecundity-weight relationship

Table 7 shows the fecundity-weight relationship of *J. borneensis* with low correlation coefficient. This result is similar to the other study of *J. borneensis* in Lower Agusan River basin with r^2=0.38 which means the fecundity was not correlated to its body weight [3]. These findings are not in accordance to the fecundity and body weight of other sciaenids studies in which it shows strong correlation coefficient (r^2=0.87) in its relationship [10]. This relationship can be accounted to the fact that the caught samples are less of having heavier gonads. Moreover, June, August and September shows positive correlation. This relationship suggests that the heavier the gonads the higher the fecundity is. This only implies that as the body weight increases the fecundity also increases in a geometric fashion.

CONCLUSION

Johnius borneensis exhibit a short reproductive period. Female individuals are already capable for spawning at small sizes with a size ranged of 10.2-35.9cm. Seasonal timing of the reproduction was identified from the alterations in the GSI that determine the reproductive or spawning season of every fish such as their ovarian activity. GSI value is always species specific. Fecundity-length and fecundity-weight showed low correlation and no significance in its relationship may be due to the size of fish samples. This can be accounted to the fact that the caught samples are less of having heavier gonads. It has also been observed that the gonads of both sexes changed their shape, size, color and other morphological aspects in different stages of gonad maturity.

Table 6: Significant relationship between the length and fecundity of collected fish samples across the months of assessment.

Month	Correlation coefficient	P-value	Remarks
May	0.34	0.27	Not Significant
June	0.45	0.06	Not Significant
July	0.03	0.91	Not Significant
August	0.60	0.50	Not Significant
September	0.62	0.00	Significant
October	-0.03	0.91	Not Significant
November	0.39	0.22	Not Significant
December	-0.27	0.43	Not Significant
January	0.23	0.06	Not Significant

*Significant when p-value is less than 0.05 level of significance

Table 7: Significant relationship between weight and fecundity of *J. borneensis* samples across the months of assessment in Lower Agusan River basin

Month	Correlation coefficient	P-value	Remarks
May	0.36	0.23	Not Significant
June	0.56	0.01	Significant
July	0.01	0.97	Not Significant
August	0.72	0.01	Significant
September	0.64	0.00	Significant
October	0.06	0.83	Not Significant
November	0.24	0.46	Not Significant
December	-0.24	0.50	Not Significant
January	0.44	0.06	Not Significant

*Significant when p-value is less than 0.05 level of significance

RECOMMENDATIONS

Assessing the yearly breeding of *J. borneensis* is important to have a success in fish culture and to create an effective management in fisheries. April and September are the spawning season of *J. borneensis* therefore fishing is strictly restricted during these months. There should be a long-term monitoring of the study in its reproductive phenology with increased number of samples for more reliable data. Moreover, histological characteristics of the gonads should also be performed to further characterize the oocytes and spawning characteristics in the fish.

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