MARA COLLEGE BANTING

International Baccalaureate Diploma Programme

Extended Essay

Biology Higher Level

Research Title:

The relationship between the population density of *Pandanus heliacorpus* and the population size of *Macrobrachium rosenbergii sp.*

Research Question:

Is there any correlation between the population density of *Pandanus heliacorpus* and the population size of *Macrobrachium rosenbergii sp.* ?

No of Words : 3813

ABSTRACT

Macrobrachium rosenbergii sp or commonly known as Freshwater King prawn is an exotic creature that is very popular for aquaculture development. However the population of this species in its natural habitat seems to decline. From the observation and claimed made by the local people there is a one type of plant scientifically known as ***Pandanus heliacorpus*** that act as an indicator if there were abundance of freshwater prawns. In this extended essay, scientific study has been done to test the claim. Hence, the research question "Is there any correlation between the population density of ***Pandanus heliacorpus*** and population size of ***Macrobrachium rosenbergii sp***?" was constructed. Firstly, the area was designated and mapped before ***Macrobrachium rosenbergii sp*** was trapped using the 'empang' method. This 'empang' method was basically to create an enclosure along the river bank by using a net laid out during low tide and had it rigged up to a wooden poles during high tide. The Lincoln index method is then used to calculate the population size of ***Macrobrachium rosenbergii sp*** while the population density of ***Pandanus heliacorpus*** being calculated by counting the exact number of its trunk submerged within the catchment's area. From the data obtained, it seems that there is a relation between the number of *Pandanus heliacorpus* and the population size of *Macrobrachium rosenbergii sp*. Hence the correlation between the two species was then being tested by statistical method which is product-moment correlation coefficient and further significant test. This research has proved that at 5% significant level were achieved therefore enough evidence to suggest that there is a positive correlation between the population density of ***Pandanus heliacorpus*** and the population size of ***Macrobrachium rosenbergii sp***. on the research site. (282 words)

ACKNOWLEDGEMENT

First of all, all praise to God Almighty who has given me the strength, courage and determination to complete this Extended Essay. My thanks and regards to my Biology teacher, Madam Norhayatee who has always given me the guidance and support in carrying out the research.

Besides that, I would like to express gratitude and appreciation to:

- Both of my parents for giving their continous support and trust while carrying out the research.
- All the local people of Kampung Panti and Kelantan especially Pak Mat who had always ever willing to help me in catching the freshwater king prawn, letting me use the boat, and always concern about my safety during the research.
- My friends, for always being there by my side, contributing their ideas, lent me their laptop and giving out criticisms for a better outcome of my essay.
- Last but not least, I like to congratulate myself for embarking on this ambitious research with much limitation and obstacles till this research is complete.

Thank You and May God bless us all.

The relationship between the population density of *Pandanus heliacorpus* and the population size of *Macrobrachium rosenbergii sp.*

ABOUT THE WRITER

Born in 15th June 1987, received his early education in Sekolah Kebangsaan Kota Jaya and continue his secondary education in the prestigious Malay College Kuala Kangsar also known as 'Eton of the East' His academic credentials include the recognition award from the Prime Minister of Malaysia. Passion for biology and neuroscience, he was currently doing his International Baccalaureate at MARA College Banting, Malaysia in preparation for his medical degree.

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1.0 INTRODUCTION

Locally known as "Udang Galah" the Malaysian Freshwater King Prawn was dominance of Johor River in Kota Tinggi, Malaysia. Scientifically known as ***Macrobrachium rosenbergii sp*** , this exotic species had attracted many from all over the country. Its abundance was evident by the bountiful catch among fishing enthusiast. Nevertheless over the years its population had dwindled. This was evident by the meager catch which was once abundance.

Have you ever wondered why certain marine species "disappear". A lot of blame goes to the water quality as it is apparent that they are very dependent on it. Water pollutions are almost a spontaneous answer when question of decline of abundance were raised for ***Macrobrachium rosenbergii sp***. However I believe that there must be other reasons contributing to this decline. Johor River was only about 12 km away from the sea, she was subjected to the tide and these changes of water flow helps to 'neutralize' the contamination thus very much retain its water quality.

Macrobrachium rosenbergii sp does not exist in isolation but form an integrated part of layers that assemble other aquatic animal and plants which interact in a complex way to form a community[1]. I had followed my father over the years for many of his fishing trips of which I had observed the apparent decline in the density of ***Pandanus heliacorpus*** which belong to the 'screwpine' class. It was once a very prominent landscape of the river banks.

Locally known as "pokok rasau" it is an edge species, sparingly distributed along the river. In early 1980 a massive cut down of ***Pandanus heliacorpus*** was carried out by Drainage and Irrigation Department. This was done because their dominance had greatly reduces the river width[2]. This action had greatly reduced the density of ***Pandanus heliacorpus.*** The dominance of the waterlily that engulfed ***Pandanus heliacorpus*** and due to its parasite nature had again reduced the density of ***Pandanus heliacorpus***. I was curios and wondered whether the decline in the population of ***Macrobrachium Rosenbergii sp*** had any relation to the diminishing density of ***Pandanus heliacorpus***. Whilst selecting my extended essay topics in IB programme this topic had come naturally to me. The other reasons are the fact that ***Macrobrachium rosenbergii sp*** has huge potential of aquaculture farming and had been successfully breed in many parts of the world far away from its native enclosure. The attraction for this beautiful 'huge' ***Macrobrachium rosenbergii sp*** had brought much to the locals residing along the river. If this research could in any way helps preserving this species, it could have suffice my effort as it is a shame to let these beautiful species disappear.

[1] Robert Leo Smith and Thomas M.Smith, Element of Ecology, 4th Edition, Benjamin/Cummings Science Publishing, 1301 Sansome Street San Farisco,2000
[2] Interview with the Drainage and Irrigation Department Officer on 17th July 2007.

2.0 REVIEW OF LITERATURE

2.1 Background of *Macrobrachium rosenbergii sp.*[3]

Macrobrachium rosenbergii sp is a scientific name for the Freshwater King Prawn. In Malaysia it was known local as 'Udang Galah'. It might be because of its very long claws. Within the past 20 years the giant Malaysian Freshwater King prawn had attracted many researchers for intensive study. It was much because of its commercial value.

Macrobrachium rosenbergii sp Are members of the phylum Arthropod. They are decapods crustaceans related to crabs and marine shrimp. However, in their native land of Malaysia and Southeast Asia, ***Macrobrachium rosenbergii sp*** .has evolved to survive in brackish water of the estuaries and the fresh water river. There are 4 distinct phases in the life cycle of ***Macrobrachium rosenbergii sp*** namely eggs, larvae, post larvae and adults. The time they spent in each stage of their life cycle varies and depends on tide level, temperature, salinity of water, and other environmental element[4].

[3] Sources taken from :
1. Daaniel Spotts, www..miami- aquaculture.com
2. www. fao.org/documents/show_cdr.aspurl_file=

[4] Louis R.D,Abramo, www. aquanic org/ publicat/ usda_rac/efs/srac/483fs.pdf

2.1.1 Behaviour

Macrobrachium rosenbergii sp will eat just anything. Through my observation I have found that ***Macrobrachium rosenbergii sp*** to be most fond of shrimp pellet. This was evidence by the bountiful catch when shrimp pellet were used as bait. *Macrobrachium rosenbergii sp* do best in water of 20° C to 30° C. ***Macrobrachium rosenbergii sp*** need somewhat alkaline water, pH 7.2 to 8.4. At pH's below 7.0 ***Macrobrachium rosenbergii sp*** had a difficulty hardening their new carapace after molting[5]

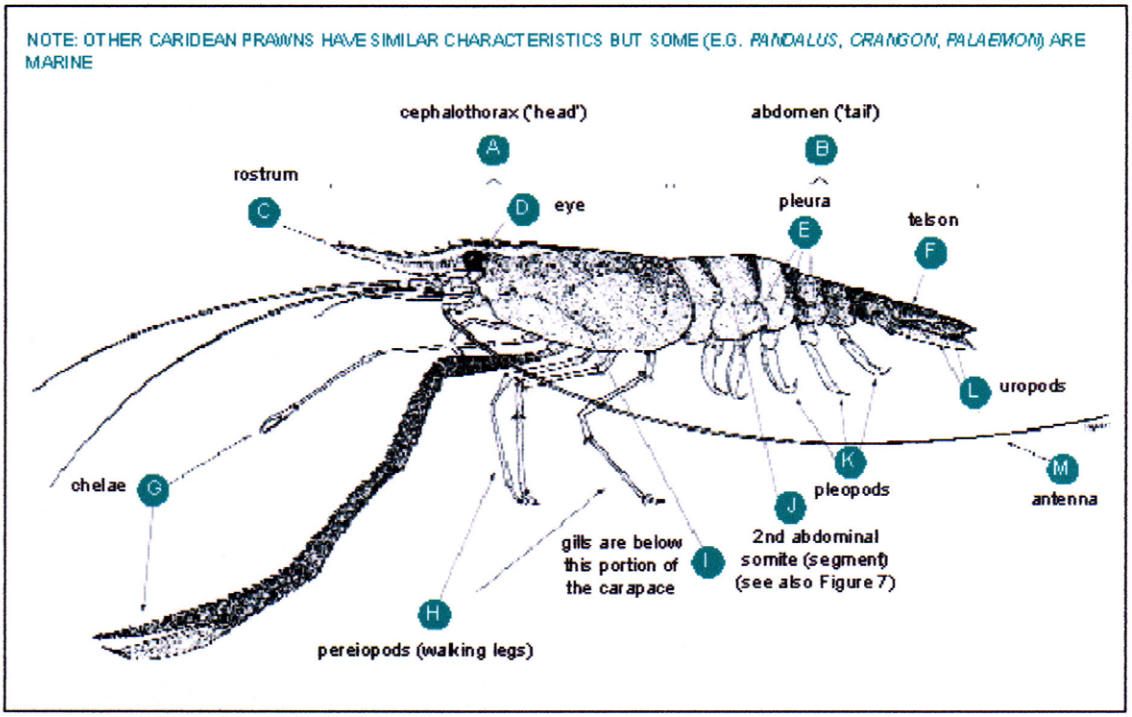
Adult ***Macrobrachium Rosenbergii sp*** can be very aggressive and voracious, especially female prawn that carried eggs. Due to this nature ***Macrobrachium rosenbergii sp*** requires space. On the contrary, young ***Macrobrachium rosenbergii sp*** can some how tolerate and survive with each other in close proximity. But once they reach the adult phase (a 5cm body size) their claws are strong enough to defend a territory.

Molting is the most unique process that ***Macrobrachium rosenbergii sp*** has to undergo. They must shed their carapace in order for the body to grow. Young prawns molt much frequently, once every two or three day. As they grow older, the rate of molting decline. Adult female of ***Macrobrachium Rosenbergii sp*** will molt less frequently as compared to male adults, it will molt once in every 20 to 40 days while male adult will molt once in every 6 months[6].

[5] Uno, Y. K.C. Soo. 1969 Larval development of Macrobrachium rosenbergii sp (de man) reared in the labaratory. Journal of the Tokyo University of Fisheries, 55(2) 179-190

[6] Ling, S.W., 1962 studies on the culturing of adults of Machrobrachium *Rosenbergii sp.*

2.1.2 Physical characteristics of *Macrobrachioum Rosenbergii sp.*



Picture of *Macrobrachium rosenbergii sp*

Older juveniles and adults usually have a distinctive blue-green color, although sometimes they may take on a brownish hue. Color is usually the result of the quality and type of diet consumed. Adult males are larger than the females, and the sexes are easily distinguishable. The second walking legs or claws (chela) and the head region of males are larger than those of the females (Figure 1).[7]

[7]Louis R. D'Abramo and Martin W. Brunson, Missipi State University on 'biology and life history of freshwater prawn"

3.2 Background of *Pandanus heliacorpus*

Pandanus heliacorpus was locally known as 'Rasau tree'. It is in the same class with other screwpine. Screw Pine is a common name applied to any plant of the representative genus of the screw pine family, and to certain plants of a related genus[8]. The representative genus is typical of the screw pine family, which is the only member of its monocotyledonous order. Of worldwide distribution, the order is characterized by reduced, unisexual flowers borne in tight spikes or heads and by ovules with fleshy or mealy endosperm. It has the characteristic of **plant with big roots:** a plant resembling a palm, with prop roots and a crown of narrow leaves[9].

Picture of *Pandanus heliacorpus*

[8] Microsoft Encarta Encyclopedia 2006
[9] James d. Mauseth, Botany: An Introduction to Plant Biology, Third Edition Jones and Barlett Publishers, Sudbury Massachusetts, 2003.

3.0 HYPHOTESIS

From my observation, the decline in the ***Macrobrachium rosenbergii sp*** population may have a correlation to the declining density of ***Pandanus heliacorpus***. It might be because of *Pandanus heliacorpus* roots structure and other characteristics that provide a good habitat for *Macrobrachium rosenbergii sp* and hence give an impact to its population size. Using this assumption, the hypothesis that the population size of ***Macrobrachium Rosenbergii sp*** increases with the increase in the population density of ***Pandanus heliacorpus*** is constructed.

4.0 METHOD DEVELOPMENT AND PLANNING

In order to test the hypothesis, the population of ***Macrobrachium rosenbergii sp***. must be quantified in relation to the density of the ***Pandanus heliacorpus***. Direct relation of these two can thus be clearly examined. Apart from that, the study of ***Pandanus heliacorpus*** roots structure and others characteristics are crucial in order to support the conducive environment of ***Macrobrachium rosenbergii sp*** thus an impact to its population size.

4.1 Calculation of the population size of *Macrobrachium rosenbergii sp*

I encountered difficulty in finding and choosing suitable method to quantify the population size of ***Macrobrachium rosenbergii sp.*** At first I got an idea based on the computer fishing game by counting on the number of bites.However, there is no certainty to confirm it is of different prawn each time the bait got its bite. This could not give an accurate count of the population size of ***Macrobrachium rosenbergii sp***. The other factor is that it depends very much on the tide level and weather conditions as such would not provide specific interval time sequence of the research. This planned sequential timing was crucial to keep a near constant value of the variables against the manipulated variable which is the density of both subjects in reference. I had decided to adopt the 'empang method[10]' to catch ***Macrobrachium rosenbergii sp*** and use the simplest mark-recapture technique which is known as Lincoln index[11] to calculate the population of ***Macrobrachium Rosenbergii sp*** on the research site.

[10] Traditional way used by local fisherman to catch fish and prawn.

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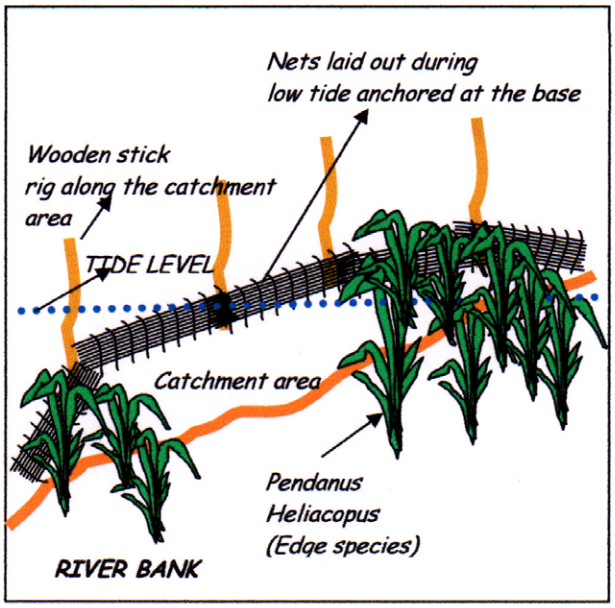
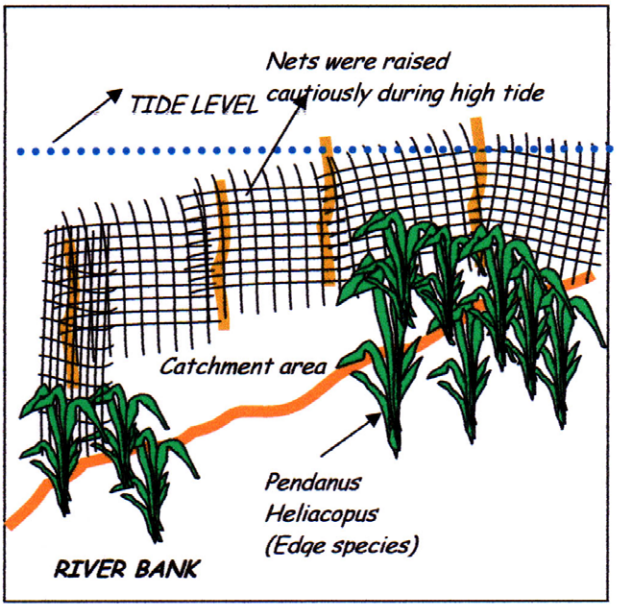
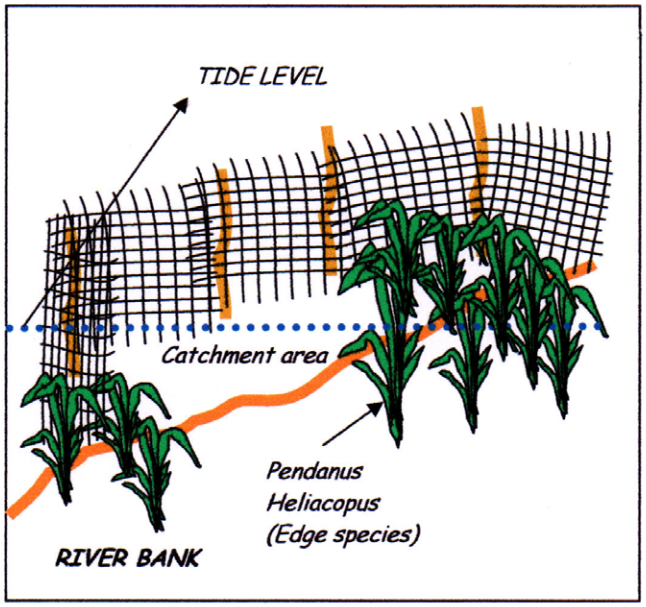
EMPANG METHOD



STAGE 1 : Nets laid out along designated research area during low tide with wooden poles.



STAGE 2 : Nets were raised during high tide



STAGE 3 : Catch were made and marked and released method was done on adults Macrobrachium Rosenbergii

[11] Robert Leo Smith and Thomas M.Smith, Element of Ecology, 4th Edition, Benjamin/Cummings Science Publishing, 1301 Sansome Street San Farisco,2000

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The capture-recapture method involves a number of assumptions:

- All ***Macrobrachium Rosenbergii sp*** individuals have an equal chance of being captured. None are trap-happy and none are trap-shy.
- The ratio of marked to unmarked animals remains the same from the time of capture to the time of recapture.
- Marked individuals, once released, redistribute themselves throughout the population with respect to unmarked ones, as they were before capture.

The population of ***Macrobrachium rosenbergii sp*** is closed. No emigration or immigration takes placed during the sampling period. Mark-recapture technique is suitable as ***Macrobrachium rosenbergii sp*** is bottom-dwellers and keeps on moving within an area. The time interval for the second catch would be after one week the first catch was made. Only the adult ***Macrobrachium rosenbergii sp*** will be taken into the count. It is because the molting period of young ***Macrobrachium rosenbergii sp*** is once in two to three days as such the marked carapace shed will be away during the molting process. In one week it can be assumed that this species had dispersed among themselves throughout the population. Initially I had intended to use permanent marker to mark ***Macrobrachium rosenbergii sp*** caught but used Indian ink instead. The xylene and toulene contends of the permanent marker might harm the species. Indian ink was tested to mark the carapace of live ***Macrobrachium rosenbergii sp*** and after one week the mark was still apparently visible.

4.2 Designation of suitable research site

I had traveled by boat to designate the location of the intended site, by observing the tide level of the riverbanks. This observation was crucial because the research site must recede at low tide level in order to rig the net as the catchments area. Another important observation was the disparity density of ***Pandanus heliacorpus***. These elements are the manipulated variables to support their relation which is relevant to the hypothesis of the research. The area where ***Pandanus heliacorpus*** existed must be submerged as to provide the intended observation. (pandanus heiacorpus can occupy quite an extended area inland thus gave no significant to the observation of the study) The area must also be away from the fishing spot and other interference. Observation was also made on the water temperature and its pH level which must be within the tolerance range of ***Macrobrachium rosenbergii sp***. After much observation the research site was finally designated.

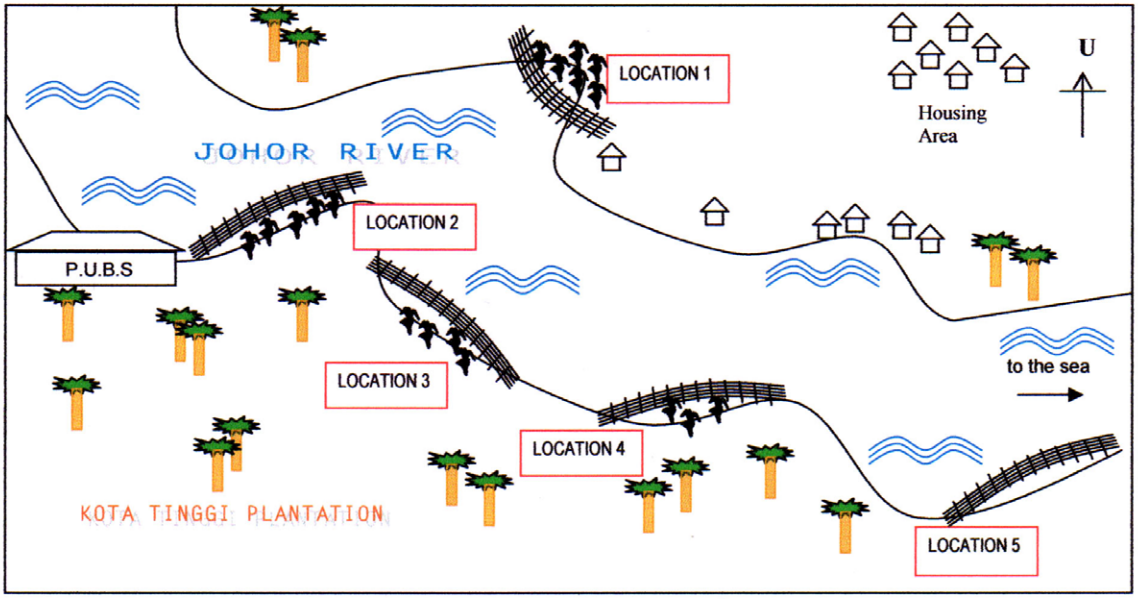
4.3 Calculation of the density of *Pandanus heliacorpus* on the research site

It is quite difficult to quantify ***Pandanus heliacorpus*** as it grows quite close to each others. I have decided to calculate the number of ***Pandanus heliacorpus*** trunks submerged during high tide within the same length and breath of the catchments area. This was possible as the length of the net used were of the same during each sampling. The breath of the area very much depends on the tide condition. This was well taken into account during the planned sequential timing of the intended sampling area of which the tide level were almost similar.

STUDY AREA

Map 1: The location of the study area in the Malaysia map.

RESEARCH STUDY AREA



Map 2: Local area of the research study on the Kota Tinggi map[12].

The study is carried out at the Johor River, Kota Tinggi, Johor, Malaysia (1° 43′ N, 103 ° 53′). The research site is 3 km stretch from Kampung Panti. This area has equatorial climate with average daily temperature varies between 20 °C and 30 °C (70 ° to 90 ° F)[13].

[12] Refer Appendixes 3
[13] Microsoft Encarta Reference Library 2006.

5.0 MATERIAL AND PROCEDURES

Variables

Independent variable:

- The number of ***Pandanus Heliacorpus*** within the catchment's area

Dependant variable:

- The number of ***Macrobrachium Rosenbergii sp*** within the catchment's area

Constant variable:

- pH of the water
- Temperature of the water
- Tide level of the location of study

MATERIALS

(a) Apparatus

1. 2 x Boat equipped with outboard motor
2. 2 x Net(of 3 meter length each)
3. Wooden poles
4. Floating basket
5. Torch light
6. Life jacket
7. Hand phone
8. Thermometer
9. pH paper

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(b) Chemicals

1. Indian ink

PARAMETERS

Through my study, the following parameters are recorded:

1. Population size of ***Machrobrachium Rosenbergii sp***
2. Population density of ***Pandanus Heliacorpus***
3. Location of the research site along the river
4. Water temperature on the research site
5. Water pH in the research site
6. Tide level of the research site

PROCEDURES

A. Mapping research site (catchments area) along the river

1. Map of the research site (3 km stretch from the jetty) is sketched
2. Suitable catchments area is designated.
3. Scheduled time frame is planed and tide condition is taken into account

B. Setting the Empang

1. Wooden pole is rig along the designated catchment's area with both ends reaching the river bank to provide an enclosure.
2. 2 piece of measured net of 3 meters is used.
3. The net were laid along the wooden poles and one of its ends was anchored to the ground.
4. Wait for the next high tide cycle.
5. Approach research site by using boat cautiously and pull up the net were rigged to the wooden poles.
6. ***Macrobrachium rosenbergii sp*** caught in the enclosure during the next low tide was marked and released.
7. After a week, the empang being set up again at the same place.
8. ***Macrobrachium rosenbergii sp*** caught in the enclosure being counted.
9. Repeat the sequence based on the scheduled time frame

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6.0 DATA COLLECTION

6.1 Qualitative Data

LOCATION	WATER CONDITION AT THE RESEARCH SITE	
	HIGH TIDE	LOW TIDE
1	The colour is light brown	The colour is dark brown
2	The colour is light brown	The are a lot of particles floating on the water surface and give a very dark brown colour
3	The colour is light green	The colour is light brown
4	The colour is slightly bluish	The colour is light brown
5	The colour is light bluish and a bit transparent	The colour is light brown

Table 1: The water condition at each of the research site

6.2 Quantitative Data

A. THE NUMBER OF *PANDANUS HELIACORPUS*

LOCATION	NUMBER OF *PANDANUS HELIACORPUS*
1	23
2	18
3	11
4	04
5	00

Table 2: The number of Pandanus Heliacorpus in each of the research site

B. THE NUMBER OF *MACROBRACHIUM ROSENBERGII* CATCHED

LOCATION NUMBER: 1

	FIRST CATCH		SECOND CATCH	
DATE	1st JULY 2006		11th JULY 2006	
TIDE LEVEL	Highest: 2.4 m Lowest: 0.2 m		Highest: 2.8 m Lowest: 0.2 m	
TEMPERATURE	27.3		28.1	
pH READING	7		7	
NUMBER OF *M.rosenbergii* CATCHED	MALE	FEMALE	MALE	FEMALE
	22	10	16	19
NUMBER OF *M.rosenbergii* CATCHED WITH MARK	-		16	

Table 3: The number of *Macrobrachium Rosenbergii sp* catched and the condition of the location 1 in term of pH, temperature, and tide level.

LOCATION NUMBER: 2

	FIRST CATCH		SECOND CATCH	
DATE	3rd JULY 2006		13th JULY 2006	
TIDE LEVEL	Highest: 2.2 m Lowest: 0.6 m		Highest: 2.9 m Lowest: 0.0 m	
TEMPERATURE	27.0		27.6	
pH READING	7		7	
NUMBER OF *M.rosenbergii* CATCHED	MALE	FEMALE	MALE	FEMALE
	17	11	10	14
NUMBER OF *M.rosenbergii* CATCHED WITH MARK	-		14	

Table 4: The number of *Macrobrachium Rosenbergii sp* catched and the condition of the location 2 in term of pH, temperature, and tide level.

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LOCATION NUMBER: 3

	FIRST CATCH		SECOND CATCH	
DATE	16th JULY 2006		24th JULY 2006	
TIDE LEVEL	Highest: 2.9 m Lowest: 0.3 m		Highest: 2.8 m Lowest: 0.4 m	
TEMPERATURE	28.0		27.5	
pH READING	7		7	
NUMBER OF *M.rosenbergii* CATCHED	MALE	FEMALE	MALE	FEMALE
	7	18	12	10
NUMBER OF *M.rosenbergii* CATCHED WITH MARK	-		9	

Table 5: The number of *Macrobrachium Rosenbergii sp* catched and the condition of the location 3 in term of pH, temperature, and tide level.

LOCATION NUMBER: 4

	FIRST CATCH		SECOND CATCH	
DATE	27th JULY 2006		31st JULY 2006	
TIDE LEVEL	Highest: 2.6 m Lowest: 0.1 m		Highest: 2.4 m Lowest: 0.4 m	
TEMPERATURE	27.0		28.5	
pH READING	8		8	
NUMBER OF *M.rosenbergii* CATCHED	MALE	FEMALE	MALE	FEMALE
	3	9	5	10
NUMBER OF *M.rosenbergii* CATCHED WITH MARK	-		7	

Table 6: The number of *Macrobrachium Rosenbergii sp* catched and the condition of the location 4 in term of pH, temperature, and tide level.

The relationship between the population density of *Pandanus heliacorpus* and the population size of *Macrobrachium rosenbergii sp.*

LOCATION NUMBER: 5

	FIRST CATCH		SECOND CATCH	
DATE	20th AUGUST 2006		29th AUGUST 2006	
TIDE LEVEL	Highest: 2.7 m Lowest: 0.4 m		Highest: 3.0 m Lowest: 0.2 m	
TEMPERATURE	27.5		27.1	
pH READING	8		7	
NUMBER OF M.rosenbergii CATCHED	MALE	FEMALE	MALE	FEMALE
	1	7	2	4
NUMBER OF M.rosenbergii CATCHED WITH MARK	-		3	

Table 7: The number of *Macrobrachium Rosenbergii sp* catched and the condition of the location 5 in term of pH, temperature, and tide level.

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7.0 DATA ANALYSIS

7.1 Data Processing

CALCULATION FOR POPULATION DENSITY OF *PANDANUS HELIACORPUS*

Population density can be calculated using following formula:

$$\text{Population density (p.d)} = \frac{\text{Number of } \textit{Pandanus Heliacorpus}}{\text{Catchment Area } (m^2)}$$

LOCATION	POPULATION DENSITY OF *PANDANUS HELIACORPUS*
1	p.d = (23) / 6 m^2 = 3.83 m^{-2}
2	p.d = (18) / 6 m^2 = 3.00 m^{-2}
3	p.d = (11) / 6 m^2 = 1.83 m^{-2}
4	p.d = (04) / 6 m^2 = 0.67 m^{-2}
5	p.d = (00) / 6 m^2 = 0.00 m^{-2}

Table 8 : Location of the catchment area and its *Pandanus Heliacorpus* population density

*p.d : population density

CALCULATON FOR POPULATION SIZE OF *MACROBRACHIUM ROSENBERGII*

Lincoln index of relative population size of *Macrobrachium Rosenbergii sp*:

n= QM/R

where

M = is the number marked in precensus period
R = is the number of marked animals trapped in census period
n = is the population estimate
Q = is the total number of animals trapped

LOCATION	ESTIMATE POPULATION SIZE OF *MACROBRACHIUM ROSENBERGII*
1	n = (32 x 35) / 16 = 70
2	n = (28 x 24) / 13 = 52
3	n = (25 x 22) / 9 = 61
4	n = (12 x 15) / 07 = 26
5	n = (08 x 06) / 03 = 16

Table 9 : Location of the catchment area and its estimate population size of ***Macrobrachium Rosenbergii sp***

*n mean estimate population size of ***Macrobrachium Rosenbergii sp***

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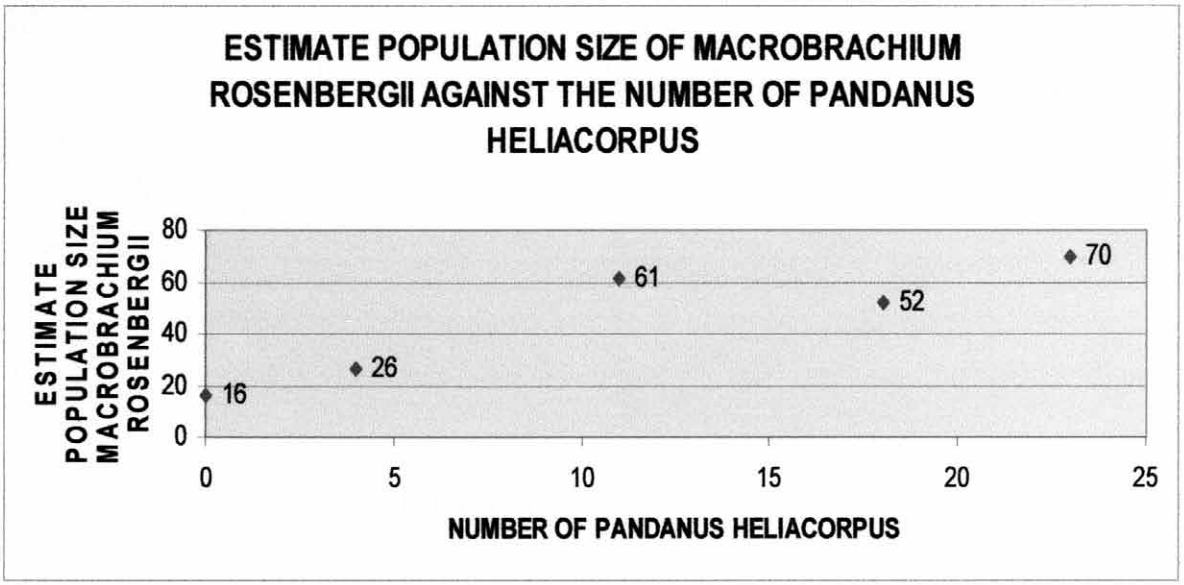
Combining those two tables above 5 pairs of data can be put together in one as below:

LOCATION	NUMBER OF PANDANUS HELIACORPUS	ESTIMATE POPULATION OF MACROBRACHIUM ROSENBERGII
1	23	70
2	18	52
3	11	61
4	4	26
5	0	16

Table 10: Table of *Pandanus heliacorpus* population density and estimate population size of ***Macrobrachium Rosenbergii sp*** in relation to its catchments' area.

Based on values in Table 3, the following scatter diagram is constructed.



Graph 1: A scatter diagram of the population size of *Macrobrachium Rosenbergii sp* against population density of *Pandanus heliacorpus*.

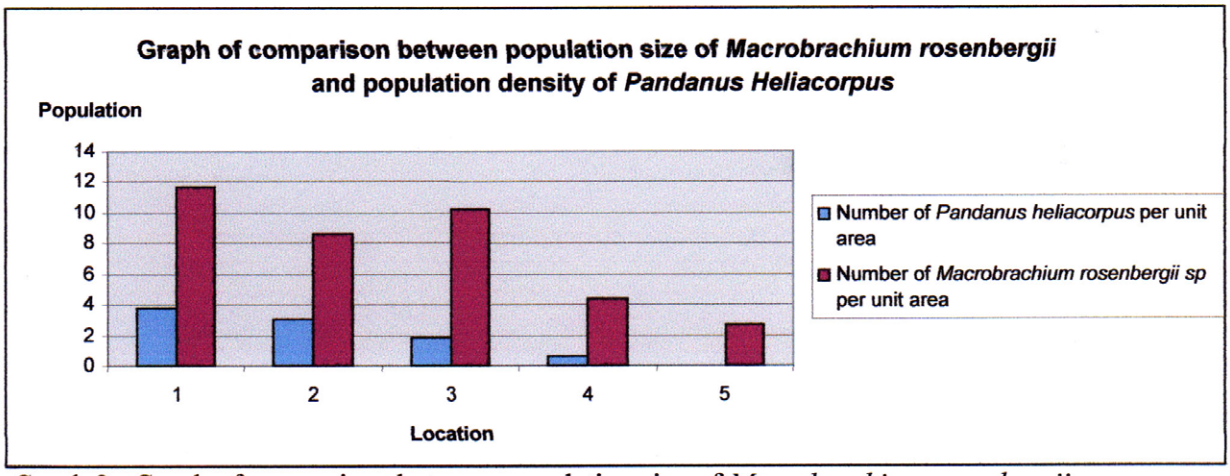
Scatter diagram above show the population size of Macrobrachium rosenbergii sp in relation to the number of Pandanus heliacorpus. The diagram shows there is an unclear relation between the two variables as the scatter diagram is not consistent.

From the information in Table 10, further calculation can be done to find the number of the species per unit area

Location	1	2	3	4	5
Number of *Macrobrachium rosenbergii sp* per unit area (m^{-2})	= 70 / 6 = 11.67	= 52 / 6 = 8.67	= 61 / 6 = 10.17	= 26 / 6 = 4.33	= 16 / 6 = 2.67
Number of *Pandanus heliacorpus* per unit area* (m^{-2})	= 3.83	= 3.00	= 1.83	= 0.67	= 0.00

Table 11 : Table for number of species per unit area
*refer table 1 as the calculation process is the same.

. Comparison between this two species also can be portrayed by the graph below :



Graph 2 : Graph of comparison between population size of *Macrobrachium rosenbergii sp* and population density of Pandanus heliacorpus.

From the above graph of comparison there seem to be a relationship between the population density of *Pandanus heliacorpus* and the population size of *Macrobrachium Rosenbergii sp* where over period of time, there has been an increase of the population size of *Macrobrachium Rosenbergii sp*. However this does not imply that there is a causal relationship between the two variables in the reality. The regression function, where the function f(x)=y will be determined to investigate this suspicion further.

7.2 Statistical Analysis

CALCULATING REGRESSION LINES FUNCTION[14]

As in the scatter diagram it appear that linear relationship is sensible, hence a model of the relationship in the form regression line should be construct. To find the regression line the data should be classified and simplified to the table below:

x	Y	x^2	y^2	xy
23	70	529	4900	1610
18	52	324	2704	936
11	61	121	3721	671
4	26	16	676	104
0	16	0	256	0
$\sum x$=56	$\sum y$=225	$\sum x^2$=990	$\sum y^2$=12257	$\sum xy$=3321

Where,

x : " the number of *Pandanus heliacorpus*"
y : " the estimate population size of *Macrobrachium Rosenbergii sp*"

There are five pairs of data so n=5

$$\bar{x} = \frac{\sum x}{n} = \frac{56}{5} = 11.2 \qquad \bar{y} = \frac{\sum y}{n} = \frac{225}{5} = 45$$

$$S_{xy} = \frac{\sum xy}{n} - \overline{xy} = \frac{3321}{5} - (11.2)(45) = 160.2$$

$$S_{xx} = \frac{\sum x^2}{n} - (\bar{x})^2 = \frac{990}{5} - (11.2)^2 = 72.56$$

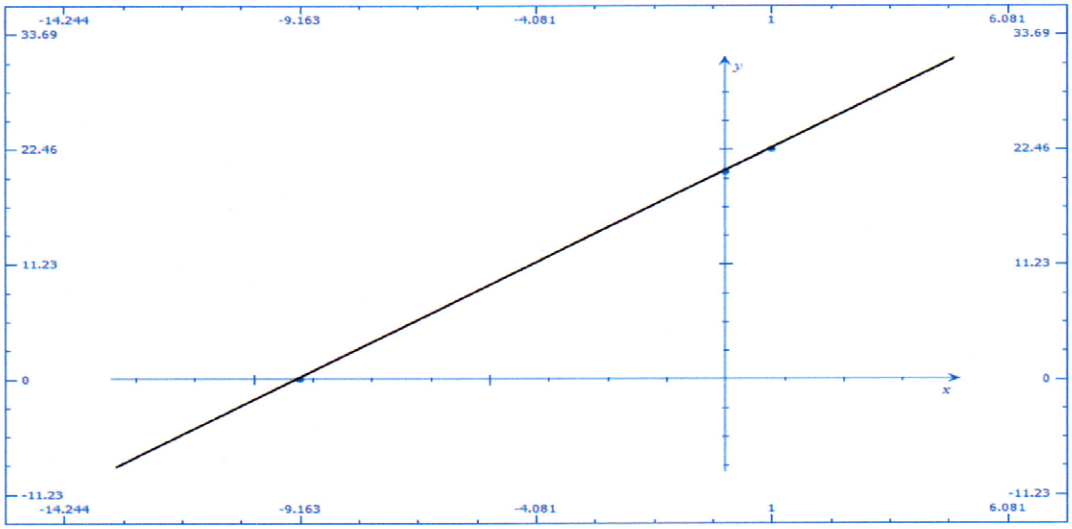
For the regression line y on x in the form y = a + bx:

$$b = \frac{S_{xy}}{S_{xx}} = \frac{160.2}{72.56} = 2.21 \text{ (2d.p.)} \quad \text{and} \quad a = \bar{y} - b(\bar{x}) = 45 - 2.21(11.2) = 20.25 \text{(2d.p.)}$$

[14] John E.Freund and Benjamin M.Perles, Statistics:A First Course: Nelson Pearson Prentice Hall., 2004 (p. 418 - 422)

So the equation of the regression line y on x is y = 20.25 + 2.21x

The graph of the regression line:



Graph 3 : Graph of the linear regression line

From the regression line above, referred to as estimated regression line, since the values of 'a' and 'b' are determined on the basis of the sample data. As being mentioned that 'a' and 'b' are referred to **population regression coefficient**. The true regression line is $y = \alpha + \beta x$. To distinguish between a and α and between b and β, we refer α and β as the **estimated regression coefficient** while a and b as being mention before. As in the regression line above it appear to be a strong positive linear correlation. It indicates that from the sample obtain the presence of ***Pandanus heliacorpus*** does give an effect to the population size of ***Macrobrachium Rosenbergii sp.*** Product-moment correlation coefficient is use to test whether this is true or not.

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PRODUCT-MOMENT CORRELATION COEFFICIENT[15]

Using big S format:

$$r = \frac{S_{xy}}{S_x S_y}$$

Where $S_{xy} = \sum xy - \frac{\sum x \sum y}{n}$

$$S_x = \sqrt{S_{xx}} = \sqrt{\sum x^2 - \frac{(\sum x)^2}{n}}$$

$$S_y = \sqrt{S_{yy}} = \sqrt{\sum y^2 - \frac{(\sum y)^2}{n}}$$

From the calculating the regression function section, the value for S_{xy} and S_{xx} had been calculated and the value as below:

$S_{xy} = 160.2$

$S_{xx} = 72.56$

$S_x = \sqrt{S_{xx}} = \sqrt{72.56} = 8.518(3\text{d.p.})$

Now calculate the value of S_y,

$$S_{yy} = \frac{\sum y^2}{n} - (\bar{y})^2 = \frac{12257}{5} - (45)^2 = 462.4$$

$S_y = \sqrt{S_{yy}} = \sqrt{462.4} = 21.503(3\text{d.p.})$

$$\therefore\ r = \frac{S_{xy}}{S_x S_y} = \frac{160.2}{(8.518)(21.503)} = 0.8746 \ldots\ldots \text{(a)}$$

[15] J. Chambers and J. Crawshaw, A Concise Course in Advanced Level Statistics. Cheltenham: Nelson Thornes Ltd., 2001 (p. 140 - 141, 600 - 604)

r such that $-1 \leq r \leq 1$, where

$r = -1$ indicates perfect negative correlation

$r = 0$ indicates no correlation

$r = +1$ indicates perfect positive correlation

The value of product-moment correlation coefficient obtain was 0.8746. This value is quite close to +1 but does it indicate positive correlative between the variables? A significant test was calculated.

SIGNIFICANT TEST

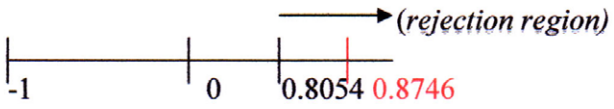
$H_o: p = 0$ (there is no correlation between variables x and y)

$H_1: p > 0$ (there is positive correlation between variables x and y)

Perform a one-tailed test at the 5% level

The sample size is 5.

From critical value of product-moment[16] correlation coefficient table, the critical value is 0.8054, so reject H_o if $r > 0.8054$



From (a), $r = 0.8746$

Since $r > 0.8054$, H_o is rejected in favour of H_1.

So, at 5% confidence level there is enough significant evidence that there is positive correlation between number of ***Pandanus heliacorpus*** and the population size of ***Macrobrachium Rosenbergii sp*** in the location of the research site.

[16] J. Chambers and J. Crawshaw, A Concise Course in Advanced Level Statistics. Cheltenham: Nelson Thornes Ltd., 2001 page 623

8.0 DISCUSSION

From the statistical test that had been done to analyze the data, it had been found that there is a positive correlation between the two variables being studied. There is a significant evidence to suggest that at 5% confidence level of the population size of ***Macrobrachium rosenbergii sp*** increases with the increase of the population density of ***Pandanus heliacorpus***. The possibilities of why this is happen will be discussed below.

From the experiment, research site no 2 is not consistent with the other research site by showing a negative correlation. The population density of ***Pandanus heliacorpus*** at location 2 is more than in location 3 but the data showed that the population size of ***Macrobrachium rosenbergii sp*** in location 2 is less. The possible reason to this is perhaps due to the water quality. Location of the research site 2 is close to Public Utility Board of Singapore (PUBS) water catchment's area which may had an unfavora/ble effect to the environment around it especially the quality of the water. Some of the local people was adamant that the area around PUBS is not suitable for fishing as you could hardly had any catch. ***Macrobrachium rosenbergii sp*** are very sensitive to the water quality, thus polluted water might drive ***Macrobrachium rosenbergii sp*** away from the area.

At location 5 although there were no ***Pandanus heliacorpus*** presences in the research site, *Macrobrachium* ***rosenbergii sp*** were still found to exist. Although this result shows that ***Macrobrachium rosenbergii sp*** does not solely dependant on the presence of ***Pandanus heliacorpus,*** the data shows the population count decrease significantly when ***Pandanus***

heliacorpus was none existence. Another assumption is that the female ***Macrobrachium rosenbergii sp*** may instinctively moves towards the sea for assurance of saline water to lay eggs. This is evident by the bigger ratio of female ***Macrobrachium rosenbergii sp*** observed during the catch. Post larvae and larvae of ***Macrobrachium rosenbergii sp*** require higher salinity level about 9 to 19 parts per thousands[17] to survive.

The constant variables susceptible to the ***Macrobrachium Rosenbergii sp.*** had been kept constantly to ensure the manipulated variables which are the density of ***Pandanus heliacorpus*** and the population count of ***Macrobrachium rosenbergii sp.*** is prominent during the research. Local expertise was sought for advice on the setting of empang for successful catch. This 'empang method' had literally isolated the study area, leaving no possible intervention or disturbance that might offset the result. No baits were used as previously intended as they might gave a false attraction to ***Macrobrachium rosenbergii sp.*** in the study area. The natural onset of the study area was preserved to have a 'true' deposition of ***Macrobrachium rosenbergii sp*** and its relation to the density of ***Pandanus heliacorpus***.

One of the possible reason why ***Macrobrachium rosenbergii sp*** favors location with the presence of ***Pandanus heliacorpus*** is because it give some sort of defense due to its razor sharp saw like leaves which makes the area impenetrable for any activity such as fishing and other predators. The characteristic of ***Pandanus heliacorpus*** which have the 'razor sharp saw like leaves' also make it a good hiding place for ***Macrobrachium***

[17] Louis R. D'Abramo and Martin W.Brunson, http://www.aquanic.org/ publicat/usda_rac/efs/srac/483fs.pdf

rosenbergii sp and its young from predators such as prawn-eating monkey. This monkey which under the family of macaque prowls the river banks at low tide to search for marine animals for food. This includes ***Macrobrachium rosenbergii sp***.

`The buffer effect of ***Pandanus heliacorpus*** along the river had kept the strong river current to its minimum at the bank. This had preserved the bank susceptibility to erosion thus maintaining the natural habitat of the ecology[18]. ***Macrobrachium Rosenbergii sp*** does not like direct light[19]. ***Macrobrachium rosenbergii sp*** is weak and were very venerable when they molt thus need to have some form of hideout as a shelter for a certain period of time before the new carapace harden.

Pandanus heliacorpus provide dark hiding places due its **prop root** and **dense leaves** that somehow sheltered the area below it from direct light. This characteristic had complimented the needs for ***Macrobrachium rosenbergii sp*** higher survival rate. The ***Pandanus heliacorpus*** produces extremely long and adventitious prop roots for stability and this had provide a natural rubbish trap barrier[20]. They form a 'net', which skirmished the alien material yet provide a space underneath for ***Macrobrachium rosenbergii sp*** which were bottom dwellers.

[18] D.J. Taylor, N. P. O. Green, G. W. Stout, Biological Science, Third Edition, 1997
[19] Daaniel Spotts, www..miami- aquaculture.com
[20] C.J. with D.G. Mackean, Advanced Biology Principles & Applications, Second International Student

9.0 EVALUATION, LIMITATION AND SUGGESTION

There are limitations in the course of the research study. The pH value and water temperature was unable to be kept constant. However the ranges of the readings are within the susceptible range for ***Macrobrachium rosenbergii*** sp. Another variation was the tide level condition as this limitation hampers the time interval desired of the experiment. Careful planning based on the tide table for the area was carefully planned to minimize those variation and timing.

There are locations where the manipulated variables which are the ***Pandanus heliacorpus*** were dominance but due to non accessibility and the tide level, had rendered the area not practical for the application of the research. A more adequate technology such as sensor similar to a 'fish finder' gadget would probably yield more significant and accurate result.

Due to the diversity of communities of the river there are lustrates, where a predator to ***Macrobrachium rosenbergii sp*** was confined within the same enclosure. A riverine sea bass may have its last buffet with abundance array of ***Macrobrachium rosenbergii sp*** thus offsetting the count. When such occurrence happened, the study was rendered null and void and to be repeated again. This repetition may prolong the desired sequential timing with variables such as water temperature, pH difference and the tide level to vary. The extended timing would compromise the markings done on ***Macrobrachium rosenbergii sp*** earlier thus slight differences of constant variables were tolerated. The weather conditions also play an

important role at the research site. When the experiment need to be extended the whole schedule was further delayed.

Another limitation is the counting was only done on adult ***Macrobrachium rosenbegii sp.*** During the catch, there are a lot of young prawns that were trapped in the 'empang'. However due to the fact that young ***Macrobrachium rosenbergii sp*** will molt once in 2 or 3 days, the markings made with Indian ink will be shed away together with the old carapace during the molting. This difference of 2 to 3 days had made the rigging of 'empang' and keeping the same constant variables almost impractical. The research may be more significant if there are ways to quantify these young prawns. As these limitations had me exhausted for solution I had decided that only adult ***Macrobrachium rosenbergii sp*** to be counted.

Other limitation of the research is that the salinity of the water on each research site was not taken. The salinity levels of the research site are greatly influence by the tide level. During high tide, the salinity level of the water increases. Hand-held refractometer requires to measure the salinity of water could not be made available. The research site no 5 probably had a higher salinity level thus supporting the higher ratio of females[21] ***Macrobrachium rosenbergii sp*** presence.

[21] Refer Appendixes 1

9.0 CONCLUSION

The research proves that **there is a relationship between *Pandanus heliacorpus* and *Macrobrachium rosenbergii sp.*** There is a **positive correlation between the population size of *Macrobrachium rosenbergii sp* and the population density of *Pandanus heliacorpus.***

Certain step must be taken to ensure that the ***Pandanus heliacorpus*** be preserved along the river bank. Although ***Pandanus heliacorpus*** could reduce the width of the river, it must not be totally destroy. The effects are really significant to the population size of ***Macrobrachium rosenbergii sp.*** The natural nature of its roots could prevent erosion of the river bank. By knowing this fact, further implementation or improvement can be made to the species especially for the aquaculture development of ***Macrobrachium rosenbergii sp***

This investigation only focuses on the relation of ***Pandanus heliacorpus*** and ***Macrobrachium rosenbergii sp.*** As every living organism react to its environment it can be said that there are others abiotic and biotic factors that contribute to the population of ***Macrobrachium rosenbergii sp*** hence further research should be done.

10.0 REFERENCE AND BIBLIOGRAPHY

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World Wide Web

1. Daniel Spotts, 12:10 pm, July 1, 2006

   Introducing Macrobrachium Rosenbergii

   http://www.miami-aquaculture.com

2. Louis R. D'Abramo and Martin W.Brunson, 1:47 pm, May 9, 2006

   Biology and Life History of Freshwaters Prawns

   http://www.aquanic.org/ publicat/usda_rac/efs/srac/483fs.pdf

3. Author's name not stated, time or date not stated, 10.01 am, March 11,2006

   Macrobrachium Rosenbergii,

   http://en.wikipedia.org/wiki/Bacterium

4. Author's name not stated, time or date not stated, 11.23 am, March 12,2006

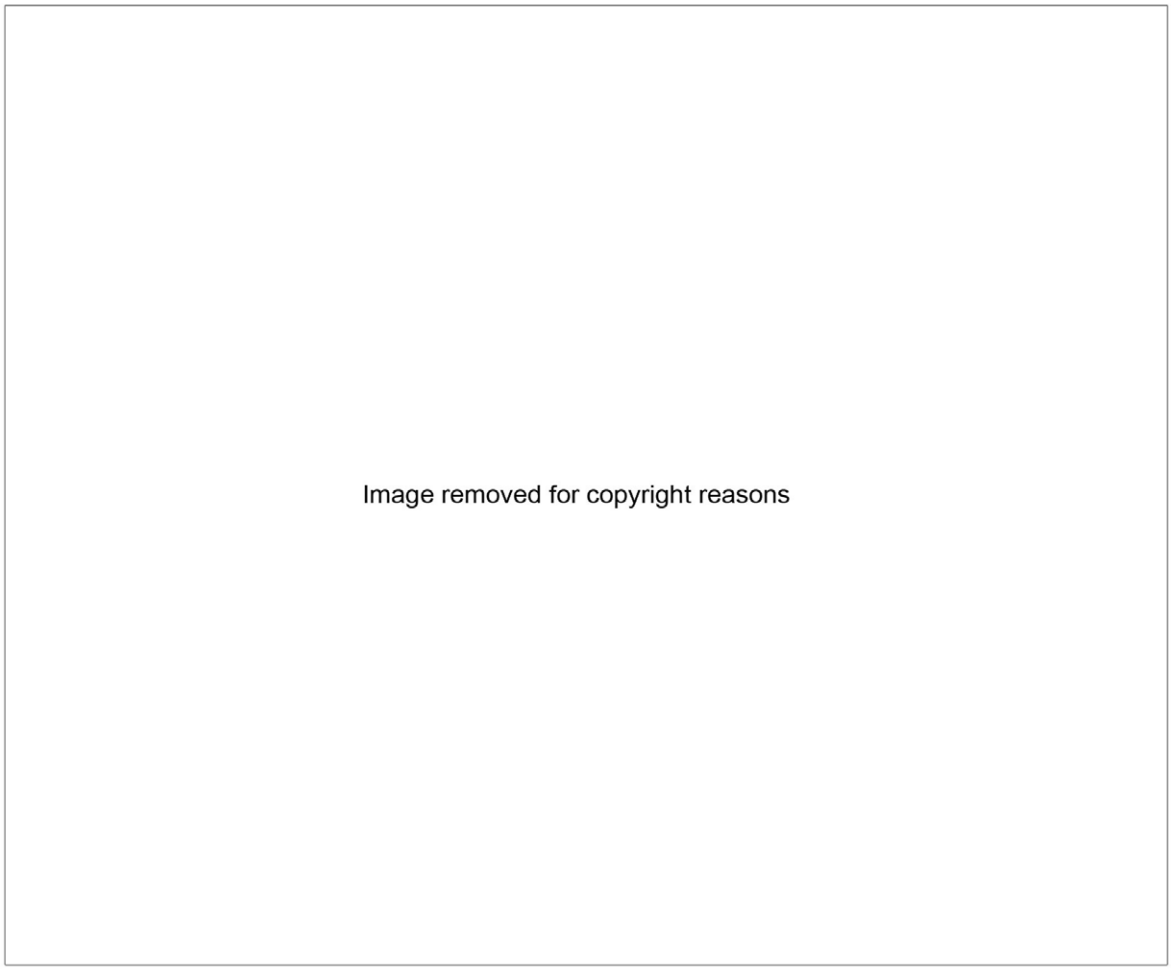
   Chapter 1: Biology

   http://www.fao.org/documents/ show_cdr.asp?url

   _file=/DOCREP/005/y4100E/y4100e03.htm

12.0 APPENDIXES

APPENDIX 1



SOURCE: EMANUELA D'ANTONI, AFTER MARIO PEDINI

APPENDIX 2

Some of the research location site

Research location 3

Research location 5

Predator that enter the empang

Riverine sea-bass that enter one of my research location site

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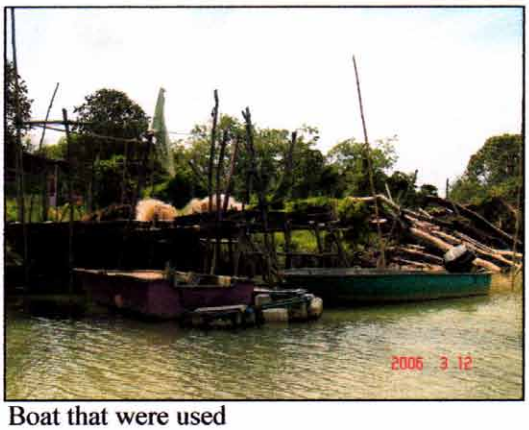
Things that were used during the research

The net used in the research



Boat that were used

Those who involve in the research

My father who always accompany me during the research

Pak Mat, one of the local in fisherman who always help me in running this research

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The relationship between the population density of *Pandanus heliacorpus* and the population size of *Macrobrachium rosenbergii sp.*

Picture of *Macrobrachium rosenbergii sp*

Adult king prawn that was marked by the indian ink

Young king prawn that were not included in the counting process

King prawn that were caught during fishing

Beautiful huge king prawn that were captured in the 'empang'

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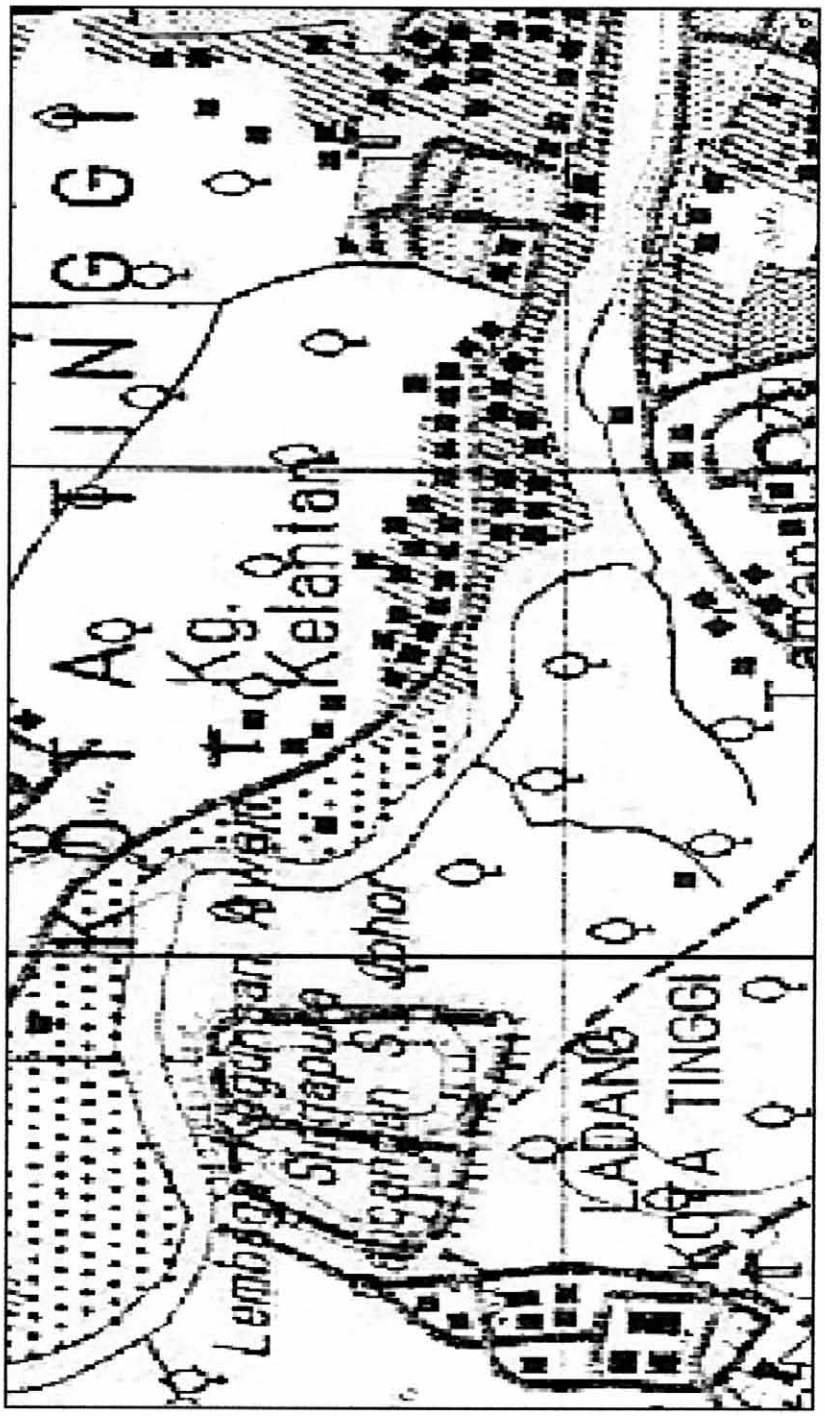
APPENDIX 3



Map of Kota Tinggi.

40

The relationship between the population density of *Pandanus heliacorpus* and the population size of *Macrobrachium rosenbergii sp.*

SUNGAI BELUNGKOR, JOHOR DARUL TAKZIM

Lat 01 27 N Long 104 04 E

TIME ZONE -0800 TIMES AND HEIGHTS OF HIGH AND LOW WATERS 2006

JANUARY

	Time	m		Time	m		Time	m		Time	m
1 Su	0059	3.1	16 M	0139	2.8	1 W	0201	3.2	16 Th	0155	2.8
	0541	1.8		0631	1.6		0650	1.3		0704	1.0
	1157	3.1		1218	2.7		1321	3.2		1318	2.7
	1751	0.2		1828	0.2		1908	0.1		1912	0.3
2 M	0143	3.1	17 T	0208	2.8	2 Th	0235	3.2	17 F	0218	2.7
	0622	1.7		0701	1.4		0727	1.1		0728	0.8
	1241	3.1		1253	2.6		1407	3.1		1353	2.7
	1834	0.1		1859	0.2		1948	0.3		1940	0.4
3 T	0225	3.1	18 W	0235	2.7	3 F	0308	3.1	18 Sa	0241	2.7
	0701	1.6		0730	1.3		0806	0.9		0754	0.7
	1326	3.1		1328	2.6		1454	3.0		1429	2.7
	1916	0.1		1930	0.2		2028	0.5		2008	0.6
4 W	0306	3.1	19 Th	0300	2.7	4 Sa	0339	3.0	19 Su	0305	2.7
	0741	1.5		0759	1.2		0845	0.8		0823	0.6
	1412	3.0		1403	2.6		1547	2.9		1508	2.6
	1959	0.2		2001	0.4		2109	0.8		2037	0.9
5 Th	0344	3.1	20 F	0325	2.7	5 Su	0410	2.9	20 M	0330	2.6
	0823	1.5		0827	1.1		0928	0.8		0855	0.6
	1502	3.0		1441	2.5		1645	2.7		1553	2.4
	2043	0.5		2032	0.5		2154	1.2		2106	1.2
6 F	0422	3.0	21 Sa	0352	2.6	6 M	0441	2.8	21 T	0357	2.6
	0909	1.4		0859	1.0		1020	0.8		0936	0.7
	1555	2.8		1523	2.5		1759	2.5		1650	2.3
	2132	0.8		2106	0.8		2251	1.6		2138	1.5
7 Sa	0459	2.9	22 Su	0419	2.6	7 T	0516	2.6	22 W	0428	2.5
	1002	1.3		0936	1.0		1129	0.9		1032	0.9
	1659	2.7		1612	2.4		1946	2.3		1821	2.1
	2229	1.1		2142	1.1					2220	1.9
8 Su	0538	2.8	23 M	0450	2.5	8 W	0025	1.9	23 Th	0511	2.5
	1109	1.2		1023	1.1		0558	2.5		1208	1.0
	1817	2.5		1715	2.3		1310	0.9		2123	2.2
	2347	1.5		2232	1.5		2150	2.5			
9 M	0619	2.7	24 T	0525	2.5	9 Th	0221	2.0	24 F	0110	2.1
	1235	1.1		1136	1.1		0708	2.4		0625	2.5
	1958	2.5		1853	2.2		1445	0.8		1358	1.0
							2258	2.6		2237	2.5
10 T	0118	1.7	25 W	0010	1.8	10 F	0349	2.0	25 Sa	0255	2.1
	0708	2.6		0614	2.5		0852	2.3		0824	2.5
	1353	0.9		1306	1.0		1553	0.7		1511	0.8
	2141	2.6		2122	2.3		2341	2.8		2314	2.8
11 W	0236	1.9	26 Th	0156	2.0	11 Sa	0445	1.9	26 Su	0353	2.0
	0809	2.6		0724	2.5		1008	2.4		0952	2.8
	1457	0.8		1421	0.9		1641	0.5		1606	0.6
	2253	2.8		2239	2.6					2348	3.0
12 Th	0341	1.9	27 F	0308	2.0	12 Su	0016	2.8	27 M	0438	1.7
	0917	2.6		0853	2.6		0522	1.7		1050	3.0
	1551	0.6		1522	0.7		1057	2.5		1651	0.4
	2345	2.9		2327	2.8		1718	0.4			
13 F	0436	1.9	28 Sa	0403	2.0	13 M	0045	2.8	28 T	0021	3.1
	1014	2.6		1005	2.8		0550	1.5		0517	1.5
	1638	0.4		1614	0.5		1137	2.6		1139	3.2
						○	1748	0.4	●	1733	0.3
14 Sa	0028	2.9	29 Su	0008	3.0	14 T	0110	2.8			
	0520	1.8		0450	1.8		0616	1.3			
	1101	2.7		1100	3.0		1211	2.6			
	1719	0.3	●	1701	0.3		1817	0.3			
15 Su	0107	2.9	30 M	0047	3.1	15 W	0133	2.8			
	0557	1.7		0532	1.7		0640	1.1			
	1141	2.7		1148	3.1		1245	2.7			
○	1754	0.3		1744	0.2		1844	0.3			
			31 T	0124	3.2						
				0611	1.5						
				1235	3.2						
				1826	0.1						

FEBRUARY

	Time	m		Time	m
1 W	0201	3.2	16 Th	0155	2.8
	0650	1.3		0704	1.0
	1321	3.2		1318	2.7
	1908	0.1		1912	0.3
2 Th	0235	3.2	17 F	0218	2.7
	0727	1.1		0728	0.8
	1407	3.1		1353	2.7
	1948	0.3		1940	0.4
3 F	0308	3.1	18 Sa	0241	2.7
	0806	0.9		0754	0.7
	1454	3.0		1429	2.7
	2028	0.5		2008	0.6
4 Sa	0339	3.0	19 Su	0305	2.7
	0845	0.8		0823	0.6
	1547	2.9		1508	2.6
	2109	0.8		2037	0.9
5 Su	0410	2.9	20 M	0330	2.6
	0928	0.8		0855	0.6
	1645	2.7		1553	2.4
	2154	1.2		2106	1.2
6 M	0441	2.8	21 T	0357	2.6
	1020	0.8		0936	0.7
	1759	2.5		1650	2.3
	2251	1.6		2138	1.5
7 T	0516	2.6	22 W	0428	2.5
	1129	0.9		1032	0.9
	1946	2.3		1821	2.1
				2220	1.9
8 W	0025	1.9	23 Th	0511	2.5
	0558	2.5		1208	1.0
	1310	0.9		2123	2.2
	2150	2.5			
9 Th	0221	2.0	24 F	0110	2.1
	0708	2.4		0625	2.5
	1445	0.8		1358	1.0
	2258	2.6		2237	2.5
10 F	0349	2.0	25 Sa	0255	2.1
	0852	2.3		0824	2.5
	1553	0.7		1511	0.8
	2341	2.8		2314	2.8
11 Sa	0445	1.9	26 Su	0353	2.0
	1008	2.4		0952	2.8
	1641	0.5		1606	0.6
				2348	3.0
12 Su	0016	2.8	27 M	0438	1.7
	0522	1.7		1050	3.0
	1057	2.5		1651	0.4
	1718	0.4			
13 M	0045	2.8	28 T	0021	3.1
	0550	1.5		0517	1.5
	1137	2.6		1139	3.2
○	1748	0.4	●	1733	0.3
14 T	0110	2.8			
	0616	1.3			
	1211	2.6			
	1817	0.3			
15 W	0133	2.8			
	0640	1.1			
	1245	2.7			
	1844	0.3			

MARCH

	Time	m		Time	m
1 W	0053	3.2	16 Th	0051	2.8
	0553	1.2		0609	0.8
	1226	3.3		1233	2.8
	1813	0.2		1823	0.5
2 Th	0125	3.2	17 F	0112	2.8
	0629	0.9		0631	0.6
	1312	3.3		1307	2.8
	1853	0.3		1850	0.6
3 F	0157	3.2	18 Sa	0136	2.7
	0706	0.6		0655	0.4
	1359	3.2		1342	2.8
	1931	0.5		1917	0.7
4 Sa	0227	3.1	19 Su	0200	2.7
	0741	0.4		0723	0.3
	1446	3.1		1420	2.8
	2008	0.7		1944	0.9
5 Su	0255	3.0	20 M	0224	2.7
	0819	0.3		0753	0.3
	1537	2.9		1501	2.6
	2046	1.0		2011	1.1
6 M	0323	2.8	21 T	0251	2.7
	0857	0.4		0826	0.3
	1634	2.6		1547	2.5
	2124	1.4		2038	1.3
7 T	0351	2.7	22 W	0318	2.6
	0941	0.5		0906	0.5
	1745	2.4		1647	2.3
	2208	1.7		2108	1.6
8 W	0419	2.5	23 Th	0350	2.6
	1038	0.7		0958	0.7
	1934	2.2		1817	2.2
	2324	2.0		2145	1.9
9 Th	0455	2.3	24 F	0436	2.5
	1221	0.9		1126	1.0
	2150	2.3		2043	2.3
10 F	0226	2.1	25 Sa	0041	2.2
	0609	2.2		0602	2.5
	1441	0.9		1340	1.0
	2246	2.5		2203	2.5
11 Sa	0404	1.9	26 Su	0246	2.1
	0838	2.1		0808	2.5
	1552	0.8		1456	0.8
	2320	2.7		2239	2.8
12 Su	0442	1.7	27 M	0338	1.8
	1002	2.3		0938	2.8
	1633	0.7		1548	0.7
	2346	2.8		2311	3.0
13 M	0507	1.5	28 T	0417	1.5
	1050	2.5		1039	3.0
	1703	0.6		1633	0.6
				2343	3.1
14 T	0008	2.8	29 W	0453	1.2
	0528	1.3		1130	3.2
	1126	2.6		1714	0.5
	1729	0.5	●		
15 W	0030	2.8	30 Th	0014	3.2
	0549	1.1		0529	0.8
	1200	2.7		1217	3.3
○	1756	0.5		1754	0.6
			31 F	0045	3.2
				0605	0.5
				1304	3.3
				1833	0.7

APRIL

	Time	m		Time	m
1 Sa	0115	3.1	16 Su	0055	2.7
	0640	0.2		0624	0.2
	1352	3.2		1336	2.9
	1910	0.8		1854	1.0
2 Su	0144	3.0	17 M	0123	2.7
	0716	0.1		0655	0.1
	1440	3.0		1418	2.8
	1948	1.0		1923	1.2
3 M	0212	2.9	18 T	0152	2.7
	0753	0.1		0729	0.1
	1531	2.8		1504	2.7
	2023	1.3		1951	1.3
4 T	0240	2.7	19 W	0222	2.7
	0831	0.2		0807	0.2
	1626	2.6		1555	2.5
	2100	1.5		2022	1.5
5 W	0308	2.6	20 Th	0254	2.7
	0911	0.4		0849	0.4
	1734	2.3		1656	2.4
	2139	1.8		2057	1.8
6 Th	0337	2.4	21 F	0334	2.6
	1001	0.7		0941	0.7
	1906	2.2		1810	2.3
	2249	2.0		2150	2.0
7 F	0413	2.2	22 Sa	0431	2.5
	1127	0.9		1105	0.9
	2106	2.3		1938	2.4
8 Sa	0216	2.0	23 Su	0034	2.1
	0535	2.0		0602	2.5
	1406	1.0		1312	1.0
	2205	2.4		2054	2.6
9 Su	0337	1.8	24 M	0219	1.9
	0814	2.0		0753	2.5
	1515	0.9		1427	1.0
	2236	2.6		2144	2.8
10 M	0408	1.5	25 T	0308	1.6
	0944	2.2		0923	2.7
	1556	0.9		1521	0.9
	2300	2.7		2223	2.9
11 T	0430	1.3	26 W	0348	1.2
	1033	2.4		1027	3.0
	1629	0.8		1608	0.9
	2322	2.7		2257	3.0
12 W	0450	1.1	27 Th	0425	0.8
	1109	2.6		1121	3.2
	1659	0.8		1651	0.9
	2343	2.7		2330	3.0
13 Th	0510	0.9	28 F	0502	0.5
	1144	2.7		1210	3.2
	1728	0.8		1733	1.0
○			●		
14 F	0006	2.7	29 Sa	0002	3.0
	0533	0.6		0539	0.2
	1220	2.8		1259	3.2
	1757	0.8		1812	1.1
15 Sa	0030	2.7	30 Su	0034	3.0
	0557	0.4		0617	0.0
	1256	2.9		1348	3.1
	1825	0.9		1852	1.2

The relationship between the population density of *Pandanus heliacorpus* and the population size of *Macrobrachium rosenbergii sp.*

SUNGAI BELUNGKOR, JOHOR DARUL TAKZIM

Lat 01 27 N Long 104 04 E

TIME ZONE -0800 TIMES AND HEIGHTS OF HIGH AND LOW WATERS 2006

MAY

	Time	m		Time	m
1 M	0105 2.9 0654 0.0 1438 2.9 1929 1.3		16 T	0054 2.7 0637 0.0 1422 2.8 1905 1.4	
2 T	0136 2.8 0732 0.0 1528 2.7 2006 1.5		17 W	0130 2.8 0715 0.0 1510 2.7 1938 1.5	
3 W	0207 2.6 0810 0.1 1620 2.5 2043 1.6		18 Th	0207 2.7 0755 0.1 1600 2.6 2016 1.6	
4 Th	0238 2.5 0850 0.3 1715 2.3 2126 1.7		19 F	0248 2.7 0840 0.3 1653 2.6 2100 1.7	
5 F	0313 2.3 0936 0.6 1817 2.2 2234 1.8		20 Sa	0337 2.6 0934 0.6 1747 2.6 2202 1.8	
6 Sa	0359 2.1 1040 0.9 1929 2.2		21 Su	0438 2.5 1047 0.8 1843 2.6 2354 1.8	
7 Su	0102 1.8 0515 2.0 1246 1.0 2038 2.3		22 M	0559 2.5 1230 1.0 1941 2.7	
8 M	0226 1.6 0718 1.9 1408 1.1 2124 2.4		23 T	0133 1.6 0735 2.5 1349 1.1 2036 2.7	
9 T	0308 1.4 0907 2.1 1501 1.1 2157 2.5		24 W	0229 1.3 0907 2.7 1448 1.2 2124 2.8	
10 W	0337 1.2 1007 2.3 1543 1.1 2225 2.6		25 Th	0314 0.9 1018 2.9 1539 1.3 2207 2.9	
11 Th	0403 0.9 1050 2.5 1622 1.1 2253 2.6		26 F	0356 0.6 1116 3.0 1628 1.3 2246 2.9	
12 F ○	0428 0.7 1129 2.7 1656 1.1 2320 2.7		27 Sa ●	0438 0.3 1208 3.1 1713 1.4 2323 2.8	
13 Sa	0456 0.4 1209 2.8 1729 1.2 2350 2.7		28 Su	0518 0.1 1259 3.0 1755 1.5 2359 2.8	
14 Su	0526 0.2 1252 2.9 1802 1.3		29 M	0558 0.0 1349 2.9 1836 1.5	
15 M	0022 2.7 0600 0.1 1336 2.8 1833 1.3		30 T	0035 2.7 0638 0.0 1436 2.8 1914 1.5	
			31 W	0110 2.6 0717 0.0 1521 2.6 1953 1.5	

JUNE

	Time	m		Time	m
1 Th	0146 2.5 0755 0.1 1602 2.5 2031 1.5		16 F	0201 2.8 0750 0.1 1549 2.8 2013 1.5	
2 F	0223 2.4 0834 0.3 1642 2.4 2114 1.5		17 Sa	0248 2.8 0835 0.3 1630 2.8 2059 1.5	
3 Sa	0303 2.3 0914 0.5 1722 2.3 2208 1.5		18 Su	0338 2.7 0924 0.5 1711 2.7 2153 1.5	
4 Su	0350 2.1 1002 0.7 1803 2.3 2327 1.5		19 M	0438 2.6 1024 0.8 1753 2.7 2307 1.4	
5 M	0451 2.0 1116 1.0 1849 2.3		20 T	0549 2.5 1143 1.1 1838 2.7	
6 T	0053 1.4 0615 1.9 1251 1.1 1938 2.3		21 W	0034 1.2 0717 2.5 1307 1.3 1927 2.7	
7 W	0151 1.3 0805 2.0 1400 1.3 2028 2.3		22 Th	0145 1.0 0854 2.6 1416 1.5 2021 2.6	
8 Th	0235 1.0 0934 2.2 1454 1.3 2115 2.4		23 F	0242 0.7 1015 2.7 1516 1.6 2115 2.7	
9 F	0312 0.8 1031 2.4 1542 1.4 2157 2.5		24 Sa	0333 0.5 1118 2.9 1610 1.7 2207 2.7	
10 Sa	0349 0.6 1119 2.6 1624 1.4 2237 2.6		25 Su	0421 0.3 1212 2.9 1700 1.7 2253 2.7	
11 Su ○	0425 0.4 1205 2.7 1704 1.5 2316 2.7		26 M ●	0506 0.1 1300 2.9 1745 1.6 2338 2.7	
12 M	0505 0.2 1250 2.8 1740 1.5 2355 2.7		27 T	0549 0.0 1345 2.8 1825 1.6	
13 T	0545 0.1 1337 2.8 1817 1.5		28 W	0018 2.6 0628 0.0 1424 2.7 1904 1.5	
14 W	0037 2.8 0625 0.0 1422 2.8 1853 1.5		29 Th	0057 2.6 0707 0.0 1459 2.6 1939 1.4	
15 Th	0118 2.8 0708 0.0 1506 2.8 1932 1.5		30 F	0135 2.5 0742 0.1 1530 2.5 2015 1.3	

JULY

	Time	m		Time	m
1 Sa	0212 2.4 0816 0.2 1558 2.5 2051 1.2		16 Su	0243 2.9 0824 0.3 1556 2.9 2044 1.1	
2 Su	0251 2.3 0851 0.4 1626 2.4 2128 1.2		17 M	0334 2.8 0908 0.5 1630 2.8 2129 1.0	
3 M	0333 2.2 0928 0.6 1655 2.4 2212 1.1		18 T	0430 2.6 0957 0.9 1705 2.7 2224 1.0	
4 T	0423 2.1 1013 0.9 1728 2.3 2310 1.1		19 W	0537 2.5 1058 1.2 1742 2.7 2335 0.9	
5 W	0526 2.0 1122 1.2 1806 2.3		20 Th	0702 2.4 1222 1.6 1825 2.6	
6 Th	0022 1.1 0656 2.0 1253 1.4 1853 2.3		21 F	0059 0.8 0851 2.4 1348 1.8 1921 2.5	
7 F	0129 1.0 0858 2.1 1407 1.6 1953 2.3		22 Sa	0217 0.7 1022 2.6 1504 1.8 2033 2.5	
8 Sa	0227 0.8 1022 2.3 1507 1.7 2101 2.4		23 Su	0322 0.5 1123 2.7 1607 1.8 2145 2.5	
9 Su	0318 0.6 1116 2.5 1558 1.7 2201 2.5		24 M	0417 0.4 1210 2.8 1658 1.8 2242 2.6	
10 M ○	0406 0.4 1202 2.7 1643 1.7 2253 2.7		25 T ●	0504 0.2 1252 2.8 1740 1.6 2329 2.6	
11 T	0452 0.2 1245 2.8 1724 1.6 2340 2.8		26 W	0545 0.2 1326 2.7 1816 1.5	
12 W	0536 0.1 1327 2.9 1805 1.6		27 Th	0010 2.6 0621 0.1 1357 2.7 1849 1.3	
13 Th	0025 2.9 0619 0.0 1407 2.9 1843 1.4		28 F	0048 2.6 0653 0.1 1423 2.6 1919 1.1	
14 F	0110 2.9 0701 0.0 1445 2.9 1923 1.3		29 Sa	0123 2.5 0724 0.2 1447 2.6 1948 1.0	
15 Sa	0156 2.9 0742 0.1 1521 2.9 2002 1.2		30 Su	0159 2.5 0754 0.3 1510 2.5 2017 0.8	
			31 M	0235 2.4 0824 0.4 1534 2.5 2046 0.8	

AUGUST

	Time	m		Time	m
1 T	0313 2.3 0854 0.7 1559 2.4 2119 0.8		16 W	0420 2.7 0930 1.1 1618 2.7 2147 0.6	
2 W	0356 2.2 0928 0.9 1626 2.4 2159 0.8		17 Th	0526 2.5 1020 1.5 1652 2.6 2246 0.7	
3 Th	0450 2.1 1008 1.3 1659 2.3 2255 0.9		18 F	0654 2.4 1136 1.8 1732 2.5	
4 F	0608 2.0 1114 1.6 1740 2.3		19 Sa	0016 0.8 0856 2.4 1335 2.0 1832 2.4	
5 Sa	0023 0.9 0832 2.1 1318 1.8 1842 2.3		20 Su	0206 0.8 1025 2.6 1511 2.0 2011 2.3	
6 Su	0151 0.9 1023 2.3 1440 1.9 2013 2.4		21 M	0326 0.7 1117 2.7 1616 1.8 2142 2.4	
7 M	0300 0.7 1111 2.5 1541 1.9 2138 2.6		22 T	0423 0.5 1154 2.8 1658 1.7 2240 2.5	
8 W	0355 0.5 1151 2.7 1629 1.8 2238 2.8		23 W	0504 0.4 1226 2.8 1730 1.5 2325 2.6	
9 W ○	0443 0.3 1227 2.9 1710 1.6 2329 3.0		24 Th ●	0537 0.4 1253 2.8 1758 1.3	
10 Th	0527 0.2 1303 3.0 1749 1.4		25 F	0002 2.6 0606 0.4 1316 2.7 1824 1.0	
11 F	0016 3.1 0608 0.1 1338 3.0 1826 1.2		26 Sa	0037 2.6 0634 0.4 1338 2.7 1849 0.8	
12 Sa	0102 3.1 0648 0.1 1411 3.1 1904 1.0		27 Su	0109 2.6 0701 0.4 1359 2.6 1914 0.7	
13 Su	0148 3.1 0727 0.2 1443 3.0 1941 0.8		28 M	0143 2.6 0729 0.5 1422 2.6 1938 0.5	
14 M	0235 3.0 0807 0.4 1515 3.0 2020 0.6		29 T	0218 2.6 0756 0.6 1445 2.6 2006 0.5	
15 T	0325 2.9 0847 0.7 1546 2.9 2100 0.6		30 W	0255 2.5 0823 0.9 1509 2.5 2037 0.5	
			31 Th	0338 2.4 0852 1.1 1536 2.5 2113 0.6	

The relationship between the population density of *Pandanus heliacorpus* and the population size of *Macrobrachium rosenbergii sp.*

SUNGAI BELUNGKOR, JOHOR DARUL TAKZIM

Lat 01 27 N Long 104 04 E

TIME ZONE -0800 TIMES AND HEIGHTS OF HIGH AND LOW WATERS 2006

SEPTEMBER

	Time	m		Time	m
1 F	0429	2.3	16 Sa	0650	2.4
	0921	1.4		1057	2.0
	1607	2.5		1648	2.4
	2202	0.8		2337	0.9
2 Sa	0548	2.1	17 Su	0850	2.4
	0956	1.8		1346	2.1
	1648	2.4		1801	2.3
	2323	1.0			
3 Su	0819	2.1	18 M	0207	0.9
	1220	2.0		1008	2.6
	1756	2.4		1525	1.9
				2008	2.3
4 M	0127	1.0	19 T	0326	0.8
	1012	2.4		1051	2.7
	1431	2.0		1612	1.7
	1948	2.5		2141	2.4
5 T	0249	0.8	20 W	0412	0.8
	1051	2.6		1122	2.8
	1530	1.9		1642	1.5
	2123	2.7		2236	2.6
6 W	0345	0.7	21 Th	0446	0.7
	1123	2.9		1146	2.8
	1613	1.7		1707	1.3
	2227	2.9		2315	2.7
7 Th	0430	0.5	22 F ●	0514	0.7
	1154	3.0		1208	2.8
	1651	1.5		1729	1.1
○	2318	3.1		2350	2.7
8 F	0511	0.4	23 Sa	0541	0.7
	1226	3.1		1229	2.8
	1727	1.2		1752	0.8
9 Sa	0005	3.3	24 Su	0022	2.8
	0551	0.4		0608	0.7
	1258	3.2		1251	2.8
	1803	0.9		1814	0.6
10 Su	0051	3.3	25 M	0054	2.8
	0629	0.5		0636	0.8
	1330	3.1		1312	2.7
	1839	0.6		1838	0.5
11 M	0138	3.3	26 T	0128	2.8
	0708	0.6		0703	0.9
	1401	3.1		1337	2.7
	1916	0.4		1904	0.3
12 T	0225	3.2	27 W	0205	2.8
	0746	0.8		0729	1.0
	1431	3.0		1401	2.7
	1953	0.3		1933	0.3
13 W	0317	3.0	28 Th	0245	2.7
	0824	1.1		0756	1.2
	1501	2.9		1428	2.6
	2032	0.3		2006	0.3
14 Th	0413	2.8	29 F	0331	2.5
	0904	1.4		0823	1.4
	1532	2.7		1456	2.6
	2115	0.4		2044	0.5
15 F	0520	2.6	30 Sa	0428	2.4
	0949	1.7		0852	1.7
	1606	2.6		1530	2.6
	2208	0.7		2131	0.8

OCTOBER

	Time	m		Time	m
1 Su	0548	2.3	16 M	0807	2.5
	0927	1.9		1345	2.1
	1618	2.5		1743	2.2
	2246	1.0			
2 M	0744	2.3	17 T	0138	1.1
	1122	2.2		0922	2.6
	1738	2.5		1505	1.8
				1953	2.2
3 T	0107	1.1	18 W	0253	1.1
	0923	2.5		1004	2.7
	1420	2.1		1542	1.6
	1935	2.6		2129	2.4
4 W	0231	1.0	19 Th	0338	1.1
	1007	2.8		1033	2.8
	1510	1.9		1608	1.4
	2109	2.8		2222	2.5
5 Th	0323	0.9	20 F	0412	1.0
	1040	3.0		1057	2.8
	1550	1.6		1631	1.1
	2214	3.1		2300	2.7
6 F	0407	0.8	21 Sa	0442	1.0
	1112	3.1		1120	2.8
	1625	1.2		1653	0.9
	2307	3.3		2334	2.8
7 Sa	0448	0.8	22 Su ●	0512	1.1
	1143	3.2		1142	2.8
	1701	0.9		1715	0.7
○	2354	3.4			
8 Su	0528	0.8	23 M	0008	2.9
	1215	3.2		0541	1.1
	1737	0.6		1206	2.8
				1739	0.5
9 M	0041	3.4	24 T	0042	3.0
	0608	0.9		0609	1.2
	1246	3.2		1231	2.8
	1813	0.3		1806	0.3
10 T	0129	3.4	25 W	0120	2.9
	0647	1.1		0638	1.2
	1318	3.1		1258	2.8
	1851	0.2		1836	0.2
11 W	0220	3.2	26 Th	0201	2.9
	0725	1.2		0706	1.4
	1349	3.0		1327	2.8
	1929	0.1		1909	0.2
12 Th	0312	3.1	27 F	0246	2.8
	0804	1.4		0735	1.5
	1420	2.9		1358	2.8
	2008	0.2		1946	0.3
13 F	0409	2.8	28 Sa	0337	2.7
	0843	1.7		0805	1.7
	1453	2.7		1433	2.7
	2051	0.4		2026	0.5
14 Sa	0514	2.6	29 Su	0435	2.5
	0926	1.9		0839	1.9
	1529	2.6		1514	2.7
	2141	0.7		2115	0.8
15 Su	0632	2.5	30 M	0540	2.5
	1036	2.1		0927	2.0
	1617	2.4		1610	2.6
	2300	1.0		2224	1.0
			31 T	0654	2.5
				1122	2.2
				1734	2.6

NOVEMBER

	Time	m		Time	m
1 W	0030	1.2	16 Th	0149	1.3
	0807	2.7		0848	2.6
	1347	2.0		1449	1.5
	1918	2.6		2058	2.2
2 Th	0157	1.2	17 F	0244	1.3
	0903	2.9		0927	2.6
	1438	1.7		1521	1.3
	2053	2.8		2200	2.5
3 F	0253	1.2	18 Sa	0328	1.4
	0946	3.0		0959	2.7
	1519	1.4		1547	1.0
	2201	3.1		2242	2.7
4 Sa	0339	1.2	19 Su	0407	1.4
	1023	3.1		1028	2.7
	1556	1.0		1613	0.8
	2256	3.3		2321	2.8
5 Su	0423	1.2	20 M	0442	1.4
	1058	3.2		1056	2.8
	1634	0.7		1640	0.6
	2347	3.4		2358	2.9
6 M ○	0506	1.3	21 T ●	0515	1.5
	1132	3.2		1126	2.8
	1712	0.4		1710	0.4
7 T	0037	3.4	22 W	0038	3.0
	0548	1.4		0547	1.5
	1206	3.1		1157	2.8
	1752	0.2		1742	0.3
8 W	0127	3.4	23 Th	0120	3.0
	0628	1.5		0618	1.6
	1239	3.1		1231	2.9
	1831	0.1		1818	0.2
9 Th	0218	3.2	24 F	0204	2.9
	0708	1.6		0649	1.6
	1314	3.0		1307	2.9
	1910	0.1		1855	0.2
10 F	0310	3.0	25 Sa	0251	2.9
	0748	1.7		0722	1.7
	1350	2.9		1344	2.9
	1952	0.2		1936	0.3
11 Sa	0403	2.8	26 Su	0338	2.8
	0828	1.8		0757	1.8
	1426	2.7		1425	2.9
	2034	0.4		2018	0.5
12 Su	0457	2.7	27 M	0425	2.8
	0913	1.9		0838	1.8
	1508	2.5		1513	2.8
	2120	0.7		2106	0.7
13 M	0553	2.5	28 T	0514	2.7
	1018	1.9		0931	1.9
	1601	2.3		1611	2.7
	2222	1.0		2206	1.0
14 T	0653	2.5	29 W	0604	2.8
	1231	1.9		1053	1.9
	1718	2.2		1726	2.6
				2336	1.3
15 W	0016	1.2	30 Th	0656	2.8
	0755	2.5		1246	1.8
	1403	1.7		1857	2.6
	1909	2.1			

DECEMBER

	Time	m		Time	m
1 F	0110	1.4	16 Sa	0137	1.5
	0750	2.9		0753	2.5
	1354	1.5		1418	1.2
	2033	2.8		2132	2.3
2 Sa	0216	1.5	17 Su	0239	1.6
	0842	2.9		0845	2.5
	1444	1.1		1458	1.0
	2151	3.0		2229	2.5
3 Su	0311	1.6	18 M	0331	1.7
	0930	3.0		0932	2.6
	1528	0.8		1536	0.8
	2253	3.2		2313	2.7
4 M	0401	1.6	19 T	0416	1.7
	1014	3.0		1015	2.7
	1611	0.5		1612	0.6
	2347	3.3		2355	2.9
5 T	0449	1.7	20 W ●	0454	1.7
	1055	3.1		1056	2.8
	1654	0.3		1651	0.4
6 W ○	0038	3.3	21 Th	0037	2.9
	0533	1.7		0531	1.7
	1135	3.0		1136	2.9
	1737	0.1		1730	0.3
7 Th	0128	3.2	22 F	0119	3.0
	0616	1.7		0605	1.7
	1214	3.0		1216	2.9
	1819	0.1		1809	0.2
8 F	0217	3.1	23 Sa	0201	3.0
	0656	1.7		0639	1.7
	1253	2.9		1257	3.0
	1900	0.1		1850	0.2
9 Sa	0302	3.0	24 Su	0242	3.0
	0737	1.7		0714	1.6
	1334	2.8		1340	3.0
	1940	0.2		1930	0.2
10 Su	0344	2.8	25 M	0322	3.0
	0816	1.6		0752	1.6
	1414	2.7		1424	2.9
	2020	0.4		2011	0.4
11 M	0423	2.7	26 T	0400	2.9
	0859	1.6		0833	1.5
	1456	2.5		1512	2.9
	2059	0.6		2054	0.6
12 T	0500	2.6	27 W	0438	2.9
	0948	1.6		0920	1.5
	1543	2.3		1608	2.8
	2143	0.9		2144	0.9
13 W	0537	2.5	28 Th	0516	2.9
	1054	1.6		1018	1.5
	1642	2.2		1713	2.7
	2242	1.2		2247	1.3
14 Th	0617	2.5	29 F	0556	2.8
	1220	1.5		1135	1.4
	1803	2.1		1836	2.6
15 F	0015	1.4	30 Sa	0014	1.6
	0702	2.5		0642	2.8
	1328	1.4		1300	1.2
	1954	2.1		2016	2.6
			31 Su	0138	1.8
				0736	2.8
				1408	1.0
				2150	2.8

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