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Reproductive Biology of *Terapon jarbua* from the Estuary of Tamshui River

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Like most of estuarine fishes, occurrence of *Terapon jarbua* reveals a clear seasonal pattern, with a mass invasion of larvae and juveniles to the river mouth during May and November for feeding, and retreats to the farther deeper ground for spawning when fully grown. The prolonged spawning takes place during April and October, or even longer, determined by the monthly observations of gonad conditions and the occurrence of postlarvae and juveniles. The cycle of liver lipid content is more or less in agreement with the reproductive cycle of the fish. *T. jarbua* is a protogynous fish with the sex reversal commenced at the fish of larger than 10.5 cm in fork length (FL). Among the adults, female is outnumbered with the proportion of 1.8: 1 to the male. This species seemed to be a fractional spawner. Batch fecundity ranged 37,083–480,400 (mean 145,816) which is equivalent to the relative fecundity of 334–1,258 (520) per gram body weight. Biological minimum size of maturation is 143 mm FL for male and 148 mm FL for female.

Key words: Terapon jarbua, Tamshui estuary, Gonad condition, Spawning season, Sex ratio, Fecundity, Larval occurrence.

關鍵詞：花身鷄魚，淡水河口，生殖腺狀況，產卵季節，性比，抱卵數，仔稚魚出現。

INTRODUCTION

Terapon jarbua (Forskal) belonging to the family Teraponidae, is a medium-sized food fish that inhabits the inshore and brackish waters of much of the tropical and subtropical Indo-Pacific regions on sandy bottoms. This species is widely distributed from southern Japan to northwestern Australia and extending westwardly to South Africa. In Taiwan, this species occurred around most of the coast of Taiwan except the abruptly deep eastern coast, and is a popular game fish for anglers and caught mainly for food. Larvae and juveniles of the species enter the estuaries with great abundance during May and November for feeding, and retreat to the deeper water of farther away from the mouth of Tamshui river for spawning when fully grown. The adults are commercially caught by longliners and trawlers at the depth of shallower than 50 m. The fish from different habitats of Tamshui estuarine system may have link one another, being probably involved with the annual recruitment of the species. Reproduction is a main cause of the recruitment of the fish stock.

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This paper describes some aspects of the reproductive biology of *T. jarbua* in the estuary of Tamshui river (Fig. 1) in northwestern Taiwan. Despite the extensive range of the species throughout the Indo-Pacific region and ecological importance, little information have been published elsewhere on the biology of this species. Yet, Liu (1978) gave a brief account on the reproductive cycle and sex reversal of this species based on 89 specimens, and You and You (1987) stated a limited information on the experiments of stocking density for aquacultural purpose.

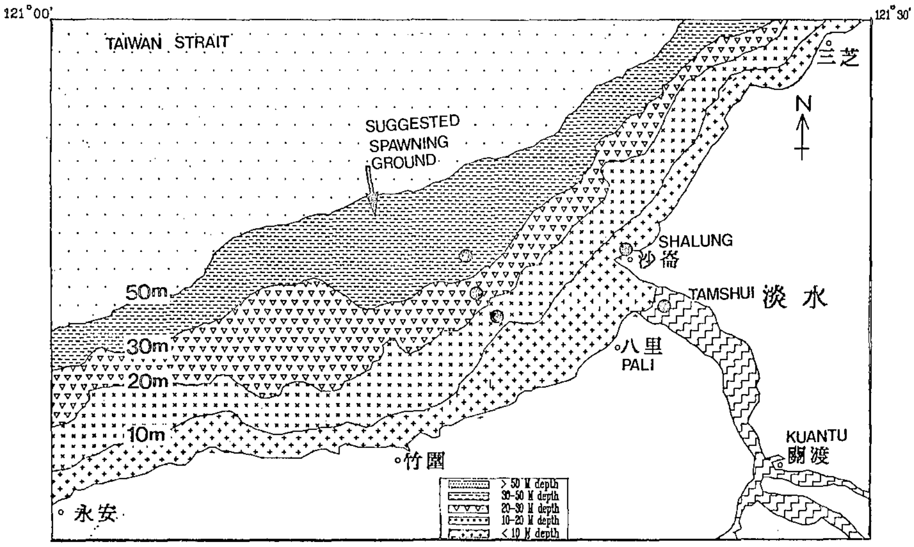

Fig. 1. Map showing sampling stations (black dots) around Tamshui river estuarine system, with water depths indicated.

Since the seasonality of increasing abundance of larvae and juveniles in the estuary during May and November is perhaps linked with the reproductive characteristics of adult population from the deeper ground, it is worthy to study in detail on this respect. Thus the descriptions should broadly include gonad maturity, sex ratio, ovum size frequency distribution, a conclusive information on the reproductive potential of this species will be uncovered.

MATERIALS AND METHODS

A total of 11,446 postlarvae and juveniles (10.4–103.7 mm FL) from the immeiate outlet of Tamshui river and 486 adults (120–319 mm FL) from farther outer deeper ground are used for this study. The adults were dissected with the gonad removed and weighed to the nearest 0.01 g. GSI (gonad somatic index) of each specimen was calculated from GSI = (Gonad weight/Body weight) $\times 10^3$. Mean diameter of 150 ova was measured along the long axis of eggs while magnified at 50× under the profile projector. Only eggs of larger than 0.1 mm were taken.

Absolute fecundity was estimated from the most advanced mode oocytes of stages III and IV from a piece of 0.05 g ovarian tissue. A total of absolute fecundity of known weight ovary were then obtained thereafter.

Gonad maturity stages were defined according to the microscopic examination of ovaries: stage I, immature or oogonium; stage II, previtellogenic stage including chromatin nucleus and perinucleus stage; stage III, vitellogenic stage including early yolk vesicle, late yolk vesicle, primary yolk globule and secondary yolk globule and tertiary yolk stages; stage IV, mature stage including migratory nucleus stage, germinal vesicle break down stage, with ripe eggs; stage V, spent. These criteria will be described detailedly in a separate forthcoming paper.

Total lipid was extracted with chloroform-methanoal (2/1 v) from liver and skeletal muscle on back, according to the method modified from Folch *et al.* (1956). Tissues were dried at 85°C for 12 h, prior to extraction. Total lipid was expressed as % weight of wet fresh tissues.

RESULTS

Seasonal change in gonad condition

As shown in Fig. 2, the GSI of both female and male gradually increase from January until April when the climax is reached, with the value of 15.14 and 4.17 respectively. In order to avoid a possible disadvantage due to sampling error, the data for mature and immature females were treated separately as indicated in Fig. 3. Subsequently, a clear seasonal pattern is expected. The sudden drop of GSI in May indicated the commencement of egg spent.

Size of oocytes

The ovum diameter polygons of size frequency distribution with respect to maturity stage were shown in Fig. 4. The progressive maturation of the ovary was indicated by the increase in the size of the modal groups of eggs. At the initial stage I (immature), only single modal size at 0.1 mm was observed, with very few reaching 0.2 mm, GSI not exceeding 2. When the most advanced eggs growing to 0.4 mm with the mode at 0.3 mm and with the GSI of 2.5–7.8, it was defined as stage II, or previtellogenic stage, at this stage, two modes of egg size were formed. In stage IIIa (early ripening or vitellogenic), two modes were formed: the first with the most advanced eggs of 0.4 mm at mode, and the second being 0.2 mm at mode. The above two modes were not yet widely discriminated, with GSI of about 10–12. In stage IIIb (late ripening or vitellogenic), two modes were clearly separated, with the GSI of 13–21. There is no change of egg size between substages IIIa and IIIb though GSI increases in the latter. In stage IV (mature), two clearly separated modes of eggs were recognized, the first with the peak at 0.6 mm while the second with the modal size of 0.3 mm. Only one fish with spent condition (stage V) was obtained during this study.

Seasonal change of gonad maturity stages

As shown in Table 1, ripening eggs (or stage III) occurred all year round while the eggs in stages IV and V occurred only in June and July.

Maturation and size

According to De Silva (1973), the average minimum body size at maturation was determined when 50% maturity level was read off on the graph with percentage of mature (stages III and IV) as shown in Figs. 5 and 6. It was found to be 143 mm in male and 148 mm in female, both sexes were very close one another.

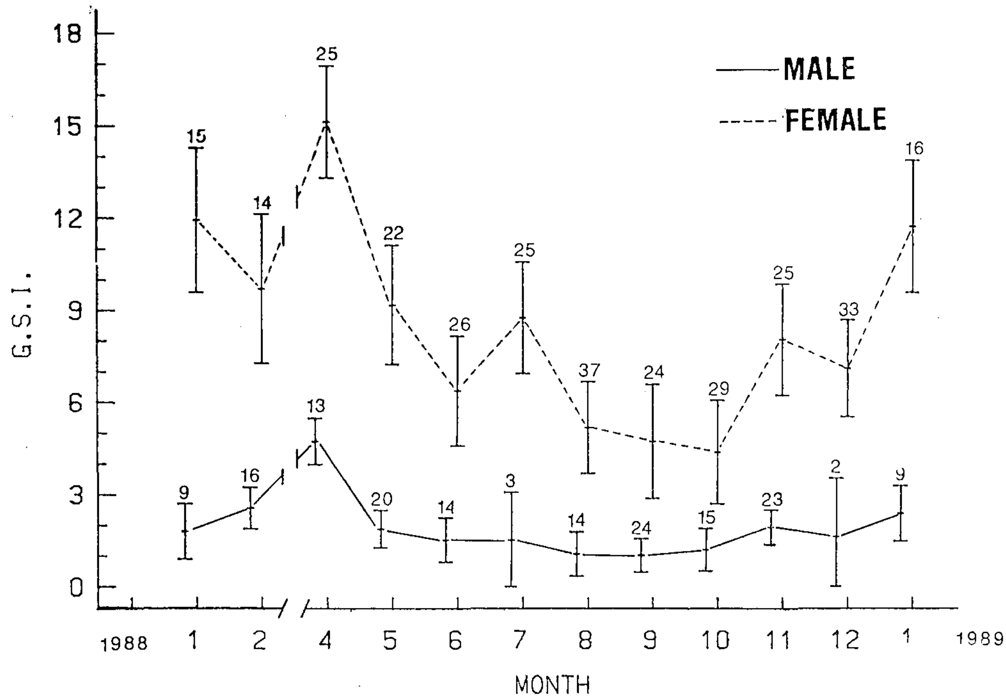

Fig. 2. Seasonal variations of mean gonadosomatic index (GSI) of *Terapon jarbua* (mean±1 SE). Numerals indicate sample size.

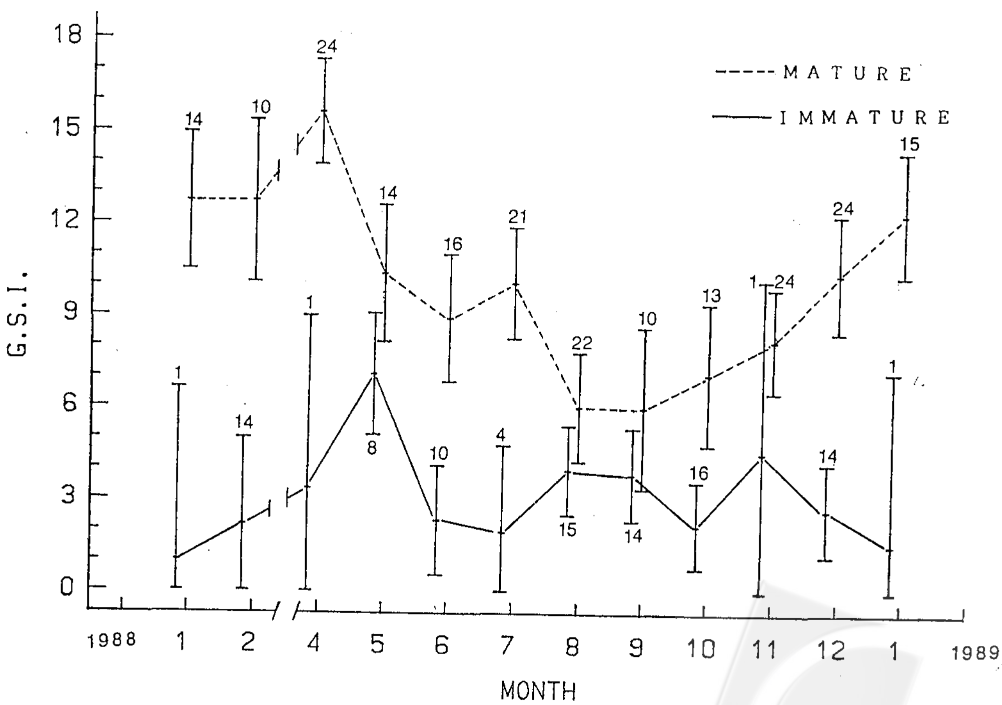

Fig. 3. Seasonal variations of mean gonadosomatic index (GSI) of inmature and mature female *Terapon jarbua* (mean±1 SE). Numerals indicate sample size.

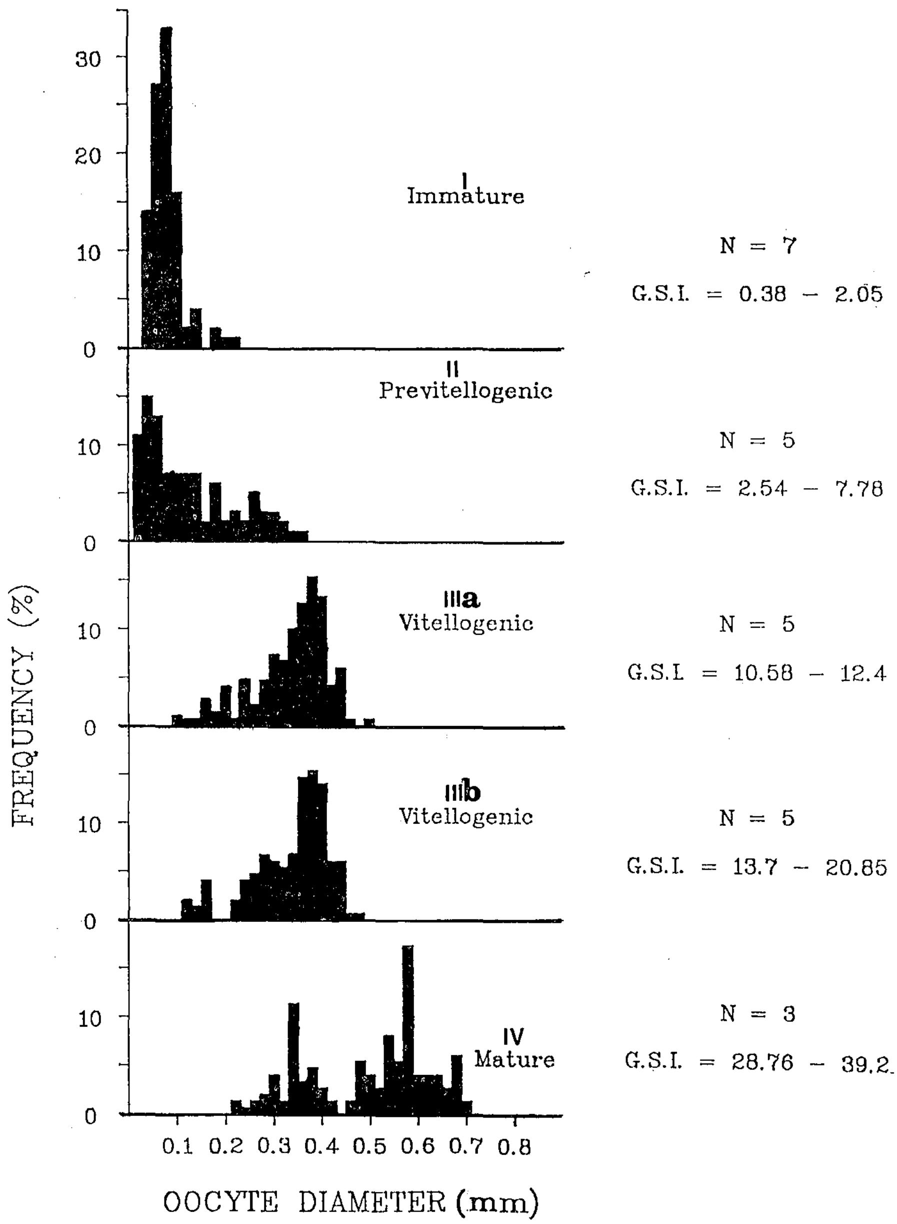

Fig. 4. Frequency distribution of oocyte diameters from *Terapon jarbua.*

Sex ratio

The sexes were disproportionate in the commercial catch, with the females generally outnumbering males. The proportion of females and males were found to be 1.8:1.

Occurrence of postlarvae and juveniles in the estuary

Postlarvae and juveniles of *Terapon jarbua* from the outermost part of the river mouth occurred all year round (Table 2) with two peaks in June-September, and November-December, while those from the inner part of the river mouth

Table 1. Seasonal variations of maturity stages of female *Terapon jarbua*

Month	No. of fish examined	Maturity stage				
		I	II	III	IV	V
Februruary, 1988	8	2	5	1	0	0
April	22	5	8	7	2	0
May	19	4	9	6	0	0
June	17	3	6	7	1	0
July	19	2	6	7	3	1
August	13	1	5	7	0	0
September	15	3	8	4	0	0
October	18	2	9	5	2	0
November	10	1	7	2	0	0
December	32	5	12	15	0	0
January, 1989	12	2	6	4	0	0
Total	185	30	81	65	8	1

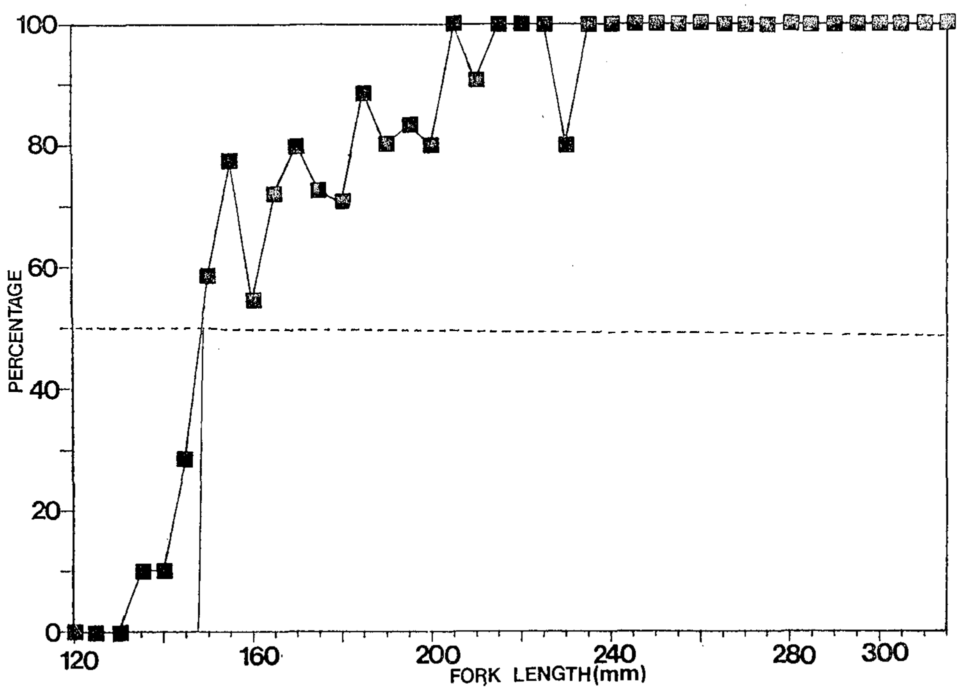

Fig. 5. Changes of percentage of mature female *Terapon jarbua* with fork length.

peaked only once with very few number in catch. As the size frequency distribution of larvae concerned, two widely separated modes in August (Fig. 7) suggested that they were from two different broods. A tendency of continuous growth from November was also noticed. Very scarce of larva was in catch with the fine-mesh set net during February and March.

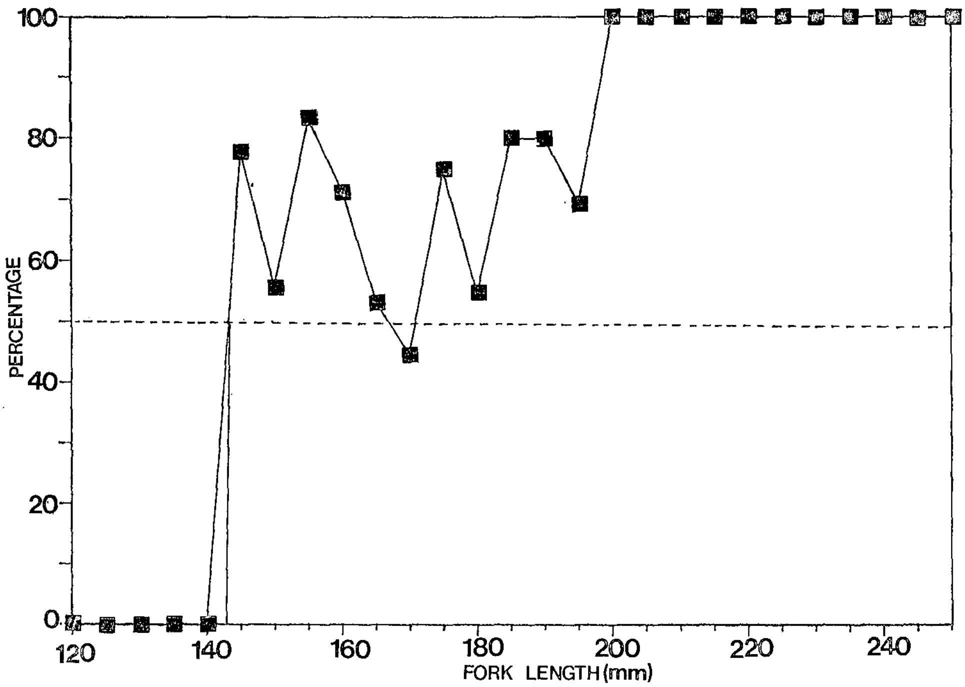

Fig. 6. Changes of percentage of mature male *Terapon jarbua* with fork length.

Table 2. Monthly occurrence of larvae and juveniles of *Terapon jarbua* collected with set net at Gung-shy Tyan River, parentheses indicate percentage

Date	Fish larvae and juvenile No./haul (% composition)		Range of fork length (mm) of *Terapon jarbua*
	Total	*Terapon jarbua*	
Apr. 26, 1988	1,562	20 (1.28)	13.9- 46.9
May 12	1,420	369 (25.99)	10.6- 20.0
Jun. 13	4,880	3,328 (68.20)	12.0- 36.4
Jul. 13	5,712	3,816 (66.81)	11.2- 23.6
Aug. 13	77	52 (67.53)	11.2- 68.3
Sep. 20	5,096	2,112 (41.44)	11.4-103.7
Oct. 9	3,952	908 (24.49)	10.4- 21.6
Nov. 10	1,006	528 (52.49)	11.7- 28.6
Dec. 15	340	160 (47.06)	10.9- 28.9
Jan. 11, 1989	127	90 (70.87)	17.3- 32.6
Feb. 16	48	1 (2.08)	13.1
Mar. 14	233	2 (0.86)	13.2- 14.3
Total	244,453	11,446	10.4-103.7

Fecundity

Based on the counts of the most developed eggs from 6 ripe females, collected in April, July and October, an estimated batch fecundity ranging 69,900-480,400

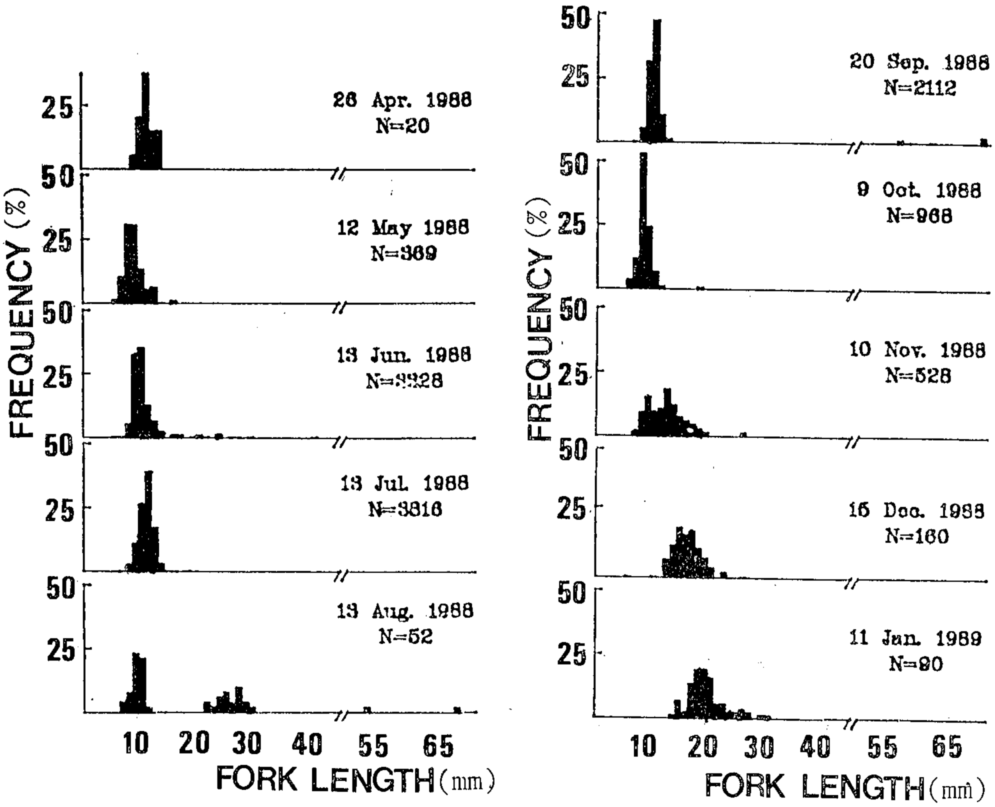

Fig. 7. Monthly length frequency distribution of larval and juvenile *Terapon jarbua*. N, sample size.

were listed in Table 3. In order to make observations on fish of different size, and of different species from different ecotypes, more comparable, relative fecundity was determined being defined as the number of eggs per unit of body weight (g). The relative fecundity of the species was obtained as 334–1,258 (mean 520) per gram body weight.

Spawning season

The spawning season was determined by direct observation of gonad conditions during different months and by the occurrence of postlarvae and juveniles.

Table 3. Estimates of the batch fecundity of *Terapon jarbua*

Collecting date	Fork length (mm)	Body weight (g)	Gonad weight (g)	Batch fecundity	Relative fecundity No./BW (g)
April 9, 1988	210	181	5.00	69,900	386
April 9	219	193	5.55	64,500	334
July 13	179	131.9	5.17	75,400	421
July 13	177	103.8	2.77	37,100	357
October 9	274	406	19.50	148,000	365
October 9	265	382	43.80	480,400	1,258

Although only few mature females were found during April and October and 1 spent fish was found in July, the post-larvae and juveniles measuring 10.4–68.3 mm FL occurred almost throughout the year with higher abundance during June and September. The spawning season of the species seems to be very prolonged with the peak season estimated to be April and October which was nearly in agreement with the seasonal pattern of GSI.

Fat cycle

As shown in Fig. 8, the fat content in liver increased rapidly from April to the peak in June, and lowered down smoothly until the end of spawning season in October. The building up of lipid storage resumed thereafter in the subsequent feeding period. There is no obviously seasonal change of lipid contents in skeletal muscle.

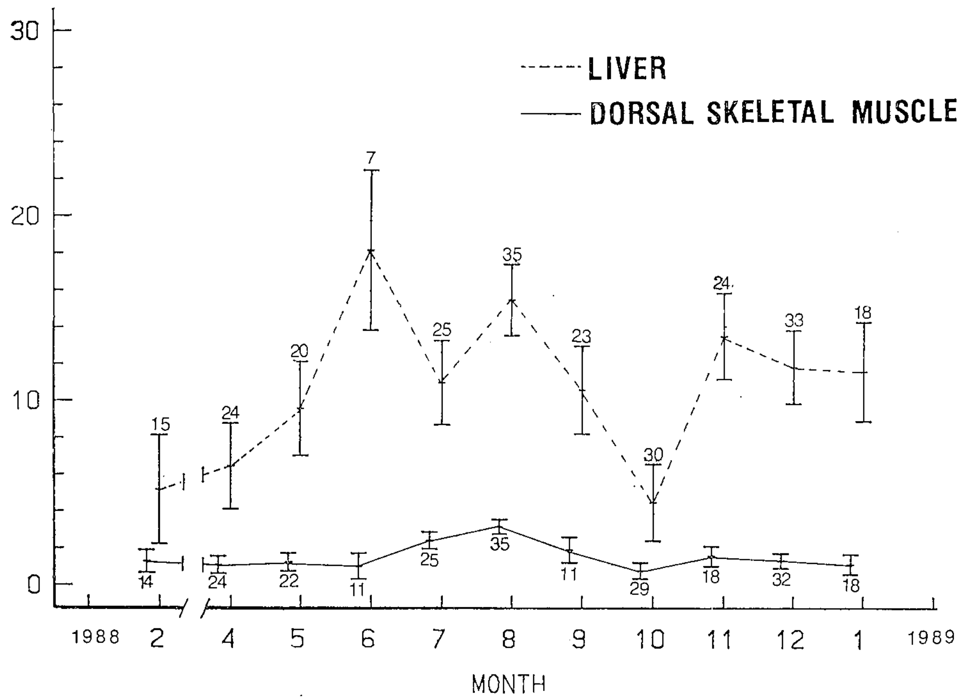

Fig. 8. Seasonal variations of total lipid contents in dorsal skeletal muscle and liver of female *Terapon jarbua* (mean±1 SE). Numerals indicate sample size.

DISCUSSION

In this species, estimation of spawning period by monthly change of GSI does not quite fit with that by histological observation on ovary. The GSI in spawning season is low with the ovary containing predominately ripening or mature eggs. On the other hand, the fish caught during non-spawning season, has higher GSI in association with high proportion of non-yolked oocytes is noticed. The result is similar to that in gold-fish (Delahunty and De Vlaming, 1980). The extension of spawning period from April to October or even later, agrees with that investigated by Liu (1978). Such a lengthy spawning season in this species is probably due to the asynchronous spawning characteristics of the fish. From multimodal size frequency distribution of egg groups in ovary at any gonad stage, suggested that it is a fractional spawner. Fractional spawner and a prolonged spawning season are main characteristics of tropical and subtropical fishes (Nikolsky, 1963) which are adapted to spawn in several batches in order to avoid overcrowding of larvae and to reduce their food competition.

Timing and duration of the breeding season is adaptive to ensure success in recruitment of next generation. The factors controlling the reproductive cycle are both extrinsic and intrinsic. Beside the intrinsic factor (endocrine system), the external factors include temperature, photoperiod, density of food supply and that of fish population (De Vlaming, 1982; Nikolsky, 1963; You and You, 1987). The commencement of spawning in April coincides with the rising temperature when larvae start appearing in the estuary. The highest peak of larval abundance in July is related to the warmest temperature at the same time. Temperature and its accompanied longer photoperiod may play role on gonad maturation. The mass occurrence of postlarvae in the estuary also related to the timing of spawning season, i.e., larval peak in July corresponds with the spawning peak. Simultaneously, peaks of zooplankton production in summer/early autumn and late winter/early spring (Lei, 1989) allow the postlarvae having no shortage of food sources. Accumulation of lipid has begun far before April, with the growth of fish increasing gradually toward the apex in June and declining slightly until the lowest level at the end of the season, when most of fat are utilized. The lipid accumulation recovers later in the forthcoming feeding period. Liver is a main lipid depot being transferred for gonad maturation during the long breeding season. The long breeding season is adaptive to the production pattern of plankton in middle and low latitudes which goes on throughout the spring and summer (Qasim, 1956) to ensure the food availability for larvae.

There is no influence of spawning activity caused by heavier population density since the mature adult fish are rare in the immediate outer part of the river mouth by commercial catches. The above site is not their spawning ground since the large-sized (25–30 cm FL) fish caught during the breeding season are scarce while the fish caught commercially are almost entirely 14–15 cm FL with gonad stage of nearly in early maturing stage. However, in the postspawning season, the adult of 25–30 cm FL occurred in the vicinity of river mouth are in resting or early developing stage. They are the spent school which left the spawning ground on farther deeper water, and resumed their feeding while approaching the vicinity of river mouth.

Fecundity is an indicator of recruiment for a fish. Since the *T. jarbua* is expected to spawn more than once in such a prolonged breeding season, it is difficult to estimate actual total fecundity, because one cannot assure how frequency does the fish actually spawn. Therefore, relative fecundity can also be used to compare this species with other species of different ecotypes to interprete their possible evolutionary traits. Mean relative fecundity of the species is about 520 per gram body weight which is close to 503 in intertidal *Istiblennius lineatus* (Lee and Chang, 1977), and higher than 305 in the demersal oviparious rockfish, *Sebastiscus marmoratus* (Chen and Lee, 1980), and in the strong nest-guarding Indian catfish, *Pseudentropius taakree* (Remakrishnaiah, 1984). The evolutionary trait is related to the size of fish and that of predation pressure.

Outnumbered females in large-sized group are probably a result of sexual reversal as suggested by Liu (1978). *T. jarbua* is a protogynous type, having no male below 10.5 cm in length, gradually increasing in male from 10.5 cm size class to large adults when the females are still in predominance. Our result in this investigation did not find any sexual reversal since the fish sample examined are entirely exceeding 14 cm.

It is concluded from this study, the reproductive cycle of this species is adapted to production cycle of zooplanktons, to ensure the availability of food source for larvae. Like other estuarine and inshore fishes, mass mortality of this species during larval and juvenile stages are also noticed. It is resulted that the survival spawned adult fish becomes much rarer after spring and the coming winter months, though very common in the vicinity of the estuary.

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淡水河口花身鷄魚之生殖生物學研究

繆自昌・李信徹・曾萬年

如同一般之河口性魚類，花身鷄魚之出現呈明顯之季節性變動：仔稚魚大致於5～11月間大量湧現於河口域及其緊隣之沿岸淺灘攝食，長成後即移棲至外海深水處產卵。由生殖腺狀況之連續月別觀察以及仔稚魚出現之時序變化不難看出生殖期大約為 4～10 月或更長 。為因應生殖腺的發育、肝臟脂質量之變化周期大致與生殖周期符合。花身鷄魚為先雌後雄之性轉變魚類。10.5 cm 尾叉長 (FL) 以下者幾為雌魚，爾後有部分轉變為雄性。在成魚中， 雌雄魚之性比為 1.8 比 1 。花身鷄魚為多回產卵型魚類，分批抱卵數為 37,083～480,400 (平均 145,816) 換算為相對抱卵數則為每克體重 334～1,258 (520)，本種最小生物成熟體長，雄魚為 143 cm FL，雌魚為 148 cm FL。