Population Abundance and Reproductive Biology of *Sillaginopsis panijus* (Hamilton-1822)

Khin Thuzar Win[1], Kalayar Win Maung[2]

Abstract

The present study was conducted the seasonal abundance and reproductive biology of *Sillaginopsis panijus* from January 2018 to December 2019. Total population were 1644.42 ± 314.42 individuals in 2018 and 1562.5 ± 239.28 individuals in 2019.The largest individuals of captured 37 cm of male and 43 cm of female. The sex ratio of male to female (1:2) was observed. The reproductive cycle had been identified through the seasonal variation of the GSI, HSI and K. Significant but reverse correlation was observed for GSI to HSI and K. The highest GSI value of male was recorded in August 6.38% whereas female GSI is highest in August 19.46%. Similar pattern of spawning periods were found in both sexes of *Sillaginopsis panijus.* Six histological stages of gonadal development were recorded.

Key Words: *Sillaginopsis panijus*, population, GSI, HSI, Sex ratio

Introduction

Myanmar possesses a long coastal line and many rivers and lakes for our fishery sector to play a vital role in providing human food supply and family income. The highest amount of fish is produced from the river. The abundance of fish species and aquatic products of the inland rivers are important earnings for the people of Myanmar. Bago River is one of the rivers in Myanmar. It is being a tidal river, it has regular rise and fall of the tides. People along the river rely on fishing for their livings.

Fisheries provide much of the human diet in many parts of the world. Fishes, like many other forms of life, are of immense value to mankind. They have long been a staple thing in the diet of many peoples. Nowadays they form a vital component in the economy of many nations.Family Sillaginidae is restricted numbers and distribution. They spend their lives in the mouths of estuaries. *Sillaginopsis panijus* is found in estuaries and brackish waters of rivers, seas of India and Myanmar. It is commonly known as Whiting and locally called Nga-pa-lway in Myanmar. It can be found more or less throughout the year. The mark of this species is the second spine. Its spine is elongated into a filament as far back as to the base of the caudal fin.

The scientific knowledge of the reproductive biology of fish population is imperative for effective management and understanding of fish population dynamics (Nikolsky, 1969).

Reproduction represents one of the most important aspects of the biology of a species, because the maintenance of viable populations depends of its success (Agostinho and Suzuki, 1999). The reproductive cycles of fish are known to be closely correlated with annual seasonal changes in their environment due to seasonal variation in development of gonads. Species composition, abundance and distribution of fishes along the Bago River have been well documented by previous workers. The biology of *Sillaginopsis panijus* has not yet been studied and these species are common throughout the year in the study area.

The present study was conducted to investigate the population abundance of *Sillaginopsis panijus* based on the daily catch number and weight, to analyze the reproductive biology relation to their some environmental factors and to examine the developmental stages of gonads by histological examination.

[1] Lecturer, Department of Zoology (Fisheries & Aquaculture), University of Yangon
[2] Associate Professor, Department of Zoology, Hakha University

Materials and Methods

The study area was located between Thanlyin Bridge No.1 (N 16◦ 47' 4" E 96◦ 14' 5") and kalawel village (N 16◦ 49' 45" E 96◦ 17' 51") in Bago River, Thanlyin Township, Yangon Region.

The study period lasted from January 2018 to December 2019.

Collection and identification of specimens

Monthly visits were made to the chosen study site where fishing was mainly done by Bag-net which was set once in the morning and once in the evening. Collection fishes were measured as their total length and weight by centimeter and gram. Gonads and livers were weighed fresh and preserved in 10 percent buffered formalin. The fish species were identified according to Talwar and Jhingran (1991) and Ferraris Jr. (1997).

Recording fish population

Seasonal abundance of fish species were assessed from daily catches.

Breeding analysis

A total of 480 specimens were dissected fresh to examine the gonads and gonadal development.

$$\text{GSI} = \frac{\text{Weight of the gonad}}{\text{Weight of the fish}} \times 100 \text{ Agarwal (1996)}$$

$$\text{HSI} = \frac{\text{Liver weight}}{\text{Whole body weight}} \times 100 \text{ Wingfield and Grimm (1977)}$$

$$\text{K} = \frac{\text{Body weight - gonad weight}}{\text{Length}} \times 100 \text{ Jones (1970)}$$

Gonad samples were taken for further histological examination according to Harris’s Hematoxylin and Eosin methods and identification of the stages of oocytes and spermatocytes was according to Agarwal (1996). Six stages of oogenesis were defined as oogonia (stage I), primary oocyte (stage II), secondary oocyte (stage III), primary vitellogenesis (stage IV), secondary vitellogenesis (stage V) and tertiary vitellogenesis (stage VI).Six stages of spermatogenesis were recorded as spermatogonia (stages I and II), spermatocyte (stages III and IV), spermatid (stageV) and spermatozoa (stage VI).

The data were analyzed by Chi-square test, Student's "t" test performed by Microsoft Office Excel programs and Pearson's Correlation Coefficient test using Statistical Package for Social Science (SPSS) Version 26.

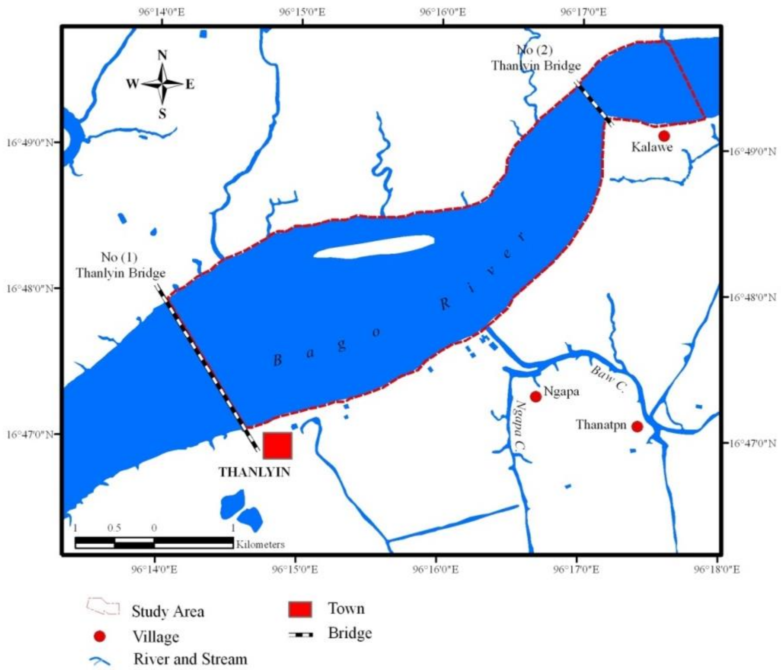


Fig.1. Location map of study area

Source: Village and Town based on Topographic Map (1:63360), Map No.94 D1 and 94 D 5, Water Body based on Landsat TM 7 (2010)

Results

Sillaginopsis panijus was monthly collected in Bago River from January 2018 to December 2019.

Fig.2 Morphology of *Sillaginopsis panijus*

Population abundance

The total catch number was 51.28% in 2018 and 48.72% in 2019.Both catch number and weight were not significantly different between 2018 and 2019 ($p>0.05$). During the studied years the catch number of the fishes was lower in hot season and then steadily increased from June till December.Catch number and weight showed highly significant difference in 2018 ($p<0.01$). However in 2019, catch number was highly significant ($p<0.01$) but was not significantly different catch weight ($p>0.05$) between seasons (Fig.3, Table 1).

Table 1. Seasonal mean catch number and weight (kg) in 2018 and 2019

Year	Season					
	Hot		Wet		Cool	
	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)
2018	847 ±435.60 (17.17%)	263.03 ±140.28 (22.23%)	1499.75 ±371.96 (30.40%)	399.48 ±113.39 (33.80%)	2586.50 ±419.04 (52.43%)	519.55 ±83.50 (43.95%)
2019	734.5 ±247.22 (15.67%)	296.88 ±176.71 (23.42%)	1868.25 ±291.08 (39.86%)	478.65 ±132.12 (37.76%)	2084.75 ±326.39 (44.47%)	491.95 ±116.99 (38.81%)

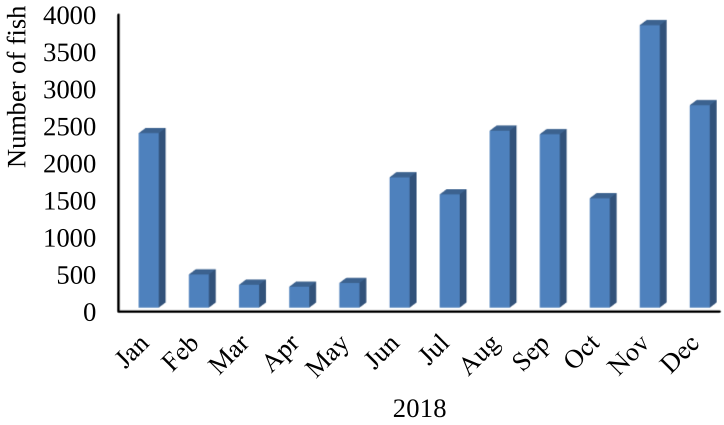


Fig.3 Monthly fish population of *Sillaginopsis panijus* in 2018

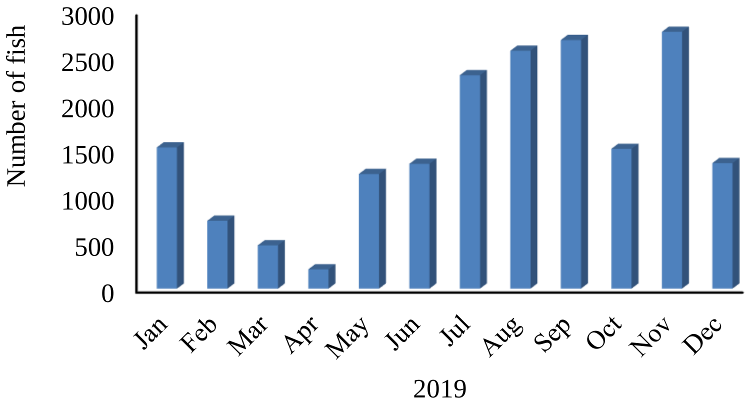


Fig.4 Monthly fish population of *Sillaginopsis panijus* in 2019

Correlation between population abundance of *Sillaginopsis panijus* and water parameters

In 2018, negative correlation with water temperature, salinity and DO and positive correlation with BOD were highly and significantly correlated with the population abundance ($p<0.01$).In 2019, salinity and alkalinity were highly significant negative correlation with population abundance ($p<0.01$) and pH was significant but negatively correlated to abundance ($p<0.05$) (Table 2)

Table 2. Correlation between population of *Sillaginopsis panijus* and water parameters (Analysed by Pearson's Correlation Coefficient Test)

Year	Value	Water temp:	p^H	Salinity	Alkalinity	DO	BOD
2018	r	- 0.711**	0.130	-0.749**	- 0.347	- 0.761**	0.802**
	p	0.009	0.688	0.005	0.269	0.004	0.002
2019	r	- 0.138	- 0.638*	-0.745**	- 0.787**	- 0.387	0.048
	p	0.668	0.026	0.005	0.002	0.213	0.883

* Correlation is significant at the 0.05 level

** Correlation is highly significant at the 0.01 level

Sex ratio of *Sillaginopsis panijus*

Females outnumbered males. The percentages of males and females were 38.52% and 61.48% in 2018; 39.47% and 60.53% in 2019 respectively. Especially in August 2018, the female population was highly and significantly more than male population (χ^2=8.02, d_f=1, p<0.01).In April and November 2019, the male population was more than female population but they were not significantly different (p>0.05) .During studied period, male and female sex ratio of *S.panijus* was 1:2(Fig.4).

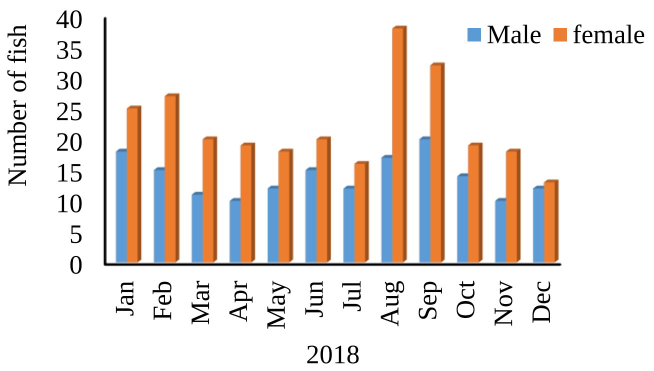


Fig. 5 Monthly sex ratio in 2018

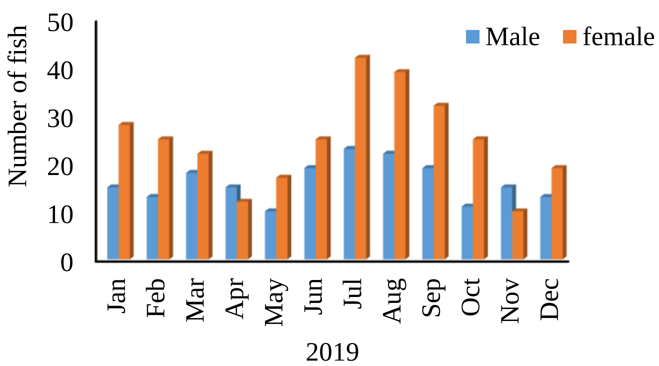


Fig. 6 Monthly sex ratio in 2019

Reproductive conditions of *Sillaginopsis panijus*

During the spawning season, the body of female and male become greenish-yellow colour. Especially, males were brighter in colour. No sexual dimorphism was observed. Two reproductive cycles in male and female were observed in a year with similar reproductive development. The first spawning period was in January to February and the second in August to September. The resting period was observed between March and November. The male spawning period coincided with that of female. The GSI of female *Sillaginopsis panijus* was significantly negative correlated with HSI and K in both the studied years. In male, significantly negative correlated with K, but not with HSI ($p>0.05$) were observed in both years (Table 3). The GSI value of female was higher than male during the study period. Monthly mean value of GSI, HSI and K of male and female in 2018 and 2019 were shown in Fig. 7,8,9,10.

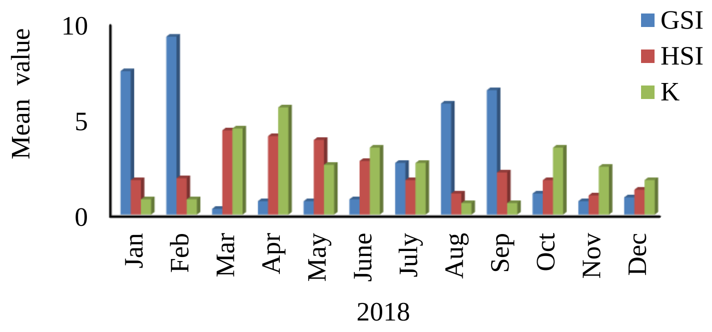


Fig.7 Monthly mean value of GSI, HSI and K of male in 2018

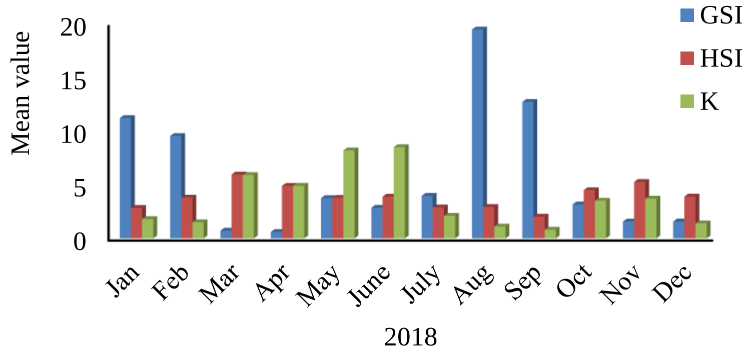


Fig.8 Monthly mean value of GSI, HSI and K of female in 2018

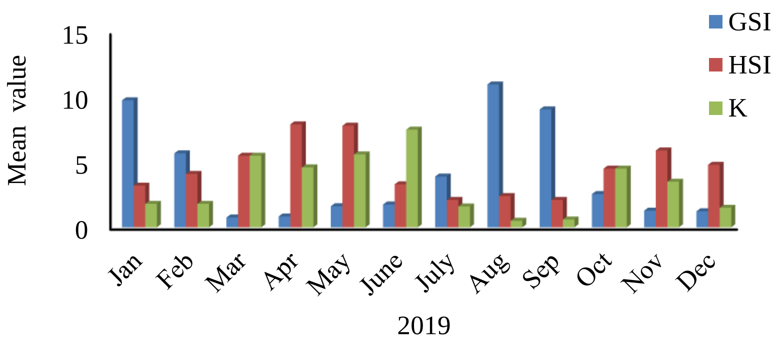


Fig.9 Monthly mean value of GSI, HSI and K of male in 2019

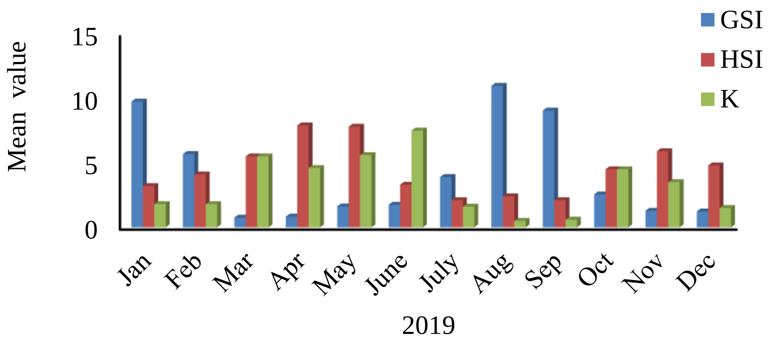


Fig.10 Monthly mean value of GSI, HSI and K of female in 2019

Table 3. Correlation between GSI, HSI and K in 2018 and 2019

Year	Value	Female		Male	
		HSI	K	HSI	K
2018 GSI	r	- 0.719**	-0.572*	-0.108	-0.633*
	p	0.008	0.052	0.739	0.027
2019 GSI	r	-0.695*	-0.713**	-0.399	-0.787**
	p	0.012	0.009	0.199	0.002

Histological examinations of gonads

Sillaginopsis panijus was observed to have similar gonadal development with six stages of oogenesis and spermatogenesis.

Oogenesis of *Sillaginopsis panijus*

Oogonia (Stage I) -The oogonia were small and spherical. They were arranged in small groups in the lamellar epithelium.

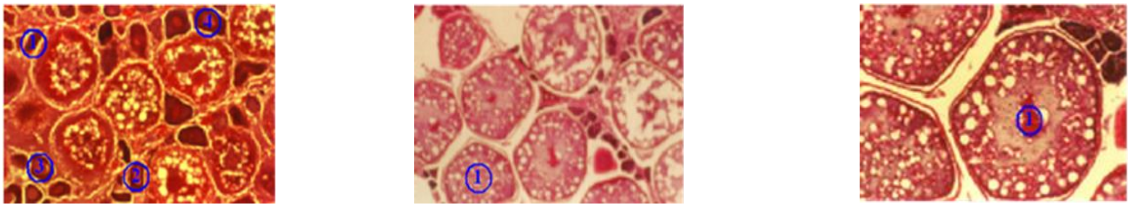
Primary oocyte (Stage II) -The size of nucleus and cytoplasm were larger than the oogonium and the number of nucleoli increased.

Secondary oocyte (Stage III) -The size of nucleus and cytoplasm increased.

Primary vitellogenesis (Stage IV) -Vitellogenesis initiated with the vascularization of the oocyte. Primary yolk appeared at periphery. Nucleus and cytoplasm continued to grow.

Secondary vitellogenesis (Stage V) - Oocytes contained yolk granules and large vacuoles. The nuclear membrane disintegrated.

Tertiary vitellogenesis (Stage VI) - The ovary was densely packed with vitellogenic oocytes and ova with hydrated yolk. Nucleus disappeared due to heavy yolk accumulation.



A. Various stages of oocytes (100µm)
1. oogonia
2. primary oocyte
3. secondary oocyte
4. primary vitellogenesis

B. Vitellogenesis (100µm)
1. secondary vitellogenesis

C. Late vitellogenesis (100µm)
1. tertiary vitellogenesis

Plate 1. Microscopic examination of ovary showing oocytes in various stages

Spermatogenesis of *Sillaginopsis panijus*

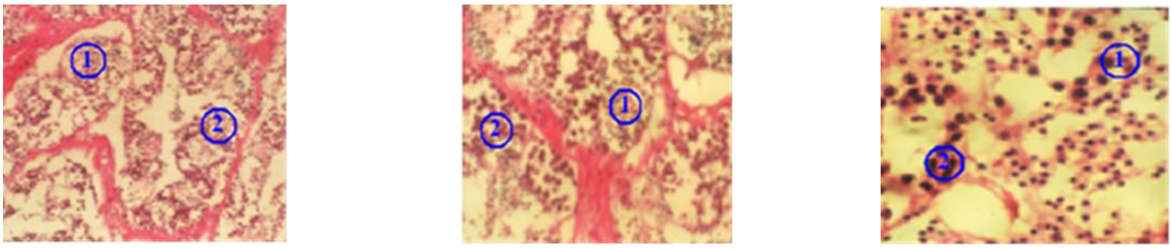
Spermatogonia (Stage I)-Spermatogonia possessed a large round nucleus and one or two distinct round nucleoli. The cells were spherical in shape.

Secondary spermatogonia (Stage II)-The secondary spermatogonia were structurally similar to spermatogonia except in their sizes.

Primary spermatocyte (Stage III)-The primary spermatocyte were morphologically similar to spermatogonia and secondary spermatogonia.

Secondary spermatocyte (Stage IV)-These stages were smaller in size than the primary spermatocytes.

Spermatids (Stage V) -The spermatids were spherical in shape and dark appearance. Spermatozoa (Stage VI) - Spermatozoa were fully developed in the lumen of the seminiferous tubules. These were the functional male gametes.



A.Spermatogonial stages(100µm)
1. primary spermatogonia
2. secondary spermatogonia

B. Spermatocytes stages(100µm)
1.primary spermatocyte
2. secondary spermatocyte

C. Late stages (100µm)
1. spermatid
2. spermatozoa

Plate 2 . Microscopic examination of testis showing spermatocytes in various stages

Discussion

Population of *Sillaginopsis panijus* in 2018 was more than that of 2019 in which the salinity was high. Win Win Than (2007) stated that the reduced number of brackish water fish species could be related to salinity level in the river water. Maximum catches were observed in low salinity during wet and cool season of 2018.Thus, *S.panijus* could be regarded as euryhaline fish.

Rainfall may also play an indirect role in the population abundance of studied fish species. Since the volume of water increased due to heavy rainfall which consequently caused to decrease the salinity and thus affecting the population of fish. Due to the present finding, high pH value was recorded in 2019 than in 2018. Harvey .,*et.al* (1984) stated that high pH value which lead to the high acidity and low metabolic rate for the fishes in that water and the number of fish populations lost due to acidic deposition. Thus it can be assumed that *S.panijus* was adapted to high pH and acidity.

Nikolsky (1963) stated that temperature is one of the important factors influencing population richness and the increases of activities in life. Linde and Grau (2009) observed the large size at maturity could be related to the lower water temperature. Other differences in environmental conditions, food availability and quality of food resources can influence on their size difference at maturity and the growth of fish and further affect the age of first maturity (Tormosova, 1983).The water temperature may have some effects on the population abundance of the studied fishes.

Increase in alkalinity was recorded from November to April in both years. Breeding seasons of the studied fishes were found to overlap during November to April with increased alkalinity. Thus, more population was recorded in cool season. Nikolsky (1963) observed diverse species of fishes are adapted to live at different concentrations of dissolved oxygen. The population abundance of *Sillaginopsis panijus* was found to be highly significant negative correlated with DO in the river water in both years. This finding is agreement with that of Nikolsky (1963).

Females were observed to be bigger than males. Lagler (1956) stated that most of the vertebrates particularly females are larger than males. This condition was common in lower vertebrates. In the present study, the reproductive cycle of studied species were identified through the seasonal variation of the gonadosomatic index. Gonadosomatic index provides a useful general indication of breeding. Size of both sex organs increase as it attained the stage of maturity to produce fully matured gametes. Maturity estimations was based on monthly changes in gonadosomatic index in both sexes.

In *Sillaginopsis panijus*, male and female sex ratio was 1:2 during studied period. The minimum size at first maturity was attained at a length of 12 cm.Mc Kay (1992) stated that the minimum size at first maturity attained about 12 cm in *S.panijus*.During the spawning season of *Sillaginopsis panijus* ,the females and males become greenish-yellow colour on the body especially in males with brighter in colour. Change in the colour of fish during the breeding season was also reported by Lagler (1962). A mark of sexual distinction was colouration in fishes. Generally, the males are brighter color than the females. Seasonal pattern of reproduction was similar in male and female.

Reproductive period of both sexes in *Sillaginopsis panijus* was in January, February and August. Mc Kay (1992) also stated that *S. panijus* probably spawn twice a year during the periods from November to February and August to September. It may be assumed that *S. panijus* were continuous breeders . Lowe-Mc Connell (1987) presented that fish species in tropical river systems are particularly noted for very rapid maturation and multiple spawning behaviour is an adaptive response to fluctuations in water level.

Negative correlation between the values of GSI, HSI and K were observed.The HSI values declined with corresponding increase in GSI values. This is because fat reserves stored during prespawning period were mobilized towards the developing ovaries. Wootton (1990) also stated that the liver weight (HSI) decreased as the ovary weight increased during vitellogenesis. This showed that HSI have reverse action on GSI. Similar condition was recorded in the present study, ova in the ovaries attained highest maturity with heavily laden yolk in the breeding time.

Condition factor (K) remains constant throughout the study period with a slight drop in the index when the cessation of spawning. Jones (1970) reported that the body weight (condition factor K) was found to be the lowest after the fish has spawned. It could be concluded that female GSI has negative correlation to HSI and K. The males showed a general pattern similar to females although with minor variations during the reproductive period. No significant correlation between female GSI with water and meteorological parameters. It may be assumed that the timing and duration of spawning probably coincided with environmental conditions are favourable for survival and growth of larvae. In *Sillaginopsis panijus*, the maturation of sex organs are rhythmic and overlapped in both male and female. Billard and Breton (1978) reported that rhythms of reproduction in teleost fish. In “Rhythmic activity of fishes” is often associated with rainfall and floods in the tropical and sub-tropical species.

Histological examinations were observed to be similar in gonadal development having six stages of spermatogenesis and oogenesis. Based on the information given by the local fishers, the fish population is declining year after year as the fish are in high demand for local consumption as well as for export product. Thus, awareness on over exploitation of the fish species should be considered to prevent the fish species from going into extinction.

Conclusion

Information on the length at first maturity is of use in assessing the spawners lost from the stock by fishing. No significant difference in population abundance between both years. The sex ratio was recorded in 1:2. No sexual dimorphism was noted but females were generally larger than males. Similar seasonal pattern of reproductive cycle was noted in male and female .The spawning period was observed as January to February and August to September for both sexes. Reproductive biology also may assist fishery scientists and conservationists to develop sustainable management.

Acknowledgements

I am greatly indebted to Dr. Tin Maung Tun, Rector, University of Yangon. My deepest obligation goes to Professor Dr.Kay Lwin Tun, Head of Zoology Department, University of Yangon, for her permission.

References

Agarwal, N. K. 1996. *Fish reproduction*. Publishing Corporation, New Delhi, 157 pp.

Agostino, A.A., Suzuki, H.I. 1999. Patterns of colonization in Neotropical reservoirs and prognoses on aging. *Theoretical Reservoir Ecology and its Applications*. pp 227-265.

Billard, R, Breton, B. 1978. Rhythms of reproduction in teleost fish. In “Rhythmic activity of fishes”. Academic Press, New York. pp 31-53.

Froese,R.;Pauly,D.2014.‘‘*Sillaginopsispanijus*”inFishBase. <http://fishbase.sinica.edu.tw/summary/Sillaginopsis-panijus>

Hora, W.S., 1957. *The Gonads and Reproduction*. *The Physiology of Fishes.* Volume I, Academic Press Inc, Publisher, New York. pp 285-317.

Islam, M.R., Sultana, N., Belal Hossain, M., Mondal, S. 2012.Estimation of fecundity and gonadosomatic index of gangetic whiting, *Sillaginopsis panijus* (Hamilton, 1822) from the Meghna river estuary. World Applied Science Journal 17 (10), pp1253–1260.

Jones, A. 1970. Some aspects of the biology of the turbot (*Scaphthalmus maximus* L) with special reference to feeding and growth in the juvenile stage. *PhD Thesis*, *University of East Anglia*, *kk*. 145 p.

Kan Myint**.** 1996. A fishery survey of the Bago River, Estuary (Esturine region), *MSc Thesis*, University of Yangon. 288 p.

Krishnayya, C.G. 1963. On the use of otoliths in the determination of age and growth of the Gangetic whiting, *Sillago panijus* (Hamilton), with notes on its fishery in Hooghly estuary. Indian Journal Fish.10, pp 391–412.

Lagler, K.F., Bardach, J.E., Miller, R.R. 1962. *Ichthyology* John wiley and Sons, Inc, Toppan Printing Co., Ltd. New York, 545 p.

Lagler, K.F., Bardach, J.E., Miller, R.R., Passino, D.R. 1977. *Ichthyology*, 2nd edition. John Wiley and Sons, New York.

Le Cren, E.D.1951. The length-weight relationship and seasonal cycle gonad weight and condition in the perch (*Perca fluviatilis*) *Journal of Animal Ecology*, Oxford 20:

pp 201-219.

Lowe-Mc Connell, R.H. 1987. *Ecological studies in tropical fish communities*, 1st edition. Cambridge University Press, Cambridge,382 p.

Mc Kay, R.J. 1992. FAO species catalogue: Volume 14. Sillaginid *fishes of the world*. Rome: Food and Agricultural Organization, pp 19 – 20.

Nelson J.S**.** 1976. *Fishes of the world*. A Wiley Interscience Publication, John Wiley and sons, New York 416 p.

Nikolsky, G.V. 1969. *Theory of Fish Population Dynamics*. Oliver and Boyd, Ltd. Edinburgh 323 p.

Talwar**,** P.K., Jhingran, A.G. 1991. *Inland fishes of India and adjacent countries.* Oxford, IBH Publishing CO. PVT. LTD; New Delhi; Bombay. Volume I and II, 1158 p.

Wingfield, J.C., Grimm. A.S. 1977. Seasonal changes in the plasma cortisol, Testoterone and Oestradiol 17- beta in the Plaice, *Pleuronectes platessa* L. Gen. Comp. *Endocrinology* 31 (1): pp1-11.

Wootton, R.J. 1990. *Ecology of Teleost Fishes*, 1st edition. Chapman & Hall, London.