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# Eco-geographic Difference of Larval Fish Assemblage in the Coastal Waters of the Western Central Taiwan

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To estimate the larval fish assemblage in the intertidal zone of the western coast of central Taiwan, two sampling sites were selected for representing estuary and plain coast. Species composition, monthly occurrence and size variation were measured. The differences between eco-geographic regions were compared.

Environmental factors, such as water temperatures, salinity, dissolved oxygen, and pH value were measured. No annual differences between eco-geographic types were found. On the other hand, the differences on the attribute of the assemblage could be confirmed.

In the estuary, a total of 4,603 larvae assigned to 38 species was collected. *Acanthopagrus schlegeli* was the most abundant species which counted to 18.4% of total catch. The remaining dominant species were *Liza macrolepis* (16.01%), *Stolephorus indicus* (15.18%), and *Gerres abbreviatus* (11.07%). In the plain coast, a total of 54,007 larvae assigned to 53 species was sampled. *Ambassis gymnocephalus* was the most abundant species which was counted to 55.81% of total catch. The leftover dominant species were *A. schlegeli* (19.2%), *G. abbreviatus* (5.65%), gobiid (5.47%), and *L. macrolepis* (3.94%). A significant difference in species composition was found between assemblages of estuary and plain coast.

In the estuary, monthly richness of species ranged 3–16 taxa. The larval assemblage indicated a higher abundance from April to August. The monthly diversity index of estuary assemblage ranged 0.17–0.81. In plain coast, monthly richness of species ranged 4–27 taxa. The larval assemblage indicated higher abundance from April to July. The monthly diversity index of plain coastal assemblage ranged 0.24–0.83.

Four major species were selected for comparison on monthly size variation between eco-geographic types. Differences were found on *L. macrolepis*, *T. jarbua*, and *G. abbreviatus*, but not on *A. schlegeli*.

*Key words: Occurrence, Regional variation, Fish larva, Intertidal zone, Coast of Taiwan.*

關鍵詞：出現、地區變異、仔稚魚、潮間帶、臺灣海岸。

## INTRODUCTION

The western coast of Taiwan is part of the continental shelf of the East China Sea. Inland discharges fertilized the waters of shelf and made Taiwan Strait an important fishing ground. In central Taiwan, the Da-du River is the main source that supplied terrestrial material to the Taiwan Strait. At least two

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types of topographic coast occurred in the west of central Taiwan, one estuary and the other plain coast. We selected a sampling site at Li-sui as a representative of estuary and a site at Wan-kun as representative of plain coast to study their fish larval constitution.

Utilization of specific habitat by fishes is a consequence of evolution which is thought to be a compound effect of ecology. Along the sandy shore, estuary and plain coast are the two major type of nursery areas for the early life history of fishes (Boehlert and Mundy, 1988; Cowan and Shaw, 1988; Krygier and Pearcy, 1986; Rijnsdorp *et al.*, 1985;). Therefore, they need to be studied from both theoretical and practical points of view.

Estuaries are continuously supplied with fresh water and excess terrestrial nutrient which supported higher primary productivity. Early life history of fishes utilize this habitat for both feeding and avoidance of predators. Plain coast has no direct supply of fresh water. In the western coast of Taiwan, the plain coast is rather flat in which shellfish aquaculture became the major utility of brackish water. Either in estuary or in plain coast, these marine environments are significantly influenced by regular tidal cycle. We adopted two special sampling gears to sample fishes in the intertidal zone in order to realize the assemblage of early staged fishes.

In Taiwan, larvae of *Anguilla japonica, Acanthopagrus latus, A. schlegeli, Mugil cephalus, Chanos chanos*, and *Lateolabrax japonicus* are conventionally collected by coastal fishermen for pond cultivation and their life history have been known to the local fishermen. Most of other larvae are still need to be studied for various purposes, such as environmental monitoring and resource management. Some survey on the coastal fish larvae had been carried in mid 1980's, such as estuaries of Tan-sui and Shuang-hsi rivers (Tzeng, *et al.*, 1985), of Kao-ping and Chao-sui Rivers (Chen, 1985); plain coast in the north-western Taiwan (Chan, 1985), and off the Taitung area (Hung, 1985). We attempted to add more basic information to coastal water around Taiwan. This report put primarily concerned on the coastal area of western central Taiwan.

## MATERIALS AND METHODS

There are two types of coastal environments for larvae or juveniles: one is estuary and the other plain coast. We selected Li-sui, Tai-chung County as the sampling location for estuary environment and Wan-kun, Chang-wha County for plain coast (Fig. 1). The monthly sampling schedule lasted for one year round from February 1990 to February 1991. Two types of intercept net were deployed for each sampling site (Fig. 2). In the estuary, the dimension of the intercept net (Fig. 2A) was 7.1 m in mouth stretch, 19.45 m in length (13.9 m selves, 4.76 m conical body and 0.79 m collector), and 1.55 mm mesh size in the conical net. In the plain coast, the dimension of the net (Fig. 2B) was 7.22 m in mouth stretch, 11.57 m in length (6.8 m selves, 4.77 in conical body), and 1.95 mm mesh size in the conical net. Both nets were modified from those nets conventionally used by local fishermen. Each sampling started at onset of the day-time ebb tide and lasted for one hour. Samples were fixed in 15% formain of the brackish water.

Parameters from background environment were also recorded. Salinity and temperature were measured by a digital salinometer (WTW model LF 191). The pH value was determined by a pH meter (BECKMAN PHI 12). The dissolved oxygen was measured following the Winkler method.

In the laboratory, fish larvae and juveniles were sorted out from samples and

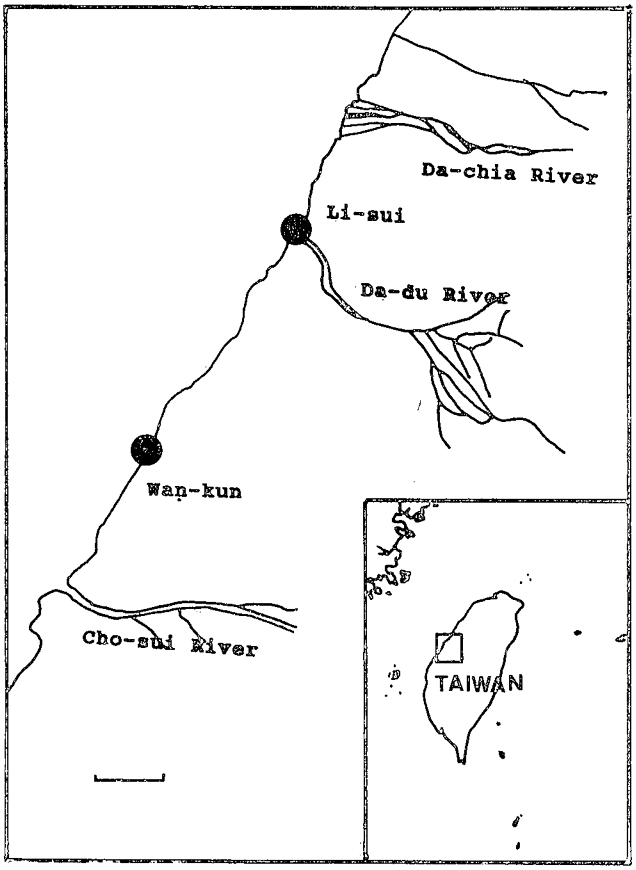


Fig. 1. Maps showing the localities of larval fish sampling.

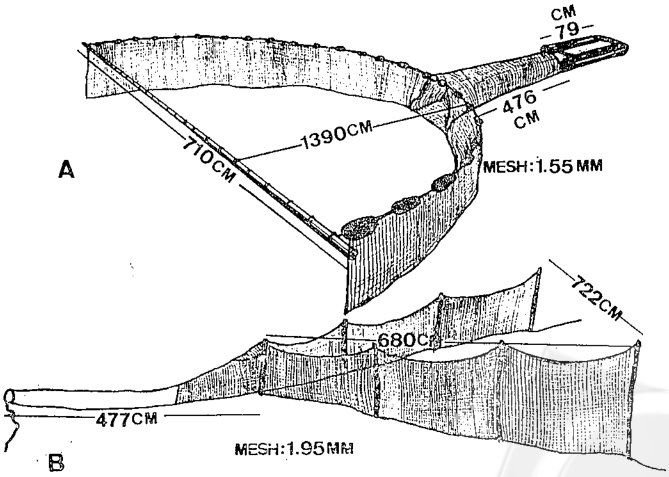


Fig. 2. Schematic diagrams of intercept net used for larval sampling in the intertidal zone.

identified to the lowest taxonomic level as possible. Numbers of fish larva and juvenile were counted. Indices of species diversity and evenness were used to denote the heterogeneity of larval assemblage. Both parametric and non-parametric statistics were used to test the eco-geographic difference.

## RESULTS

### Hydrographic conditions

Four hydrographic parameters were measured in prior to sampling of larvae and juveniles (Table 1). In the estuary, the annual water temperatures ranged

Table 1. Hydrographic parameters measured during fish larval sampling period

| Sampling date | Temperature (°C) | Salinity (‰) | Dissolved oxygen (ml/l) | pH |
|---|---|---|---|---|
| Estuary | | | | |
| Feb. 7, 1990 | 17.2 | 29.9 | 8.7 | 7.39 |
| Mar. 13 | 20.6 | 22.6 | 6.4 | 8.06 |
| Apr. 9 | 22.4 | 32.2 | 6.9 | 8.25 |
| May 7 | 26.1 | 10.2 | 5.7 | 6.80 |
| June 21 | 29.0 | 17.7 | 6.7 | 8.26 |
| July 11 | 31.1 | 16.1 | 6.4 | 8.25 |
| Aug. 12 | 30.6 | 28.2 | 5.7 | 8.32 |
| Sep. 2 | 26.3 | 27.0 | 6.1 | 10.01 |
| Oct. 7 | 26.1 | 32.1 | 6.7 | 8.48 |
| Nov. 16 | 25.0 | 21.1 | 5.9 | 7.80 |
| Dec. 4 | 20.4 | 29.2 | 7.9 | 7.79 |
| Jan. 18, 1991 | 19.3 | 30.2 | 7.0 | 8.13 |
| Avg. | 24.5 | 24.7 | 6.7 | 8.13 |
| SD | 4.5 | 7.1 | 0.9 | 0.76 |
| Plain coast | | | | |
| Mar. 14, 1990 | 22.9 | 30.7 | 7.2 | 8.13 |
| Apr. 23 | 23.9 | 24.5 | 5.7 | 8.12 |
| May 8 | 28.4 | 28.5 | 6.6 | 8.21 |
| June 11 | 31.5 | 20.3 | 6.9 | 8.15 |
| July 12 | 32.9 | 28.6 | 5.7 | 7.60 |
| Aug. 10 | 32.0 | 27.9 | 5.2 | 8.19 |
| Sep. 3 | 30.8 | 30.0 | 6.4 | 9.67 |
| Oct. 6 | 25.7 | 31.3 | 6.5 | 8.51 |
| Nov. 17 | 26.9 | 31.8 | 6.7 | 8.03 |
| Dec. 5 | 20.5 | 32.2 | 8.1 | 7.96 |
| Jan. 17, 1991 | 19.7 | 30.9 | 6.6 | 8.01 |
| Feb. 4 | 16.8 | 30.5 | 7.3 | 8.04 |
| Avg. | 26.0 | 28.9 | 6.6 | 8.22 |
| SD | 5.3 | 3.4 | 0.8 | 0.50 |
| Student's *t*-test for difference between groups: | | | | |
| Difference (*D*) | 1.5 | 4.2 | 0.1 | 0.09 |
| *P*-value | 0.468 | 0.077 | 0.773 | 0.073 |
| Rank test for difference between groups: | | | | |
| *Z*-value | 0.01 | 0.04 | 0.61 | 0.94 |
| Significance | ** | ** | | |

17.2°C (Feb.) -31.1°C (July). The annual average temperature was 24.5±4.5°C. The salinities ranged 10.2‰ (May)-32.2‰ (Apr.). April was the drought month of the year and followed by plume-rain season which begun in May and supplied heavy inland run-off to the estuary. Annual salinity averaged 24.7±7.1‰. The pH values ranged 6.80-10.01 and averaged 8.13±0.76. Dissolved oxygen ranged 5.7-8.7 ml/l and averaged 6.7±0.9 ml/l. In the plain coast, the annual water temperatures ranged 16.8°C (Feb.)-32.9°C (July). The annual average temperature was 26.0±5.3°C. The salinities ranged 20.3‰ (June)-32.2‰ (Dec.). The plume-rain season did not put much effect on the marine environment of plain coast. Annual salinity averaged 28.9±3.4‰. The pH values ranged 7.6-9.67 and averaged 8.22±0.50. Dissolved oxygen ranged 5.2-8.1 ml/l and averaged 6.6±0.8 ml/l.

The student's $t$-test was applied for comparison of two different eco-geographic environments. No statistical difference was found in all the hydrographic parameters. The statistic results for difference ($D$) of temperature were $D$=1.5°C, $P$-Value ($P$)=0.468; for salinity $D$=4.2‰, $P$=0.077; for pH $D$=0.09, $P$=0.073; and for dissolved oxygen $D$=0.1 ml/l, $P$=0.773. Rank test applied on the monthly trend of two ecogeographic regions indicated that temperature trend was different ($Z$=0.04) at 5% significant level. Within each eco-geographic region, rank correlation applied on monthly measurements indicated that dissolved oxygen was significantly correlated with water temperature (in estuary $r_s=-0.66$, $P$=0.029; in plain coast $r_s=-0.63$, $P$=0.037).

**Annual species composition**

In the estuary, a total of 4,603 larvae assigned to 38 species was caught during this study. *Acanthopagrus schlegeli* was the most abundant species which counted to 18.4% of total catches. The remaining dominant species were *Liza macrolepis* (16.01%), *Stolephorus indicus* (15.18%), and *Gerres abbreviatus* (11.07%). The Simpson diversity index for the estuary assemblage was 0.88 and evenness was 0.56 (Table 2).

Table 2. Annual species composition from estuary and plain coast of western Taiwan

| Species | Estuary | | Plain coast | |
|---|---|---|---|---|
| | Catch | Rank | Catch | Rank |
| *Acanthopagrus latus* | 16 | 17 | 192 | 15 |
| *Acanthopagrus schlegeli* | 839 | 1 | 10,328 | 2 |
| *Ambassis gymnocephalus* | 272 | 6 | 30,145 | 1 |
| *Ambasssis urotaenia* | 62 | 12 | 2 | 41 |
| *Apocryptodon madurensis* | | | 2 | 41 |
| *Apogon cookii* | | | 1 | 45 |
| *Benthosema pterotum* | 4 | 23 | 1 | 45 |
| Blennid | | | 1 | 45 |
| *Caranx sexfasciatus* | | | 4 | 32 |
| *Chanos chanos* | 4 | 23 | 67 | 18 |
| *Clupea pallasi* | | | 47 | 20 |
| *Ecsenius namiyei* | | | 3 | 38 |
| *Elops hawaiensis* | 11 | 19 | 362 | 11 |
| *Engraulis japonicus* | 33 | 16 | 1,384 | 6 |
| *Eopsetta grigorjewi* | | | 1 | 45 |
| *Gerres abbreviatus* | 509 | 5 | 3,049 | 3 |
| *Girella punctata* | 1 | 35 | 268 | 13 |
| Gobiid | 520 | 4 | 2,955 | 4 |

Table 2. (continued)

| Species | Estuary Catch | Estuary Rank | Plain coast Catch | Plain coast Rank |
|---|---|---|---|---|
| *Hirundichthys oxycephalus* | | | 2 | 41 |
| *Hypoatherina bleekeri* | | | 14 | 27 |
| *Lagocephalus wheeleri* | 3 | 28 | 3 | 38 |
| *Lateolabrax* sp. | 116 | 10 | 5 | 30 |
| Leiognathid | | | 25 | 23 |
| *Leiognathus* sp. | 4 | 23 | 1 | 45 |
| *Lestidiops indopacifica* | | | 4 | 32 |
| *Liza macrolepis* | 736 | 2 | 2,079 | 5 |
| *Liza* sp. 1 | | | 41 | 22 |
| *Liza* sp. 2 | | | 6 | 29 |
| *Liza* sp. 3 | | | 4 | 32 |
| *Lutjanus monostigma* | 1 | 35 | | |
| *Lutjanus russellii* | | | 4 | 32 |
| *Megalops cyprinoides* | 4 | 23 | 370 | 10 |
| *Micropterus* sp. | 5 | 20 | | |
| *Monodachtylus argenteus* | 1 | 35 | 3 | 38 |
| *Mugil cephalus* | | | 51 | 19 |
| *Nibea japonica* | | | 1 | 45 |
| *Omobranchus elegans* | 5 | 20 | 143 | 16 |
| Ophichthinae sp. 1 | | | 5 | 30 |
| *Paramonacanthus japonicus* | | | 1 | 45 |
| *Parasyngnathus argyrostictus* | 3 | 28 | 17 | 24 |
| *Petroscirtes springeri* | | | 1 | 45 |
| *Pictiblennius yatabei* | | | 1 | 45 |
| *Platycephalus indicus* | 2 | 33 | 15 | 26 |
| *Scartella cristata* | 3 | 28 | | |
| *Sardinella zunasi* | 2 | 33 | 2 | 41 |
| *Scatophagrus argus* | 5 | 20 | 8 | 28 |
| *Scomberoides tol* | 12 | 18 | | |
| *Secutor insidiator* | 33 | 15 | 4 | 32 |
| *Sillago japonica* | 60 | 13 | 127 | 17 |
| *Sillago maculata* | 40 | 14 | 43 | 21 |
| *Sillago sihama* | 237 | 7 | 357 | 12 |
| *Sphyraena barracuda* | 8 | 28 | 15 | 25 |
| *Stolephorus indicus* | 698 | 3 | 629 | 7 |
| *Synodus macrops* | | | 4 | 32 |
| *Takifugu niphobles* | 132 | 9 | 548 | 8 |
| *Terapon jarbua* | 73 | 11 | 406 | 9 |
| *Thrissa purava* | 141 | 8 | 255 | 14 |
| *Tilapia nilotica* | 1 | 35 | | |
| *Trachinocephalus myops* | 3 | 28 | | |
| *Trichiurus lepturus* | 4 | 23 | | |
| *Tripodichthys blochii* | | | 1 | 45 |
| Total | 4,603 | | 54,007 | |

In the plain coast, a total of 54,007 larvae assigned to 53 species was sampled during this study. *Ambassis gymnocephalus* was the most abundant species which was counted to 55.81% of total catches. The leftover dominant species were *A. schlegeli* (19.2%), *G. abbreviatus* (5.65%), gobiid (5.47%), and *L. macrolepis* (3.94%). The Simpson diversity index for the plain coast assemblage was 0.64 and evenness was 0.38 (Table 3).

Table 3. Checklists of catches from estuary

| Taxon | 1990 F | M | A | M | J | J | A | S | O | N | D | 1991 J | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Clupeidae | | | | | | | | | | | | | |
| *Sardinella zunasi* | | | | | | 2 | | | | | | | 2 |
| Engraulidae | | | | | | | | | | | | | |
| *Engraulis japonicus* | | | 3 | 12 | | 6 | | | | | 12 | | 33 |
| *Stolephorus indicus* | | | | | | 1 | 637 | | 57 | 1 | 2 | | 698 |
| *Thrissa purava* | | | | | | | 92 | 45 | 4 | | | | 141 |
| Elopidae | | | | | | | | | | | | | |
| *Elops hawaiensis* | | 2 | | 6 | 2 | 1 | | | | | | | 11 |
| *Megalops cyprinoides* | | | | | | 1 | 2 | | | | 1 | | 4 |
| Chanidae | | | | | | | | | | | | | |
| *Chanos chanos* | | | | 2 | 2 | | | | | | | | 4 |
| Synodontidae | | | | | | | | | | | | | |
| *Trachinocephalus myops* | 1 | | 2 | | | | | | | | | | 3 |
| Myctophidae | | | | | | | | | | | | | |
| *Benthosema pterotum* | | | 3 | | | | | | | | | 1 | 4 |
| Syngnathidae | | | | | | | | | | | | | |
| *Parasyngnathus argyrostictus* | | | | | | 2 | 1 | | | | | | 3 |
| Mugilidae | | | | | | | | | | | | | |
| *Liza macrolepis* | 60 | 428 | 211 | 21 | 12 | | | | | 3 | | 1 | 736 |
| Sphyraenidae | | | | | | | | | | | | | |
| *Sphyraena barracuda* | | | | | 1 | 2 | | | | | | | 3 |
| Ambassidae | | | | | | | | | | | | | |
| *Ambassis gymnocephalus* | | | | 125 | 25 | 62 | 51 | 2 | | 7 | | | 272 |
| *Ambassis urotaenia* | | | | | | | | 61 | | | 1 | | 62 |
| Percichthyidae | | | | | | | | | | | | | |
| *Lateolabrax* sp. | 110 | | 6 | | | | | | | | | | 116 |
| Centrarchidae | | | | | | | | | | | | | |
| *Micropterus* sp. | | | | | | | | 5 | | | | | 5 |
| Sillaginidae | | | | | | | | | | | | | |
| *Sillago japonica* | | | 31 | 25 | | 2 | | | 1 | | 1 | | 60 |
| *Sillago maculata* | | | 19 | | | 1 | 20 | | | | | | 40 |
| *Sillago sihama* | | | 3 | 25 | 132 | 18 | 13 | 1 | 18 | 26 | 1 | | 237 |
| Carangidae | | | | | | | | | | | | | |
| *Scomberoides tol* | | | | | 10 | | 2 | | | | | | 12 |

Table 3. (continued)

| Taxon | 1990 F | M | A | M | J | J | A | S | O | N | D | 1991 J | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Leiognathidae | | | | | | | | | | | | | |
| *Leiognathus* sp. | | | 1 | 1 | | | | | 2 | | | | 4 |
| *Secutor insidiator* | | 1 | | | | | 3 | 1 | 4 | | 13 | 11 | 33 |
| Gerreidae | | | | | | | | | | | | | |
| *Gerres abbreviatus* | | | | 185 | 320 | 4 | | | | | | | 509 |
| Monodachtylidae | | | | | | | | | | | | | |
| *Monodachtylus argenteus* | | | | 1 | | | | | | | | | 1 |
| Girellidae | | | | | | | | | | | | | |
| *Girella punctata* | | | | | | | | | | 1 | | | 1 |
| Lutjanidae | | | | | | | | | | | | | |
| *Lutjanus monostigma* | | | | | | | | | | 1 | | | 1 |
| Teraponidae | | | | | | | | | | | | | |
| *Terapon jarbua* | | | | 44 | 20 | 7 | 1 | | | | 1 | | 73 |
| Sparidae | | | | | | | | | | | | | |
| *Acanthopagrus latus* | | | | | | | | | | 5 | 5 | 6 | 16 |
| *Acanthopagrus schlegeli* | | 42 | 716 | 81 | | | | | | | | | 839 |
| Scatophagidae | | | | | | | | | | | | | |
| *Scatophagus argus* | | | | | 2 | 2 | 1 | | | | | | 5 |
| Cichlidae | | | | | | | | | | | | | |
| *Tilapia nilotica* | | | | | 1 | | | | | | | | 1 |
| Trichiuridae | | | | | | | | | | | | | |
| *Trichiurus lepturus* | | | | | | | | | 4 | | | | 4 |
| Gobiidae | | | | | | | | | | | | | |
| Gobiid | | | 5 | 49 | 32 | 18 | 34 | 29 | 353 | | | | 520 |
| Blenniidae | | | | | | | | | | | | | |
| *Omobranchus elegans* | | | | | 3 | | 2 | | | | | | 5 |
| *Scartella cristata* | | | 1 | 1 | | | | | | | 1 | | 3 |
| Platycephalidae | | | | | | | | | | | | | |
| *Platycephalus indicus* | | | 1 | | | | | | 1 | | | | 2 |
| Tetraodontidae | | | | | | | | | | | | | |
| *Lagocephalus wheeleri* | | | | | 3 | | | | | | | | 3 |
| *Takifugu niphobles* | | | | | 124 | 6 | 2 | | | | | | 132 |
| Grand total | 171 | 473 | 1,003 | 578 | 689 | 135 | 861 | 144 | 444 | 44 | 38 | 19 | 4,603 |

Table 4. Checklists of catches from plain coast

| Taxon | 1990 M | A | M | J | J | A | Month S | O | N | D | 1991 J | F | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Clupeidae | | | | | | | | | | | | | |
| *Clupea pallasi* | | 6 | 41 | | | | | | | | | | 47 |
| *Sardinella zunasi* | | | | 2 | | | | | | | | | 2 |
| Engraulidae | | | | | | | | | | | | | |
| *Engraulis japonicus* | | 62 | 396 | 92 | 834 | | | | | | | | 1,384 |
| *Stolephorus indicus* | | | 7 | 2 | 12 | 41 | 410 | 9 | 142 | 6 | | | 629 |
| *Thrissa purava* | | | | | | 192 | 59 | 1 | 3 | | | | 255 |
| Elopidae | | | | | | | | | | | | | |
| *Elops hawaiensis* | 18 | 15 | 213 | 73 | 3 | 8 | 1 | | 31 | | | | 362 |
| *Megalops cyprinoides* | | | | 243 | 13 | 100 | 2 | | 12 | | | | 370 |
| Ophichthidae | | | | | | | | | | | | | |
| Ophichthinae sp. 1 | | | | | | | | | | | 5 | | 5 |
| Chanidae | | | | | | | | | | | | | |
| *Chanos chanos* | | | 7 | | 13 | 46 | 1 | | | | | | 67 |
| Synodontidae | | | | | | | | | | | | | |
| *Synodus macrops* | | | 4 | | | | | | | | | | 4 |
| Myctophidae | | | | | | | | | | | | | |
| *Benthosema pterotum* | | | 1 | | | | | | | | | | 1 |
| Paralepididae | | | | | | | | | | | | | |
| *Lestidiops indopacifica* | 4 | | | | | | | | | | | | 4 |
| Exocoetidae | | | | | | | | | | | | | |
| *Hirundichthys oxycephalus* | | | 2 | | | | | | | | | | 2 |
| Syngnathidae | | | | | | | | | | | | | |
| *Parasyngnathus argyrostictus* | | | 2 | 7 | | 8 | | | | | | | 17 |
| Atherinidae | | | | | | | | | | | | | |
| *Hypoatherina bleekeri* | | | 12 | | | | 1 | 1 | | | | | 14 |
| Mugilidae | | | | | | | | | | | | | |
| *Liza macrolepis* | 167 | 362 | | 17 | 5 | | 3 | 485 | 10 | 50 | 889 | 91 | 2,079 |
| *Liza* sp. 1 | | | 41 | | | | | | | | | | 41 |
| *Liza* sp. 2 | | | 6 | | | | | | | | | | 6 |
| *Liza* sp. 3 | | | 4 | | | | | | | | | | 4 |
| *Mugil cephalus* | | | | | | | | | | 33 | 2 | 16 | 51 |

Table 4. (continued)

| Taxon | 1990 M | A | M | J | J | A | S | O | N | D | 1991 J | F | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sphyraenidae | | | | | | | | | | | | | |
| *Sphyraena barracuda* | | | | 3 | | 12 | | | | | | | 15 |
| Ambassidae | | | | | | | | | | | | | |
| *Ambassis gymnocephalus* | 142 | 197 | 23,591 | 1,921 | 3,508 | 100 | 234 | 347 | 105 | | | | 30,145 |
| *Ambassis urotaenia* | | | | | | | | | | 2 | | | 2 |
| Percichthyidae | | | | | | | | | | | | | |
| *Lateolabrax* sp. | 5 | | | | | | | | | | | | 5 |
| *Apogon cookii* | 1 | | | | | | | | | | | | 1 |
| Sillaginidae | | | | | | | | | | | | | |
| *Sillago japonica* | 1 | 10 | 5 | 3 | | | | 84 | 22 | 2 | | | 127 |
| *Sillago maculata* | | 1 | 13 | | | | 1 | 28 | | | | | 43 |
| *Sillago sihama* | 5 | 12 | 53 | 3 | 25 | 9 | 11 | 159 | 54 | 26 | | | 357 |
| Carangidae | | | | | | | | | | | | | |
| *Caranx sexfasciatus* | | | | | | 4 | | | | | | | 4 |
| Leiognathidae | | | | | | | | | | | | | |
| *Secutor insidiator* | | | | | | | | 1 | 3 | | | | 4 |
| *Leiognathus* spp. | | 1 | 13 | | | 11 | | 1 | | | | | 26 |
| Gerreidae | | | | | | | | | | | | | |
| *Gerres abbreviatus* | | 1 | 2,795 | 150 | 79 | 3 | | 21 | | | | | 3,049 |
| Sciaenidae | | | | | | | | | | | | | |
| *Nibea japonica* | | | | | | | | | 1 | | | | 1 |
| Monodachtylidae | | | | | | | | | | | | | |
| *Monodachtylus argenteus* | | | 3 | | | | | | | | | | 3 |
| Girellidae | | | | | | | | | | | | | |
| *Girella punctata* | | 99 | 151 | | | | | 3 | 10 | 5 | | | 268 |
| Lutjanidae | | | | | | | | | | | | | |
| *Lutjanus russellii* | | | | | | | | 4 | | | | | 4 |

Table 4. (continued)

| Taxon | 1990 M | A | M | J | J | A | Month S | O | N | D | 1991 J | F | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Teraponidae | | | | | | | | | | | | | |
| *Terapon jarbua* | | 26 | 44 | 66 | 65 | 57 | | 32 | 1 | 115 | | | 406 |
| Sparidae | | | | | | | | | | | | | |
| *Acanthopagrus latus* | | | | | | | | | 24 | 43 | 113 | 12 | 192 |
| *Acanthopagrus schlegeli* | 405 | 5,677 | 4,226 | | | | | | | | 20 | | 10,328 |
| Scatophagidae | | | | | | | | | | | | | |
| *Scatophagus argus* | | | | 5 | 1 | 2 | | | | | | | 8 |
| Gobiidae | | | | | | | | | | | | | |
| *Apocryptodon madurensis* | | | | | | | | | | | | 2 | 2 |
| Gobiid | 2 | 167 | 2,389 | 163 | 93 | 40 | 5 | 68 | 27 | | 1 | | 2,955 |
| Blenniidae | | | | | | | | | | | | | |
| *Ecsenius namiyei* | 3 | | | | | | | | | | | | 3 |
| *Omobranchus elegans* | | | 139 | 2 | | | | 2 | | | | | 143 |
| *Petroscirtes springeri* | | | | | | | | 1 | | | | | 1 |
| *Pictiblennius yatabei* | | | | | | | | 1 | | | | | 1 |
| Blennid | | | | | | | | | | | 1 | | 1 |
| Platycephalidae | | | | | | | | | | | | | |
| *Platycephalus indicus* | | 9 | 3 | | 1 | | | | 2 | | | | 15 |
| Pleuronectidae | | | | | | | | | | | | | |
| *Eopsetta grigorjewi* | | 1 | | | | | | | | | | | 1 |
| Triacanthidae | | | | | | | | | | | | | |
| *Tripodichthys blochii* | | | | | | 1 | | | | | | | 1 |
| Monoacanthidae | | | | | | | | | | | | | |
| *Paramonacanthus japonicus* | | | | | | | 1 | | | | | | 1 |
| Tetraodontidae | | | | | | | | | | | | | |
| *Lagocephalus wheeleri* | | | 3 | | | | | | | | | | 3 |
| *Takifugu niphobles* | 1 | | | 384 | 159 | 4 | | | | | | | 548 |
| Grand total | 754 | 6,646 | 34,164 | 3,136 | 4,814 | 638 | 729 | 1,249 | 447 | 282 | 1,031 | 121 | 54,007 |

The rank test between the assemblages from estuary and plain coast indicated a significant difference in species composition ($Z=3.94$, $P=0.000$).

**Monthly occurrence**

Checklists for monthly variation of abundance are shown in Table 3 for estuary and Table 4 for plain coast.

In the estuary, monthly richness of species ranged 3–16 taxa. Low taxon abundance occurred in spring (Jan.–Mar.) assemblage. On the other hand, high taxon abundance exhibited in summer-autumn assemblages. The larval assemblage indicated the highest abundance from April to August. The spring assemblage was mainly composed of *L. macrolepis* and *A. schlegeli*. In summer, the larval assemblage was constituted by *A. gymnocephalus*, *Sillago sihama*, and *G. abbreviatus*. Turning to autumn, clupeoid fish, such as *S. indicus* and *Thryssa kammalensis*, dominated the assemblage. In winter, the larval abundance was rather low, although in the autumn-winter boundary gobies were rather abundant. The monthly diversity indices of estuary assemblage ranged 0.17–0.81 The highest diversity was reached in May and lowest diversity occurred in March. The diversity index fluctuated around year.

In the plain coast, monthly richness of species ranged 4–27 taxa. Low taxon abundance occurred in spring (Jan.–Mar.) assemblage. On the other hand, highest taxon abundance exhibited in May. The larval assemblage indicated highest abundance from April to July. The spring assemblage was mainly composed of *L. macrolepis* and *A. schlegeli*. In summer, the larval assemblage was significantly constituted by *A. gymnocephalus*, although *G. abbreviatus* and *A. schlegeli* were also abundant. Clupeoid fish did not occur in the autumn assemblage of plain coast. In winter, the larval abundance was rather low, although in the autumn-winter boundary, *L. macrolepis* and *S. sihama* were the major species. The monthly diversity indices of plain coastal assemblage ranged 0.24–0.83. The highest diversity was reached in August and lowest diversity occurred in January.

Both eco-geographic parameters and monthly species compositions were subjected to canonical analysis in order to find out if there were any relations occurred between monthly transitions. But, no canonical correlations can be confirmed at 5% significant level.

**Monthly size variation of selected taxa**

Four major species, *L. macrolepis*, *T. jarbua*, *G. abbreviatus* and *A. schlegeli*, were selected for description of monthly size variation. Monthly mean body length, standard deviation and sampling size are shown in Table 5.

*Liza macrolepis:* The body size ranged 5.9–20.4 mm (Avg.=13.1 mm, SD=2.4 mm, N=161) in estuary and 4.0–24.2 mm (Avg.=14.3 mm, SD=3.2 mm, N=306) in plain coast. Monthly size variation indicated that small sized larvae occurred in November-January (Avg.=7.9–8.6 mm) and largest size reached in March (Avg.=15.3 mm) in the estuary. On the other hand, *L. macrolepis* larvae had small size in July-September (Avg.=5.7–6.5 mm) and largest size in February (Avg.=16.3 mm). Those larvae from plain coast were larger than those from estuary ($D=1.1$ mm, Student's $t=3.91$, $P=0.000$).

*Terapon jarbua:* The body size ranged 8.8–18.4 mm (Avg.=11.0 mm, SD=1.9 mm, N=63) in estuary and 7.7–16.8 mm (Avg.=10.5 mm, SD=1.5 mm, N=198) in plain coast. The larvae of *T. jarbua* concentrated in April-August. Monthly size variation was rather subtle. All larvae caught had an average body size of 10 mm.

Table 5. Monthy body size (in mm) variation of selected species

| Month | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1) *Liza macrolepis* | | | | | | | | | | | | |
| Estuary: | | | | | | | | | | | | |
| Avg. | 8.6 | 12.9 | 15.3 | 13.7 | 10.3 | 12.0 | | | | | 7.9 | |
| SD | — | 1.0 | 1.9 | 1.8 | 1.7 | 0.8 | | | | | 2.1 | |
| N | 1 | 30 | 34 | 58 | 23 | 12 | | | | | 3 | |
| Plain coast: | | | | | | | | | | | | |
| Avg. | 13.2 | 16.3 | 15.0 | 15.6 | | 13.7 | 5.7 | | 6.5 | 12.9 | 10.3 | 12.4 |
| SD | 1.2 | 3.8 | 2.2 | 2.9 | | 2.0 | 2.4 | | 3.4 | 0.7 | 1.5 | 1.0 |
| N | 35 | 40 | 51 | 93 | | 10 | 5 | | 3 | 30 | 10 | 30 |
| 2) *Terapon jarbu* | | | | | | | | | | | | |
| Estuary: | | | | | | | | | | | | |
| Avg. | | | | | 10.6 | 12.1 | 10.4 | 11.0 | | | | 31.9 |
| SD | | | | | 0.5 | 3.1 | 0.5 | — | | | | — |
| N | | | | | 36 | 19 | 7 | 1 | | | | 1 |
| Plain coast: | | | | | | | | | | | | |
| Avg. | | | | 10.6 | 9.9 | 10.5 | 10.3 | 10.9 | | 9.9 | 10.4 | 11.7 |
| SD | | | | 0.9 | 1.0 | 0.8 | 0.7 | 1.9 | | 1.9 | — | 1.4 |
| N | | | | 24 | 26 | 28 | 29 | 30 | | 30 | 1 | 30 |
| 3) *Gerrs abbreviatus* | | | | | | | | | | | | |
| Estuary: | | | | | | | | | | | | |
| Avg. | | | | | 9.0 | 12.7 | 11.1 | | | 10.0 | | |
| SD | | | | | 2.7 | 1.0 | 0.5 | | | — | | |
| N | | | | | 182 | 32 | 4 | | | 1 | | |
| Plain coast: | | | | | | | | | | | | |
| Avg. | | | | 17.0 | 10.9 | 12.5 | 10.3 | 10.9 | | 10.5 | | |
| SD | | | | — | 0.7 | 0.6 | 0.6 | 0.7 | | 0.5 | | |
| N | | | | 1 | 61 | 30 | 30 | 3 | | 21 | | |
| 4) *Acanthopagrus schelgeli* | | | | | | | | | | | | |
| Estuary: | | | | | | | | | | | | |
| Avg. | | | 11.2 | 10.2 | 10.2 | | | | | | | |
| SD | | | 1.6 | 1.0 | 0.4 | | | | | | | |
| N | | | 41 | 101 | 161 | | | | | | | |
| Plain coast: | | | | | | | | | | | | |
| Avg. | 10.1 | | 10.3 | 10.3 | 9.8 | | | | | | | |
| SD | 0.7 | | 1.9 | 1.5 | 0.4 | | | | | | | |
| N | 19 | | 66 | 193 | 69 | | | | | | | |

Those larvae from estuary were larger than those from plain coast ($D$=0.5 mm, $t$=2.14, $P$=0.033).

*Gerres abbreviatus:* The body size ranged 4.9-16.2 mm (Avg.=9.6 mm, SD=2.8 mm, N=219) in estuary and 8.7-17.0 mm (Avg.=11.1 mm, SD=1.1 mm, N=146) in plain coast. The larvae of *G. abbreviatus* also concentrated in April-August. Monthly size variation indicated that larvae were small sized in May, but larger sized larvae occurred after June. Those larvae from plain coast were larger than those from estuary ($D$=1.5 mm, $t$=5.98, $P$=0.000).

*Acanthopagrus schlegeli:* The body size ranged 4.4-13.6 mm (Avg.=10.3 mm, SD=

1.0 mm, N=303) in estuary and 4.6–15.0 mm (Avg.=10.2 mm, SD=1.5 mm, N=347) in plain coast. The larvae of *A. schlegeli* concentrated in March-May. Monthly size variation was rather subtle. All larvae caught had an average body size of 10 mm. No size difference was found between the two assemblages ($D$=0.2 mm, $t$=1.90, $P$=0.057).

## DISCUSSION

Estuary and plain coast are two different types of environment for early life history of fishes. Statistical analysis indicated a significant difference in both total abundance and their species composition. Nonetheless, both habitats reached a major peak abundance in spring-summer boundary and a minor peak in summer-autumn boundary. In the estuary, black bream (*A. schlegeli*) dominated the spring-summer assemblage and clupeoid larvae, such as *S. indicus* dominated the other. In the plain coast, the major components of the peak assemblage were *A. gymnocephalus* and *A. schlegeli*. All these differences supported that different eco-geographic types housed their specific larval assemblages. On the other hand, we should also notice that difference due to selection of sampling gear should be ruled out before further inference was made. Since our sampling gear have sophisticated design for specific marine topology, the bias from gear selection can hardly be avoided at this moment. Further examination on the size spectra of various species indicated that a minimum difference was detected in the size selection, but taxon selection on the gear type was still wanting.

Other studies on the fish larval assemblage of Taiwan indicated a consentaneous peak abundance in the spring-summer boundary. Wang (1987) reported that the peak occurred in May and June in Tan-sui and Suan-shi estuaries. The dominant species in these estuaries were *E. japonicus* and *Trachurus japonicus*. The occurrence of former species supported our inference that clupeoid larvae dominated Taiwanese estuary in summer assemblage. The later species was a common species came with the Kuroshio, but it was not the major component in shelf water as this study area located. Other studies which supported richness of fish larvae in spring-summer boundary were Leiu (1986), Hung (1985), and Tzeng, *et al.* (1985). In this period, the water temperature is getting warmer and daytime hours are getting longer. Greater primary productivity accomplished by marine producer supplied the water with abundant food items. Excess food might be carried shore-ward by tidal current and sometimes was accumulated on the intertidal zone. Therefore, both in estuary and in plain coast, the intertidal zone became an important area for the growth of larval fishes in the spring-summer period. On the other hand, this general pattern might not be necessarily point to that the larva and juvenile recruit to the nursery ground inadequately in winter. Some eel-like fishes, for example *Anguilla japonica* returned to the estuary in winter, although their migratory movement may not be counted for the purpose of feeding.

The species compositions were different in different region although the peak months were highly correlated. In the Hen-tzun peninsula, the major component was blennid and myctophid (Leiu, 1986). In the coastal waters of Taitung, the dominant species were apogonid, mugilid and engraulid (Hung, 1985). In the coastal waters off north-eastern Taiwan, the dominant species were scombrid, serranid and carangid (Tzeng, 1985).

The abundance of fish larvae was higher in plain coast than that in estuary. The taxon abundance was about 1.5 times higher in plain coast than that in estuary. Generally, estuary was an environment under higher stress, such as fluctuation on the tidal level and riverine discharge. Therefore, the dispersal and distribution of larva and juvenile were constrained by irregular change of salinity (Horne and Campana, 1989; Misitano, 1973).

Elver of Japanese eel (*A. japonica*) is an important species caught by local fishermen during winter period. This common elver was not found in our collections. This difference came from operational difference. Fishermen set their net at night specifically for elvers, but our design was for general purpose and was set during the daytime. Diurnal difference on the larval sampling was quite common and well-known in the off-shore survey, therefore for allopatric comparison of larval assemblage, fixed sampling hour should be the minimum consideration.

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# 臺灣西部中區沿岸仔稚魚羣集的生態地理差異

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為瞭解臺灣西部中區沿岸，仔稚魚在潮間帶上的組成型態，並比較河口域及平直岸的羣集差異，本研究以 1990 年 3 月至 1991 年 2 月間於麗水（大肚溪口）及王功（平直海岸），兩測站採集一年的仔稚魚標本進行分析研究。

實驗區的背景環境因素，包括溫度、鹽度、pH 値及溶氧等水文因子。背景因子的統計分析顯示：全年地域間之差異不顯著；但這兩個生態地理區，在魚種組成上，可以斷定為不同。

在河口域，共捕獲仔稚魚38種、4,603 尾；黑鯛為主要種，佔 18.4%；其餘依序為大鱗鯔 (16.0%)，印度銀帶鰶 (15.18%) 及短鑽嘴魚 (11.07%)。在平直岸，共捕獲 53 種、54,007 尾仔稚魚；眶棘雙邊魚為主要種，佔 55.81%；其餘依序為黑鯛 (19.2%)，短鑽嘴魚 (5.65%)，鰕虎 (5.47%) 及大鱗鯔 (3.94%)。

在河口域，月別魚種的豐度在 3-16 個之間，個體出現之豐度以 4 至 8 月為最高，歧異度在 0.1737-0.8140 間。在平直岸，魚種的豐度在 4-27 個之間，個體出現之豐度以 4 至 7 月為年內高峯，歧異度在 0.2443-0.8317 間。平直岸的複雜度高於河口域。

在兩個不同的生態地理區，同種的大鱗鯔、花身鷄魚及短鑽嘴魚其體長組成不同；但黑鯛在兩區間，其體長組成無差異。