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A Preliminary Study on Species Composition and Seasonal Abundance of Fish Eggs and Larvae from the Coastal Waters Adjacent to the Tansui River Estuary, Taiwan (1984-1985)

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To clarify the species composition and seasonal abundance of fish eggs and larvae in the coastal waters adjacent to the Tansui River estuary, fish eggs and larvae were collected monthly from three stations at the depth of 5 m, 10 m and 20 m during the period from September 1984 to August, 1985. Meanwhile the environmental factors including water temperature, salinity and pH were also monitored. A total of 41,734 eggs and 1,428 larvae representing 31 families, and 63 species were collected from 36 net hauls. *Stolephorus buccaneeri* was the most dominant species making up 55.39% of the total catch in number, and followed by *Sebastiscus marmoratus* (18.28%), Blenniidae (4.90%) and Gobiidae (2.66%). The above four species groups constituted 80% of the total catch. Most of the fish collected belonged to egg stage and preflexion larvae indicating that there was a spawning ground near the estuary.

The occurrence of the fish eggs and larvae was higher in spring with a peak in April-May when water temperature commenced to increase, and with a minor peak in winter. The higher peak coincided with the occurring period of *S. buccaneeri*, while the lower peak coincided with that of *S. marmoratus*. Fish eggs were abundantly occurred at water temperature 25.5-28°C and salinity 24-34‰. Similar trend was seen in fish larvae when they dispersed with growth, except their adaptive ranges to temperature and salinity were wider. Larval fish community structure was more complicated in spring and autumn than that in summer and winter. The affinity of fish larvae were seperated into four seasonal groups, which were listed in the order of spring (April-May), winter (November-March), summer (June-August) and autumn (September-October) groups. The duration of each group with high similarity in community structures lasted for about 2-3 months except that in the winter group.

Key words: Fish eggs, Fish larvae, Species composition, Seasonal abundance, Coastal water adjacent to Tansui River estuary.

關鍵詞：種類組成，魚卵，仔稚魚，季節性變動，淡水河口緊隣沿岸。

INTRODUCTION

Fishes no matter what inhabit in pelagic or benthic system would once experience a planktonic eggs and larval stages during their early life history. The

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immobile eggs and the weak-mobility larvae are usually passively drifted with current. Therefore, these tiny little creatures are also traditionally recognized as ichthyoplankton.

The study of larval fishes was widely applicable to the fishery management and aquaculture. Occurrence of fish eggs and larvae at different time and location can be used to estimate spawning season and spawning and nursery grounds of the fish (Jang *et al.*, 1983; Ueyanagi, 1969). The larval abundance was used to predict the coming year-class strength (Postuma and Zijlstra, 1974; Tanaka, 1974). In addition, the distribution and abundance of fish larvae could also be employed as a probe to search the new fishing grounds of fishable stocks. Feeding stragities of the larvae and the associated environmental conditions can also provide informations for aquaculture (Snyder, 1983). Moreover, the larvae and juveniles of anchovies and sardines in Taiwan are consumed popularly by local people, which have become a major catching target for larval fishing industries (Cheng, 1980).

The Tansui River estuary was once to be an important fishing ground for fish fry production. They include larval *Anguilla japonica*, *Acanthopagrus latus*, *A. schlegeli* and *Lutjanus argentimaculatus* for pond cultivation, and larval sardines and anchovies for direct consuming in the market.

Because of the rich nutrients from river discharge, a higher primary production in the estuary and its immediate adjacent coastal waters might be expected. Subsequently, the area becomes a main nursery ground for several fish species in the vicinity. However, very few studies concerning the species composition of the fish larvae and juveniles have been conducted (Tzeng and Wang, 1986).

The catches in the Tansui River estuary and its adjourning coastal waters are droped considerably in the recent years due to the environmental impact from urban sewages and industrial pollutions. It is now urgent need to conserve these natural resources through the establishment of basic ecological data. In order to meet this goal, it is aimed to investigate the fauna, abundance, distribution and seasonal occurrence of the larvae existed at the present circumstances.

MATERIALS AND METHODS

During the period from September 1984 through August 1985, fish larvae were collected monthly with a modified Maruchi-D larval net (Nakai, 1962) from each of three stations (Fig. 1) at the depths of 5 m, 10 m and 20 m, respectively. Nets were towed on surface water for 10 minutes at the speed of ca. 2 knots during the day-time flood tide. The size of the net is 1.3 m in diameter and 4.5 m in length with the mesh size of 0.5 mm by 0.5 mm, a flow-meter is attached in the net mouth to measure the filtrated water volume. Temperature and pH value were determined simultaneously during sampling operation while salinity was determined with MC-5 salinometer when the water samples were brought back to the laboratory. The specimens recovered from the net were fixed immediately in 10% seawater formalin solution for specific identification and counting. The most useful references as aids to identification were Chen and Yu (1986), Leis and Rennis (1983), Mito (1966), Ozawa (1986) and Uchida *et al.* (1958). Specimens will be divided according to their development stages, e. g., yolk sac larva, preflexion larva, flexion larva, postflexion larva, juvenile and young, adopted from Kendall *et al.* (1984). Numbers of eggs and larvae were counted and the raw data were transformed to numbers per 1000 m^3 sea water. Indices of species richness (d') (Margalef, 1969) and degree of overlap of the similarity of species composition (C_π)

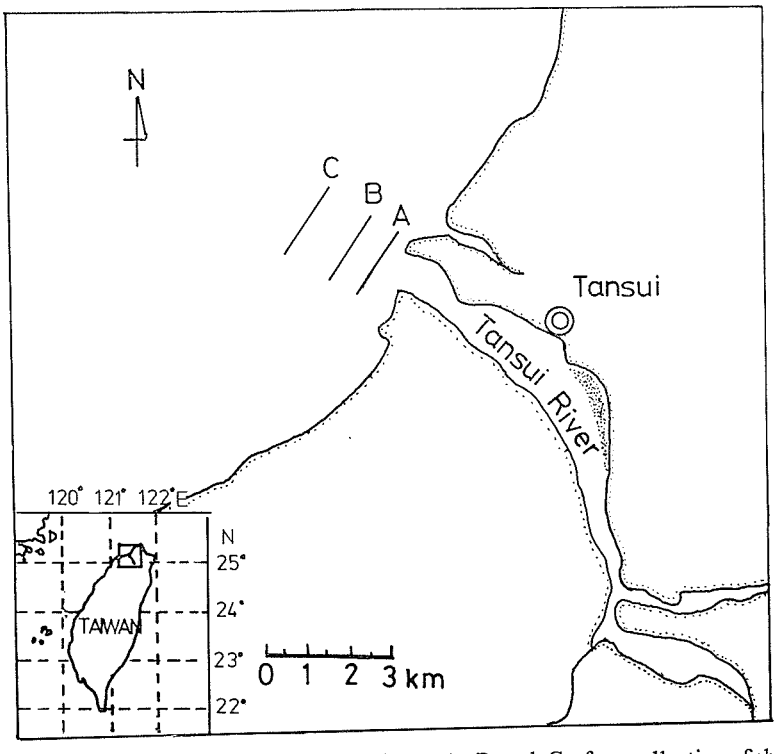

Fig. 1. Map showing sampling stations, A, B and C, for collecting fish eggs and larvae from coastal waters adjacent to the Tansui River estuary.

(Kimoto, 1976) were subsequently obtained accordingly, in order to analyze the community structure of larval fishes.

RESULTS

Environmental factors

Water samples were taken from the surface layer of water column. The surface water temperatures at three stations ranged from 16°C in December to 30.5°C in August, with a difference of not greater than 0.5°C among stations. Salinity ranged from 12‰ in December to 34‰ in January. The values of pH were almost entirely beyond 8.0 with the exception of 7.0 measured in December at the time of river flooding (Fig. 2).

Seasonal fluctuations in abundance of fish eggs and larvae

The seasonal variation in number of species was similar among stations, the number of the species of larval fishes were less than 5 species during autumn and winter, and reached the highest of the whole year, with 17 species in April at station C (Fig. 3).

Abundance of fish eggs at three stations showed a marked increase to the highest numbers (54,043/1000 m^3) in April at station B, declining shortly after May until the lowest level between June and August (Fig. 3). Trend in seasonal fluctuations of larval fish abundance is more or less in parallel with that in the fish eggs, except that the timing of highest larval bloom reveals one month later.

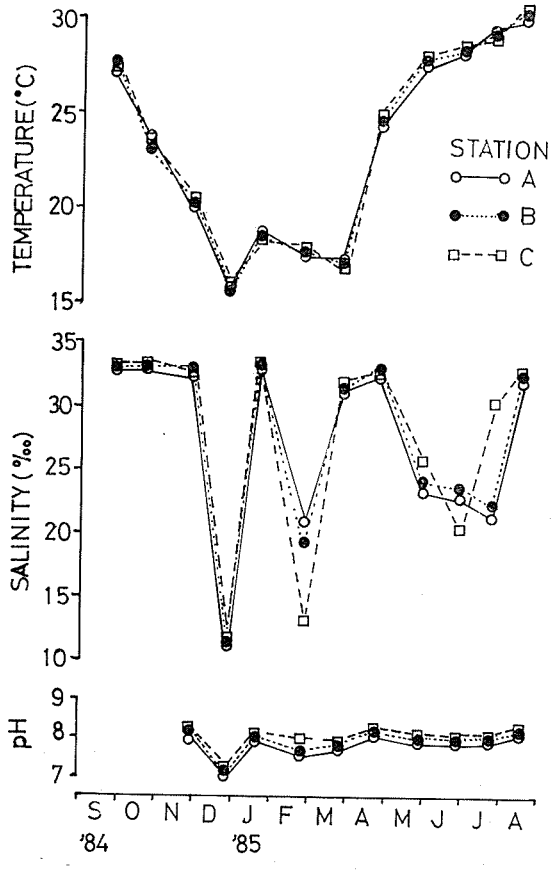

Fig. 2. Monthly changes of surface water temperature, salinity and pH value at three stations from the adjacent coastal waters to the Tanshui River estuary during September 1984 and August 1985.

Species composition

Among 1,428 larvae in 63 species sampled during the survey, the anchovy nominated as *Stolephorus buccaneeri* is the most abundant species occupied 55.39% of total catch in number, and followed by *Sebastiscus marmoratus* (18.28%), 4 undetermined species of blennies (4.90%) and 10 undetermined species of gobies (2.66%). The above four major categories comprised 80% of total catch, while the remaining 47 species shared other 20% (Table 3).

Seasonal occurrence of these dominant species are variable: *Stolephorus buccaneeri* presents with the higher numbers only between April and June, *Sebastiscus marmoratus* appears with high numbers from November through February, while the gobies reveal two peaks, one from January through July and the other between September and October, depending on what species they belonged to.

Among 40,597 eggs collected are assumed to be the anchovy, *Stolephorus buccaneeri* in great possibility, which occupied 97.28% in composition. The suggested nomenclature for the eggs collected is designated according to the criterion that the peak season for having highly abundant eggs between April and May is in parallel with that already known in larval *S. buccaneeri*, and the ellipse-shaped eggs is subjective to fit in the character recorded previously in *S. buccaneeri*.

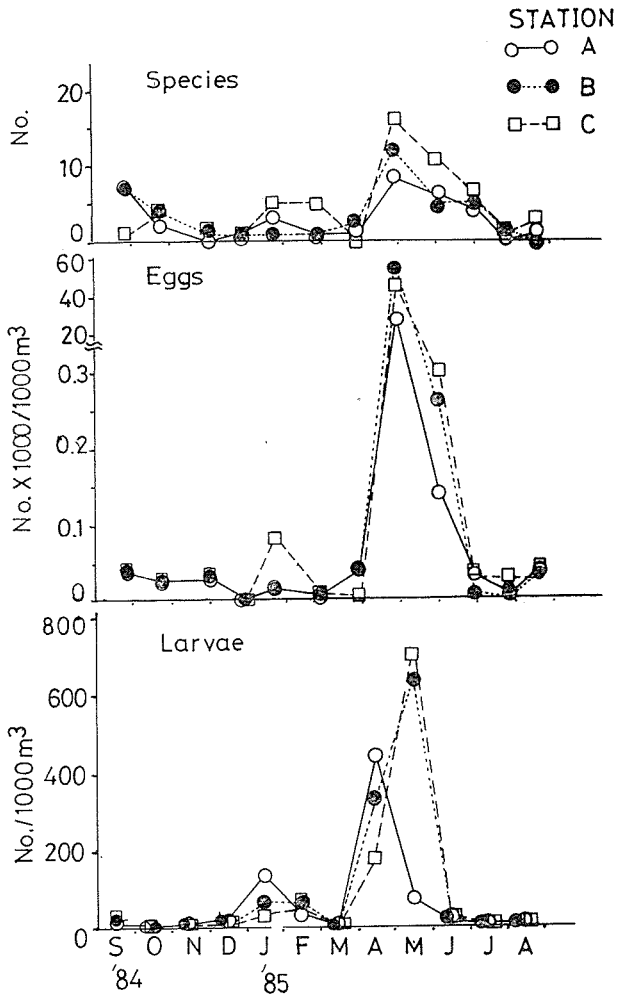

Fig. 3. Monthly changes of total numbers of species, abundances of eggs and larvae collected at three stations from the coastal water adjacent to the Tansui River estuary during September 1984 and August 1985.

Developmental stages and body size in larval fishes

Table 2 indicates that the fish materials recovered in the net are predominately freshly fertilized or undeveloped eggs occupying 96.4-97.02% in composition, and followed by the order of decreasing importance of preflexion larva (1.42-2.74%), yolk-sac larva (0.6-1.39%) and the following minor components including postflexion larva, flexion larva, juvenile and young which are not accounted for percentages.

Body size of *S. buccaneeri* (Fig. 4) at yolk-sac larval stage ranged 1.5-3.0 mm with the mode at 2.0-2.5 mm while that at preflexion larval stage ranged 1.5-4.0 mm with the mode at 2.0-2.5 mm. Although the developmental stages progressed advancedly, neverthless, the modal length is not increased. The abundance of *S. buccaneeri* larvae tends to intensify progressively from inner part of bay toward outer offshore area. Body size of *Sebastiscus marmoratus* from every stations ranged 2.0-4.0 mm with the mode at 3.0-3.5 mm. Its abundance is otherwise decreased gradually from the inner part toward the outer part of the bay, which is different from that of *Stolephorus buccaneeri*.

Table 1. Species composition of fish eggs and larvae collected from the coastal water adjacent to Tansui River estuary during September 1984 and August 1985

Taxon	1984				1985								Total
	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	
Muraenidae													
sp.		1											1
Engraulidae													
Stolephorus buccaneeri								140	651				791
Stolephorus sp.										1			1
Thrissocles kammalensis									1				1
Gonostomatidae													
Cyclothone alba	1												1
Synodontidae													
Trachinocephalus myops		1											1
Myctophidae													
Diaphus sp.		1						1					2
Lampanyctus sp. 1								1					1
Lampanyctus sp. 2								1					1
Benthosema sp.	1	1											2
Bregmacerotidae													
Bregmaceros nectabanus	1	2											3
Bregmaceros sp.								1					1
Trachipteridae													
sp.									1				1
Scorpaenidae													
Sebastiscus marmoratus			12	19	131	96	3						261
Percichthyidae													
Lateolabrax japonicus						2							2
Teraponidae													
Terapon jurbua									5				5
Apogonidae													
sp.	1												1
Sillaginidae													
Sillago japonica	1								4				5
Carangidae													
Decapterus maruadsi								2		6			8
Alepes djedaba									1	12		1	14
Formionidae													
Formio niger										2			2
Leiognathidae													
sp.								1		2			3
Gerreidae													
Gerres sp. 1								1					1
Gerres sp. 2										1			1
Sciaenidae													
sp. 1								6					6
sp. 2	1	1						1	2				5
sp. 3									2				2
Pempheridae													
sp.									2				2
Scaridae													
sp.								2					2
Champsodontidae													
Champsodon sp.								1					1

Table 1. (Continued)

Taxon	1984 Sep.	Oct.	Nov.	Dec.	1985 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Total
Tripterygiidae													
sp.									1				1
Blenniidae													
sp. 1								2	63				65
sp. 2									1				1
sp. 3										3			3
sp. 4									1				1
Gobiidae													
sp. 1									4	2			6
sp. 2											1		1
sp. 3	7							3		1			11
sp. 4	1								2				3
sp. 5		1											1
sp. 6					1	5	1						7
sp. 7								5					5
sp. 8	1												1
sp. 9										1			1
sp. 10	1	1											2
Gobioididae													
Taenioides sp.	3												3
Trichiuridae													
Trichiurus lepturus		1			2								3
Callionymidae													
sp. 1												1	1
sp. 2						1		3					4
sp. 3								1					1
Paralichthyidae													
Pseudorhombus sp.								3					3
Bothidae													
sp.								6					6
Soleidae													
sp.								1					1
Cynoglossidae													
sp.								2					2
Monacanthidae													
Stephanolepis cirrhifer										1	2	2	5
Unidentified species													
sp. 1	1												1
sp. 2						1							1
sp. 3								2					2
sp. 4	1												1
sp. 5					3								3
sp. 6					1								1
sp. 7												1	1
sp. 8								3					3
sp. 9	1							147	1				149
Larvae													
Total no. species	14	9	1	1	5	5	2	24	16	11	2	4	64
Total no. individuals	22	10	12	19	138	105	4	336	742	32	3	5	1,428
Eggs													
Engraulids								40,575	22				40,597
Others	65	45	38	3	46	16	50	424	345	43	16	48	1139
Total	65	45	38	3	46	16	50	40,999	367	43	16	48	41,736

Table 2. Stage composition of fish eggs and larvae collected from the coastal water adjacent to the Tansui River estuary during September 1984 and August 1985

Development stage	Station A			Station B			Station C			Total		
	No.	%	Rank	No.	%	Rank	No.	%	Rank	No.	%	Rank
Egg	12,113	97.02	1	11,965	96.41	1	17,656	96.66	1	41,734	96.69	1
Yolk-sac larva	174	1.39	3	74	0.60	3	129	0.71	3	377	0.87	3
Preflexion larva	178	1.42	2	340	2.74	2	449	2.46	2	967	2.24	2
Flexion larvae	4	0.03	5	5	0.04	6	3	0.02	6	12	0.03	6
Postflexion larva	14	0.11	4	18	0.14	4	14	0.08	4	46	0.11	4
Juvenile	2	0.02	6	9	0.07	5	13	0.07	5	24	0.06	5
Young							2	0.01	7	2	0.00	7
Total	12,486	99.99		12,411	100.00		18,266	100.01		43,162	100.00	

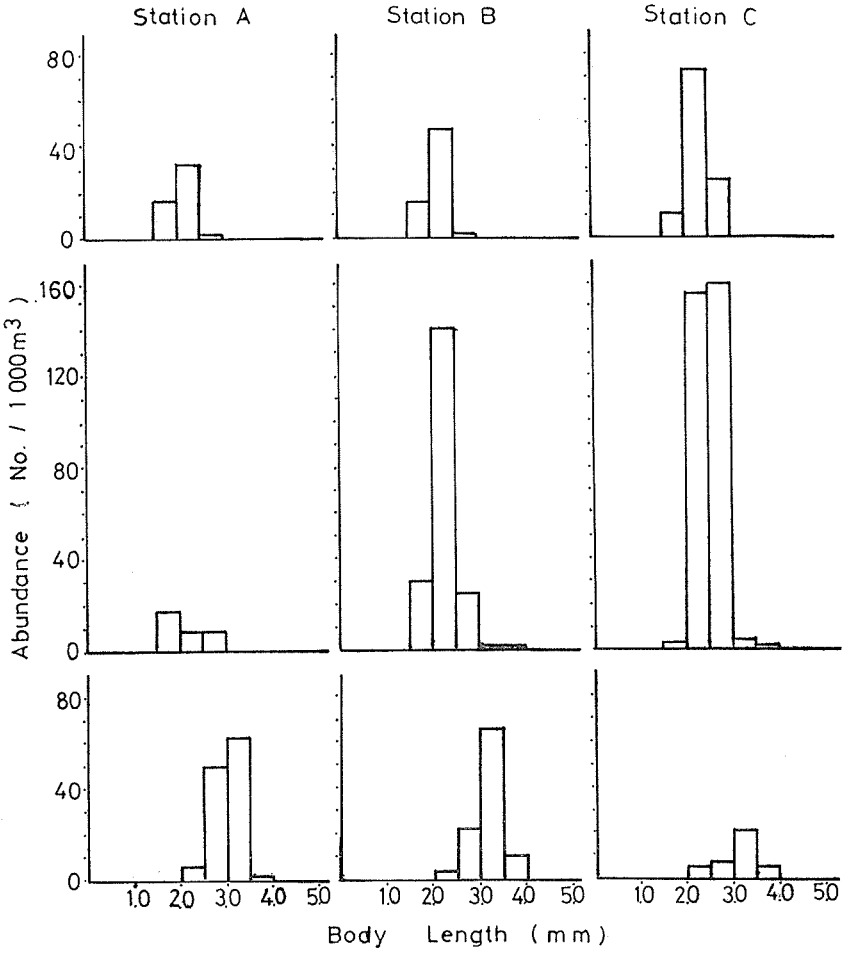

Fig. 4. Length composition of *Stolephorus buccaneeri* (Upper panel, yolk-sac larvae; middle panel, preflexion larvae) and preflexion larvae of *Sebastiscus marmoratus* (Lower panel) collected at the three stations from the adjacent coastal waters to the Tansui River estuary during September 1984 and August 1985.

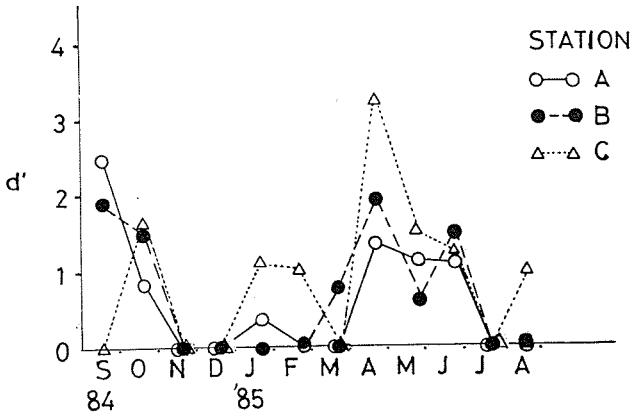

Fig. 5. Monthly changes of Margalef's index of species richness (d') for the fish larva assemblages collected from adjacent coastal waters to the Tansui River estuary during September 1984 and August 1985.

Community structure

Margalef's index of species richness(d') ranged from 0 to 3.2 with mean annual figures of 0.74 (Fig. 5). Seasonal pictures of the species richness indices at stations show similar trends; a small peak in September declining to the lowest between

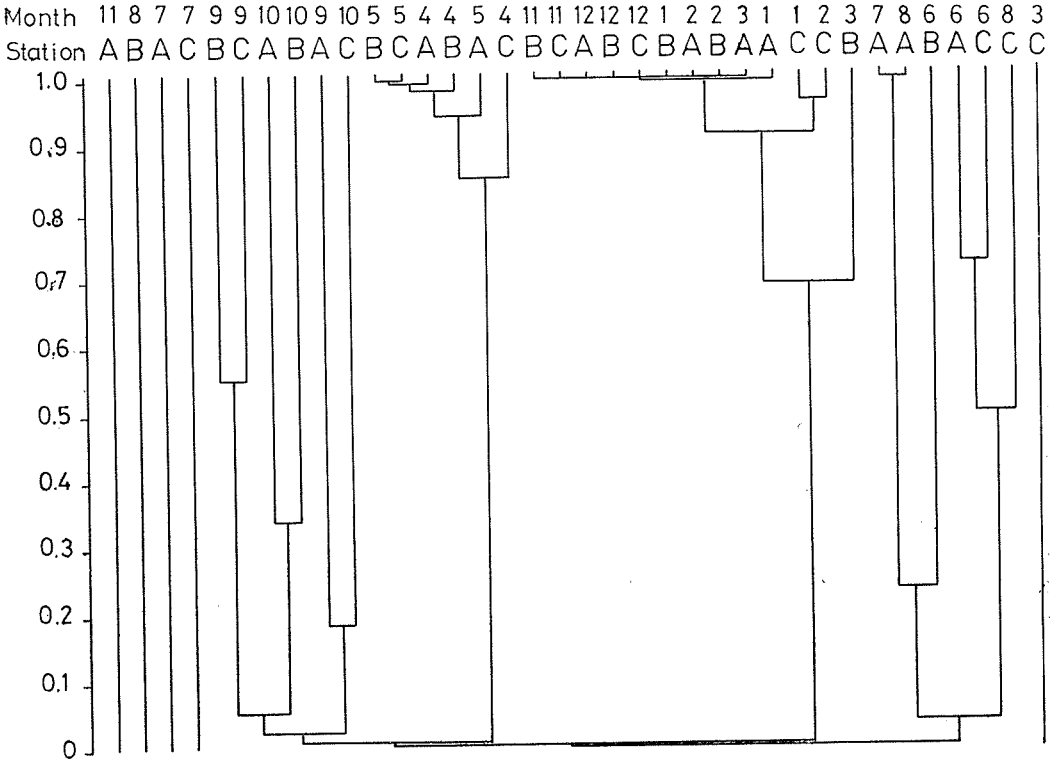

Fig. 6. Dendrogram produced by Mountford's (1962) method for 36 times of collections, linkage was based on the Kimoto's index of degree of overlap (C_π).

November and December, resuming the increase from January until the highest in April with a smooth drop shortly thereafter. The community structure during spring and autumn are more complicated than that of summer and winter due to more numerous fish species entering the estuary during spring and autumn.

A further speculation from the results of overlap index and the analysis of average linkage (Fig. 6), it is found that the monthly measurements of community structure between stations are generally in high similarity over the year. However, temporal changes in similarity values are not even, eg., the station similarity index is highest during April and May, which is seconded by November and March, in particular, the values for the group surveyed during the period from December through Feburary is almost approaching 1.0. The similarity indices during the periods June-August, and September-October, are relatively low, because the fish species occurred during the period are quite different from those in other periods. It is resulted from the seasonal turn over of fish species. The community with high similarity index sustans a more prolonged period in winter (4 months, from November through March) rather than other seasons (2-3 months).

DISCUSSION

Since great majority of eggs obtained in this survey belong to freshly fertilized ones, with partial preflexion larvae, it could be certain that the spawning grounds might be very close to the mouth of Tansui river. For example, the suggested spawning ground in *Sebastiscus marmoratus* is located probably at the northeastern corner of the river mouth with the bottom of sand and rocks in mixture. This is evidenced from the decreasing larval abundance from near shore toward offshore In addition, timing of larval bloom in *S. marmoratus* is also in agreement with the occurrence of spawners extending from December through March (Chen and Lee, 1980).

Stolephorus buccaneeri is by far the most dominant species among the commercial catch by local larval fishery which is almost entirely at postlarval stage against the more earlier stages of larvae such as eggs and preflexion larvae obtained during our surveys. A further detailed comparison between the above two results is needed for interpretation concerning if they are identical in specific recognization. It should be borne in mind that the earliest larval stages are more numerous than those of postlarvae from commercial catch. However, our results are otherwise in different story due to the possible sampling errors, eg., selectivity in fishing gears. The dispersal patterns of the larvae at different stages are important base line informations for the study of fish population dynamics, as well as the prediction for fisheries resources and their possible utilization. This would involve a further detailed investigation.

The environmental factors are more or less to influence the occurrence of fish eggs and larvae. The optimum temperature and salinity for fish eggs (Fig. 7) are 24.5-28°C and 24-34‰, respectively with the higher numbers of 140-5,400/1000 m^3 sea water in catch. Other factors might cause a reduction of numbers to below 42/1000 m^3. The highest numbers of larvae are 77-642/1000 m^3 sea water at 24.5-28°C and 24-34‰, decreasing to 45-141/1000 m^3 when temperature dropped to 16-20°C accompanied by the salinity of 11.3-33.5‰. Larval density becomes scarcer than 30/1000 m^3 under other factors. The distributional limit of fish eggs tend to adapt to narrower range of temperature and salinity while the larvae are more adaptive to wider range of thermal and salinity conditions. Species numbers of larval fishes and the density of fish eggs and larvae increased to the highest between

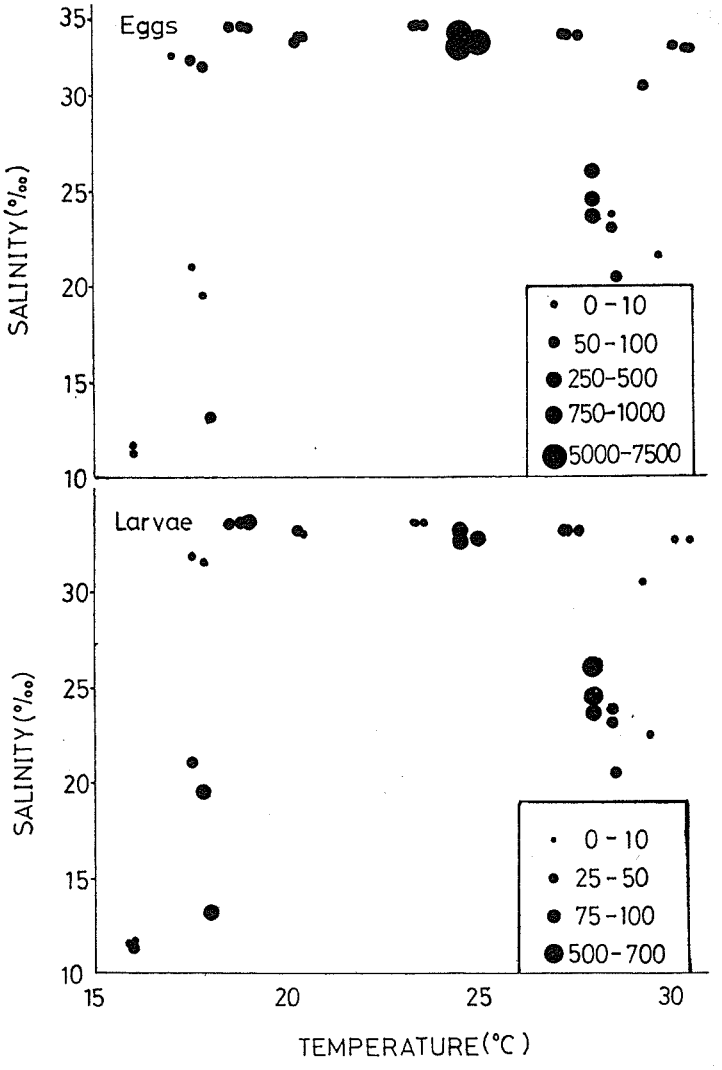

Fig. 7. Relationship between temperature and salinity and abundances (no./1000 m³) of eggs and larvae collected from the coast adjacent to the Tansui River estuary during September 1984 and August 1985.

April and May with the less peak during January and February, the former being correlated with the rising temperature while the latter being in conjunction with the low temperature influences. In the temperate regions, larval bloom is normally adaptive to the presence of two peaks in plankton production cycle, one in spring and the other in autumn (Heinrich, 1962). Most fishes are evolved to adjust their timing for spawning for more easy availability of food resources (Cushing, 1975). The highest production of eggs and larvae during April and May in the adjacent sea of Tansui River estuary is an adequate example for this explanation, but the insignificant smaller peak in autumn is probably caused by sampling errors. An exceptional peak appeared in winter results from the entrance of recruitments in *Sebastiscus marmoratus* which spawns normally in winter.

Numbers of larval fish species vary yearly, eg., 63 species (present study)

during 1984–1985 against 39 species in 1982–1983 survey (Tzeng *et al.*, 1985). They also vary with areas, eg., the species numbers in the adjacent waters of Tansui River estuary are fewer than other part of Taiwan (Tzeng and Wang, 1986). The species richness index (d') in the adjacent waters of Tansui estuary is relatively low with a mean of only 0.74 against 4.15–4.85 (Tzeng and Wang, 1986; Wang, 1987), respectively for 1982–1983 and 1984–1985 surveys from Shuang-Hsi estuary.

Since community structure can be determined by topography and sediment conditions of habitat along with the biological productivity in the area (Allen, 1982). The present surveyed area is such a sandy bottom with very simple faunanistic constitutions. However, physical environmental factors in the area change rapidly with a subsequently higher productivity as might be expected, these would cause a reduction in species diversity.

As a generalization, estuary has a more variable environmental conditions, in particular, change of tidal level might influence the transportation of larvae with a subsequent effect on the amount of materials sampled (Boehlert and Mundy, 1988; Rijnsdorp *et al.*, 1985). In the present study, fish eggs and larvae are found to be correlated with higher salinity suggesting their parent might spawn on the immediate outer margin of the river mouth, with their produced eggs and larvae drifting inward by the flood tide. The transportation, dispersal and distribution of eggs and larvae are determined by the optimum salinity which being in turn, influenced by the tidal action. The abundance of eggs and larvae collected are certain to correlate with tide. A further study in detail on the link between them should be intensified.

Besides, the well known elvers of *Anguilla japonica* from the adjacent coast to estuary of Tansui are very abundant. They are not found in pure regular daytime collection since they only appear at night. Thus the population dynamics of the anguillid elvers in the area are provisionally excluded from this report.

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淡水河口外緣沿岸之魚卵及仔稚魚種類組成及豐度季節性變動之初步研究 (1984-1985)

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爲明瞭淡水河口仔稚魚種類組成及數量的季節性變化，於 1984 年 9 月起至 1985 年 8 月止，按月分別於淡水河河口外緣的 5 m、10 m 及 20 m 等深線處設置三個測站，用仿製的 Maruchi-D 型仔魚網（直徑 1.3 m、網身長 4.5 m、網目 0.5×0.5 mm）以水平採集方式採集魚卵及仔魚，同時測定環境因子包括水溫、鹽度及 pH 值。

全年共計進行了 36 站次的仔魚採集，計採獲魚卵 41,734 粒和仔魚 31 科 63 種 1,428 尾，其中以布氏銀帶鰶 (*Stolephorus buccaneeri*) 791 尾爲最多，佔 55.39%；其次是石狗公 (*Sebasticus marmoratus*) 261尾，佔 18.28%；第三是鰨科 (Blenniidae) 四種合計 70尾，佔 4.90%；第四是鰕虎科 (Gobiidae) 十種合計 38 尾，佔 2.66%。其餘各種所佔比例均在 1%以下。就發育階段組成而言，出現最多的是魚卵 (egg)，其次是脊索末端上屈前期仔魚 (preflexion larva)，其餘發育階段所佔比例非常低。由於魚卵的數量相當多，河口域附近可能有產卵場存在。

魚卵及仔魚出現量有明顯的季節性變化，4～5 月水溫上升期魚卵及仔魚種類和數量大量出現，呈現月別變化之全年最高峰，冬季的 1 月有一個小高峰，夏秋兩季則很少。造成 4～5 月高峰期的仔魚爲布氏銀帶鰶，1 月爲石狗公。仔魚大量出現的時期大約比魚卵延遲一個月。魚卵在水溫 24.5～28°C 以及鹽度 24‰～34‰的範圍內有較多的出現量，而仔魚也有類似的傾向，但分布的鹽度範圍較廣，顯示仔魚的移動、擴散範圍比魚卵大。

仔稚魚的羣聚構造春秋兩季較複雜，夏冬兩季則較單純。仔魚羣聚構造同月份站間的相似程度高，月別間的相似程度大致可分成四個羣集。相似程度最高的是春季羣 (4～5月)，其次則是冬季羣 (11～3 月)，在夏 (6～8 月)、秋 (9～10月) 兩季，各次採集的相似程度較低。相似羣集的持續性除冬季羣的期間較長 (11～3月) 外，其餘各羣爲時均在 2～3 個月間。