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Ecological studies on the Hydromedusae, Siphonophores and Ctenophores in the Xiamen Harbour and adjacent waters

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Abstract—— This paper deals with species composition, seasonal change and horizontal distribution of the Hydromedusae (Hyd.), Siphonophores (Sip.) and Ctenophores (Cte.) and their relationship to the environmental factors. Materials from 17 stations in the Xiamen Harbour and adjacent waters were taken once monthly for the period from Sep. 1980 to Aug. 1981. The results indicate that for the dominant species of *Phialidium folleatum*, *Lensia subtiloides* and *Pleurobrachia globosa*, the total annual number of species has one peak and the total annual number of individual has one peak and two secondary peaks. On the basis of their ecological characteristice, the Hydromedusae, Siphonophores and Ctenophores found in the region investigated may be divided into the following ecological groups: estuarine group, neritic group and oceanic group. Their seasonal succession is correlated with the relative intensity of several water systems.

INTRODUCTION

Detailed reports are available for the taxonomic studies of the Hydromedusae, Siphonophores and

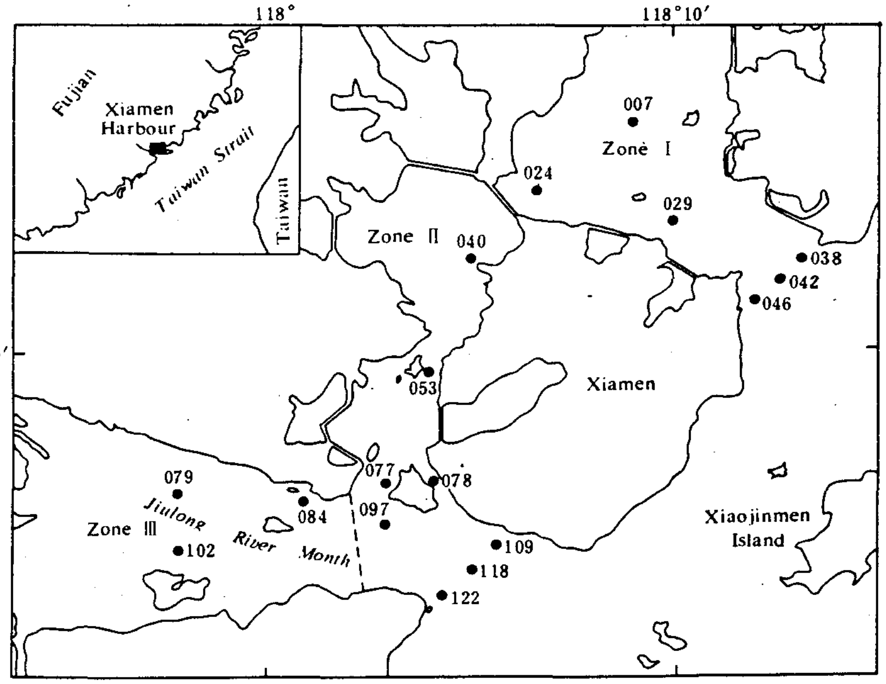

Fig. 1. A diagram of sampling stations.

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Ctenophores in the Xiamen Harbour and adjacent waters. However, only two papers are available dealing with their ecology in Zone III (Jiulong River) in the region investigated. This paper reports the results for ecological studies on the Hydromedusae, Siphonophores and Ctenophores. Materials from 17 stations of Zone I (Xunjiang zone), Zone II (Western zone) and Zone III (Jiulong River zone) were taken once in a month for the period from Sep. 1980 to Aug. 1981. Altogether 221 quantitative zooplanktonic samples were obtained with planktonic net (cone-shaped, 140 cm in length, 50 cm in mouth diameter, 15 meshes/cm) hauling vertically from the bottom to the surface at a speed of 0.5 m/s. The degree of biomass is expressed by numder of individuals per 100 m^3 of water filtered.

SPECIES COMPOSITION AND THEIR SEASONAL CHANGE

In this investigation, sixty-eight species of the Hydromedusae including two new species (Zhang and Lin, 1984), five species of the Siphonophores, two species of the Ctenophores were identified (Table 1). On the basis of this investigation and previous words (Qiu, 1954a; 1954b; 1962; 1980; Xu and Chin, 1962; Xu and Huang, 1983; Xu *et al.*, 1985; Zhang and Lin, 1984; Zhang and Wu, 1981), up to now, 78 species of the Hydromedusae, 5 species of the Siphonophores, 5 species of the Ctenophores have been noted in the region investigated. Among species mentioned above, fourty-three species were found in Zhejiang Province and the middle and northern sections of Fujian Province (Xu and Zhang, 1964; Zhang, 1977; Zhang and Xu, 1980), sixty-two species in the southern section of Fujian, Guangdong and the South China Sea (Xu and Zhang, 1964; 1978; 1981; Zhang and Xu, 1979; 1980; 1982), of which *Dipurena ophiogaster*, *Platystoma nanhaiense*, *Cirrholovenia polynema*, *Blackfordia polytentaculata*, *Octophialucium medium*, *Eutima gracilis*, *E. curva*, *Merga tetrastina* and *Petasiella asymmetrica* were only found in the region investigated and waters to its south. This indicates that the region investigated is more similar with the southern section of Fujian, Guangdong Provinces and the South China Sea on the fauna of the Hydromedusae, Siphonophores and Ctenophores.

Table 1. Species list of the Hydromedusae, Siphonophores and Ctenophores in this survey

Name of species	Month											
	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Hydromedusae												
Dipurena ophiogaster												—
D. strangulata												—
Sarsia replendens									—			
S. nipponica								—				
Ectopleura minerva												—
E. xiamenensis										—		—
Euphysa aurata				—								
Euphysora bigelowi								—		—	—	—
Ramus xiamenensis	—	—										—
Hybocodon prolifer								—				
Pennaria tiarella								—				
Zanclea costata												—
Cytaeis tetrastyla								—				

(To be continued on the next page)

(*continued*)

Name of species	Month											
	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Turritopsis lata										—	—	—
Podocoryne apicata											—	—
Podocoryne minima								—	—			
pLatystoma nanhaiense												—
Rathkea octopunctata						—	—	—				
Bougainvillia ramosa									—			—
B. platygaster												—
Nemopsis bachei							—	—			—	
Amphinema dinema												—
A. rugosum							—					
Euphysilla pyramidata							—					
Obelia spp.	—	—						—		—	—	—
Phialidium chengshanense							—	—				
P. folleatum	—	—						—	—	—	—	—
P. discoidum											—	
P. hemisphaericum	—	—						—		—	—	—
Cirrholovenia polynema											—	
C. tetranema								—				—
Eucheilota menoni								—				—
E. ventricularis										—		—
E. tropica										—	—	—
E. macrogona												—
Lovenella assimilis								—	—	—		—
Blackfordia manhattensis												—
B. virginica								—				
Octophialucium indicum	—									—		—
O. medium												—
Phialucium carolinae	—	—						—	—			—
P. condensum	—									—		—
Eirene ceylonensis	—	—						—	—	—	—	—
E. menoni	—	—						—	—		—	—
E. kambara		—										
E. brevigona											—	
E. pyramidalis									—			
E. palkensis												—
E. varidula												—
Helgicirrha malayensis	—	—										—
Eutonina scientillans												—
Eutima gracilis											—	
E. levuka	—	—							—	—	—	—
E. gegenbauri									—			
E. modesta												—
E. orientalis											—	—
E. neucaledonia											—	—
E. japonica										—	—	—
Aequorea australis		—										—
A. conica	—	—								—		—
Tiaricodon coeruleus				—	—	—	—	—				

(*To be continued on the next page*)

(*continued*)

Name of species	Month											
	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Proboscidactyla ornata	—									—		—
P. flavicirrata	—											
Liriope tetraphylla		—	—					—	—	—	—	—
Petasiela asymmetrica											—	—
Aglaura hemistoma	—	—										—
Aeginura grimaldii	—		—									—
Solmundella bitentaculata	—	—								—		—
Siphonophora												
Agalma elegans												—
Physophora hydrostatica	—	—	—	—						—	—	—
Diphyes chamissonis	—	—	—	—	—					—	—	—
Lensia subtiloides	—	—	—		—	—	—	—	—	—	—	—
Muggiaea atlantica						—	—	—	—	—		
Ctenophora												
Pleurobrachia globosa	—	—	—	—	—	—	—	—	—	—	—	—
Beroe cucumis	—	—	—		—	—		—	—	—	—	—

Figure 2 shows the positive correlation between number of species and seasonal temperature change. However, no close correlation between number of species and salinity is found. In August,

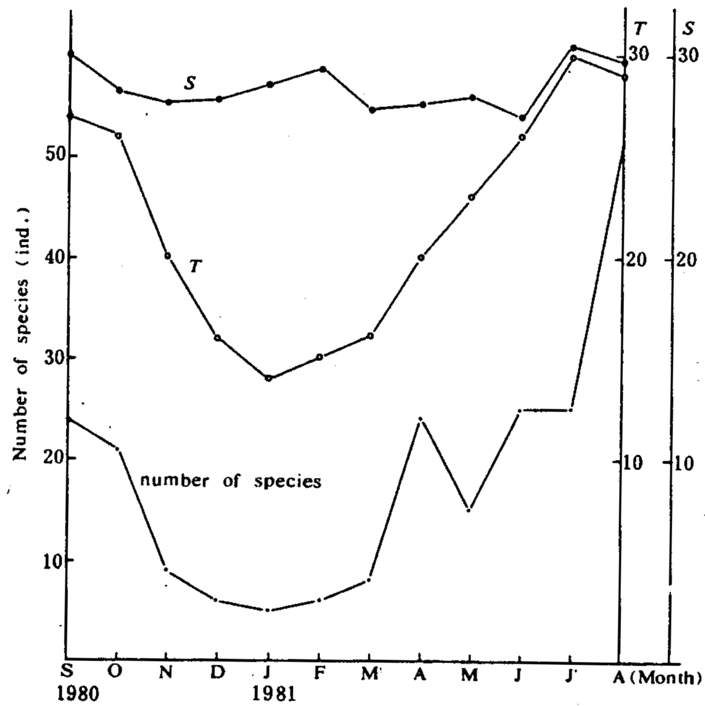

Fig. 2. Relationship between number of species and temperature and salinity.

the Hydromedusae number increased with the increases of temperature and arrived at its annual peak. There were only 5 to 9 species as the temperature decreased from 20 to 14℃ in the period from Nov. to March, thus resulting in the valley of number of species in March. During the periods of April, May, June, July, Sep. and Oct. about 20 species appeared as the temperature was above 20℃. It was worthwhile to note, although May had a higher temperature, number of species was less in May than in April. This was caused by the general disappearance of warm-themperate species and low appearance of warm-water species in May.

DISTRIBUTION OF TOTAL NUMBER OF INDIVIDUAL

For annual number of individual, the Hydromedusae came first with a mean value of 1 798 $\times 10^{-2}$ ind. /m^3, the Siphonophores the second with a mean value of 1 547 $\times 10^{-2}$ ind. /m^3 and the Ctenophores the third with a mean value of 1 019 $\times 10^{-2}$ ind. /m^3. There was an annual peak of total number of individual in Aug. , with a mean value of 6 336 $\times 10^{-2}$ ind. /m^3 (Fig. 3), of which the Hydromedusae was dominant with a mean value of 3 726 $\times 10^{-2}$ ind. /m^3 and a percentage of 58. 8%. The concentration regions of the Hydromedusae, Siphonophores and Ctenophores were found at Station 084 and Station 102 with value of 12 033 $\times 10^{-2}$ ind. /m^3 and 31 650 $\times 10^{-2}$ ind. /m^3. The first secondary peak (3 025 $\times 10^{-2}$ ind. /m^3) appeared in April, on which the Siphonophores (1 362 $\times 10^{-2}$ ind. /m^3) accounting for 44% and the Ctenophores (1 362 $\times 10^{-2}$ ind. /m^3) 45% were the dominant. The concentration regions of the Hydromedusae, Siphonophores and Ctenophores were found in the southern part of Zone Ⅱ, with a centre at Station 077 (9 935 $\times 10^{-2}$ ind. /m^3). The secondary peak (3 159 $\times 10^{-2}$ ind. /m^3) appeared in June, of which the Hydromedusae with mean a value of 1 848 $\times 10^{-2}$ ind. /m^3 and a percentage of 61% was the dominant. Concentration regions were found at Station 079 with a value of 8 318 $\times 10^{-2}$ ind. /m^3, Station 084 with a value of 7 200 $\times 10^{-2}$ ind. /m^3 and Station 102 with a value of 5 750 $\times 10^{-2}$ ind. /m^3 near the Jiulong River. Other concentration regions were found at Station 024 with a value of 6 872 $\times 10^{-2}$ ind. /m^3 and Station 029 with a value of 6 300 $\times 10^{-2}$ ind. /m^3. In the other months other than April, June and Aug. , numder of individuals were low. The valley appeared in the period from December to Feburary, with the concentration regions still in the waters near the Jiulong River.

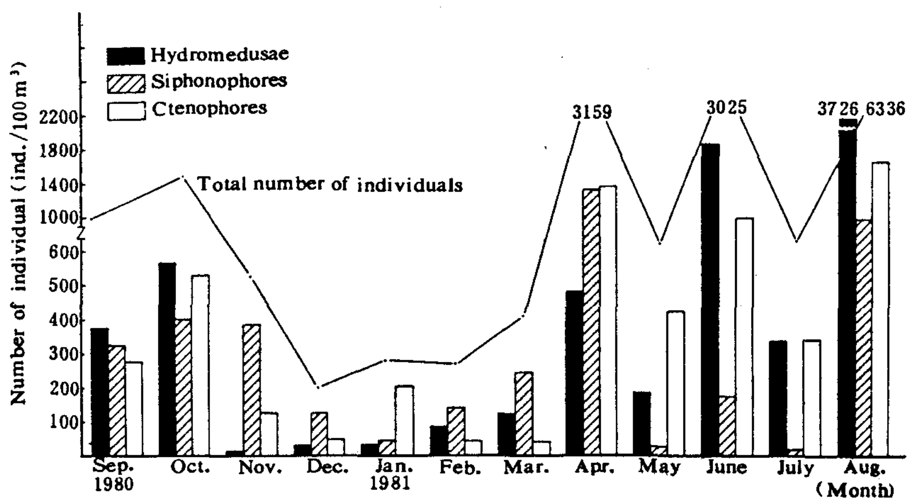

Fig. 3. Seasonal quantitative change of the Hydromedusae, Siphonophores and Ctenophores in the region investigated.

DISTRIBUTON OF DOMINANT SPECIES

Phialidium folleatum (McCrady)

Phialidium folleatum dominated in the Hydromedusae, appeared for the period from April to November (Fig. 4) in the region investigated. In April, a small number of this species occurred for the first time in the eastern parts of Zone I and Zone Ⅲ. An annual peak with a monthly mean value of 788×10^{-2}ind./m^3 appeared in June, concentrating near the Jiulong River of Zone Ⅲ ($2\,858\times10^{-2}$ind./m^3). A secondary annual peak with a monthly mean value of 260×10^{-2}ind./m^3 appeared in October, concentrating in the southern part of Zone II (876×10^{-2}ind./m^3). *Phialidium folleatum* belongs to the neritic warm-water species (Xu, 1983). In the region investigated, this species adapts to the salinity range of 20.99～31.37.

Lensia subtiloides (Lens & van Riemsdijk)

Lensia subtiloides was dominated in the Siphonophores. Its number of individual just less than *Pleurobrachia globosa*, occupied the second among the Hydromedusae, Siphonophores and Ctenophores in the region investigated. Except December, it occurred all the year round. An annual peak with a monthly mean value of $1\,148\times10^{-2}$ind./m^3 appeared in April, concentrating in Zone Ⅱ and Zone Ⅲ. A centre of concentration with a value of $5\,609\times10^{-2}$ind./m^3 appeared in waters in the southern part of Zone Ⅱ. The secondary annual peak with a mean value of 837×10^{-2}ind./im^3 appeared in August, concentrating in the eastern part of Zone Ⅲ ($2\,919\times10^{-2}$ind./m^3).

Diphyes chamissonis and *Lensia subtiloides* are all the neritic eurythermal species, dominating for the Siphonophores in China Seas (Alvarino, 1971; Zhang and Xu, 1980). In the region investigated, the former with a higher temperature range (13.6～32.17℃) occurred for the period form June to Jan., the latter with wider temperature range (12.72～32.15℃) occurred almost all the months throughout the year, its number of individual was increasing in high-salinity waters and decreasing in low-salinity waters (Fig. 5).

Pleurobrachia globosa Moser

Pleurobrachia globosa dominated in the Ctenophores, accounts for the most aboundant among the Hydromedusae, Siphonophores and Ctenophores in the region investigated. An annual peak with a mean value of $1\,637\times10^{-2}$ind./m^3 appeared in August. The first secondary annual peak with a mean value of $1\,193\times10^{-2}$ind./m^3 appeared in April and the second one with a mean value of 868×10^{-2}ind./m^3 appeared in June (Fig. 4). The concentration regions were found in the waters near the Jiulong River and in the southern part of Zone Ⅱ during most months throughout the year. In April, a concentration region with a value of $3\,350\times10^{-2}$ind./m^3 was found at Station 024 of Zone I where a low salinity of 20.09 was detected. Figure 5 shows that the number of individual of *Pleurobrachia globosa* increaeses in the low-salinity range and decreases in the high-salinity range. This indicates that *Pleurobrachia globosa* is more suitable to low-salinity and its distribution may be related with the input of the Jiulong River runoff.

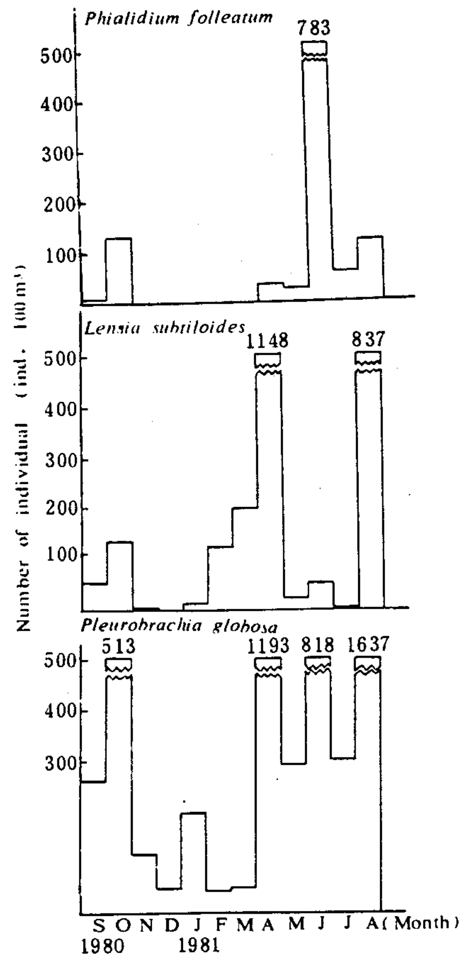

Fig. 4. Seasonal change of dominant species for the Hydromedusae, Siphonophores and Ctenophores on number of individual.

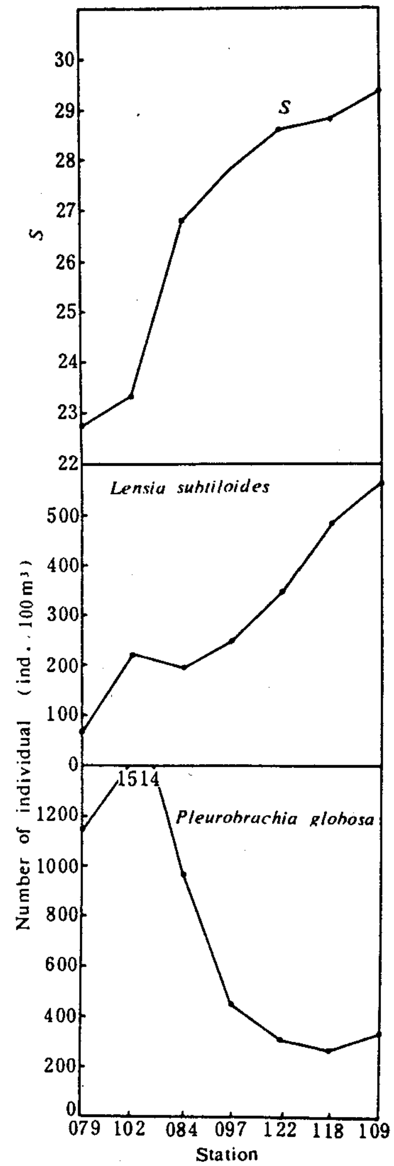

Fig. 5. The relationship between horizontal distribution of *Lensia subtiloides* and *Pleurobrachia gobosa* and salinity.

Besides 3 dominant species mentioned above, the common species were as follows: *Ramus xiamenensis*, *Turritopsis lata*, *Phialidium hemisphaericum*, *Phialucum carolinae*, *Eirene ceylonensis*, *E. menoni*, *Eutima levuka* and *Diphyes chamissonis*, which belonged to the neritic warm-water species and appeared mainly in the period from May to November; *Muggaea atlantica*, *Rathkea octopunctata* and *Tiaricodon coeruleus*, which belonged to the neritic warm-temperature species and appeared mainly in the period from December to April.

RELATIONSHIP BETWEEN THE DISTRIBUTION OF THE HYDROMEDUSAE, SIPHONOPHORES AND CTENOPHORES AND ENVIRONMENTAL FACTORS

On the basis of the relationship between the distribution of the Hydromedusae, Siphonophores and Ctenophores and hydrographical condition, five ecological groups may be recognized.

Estuarine warm-temperature group

This group, with *Tiaricodon coeruleus* as the representative, appeared in the period from December to April in the waters of 12.78～19.76℃ and 21.87～30.02 in temperature and salinity.

Estuarine warm-water group

This group, with *Nemopsis bachei*, *Blackfordia manhattensis*, *B. virginica* and *Proboscidactyla ornata* as the representatives, appeared in the period from April to October in the waters of 17.04～29.26℃ and 21.87～30.62 in temperature and salinity, indicating the adaptation to high temperature and low salinity.

Tiaricodon coeruleus was one of the dominant species for the Hydromedusae in Zone Ⅲ and considered as indicator of the Jiulong River water for the period of winter and spring (Xu and Huang, 1983). In this investigation, it did not dominate in the Hydromedusae because Zone I and Zone Ⅱ have high salinity on the basis of the annual data, it is concluded that estuarine-water species concentrate mainly near the Jiulong River, of which *Tiaricodon coeruleus* dominates for the periods from winter to early spring (from December to March) and *Nemopsis bachei* for the period from spring to early fall (from April to Sep.). The latter can tolerate a range of the salinity 20.95～28.72 and the temperature of 17.04～29.26℃ and therefore we consider that it may be an indicator of the estuarine water for the period of warm season.

Neritic warm-temperature group

The species belonging to this group only accounted for 6.7% in all the species found. They appeared in winter and spring below 21℃ in temperature. The principal representatives are *Euphysa aurata*, *Hybocodon prolifer*, *Phialidium chengshanense*, *Rathkea octopunctata* and *Muggiaea atlantica*.

Neritic warm-water group

The species belonging to this group accounted for 70.7% in all the species found. The principal representations are as follows: *Diphyes chamissonis*, *Phialidium folleatum*, *Eutima Levuka*, *Turritopsis lata*, *Euphysora bigelowi*, *Ramus xiamenensis*, *Phialucium carolinae* and *Eirene menoni* etc. They appeared mainly in the period from April to Nov. above 20℃ in temperature. This group was dominating over the amount in region investigated. Except those, there are *Liriope tetraphylla*, *Aglaura hemistoma*, *Agalma elegans*, *Physophora hydrostatica*, *Cytaeis tetrastyla* and *Bougainvillia platygaster*. They occurred mainly in the high-salinity waters in the eastern part of Zone I and Zone Ⅲ and the southern part of Zone Ⅱ under the effects of neritic water in the higher-temperature period from April to Nov. This indicates that their distribution is correlated with the relative intensity of the neritic water. This group accounted for 6.7% in all the species found and low amount.

DISSCUSION

In the region investigated, typical oceanic high temperature, high salinity and narrowly-distributed species do not occur. This indicates that the oceanic water doesn't affect directly the region investigated. The oceanic eurythermal water species are found mainly in waters mixed by the neritic and oceanic waters in the western Taiwan Strait (Xu, 1983), indicating that the mixed water affects the region investigated.

In summer, some species tolerating temperature with the range above 23℃, such as *Dipurena ophiogaster*, *Platystoma nanhainense*, *Cirrholovenia polynema* and *Eutima gracilis*, occurred one by one. These species are only found in the region investigated and waters to its south. This indicates that East Guangdong Coastal Current occurring in the western Taiwain Strait (Third Institute of Oceanography, State Oceanic Administration, 1987) may affect the region investigated.

In winter and spring, *Phialidium chengshanense* are found besides low-temperature representative species, *Euphysa aurata*, *Hybocodon prolifer* and *Rathkea octopunctata* (Zhang and Xu, 1975). *Phialidium chengshanense* was a main species in low-salinity waters of Zhejiang coast and related closely with the distribution of the low-salinity water (Gao, 1981). It only occurred in winter and spring in the region investingated before (Qiu, 1954a; Xu and Huang, 1985). Its distribution corresponds with the moving trend of Zhejiang-Fujian Coastal Current in the western Taiwan Strait (Lin Mao and Zhang Jinbiao, 1989). Therefore we consider the occurence of all the low-temperature species mentioned above as an indication of the effects of Zhejiang-Fujian Coastal Current in the region investigated.

Pleurobrachia globosa is the most dominant species in the region investigated, its abundance increasing in the low-salinity waters and decreasing in the high-salinity waters. Its trend of distributon is not the same as *Lensia subtiloides* (Fig. 5). *Pleurobrachia globosa* doesn't dominate among the Hydromedusae, Siphonophores and Ctenophores in the southern section of Fujian (Zhang and Xu, 1975). Usually it is more concentrated in the estuaries and harbour than in the neritic and oceanic waters in the warm season period (Zhang, 1984).

In a word, *Pleurobrachia globosa* more suitable to the low-salinity estuarine waters may belong to an euryesturine water species. Its condition of distribution may be related with the movement of the low-salinity esturine water.

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