A HYDROBIOLOGICAL SURVEY (1988) OF SUNGEI PUNGGOL

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ABSTRACT

Sampling at six selected stations along Sungei Punggol on 5th and 6th April 1988 using the grab, dredge and trammel net yielded 5351 specimens from 24 families belonging to 4 phyla. Two major phyla which made up more than 90% of the benthic fauna in the estuary were the molluscs (65.7%) and the annelids (29.8%). The dominant group was a molluscan family, Thiaridae, which made up 68.1% of the samples. Physico-chemical parameters of temperature, salinity, dissolved oxygen and light penetration when compared to an earlier study in 1966, showed a similar trend of improvement towards the river mouth.

INTRODUCTION

This study of the Sungei Punggol estuary was conducted 21 years after the last and only known recorded survey by Chua (1966). The estuary, lying between latitude 1° 22' 54"N and 1° 24' 42"N and longitude 139° 52' 24"E and 139° 54' 12"E on the northern side of the island of Singapore, is approximately 2.5km long and drains into the East Johore Strait (Fig. 1).

The river banks are covered with a high content of organic matter which is frequently washed into the river by the rain. The river bed is composed mainly of mud. Water movement in the estuary is influenced by the water movement of the East Johore Strait which is in turn affected by the currents in the surrounding seas.

Many changes have taken place in the area around Sungei Punggol since 1966. Originally a pig-farming area, steps were taken in 1984 to phase out this activity in order to reduce environmental pollution. Another recent project is the ongoing reclamation of the area around the river mouth, which will link nearby Coney Island with the mainland (Lim, 1987). Such perturbations on the ecosystem will affect the faunal composition of the estuary. The extent of the changes caused in the benthic community may be seen by comparing the results of the present study with the data obtained in 1966.

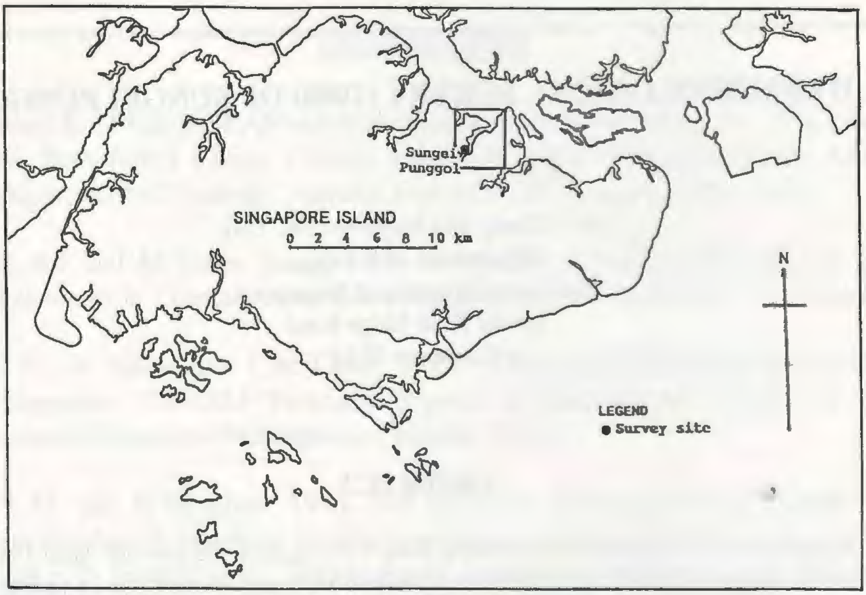

Fig. 1. Map of Singapore showing the location of Sungei Punggol.

MATERIALS AND METHODS

Field sampling was carried out on the 5th and 6th of April 1988. Six stations were selected stretching from the upper reaches of the river to the river mouth (Fig. 2). The sampling method was modified after Dartnall and Jones (1986). Water conditions at all six stations were investigated by measuring temperature, pH, salinity, conductivity and dissolved oxygen content at 0.5m depth intervals from the surface to the bottom. Light penetration was measured using a Secchi disc. Salinity and temperature were measured with a portable YSI Model 33 Salinity-Conductivity-Temperature meter, while conductivity was measured with a pHOX 52E Conductivity meter. A YSI Model 57 Oxygen meter was used to measure the dissolved oxygen content. An Orion portable pH meter Model SA 250 was used for the measurement of pH. Light intensity was measured with a LI-COR underwater light sensor.

An Ekman grab (15cm x 15cm) and a naturalist's rectangular dredge (with 75cm x 20cm opening and an attached 50cm long polypropylene net bag with stretched mesh size of 2.5cm) were used to collect the benthic fauna at all 6 stations. The dredge was towed at 1 knot for 10 minutes at each station. Two trammel nets were set up, one each at stations 4 and 6 and left for 24 hours. Dredged specimens collected were sorted on-site and labelled according to stations. Grab samples were preserved in 10% buffered formalin dyed with Bengal rose and brought back to the laboratory for sorting. Trammel net samples were kept in seawater and also brought back to the laboratory for identification and enumeration.

Fig. 2. Map of Sungei Punggol showing sampling stations (numbered 1- 6) and the distribution of benthic fauna in 1988.

RESULTS

The physico-chemical parameters recorded showed that there was no distinct temperature gradient both vertically and horizontally. The mean temperature for all stations was 29.1 ±0.4°C. Station 1 had the highest mean temperature of 29.4 ±0.4°C (Table 1). There was also no distinct salinity gradient with increasing depth, but a difference in the mean salinity of 1.6 °/oo and 3.8 °/oo existed between the upstream stations (stations 1 and 2 respectively) and the river mouth station (station 6). pH values ranged from 7.3 to 8.1 with the mean indicating a small increase towards the river mouth. Dissolved oxygen ranged from a mean of 2.8ppm to 4.5ppm moving downstream. Vertical differences in dissolved oxygen were not distinct, the greatest difference being only 1.8ppm recorded at station 5. Light intensity beneath the water surface was relatively high at stations 2 and 3 (1915.0µmoles/sec/m^2 and 738.6µmoles/sec/m^2) and low at station 5 (185.6µmoles/sec/m^2) at station 6. Light penetration increased from 0.4m upstream to 1.6m at the river mouth.

A total of 5351 specimens was collected, represented by 24 families from four phyla (Table 2). The Annelida represented by 9 families was the dominant phyla present at all 6 sampling stations. However, most of the annelids sampled were from station 4, dominated by the family Parergodrilidae with 1002 specimens. The Eunicidae was the next most abundant family with 311 specimens followed by the family Onuphidae with 233 specimens.

Table 1. Mean values of physico-chemical parameters of Sungei Punggol (standard deviation in parenthesis)

PARAMETERS	STATION 1	2	3	4	5	6
TEMPERATURE (°C)	29.4 (0.4)	28.8 (1.0)	29.3 (0.3)	29.0 (0.0)	29.0 (0.0)	28.9 (0.2)
SALINITY (°/oo)	17.2 (0.8)	15.0 (1.0)	17.0 (0.0)	18.1 (0.1)	17.9 (0.4)	18.8 (0.3)
DISSOLVED OXYGEN (ppm)	2.8 (0.3)	2.8 (0.2)	2.6 (0.0)	2.7 (0.1)	4.4 (0.6)	4.5 (0.6)
pH	7.5 (0.1)	7.5 (0.1)	7.7 (0.1)	7.6 (0.1)	8.0 (0.0)	8.0 (0.1)
CONDUCTIVITY ($x10^4$ μs)	4.0 (0.1)	3.8 (0.1)	4.2 (0.1)	4.2 (0.1)	4.2 (0.2)	4.3 (0.0)
LIGHT PENETRATION (m)	0.4	0.5	0.5	0.7	1.4	1.6

Table 2. List of specimens sampled at stations at Sungei Punggol.

PHYLUM	CLASS	FAMILY	STATIONS 1	2	3	4	5	6	TOTAL
Annelida	Polychaeta	Arenicolidae	-	-	-	-	-	1	1
		Cirratulidae	1	-	-	-	-	6	7
		Dorvilleidae	-	1	-	-	-	-	1
		Eunicidae	-	1	-	1	-	309	311
		Nereidae	4	9	-	-	-	5	18
		Onuphidae	-	-	201	-	-	32	233
		Parergodrilidae	1	2	1	1002	-	-	1006
		Spionidae	1	-	1	-	7	9	18
		Pilargiidae	-	-	-	-	-	1	1
Mollusca	Gastropoda	Crepidulidae	-	-	-	-	-	1	1
		Muricidae	-	-	-	-	-	12	12
		Nassariidae	-	-	-	-	-	1	1
		Thiaridae	-	-	-	-	3500	-	3500
	Bivalvia	Corbiculidae	-	-	-	1	-	-	1
		Mytilidae	-	-	-	-	-	2	2
Arthropoda	Crustacea	Balanidae	-	74	-	-	100	51	225
		Cirolanidae	-	-	-	-	-	1	1
		Cymothoidae	-	-	-	2	-	-	2
		Paguridae	-	-	-	-	-	1	1
		Portunidae	-	-	-	2	-	3	5
Chordata	Osteichthyes	Balistidae	-	-	-	-	-	1	1
		Ciclidae	-	-	-	1	-	-	1
		Clupeidae	-	-	-	1	-	-	1
		Mugilidae	-	-	-	1	-	-	1
TOTAL			7	87	203	1011	3607	436	5351

Molluscs were found only at stations 4, 5 and 6, consisting of four gastropod families and two bivalve families. A total of 3517 specimens was obtained. Some of the families were represented by single specimens. The gastropod family, Thiaridae (formerly Melaniidae), was found in abundance at station 5 from the dredge samples. An interesting observation of this gastropod is that every specimen collected had at least one barnacle attached to the shell (Fig. 3).

Of the 234 crustaceans obtained, the family Balanidae dominated with 225 specimens found attached to pieces of wood dredged up from the river bed at stations 2, 5 and 6. Other crustaceans included one specimen each of the families Cymothoidae and Cirolanidae.

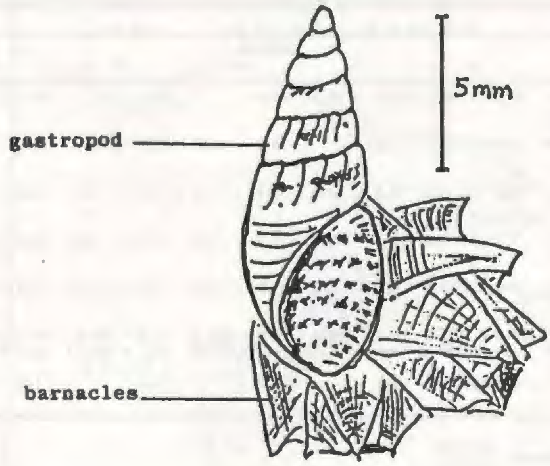

Fig. 3. *Thiara tuberculata* (gastropod) with barnacles attached.

The trammel net laid at station 4 yielded 1 specimen each of the fish families Ciclidae (*Tilapia* sp.), Clupeidae (*Anodontosoma chacunda*) and Mugilidae. The net at station 6 yielded only one fish (Balistidae) and one crab (*Portunus pelagicus*).

DISCUSSION

In this study, the physico-chemical conditions improved towards the river mouth. In Chua's (1966) study, the conditions were also found to be better at the river mouth. Chua's (1966) work on hydrology was more extensive taking into consideration seasonal and tidal variations. The present study had only four parameters common with the 1966 study: temperature, salinity, dissolved oxygen and light penetration.

Chua (1966) recorded a maximum temperature of 31.1°C in the month of April. This study, carried out also in April, recorded a maximum mean temperature of 29.4°C at station 2 (Table 3). Seasonal variations of salinity observed in Chua's (1966) study included two maxima (October, April) and two minima (July, January). A maximum salinity of 28.77 °/oo was recorded at the river mouth during high water in the 1966 study. The present sampling, carried out during the period of mid to high water, recorded a maximum of only 19 °/oo at the river mouth (Table 3). This decrease in salinity between the two investigations could be due to the different weather conditions during the time of sampling. The rainfall which occurred prior to sampling could account for the lowered salinity. In Chua's (1966) study, he noted that any water movement in the estuary of Sungei Punggol was influenced by the water movement in Johore Strait which was in turn influenced by the water movement in Singapore Strait. As such, the reclamation around the river mouth could change the water movement around the area which would affect conditions in the estuary. No horizontal salinity gradient was observed as Sungei Punggol is comparatively short. Its shallowness with a maximum depth of approximately 4m during mid-water did not allow any stratification.

Table 3. Minimum and maximum values of physico-chemical parameters of Sungei Punggol

PARAMETERS	STATION 1	2	3	4	5	6	FOR ALL STATIONS
TEMPERATURE (°C)	29.0 - 30.5	28.0 - 30.5	29.0 - 29.5	29.0	29.0	28.5 - 29.0	28.0 - 30.5
SALINITY (°/oo)	16.0 - 18.0	14.0 - 16.0	17.0	18.0 - 18.3	17.2 - 18.2	18.5 - 19.0	14.0 - 19.0
DISSOLVED OXYGEN (ppm)	2.2 - 3.1	2.7 - 3.0	2.5 - 2.6	2.6 - 2.8	3.3 - 5.1	3.6 - 5.3	2.2 - 5.3
pH	7.3 - 7.6	7.5 - 7.6	7.6 - 7.7	7.5 - 7.8	8.0 - 8.1	8.0 - 8.1	7.3 - 8.1
CONDUCTIVITY ($x10^4$ μs)	3.9 - 4.1	3.8 - 3.9	4.1 - 4.2	4.1 - 4.2	3.7 - 4.3	4.3 - 4.4	3.7 - 4.4
LIGHT INTENSITY (μmoles/sec/m^2)	2.8 - 520.7 (air = 911.3)	83.0 - 1915.0 (air = 2579.0)	52.3 - 738.6 (air = 881.9)	0.3 - 340.6 (air = 613.6)	13.3 - 185.6 (air = 383.4)	21.1 - 276.0 (air = 451.8)	0.3 - 1915.0
LIGHT PENETRATION (m)	0.4	0.5	0.5	0.7	1.4	1.6	0.4 - 1.6

Lim (1984) has shown in his study that meteorological parameters like wind force and rainfall greatly affect variations in temperature and salinity in the East Johore Strait. In addition, water movement (especially monsoonal current) in the Strait and its surrounding area influence the values of temperature and salinity. Chua (1966) has also shown similar factors affecting the variations of temperature and salinity. Since the Sungei Punggol estuary is directly affected by conditions in the East Johore Strait, the differences in the data between the 1966 and the 1988 studies could be due to changed conditions in the Strait.

In the study done by Chua (1966), the lowest dissolved oxygen was recorded in April. Dissolved oxygen was also generally higher at the river mouth. This study, also carried out in April, recorded the lowest dissolved oxygen at station 4 (middle reach of river) and the highest at station 6 (river mouth) (Table 3). Values for light penetration showed a difference of 0.9m between the two surveys at the river mouth (1.6m in 1988 as compared to 2.5m in 1966). This difference may be attributed to a higher sediment load in the river. Values for pH, conductivity and light intensity were not included in Chua's (1966) study. However, the 1988 study revealed no obvious trends in any of these parameters.

The benthic organisms showed an increase in diversity and richness towards the river mouth. Dredge samples at station 6 yielded specimens of almost all the families of the annelids, molluscs and crustaceans in the whole investigation. Only the Parergodrilidae and Dorvilleidae (Annelida), Thiaridae (Mollusca), and Cymothoidae (Crustacea) were absent. This higher diversity may be correlated with the physico-chemical parameters, especially dissolved oxygen, which is highest at the river mouth.

Compared with the other four rivers studied in this project, Sungei Serangoon (Goh & Goh, 1990), Sungei Buloh (Quek & Chua, 1990), Singapore River (Goh & Loo, 1990) and Kallang Basin (Chua & Loo, 1990) where sampling methodologies were similar, Sungei Punggol ranks second in terms of specimen abundance but in terms of diversity, was lower than all the rivers except Sungei Serangoon (Lim *et al.*, in press). The higher richness at Sungei Punggol was mainly due to the abundance of the molluscan family Thiaridae (3500 specimens collected), consisting of a single species, *Thiara* (formerly *Melanoides) tuberculata*. These gastropods are freshwater to brackish water species and

Fig. 4. Map of Sungei Pungool showing distribution of benthic fauna in 1966 (modified after Chua, 1966)

are known to be the most tolerant of all freshwater snails. In Singapore, these gastropods are common in streams, ditches and fish ponds (Ponniah, 1962). The survival limit of these snails are in the region of 25 ^{o}/oo to 33 ^{o}/oo (Sung, 1968). Since the maximum salinity at the sampling station 5 where they were found was 18.2 ^{o}/oo (Table 3), the gastropods have adapted to the higher salinity and survived in the estuary.

Comparing the results of the two studies (1966 and 1988), the distribution of the benthic fauna has changed almost entirely over the past 22 years. This is especially true for the dominant families. The dominant molluscs in 1966 have been replaced by the annelids in 1988 (Figs. 2 and 4).

Chua's (1966) study on the nekton was based on a small type of beach seine. The catch was dominated by crabs and prawns. Large catches of the flower-crab *Portunus pelagicus* were reported. Members of the family Penaeidae were also reported to be abundant. Apart from the crabs and prawns, the nekton specimens also consisted of fishes. The present sampling with a trammel net netted only one specimen of *Portunus pelagicus* (but four were caught in the dredge samples), no prawns, and four families of fish from Chua's (1966) recorded list of 55 fish families. From his study of the mud bottom fauna, Chua (1966) reported the presence of the bivalve *Pharella acuminata* in the area where the gastropod, *Thiara,* was found in great abundance in the present study. Chua (1966) considered the fauna found on the river bed of Sungei Punggol as a representation of the littoral animals of the muddy shore with dominant species indicating zonation. This zonation pattern is a result of many factors like shade, tidal oscillation, type of soil, range of temperature, type of vegetation, salinity, etc. as discussed by Chuang (1961).

The results show some obvious changes in time, such as the replacement of the once dominant molluscs by annelids. However, this is at best a semi-quantitative study. A study over a longer period of time should give a more accurate representation of the changes in composition and distribution of the benthic fauna in the Sungei Punggol estuary.

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